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LASS Annual Report, November 2006

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Borås, Sweden, November 2006

Abstract

The project LASS, **Lightweight construction applications at sea**, aims at improving the efficacy of marine transport and increasing the competitiveness of the Swedish shipbuilding 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. In addition, international insulation companies as well as several Swedish offshore industries have recently joined LASS as “associate members”.

The three-year project started in January 2005. LASS is sponsored by VINNOVA (www.vinnova.se), participating industries and partners. This report contains a brief description of the accomplishments so far (30 September 2006) with particular emphasis on development during the period October 2005 to September 2006.

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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 and offshore industries. By developing demonstration models or concepts, we will seek to identify opportunities for cost-efficient, environmentally sound production using the lightweight materials aluminium or composites.

The consortium behind the project consists of representatives from the Swedish shipping and offshore industries, 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 since then, with emphasis of project development since the latest Annual Report, i.e. from October 2005 to the end of September 2006.

1 Background

The original LASS concept – lightweight construction applications at sea – was to develop technical solutions for four different types of vessels using lightweight materials (aluminium and sandwich composite) to various extents. During 2006, however, the project was expanded to include a fifth vessel design as well as a housing module intended for living quarters on an offshore oil platform. The reasons for this expansion are interest from the industry and the opportunities for cross-pollination when working with the two new concepts.

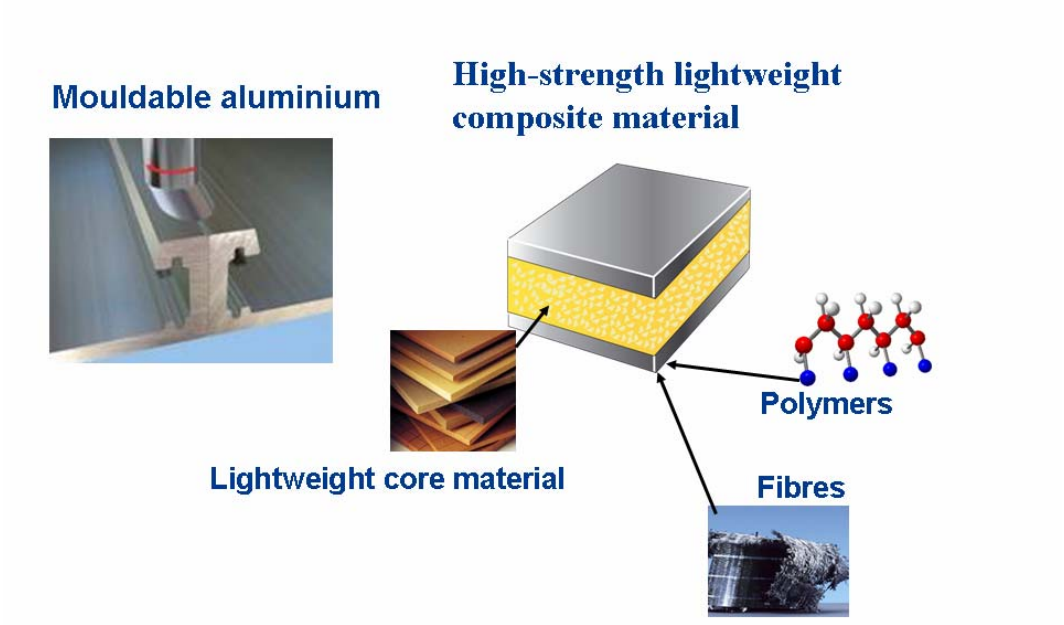


Figure 1 Lightweight materials used in LASS

1.1 Safety demands and lightweight

Some 10% of all fatalities at sea are caused by fires. Fires also account for the third highest insurance cost, after collisions and running aground. Any proposals for constructing ships with materials offering a lower level of fire safety than conventional steel must therefore clearly demonstrate that the new design will not entail increased risks.

Chapter II of the SOLAS functional requirements speaks of "restricted use of combustible 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*". 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 prescriptive demands for non-combustibility. This new rule implies that the prescriptive demands can be replaced by *function-based* demands.

HSC-rated ships have already been built in aluminium. 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 requirements for such material are severe, but nevertheless constitute an opening compared to the request for non-combustibility.

