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RAMSSES – Realisation and Demonstration of Advanced Material Solutions for Sustainable and Efficient Ships

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Abstract

The RAMSSES project aims to show the benefits of advanced materials in maritime applications by implementing 13 market driven demo cases. The entire process chain and a wide range of applications (structural components, equipment, ship integration, repair) are covered. Installation and assessment of demonstrators on shore or on board will reveal the high technology readiness. The test program, based on risk assessment and supervised by rule making bodies, targets on ensuring relevance for commercial approval beyond the project. While demonstrators will support commercialisation of specific products, RAMSSES is also engaged strategically in enabling more rapid and agile material innovation in the European Maritime industry. The first key element is a knowledge repository for test data and best practice procedures, allowing reuse of such information for similar future cases. Secondly, standardised risk scenarios will help easing approval processes in the future, and finally a new materials innovation platform will enhance continuous technology transfer within the maritime sector and beyond.

Keywords: Material innovation; Shipbuilding; Rules and regulations; Life Cycle Performance Assessment, Composite materials; Ship equipment

Nomenclature

AL	Assessment Layer
AM	Additive Manufacturing
DDL	Development and Demonstration Layer
E-LASS	European network for lightweight applications at sea
FRP	Fibre reinforced plastics
HTS	High tensile steel
ICL	Information and Communication Layer
LCPA	Life Cycle Performance Assessment
PAX	Passenger(s)
RAMSSES	Realisation and Demonstration of Advanced Material Solutions for Sustainable and Efficient Ships
RoRo	Roll on Roll off
SOLAS	International Convention for the Safety of Life at Sea
WAAM	Wire Arc Additive Manufacturing

1. Introduction – What is the RAMSSES project about?

Innovative materials and their wider use are important to improve the life cycle performance of European built ships and maritime structures, to reduce their environmental footprint, to make the industry more competitive at a global scale and thus to create and maintain employment. In this area, considerable progress has been made in European research and development as well as first commercial applications in recent years. The EU funded projects BONDSHIP, DE-LIGHT Transport, ThroughLife (http://www.throughlife.eu/Throughlife/index.xhtml) and ADAM4EVE (http://adam4eve-project.eu/) may serve as examples. However, the use of lightweight and other advanced materials in the maritime sector is lagging behind the potential. The reasons for this situation are manifold and complex. Therefore, it takes a comprehensive initiative of a dedicated group to overcome existing barriers.

The European Innovation Action RAMSSES is addressing the most relevant problems that hinder a broader and quicker technology uptake, thus to obtain recognition and an established role for advanced materials in the European maritime industry. The project comprises both practical measures that are dedicated to improving, assessing and showing the readiness of certain technologies, and strategic actions that aim at enhancing the innovation capability of the European maritime industry on the long run and in a sustainable manner. This paper discusses the particular problems that need to be tackled, and, in answer to those, the specific objectives RAMSSES has set itself. The industry driven demo cases pursued in the project are introduced, followed by a discussion of the expected impact. Furthermore, collaboration activities and opportunities are introduced.

2. What are the challenges and objectives RAMSSES is facing?

The RAMSSES project has been established to provide answers to specific problems that the players in the European maritime industry have in common when it comes to material innovation. For the three most relevant problems, specific project objectives have been defined. Each of the objectives corresponds with a set of activities which have been translated into layers of the ‘RAMSSES pyramid’ which represents the project structure, Fig. 1. The problems and objectives, as well as RAMSSES’s approach to respond is outlined in the sub sections below.

2.1. Foster the use of new materials in real applications with high market potential

Problem: When it comes to innovative material solutions, many ship operators, shipyards and suppliers are lacking confidence and awareness both of such designs’ long-term technical properties in maritime operation and economic benefits over the life cycle. There is no clear evidence that cost savings in ship operation can compensate potentially higher expenses for purchasing raw materials and applying more sophisticated life cycle processes. Consequently, industry uptake of new materials is lagging behind the potential.
RAMSSES’s answer: Market driven demonstrators. Shipbuilders and sub suppliers are leading 13 different demo cases, dedicated to show the variety of innovative materials, their suitability for maritime applications, and the related potential. To assess the particular solutions’ maturity but also to create confidence in advanced materials for maritime use in general, one physical demonstrator is built for each demo case, and tested on board or under realistic conditions. Demos in RAMSSES cover the entire maritime supply chain from component and equipment

production through integration in complex products to repair. This is essential to optimise the entire process chain, to develop modular products, processes and procedures, and to reduce cost while maintaining high flexibility. These effects will be validated by an accompanying economic and environmental performance assessment.

