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5 November 2005



# **LASS Annual Report, November 2005**



LASS Annual Report, year 1  
Borås, Sweden, November 2005

## Abstract

The LASS project– **Lightweight construction applications at sea** – aims at improving the efficiency of marine transport and increasing the competitiveness of the Swedish shipping industry. This will be accomplished through the development and demonstration of techniques for using lightweight materials for ship construction.

The consortium behind the project consists of representatives from the Swedish shipping industry, Swedish materials manufacturing industries, Swedish universities and research institutes as well as public authorities and classification societies. The three-year project started in January 2005. LASS is sponsored by VINNOVA ([www.vinnova.se](http://www.vinnova.se)), participating industries and partners. This report contains a brief description of the accomplishments so far.

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## **Preface**

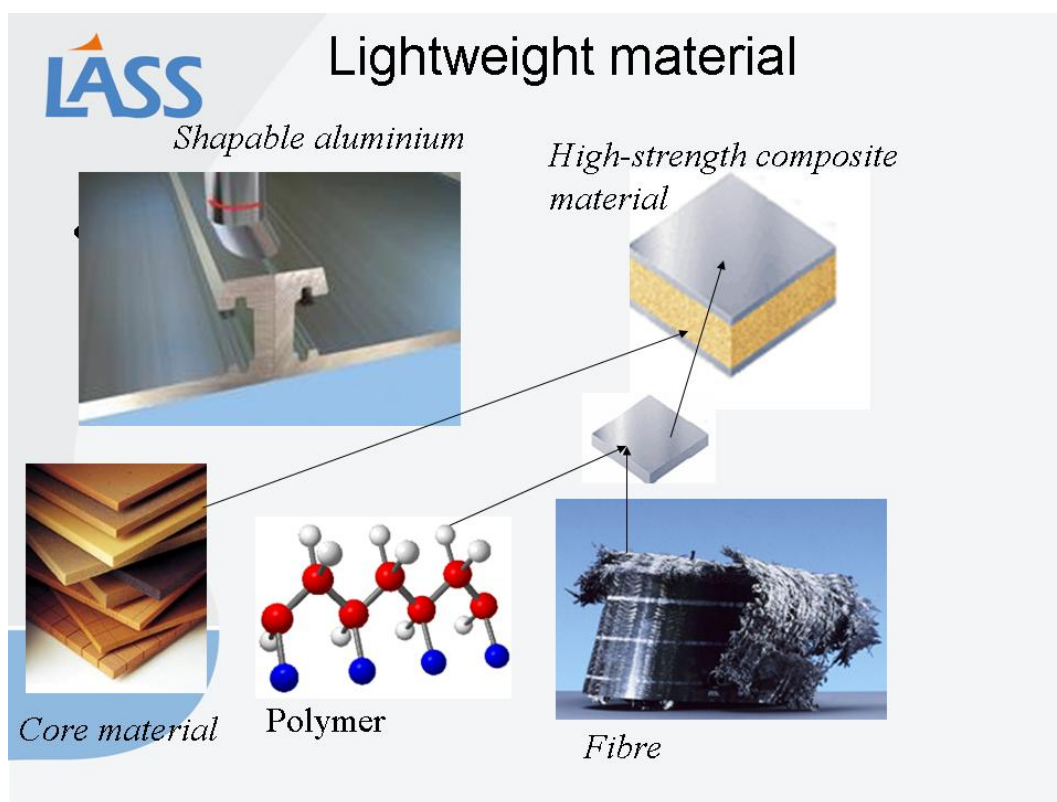
The overall aim of LASS is to make marine transports more efficient and to improve the competitiveness of the Swedish shipping industry. The intention is to accomplish this by means of four models, or conceptual ships, demonstrating the opportunities for cost-efficient, environmentally sound production of boats and ships using the lightweight materials aluminium or composites.

The consortium behind the project consists of representatives from the Swedish shipping industry, the Swedish leisure craft industry, Swedish material manufacturers, Swedish universities and research institutes as well as public authorities and classification societies. The LASS project began in January 2005, and this Annual Report contains a brief description of the accomplishments to the end of September 2005.



# 1 Background

The purpose of LASS – lightweight construction applications at sea – is to develop technical solutions for the construction of four different types of ships using lightweight aluminium and sandwich composite construction materials. Two of these ships will qualify for classification for international maritime traffic in accordance with SOLAS (Safety Of Life At Sea), and the other two will be classified in accordance with the HSC (High Speed Craft) code, which primarily governs high-speed (passenger) ships in coastal traffic.



**Figure 1** Lightweight materials covered by the LASS project

Chapter II of the SOLAS functional requirements speaks of “restricted use of combustibile materials”, while chapter II, rule 11, goes even further: “*The hull, superstructures, structural bulkheads, decks and deckhouses shall be constructed of steel or other equivalent material*”. This text would render impossible the use of a lightweight material such as sandwich composite. There is, however (since 1 July 2002), a new rule 17 in SOLAS chapter II, “Alternative design and arrangements”, that in principle allows any construction material, *provided* it can be shown to maintain the same safety level the ship would have if constructed in accordance with the proscriptive demands for non-

combustibility. This new rule implies that the proscriptive demands can be replaced by *function-based* demands.

