Transport Research Knowledge Centre

WATERBORNE TRANSPORT
THEMATIC RESEARCH SUMMARY

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Thematic Research Summary:

Waterborne Transport

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Foreword

This paper has been produced as part of the TRKC (Transport Research Knowledge Centre) project of the Sixth Framework Programme, priority thematic area "Sustainable Development, Global Change and Ecosystems".

The role of TRKC, as its predecessor project EXTR@Web, is to collect, structure, analyse and disseminate transport research results. It covers EU-supported research as well as key research activities at national level in the European Research Area (ERA) and selected global programmes. The main dissemination tool used by TRKC is the web portal at www.transport-research.info

The approach to dissemination of results of research projects adopted by the TRKC team includes the following three levels of analysis:

- Project Analysis, which provides, project by project, information on research background, objectives, results, technical and policy implications;
- **Thematic Analysis**, which pools findings of research projects according to a classification scheme based on thirty themes, fixed for the project life time; the product of this analysis activity is the set of **Thematic Research Summaries (TRS)**; the present document belongs to this set;
- Policy Analysis, which pools findings of research projects according to combinations of themes, based on ad-hoc policy priorities which are agreed with DGMOVE of the European Commission and a representative group of research users.

This Thematic Research Summary deals with Waterborne Transport. The aim is to provide the reader with a synthesis of completed EU-funded projects which have dealt with the theme. The paper is intended for policy makers at the European, national and local levels, as well as any interested reader from other stakeholders, and from the academic and research communities.

Disclaimer and acknowledgement

The TRKC team is fully responsible for the content of this paper. The content of this paper does not represent the official viewpoint of the European Commission and has not been approved by the coordinators of the research projects reviewed.

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Executive summary

This paper has been produced as part of the TRKC (Transport Research Knowledge Centre) project of the Sixth Framework Programme. The role of TRKC, as its predecessor project EXTR@Web, is to collect, structure, analyse and disseminate transport research results. TRKC provides comprehensive coverage of transport research in EU programmes as well as key research activities at national level within the European Research Area and selected global programmes.

The paper is one of the thematic research summaries (TRS). The TRSs aim at providing a synthesis of research results and policy implications from completed projects. Each TRS deals with a theme according to the classification which the TRKC project has adopted. The theme of this TRS is “Waterborne Transport”.

The first part of the paper includes a brief analysis of the scope of the theme, and a policy review where the main policy developments at EU level are summarised. The paper then summarises results of 21 projects, spread across 5 sub-themes:

The **scope of the Waterborne Transport theme is wide-ranging**, overlapping with numerous other themes. Waterborne Transport relates to maritime and river routes, operations, actors, and institutional setting. These broad thematic aspects encompass topics such as safety, vehicle design and technology, efficient operations, intermodality, trans-boarder and regional development, regulatory issues, cooperation, and economic aspects.

Set against the basic aim of providing greener, safer, and cost-effective transport, **the EU has devoted considerable resources towards the promotion of Waterborne Transport, viewed as a major aspect of its transport policy**. This leads to a set of specific policies dealing with: alternative mode promotion, safety enhancement, security enforcement, pollution reduction, ICT norm and standards’ setting, European and International law and regulations, and the strengthening of a European transport sector.

The first sub-theme summarises project results in the area of **short-sea shipping**. Projects take on themes such as vehicle technology and trans-border cooperation, and stress the necessity of stakeholder and institutional cooperation at regional and European levels.

The second sub-theme studies projects related to the development of **Inland Waterways**. The projects demonstrate the positive socio-economic impacts of inland waterway

navigation development, and also the need for trans-national cooperation, for safe navigation.

The third sub-theme concerns **Ship design, operation, and maintenance**.

- A first cluster of projects develops risk-based methodologies and DSS solutions for the efficient and safe design of ships.
- A second cluster of projects, addresses ships' physical aspects, focusing hull design for high-speed vessels, and the economic viability of innovative on-board materials.

A fourth sub-theme deals with **Maritime Safety**, encompassing technical, institutional, regulatory, and environmental issues.

- A first cluster of projects deals with on-board safety of crew and navigational aspects, highlighting ICT (Information and Communication Technologies) benefits and European cooperation.
- A second cluster of projects specifically addresses maritime safety in the pollution prevention sense. Projects produce solutions for prevention and response to accidents involving dangerous cargo, such as oil spills.

A fifth sub-theme, concerns **Ports and port operations**. Projects in this sub-theme devise methodologies and tools for enhancing ports' business process efficiency. Other projects explore the sustainability of ports, relating in particular to ship pollutants.

In view of the projects reviewed in this TRS, **future research relating to Waterborne Transport** would mainly concern:

- Pollution prevention / response, and ship dismantling;
- Vessel technology: propulsion, hull, on-board materials;
- Safety of crew, passengers, port personnel;
- Integration in the inter-modal transport chain;
- Economics and business studies;
- Institutional cooperation.

Abbreviations and acronyms used

AIS	Automatic Identification System
ASP	Application Service Provider
BPG	Best Practice Guide
CA	Concerted Action
CEC	Commission of the European Communities
CESA	Community of European Shipyard's Associations
DGMOVE	Directorate General for Mobility and Transport (new EC Directorate General from 2010)
DGTREN	Directorate General Transport and Energy (former EC Directorate General up to the end of 2009)
DSS	Decision Support Systems
EC	European Commission
ERA	European Research Area
EMSA	European Maritime Safety Agency
ET	Event Tree
ETA	Estimation of Time of Arrival
ESN	European Shortsea Network
EU	European Union
EXTR@Web	Exploitation of Transport Research via the Web (predecessor project to TRKC)
FP5 / 6 / 7	Fifth / Sixth / Seventh Framework Programme (EU R&D programmes)
FSA	Formal Safety Assessment
FT	Fault Tree
ECMT	European Conference of Ministers for transport
GIS	Geographic Information System
ECDIS	Electronic Chart Display Information System
HMI	Human-Machine Interface
IALA	International Association of Lighthouse Authorities
ICT	Information and Communication Technologies

ICZM	Integrated Coastal Zone Management
ILO	International Labour Organisation
IMO	International Maritime Organisation
INE	Inland Navigation Europe
IT	Information Technology
ITS	Intelligent Transport Systems
MLC	Maritime Labour Convention
NEBA	Net-Environmental Benefit Analysis
OSR	Oil-Spill Response
PTA	Priority Thematic Area (sub-groupings in FP6)
R&D	Research and Development
RIS	River Information Services
RoRO	Roll-on-Roll-off
RoPax	Roll-on-Roll-off-Passenger-Ship / Ferry
SAR	Search And Rescue
SPC	Shortsea Promotion Centre
SRA	Strategic Research Agenda
STCW	Standards, Training, Certification and Watchkeeping
SSS	Short Sea Shipping
TBT	Tributyltin
TEN	Trans-European transport Network
TRKC	Transport Research Knowledge Centre
TRS	Thematic Research Summary
VNE	Voies Navigables d'Europe
VTM	Vessel Traffic Management
VTS	Vessel Traffic Services
WP	Work Package
WSRA	Waterborne Strategic Research Agenda
WTP	Waterborne Technology Platform

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1. Introduction

This paper provides a structured review of recent research relating to Waterborne Transport carried out in EU-funded research projects. “Waterborne Transport” is one of thirty themes in the classification scheme adopted by the TRKC project, shown in the table below.

Table 1. The classification scheme adopted in TRKC

Dimension 1: sectors
• passenger transport • freight transport
Dimension 2: geographic
• urban transport • rural transport • regional transport • long-distance transport • EU accession issues
Dimension 3: modes
• air transport • rail transport • road transport (including walking and cycling) • **waterborne transport** • innovative modes • intermodal freight transport
Dimension 4: sustainability policy objectives
• economic aspects • efficiency • equity and accessibility • environmental aspects • user aspects • safety and security
Dimension 5: tools
• decision support tools • financing tools • information and awareness • infrastructure provision including Trans-European Networks (TENs) • integration and policy development • Intelligent Transport Systems (ITS) • regulation/deregulation • land-use planning • transport management • pricing and taxation • vehicle technology

The scheme has been adopted to enable search facilities in the TRKC portal, and to ensure comprehensive coverage of research results and appropriate policy analysis in the Thematic Research Summaries (TRS). Definitions for each theme are found on the TRKC portal at http://www.transport-research.info/web/projects/transport_themes.cfm.

In the predecessor project EXTR@Web, TRSs have been produced for 28 out of the 30 themes (the reduced number of TRSs resulting from merging of some themes into a single TRS). The TRKC project has planned to produce final versions of the TRSs for all themes by June 2010. This is the final version of the TRS on Waterborne Transport.

A large number of research projects have dealt with the Waterborne Transport theme and the nature of the TRKC's classification scheme is that all overlap with at least one other theme, and in many cases several themes. The “Waterborne transport” TRS produced in the predecessor project (EXTR@Web, 2006), reviewed research from 23 projects – European projects belonging to the Fourth and Fifth Framework Programmes for R&D (FP4 and FP5) and selected national projects. The present paper adds previously unreported projects – European projects from FP5, FP6 and national projects – and, for prominent projects, FP6 projects for which results are not published, and FP7 projects still ongoing.

The research reviewed in this paper does not represent the entire range of research dealing with Waterborne Transport carried out in Europe. The paper focuses on research from those projects which have made documentation on results available to the TRKC team after the issue of the EXTR@Web paper in 2006. When relevant, a summary of the research on Waterborne Transport topics reported on in the previous EXTR@Web paper is also included to make the reader aware of the full range of research which has dealt with the theme.

The paper is organised as follows. Sections 2 and 3 set the scene. Section 2 includes a brief analysis of the scope of the theme. Section 3 provides an overview of the policy priorities at EU level which underpin the research objectives. The sources for this section are principally European Commission documents which have set the policy agenda such as white papers, green papers, and communications.

Section 4 reports on the results from research. The section is structured into five sub-themes to make the broad area of research in the Waterborne Transport field more manageable. For each sub-theme, overall research objectives are presented and linked to policy goals, then research findings are synthesised. A special focus is given to the policy implications of research results. Sources for Section 4 are documents available from the projects and reporting on their achievements, essentially the projects’ final reports.

The sub-themes covered in section 4 are:

- Short-Sea Shipping;
- Inland Waterways;
- Ship Design, Maintenance & Operation;
- Maritime Safety;
- Ports & Port Operations.

The Annex includes the list of the research projects for each of the five sub-themes. When available, addresses of the websites of the projects are included with hyperlinks. In several cases these websites make the project documentation available to the public. This may include final reports and project deliverables.

2. Scope of the theme

At a first level, the scope of the Waterborne Transport theme consists of short-sea shipping, deep-sea transport, inland navigation, sea-river shipping, and related land operations, such as cargo handling/transferring between the waterborne transport mode and the other modes. Summarised, the transportation aspect of the Waterborne theme refers to:

- Seas and waterway arteries;
- Vehicle technologies and operation;
- Freight and passenger handling;
- Operations organisation and management.

However, a second level of scope for this theme is linked to European transport policy and its strong commitment to furthering the development of waterborne transport usage, as a greener and often cost-effective transport means – and a sustainable alternative mode to road transport and haulage. In this respect, EU promotion and a number of resulting innovations are effectively enhancing Waterborne Transport, owing notably to the general incorporation of ICT (Information and Communication Technologies) systems, and improvements in vessels' design and propulsion methods. These methods have, in particular, increased Waterborne Transport's flexibility, thus reducing the traditional bottlenecks hindering its development. Enhancing Waterborne Transport's flexibility is thus one of the major topics pertaining to his mode, and a relevant condition for advancing it as a technically and economically viable alternative.

In this general framework of setting Waterborne Transport in an intermodal transport chain, several topics are addressed, relating to its routes, its operations, its actors (institutional, industrial, crew, port operators, passengers), and the institutional framework.

Considering routes, the promotion of short-sea shipping and inland waterways comes to mind, as a foremost theme, and is particularly important in light of cross-border and inter-regional aspects. However, routes' consideration also encompasses relevant vehicle design and safety issues. Further, deep-sea routes fall into this scope, entailing notably safety aspects (particular hazardous routes, vessel resistance, and maritime pollution).

Waterborne Transport operations are an integral part of the theme, as they condition the extent to which this mode fits within the intermodal transport chain. The issues addressed

therefore pertain to vessel manoeuvring, on-board safety, robust and efficient ICT architectures, freight/passenger handling, and port operations in the general sense (including customs, or service development, as examples).

The theme also encompasses a study of Waterborne Transport's actors. First, actor's safety is an eminent topic, discussed for crew, passengers, port operators, in order to design, test and implement safety-ensuring methods and procedures, and tools – whether technically-based or not. Further, this theme includes training and human resources development issues, as central to the attractiveness of the European Maritime Industry. A third topic pertains to Waterborne Transport as an industry, therefore assessing current business practices, in relation to their impacts on personnel, authorities, competition, and other modes.

Finally, and in line with the EU's commitment to Waterborne Transport, its institutional framework is an important topic, where regulatory issues and efficient cooperation mechanisms can be designed and promoted.

From the scope of the topics that could be considered for Waterborne Transport, it appears clear this theme overlaps many of the other themes studied by the Transport Research Knowledge Centre, and, if interested in a specific topic, we recommend that the reader browses related Thematic Research Summaries for further insights, such *Safety & Security*, *Vehicle Technology* or *Intelligent Transport Systems*.

3. Policy context

Over the last ten years, the European Union has built its Waterborne Transport policy gradually: first setting the framework for modal shifting promotion, then to intermodality issues, and, after fully taking into account EU enlargement, is now advocating an Integrated Maritime Policy.