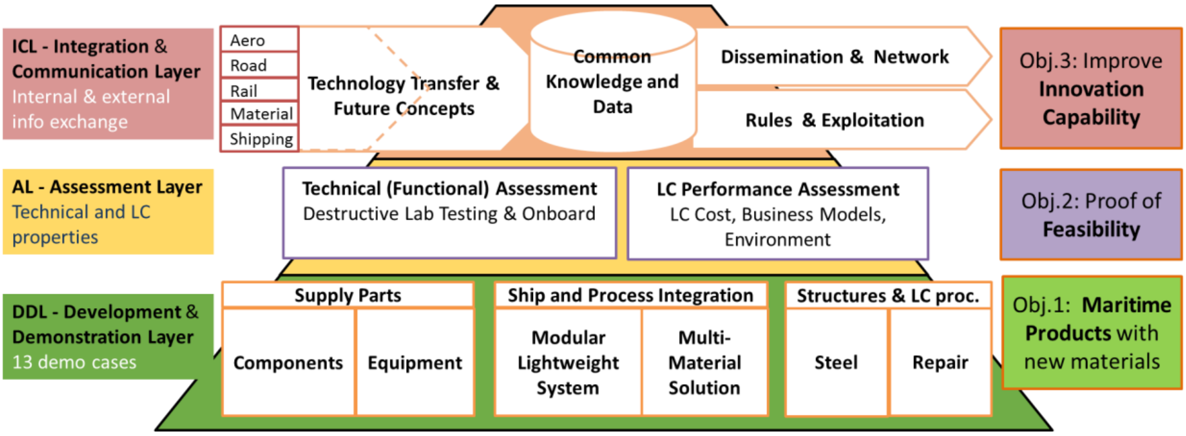

Fig. 1 Layer structure within the RAMSSES project, and main objectives

2.2. Prove full technical and economic feasibility of the solutions using best practice, and consolidate knowledge

Problem: There is a lack of information and overview on available technical performance test data for innovative materials at lab scale and in realistic maritime environments. Consolidated and harmonised design, testing, simulation and approval procedures are largely missing. The same applies for methods for life cycle performance assessment (LCPA – cost and environmental impact). Consequently, approval is carried out on a case-by-case basis, repeating risk assessment and testing, thus requiring extra time and cost.
RAMSSES's answer: Assessment teams take care of performing technical assessment, including destructive testing and on-board measurements, and LCPA in a harmonised way, using leading edge expertise and combining tests where appropriate. They take existing test results and experiences in maritime and other sectors into account and document the results of approval tests in a common data repository for future use in similar cases.

2.3. Support the maritime sector's innovation capabilities

Problem: Existing expert knowledge on innovative materials in the maritime field, as well as related test data etc. is widely distributed and difficult to access. Hence, a reduced awareness on 'what is possible' hinders commercial uptake of solutions by a wider community, and reduces economy of scale. The situation is caused by insufficient systematic knowledge exchange as well as trans- and intersectorial technology transfer. Current maritime rules and regulations do not consider the use of innovative materials appropriately; most applications require time consuming and costly case-by-case proof of equivalent safety versus conventional solutions.
RAMSSES's answer: In a knowledge and data repository, RAMSSES is collecting project results and information from external sources. In cooperation with existing initiatives, a Maritime Innovation Platform is being formed which helps to spread excellence to a wider community. Experience in practical applications, test data and a more efficient methodology to prove equivalent safety for new materials will feed into the rule making process and improve the expertise of the sector.

3. Where and how are the technologies applied?

Considering the wealth of new metallic, non-metallic and hybrid material developments, as well as the variety of application areas in terms of ship types with their complexity (structural members, outfitting systems), the maritime industry offers a manifold of opportunities for material innovation. The 13 demo cases in RAMSSES, selected with the aim to cover the full range of opportunities, (Fig. 2) mirror this situation.

To demonstrate the maturity of innovative solutions convincingly, various aspects have to be taken into account. The development of design solutions that are fit for application in commercial products includes the elaboration of interfaces between novel and conventional structures, development and analyses of production and assembly concepts, definition of life cycle processes in maintenance, repair and end-of-life. Evidence of the solutions' feasibility, performance and readiness for approval will be given both by the production of physical demonstrators, and in the assessment of decisive technical properties, environmental impact and economic key figures. All physical demonstrators will undergo real-life tests which are undertaken either on board or in a close-to-reality environment. Following the definition of the following three clusters which represent different types of application, demo cases are introduced in the sub sections below:

- **Cluster 1 – Components and equipment**: Material and process innovation is focused primarily in the Component and Equipment demo cases. Fire retardant and bio-based materials are covered as well as innovative production techniques such as 3D printing, and upscaling of new construction principles like truss core panels. The solutions bear a high potential for SME suppliers.
- **Cluster 2 – Ship integration for non-metallic and multi-material structures**: The demo cases in this cluster are all facing the challenge to find solutions for integrating innovative materials into complex ship structures, and for integrating the required production and assembly processes into the manufacturing and supply chain.
- **Cluster 3 – Advanced steel structures and innovative repair methods**: Material innovation does not necessarily mean introduction of materials other than steel. The demo cases in this cluster are related to the application of innovative steel types, and repair methods for steel and others.