HSC-rated ships have already been built in aluminium, e.g. STENA's HSS ferries (Figure 2). Composites have not been used in the same way, however, primarily due to fire-rating problems. The HSC code provides an opening for the use of combustible materials by permitting the use of "fire-restricting materials", i.e. materials that do not themselves spread fires. The test procedure for proving that a material meets this demand is difficult, but nevertheless constitutes an opening compared to the demand for absolute non-combustibility.



**Figure 2 Aluminium catamaran**

For SOLAS- and HSC-rated ship concepts, it is thus the fire-safety aspect that is crucial in terms of the use of lightweight materials.

There are, however, other technical problems associated with lightweight marine constructions than those related to fire safety, even if the fire-safety problem can be said to be the main obstacle to the use of lightweight materials. Other key problems are:

- Fixture installation. Different materials with different mechanical properties must function together.
- Noise abatement. Both aluminium and composite are poor at noise reduction.
- Robustness. It may be difficult to achieve sufficient robustness, particularly in smaller ships, even if design rules are followed.
- Cost. The initial cost of lightweight materials is higher than for conventional steel, and methods for LCC (Life Cycle Cost) analysis must be used to prove cost advantages.

- Producibility. This is closely related to cost.
- Maintenance/aging/recycling. All of these points must be considered in terms of cost and the environmental perspective by means of LCC and LCA (Life Cycle Analysis).

Apart from the purely technical obstacles, there are also obstacles of tradition to be overcome on various levels: shipping companies, designers, shipyards and other users. The best way to overcome them is probably to demonstrate functioning technology for making lightweight marine constructions, which is the primary goal of LASS.

## 2 Ship concept

Four different ships are being studied in the project. Drawings and other technical documentation pertaining to the ships have been transferred from the shipowners (LASS consortium members) to TEKKOM, the LASS technical committee.

**Table 1 LASS ship concept**

<b>WP</b>	<b>Ship</b>	<b>Owner</b>	<b>Description</b>	<b>Rule code</b>
<b>WP3a</b>	Amphibious transport boat 2000	FMV	A 24-m aluminium amphibious transport boat to be converted into a passenger ship in composite	HSC code
<b>WP3b</b>	HSS ferry (STENA Carisma)	STENA	A high-speed, 88-m aluminium ferry where some of the superstructure will be replaced with a composite material	HSC code
<b>WP3c</b>	Ro-ro (M/S Undine)	Wallenius	A 199-m car transport ferry where two steel decks in the upper part of the ship will be replaced with aluminium decks	SOLAS
<b>WP3d</b>	Ro-pax (STENA Hollandica)	STENA	A 188-m combination car-and passenger ship where the steel superstructure will be replaced with composite	SOLAS

The figures below show the four ship models covered by LASS.



Figure 3 Ship models for WP3a and WP3b (above) and for WP3c and WP3d (below)

### 3 Activities during 2005

LASS was actually launched during the last quarter of 2004, but the “official” start-up was effective as from the kick-off meeting at SP on 10-11 January 2005, at which nearly all consortium members participated. That meeting included an organised “brainstorming” activity for the purpose of defining new and old problems that could conceivably arise for the different ship models. The kick-off was also the occasion of the first PROKOM<sup>i</sup> meeting, where Jesper Lögdstrom (Wallenius) was appointed PROKOM chairman, and Tommy Hertzberg (SP) was appointed vice-chairman. A second PROKOM meeting was held at SSPA in Stockholm on 21 June, also attended by many delegates.

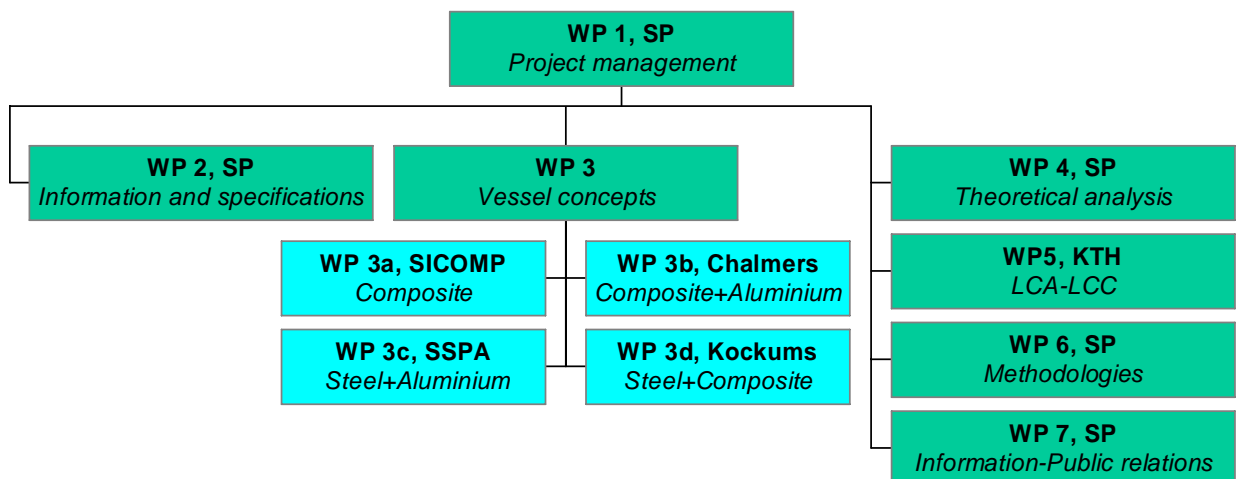
The first PROKOM meeting, held in connection with the kick-off at SP, was of a more formal nature, while the June meeting at SSPA was used to inform delegates and gather input about the project.