3.1 Background: the 2001 Transport White Paper[1]

Albeit being previously mentioned by official communications, notably in the European Commission's Transport White Paper of 1992 (CEC, 1992), the foundations, guiding lines, and action points for a European policy on waterborne transport were laid in the Transport White Paper of 2001 (CEC, 2001).

The White Paper acknowledged that "in the new context of sustainable development, Community co-financing should be redirected to give priority to rail, sea and inland waterway transport", building on a previous statement made by the Gothenburg European Council which called for a shift of balance between modes by way of an investment policy in infrastructure geared to the railways, inland waterways, short sea shipping and intermodal operations (COM (2001).

Several policies were decided through this White Paper:

1. Acknowledging that **short-sea shipping** and **inland waterway** transport are the two modes which could provide a means of coping with the congestion of parts of the road infrastructure and the lack of railway infrastructure, the first aim of the Commission was to **promote transport by sea and inland waterway**, as clean and efficient transport systems

2. In this setting, the Commission sought to revive short-sea shipping by building **sea motorways** within the framework of the master plan for the trans-European network – ideed requiring better connections between ports and the rail and inland waterway

[1] For extensive comments on the 2001 Transport White Paper, see "Third Annual Thematic Research Summary – Waterborne transport", (EXTRA@Web, 2006)

networks, together with improvements in the quality of port services. Therefore, the second of the fundamental policies related to the **adaptation of the maritime and inland waterway transport system**.

3. **Enlargement issues** were also taken into account, for the upgrading of accessing countries' port infrastructure, the necessary **harmonisation of technical requirements regarding ships' structure and maintenance criteria**, but also social standards, starting with the International Labour Organisation's standards for seafarers. In particular, these issues were one of the main stakes for the **creation of a European Maritime Safety Agency**[2].

4. Stakes regarding **Maritime traffic safety** are also high, particularly regarding dangerous goods or pollutants. The risk of accidents due to traffic concentration in Europe's main sea lanes is particularly high in bottlenecks such as the Straits of Gibraltar or the Ushant traffic separation scheme, and the Commission sought to minimise these risks by organising the monitoring of shipping more effectively through **a trans-European network of shipping management and information**. Such a network should improve the management and supervision of traffic and reduce the administrative burden on ships' captains, while improving the preparedness and response of maritime authorities faced with accidents or pollution risks.

3.2 The 2006 Mid-term Report

The Mid-term report (CEC, 2006a), acknowledging the enlargement process, advocated that the EU should take advantage of the existing potential, long coast-line and number of ports of the Union, in order to be a viable alternative to land transport. In this respect, the report highlighted two key challenges for the development of waterborne transport:

- The absence of a seamless internal shipping market;
- The lack of ports' capacity to face the expected growth of sea transport.

Therefore, in the area of Waterborne transport, the 2006 Mid-term report innovated in 2 ways:

First, the Mid-term report developed along the lines set down in the 2001 White Paper, seeking to further action in the following areas:

- Develop a comprehensive European ports policy;
- Reduce pollutant emissions from waterborne transport;
- Continue to promote short sea shipping and motorways of the sea; and
- Implement the NAIADES[3] action plan for river transport.

[2] European Maritime Safety Agency website: www.emsa.eu.int/end173d001.html
[3] See section 3.4 of this present document.

In particular, the Mid-term report specifically acknowledged the importance and role of the "Marco Polo II program" in building the Motorways of the seas (CEC, 2004).

Second, whereas the 2001 White Paper focused on sectoral and enlargement issues, the 2006 mid-term review argued for "a comprehensive, holistic approach to transport policy", thus promoting an enlarged view of policy based on the mutual consent and cooperation of stakeholders (national, regional and local levels of government as well as by citizens and industry themselves). The Commission's strategy was clear: to develop a comprehensive strategy for a “common European space”.

These actions prompted the wide consultation of stakeholders contained in the "Green Paper on a future EU maritime policy" (CEC, 2006b) and the wider set of policies put forward in the 2007 "Blue Paper” promoting “An Integrated Maritime Policy for the European Union" (CEC, 2007). In addition, a parallel policy was devised, specifically addressed to Inland waterway transport (the NAIADES Integrated Action Programme).

3.3 The foundations of an Integrated Maritime Policy: the 2007 "Blue Paper"

As stated in the previous paragraph, the Blue Paper's rationale is the "Commission's vision for an integrated maritime policy that covers all aspects of [the EU's] relationship with the oceans and seas", thus promoting a holistic approach to building a policy framework encompassing all sea-related activities in a sustainable manner.

As a fundamental policy statement, the Blue Paper set out:

- A governance framework and tools,
- Action points.

3.3.1 Governance framework and tools

In order to apply an Integrated Approach to Maritime Governance, the aim of the Commission is to coordinate and harmonise national integrated maritime policies by Member States, themselves working closely with stakeholders, in particular the coastal regions. Within this framework, the Commission organised a stakeholder consultation structure, allowing exchange of best practises[4].

[4] See for example the "Report from the Group of Senior Shipping Professionals to the Commission" (2008)

Specifically, this Integrated approach shall be based on the development of fundamental maritime tools, such as:

- A European network for maritime surveillance, promoting improved cooperation between Member States' Coastguards and appropriate agencies and the development of an interoperable surveillance system;
- Maritime Spatial Planning and Integrated Coastal Zone Management (ICZM), as a fundamental tool for the sustainable development of marine areas and coastal regions, and for the restoration of Europe's seas to environmental health;
- Data and Information availability, as a basis of strategic decision-making on maritime policy, through the creation of a European Marine Observation and Data Network.

3.3.2 Action areas

The Commission focused its Integrated Maritime Policy on the following five areas:

3.3.2.1 Maximising the Sustainable Use of the Oceans and Seas

The Commission will continue to promote safe and secure shipping, as it being a "greener" mode, apt at reducing road congestion. In this respect, the TEN-T and MARCO POLO programmes will continue to support the creation of the Motorways of the Sea/Short Sea Shipping Networks. Moreover, the Commission will propose a European Maritime Transport Space without barriers and prepare a comprehensive maritime transport strategy for 2008-2018 (CEC, 2009a)[5].

In line with maritime barrier reduction, the Commission also focused its attention on European seaports, and aimed to make proposals to reduce the levels of air pollution from ships in ports, namely by removing tax disadvantages for shore side electricity, and issue guidelines on the application of the relevant Community environmental legislation to port development.

Moreover, the shipping industry was also recognised as a central element of Integrated Maritime policy, to be based on the creation of multi-sectoral clusters and regional centres of maritime excellence, in order to foster the business integration and competitiveness in the maritime sector. As for the social context, the Commission also stated the need to increase the number and quality of maritime jobs, by improving staffing policies and working conditions (including health and safety), and create a Certificate of Maritime Excellence.

[5] See section 3.5 of this document.

In the field of sustainable development, the Commission's goal is to reach the objectives of EU environmental legislation, in particular the Habitats Directive (CEC, 1992b) and the proposed Marine Strategy Directive (CEC, 2008). Several broad actions are stated for this:

- Launch pilot actions to reduce the impact of human activity and adapt to climate change in coastal zones;
- Support actively international efforts to diminish air pollution caused by ships and greenhouse gas emissions;
- Make proposals for dismantling obsolete ships in an efficient, safe and environmentally sustainable manner;
- Take firm action towards the elimination of discards and of destructive fishing practices such as high seas bottom trawling in sensitive habitats;
- Promote the development of an environmentally safe aquaculture industry in Europe.

3.3.2.2 Building a knowledge and innovation base for the maritime policy

The Commission recognized that "Marine science, technology and research are crucial for the sustainable development of sea-based activities", in decoupling the development of sea based activities from environmental degradation and advocated the development of the Marine Observation and Data Network.

Moreover, the Commission launched joint cross-cutting calls under the 7th Research Framework Programme to promote an integrated approach and improve understanding of maritime affairs, and support research to predict, mitigate and adapt to the effects of climate change on maritime activities, the marine environment, coastal zones and islands, and, last, to support the creation of a European marine science partnership for a concerted dialogue between the scientific community, the industry and policy makers.

3.3.2.3 Quality of Life in Coastal Regions

Another important aspect of the Commission's Integrated policy is the improvement of quality of life in the coastal regions, as population growth in coastal regions and islands has been double the EU average over the last decade, rendering the need to reconcile economic development, environmental sustainability and quality of life particularly acute in these regions.

In particular, the Commission's policy priorities in this field were to propose a Community Disaster Prevention Strategy highlighting the risks to which coastal regions are exposed, promote the development of the maritime potential of Outermost regions and islands.

On an operational level, these broad initiatives will translate into:

- The preparation of a data-base on Community funding available for maritime projects and coastal regions, as well as a database on socio-economic data for maritime sectors and coastal regions;
- The promotion of coastal and maritime tourism.

3.3.2.4 Promoting Europe's Leadership in International Maritime Affairs

Following the EU's enlargement to new Member States, the policy and action in the field of international maritime governance are, understandably, also a priority on the Commission's maritime policy agenda.

Therefore, the Commission has stated that she will actively urge Member States to ratify the relevant instruments and conventions, in order to improve the efficiency of international governance of maritime affairs and effective enforcement of international maritime law.

In particular, in the framework of broad policy statement, the Commission deemed necessary the promotion of cooperation under the Enlargement and European Neighbourhood Policies, and the Northern Dimension, to cover maritime policy issues and management of shared seas. Further, the Commission recognised the need for the external projection of the Union's Maritime Policy through a structured dialogue with major partners.

3.3.2.5 Raising the Visibility of Maritime Europe

Last among the action points of the Commission's broad range Integrated Policy measures, was the need to raise public and professional awareness of the value of the maritime economy and heritage. In order to enhance such a symbolic goal, the Commission launched a European Atlas of the Seas, as an educational tool, and proposed the celebration of an annual European Maritime Day, raising the visibility of maritime affairs and promoting links between maritime heritage organisations, museums and aquaria.

3.4 The specific agenda for Inland Waterways

In parallel to the maritime agenda, the Commission equally paid specific attention to building a framework policy for Inland Waterways, as the EU comprises 35.000 km of waterways in 18 out of the 27 Member States.

The policy approach adopted by the Commission is contained in the NAIADES project[6], an Integrated Action Plan for 2006-2013, based on a thorough assessment and an extensive consultation with the Member States and sectoral actors.

Indeed, inland waterway transport is an obvious choice to play a more prominent role in reaching emission reduction targets. Given that inland navigation is often a cross-border transport mode, action at both national and Community level was required

The programme includes recommendations for action to be taken between 2006 and 2013 by the European Community, its Member States and other parties concerned:

- Create favourable conditions for services,
- Stimulate fleet modernisation and innovation,
- Promote jobs and skills,
- Improve image and co-operation,
- Provide adequate infrastructure, in particular by building missing links and removing bottlenecks in the EU's waterway infrastructure.

The implementation of the programme shall be carried out in close co-operation with national and regional authorities, River Commissions, as well as the European inland waterway transport sector[7].

Alongside NAIADES, targeted initiatives are launched on the European level to assist inland waterway transport in unfolding its full potential and to provide favourable framework conditions for this particular mode of transport. These initiatives comprise legal measures, in-depth scientific studies and development projects.

[6] See www.naiades.info

[7] See Inland Navigation Europe's "Annual Report" for 2008" (INE, 2008)

3.5 Europe's strategic goals for 2018

In the broad policy framework of the Blue Paper, the Commission assessed its policy priorities and action points in 2009 (CEC, 2009a), after careful consideration of

- Stakeholder views,
- The pressure put upon the European maritime industry due to the general economic slump during 2008[8],
- The EU's current energy and environmental policy.

The Commission's therefore devised 6 strategic action points for the coming decade.

3.5.1 European shipping competitiveness in globalised markets

The Commission's first priority is to enhance European shipping's competitiveness, through:

- A clear and competitive EU framework for tonnage taxation, income taxation and state aid
- Strong action in support of fair international maritime trade conditions and access to markets, through multilateral and bilateral agreements with key trade and shipping partners.
- Commitment to achieving a level playing field for maritime transport,
- Promoting alignment of the substantive competition rules globally.

3.5.2 Human resources, seamanship, and maritime know-how

The Commission's interest here is in emphasising the attractiveness of the maritime professions to Europeans, striking the right balance between the employment conditions of EU seafarers and the competitiveness of the European fleet:

[8] See the document "OPTIMAR — Benchmarking strategic options for European shipping and for the European maritime transport system in the horizon 2008-2018", where all relevant statistics and figures are provided (Lloyd's Register – Fairplay, 2008), and EUROSTAT – Maritime Transport Statistics - http://ec.europa.eu/eurostat/

- Adopt positive measures facilitating lifelong career prospects in the maritime clusters,
- Support the work of the International Maritime Organisation (IMO) and the International Labour Organisation (ILO) on the fair treatment of seafarers,
- Ensure thorough enforcement of international and Community requirements under the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) by all nations granting seafarers' certificates of competence,
- Ensure the implementation of the ILO 2006 Maritime Labour Convention (MLC) to improve working and living conditions on board ships.

3.5.3 Maintaining the maritime sector's quality

The Commission sees the qualitative aspects of the maritime sector as essential to its competitiveness, particularly in the areas of:

- Environmental performance, working towards the long-term objective of 'zero-waste, zero emission' of maritime transport.
- Transport safety, owing to the growth of the fleet, the entry into service of very large carriers for the transport of both passengers and freight and the exponential growth in shipping operations.
- Security, by establishing a comprehensive framework of security measures based on prevention, reaction capacity and resilience, leading to a genuine 'security culture' becoming an integral part of quality shipping and port operations.
- Surveillance, by putting in place an integrated information management system to enable the identification, monitoring, tracking and reporting of all vessels at sea and on inland waterways to and from European ports and in transit through or in close proximity to EU waters.