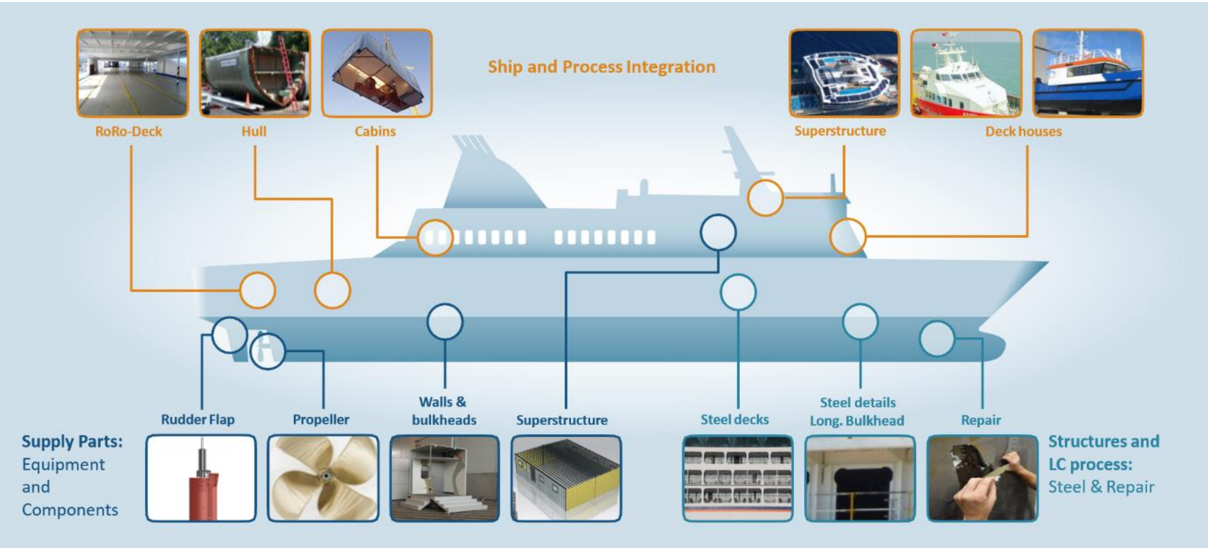

Fig. 2 RAMSSES demonstration cases overview

3.1. Modular Light System for Less Critical Internal Walls and Superstructure (Cluster 1, Component)

The conventional solution in this area foresees steel walls with external insulation to reach fire class A-0, coming with a mass about 50 kg/m^2 and cost up to 220 €/m^2, including insulation. Very rarely (primarily for non-SOLAS ships), FRP structures or foam-core panels are used which are produced and assembled mostly manually. Truss core panels and some connecting elements have been developed in previous projects at small scale, but no modular system for a wider range and industrialised production is available.
The demo case provides a modular standard system consisting of panels, connecting elements and outfitting elements (e.g. doors, windows, cables), produced in a highly automated winding process, allowing for easy assembly onboard, Fig. 3. Thanks to a high-performance carbon fibre truss structure, the solution comes with ultra-low mass (<< 10 kg/m^2), improved noise damping, and reduced raw material consumption (truss structure instead of low-density foam) at equivalent fire safety and equal cost to the conventional solution. There is a wide range of applications for the solution in various ships (PAX, ferries, deckhouses of cargo ships), offshore accommodation and in land based buildings. Further use of advanced truss-core structures in bridges and other applications is also possible.

3.2. Lightweight Components for High Loads and Fire Class (Cluster 1, Component)

The use of non-metallic lightweight structures for critical applications in SOLAS ships is very limited and not system based, even though their feasibility has been tested and pre-proven in previous projects. Projects in material sciences have demonstrated potentials of new raw materials (bio-based, fire retardant). However, the test results

available are not sufficient for maritime approval. Production, assembly and outfitting processes are not developed to industry needs. Hence, steel structures are by far dominating.
Sustainable lightweight components largely using bio-based and other innovative raw materials are qualified for maritime use in this demo case. The system integrates advanced properties like reduced weight, fire safety equivalent to steel and improved thermal and acoustic insulation. The foreseen development comprises panels (FRP or foam filled sandwich), connecting and outfitting elements for critical applications, industrialised production and easy assembly. The target fire class is up to A-60 and B-30, with a thermal conductivity < 0.4 W/mK, and a weighted sound reduction index > 38 dB. The range of applications in ships and offshore includes decks, bulkheads, and walls. There is also a potential for use in rail vehicles and buildings, with a significant greening potential through bio-based and recyclable/reusable materials and components.