<sup>i</sup> Project Committee, see Figure 6

A homepage ([www.lass.nu](http://www.lass.nu)) was created early in the project with a special members' page for exchanging information. During the year, the homepage has proved very useful for disseminating general information about LASS and sharing information within the consortium membership.

During the spring, a document describing “state-of-the-art” was produced jointly with TEKKOM<sup>ii</sup>. The document is to be regarded as an open document, i.e. modifications and updates are made continuously.

The driving force in LASS during the year has been the “work packages” (WP) aimed at the ship models, WP3a-d, while the other WPs have mainly served as support for them (see Figure 4).



**Figure 4** LASS working structure. The names to the right of the numbers indicate the WP leaders.

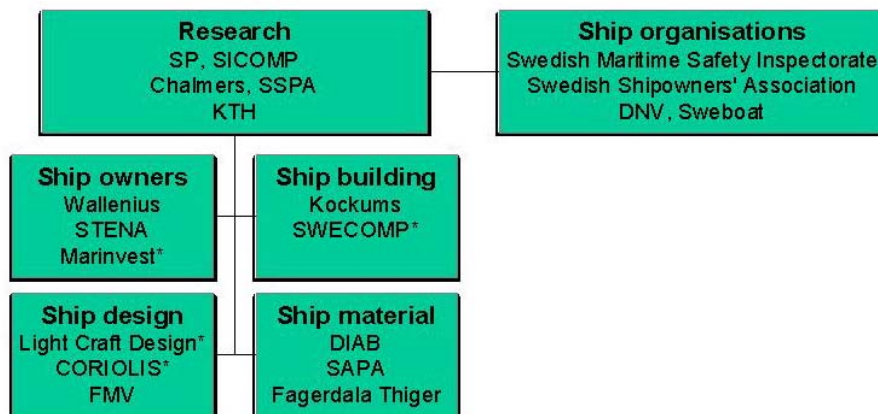
The principal goal of LASS can be said to be contained in WP6, “Methodologies”, but the way to get there is via the concrete case studies in WP3. During the year, interest groups have been formed around WP3a-d, with different participants from the consortium, depending on the area of interest.

The ship model concepts are different from each other, with different types of problems. The methods for dealing with them also vary, partly due to the functions of the composition and competence of the groups involved in the meetings and discussions.

<sup>ii</sup> Technical Committee, see Figure 6

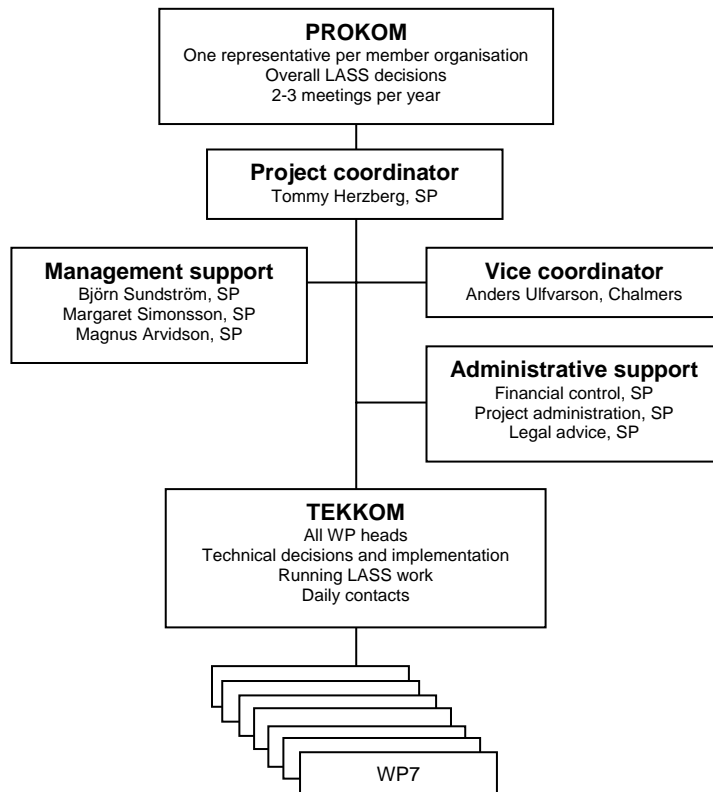
There are, however, a number of points in common, e.g. fire safety, noise and fixture installation problems, where efforts have been aimed at coordinating resources to the greatest possible extent. The coordinating groups working with noise abatement and robustness are examples of this. In many cases, WP3 leaders also participate actively in the each other's WP3-group meetings and discussions, which enhance the exchange of information between the groups and facilitate efficient ways of solving mutual problems and issues within the groups.