3.5.4 Europe on the international scene

The global challenges confronting shipping and maritime services today demand convincing answers from the international community. The Commission – and the Member States – wishes to achieve and implement a comprehensive international regulatory framework for shipping.

3.5.5 Short-sea shipping and sea transport services for business and citizens in Europe

The existing system of port infrastructure, including hinterland connections and freight corridors, has to be adapted to cope with the expected growth of goods and passenger transport between 2009 and 2018, thus calling for the provision of new infrastructures and

the improvement of existing capacities by increasing port productivity. In line with previous policy statements, the Commissions aim in this field is to:

- Establish a true 'European maritime transport space without barriers',
- Implement the measures announced in the Communication on a European Ports Policy,
- Prioritise modernisation and expansion of port and hinterland connection infrastructure projects in those areas that are more likely to suffer from congestion problems,
- Issue guidelines on the application of relevant Community environmental legislation to port development,
- Ensure the full deployment of Motorways of the Sea projects,
- Promote measures to facilitate better connection of islands and long-distance intra-EU passenger transport through quality ferry and cruise services, and appropriate terminals,
- Implement pricing schemes encouraging users to make use of short sea shipping alternatives,
- Address the issue of passenger rights for users of ferry and cruise services in Europe.

3.5.6 Innovation policy

The Commission recognises that the competitiveness of Europe's maritime industries, and their ability to meet the environmental, energy, safety and human-factor challenges they face is influenced to a large degree by research and innovation efforts, which are to be further encouraged, as they represent significant opportunities for industry growth and efficiency[9].

Previous RTD developments are therefore to be pursued, particularly in the areas of:

- New ship designs and equipment to improve safety and environmental performance.
- Technological development and advanced logistics conceptions which maximise the efficiency of the overall transport chain by means of short sea shipping and inland waterway transport.
- Marketing tactics for implementation of research efforts.
- The development of ICT inspection and monitoring tools, related to the technical management of the fleet.

[9] These innovations are to be linked with fundamental research. See the Commission's "Communication on a European Marine and Maritime Research Strategy", CEC (2008b).

3.6 The E-Maritime initiative: the Commission's main policy "tool"

In order to set out these policy objectives for 2018, the Commission designed the E-Maritime initiative as one of its principal tools. The E-Maritime initiative is a holistic approach to addressing, in one breast, the development of transport services, logistics, customs, border control, environmental and fishing control operations (SKEMA, 2010).

The short-term objective is a simplification and cohesion of administrative requirements and procedures, with a spill-over into commercial applications, such as standardization and interoperability for cooperative networking strategies in intermodal operations.

E-Maritime is basically the development of a common framework built around the use of information, communication, and surveillance technologies, thus providing interoperability between all maritime administrative functions, with important applications in commercial operations encompassing both:

- Administration Domain Applications, including a common reporting interface and integrated maritime surveillance for cargo and ship movements.
- Business Domain Applications, such as shipping and port operations, and logistics chains' integration.

It is hoped, in the medium term, to provide fully efficient functioning of intermodal networks, even for interregional services, without incurring massive IT infrastructure costs, therefore facilitating overall commercial transactions in the maritime industry, and promoting the transformation of intermodal networks into efficient open networks.

4. Research findings

4.1 Introduction

The research reviewed in this Thematic Research Summary (TRS) deals with 5 sub-themes and their scope often overlap with other TRSs (TRKC 2010).

The first sub-theme deals with **short-sea shipping**, detailing projects that focus on developing the usage of short-sea shipping and enhancing its efficiency. Readers interested in this sub-theme are also referred to the TRS on Intelligent Transport Systems, the TRS on Intermodal Freight Transport, and the TRS on Infrastructure Provision Including Trans-European Networks (TENs).

The second sub-theme studies research related to **inland waterways**, the goal of which is to provide alternative and greener inland traffic routes to road transport. Readers interested in this sub-theme are also referred to the TRS on Infrastructure Provision Including Trans-European Networks (TENs), and the TRS on Integration and Policy Development.

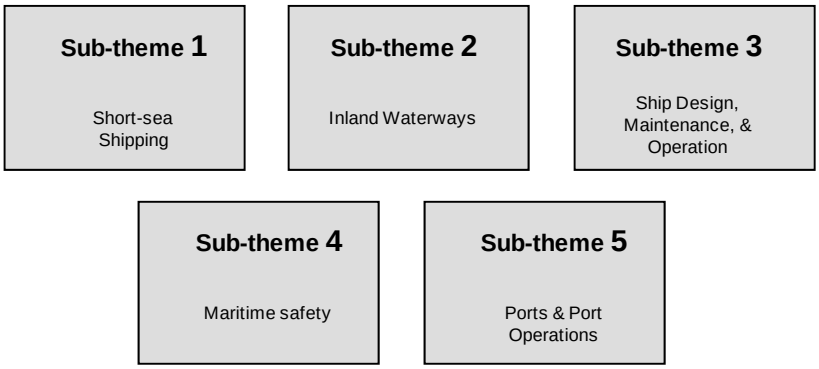
The third sub-theme reviews **ship design, maintenance and operation**, with respect to the design of waterborne transport systems' and vehicles' technical architecture. Further information on these issues can be found in the Intelligent Transport Systems TRS, the Decision Support Tools TRS, and the Vehicle Technology TRS.

The fourth sub-theme treats of **maritime safety**, and is related to a major concern for EU policy. Related topics are also discussed in the Intelligent Transport Systems TRS, the Passenger Transport TRS, the Safety & Security TRS, and the TRS devoted to Environmental Aspects.

Finally, the fifth sub-theme deals with **ports and port operations**, reviewing the design of efficient tools, processes and equipment. Interested readers may also refer to the TRS on Freight Transport, the TRS on Pricing & Taxation, the TRS on Economic Aspects, and the TRS on Environmental Aspects.

The abovementioned documents are available on the TRKC website at:

http://www.transport-research.info/web/publications/



The structure of the sub-themes in this TRS differs slightly from the one in the EXTR@Web TRS (EXTR@Web, 2006), as a new sub-theme on "Ship design, maintenance and operation" has been included.

Table 2 shows the projects which have dealt with each sub-theme. The table includes:

- Completed projects which are synthesised in this TRS and for which the following sub-sections report on research objectives, research results, policy implications and implications for further research;
- Projects which had been synthesised in the EXTR@Web TRS;
- Other EU-funded projects which are still on-going, or which, although completed, have yet not made final results publicly available.

Table 2. Projects relevant to the theme

Sub-theme	Contributing projects
Short-sea shipping	EU projects covered in this paper: MARIDES; MTCP Other projects covered in this paper: Outlook of short-sea shipping in the Mediterranean sea Projects covered by EXTR@Web paper: REALISE; EROCAV; EMBARC Projects covered by EXTR@Web paper not mentioned in this report: B8; HYTECH; REMARCC II; UK Marine Motorways Study Other FP6 projects with results not yet available:

Sub-theme	Contributing projects
Inland waterways	EU projects covered in this paper: D4D - Data Warehouse for Danube Waterway; CANAL LINK; Other projects covered in this paper: Projects covered by EXTR@Web paper not mentioned in this report: ALSO DANUBE; INDRIS; MD/DD17; PACSCAT; RISVD Other FP6 projects with results not yet available:
Ship design, maintenance, & operation	EU projects covered in this paper: TELEMAS; SAND.CORe; ADOPT; SAFEDOR Other projects covered in this paper: Hydrodynamic characteristics of innovative high-speed vessels Projects covered by EXTR@Web paper: SANDWICH Other FP6 projects with results not yet available:
Maritime safety	EU projects covered in this paper: OPTINAV; MARNIS; SPREEX; SAFEICE; POP&C Projects covered by EXTR@Web paper not mentioned in this report: ADVANCES; ATOMOS II; NAUPLIOS; PODS IN SERVICE; ROROPROB; SANDWICH; SEAM; THEMES Other FP6 projects with results not yet available: FLAGSHIP
Ports and port operations	EU projects covered in this paper: GREEN NSD; MARQUAL; INMARE Other projects covered in this paper: OPSPEMAPT Projects covered by EXTR@Web paper: S-CBB; TRAPIST Projects covered by EXTR@Web paper not mentioned in this report: WATERMAN-TS Other FP6 projects with results not yet available: CAPOEIRA

4.2 Sub-theme 1: Short-sea shipping

4.2.1 Background

The previous Extr@Web TRS on Waterborne transport included a wide variety of projects relating to Short-sea shipping (SSS). These previous projects related to the - then - recent promotion of one of the European Union's main policy objectives, namely the development of short-sea shipping as a viable alternative to road transport. In this setting, projects evolved around three main topics:

- The economic impact of using short-sea shipping as an alternative to road transport and measures to increase its importance (for example, REALISE, 2005).
- The development of new ship technologies, allowing faster short-sea shipping at lower costs and greater safety (EROCAV, 2003).
- The development of technologies and processes for better maritime transport efficiency, through IT processes and networks (EMBARC, 2004).

Recent projects built on this framework, but their starting point was the observation that there seems to be a gap between present growth rate and the goals of policy makers, namely in the European Union (EU). Indeed, although short sea shipping has shown an increase in growth rates over the last years[10], it still offers an even larger capacity that should be exploited to re-balance the different transport modes. In particular, SSS does not appear as a real alternative to land transport, and road haulage.

The background for recent research therefore focused on the critical factors surrounding SSS, in order to ultimately pin those that actually impede SSS development. This background hinged upon three major issues.

First, waterborne transport efficiency is a complex process, dependent on various factors such as the operating costs of the vessels, the charter selection, port time, the route followed, costs of cargo handling, communications reliability and efficiency. The value-chain involves numerous related and intricate stages, and a large number of actors (sellers, buyers, charterers, ship-managers, ship-owners along with their corresponding brokers, services providers, etc). All these factors heavily influence short-sea shipping's

[10] 90% of the EU external trade and 41% of the intra-EU trade in volume are transported by sea (CEC, 2009a)
.

relative efficiency and cost. In this context, the various business processes, and the crucial activity of chartering in particular, are dynamic by nature and their operation requires complex algorithms.

Second, a significant share of short-sea shipping traffic is concentrated around internal seas (Baltic, Mediterranean/Black Sea) and its growth is mainly related to captive markets caused by geographic and/or infrastructure constraints, or by feeder traffic for hub-and-spoke deep-sea transport. However, SSS can hardly compete with land transport, namely road haulage, when both land and sea links are available between origin and destination. Therefore, the critical factors regarding the competition between SSS and land transport must be put in perspective: for example, low relative competitiveness may be due to geographical characteristics (too short distances between origin and destination, a bad ratio of maritime distance to land transport distance) or to demand characteristics (types of goods, volumes, etc.).

Last, as short-sea shipping is a main policy objective for the European Union, research should also study how to provide its most relevant institutional setting and address the need to enhance the Europe's maritime research and education in matters of maritime policy, all in relation to sustainable surface transport, European competitiveness and safe, secure and efficient operation of maritime transport.

4.2.2 Research objectives

A first IT-oriented project, MARIDES (2003), sought to examine how a new trend of software automation packages could reduce shipping costs and enhance efficiency, by specifically incorporating the shipping business process at the outset of a decision-support system. Of particular interest was to improve the decision-making process in the chartering departments of the shipping companies, in order to assist shipping personnel operating both on-board and ashore to deal with the mass of data and to provide an accurate, fast and on-line consultation. The overall goal was to improve the way chartering departments function by integrating a number of state-of-the-art technologies into one unified tool, based on comprehensive artificial intelligence solutions with user-friendly interfaces.

To reach this objective, the method was to connect the shipping companies' chartering department and the company's fleet, in order to provide real-time bi-directional information exchange in a highly integrated business communications network.

MARIDES aim was therefore to propose data management, communications automation and decision optimisation software tool that would complement, rather than compete with

existing software. The system would combine an enhanced communication intranet, web-enabled information accessing technology, an intelligent decision support tool, and a powerful knowledge base.

Regarding short-sea shipping's value-chain and the competitive implications relatively to other transport modes, a study carried out in Italy, Outlook of short-sea shipping in the Mediterranean sea (2005, Italy), carried out an assessment of the Mediterranean basin, analysing both the Tyrrhenian and Adriatic connections towards the countries in the Mediterranean area. The project's primary objective was to build a methodology for understanding the nature and the characteristics of all the variables which mainly influence the profitability and competitiveness of SSS. The ambition was to be able to apply this theoretical framework to specific case studies, regarding a particular market (passenger, cargo, geographical area, shipping route and so forth). Of major importance, is cargo traffic flow analysis, as it competes directly with road haulage: using the model, the study sought to identify potential demand, price levels and service quality, and eventually connections which could be opened, after having evaluated their effectiveness.

Modelling the SSS structure across the Mediterranean basin would allow for an assessment of possible inefficiencies regarding the actual organisational structure of services, and therefore identify relevant solutions. Last, the study also sought to develop a particular analysis regarding the relevance of dedicated port terminals and on the possible SSS routes in the Mediterranean Sea.

As stated previously, the European Commission decided to match its commitment towards short-sea shipping by setting up a relevant institutional framework: the Maritime Transport Co-ordination Platform (MTCP, 2007). The broad objectives of the platform are to produce high quality and policy relevant reports, specifications, forecasts, standard methodologies, decision support tools and information products. The project, carried out during three years and including a wide range of stakeholders and experts, aimed to support EU policy on the following themes:

- Development and attractiveness of maritime transport (quality and efficiency), with an emphasis on short-sea shipping;
- Safety, security and environmental impact;
- Maritime human resource in Europe.