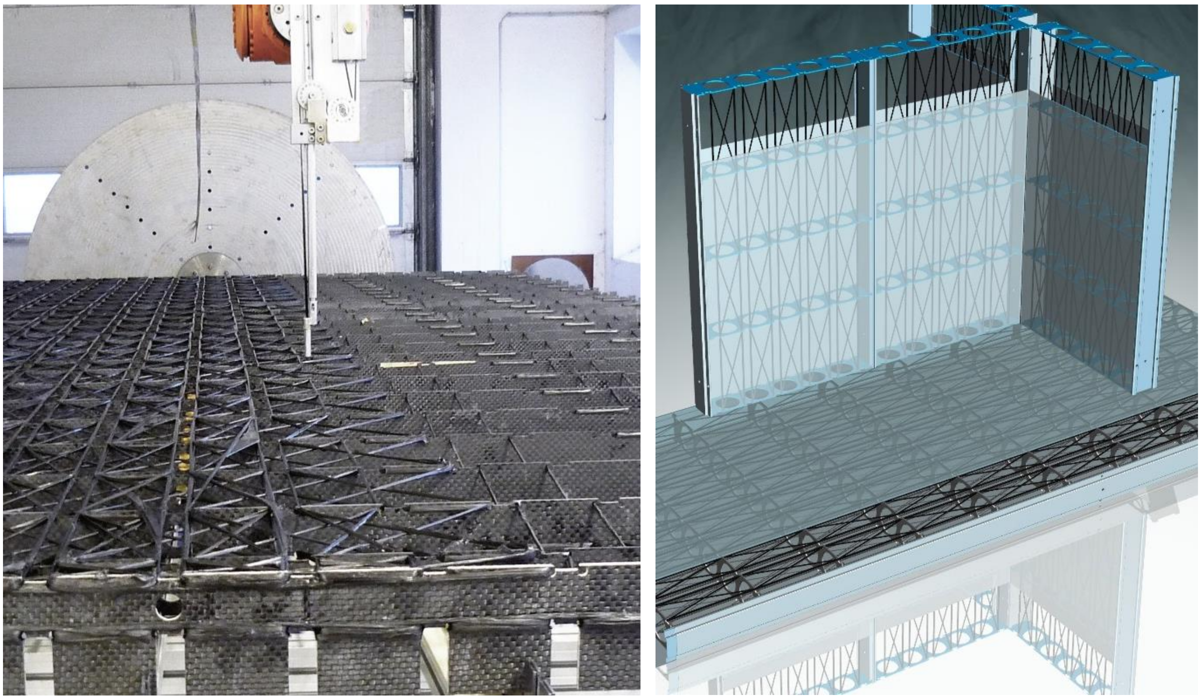

Fig. 3 truss core panels. (a) winding process; (b) assembled structure

3.3. Propeller Blade made by Additive Manufacturing (Cluster 1, 3D-printing, Equipment)

Large propellers are currently cast from metal, while smaller ones are occasionally made of composites. Additive Manufacturing (AM) technology is developed at lab scale and in industrial applications for highly complex and weight critical parts (e.g. in airplanes). AM of large parts (>1 m) with complex twisted skins and closed cavities is limited to several lab scale experiments. Fatigue properties and productivity do not meet maritime needs.
The demo case foresees development and proof of feasibility of a highly productive and reliable Wire Arc Additive Manufacturing (WAAM) process using different metal alloys, e.g. cupro-aluminium, martensitic or duplex steels. The process features a high deposit volume and a defect free and cost-efficient process. The demonstrator, coming with 1.5-2 m diameter and less weight through internal cavities, will be tested against fatigue and corrosion, while hydrodynamic properties are assessed by numerical simulation. The proof of functional and economic feasibility for maritime real-scale applications will catalyse the use of AM and the realisation of corresponding new design opportunities. The AM processes for large structures will be attractive for propellers and turbines in the maritime and energy sector, but also for offshore and general engineering.

3.4. Lightweight Rudder Flap (Cluster 1, Equipment)

Smaller rudders e.g. for leisure boats are occasionally made of FRP, while large rudders for container ships and tankers with a size of up to 100 m^2 are nowadays exclusively made of steel, resulting in heavy hinges, shafts and supports, and correspondingly high loads and energy demands. Increased freedom of design of a composite rudder flap can improve hydrodynamic performance, lifetime and reduce maintenance cost. High loads and a lack of experience in production processes currently inhibit the use of advanced materials.