The first steps for the WP3 groups have been to penetrate the drawing documentation and other accompanying information, then to decide what materials and design philosophy to pursue, in order to be able to design ships using the new materials. The choices have not been obvious, as there are a number of different materials and combinations available, particularly among the composites, but also for aluminium – to match the material



**Figure 5 The LASS consortium**

strength requirements for the ship design in question with possible alloys or aluminium plate thickness. WP3a and WP3b have based decisions on the DNV design rules for HSC-type ships, while WP3c and WP3d base their drawings on the design rules for SOLAS-rated ships from Lloyd's and DNV respectively. The progress of the groups' work varies due to differing degrees of difficulty, but for example the progress of WP3d (ro-pax ships with composite superstructures on steel bulkheads) on strength calculations and detailed drawings has reached the point where all that remains for a first concrete LASS proposal is basically how to deal with the fire safety problem. As previously mentioned, however, this is a rather complex problem.

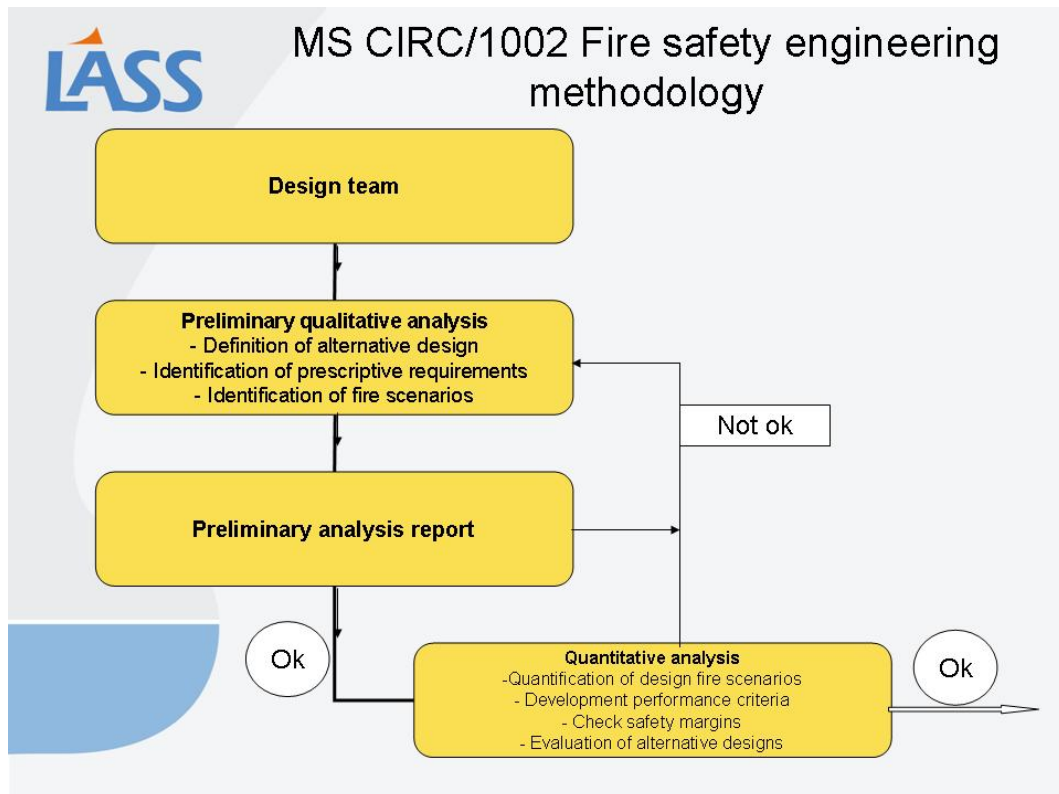


**Figure 6** The LASS organisation

## **3.1 Fire safety and the LASS philosophy**

### **3.1.1 Regulations**

The new SOLAS rule 17 permits, as mentioned above, a function-based fire-safety design. IMO (International Maritime Organisation) has also published a document (MSC/Circ 1002) that in detail specifies how a fire-safety analysis should be made. The method is illustrated schematically in Figure 7.



**Figure 7 Method for function-based fire safety as per MSC/Circ. 1002**

One complication is that SOLAS requires an assessment of the equivalent safety level using the normal prescriptive safety design (i.e. for ships designed with conventional materials), but that safety level is only specified in the prescriptive requirements<sup>iii</sup> themselves. Making an equivalence assessment thus also requires making a quantification of the safety level of a standard design.