Offshore constructions have fire requirements similar to those for ships. There are, however, some tougher demands for oil-drilling platforms due to the special environment, e.g. in terms of the risks of fires and explosions. Regulations are complicated as several different systems are used. The most important one is “The MODU code” (MOdular Drilling Unit) and, for Scandinavia in particular, NORSOK, which is a series of regulations given by the Norwegian Petroleum Directorate. In addition, different oil companies have their own regulations; Statoil requirements are not necessarily equal to Shell requirements. Moreover, there are different rules depending on whether the platform is floating or standing on the sea bed; in the latter case it is regarded as just another industry, subject to the laws of the land where it is located.

For LASS, however, the basis for work is the MODU code, which speaks in general terms about steel constructions, but permits (MODU 9.1.2) all materials provided that “the administration” (i.e. the classification society /maritime authority/IMO) is convinced that the level of fire safety achieved is equivalent to steel. The rule is thus comparable to the above-mentioned new SOLAS regulation 17.

Figure 2 Offshore platform with module for living quarters

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 composite 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 The concepts

During the year, the work with the four original concepts has moved forward – exceeding expectations – and all groups are ahead of schedule. The work has also been successful insofar as it seems that the targets (30% lighter and 25% lower cost) will be met by broad margins. During the course of the project, however, new targets have been defined, stating that the construction must have a maximum payback time of eight years, preferably five, in a cost comparison with a conventional construction.

The LCC analysis (WP5) has not yet resulted in a thorough analysis, but a rough estimate has been made for two of the constructions (Wp3c, Wp3d) showing that the payback time for these two ships, based on the current proposed designs, would be five years or less.

Table 1 LASS ship concepts

WP	Ship	Owner	Description	Rule code
WP3a	Amphibious transport boat 2000	FMV	A 24-meter aluminium amphibious transport boat to be converted into a passenger ship in composite.	HSC code
WP3b	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
WP3c	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
WP3d	Ro-pax STENA Hollandica)	STENA	A 188-m combination car-and-passenger ship where the steel superstructure will be replaced with composite	SOLAS

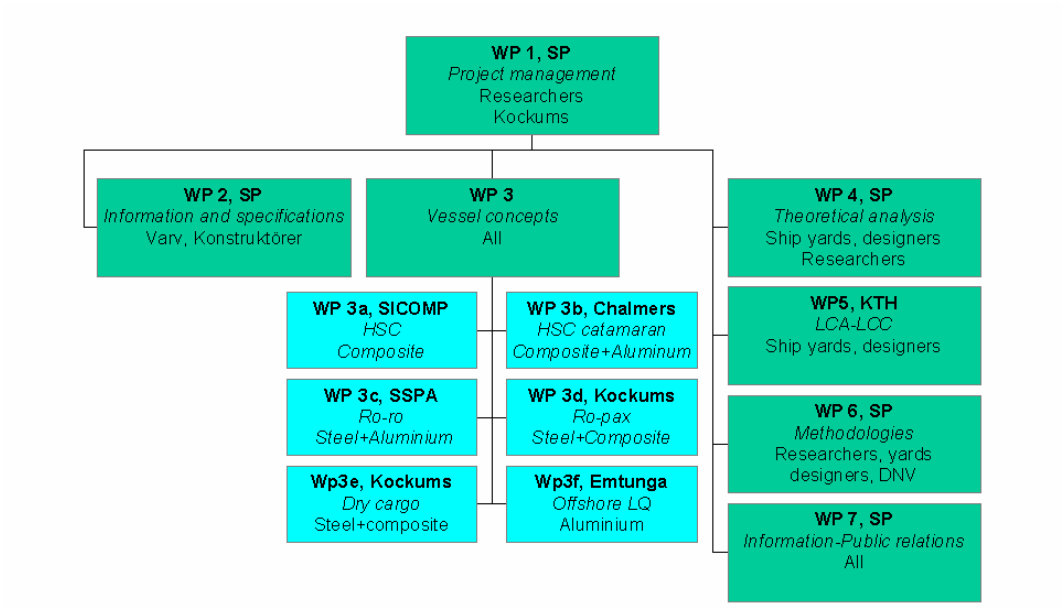
The figures below show the four ship models covered by LASS.

Figure 3 Ship used for WP3a and WP3b (top two) and for WP3c and WP3d (lower two).

2.1 Expansion of LASS

During the spring of 2006 an expansion was made of the LASS concepts. The reason was an identified interest on the part of various Swedish industries. The expansion comprises a freighter and an offshore LQ (Living Quarter). The expansion was approved at the PROKOM meeting in June and the updated working structure is shown in figure 4 below.