Further, the MTCP sought to develop a Maritime Transport Sector Observatory (MTSO) to provide access to knowledge and data.

4.2.3 Research results

The MARIDES project managed to design and develop decision support tools supporting and enhancing business processes and practices in short-sea shipping cargo transportation. Artificial intelligence was one of the main thrusts of MARIDES. However, the project adopted a change in focus for the artificial intelligence components of the decision support system (DSS), in order to make it viable for use in a real and complex business environment. Indeed, unlike decision making tools which attempt to compete with human experts' decision making, MARIDES instead focused on providing support for the maritime experts' own intuition-based decision making process. Thus, the system:

- Provides fast and effective voyage estimation process, based on estimation procedures known to be effective in the industry;
- Helps experts assess the future performance their vessels will be likely to achieve, if they make the decision they are currently contemplating by relying on predictive statistical analyses;
- Allows experts to delegate the assessment of large volumes of possible business options to the system.

The DSS was enhanced by MARIDES' interface and communications architecture, based on a networking workflow management system. Users with various roles – manager, accountant, secretary… – may all access the system from arbitrary locations and can access each other's information at any time. Finally, the shipboard application seamlessly integrates into the whole system, enabling effective co-ordination of official and ship-level operations.

The work carried out by the "Outlook of short-sea shipping in the Mediterranean sea" project effectively designed an analytical framework for studying short-sea shipping critical success factors and activities. This allowed for a complete analysis of demand, which highlighted a poor utilisation level of most existing lines, where load factor seldom reached 50% of ships' operating capacity. Concerning geographical coverage, the study took into account 22 countries, revealing three lines where the implementation of SSS services could be interesting: Eastern European countries, (especially Romania, Bulgaria, Russia, Ukraine and Turkey), Spain and North African countries, the latter, however seeming the least profitable.

Supply analysis resulted in a full assessment of existing lines, providing an incentive to carry out further research to investigate the relevance and scope for additional services.

However, the study also found that “ancient” port regions do not seem suitable to host short-sea shipping cargo traffic. Apparently, this is due to the lack of absorbing capacity of already congested port infrastructures, and scarce space availability. Therefore, minor ports would seem better suited to receive SSS traffic, on condition that dedicated infrastructures and hinterland connections are carried out.

The MTCP project achieved a flexible coordination platform, providing support to DG TREN[11], and other decision makers with fast access to timely, relevant and reliable information. The work carried out resulted in 18 policy studies, the creation of Expert Groups, and the development of the Maritime Transport Sector Observatory, accessible by both the public and the Commission. Addressing issues pertaining to short-sea shipping, the platform carried out a study regarding DG TREN’s short sea shipping promotion programme. MTCP carried out an analysis of the draft Mid-Term Review[12] and provided a commentary on each of the 14 proposed actions and discussed their impact on short sea shipping promotion. In particular, the MTCP study recommended the Commission’s programme for short-sea shipping promotion be weaved with exterior actions, even led outside DG TREN’s purview (e.g. Marco Polo, Motorways of the Sea, environmental and customs actions).

Last, the study also evaluated the framework conditions for the possible expansion of Shortsea Promotion Centres[13] (SPC) and the European Shortsea Network (ESN) towards intermodal promotion. The extension of the activities of the SPCs could represent either extending activities of the SPCs into intermodal and shortsea promotion, or coordination of intermodal promotion in a certain country by a SPC. The study determined the conditions allowing for the transposition of the SPC model into a new body, a so-called “Intermodal and Shortsea Promotion Centre”.

4.2.4 Policy implications

In view of European policy aspects, the MARIDES platform can assist in the establishment of closer business relations and partnerships in the maritime industry, thus effectively helping establish a common professional framework for short-sea operators. The prototype that was developed enhances co-operation and information exchange procedures with affiliated actors and partners, thus maximising the performance of the related business

[11] Now DG MOVE
[12] See CEC (2006a)
[13] SPCs are one of the actors that realize the European Union transport policy in practice. An initiative was taken in Holland in the early 1990´s to assemble the involved parties and to see how best practices could be explored in order to promote short sea shipping.

practises for the business entities involved. The MARIDES project also provided a breakthrough into the computerised management of the decision support process in chartering operations. The importance of these operations is amplified by the fact that the maritime market has a huge turnover (e.g. a ship's running costs amount to a few thousand Euros per day) and there is a large margin for increasing profitability by effectively assessing the available business options.

The “Outlook of short-sea shipping in the Mediterranean sea” project had far-reaching policy implications, covering a wide scope of topics.

First, the study recognised the need for an Infrastructure policy, calling for dedicated areas to short-sea shipping within ports, improvements of loading/unloading and cargo management systems, and enhancement of port accessibility. Regarding Legislation and regulation, the study advocated for the liberalisation of maritime services’ market, the integration/standardisation of port procedures and the regulation of port services. On a sectoral level, the study called for an European organisational policy, covering modal re-organisation and integration, the promotion of cooperation among operating actors, and the promotion of terminals’ specialisation and the creation of incentives towards strategic alliances between operators. Similarly, the study also recognised the need for harmonised Pricing policies (e.g. regarding port duties), as a levy to promote competition. Last, the study also covered Commercial and marketing issues, aimed at improving the image of short-sea shipping.

The MTCP project was a policy platform in itself and therefore its policy implications are embodied in the project’s actual output. One can add, however, that such a platform is vital for the coherent and harmonised promotion of short-sea shipping, providing a common institutional setting for industrial actors as well as policy makers.

4.3 Sub-theme 2: Inland waterways

4.3.1 Background

The main thrust of previous research projects was to find ways of increasing the importance of inland waterway in the intermodal transport chain. The main objective was to transform the economic, strategic and logistical conclusions from previous research into practice and demonstrate, in the field, the useful contribution of the inland waterways, as well as re-establish some of previously used inland waterways. Operational by nature, these projects focused on such topics as:

- The inclusion of inland waterways in intermodal transport chains management;
- The development of logistic networks;
- Operational systems, and communications and IT systems adapted to inland waterways utilisation (e.g. River Information Services: RIS);
- New vessel concepts, designed for freight transportation on inland waterways.

More recent research builds on these previous projects, but stresses the historical and geographical constraints of inland waterways, putting emphasis on their regional aspect[14]. One prominent example is the North Sea region, where rivers, lakes and canals have played a major role in transport for many thousands of years. During the industrial revolution, canals were constructed for freight traffic, while today recreational and tourism usage of canals and the surrounding land are increasingly popular. Bearing this in mind, a logical step would be to set the development of the region's network of navigable waterways on the basis of the cultural and environmental heritage of the region, albeit ensuring that recreation and tourism are not in conflict with other canal users.

The Danube offers an equally interesting geographical setting for inland waterway research. The background for the “Data Warehouse for Danube Waterway” project (D4D, 2005) was the Directive EC/2005/44 demanding the implementation of River Information Services along the navigable international waterway network. In this respect, D4D was set within the work carried out by the GIS Forum Danube. The GIS Forum aims at more intensive exchanges of geographical data and closer cooperation in terms of the waterway management for the Danube river. The GIS forum was founded in 1997 by the waterway

[14] Not surprisingly, the 2 projects reviewed in this sub-theme were funded under the Interreg III Programme, a community initiative which aims to stimulate interregional cooperation in the EU between 2000 and 2006.

administrations of Germany, Austria and Slovakia. Since 1999, the group joined the working group of the Danube Commission, followed afterwards by Croatia, Romania and the Ukraine.

4.3.2 Research objectives

Carried out under the Interreg III initiative, the goal of the Canal Link project (Canal Link, 2006) was to develop the North Sea region's waterway network. This seminal project aimed to lead to improvements in the viability and use of the waterways, themselves, as well as promote tourism and economic development along the waterways. Canal Link's viewpoint was to undertake a series of institutional activities, including promoting tourism linkages, developing the inland waterway network and developing the relationship between the waterways and their surroundings (local communities and businesses, natural and cultural heritage...).

Although the project focused on recreation and tourism as a levy for inland waterways' increased usage, these aspects complement the goods-transport function of inland waterways, in the context of the multi-functional use of water. Canal Link therefore had the objective of establishing a recognised network of tourism and recreational waterways in the North Sea Region, to complement the ECMT[15] network of freight transport waterways. Furthermore, the project also sought to develop tourism links between waterways, and better links between waterways and the local business community along the routes. Finally, the project involved an investigation of the feasibility of establishing a permanent tourism promotion structure for inland waterways.

More technically oriented, but equally set up on a regional basis, the D4D project's primary objective was to provide a common and harmonised implementation of European and international standards on the Danube waterway, and recommendations for inland navigation. In particular, it sought to create digital navigation charts for the Danube river in compliance with the European inland ECDIS standard[16] and set up an infrastructure to improve the accuracy of satellite based positioning systems, according to current international standards. In accordance with the regional orientation of the project, D4D also aimed to network national geographic information systems around the Danube and to ensure an efficient exchange of electronic data between responsible waterway authorities.

[15] The European Conference of Ministers for Transport has adopted a classification scheme for inland waterways.
[16] An Electronic Chart Display and Information System (ECDIS) is a computer-based navigation information system that complies with International Maritime Organisation (IMO) regulations and can be used as an alternative to paper navigation charts.

4.3.3 Research results

The primary result of the Canal Link project was to raise the profile of the network of smaller waterways and to demonstrate the numerous ways of enhancing their potential and actual contribution to the sustainable development of the European Union territory. This was achieved through several intermediary results.

First, Canal Link identified a number of waterways that had been closed to navigation, together with new links, thus effectively expanded the recreational waterway map by filling gaps and unlocking bottlenecks in the North Sea Region's recreational waterway network. Further, concerning historical and unused waterways, Canal Link undertook a number of specific – mainly institutional – actions in order to bring old waterways back into use, thus regenerating the urban and rural areas through which the waterway networks pass. To complement these waterway improvement initiatives, the project also carried out a study that reviewed methods for appraising and evaluating waterway schemes in both economic and social terms. This study highlighted that recreational users of waterways create dynamic and active water spaces, which support waterfront regeneration and development schemes.

Importantly, Canal Link also studied the problems associated with the collection of waste water from pleasure boats in the North Sea Region member states. The study found that legislation and controls vary greatly between countries and, often, within countries. This leads to a lack of clarity for water sports tourists, who wish to move from one country to another.

After having created digital charts and set-up a common infrastructure of differential positioning systems to ensure implementation of River Information Services (RIS), the D4D project managed to collect all waterways' relative data pertaining to the Danube and store it in a distributed database (data warehouse) made available to the participating countries. The common database serves as a basis for a number of additional applications, the foremost one being the conversion of the data into navigation charts complying with ECDIS standards.

The D4D data format, as published on the project website, fulfils all requirements of international data exchange, and serves the needs of all Danube countries. It is a geo-data description, which comprises all data of interest for waterway maintenance, and serves the needs of navigation charts generation as well as the cross-border management of

navigable rivers. Moreover, the positioning signal's usage meets the requirements of inland navigation, with a "better-that-three-metre" accuracy, fulfilling the requirements of the International Association of Lighthouse Authorities (IALA).

4.3.4 Policy implications

At the outset, Canal Link operated in the institutional setting of the Water Framework Directive[17]. In this framework, Canal Link assessed the applicability of the Permanent International Association of Navigation Congresses' classification to waterways in the North Sea Region – in general it was found that the system was appropriate.

A distinctive feature of Canal Link was the large number of sub-partner organisations involved in the project. Some 55 organisations in the six partner countries participated in this way. The institutional measures promoted by the project, and its broad framework, could be of considerable benefit to other authorities and communities looking to develop their waterways. In this sense, a number of Canal Link partners came together with organisations in Spain, Italy, Hungary, France and Germany to set up an Interreg IIIC project 'VNE – Voies Navigables d'Europe' (*Inland Waterways of Europe*). VNE was established in early 2005 and ran to the end of 2007. Through VNE, the results of Canal Link and other waterway-related Interreg initiatives were further developed and promoted to a wider audience, particularly in the New Member States.

Due to its technical nature and in particular the long-range of the positioning signals, D4D had to conceive measures for a harmonized and trans-national implementation of the data-warehouse and the navigational charts, and first by ensuring that all Danube stakeholders reached a common level of knowledge and understanding. The charts' GIS standard, therefore was promoted to extra-European States as well, as part of a Danube wide network plan. Furthermore, all partners and observers agree that the provision of up-to-date depth information to skippers is vital information for navigation safety and shall be provided for free download. Nevertheless, much has yet to be achieved. Especially in Eastern European countries, geo-data is under the responsibility of various bodies and hence, agreements ensuring harmonized exchange of geo-data will be hard to implement.

[17] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000, establishing a framework for Community action in the field of water policy in order to prevent and reduce pollution, promote sustainable water use, protect the aquatic environment, improve the status of aquatic ecosystems and mitigate the effects of floods and droughts.

4.4 Sub-theme 3: Ship design, maintenance and operation

4.4.1 Background

Ship design, building and maintenance processes are a crucial aspect of the competitiveness of Europe's maritime industry and the Union devotes a fair amount of resources towards ensuring a practical environment for their continuous improvement.

These processes hinge on finding the possible links between two fundamental issues: how to guarantee the safety of passengers and crew, while ensuring the economic soundness – in terms of ships' relative efficiency, time-to-market…– of the vessels?

Nowadays, one of the main ideas at the root of ships' design is the so-called "Design for Safety" concept, which describes the integration of safety as a design objective in the design process to minimise risk, alongside traditional design objectives such as minimising power requirements and maximising cargo carrying capacity. Integration of risk and reliability analysis methods into the design process for ships therefore leads to "risk-based ship design" as a core concept. In particular, five ship types have significant economic value for Europe: cruise ships, RoRo/RoPax, gas tankers, oil tankers, and container vessels. These vessels are the most knowledge intensive and safety critical and their design can undoubtedly benefit from a risk-based approach.