### 3.1.2 The LASS safety philosophy

In principle, the new SOLAS regulation permits any design, but the burden of proof is naturally heavier the greater the deviation from standard practice and the existing prescriptive requirements. The LASS philosophy is thus to fulfil all functional demands to the greatest possible extent, e.g. if an A-60 bulkhead is required, the lightweight bulkhead must have the same function as a conventional A-60 bulkhead. Since the designation “A” in SOLAS stipulates a non-combustible material, the composite construction must instead be based on the HSC-code definition of “fire-resisting

- <sup>iii</sup> One example of a prescriptive demand is that bulkheads in an engine room must be of “A-60 grade”. “Class A” material must be able to prevent flames and gases from penetrating for 1 hour. For “class B” material the time is only 30 minutes. Class A material must also be non-combustible. “A-x” (x=0,15,30,60) indicates that the mean

division”, which can be based on a combustible material, provided it meets the demands for a “fire-restricting material”. Then it is up to the group to prove that the deviation from conventional steel does not jeopardise safety onboard.

To achieve the fire-restricting properties of a material so that it will gain the approval of maritime authorities and classification societies, the insulation must be certified for a specific product, e.g. that it together with a certain deck material constitutes an A-60 deck. There are a number of such certificates for steel, as well as some products for aluminium. For composites, however, there are hardly any certified fire-restricting products.

Fire restriction is in many ways decisive for the success of a lightweight construction, as each extra kilo per unit of area constitutes a financial burden in the LCC analysis that determines the economy of the ship design.

## **3.2 Ongoing collaboration**

Considerable knowledge has been pooled within LASS, but specific issues may require external expertise. To the extent such expertise is required, LASS seeks to add groups that can become part of the LASS technology platform. Collaboration can also be desirable with groups working with tasks relating to or included in LASS.

### **3.2.1 Insulation industry**

Collaboration has been launched with industries manufacturing insulation materials for marine applications. Discussions are currently ongoing with three different companies: ISOVER, Rock-Wool and Thermal Ceramics. It is hoped that these will help to develop certified and weight-optimised products for the ship models included in LASS. The three companies have been offered associate membership in LASS and it is hoped that this collaboration will lead to a final report from WP6 (see Figure 4) containing recommended fire-safety solutions based on products from several manufacturers. Such collaboration can also facilitate finding a solution to noise abatement, another technical problem for lightweight materials.

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temperature increase on the obverse side shall be under 140°C, and that the maximum is lower than 180°C for at least “x” minutes.

### 3.2.2 Classification societies

The project consortium includes the DNV classification society, and one work group (WP3c) also has close contact with Lloyd's of London.

DNV is responsible for one sub-project within the EU project SAFEDOR ([www.safedor.org](http://www.safedor.org)), where DNV's work basically involves the same project as WP3d, i.e. designing a ro-pax ship with a composite superstructure on a steel hull. LASS WP3d has therefore initiated collaboration with DNV on this project.

Discussions with DNV within the LASS framework also led to an application to the VINNOVA maritime safety programme, for the purpose of providing documentation for creating *design fires* for ships, a crucial part of fire-safety analysis (Figure 7). The application has been approved and the results of the project will support both LASS and SAFEDOR.

### 3.2.3 Other lightweight projects

Discussions are underway with the management of the project "Lightweight, self-supportive body modules" ([www.sicomp.se/projects.htm](http://www.sicomp.se/projects.htm)) regarding possible ways of collaborating on the projects. Points in common are to be found primarily in the area of fire safety, but also in other areas such as noise abatement, robustness and fixture installation techniques, where there might be opportunities for collaboration.

### 3.2.4 Thesis work

Two theses are in progress covering a market study and analysis of the use of lightweight materials at sea. The purpose is to identify the market structure and principal players, as well as the obstacles that are not of a purely technical nature (conservatism, attitudes, levels of knowledge... ). The two theses are the projects of two engineering students focusing on industrial economics at the Linköping Institute of Technology.

Another two theses are planned for 2006 at the Marine & Aeronautical Faculty of the Royal Institute of Technology in Stockholm. The work will be seen as a first step towards finding good design criteria for creating robust constructions, primarily for smaller vessels.

## 4 Publications

Two LASS articles have been published in the Swedish SP-based journals *Provning & Forskning* and *Brandposten* (see [www.lass.nu](http://www.lass.nu), “public relations”). A review of the LASS project will also be published in the Australian journal *Work Boat World*. WP3c has written a scientific article called “Sandwich Construction – Application on a Superstructure”, including a model for weight optimization of composite constructions. The article was presented in November at the International Conference on Innovative Materials and Technologies for Surface Transport (INMAT 2005) in Gdansk, Poland ([www.cto.gda.pl/INMAT](http://www.cto.gda.pl/INMAT)).

## 5 Continued work

Work on the LASS project is well on schedule. The important thing for LASS right now is that all WP3 groups complete their first designs based on lightweight materials, including the development of feasible proposals for solutions regarding fixture installation, noise abatement etc. This will mark the start of more thorough studies of the proposals, as well as possible physical testing, LCA, LCC and fire analyses.

## 6 Appendix A : WP-details

### 6.1 WP3a: Composite ship

SICOMP ([www.sicomp.se](http://www.sicomp.se)) is responsible for WP3a and FMV have supplied a suitable concept ship. It is the 23.5 m long water jet driven “Truptransportbåt 2000” which is built according to military rules with an Aluminium hull. Two ships were built in 1998 and thoroughly tested by FMV. Test data includes performance with different load carrying, which enables the impact of lowered ship weight to be quantified in detail for this ship. The Task in WP3A is hence to design a corresponding high-speed passenger ship with a composite material hull, certified according to DNV HSC-code.