One objective is to be able to study maritime constructions where the lightweight concept offers particularly favourable economical and environmental benefits. As regards the LQ, there are good opportunities for synergies between ships and offshore constructions, as well as good opportunities for LASS members to participate in the concrete development of aluminium offshore constructions. Within the LASS consortium there are companies with good expertise in aluminium and aluminium constructions for ships, which could favourably be transferred to an offshore construction.



Figur 4 The ”new” LASS working structure.

In addition to the original four concept vessels shown in Table 1 and Figure 3, there are thus two new concepts, described and shown in Table 2 and Figure 5 below.

Table 2 The two new concepts within LASS

WP	Ship	Owner	Description	Rule code
WP3e	Freighter, Dry load (M/V	Thun	An 89-m and 4800 dwt freighter designed for canal transport. Today’s	SOLAS

	Eken)		steel superstructure, hatches and moveable decks will be replaced by sandwich composite.	
WP3f	Offshore Living quarters (LQ)	Emtunga	A 400-ton steel LQ module will be redesigned based on mouldable aluminium.	MODU-code, NORSOK

Figure 5 The new LASS concepts: WP3e, freighter (left); and WP3f, LQ (right)

3 The consortium

The total number of members increased during the last year as a number of new "associate" LASS members were accepted by PROKOM:

Table 3 New associate LASS members

Company	Expertise	Swedish?	SME?
Isover/Saint Gobain	Insulation	No	No
Thermal Ceramics	Insulation	No	No
Rockwool	Insulation	No	No
Premec	Wet-room modules	Yes	Yes
Scanmarine	Cabin modules	Yes	Yes
Isolamin	Construction elements	Yes	Yes
Emtunga	Module designs	Yes	No
Thun	Shipper	Yes	No
Sonoform	Composites	Yes	Yes

Four international corporations working with insulation materials were invited to join LASS. Three of them accepted and are participating in various ways. The reason for the invitation was to attempt to find lightweight alternatives for fire insulation. The benefits of lightweight construction materials might otherwise easily be lost, e.g. due to excessively heavy fire insulation.

The new Swedish companies listed in Table 3 contribute considerable competence and contacts, particularly regarding offshore constructions. An additional shipowner (Thun) has also joined LASS. Of the six new Swedish companies, four belong to the small or medium-size group (SME, see Figure 6).

At regular intervals, enquiries are received from various companies or projects, both Swedish and international, regarding possible collaboration with LASS, which of course is very positive. They have often read about us via one of our articles, or found us via our homepage www.lass.nu. In terms of expertise, LASS is now considered fairly complete, but depending on what the new group can deliver there is always the possibility of accepting additional associate members or inviting a new group to join some of our working meetings.