The demonstrator in this case is a high performance, multi-material rudder with a lightweight flap, including its multi-material components, manufacturing, joints and joining technique. The solution provides improved hydrodynamic design up to potentially adaptive flap shapes at equal production and reduced maintenance cost. The demonstration campaign will comprise real-life operational validation on board and maintenance/repair tests. The solution is suitable for a wide variety of rudders, a considerable share of them produced in Europe, for different types of ships. Positive experiences will trigger applications of FRP e.g. for propulsion improvement devices and adaptive hull structures. Potential synergies to offshore, e.g. renewable energy devices are also expected.

3.5. Internal Walls and Superstructure of Cruise Ships (Cluster 2, non-metallic)

Steel and aluminium dominate current applications thanks to the vast related know-how, comprehensive existing approvals and established processes related to these materials, Fig. 4 (a). Functional feasibility of non-metallic structures (mostly foam core sandwiches) was shown in R&D projects and limited industry applications. An industrialised process chain, including inspection and repair, is largely missing. External insulation and extensive approval requirements inhibit a wider, economically feasible application.
Using standardised elements (e.g. from corresponding RAMSSES component demo cases), this demo case focuses on the development of highly efficient processes for adaptation, assembly and outfitting of a modular system, and integrating this into the overall ship design and structures. Requirements for the envisaged applications comprise strength, fatigue, fire resistance, comfort, lightweight, optical appearance as well as easy, flexible and cost-efficient processes, allowing pre-outfitting and pre-fabrication of larger blocks. The application potential of lightweight modular walls and superstructure reaches several thousand m^2 in modern cruise ships. The system can also be adopted to ferries, yachts, offshore accommodation, and land-based buildings. Highly efficient processes and pre-approval will pave way for the wider application of non-metallic and multi-material structures in other parts of the ship, including critical applications.

Fig. 4 (a) typical superstructures and walls on a cruise vessel; (b) preparation of fibres for pultruded profiles for RoRo decks

3.6. Modular Deck System for RoRo Vessels (Cluster 2, non-metallic)

Nowadays, steel and partly aluminium are the predominant solutions for RoRo decks. Innovative lightweight steel and steel-plywood decks are occasionally applied at small scale, primarily for liftable (intermediate) decks which do not contribute to global strength. Non-metallic composite sandwich deck panels in a steel frame structure are tested and shown in research, and few prototype applications at small scale exist. Assembly and outfitting processes are largely manual and not adapted to larger economy of scale.
The demo case solution is a system for cargo decks based on standard lightweight panels and metallic or pultruded (composite) beams, Fig. 4 (b) – including corresponding joints and outfitting elements (lashing devices, lifting elements etc.). Fabrication, assembly, outfitting and repair processes are developed. The target is to achieve an optimum between weight and payload, and production cost at reduced maintenance (corrosion). There are several thousand m^2 of cargo decks in typical RoRo ships, the mass of which can be further reduced. Using synergies and standardisation potential together with RAMSSES component demo cases, the application potential can be further increased.

3.7. Lightweight Walls for Work Boats (Cluster 2, multi-material – Aluminium/FRP)

Currently, a variety of steel or aluminium designs with external insulations is used for superstructures and deckhouses. Extruded aluminium pre-fabrications, often joined by friction stir welding, and composite walls, allow for modular pre-fabrication and assembly, including insulation, Fig. 5 (a). However, small shipyards often lack the required knowhow on optimal solutions, material processing and integration into their specific designs.
The demo case envisages to assess, test and integrate a variety of solutions using extruded aluminium and composite panels for deckhouses and superstructures of small workboats under the specific conditions of a small shipyard. The aim is to use standardised modular lightweight systems. However, in comparison with the cruise and RoRo applications, solutions in small yards must work for single panels and provide high flexibility in design, robustness at low cost, considering limited skills and automation. There is a wide application potential especially for numerous small shipyards in Europe which produce a huge number of small vessels, often for local markets.