### Activities:

- FMV have delivered complete specifications, drawings, dimensioning calculations and type test results etc., for Trupptransportbåt 2000 to LÄSS as part of the FMV contribution to the project.
- A preliminary specification for WP3A, based on the Trupptransportbåt 2000 specification, was created and submitted to the LÄSS homepage<sup>iv</sup>.
- A preliminary technical plan for WP3A was created in March. The current plan is WP3A-Plan-3.doc on the LÄSS homepage.
- A prestudy report (SICOMP CR 05-035) on composite hull construction was submitted to the LÄSS homepage.
- Specific technical problems in composites ship design to study includes fire resistance, acoustics and damage tolerance. SICOMP have proposed a scheme for comparison measurements of these properties on DNV-dimensioned panels.
- Kurt Olofsson (SICOMP) participated in the conference "Composites in Fire" 14-16/9 in Newcastle. Information was collected regarding "State-of-the-art" for fire resistant composite constructions regarding material-, construction- and simulation technology. SICOMP have collaboration with Professor Gibson in Newcastle on composite technology. The visit led to SICOMP obtaining the source code of their latest specific

<sup>iv</sup> Consortium web-page for members only

software's (COM FIRE, CSP FIRE) for fire simulations on laminate- and sandwich plates along with 20 input files, manuals, data on phenolics, balsa core, etc.

## 6.2 WP3B – Aluminium & Composite

The concept ship, Stena Carisma is being designed for a Sandwich superstructure.

A small process of working with this has been formulated and looks as shown below.

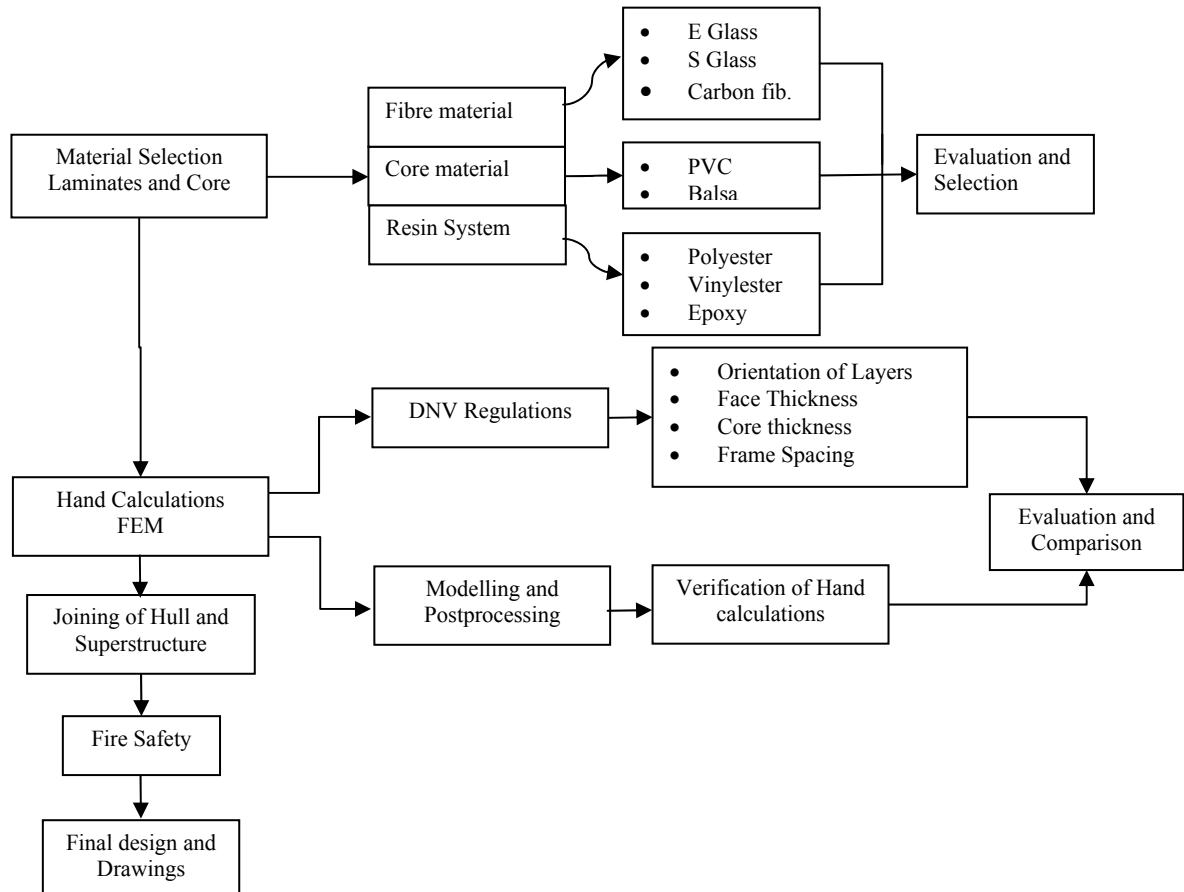


Figure 1 – Systematic approach for the development of the sandwich superstructure concept

The work started with evaluation of different materials that are suitable for this project. No conclusions were reached about the most suitable materials, however information has been collected and after a few more design cycles it will be more evident. The main materials under consideration are the E Glass and Carbon fibre as reinforcements, and a vinylester, phenolics or an epoxy resin depending on the kind of fibre selected. A PVC foam manufacture by DIAB would be adequate for this application.