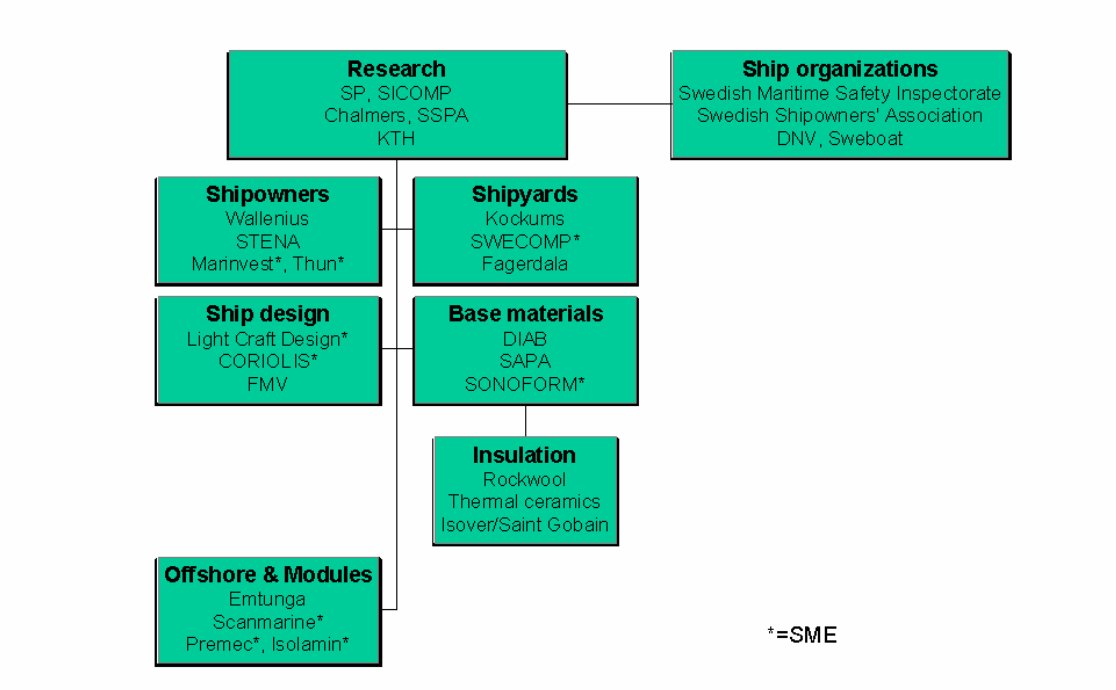


Figure 6 The LASS consortium

4 Activities

The year was marked by a high degree of activityand all WPs have developed favourably. WP3a-d will be completing the engineering solutions for their respective design tasks during the autumn of 2006.

Two PROKOM meetings were held with good attendance during the year. In December 2005 the group met at STENA's headquarters in Göteborg, and in June 2006 the meeting was held at DIAB in Laholm. Numerous TEKKOM meeting were also held. During the autumn of 2005 there was also a public information day at SP on the theme of fire

dynamics and fire-testing methods. A couple of workshops were also held, as described further below.

4.1 Working strategy

The working method used by LASS is that the respective WP leaders are responsible for gaining the support of the industries needed in the work or those who might be interested in participating in WP-related group work. The project coordinator participates in most of these meetings to assure coordination and efficient exchange of information among the groups. All WP leaders are also invited to the working meetings of other groups and have the opportunity to participate if so desired.

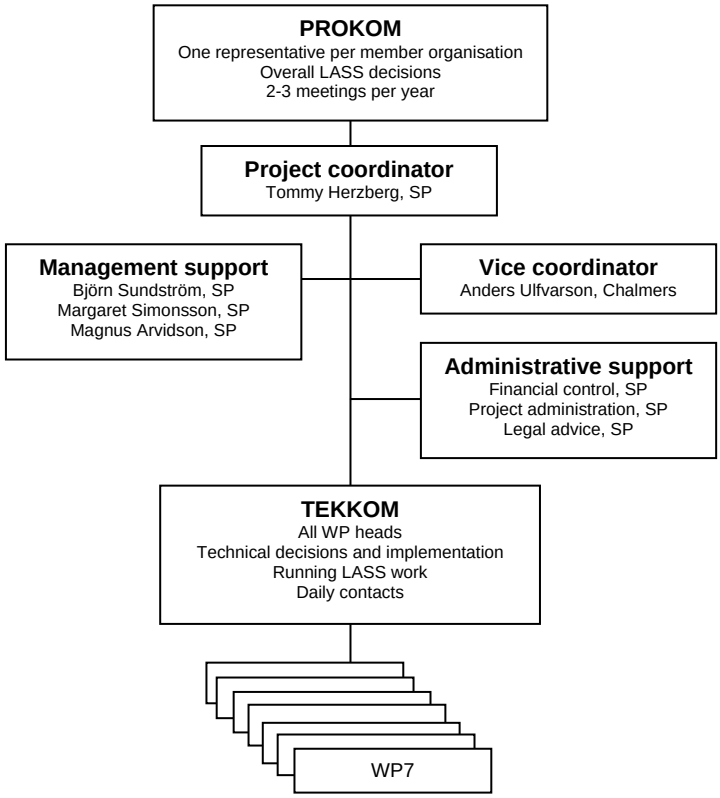


Figure 7 The LASS organization

The R&D group (TEKKOM,) convened on several occasions and also held regular telephone conferences. PROKOM, as mentioned above, held two meetings during the year. Individual WP heads have also met when required.

We are particularly pleased to note the obvious enthusiasm throughout the project, and the researchers as well as the representatives of industry often comment on the tasks as being “meaningful”. It is felt that this is due in part to the hands-on nature and focus of the product development work, and that the task of developing lightweight constructions for ships and offshore is seen as urgent. Moreover, the impressive pool of competence and know-how the project has managed to bring together simplifies the handling of many problems. Being able to pick up the phone and call a designer, shipowner, ship-builder, as well as experts in insulation, materials, regulations and fire safety within the group when a problem arises clearly facilitates the work. The group is also characterized by a high

degree of social competence, making the task of coordinating LASS an enjoyable one for many reasons.

4.2 Certified fire-safety solutions

During the autumn of 2005, discussions were started with the insulation companies Rockwool, Isover/Saint Gobain and Thermal Ceramics. These discussions eventually led to associate membership for all three companies and that two large-scale successful fire tests were conducted by SP.