3.8. Superstructure Module on a Steel Deck of Multi-Purpose Vessels (Cluster 2, multi-material – FRP/Steel)

The demo case is dedicated to smaller, fast ships with highly specialised, high-value and sensitive outfitting, operating under extreme conditions 'all year round at 24/7' (e.g. offshore patrol, coast guard, or environmental surveillance vessels). For strength reasons, hulls of these ships as well as superstructures are usually made of steel or aluminium. Superstructures are basically exposed to extreme conditions, such as wash and green water, wind, vibration or temperatures. Composites would offer benefits such as lower weight, improved noise and vibration damping, or stealth effects. However, a lack of operational experience, condition monitoring and methods for a multi-criteria design optimisation currently act as barriers to wider use.
The solution is a compact superstructure module consisting of FRP foam sandwich panels, with integrated joints to the metallic deck, outfitting elements and condition monitoring, including the necessary production, joining and repair techniques at competitive cost as well as an optimised design and approval approach for a variety of similar cases. Functional requirements include strength, fatigue, noise, vibrations, resistance to aging and survivability in case of fire. The demo case pushes the limits for current FRP applications across the sectors and enables wider applications in fast special ships for a variety of purposes, including in the offshore industry.

3.9. Custom-Made Hull of an Offshore Vessel (Cluster 2, non-metallic)

The demo case is a full-scale hull section for a large offshore vessel, operating under harsh environments under SOLAS conditions, including the internal elements, entirely from composite materials, replacing the current steel solution. 'Ingredients', such as materials, joints and joining techniques or solutions for equivalent fire safety are available from previous R&D and small-scale applications, but have never been tested, validated and approved in combination. Production processes for such large structures are still too expensive and partly not suitable for practical use under shipyard conditions.
A complete composite vessel is designed in line with SOLAS requirements and class rules. Production processes and quality assurance measures are developed, and a full-scale hull section (ca. 6m x 6m x 3m) is produced. To validate design parameters, a real-life destructive test will be performed on site under supervision of testing experts, class and flag states. Focus will be on integration of processes and components as well as on understanding and demonstrating real-life behaviour. An additional effect is the decrease of current safety margins. Suitable test procedures, as well as structural health monitoring and calculation methods to gain approval, will be developed. The demo will result in the first approved FRP SOLAS ship. All in all, shipyards', owners', flag states' and class societies' trust in the feasibility of composite solutions for large commercial ships will increase dramatically; this particular demo case will also showcase a new approach to approval for future cases. Detailed knowledge on processes, design and testing is highly relevant for large load carrying composite structures in various applications, as well as in other sectors.

3.10. Lightweight cabin area for Passenger Ships (Cluster 2, multi-material)

Prefabricated modular cabins have largely replaced the 'in-situ' made cabins in cruise ships and ferries, Fig. 5 (b). Cabins usually come without a floor (which is still part of the steel structure), making transport and installation difficult and restricting pre-outfitting. Piping and wiring is usually integrated in the steel structure, but not in the cabins. Windows and other sensitive elements can only be installed at a late stage, when the cabin is fully connected and integrated. Hence, there is still a margin for weight reduction and shipyard process improvement.
A fully integrated 'box-type' PAX cabin is developed, with extensive use of different lightweight materials, compact (space saving) design, and fully integrated outfitting and standard connectors to the global ship

distribution system. The proof of full functional fitness comprises strength, noise and vibration, and fire, along with a new structural concept of the ship. Substantial mass savings (ca. 400 kg/cabin or 1.000 t/ship), cost savings (expected 5 M€ per ship) and flexibility in design (modular approach, cabins not integrated in the load bearing steel structure) are expected as well as reduced maintenance and refurbishment cost. The modular approach allows for combining standard elements to customer specific solutions. Prefabricated, self-sustainable cabins can be used for a variety of PAX ships, offshore accommodation, but also land-based buildings and ad-hoc (emergency) accommodation.

Fig. 5 (a) Extruded Aluminium profiles in a workboat, joined by friction stir welding; (b) Conventional passenger cabins without floor

3.11. Highly Loaded Structural Details from High Tensile Low Alloy Steels for Cruise and Research Vessels (Cluster 3)

Highly loaded parts in large ships (e.g. window corners in cruise ships, Fig. 6 (a)) are currently strengthened with thick sections of conventional steel, or the design (e.g. radius of the notches) needs to be modified. High tensile steels (HTS) offer significant weight saving (5-20%, case-dependant), improved strength and more design freedom. While feasibility of HTS in shipbuilding has been shown in previous projects, joining processes and joint properties are currently weakening HTS structures and decreasing practical use.
Welding procedures, design variations and post-processing techniques (friction stir processing, over-lamination) are systematically investigated and tested to improve quality, fatigue life and corrosion behaviour of welds in design details of different HTS types, e.g. longitudinal bulkheads. Failure mechanisms and approval criteria are defined as well. Numerical simulation and statistical models will enhance process knowledge and help achieving optimised design and robust processes, thus to obtain pre-approval for similar applications. Smaller, real-scale specimens, sufficient to achieve fully valuable SN-curves, will be produced in realistic production environments. Methods and process knowledge developed in the demo are applicable for a wide variety of large structures in ships and offshore structures, including renewable energy devices. Further application is possible in land based steel structures, like bridges or buildings.