Taking this idea a step further is the incorporation of advanced decision-support systems (DSS) at the outset for the ship's design, and eventually operation. Indeed, the integration of DSS and "intelligent" middleware is at the heart of safe design, especially in a context where modern ship types are developing rapidly, and the experience gained by a crew on a certain ship does not necessarily apply to another vessel – even to vessels of the same ship class. Recent data proves that commercial losses and loss of life can potentially be reduced by introducing this kind of decision support system. Losses pertinent to the motion of ships in heavy seas recorded from April 2005 until March 2006 are 43 lives and an estimated € 100 million[18].

Nevertheless, the physical aspects of ship-design still remain at the forefront of maritime research. For example, in the last years, marine transportation with larger fast ships has

[1818] Source: www.janmaat.de from ADOPT project, covered in this report.

expanded on national and Mediterranean small and medium-ranged routes, especially with monohulls. The design of high-speed ships has appeared to be a crucial factor in the competition between shipping, especially short-sea shipping, and other modes. For such ships, non-conventional hulls, both with single hull and with more hulls, have been proposed, both for passengers and car transportation. However, major physical aspects still require deeper investigation, regarding sea-keeping, and the prediction of hull hydrodynamic resistance and motion in waves. Studies and proposals for non-conventional high-speed marine vehicles have been published in which the trimaran hull seems to be the subject of a recent appreciable international interest. Regardless, uncertainties still exist about the choice of the most suitable ship type for given distances and operating conditions.

Large ship design and building is carried out on a project oriented approach: it would therefore make economic sense to examine the possibilities of reducing the time-to-market of these vessels, particularly at the assembly phase. A promising approach has been to study the possibility of incorporating sandwich panels. Sandwich panels offer a number of advantages for transport systems, such as being lightweight (increased payload), having a reduced space consumption, provide structural safety and have a reduced assembly cost. However, various R&D projects aiming to develop sandwich structures have been carried out in several sectors at European, national and company levels. These projects have produced results, but they are difficult for industrial users to access and compare.

4.4.2 Research objectives

For analytical reasons, one can identify 2 clusters of projects, those dealing with “soft” assistance systems in ship design and operation, and those treating the ships’ physical design.

SAFEDOR's (2009) overall objective was to enhance ships’ safety at the outset, by basing their design on a risk assessment and reduction tool, thus answering two fundamental industrial and societal needs:

- Risk-based ship design and approval could provide the European maritime industries' with the possibility to deliver more efficient transport solutions to their customers.
- Risk-based ship design and approval could satisfy the European society's need to have increasingly safer transport.

SAFEDOR research activities sought to address the safety-critical issues pertaining to a knowledge-intensive and complex maritime environment: technology-intensive ships, maritime services, products, equipment and related software. The project’s rationale was

that increasing safety and security of maritime transport cost-effectively could be achieved by treating safety as a design objective at the outset and not as a constraint, as in current ship design. Increasing the competitiveness of European industry could therefore be achieved by systematic innovation in design and operations, further encouraged by pushing the maritime regulatory system towards a risk-based framework.

SAFEDOR set out five strategic research objectives to meet this outlined rationale, focusing on risk-based design methods and tools, a risk-based regulatory framework, and supporting actions:

- Develop a risk-based and internationally accepted regulatory framework to facilitate primary approaches to safety.
- Develop design methods and tools to assess operational, extreme, accidental and catastrophic scenarios, accounting for the human element, and integrate these into a design environment.
- Produce prototype designs for European safety-critical vessels to validate the proposed methodology and document its practicability.
- Transfer systematically knowledge to the wider maritime community and add a stimulus to the development of a safety culture.
- Improve training at universities and aptitudes of maritime industry staff in the proposed technological, methodological and regulatory developments, in order to foster their acceptance.

Relatedly, the ADOPT project (ADOPT, 2008) used this risk-minimising approach to design a decision-support system adapted to the maritime industry's operating conditions. The originality of this DSS is that, designed in coordination with the ship itself, it links both the ship's design and physical features to future possible operating conditions. ADOPT therefore sought to create a risk-based system that could assist the captain and crew in deciding safe and efficient ship handling with respect to the motions of the vessel in severe seas, based on the risks arising from:

- The identified hazards and their formulation of limit states;
- The actual sensed environmental situation;
- The ship's condition;
- The ship's behaviour;
- The expected sea state on all possible courses;
- The prediction of ship motions on all these courses caused by the prevailing conditions.

In effect, ADOPT's objective was to design a decision-support system based on an idiosyncratic toolbox for the prediction of ship response (according to environmental stimuli) and sea-keeping behaviour, and the integration of the predicted ship response with on-board monitoring devices.

Soft “intelligent” processes were also applied to ships’ operation and maintenance, as exemplified by the TELEMAS project (TELEMAS, 2004). The project’s objective was to increase the quality, safety and efficiency of vessel operation by exploiting available IT technologies and tools to implement an intelligent ship operation concept, linking on-board web-based services with e-services ashore. The goal was to develop an "umbrella" middleware platform containing integration components and communications management facilities in order to provide a dynamic picture of available technical, operational and human resources and accessible software tools, all using advance XML applications for web automation. In effect, the system would rely on a virtual data base providing the vessel command and ship owner accurate and timely vessel and operation information, consisting of coupled data from various sources. Therefore, TELEMAS sought to determine the relevant tools, standards, and specifications for the development of such a data-base, through the operation of different applications (ASP, tele-maintenance, e-learning, safety).

At present time, monohull and catamarans are the most applied solutions for fast marine vessels, so an Italian project, “Hydrodynamic characteristics of innovative high-speed vessels” (2005), studied the hydrodynamic characteristics of three multihull typologies applied to a fast vessel to be employed on Mediterranean routes on mean distances, for passenger and vehicle transportation. The project’s purpose was to evaluate and compare the hydrodynamic resistance and the sea-keeping performance of a trimaran hull, a pentamaran hull, and a special catamaran (the “Bulbcat”). The project sought to collect a significant database of experimental test results regarding hydrodynamic resistance and sea-keeping for the selected typologies. This would allow for improving and adapting numerical methodologies for studies on hydrodynamic resistance and sea-keeping performance applied to the considered high-speed marine vehicles. In particular, the methodology would allow wave pattern simulations in order to assess the behaviour of ships for the different hull typologies.

Regarding the incorporation of sandwich panels on board ships, the SAND.CORe project (2006) aimed to collect and compare available solutions, benchmark these solutions for concrete application cases in the maritime field, and produce a best practice guideline for potential end users. Further, through the establishment of a “sandwich solutions and data catalogue”, the project sought a harmonisation and standardisation of sandwich solutions, including testing procedures, with unification of sandwich notations and vocabulary, enabling better understanding between involved parties in sandwich design and production. The benchmark studies and comparisons of different sandwich panels in possible sandwich applications (focusing on RoRo decks, superstructures, balconies), would generate best-practice guides for sandwich applications, design, production,

exploitation and safety issues. Last, SAND.CORe also aimed to propose new ideas to further develop the composite sandwich technology, thus enhancing pre-outfitting facilities under favourable working conditions, leading to improved productivity and shorter erection lead times.

4.4.3 Research results

4.4.3.1 Design-assistance and operation solutions

SAFEDOR's results can be described along three different levels.

First, the project designed a high-level approval process and related risk acceptance criteria for risk-based ships, and complementing this by the development of the approval process and risk acceptance criteria for risk-based ship systems and functions.

Second, SAFEDOR produced new computational tools and significant enhancements of existing ones, which predict failure probabilities. These probabilities can be used as input for a risk model and, at the same time, respond to changes in design parameters likely used as risk control options. The risk areas addressed were transient flooding, structural integrity, dynamic intact stability, collision and grounding, and fire. The tools can be set in two categories:

- Design tools for safety performance prediction of a given ship design and their integration into a risk-based design procedure.
- Innovative safety-critical technologies, embodied in a methodology and computerised tools for safety and reliability analysis of innovative design proposals and innovative concepts for safe navigation.

A third achievement concerns the implementation and application of the SAFEDOR approach to the design process of novel ship designs: cruise ships, RoPax, gas tanker, one oil tanker, and container ship. Among the eight designs effectively carried out, the two best were selected by a peer evaluation panel, considering economic, environmental, safety impact, feasibility and rule challenge criteria. Ultimately, these two designs are to be patented and disseminated in commercial ventures.

The ADOPT project showed that a risk-based, ship specific Decision Support System regarding the assessment of ship responses is by today's knowledge feasible. Specifically, ADOPT's main feature is that it is ship-specific, used for both the design and future operation of a given vessel. The ADOPT project provided a process of DSS creation incorporating the following elements:

- wave sensors able to identify multi-peak seaways, e.g. swell and wind-sea,
- a calibrated database of ship's data,
- a calibrated set of limit states and respective threshold values,
- advanced state-of-the-art motion modelling tools onboard,
- a HMI embedded in typical bridge equipment as the conning display and designed from experts for users.

In addition, the actual deployment process of the ADOPT system on board is also ship-specific, thus improving real-time decision-making by master and crew.

Regarding solutions for ships' operation, the TELEMAS project designed a complete operation-management system based on web-enabled automation. Using an integrated middleware platform, the system provides tele-maintenance solutions by communicating ashore actual vessel characteristics, thus ensuring correct maintenance procedures are implemented in a timely manner. Based upon ASP concepts and applications, XML web technology, as well as real-time communication facilities, the TELEMAS system is therefore a Remote Maintenance Platform as well as a Safety Management System. In addition, the system also incorporates e-learning modules and concepts.

4.4.3.2 Ships' physical design

The "Hydrodynamic characteristics of innovative high-speed vessels" project produced technical experiments on hull specifications and reactions to given sea characteristics. The results from these sets of experiments could provide an interesting reference for researchers and industrialists involved in studying hydrodynamic characteristics of high-speed multi-hull marine vehicles.

For possible trimaran forms and a pentamaran form, and in two different scales, the project carried out systematic experiments on:

- Hull resistance,
- Roll behaviour in transverse waves,
- Heave and pitch motions in regular head waves,
- Performance of catamaran hulls fitted with forward central bulbs.

The studies concluded that the best position of the tested trimarans, as far as resistance is concerned, was found when the stern of the side hulls is aligned with the stern of the main hull, with the side hulls transversely positioned at about 10% of the length of the trimaran. Further, different bulb forms and positions were investigated on the bulb-catamaran and the project noted minor differences in resistance of the bulb against the non bulb-

catamaran. Roll experiments in beam regular waves on some configurations of the round bilge trimaran and on the pentamaran hulls evidenced the possibility of critical situations regarding safety, due to the roll motion reaching dangerous values.

Overall, the project demonstrated the utility of the complementary application of numerical methodologies applied to the aforementioned experiments, in defining multi-hull ships' behaviour in waves and resistance characteristics. Their potential for optimising the configuration of multi-hulls has been confirmed by the experiments.

It is worth noting that, among the considered vehicles, the hard chine trimaran turned out to be the best vessel as far as resistance is concerned. However, the vessels studied in this research belong to a non-conventional typology and the results obtained, although limited to their hydrodynamic behaviour, could be useful for the evaluation and validation of the hydrodynamic performance of similar vessels belonging to the same typology. As far as the trimaran and the catamaran are concerned, although they represent a typology of high speed ship for which international interest is apparent, especially for the trimaran, significant collections of data have not been so far diffused about their hydrodynamic performance and this research makes a contribution in this respect.

The main result of the SAND.CORe project was the Best Practice Guide (BPG) on sandwich structures. The BPG provides a comprehensive overview on current best practices (focused on the maritime field) on general types of sandwich structures as well as on aspects and techniques concerning their design, manufacturing, joining, assembly and outfitting, inspection and repair, legislation and approval. It also provides application case studies. The Guide reviews the three most commonly used sandwich types in the maritime sector: all-metal, hybrid-metal (a combination of metallic and non-metallic materials) and composites. This review produced an analysis of the state of the art on sandwich panels, providing a harmonised knowledge and information base. Furthermore, the project's benchmarking activity led to optimised design solutions, linked with full cost-benefit assessments. In effect, SAND.CORE's results promoted the practical application of sandwich structure in ship building. In particular, the project helped define future research needs, spinning off a new European project (DE-LIGHT TRANSPORT, 2009) that aimed to develop lightweight modules for transport systems using risk based design.

4.4.4 Policy implications

SAFEDOR can be seen as an important contribution to European policy, insomuch as it specifically evolved in a risk-based regulatory framework. The project's development of Formal Safety Assessments (FSAs), aimed at documenting the risk level for the selected

ship types, and including all major accident scenarios, helps identify cost-effective risk control options related to design and operation. The resulting risk-based regulatory framework, aimed at developing a high-level description of the whole approval process of ship design, could effectively be adopted as a common industry framework or standard throughout the Union.

Apart from SAFEDOR, the projects reviewed in this sub-theme did not put forward specific policy implications. However, they all typically contributed to building a sound competitive environment and commercial advantage for European-based shipping companies, more safety of crew and cargo, and pollution prevention, thus aiding the European maritime sector's attractiveness, which is one of the European Commission's stated policy objectives.

4.5 Sub-theme 4: Maritime safety

4.5.1 Background

This sub-theme essentially deals with ways through which safe maritime operations can be conducted, the notion of safety applying to passengers, crew, and the environment itself. The projects reviewed in this sub-theme can be therefore split in two related clusters: projects designed to assist safe transportation, and projects designed to enforce and protect environmental safety. It is important to bear in mind, however, that these issues are strongly inter-related, as damage to certain types of ships (e.g. oil tankers) also heavily impact the environment.