Calculations for different structural components is also underway, some estimates on scantlings etc have been arrived at. Initial weight estimates indicate that structurally there

could be a potential weight saving. But as is commonly known, composites are easy to burn and do not classify as ‘fire restricting materials’. Being a passenger craft, fire safety is very important to achieve. In order to achieve safety it may be necessary to use fire insulation. However if fire insulation is necessary then the advantage of using lighter materials for construction would be lost, as the combined weight of the structure and the fire insulation would exceed the weight of the present aluminium structure. A solution is currently being worked on and will be discussed further below.

There are no significant deviations from the initial plan of the project. The planning is now better than in the beginning of the project and other things like future work and how to proceed for the remaining part of the project are clearer as well. For part results, calculations have been done for a panel of the sandwich superstructure and the results are as follows –

Face Thickness of the Sandwich Laminate	2mm
Core Thickness of the Sandwich Laminate	20mm

The calculations are based on a certain set of boundary condition and can change if more stringent boundaries are assumed along the edges. So far, there has been an attempt to make the lay up of the fibre in the laminates isotropic; however some more configurations will be tried. The calculation part of the WP3B is now being closely run using a Finnish software, ESAComp, made by Compoengineering Inc. which has provided Chalmers Tekniska Hogskola with a University License of working with the software.

### **6.2.1 Fire safety**

In order to ensure a fire safe construction, innovative materials are being considered. The major fire hazard in composites comes from the fact that the resin used for construction burns. If fire insulation is installed then the insulation together with the composite material would end up weighing more than the present aluminium superstructure. In order to avoid this, innovative materials are being considered. Phenolic resins are potentially advantageous when it comes to fire safety as they inherently have the property of not burning. However they are known to be structurally unreliable and pose issues when it comes to manufacturing processes. Thus within the confines of this project we would need to make some mechanical and fire tests to ensure that the material is indeed safe. According to the High Speed Craft code 2000, most of the areas of the public deck which is covered by the superstructure should be made of fire restricting material. By means of tests etc, we have to confirm that a sandwich made of phenolics resin forms a

fire restricting material and would be safe for the passengers travelling on board the Stena Carisma. If it is not possible to ensure a phenolic resin sandwich as a fire restricting material, then fire insulation would have to be used to make the superstructure safe. In this case work would be done to find the lightest possible fire insulation material.

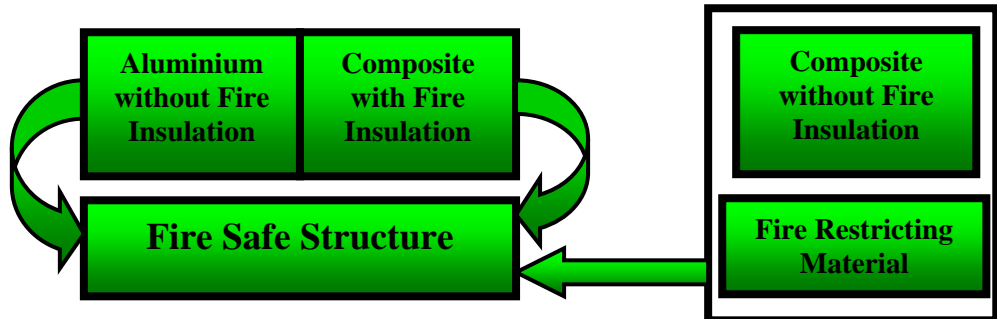


Figure 2 – Composite Structure - With or without fire insulation

### 6.2.2 Comment

In order to highlight the gains of using light weight materials, it becomes mandatory to conduct a life cycle analyses and look at the gains over a life time of a ship. The initial cost of obtaining a composite structure is high; however the cost of maintenance, cost of fuel etc goes down over the years. Also there is an increase in revenues for more weight can be carried in terms of cargo. Thus a life cycle analyses would be performed at KTH, for the same. The selection of materials would be more strengthened when this is done as different materials that satisfy the requirements will also be studied.

## 6.3 WP3c: Steel and aluminium

SSPA Sweden AB is part of the subproject WP3C within LÄSS where the consequences and benefits of replacing steel with aluminium are investigated. Wallenius Marine's PCTC ship *M/S Undine*, constructed for transport of cars and trucks, will act as concept ship for WP3C.