3.12. Lightweight Decks of High Tensile Steel in Cruise Ships (Cluster 3)

Weight saving through thinner structures or use of HTS is of increasing interest in modern cruise ships and feasible in principle. It is well known that production processes have significant impact on the quality of joints and structural distortions, which can decrease the structures' performance. While low heat input welding technology for conventional steel is in place, a lack of experience, quality assurance and confidence in the shipyard production processes does not allow for the extensive use of HTS in critical (load carrying) applications currently.
The demo case's mission is to show the feasibility of production of large steel sections using thin HTS material, Fig. 6 (b), ranging from butt and fillet welds in pre-manufacturing to assembly joints in confined spaces or overhead conditions within and outside covered facilities. Process parameters and QA procedures will be established under real-life conditions at real scale, providing the basis for approval and wider use of HTS thin sheet structures under full exploitation of their strength properties. Developing the required process skills and quality will provide competitive advantages, not only in terms of cost, but also in producing products with new design features and reliable quality. The use of HTS with yield strengths of up to 690 MPa is expected to allow

weight savings of 20% and above at high cost efficiency, leading to reduced fuel consumption and increased payload. The processing of HTS in large structures under harsh environmental conditions is applicable not only to cruise ships, but also to highly loaded structures such as cranes, bridges and offshore renewable energy devices.

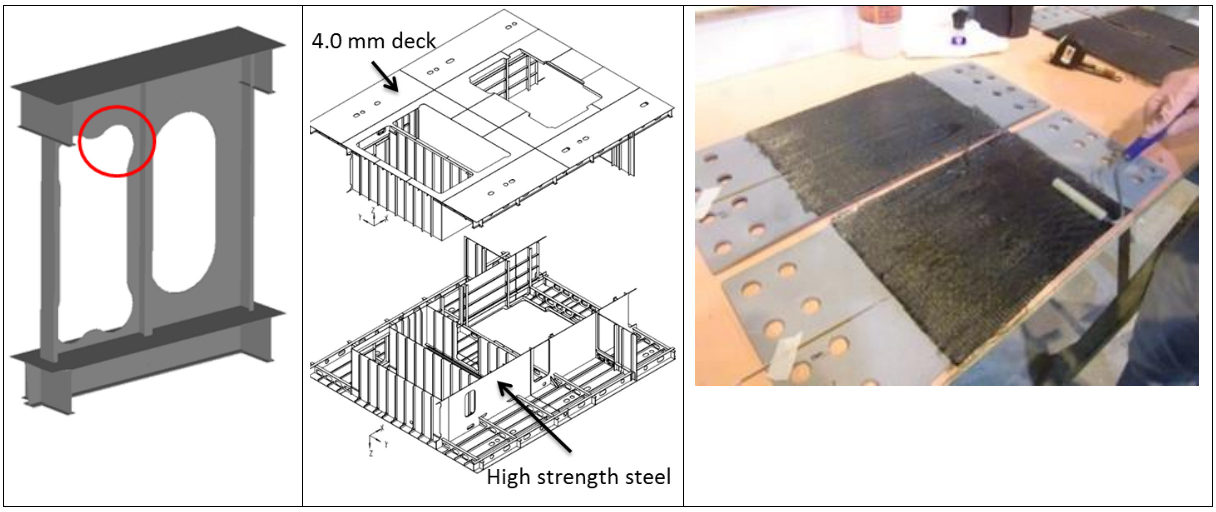

Fig. 6 (a) Curved cut-out to reduce notch effect; (b) steel deck structure; (c) composite patches being applied on welded steel specimens

*3.13. Composite Overlay to repair and Improve Metallic and Non-Metallic Structures (**Cluster 3)***

In 30+ years of global operation under harsh environments, maritime products, especially tailor-made structures with decreased safety margins and new materials, need specific, easy to handle and low-cost repair technologies to be acceptable for owners and authorities. Composite patch over-lamination was successfully tested in several projects, and has been applied e.g. for repair of aluminium aircraft structures as well as thick steel sections in offshore and pipelines, Fig. 6 (c). Composite patches work as crack arrestors for existing damages. Effects of composite over-lamination to improve fatigue life of welded joints have been studied sporadically. No systematic design and processing guidelines is available.
For wider maritime applications, both for repair and joint fatigue improvement dimensioning, design, material selection and processing procedures are established on a systematic basis, and verified by tests and parameter studies (statistical models) on fatigue, aging and corrosion, first at lab scale. This will serve as a basis for QA guidelines and approval by class societies. Tests will allow for directly comparing the effect of over-laminated specimens against untreated ones, as well as with the composite demos. Finally, real-life application tests and long-term monitoring of the effects will be carried out at a shipyard as well as on board a real ship. The solution will provide a comparatively easy-to-apply, robust and cheap method to extend the lifetime of many applications, within the maritime sector with its extreme environmental conditions, and beyond.