Maximising ship safety and navigational efficiency has benefited from developments in assistance systems, notably the introduction of limited hull monitoring systems and the availability of sea and weather state information. However, the industry needs systems that can support ships' captains and crew in strategic voyage planning, from the perspective of efficiency and safety. Decision support capabilities fill in this function and allow for the integration of on-board ship-stress monitoring and ship behaviour to sea and weather conditions, in order to provide optimal tactical navigational choices during the course of a voyage. As ships become larger and more sophisticated, issues of tracking ship fatigue and ensuring appropriate maintenance become more complex. This means being able to track the ship's actual experience, so that a comprehensive picture of the stresses it has been subjected to can be created and used as the basis for planned and preventative maintenance.

These requirements are even more strongly felt when taking into account that some of Europe's major sea routes offer perilous navigating conditions as a matter of course. In particular, international trade and oil transportation are making Europe's northern sea routes – many of them narrow and iced over during several months – crowded with activity.

In many respects technology is already very advanced, and this has been proven in limited demonstrations in recent years. Vessel Traffic Management (VTM), including Vessel Traffic Services (VTS) and Automatic Identification System (AIS) coastal networks, has been successfully developed for local and regional use to varying degrees. However Pan-European operational systems require further development and integration in order to become a reality. Whilst there is a recognized need for a more pro-active management regime of vessel traffic in all EU waters, there is also a recognized need to achieve this without increasing the burden placed upon the vessel itself, i.e. through increased reporting. In fact it has long been understood that the burden on the master should decrease from present day levels in order to allow the master to concentrate on the primary function, i.e. that of the safe navigation of the vessel.

Regarding the preservation of the environment, the demise of the Erika (1999) and the Prestige (2002) vessels highlighted EU shortcomings with respect to technologies, systems and resources for spill response effectiveness, and resulted in a number of initiatives that have been introduced on the European stage. Indeed, stricter international regulation enacted in the early 1990s and advances made in the design and safe operation of ships, especially tankers and other ships carrying dangerous products, saw a significant improvement in safety record of the maritime industry. However, the Erika and Prestige accidents incidents, with their heavy oil cargoes causing extensive pollution on European shores, have had major political, social and economic implications. Therefore, Europe still needs a more pro-active approach to the management of vessel traffic in European waters, and the enhancement of services provided to shipping in general in order to further the promotion of a safe, efficient and environmentally friendly platform for maritime transport.

This approach is exemplified by the gradual phasing out of single hull tankers, in accordance with the International Maritime Organisation's global regime, but last year Europe went beyond international regulations and implemented a unilateral accelerated phase-out, which has since led to the international phase-out being accelerated too. The control system for tankers has also been tightened up at the same time as the industry itself has taken initiatives to ensure that the structural integrity of tankers is maintained to good standards throughout the life of the ships.

Despite the political and economic importance of these issues, some of the relevant new regulation still tends to be made before incidents have been properly investigated. Political pressure rather than proper risk analysis may determine which types of vessel pose the highest pollution risk, the relative safety of ship designs, or the most appropriate response to an evolving pollution incident.

4.5.2 Research objectives

The OPTINAV project sought to address issues of navigation safety and efficiency in a comprehensive and integrated way, demonstrating the potential to improve both the safety and the economics of the shipping industry. OPTINAV had three sets of objectives, each relating to as ship's life-cycle: past, present and future.

First, OPTINAV put forward the need to construct a record of the stresses experienced by a ship, correlated with the prevailing sea and weather state information at the time. This record would provide valuable information to the captain and crew, allowing an understanding of how the stresses in the ship resulted from actions taken in the past for a given set of sea and weather data. OPTINAV's second objective was to measure actual stress levels in the ship, and compare these with acceptable tolerance levels. This was undertaken to furnish the ship's captain with continuously updated information on the remaining fatigue potential of the ship, based on the actual stresses incurred during the current voyage. Last, OPTINAV sought to provide insights on both the long term and short-term perspectives of the voyage. In the short term it shall combine ship, sea state and weather information to provide the captain with a clear idea of the stresses that the ship would experience over the next few minutes, half an hour, hour, etc. if he continues with his current course and speed and help him identify alternatives if the response of the ship is expected to be outside its normal tolerances. In the long term, the project would offer the facility to combine the three sets of data in order to plan the best available route.

A project (SAFEICE, 2007) specifically studied ways to improve icebound shipping, with the objective of decreasing the environmental and material risks associated with shipping in ice covered waters. The project sought to undertake the following tasks:

- Create a unified basis for winter navigation systems, including a methodology for defining the appropriate ice class;
- Develop semi-empirical methods based on measurements and advanced theoretical models to determine the ice loads on ships' hull and relate these to the operational scenarios and the ice conditions;
- Develop ship-ice interaction models and stochastic models to assess the design loads on ships' hull;
- Build a framework to develop design codes and regulations for plastic design of icebound ships.

The SAFEICE project's first step was to build on a database compiling earlier information on ice loads and ice pressures, related to ships of various types sailing in different sea areas. The next step was to undertake the validation of stochastic methods for ice-load evaluation by comparison with the measured data in the database. The study sought to assess if, instead of elastic design, ice rules could be based on plastic design. Probability of loads exceeding ultimate strength of various structural elements could then be estimated and the design load level be explicitly determined. Last, the models' validation for ice load predictions was to be carried out on the Baltic Sea, Okhostk Sea and Canadian waters.

The "Maritime Navigation and Information Services" project (MARNIS, 2008) had the ambition of contributing to the so-called E-Maritime concept, an integration of services and systems, in response to the need for a more transparent and harmonised approach within the maritime sector. The focus is placed on the improved exchange of information from ship to shore, shore to ship and between shore-based stakeholders, both on an authority and business level. The stakeholders may include on the one hand the vessel itself, together with the ship owner, operator and agent, and on the other hand shore-based entities, including maritime authorities (e.g. Search and Rescue (SAR), coastal and port), related authorities (e.g. customs and immigration) and commercial parties within the port sector. Within this technical and institutional setting, MARNIS' main objectives were to improve ship's and crew's safety and security, as well as the protection of the environment. Furthermore, as it included a wide array of stakeholders, the project also aimed to improve operations' efficiency and reliability, enhancing the economic aspects of sea transport, while providing a framework for legal and organisational aspects.

Dealing specifically with risks associated with oil tankers and dangerous cargo, the POP&C (2006) project aimed to deliver a framework and suitable tools for a methodological assessment of risk. The risks were to be identified according to ranking of critical hazards (collision and grounding, fire and explosion, structural failure) leading to estimates of probability of capsizing/sinking from loss of stability or structural failure.

This overall "pollution risk-based framework" was to be undertaken to provide a rational basis for making decisions pertaining to the operation and regulation of oil tankers. Indeed, such support can be used to make more informed decisions, which will in turn contribute to reducing the likelihood and severity of future oil spills. POP&C sought to develop a complete risk-based methodology to measure the oil spill potential of tankers, along with a risk-based passive pollution prevention methodology (design and operational lines of defence), and a risk-based, active, post-accident pollution mitigation and control framework.

Equally concerned with oil spills, the SPREEX project (2007) was based on existing experience of responses to oil spills, and determined to increase the industry's and policy-makers level of preparedness and response-effectiveness. SPREEX's main objectives therefore to actually identify research needs, that is pinning the main Oil Spill Response (OSR) key issues and expertise, and collecting the relevant state of the art experiences and solutions on each issue. In so doing, the project partners sought to create links with existing research programmes and generate synergies that may lead to new partnerships between authorities and regulators, end users, maritime operators, and universities and researchers. In order to meet this primary objective, SPREEX had to:

- Formulate a relevant organisation and communications architecture between stakeholders;
- Assess response means technology;
- Define powerful information and communication technologies, emphasizing the need for real time detection and tracking, and decision support systems;
- Address environmental and socio-economic aspects, impact assessment and NEBA (Net Environmental Benefit Analysis).

4.5.3 Research results

4.5.3.1 Maritime safety systems and solutions

Using a number of distinct existing tools such as real-time hull condition monitoring, bow accelerometers, static load balancing and fuel metering, OPTINAV built a ship-specific predictive event management and support system. In addition, OPTINAV incorporates weather forecasting, sea state and ship navigational response. Assessment and analysis tools were also built in the system, providing ship operators with suitable choices for the management of the vessel, whether for short or longer-term voyage planning. The basic function of the OPTINAV system is to record the stresses experienced by the ship, measure the vessel's actual stress levels, and then compare these with acceptable levels. Therefore, continuously updated information on the remaining fatigue-span of the ship can be estimated on the basis of actual stresses incurred. Overall, OPTINAV helps reduce operational costs whilst ensuring improved safety levels for the ship.

To achieve this objective, OPTINAV provided a series of technical outputs. First, the system was able to anticipate, based upon continuously monitored data, oncoming difficult navigational situations regarding hull structure, ship's equipment/performance, passengers and cargo, thus effectively developing reliable methods of automatic monitoring, prediction and shore-based expert guidance. Second, the project created an advanced yet flexible

system of data logging and processing, providing a means of continuous review of ship's fatigue-span, used to prioritise maintenance requirements and anticipating major defects, thus providing a uniform level of reliability throughout the ship's life. Last, OPTINAV explored new algorithms for extracting implicit relationships within databases and information from the load cycle spectra.

The SAFEICE project produced a number of results regarding safe icebound navigation, starting with an inventory and compilation of sources of ice loads and ice damage data. The database now contains 47 datasets with over 10,000 events for 5 types of icebound ships. In parallel, SAFEICE identified the major lacks in existing field data on ice load on ship hulls. These results were taken into account in the design of the full-scale or model-scale tests undertaken later in the project, in order to fill the data gaps. Model tests, were carried out in Japan so as to measure the ice load acting on the models. Two different types of model ships were tested, an icebreaker and a cargo vessel, and the detailed ice load data were compared to the results of the ice load's theoretical computations.

The project then put forward ice loading scenarios relevant for ship hull loading, and defined an inventory of calculation methods applicable for ice load estimates. Numerical simulations of the ice load level in specific ice conditions for several ship types were then able to be carried out in order to be compared with the ice load database and the model scale test results. SAFEICE was then able to use this work in a report assessing current ice service and icebreaking practices.

A further series of results concerned sea ice dynamics model development, in order to calculate the plane stresses in different sea areas. The main purpose of the model is to forecast ice drift, ridging, levelling, and provide ice concentrations in real wind-forcing conditions. This model can be used to compute the pressure in the ice field and it can also be used to give boundary conditions for predicting ice forces on the hull of a ship in a compressive ice field.

Last, bridging these two viewpoints, namely the ice-sea and ship characteristics, SAFEICE simulated the ship-ice interaction, notably the strength of shell plating under ice loading. Several reported damage cases were calculated, allowing to determine the load configurations, i.e. the contact area and pressure which caused the damages.

Aiming to provide integrated "Maritime Navigation and Information Services", the MARNIS project designed and published several methodologies for maritime safety management, involving a wide set of stakeholders. First, MARNIS addressed the issue of relevant supporting technology for navigation, communication and information systems to improve safety and efficiency of maritime traffic, and provided a coherent IT master-plan (MARNIS broadband platform), complete with a harmonised system architecture based on industry standards. The project also addressed the institutional setting regarding communications for maritime safety and produced legal scans, preparation of directives and policy

recommendations for preventive information services supporting traffic safety and efficiency. Further, a Human-Machine Interface (HMI) was designed and built for providing the on board information services, and for information services concerning port operations and security.

The project put these recommendations to test, in order to ensure a correct translation of user requirements and research results into technical solutions, complying with the defined standards and architecture. Finally, MARNIS carried out a full project assessment based on cost-benefit, societal, legal and technical analyses.

4.5.3.2 Environmental safety

POP&C aimed to develop a risk-based framework and tools for assessing design, operation and regulation of oil tankers and dangerous cargo. The project carried out systematic evaluations of potential hazards and ships physical characteristics, in order to be able to propose sound risk-reduction methodologies.

Of the several mainstream techniques used for hazard identification and ranking in the maritime world, the project designed a method using Fault Tree (FT) and Event Tree (ET) techniques, resulting in three classes of risk, addressing the three types of consequences that should be considered in the project, i.e. human safety, property and environmental impact. Based on a screening of risk according to probabilities, specific areas of concern, where risk has to be reduced, were then identified by ranking different critical accident scenarios according to their risk level.

Based on this risk identification, POP&C developed an Overall Risk Assessment Framework, based on previously developed quantitative assessment models applied to AFRAMAX[19] fleet. Such a quantitative analysis on the past, current and future AFRAMAX tanker fleet incorporating different designs was performed for the first time. Quantitative assessment provided some striking results in terms of environmental risk. For example, if the environmental risk in early 1990s (all single hull ships) is taken as the basis, an average of 19.4 % environmental risk reduction was achieved through tanker improvements between 1991 and 2003. Similarly, the current fleet at risk (as of end of 2005) represents a reduction of 35.6 percent compared with early 90s and when all single hull tankers will be phased out (in 2010), a 53.7 percent risk reduction will be achieved in comparison to 1990 fleet.

The use of the quantitative environmental risk assessment methodology in risk based design and optimisation process was also demonstrated with case studies. For example, a final study evaluated a conceptual AFRAMAX tanker that would apply some of the lessons learned in the course of the POP&C project. The model showed that risk reductions in the

[19] AFRAMAX is a class of tanker, where single hull vessels are largely represented.

order of 35 percent were achievable, providing a clear indication that significantly more environmentally friendly tankers are feasible.