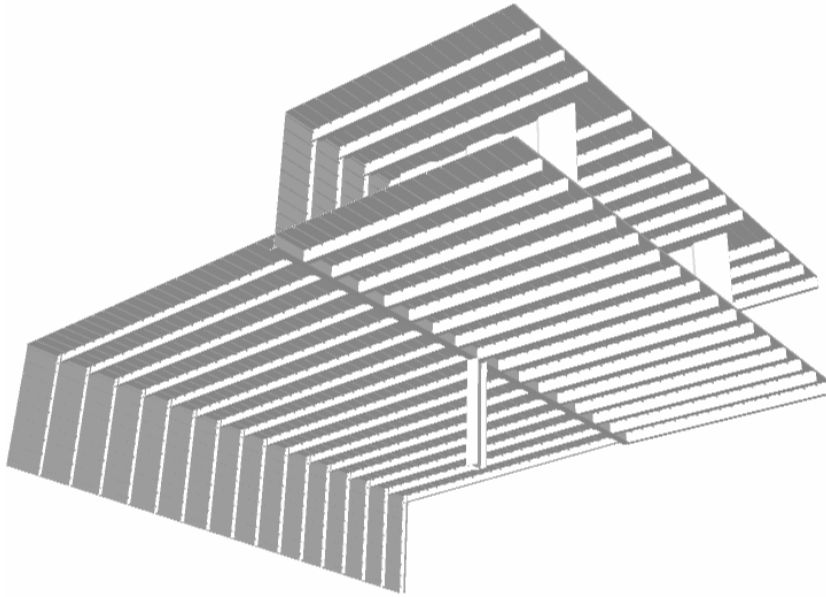


To examine the benefits associated with a lighter construction a section of the existing superstructure in steel was compared with a corresponding section manufactured in aluminium. SSPA's role within WP3C is to investigate the possibilities for such a structure, to identify benefits and disadvantages and also to summarise what gains could be made in way of e.g. increased load capacity.

WP3C has been divided into different phases where the first phase is focused on building the concept section as light as possible but still according to the traditional Lloyd's rules. In phase two the aim will be to make use of direct calculations to verify that a weight optimized structure can still obtain approval by classing societies.

Since the original structure is classed by Lloyd's the aluminium versions will also be designed to fulfil Lloyd's rules and regulations. To fully investigate the different ways of designing the structure as light as possible but still according to Lloyd's rules and regulations a majority of the structural issues have been discussed with Lloyd's.

In phase one the superstructure is proposed to be manufactured in a traditional manner, using extruded aluminium profiles that are friction welded into panels and then mounted onto a framework of transverse beams. For a schematic view see figure below. There is a potential for economical gain when using extrusions since the cross section of the extrusions can be modified to incorporate features that enable new functions. Savings can be made for instance in form of reduced mounting time of piping and electrical cableways.



*Schematic illustration of the proposed structure.*

In phase two a large amount of work will be put into deriving new designs and verifying these by direct calculations. The aim is to produce and test new methods to build a light superstructure that still fulfil the rules and regulations set by the classing societies.

The concept ship *M/S Undine* is a SOLAS vessel and therefore also the new version of the superstructure has to comply with SOLAS fire protection requirements. As for the original ship the method II C will be used. Different passive fire fighting systems are considered and the areas housing the cars will be protected by a CO<sub>2</sub> system to comply with the SOLAS regulations.

## **6.4 LÄSS WP3d Steel and composite**

The concept ship for WP3d is STENA Hollandica. A structural design for the superstructure based on DIAB core materials and glassfibre-polyester laminates has been made, according to the DNV classification rules. The result indicates that a 50 % weight reduction might be possible for this part of the vessel. A global FEM simulation is also being done.

Technical solutions for the joint between composite and steel have been developed and the result will soon be published. Fire safety requirements are known and the necessary fire insulation will be searched for.

Investigations on alternative structure materials are being made.

## **6.5 WP5 LCA/LCC**

Within this part of the project focus is set mainly on environmental effects and economy in a life cycle perspective, from cradle to grave. These issues will be investigated and compared for the origin ship and the new light weight alternative with life cycle assessment, LCA and life cycle cost analysis, LCC. By decreasing the weight of the structure both costs and impact on environment will be lowered especially during the use of the structure since large amounts of fuel can be saved. Both the LCA and LCC analysis starts with inventory of necessary information. This part of the work has started by preparation of Excel-sheets to collect important information from shipbuilders, shipowners and others.

Another important part also connected to environment and economy is to prepare the structure for final destruction at the end of the life cycle. Therefore a part of the now ongoing work within WP5 investigates design for recycling. For recycling of polymer composite materials a model for assessing methods for recycling and recovery has been developed<sup>v</sup>. This model is based on information connected to the waste as waste properties and the processes involved in the waste treatment described by the process properties. A number of specific waste properties has been identified regarding polymer composite materials. Included among these are the waste properties hazardous content, HAZ, and metallic inserts, MET. These two are specifically important to have control of so that they can be dismantled before shredding. In order to make the recycling effective these two waste properties should be known. One effective method is to mark directly on the product where MET and HAZ are situated. This marking should give adequate information to those responsible for the end of life treatment on.

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<sup>v</sup> Hedlund-Åström, A., "Model for End of Life Treatment of Polymer Composite Materials", TRITA-MMK 2005:23, ISSN 1400-1179, Doctoral Thesis in Machine Design, Stockholm, Sweden 2005