4. Will it pay off?

As explained in the demo cases' descriptions above, weight reduction is one of the most prominent technical impact factors of the RAMSSES project. It is expected that the novel structures will be 20…40 percent lighter than existing conventional ones. An educated guess by the experts working on the project suggests that the total weight of cruise vessels, work boats and car carriers can be reduced by some 4…5 per cent when applying and combining the various solutions consequently. This again will translate into reduced fuel consumption and emissions during operation and/or increased payload. Further impact resulting directly from the demo cases consists in improved processes along the design, production and life cycle chain. Standardisation of designs and the abovementioned expandability of applications beyond the demo cases' scenarios will help yielding economy of scale effects. The analyses done in the RAMSSES assessment layer will result in a comprehensive evaluation of such quantifiable impact, and industry partners will develop their individual business plans in order to exploit the competitive advantages consequently.

Beyond the obvious effects that can be attributed to the demo cases und their future commercialisation, there are further impact factors that are associated to the improved innovation capability of stakeholders in the maritime industry. Improved skills and increased confidence in new technologies, supported by a common material innovation knowledge base and a lively network for exchange of experiences (see collaboration opportunities in the section below), along with supportive approval processes will enable the maritime community to realise innovative ideas in a much greater extent and to bring them to the market more quickly than in the past.

5. How can you collaborate with RAMSSES? – Towards a Maritime Materials Innovative Platform

An important objective of RAMSSES is to improve the innovation capabilities of the European maritime sector beyond the project. This requires both to involve a wider maritime and inter-sectorial community in the work of the project and to create an infrastructure, which will – unlike in many previous projects – prevail and function after the end of the project. To achieve this, RAMSSES has implemented three major elements of communication and collaboration, which is open to any interested party:

- **Structured Technology Transfer into the maritime sector**: For various reasons, the use of lightweight materials in neighbouring transport sectors is more advanced than in the maritime sector. RAMSSES has therefore established a dedicated "Technology Transfer Group" consisting of experienced research centres and multipliers from the automotive, aeronautics, rail and construction sectors which will be complemented by RAMSSES partners working in different sectors. This group will deliver reports based on specific focus topics annually and discuss this with the RAMSSES community in public workshops. A dedicated group of RAMSSES partners will then analyse this input and establish feasibility and necessary next development steps for maritime applications.
- **The central knowledge repository**: Validated information and knowledge from outside the RAMSSES community, knowledge from the demonstrator cases which is relevant to a wider community as well as test results from the project and from previous projects will be stored in the RAMSSES central knowledge repository. This knowledge is both accessible by all project partners and partly – considering IPR protection of project results – to an external community. After the end of the project, the full content of the knowledge repository can easily be transferred to the internal knowledge base of the partners. In addition, the public part will be maintained and further complemented by a sustainable network, which will be one of the legacies of the RAMSSES project.
- **Knowledge transfer to a wider maritime community and sustainable network**: Using the RAMSSES knowledge repository as a basis, the project has established targeted communication flows and cooperation with the European maritime community. This "outbound" stream contains a Maritime Advisory Group of potential end users of lightweight solutions (i.e. shipping companies), bi-annual public workshops as well as contributions to a faster maritime approval process and measures to increase the economy of scale for new materials and consider maritime needs in European and international standards.

Very importantly, RAMSSES is not aiming to implement its communication and exploitation strategy by conducting own project-specific measures, but will use the existing E-LASS (www.e-lass.eu) network and strengthen it. E-LASS is also intended to be the platform to host the RAMSSES public knowledge and tool repository after the end of the project and thus create the basis of a sustainable and active maritime material innovations network. The E-LASS network has been established on a non-commercial basis and currently comprises some 240 members, RAMSSES will significantly add value and services to this network.

RAMSSES is widely open for knowledge exchange and cooperation with external entities, networks and projects. Close cooperation will be maintained, e.g. with FIBRESHIP (www.fibreship.eu), a European Innovation Action project running in parallel to RAMSSES and funded under the same call topic, several other European and national projects. Parties which are interested to generally participate in the knowledge exchange are advised to join the E-LASS network, which will be the main external gateway of RAMSSES. This will entitle them, among others to attend the free bi-annual workshops. In addition, RAMSSES partners can be approached through the website (www.ramsses-project.eu) or the contacts given on top of this paper to discuss more specific and direct forms of cooperation.

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References

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