These tests are of great significance, as they resulted in approved and certified FRD 60 (Fire Resistant Division 60 minutes) constructions for bulkheads and decks in sandwich composite. This enables a design showing that functional fire resistance (which is a maximum of 60 minutes for a ship) can be achieved using composite. The tests were run with a new type of lightweight insulation material from Thermal Ceramics, providing a surface weight of only 6.9 kg/m^2. Isover/Saint-Gobain will also make similar tests with their new lightweight insulation material. Further, tests are scheduled for October 2006 to obtain certified penetration constructions, e.g. for wiring, piping and ventilation. These tests will be made in collaboration with the Swedish company MCT Brattberg and the EU project SAFEDOR. LASS are working together with DNV that are running a sub-project within SAFEDOR that is virtually similar to the LASS WP3d, a composite superstructures on a Ro-pax ship. During the year a couple of workshops have been held together with DNV for the purpose of analysing the risks and finding the best possible fire-safety solutions for the vessel.

Fire-certified construction solutions obviously enhance the chances that the project will convince the authorities that fire-safety demands can be met with the new materials. For aluminium there are already quite a few certificates, and both Thermal Ceramics and Isover/Saint-Gobain have recently completed tests with their new lightweight insulation material and obtained certificates. There are, however, special demands on certain offshore constructions for which there are not yet any fire-safety-certified aluminium construction solutions. Discussions are therefore being held with the insulation companies in LASS about conducting large-scale fire tests for such constructions.

4.3 Concept work

The WP3 work, i.e. work on the lightweight material concepts, is proceeding very well and all groups are running ahead of schedule.

4.3.1 WP3a

(Passenger vessels in composite.) During the year, the work in WP3a was conducted in close collaboration with others, particularly SICOMP, FMV, Swedeship, Kockums and DIAB.

Four hull alternatives were analysed within WP3a:
Version 0 – Aluminium.
Version 1 - Sandwich with glass-fibre composite.
Version 2 - Sandwich with carbon-fibre composite.
Version 3 – Ship-optimized Version 2.

Only certified or close-to-certification materials are used. Dimensioning is done in accordance with the DNV code. Versions 0 and 1 are defined and ready, and show that vessel displacement is significantly reduced with a composite hull, compared to a lightweight-optimized aluminium hull. Version 0 has a hull displacement, including insulation, of 15.0 tonnes. The corresponding displacement for Version 1 is 10.8 tonnes.

This means a 28% reduction. Versions 2 and 3 are expected to give additional major reductions in displacement, which is thought to have a great impact on the LCC analysis.

4.3.2 WP3b

(HSC catamaran) The work with STENA's high-speed aluminium ferry has continued to go well. The Chalmers PhD student who has been working on the project, has been stationed at SSPA (the Swedish Maritime Research and Consulting Institute) in Stockholm, which made it possible to collaborate closely with WP3c. Two scientific articles were published as part of the project and a Licentiate thesis will be presented in 2007. Wp3b will be completed on schedule during the autumn of 2006.

4.3.3 WP3c

(Ro-ro vessel.) An engineering design based on aluminium plate has been completed and the work has now entered the modelling and calculation phase to achieve an optimized solution based on aluminium profiles. Intensive work together with SAPA (producer of extruded aluminium) this autumn will result in an optimized version of the concept vessel (Wallenius' ro-ro ship, the *M/S Undine*). The optimization parameters are structural strength, vibrations, weight, fire insulation and cost.

4.3.4 Wp3d

(Ro-pax ship.) This project has seen the completion of structural and scantling analysis as well as of weight calculations. The latter shows a weight reduction of 50-60%. Technical solutions for joining the hull and deckhouse have also been analysed. Extensive studies and testing of various fire insulation arrangements have been completed. Cost calculations are underway. Sub-project WP3d is expected to be completed soon.

4.3.5 WP3e

This freighter, one of the new concepts, has a total hull weight of 1100 tonnes. The hatches alone weigh 100 tonnes. The ship is optimized for canal transport, and the carrying load it is often restricted by the canal geometry. Therefore, each ton of reduced weight might directly be translated into an extra ton of load. It is therefore easy to pay off the extra investment cost of a lightweight material quickly. For the freighter, the work will be conducted with the aim of showing weigh-reduction opportunities when the steel superstructure, cargo hatches and moveable decks are replaced with composite. A simple analysis showing the total possible weight reduction if the entire ship were built in composite will also be made. The project has been initiated and Kockums are the WP-responsible. The work will enter a more intensive phase once the WP3d is finished properly.