Finally, using the framework model, POP&C presented risk reduction methodologies based on prevention, and methodologies based on mitigation and control.

SPREEX was initiated in reaction to the Prestige accident, and the observation of the consequent response. SPREEX sought to propose a series of observations and recommendations concerning response to oil-spill accidents. SPREEX's strategy was to build state of the art reports, drawing on past experience, on-going measures and research results, prior to making statements on perceived preparedness and response-gaps to maritime accidents. The project identified several major preparedness and response-gaps to be addressed by future research:

- The need for spill detection sensors with resolution and capabilities for harsh sea conditions;
- The development of models combining meteorological and hydrodynamic data;
- The development of real time information systems for the benefit of oil spill responders and concerned authorities;
- The need for Decision Support Systems based on real-time information, providing the framework for contingency planning, local response, and coordinated response on major accidents;
- The need for equipment testing procedures and performance assessment of ships' recovery systems in operating conditions and rough sea conditions;
- Studies on dispersants application guidelines and dispersion process;
- Commonly accepted methodologies and tools for assessing the effects of dispersed oil and quantifying the socioeconomic impacts on human activities;
- Need for procedures, resources and candidate sites for Bioremediation.

However, the study warned that, although spill response research needs to be based on past experience from previous accidents, it must also be proactive by anticipating the risks of new possible postulated accidents with short-term, medium-term and long-term perspectives.

Moreover, sea transport of oil and other products involves various administrations with different missions and competences. Spill response is multidisciplinary and industries and services may not be grouped in existing sectors. A spill response research framework must be outlined at a European level to avoid major gaps and to enable access to international databases, while at the same time avoiding duplication of efforts and facilitating the coordination of human resources and response means when needed.

4.5.4 Policy implications

All the projects reviewed in this sub-theme called for European-level involvement, either through the establishment of a harmonized technical framework, an institutional framework, or the implementation of collective measures.

To support the continuously growing demands in terms of safety and operational requirements, onboard systems are becoming more sophisticated and ICT dependent. Thus a major technical framework is required in the field of IT applications relating to maritime transport (e.g. for off-shore/ashore communications, maintenance, remote ship monitoring...) A shipping sector specific, open technology platform may support the integration of key IT services and applications for the shipping industry.

Further, a technically-oriented project such as MARNIS and its related E-Maritime concept could affect the tasks and responsibilities of the various authorities related to maritime transport and traffic, including not only maritime safety related authorities but also enforcement bodies such as customs and immigration. In order to clarify and support the interaction between all authorities and actors involved, a European Maritime Directive, describing the legal structure, is recommended. Whilst respecting the principle of subsidiarity, a general Directive on maritime transport and traffic will also provide uniform and transparent responsibilities for competent authorities. Further, if developed as a Framework Directive, there is sufficient flexibility to exploit existing technologies as well as allow for the emergence of new technologies. These aspects are currently handled through, for example, the FLAGSHIP (2010) project.

Despite the political, social and economic importance of safety and environment issues, sometimes pieces of regulation still tend to be made before incidents have been properly investigated, and there is a need for a harmonised and accepted methodology for taking rational decisions pertaining to the design, operation and regulation of oil tankers and vessels hauling dangerous goods – and the encouragement of best practice in the shipping community.

Finally, some of the SPREEX reported “gaps” have already drawn the attention of public authorities and organisations such as the Clean Sea Net satellite data system recently introduced by EMSA[20]. Furthermore, SPREEX called for sustained research efforts at the European level, supported by international preparedness exercises.

[20] European Maritime Safety Agency

4.6 Sub-theme 5: Ports and port operations

4.6.1 Background

Ports are key elements of the European Transport System. Over 90% of Europe's trade with the rest of the world (and almost half of intra-European trade) is shipped through ports and expected figures are much more impressive for the future: the European Sea Ports Organisation estimates that traffic in European ports will double from 2006 to 2015. At the same time, constraints (in terms of ships size, ships calls, available space, etc) and requirements (in terms of environmental protection, security, safety, profitability, etc) will have severely increased.

Consequently, the port industry has undergone major transformations in recent years, due to the increased involvement of private companies, technological changes, globalization, and increased competition between ports – and between modes. Moreover, port operations are an important part of the maritime logistics chain, especially when considering its complementarities with related modes, notably roads and rail transport: as ports are nodal points for the repartition of goods through inland transport networks, failure in one port has consequences for the entire supply chain. Port operators therefore face the challenge of providing a quality of service that is attractive to transport users, as well as both is safe and environment friendly.

However, often for environmental reasons, it has become sometimes difficult to achieve consent for port developments, explaining why previous research has focused on increasing the efficiency of port operations (TRAPIST, 2004), and at the same time aiming to reduce customs and administrative processes, especially in short sea shipping (S-CBB, 2002). One can take these considerations a step further, and take into account the complete business processes of port operations and how they may relate (and be adapted) to the inter-modal door-to-door value chain.

At the same time, in line with increasingly technical systems and tools on board ships, new technical approaches and advances to improving reliability and safety of maritime activities are therefore required at the port operating level, helping to better integrate ship and shore resources, and increasing the efficiency of ports as a node in the inter-modal chain.

Last, ports and dockyards are first and foremost industrial areas, generating potential polluting activities and therefore subject to environmental constraints. In particular, wastewaters at ports and dockyards often represent an important point source of toxic

contaminants to the aquatic environment (for example, ship hulls are coated with anti-fouling paints containing biocides). Even if regulatory measures such as the ban of tributyltin (TBT) are efficiently enforced, the problem of heavy metal and biocide contaminated waters will remain in the future if no environmental management strategies are developed and applied.

4.6.2 Research objectives

Two projects reviewed in this present TRS focused on the processes behind port services production, whether on a general business basis (MARQUAL, 2005), or for passenger administration (OPSPEMAPT, 2006).

MARQUAL's background theme was to set port operations in the framework of an integrated management and communication system. Its major objective was to demonstrate how to efficiently organise and manage intermodal door-to-door transport chains, in which shipping plays a major role, by using logistics management and communication systems. MARQUAL sought to better understand, document, and communicate how the modelling of business processes in the maritime sector may contribute to adapting such operations to meet the requirements from users of waterborne transport in door-to-door transport chains and, at the same time, make them profitable ventures for the operators and for the society as a whole. In particular, the project had the goal of demonstrating current best practice models through a benchmark study.

A Greek study, OPSPEMAPT, focused on efficient administration of passenger terminals. The objective of the project was to identify the qualitative and quantitative specifications of efficient organisational, functional and administrative characteristics, which should be observed at port passenger terminals, in order to satisfy the requirements for efficient service.

To achieve this objective, OPSPEMAPT sought to construct a complete value-chain, starting with an assessment of the rational distribution of port operation costs, and based on the assumption that port operation results in direct and/or indirect benefits for both the public and private sectors. This assessment would then allow for quantifying the benefits accruing to the various companies (port, shipping, inland transport, logistics, etc) and other stakeholders (port authorities etc) involved in the provision of passenger port services.

On a more technical and institutional level, the INMARE project (2006) sought to carry out a complete evaluation of technologies and methodologies related to efficient port and shipping operations. Its primary objective was to create the basis for further enhancing

European short sea shipping by improving port freight service capacity and reliability. In particular, conceived as a Concerted Action (CA), the project aimed at coordinating activities within five areas, identified as important topics:

- Enhanced efficiencies between operations on board and ashore;
- Human resources;
- Communication and decision-support system (DSS);
- Regulatory matters;
- Environmentally-sustainable operations.

The basic idea of the INMARE CA was therefore to integrate expertise and experience with a substantial contribution from European stakeholder representatives, relating it to the CAPOEIRA (2008) project, which aims to develop recommendations for stakeholders regarding current and future research, development and innovation projects in ports, with the objective to minimise the risk of associated public or private investments.

Regarding the problem of port and dock pollutants, the GREEN NSD project (2005), carried out under the Interreg III cooperative framework, aimed to determine best environmental practice for decontaminating TBT containing waters in the North Sea Region. The project's objective was to assist port and dockyard environmental managers and environmental administrations, by providing them with information on regulations and criteria applied in the North Sea, and state-of-the art techniques to treat biocide contaminated waters. The benchmarking process was to be carried out on a water-treatment techniques' comparison, considering not only treatment targets and costs, but also a wider range of environmental impacts.

Given this objective, GREEN NSD's expected output was first to develop, in cooperation with Port and Harbour Authorities and scientists, a common Decision Support Tool (DST), based on data generated from suitable wastewater treatment processes, in order to provide decision makers with an instrument for sustainable management of the marine environment. Second, the project sought to provide a direct contribution to sustainable development of the North Sea region by introducing an environmental assessment strategy for best environmental practice in treating dockyard waters. Last, the project found it necessary to carry out a socio-economic study to evaluate impacts and quantify societal effects.

4.6.3 Research results

The focus of the MARQUAL project was to apply the efficient use of information and communication technology in an intelligent transport system where port services play an

integral part. The project's overall achievement was the development of a transport chain management system, incorporating a web based application, a monitoring system, a system's integration tool and communication platform, tracking and tracing technology, and decision-assistance service profiling simulator. These developments were achieved after a clear review of the business processes underlying the transport and logistics chain, and the nodal aspect of port services and operations. MARQUAL therefore managed to develop:

- A generic business model for transport chain management;
- An open data model covering all aspects of intermodal transport;
- A technical solution for a commercial Freight Transport Monitoring Services;
- A technical solution for a commercial Transport Chain Management System;
- Samples of "smart" transport equipment and software illustrating the potential for smart technologies to improve the competitiveness of intermodal transport.

Tests carried out on five sites indicated that the transport chain management system overall improved processes, providing features such as task automation, improved dynamic planning, full status visibility on cargo and Estimated Time of Arrival (ETA) advice, in-transit visibility, easy-to-create functionality for transport chains, statistics for supplier monitoring and follow-up. Furthermore, these technical functionalities were corroborated with business benefits, as the tests indicated a positive impact on costs due to a streamlined workflow and the better control provided by a central co-ordination point.

The OPSPEMAPT project effectively managed to rationally define the economic boundaries between the public and private sector's respective operational scopes, when carrying out port operations. In effect, the project managed to assess the benefits derived from port services' provision, and also evaluate the associated costs, thus designing a distribution scheme for these two elements in order to allocate them fairly between public and private operators. This goal was achieved through four specific outputs. First, OPSPEMAPT carried out a review of the theoretical literature on port development, business organisation, private/public sectors' involvement in business etc. In parallel, a survey focusing on research projects in port management and port planning was conducted. The project then compared these theoretical findings to data collected through quantitative and qualitative field research regarding the costs and benefits of port services' provision. Last, the project built a set of operational hypotheses adapted to the business case of Port of Piraeus' passenger terminal, in order to undertake their validation or rejection.

The main results of the INMARE project consist of recommendations for future research/studies, considerations on the regulatory aspects of the proposed priorities, and a snapshot of the state of the art of port and ship operations. INMARE's produced studies and recommendations under five related themes.

First, studying enhanced efficiency onboard and ashore, INMARE recommended focusing on a combination of information gathering and provision, using satellite and surveillance technology for improved flexibility in logistic chains. Human resource management was a second topic, and the project recommended developing instruments enabling tasks to be undertaken at port level instead of ship level by crew. In particular, the project recommended the deployment of tools and integrated systems for DSS for handling paperwork and organisational tasks along the logistic chain. Accordingly, INMARE also suggested specific R&D action be taken in the fields of high-performance and low-cost Information and Communication Technologies (ICT) in order to explore the development of fully integrated DSSs and increase the level of port-side involvement in maintenance and repair, using tools for remote control, commands and settings. A fourth topic concerned regulatory matters and the INMARE consortium commented on upcoming IMO regulations and procedures in order to provide support to the European maritime authorities and legislators. Concerning regulatory matters themselves, INMARE also suggested developing a standard methodology for cost-benefit analysis before introduction of new regulatory measures. Last, INMARE considered environmentally sustainable operations, advocating R&D activities focusing notably on feasible and available technology for (grey / black) water treatment, including analysis of the standards and definition of requirements.

The GREEN NSD project reviewed and tested innovative technologies to treat contaminated waters, and compared them to other well established technologies already applied in some of the North Sea Region's harbours and dockyards. The comparison of the processes was carried out following a strategy based on the concept of sustainability. During the project it was found out that the heterogeneous situation of discharges from ports and dockyards in the region made it necessary to develop a decision support tool flexible enough to compare treatment technologies under different regulatory scenarios. This regulatory issue was implemented in the tool, along with the knowledge gained during the development of the processes, allowing the design of both a cross-purpose and site specific tool to help decision-makers, managers and planners implement the most suitable technology to deal with contamination at the source.

The GREEN NSD project's DSS design was structured around three main outputs. The first output was technical and consisted of testing process chains (based on adsorption and flocculation) in order to select the most appropriate commercially available materials for decreasing pollutants to the desired targets. Second, GREEN NSD carried out environmental assessments by both a life-cycle approach and bioassays (effect oriented approach). Interestingly, GREEN NSD also showed that minimisation of water consumption by closed water cycles can be achieved. Last, a socio-economic investigation was conducted to provide deeper insight about the relevant stakeholders involved, their interests, and their valuation of the problem of biocide discharges.

4.6.4 Policy implications

All the projects reviewed in this sub-theme can be recognised as important tools for stimulating a common research strategy in support of European maritime actor's' efforts in their attempt to maintain the European maritime industry at the forefront of competitiveness, and each entail consequences in terms of future EU policy.

The INMARE project's novel approach, through "Concerted Action" (CA) between major stakeholders, demonstrated the possibility of a focused attention on a specific industrial sector's issues and a common basis of action at a European level. In particular, using a tool such as dedicated Concerted Action, involving trans-national cooperation of directly or indirectly qualified parties, allowed:

- Reaching optimal and common knowledge levels;
- Setting commonly accepted priorities for technology and methodology developments required to realise the industry's aims.

The CA methodology also provided additional support of EU policies in the framework of towards upcoming IMO regulations. Further methods for ports' institutional coordination at the European level are necessary, and fruitful results may stem from the CAPOEIRA project (2008).

Equally important to European policy was MARQUAL's focus in the efficient organisation and management of an inter-modal transport chain specifically involving seaborne operation. Indeed, by introducing advanced systems for the easy implementation of complex transport chains and facilitating efficient communication between many service providers, the complexity of organising both the physical transport and the information flows is greatly reduced. The project therefore promoted a setting that supports a shift from single modal "only truck" transport to multimodal transport based on train, inland waterways and sea transportation.

However, European ports still face traditional public policy issues regarding pricing and the "fair" use of public infrastructure. Indeed, to a major extent, market distortions exist because public and private actors involved in port operations (either as service providers, or port users) do not assume responsibility for a proportion of the costs of port operation – or at least in a proportion equalling the benefit this operation results in. In this respect, the OPSPEMAPT project determined a scheme for allocation of costs for port services' production and provision between the public and private sector, thus providing a relevant tool for eliminating the existing market distortions in the port industry.

Last, GREEN NSD provided insights for future European regulation regarding environmental issues. Indeed, the project noted a lack in a harmonised set of discharge criteria applicable to port and dockyard waters, at least in the North Sea Region. It is therefore of great interest to note that, by setting up procedures for information exchange, fostering communication between problem owners and problem solvers, exchanging technical and regulatory knowledge, and supporting decision-making procedures regarding the problem of water emissions in the North Sea Region, GREEN NSD was at the incept of the Water Ordinance in Germany, specifying discharge criteria.

4.7 Implications for further research

This section summarises implications and recommendations for further research, based on some key outputs of the projects reviewed. This serves to highlight the relations with the EU's Strategic Research Agenda for waterborne transport.

4.7.1 Implications from reviewed projects

A first area of necessary research is in the field of maritime pollution, and indeed many FP6 and FP7 funded projects address this issue. Maritime pollution can be tackled at several and related levels, depending on its origination:

- Vessels' propulsion;
- Vessels' hull coatings;
- Vessels' dismantling;
- Accident-related pollutant spills.

Projects and research are therefore aiming to tackle these issues in two ways: ex ante, and ex post. Indeed, efforts are put into designing propulsion systems featuring low-emission targets, while at the same time defining low-pollutant standards for hull coatings, which also has consequences for the rate, effectiveness, and safety of future vessel dismantling. Similarly, maritime catastrophes are addressed both at the ships' design stage (e.g. safer hulls, ballast characteristics) and at the accident-response stage.

Safety issues for crew, passengers, and also port operators are an area of promising ongoing research. Apart from the ongoing design of systems and processes for the safe operation of ships at sea, research must also improve procedures for accident-response, notably the efficient evacuation of passengers and crew. Further, port personnel's safety,

particularly in the freight handling departments, is a necessary field of research, until recently neglected[21].

Apart from research and advances in ship technology relating to environmental issues, research is still required in the more classical sense of "vehicle technology" enhancement, particularly in the areas where competition with other modes is strong (short-sea shipping, and inland waterway commodity transport). Indeed, engine design and innovative propulsion methods are a promising field, providing that research finds ways of relating efficiency with economics.

A previous section detailed projects that considered the value-chain and business implications of considering ports as nodes in the transport chain. However, much still needs to be done in the field of intermodal freight management, and the efficient intermodal relationships along the handling chain, in order to reduce the bottlenecks often incurred at ports, reduce costs, and improve cost-price principles.

Last, all these research ventures and potential innovations still require improvements for the deployment of a coherent and efficient European-level institutional setting, in order to enhance coordination in scientific, industrial and regulatory issues. Framework research could therefore tackle aspects such as competitiveness, environment, energy, safety and security and human considerations[22]. Relatedly, there is an evident need for further coordination of maritime data collection, management, and sharing.

4.7.2 The Waterborne-TP Strategic Research Agenda

Several of the potential research themes proposed in the previous section are actually undertaken by the Waterborne Technology Platform[23]. The Waterborne Technology Platform (WTP) was launched in January 2005 and is a forum gathering all stakeholders from the waterborne sector (sea & inland), in order to define and share a common vision and a Waterborne Strategic Research Agenda (WSRA), steering innovation efforts. This platform is therefore an important step forward on the road to forge ties between European waterborne companies, sectors and national clusters, thus aiming to unite the whole European waterborne industry, and to defend its current and future competitive advantage.

[21] See for example SECURICRANE (2008)
[22] See for example MARPOS (FP7, ongoing) as a general framework for European maritime affairs, and PLATINA (FP7, ongoing) for inland waterway transport.
[23] See http://www.waterborne-tp.org/

The current WSRA is built around three – often overlapping – "Pillars" [24]:

- Safe, Sustainable and Efficient Waterborne Operations;
- A Competitive European Maritime Industry;
- Manage and Facilitate Growth and Changing Trade Patterns.

The first "Pillar" sets two targets for innovative projects: reducing risk, and keeping the environmental footprint of waterborne transport and operations to a minimum. The first target develops on previous research, acknowledging the need for risk-based frameworks for cost efficient safety, thus incorporating risk-based ship's design, developing new systems and procedures for safe operations, and improving vessel usability and maintainability. These themes also encompass the general area of vessels' security, highlighting research in monitoring and data logging technologies, and, overall, economically viable security strategies.

To achieve the second objective of this first "Pillar", the WSRA focuses on reducing pollution emissions from vessels and waterborne activities. Mainly concerned with the emissions resulting from vessels operation, the projects promoted here seek to minimise airborne emissions and noise and vibration, as well as devise methods for cost-effective waste management and ballast water treatment.

In the second "Pillar", A competitive European Maritime industry, the WSRA aims to respond to "a constantly changing market, society and environmental conditions, that create new opportunities and new challenges"25, through the use of innovative services and products, in order to level the competitive playing field in a globalised maritime market. Several issues are at stake here, the first pertaining to innovations in vessels' (and other floating structures) design, production, and operation. The second issue concerns innovations in maritime equipment and systems on-board vessels, incorporating intelligent automation and navigation systems, thus rendering ships more energy-efficient and also strengthening their integration in the logistics' chain through ship-shore interface design. Interestingly, these design issues are strengthened by innovations enhancing the design tools themselves, as well as vessels' production processes.

A third area of concern for industrial innovation is the improvement of waterborne and marine operations, featuring notably sea-shore DSS for operations, maintenance and planning, and enhanced sub-sea capabilities.

[24] See CESA (2008). Waterborne Strategic Research Agenda (final). Brussels.
[25] CESA (2008), *op cit*.

The rationale for WSRA's third "Pillar" is to ensure that Europe's seaways and infrastructures remain capable of safely handling the increased number and size of ships, owing to the changing distribution of population and industrial production, as well as rapidly growing global co-operation and outsourcing, The third Pillar therefore promotes efforts to "accommodate and safeguard the growth of trade flows and adapt rapidly to changes in global trade patterns", while understanding the environmental impact of infrastructure building and dredging.

In this setting, a first target is to facilitate the accelerated development of new port and infrastructure facilities, by developing planning tools for optimal logistic chains and hinterland connection, and ensuring full interoperability between transport modes, and transport intermodality. Enhancing logistics chains, the WSRA also seeks to develop real-time "Intelligent" transportation technologies and integrated ICT solutions, for automatic solutions in cargo handling, container management, data exchange between ports, and optimum vessel utilisation. Relatedly, integrated solutions and algorithms for waterborne traffic management – and user-friendly traffic management strategies in general – rank also high on the research agenda.

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Annex: List of projects by sub-theme

Sub-theme 1: Short-Sea Shipping				
Project acronym	Project title	Programme	Project website	Coverage
EMBARK	European study for baseline and advanced regional and coastal traffic management	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality		Covered in Extr@Web report
EROCAV	Erosion of Ship Propellers and Rudders - the influence of Cavitation on Material Damage	FP5 - GROWTH - KA3 - Land transport and marine technologies	www.erocav.de	Covered in Extr@Web report
MARIDES	Maritime Decision Support	FP5 - IST - KA1 - Systems and services for the citizens	www.telecom.ntua.gr/marides/home.html	In this report
MTCP	Maritime Transport Coordination Platform	FP6-SUSTDEV-2 - Sustainable Surface Transport	www.maritime-transport.net	In this report
	Outlook of short-sea shipping in the Mediterranean sea	PRIN calls 1999-2005 - Research projects of national relevance, Italy		In this report
REALISE	Regional Action for Logistical Integration of Shipping across Europe	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	www.realise-sss.org	Covered in Extr@Web report

Sub-theme 2: Inland Waterways				
Project acronym	Project title	Programme	Project website	Coverage
	D4D - Data Warehouse for Danube Waterway	INTERREG III - Trans-European cooperation (Community Initiative)	www.d4d.info	In this report
CANAL LINK	New Opportunities for Inland Waterways Across the North Sea	INTERREG III-Trans-European cooperation (Community Initiative)	northsearegion.eu/iiib/projects/details/&tid=7	In this report

Sub-theme 3: Ship Building, Operation, & Maintenance				
Project acronym	Project title	Programme	Project website	Coverage
ADOPT	Advanced Decision-support System for Ship Design, Operation and Training	FP6-SUSTDEV-3 - Global Change and Ecosystems	adopt.rtdproject.net	In this report
	Hydrodynamic characteristics of innovative high-speed vessels	PRIN calls 1999-2005 - Research projects of national relevance, Italy		In this report
SAFEDOR	Design, Operation & Regulation for Safety	FP6-SUSTDEV-3 - Global Change and Ecosystems	www.safedor.org	In this report
SAND.CORe	Coordination Action on Advanced Sandwich Structures in the Transportation Industry	FP6-SUSTDEV-2 - Sustainable Surface Transport	www.sandcore.net	In this report
SANDWICH	Advanced composite sandwich steel structures	FP5 - GROWTH - KA3 - Land transport and marine technologies	www.sandwich.balport.com	Covered in Extr@Web report

TELEMAS	Tele-Maintenance and Support through intelligent resource management for ship Operation	FP5 - IST - KA1 - Systems and services for the citizens	www.telemas.de	In this report

Sub-theme 4: User Comfort & Quality				
Project acronym	Project title	Programme	Project website	Coverage
FLAGSHIP	European Framework for Safe, Efficient and Environmentally Friendly Ship Operations	FP6-SUSTDEV-3 - Global Change and Ecosystems	www.flagship.be	When report become available
MARNIS	Maritime Navigation and Information Services	FP6-SUSTDEV-2 - Sustainable Surface Transport	www.marnis.org/home.asp	In this report
OPTINAV	The Optimal Navigation Support System	FP5 - IST - KA1 - Systems and services for the citizens	www.wondermar.net/optinav.htm	In this report
POP&C	Pollution Prevention and Control-safe Transportation of Hazardous Goods by Tankers	FP6-SUSTDEV-3 - Global Change and Ecosystems	www.martrans.org/research/projects.asp?id=popc	In this report
SAFEICE	Increasing the Safety of Icebound Shipping	FP6-SUSTDEV - Sustainable Development, Global Change and Ecosystems - Priority Thematic Area 6 (PTA6).	www.tkk.fi/Units/Ship/Research/SafeIce/Public	In this report
SPREEX	Spill Response Experience	FP6-SUSTDEV-3 - Global Change and Ecosystems	www.spreex.net	In this report

Sub-theme 5: Ports & Port Operations				
Project acronym	Project title	Programme	Project website	Coverage
CAPOEIRA	Co-ordination Action of Ports for integration of Efficient Innovations and development of adequate Research, development and innovation Activities	FP6-SUSTDEV-3 - Global Change and Ecosystems	-	When report becomes available
GREEN NSD	Green North Sea Docks: Development of the Best Environmental Practice for Decontaminating Tributyltin (TBT) Containing Waters in the North Sea Region Based on Life Cycle Assessment	INTERREG III - Trans-European cooperation (Community Initiative	www.greendocks.de	In this report
INMARE	Technologies and Methodologies for Safe, Environmentally-Friendly and Efficient Shipping Operations of the Future	FP6-SUSTDEV-3 - Global Change and Ecosystems	-	In this report
MARQUAL	Demonstration of an integrated management and communication system for door-to-door	FP5 - GROWTH - KA3 - Land transport and marine technologies	-	In this report
OPSPEMAPT	Organisation of port Services production and Efficiency Management - Administration of Passenger Terminals	COMPETITIVENESS - Operational Programme Competitiveness (2000-2006), Greece.	-	In this report
S-CBB	Secured Cargo Black Box	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	www.cargoblackbox.com	Covered in Extr@Web report

Sub-theme 5: Ports & Port Operations				
Project acronym	Project title	Programme	Project website	Coverage
TRAPIST	Tools and Routines to Assist Ports and Improve Shipping	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	www.bmt-ts.com/?/528/734	Covered in Extr@Web report

Note. The projects listed in the Annex are those that have had the focus on the theme “Waterborne Transport”, as well as those who have addressed waterborne transport as a secondary topic to some extent.
On the TRKC portal (www.transport-research.info) it is possible to use the “advanced search” functionality – with the option “Waterborne Transport” – and find all research projects, EU-funded and national, which have treated, to a variable extent, aspects that can be related to the theme.