4.3.6 WP3f

Work on the LQ was started during the summer of 2006, rather intensively, with numerous meetings. One very interesting part is an attempt to develop suitable aluminium profiles for the various construction details. SAPA, the aluminium profile producer, is working on this together with Emtunga and Light-Craft Design. Apart from them, there are other companies within LASS with experience in aluminium constructions, and it is primarily this group, together with SP and the new associate group members, who will be working on this project.

The project is of great interest, as there is a strong need today to use lightweight within offshore and it is now profitable to drill deeper than it was 10 years ago, thanks to better techniques and a higher oil price. This, however, means that more active material is requested on the platform, so the weight of other parts must be minimized.

4.4 LCA-LCC

Within WP5, data for LCA/LCC analyses are being gathered. During the year, discussions were held with SSPA and FMV about joint use of the previously developed calculation programs for LCA-LCC. The discussions are still underway, but it is likely that it will be more economical to write programs directly for the project.

LCA analysis is in progress for the superstructure for the WP3d, ro-pax, expected to be ready in early 2007.

4.5 Thesis work

Two theses at Linköping University were completed in January 2006. The work involved a market study about Swedish shipowners' attitudes regarding lightweight constructions at sea, and revealed that the majority were positive, but also sceptical, as there are still too few demonstrated examples.

During the autumn of 2005 and the spring of 2006, meetings were held to kick off the work involving robustness and composite constructions. The work was initiated by FMV, who are also bearing the costs of work at the Lightweight Construction Department at KTH (The Royal Institute of Technology in Stockholm). One theses is planned to start during the autumn of 2006.

Two theses have been started at the Lund Institute of Technology, Fire Technology Department, to simulate fire development and emergency evacuation on the *STENA Hollandica*, the Ro-pax vessel being studied in WP3d. The work, being conducted in Lund, is in collaboration with the VINNOVA project "Dimensioning fires at sea", under the auspices of SP together with DNV.

In August 2006, thesis work was started at KTH with the title: "Can the use of fibre composites in products decrease environmental effects over the life cycle?". The work is being supervised by KTH Machine Constructions, head of WP5.

Two more theses were initiated at SICOMP during the autumn of 2006; one concerns fire simulation of sandwich material (supervised by SICOMP and SP) and the other is about pipe-making techniques for composite ships (supervised by SICOMP and FMV).

5 Collaboration

The previously started collaboration on the EU project SAFEDOR, via the sub-project being run by DNV, led to two workshops during the year: on in Oslo (February) and one in Borås (June). The former meeting took up the strategy for dealing with fire hazards when using sandwich composite for the superstructure for the *STENA Hollandica* (WP3d), while the latter focused on possibilities for conducting joint fire testing. The meeting in June was also attended by the Swedish company MCT Brattberg AB, who produce and sell certified penetration constructions for deck and bulkhead. At the meeting it was decided that LASS, DNV and MCTBrattberg would jointly run test in October 2006. At the meeting it was also decided that DNV/SAFEDOR would provide LASS with a number of samples for small-scale testing. The purpose is to obtain material that will offer a certain amount of external fire protection on a sandwich panel, as the risk of external fire must be resolved within the project.

Collaboration with the VINNOVA-sponsored project "Dimensioning Fires at Sea" is continuing, having already resulted in two jointly supervised theses (see above).

6 Publications

Numerous articles, both scientific (requiring peer review) and conference papers, as well as for more popular science journals, were published during the year. LASS material was also published in a number of major trade-press journals. Some 10-20 articles were published. The exact number is a bit uncertain, as certain journals copy and publishes previously published information from the LASS consortium.

7 Continued work

The work within LASS is progressing very well according to plan. All groups (Wp3a-d) have completed or will have completed a first-draft engineering design of a lightweight ship during 2006. For certain constructions, design optimization will be the next step. For example, it will be very interesting to see what an optimized aluminium profile can mean for the WP3c (ro-ro) and WP3f (LQ) constructions. During the autumn of 2006, Wp3b and WP3d are expected to submit their final reports, whereupon WP3e can be launched. The work within WP3b will also be revealed and reported in a thesis at Chalmers.

The foremost development need within LASS is now the LCA/LCC tools, and this work is underway. Key tasks for WP1 and WP7 (see Figur 4) will then be to develop, in collaboration with the consortium, information material and then to market the work and results effectively. It can be important, particularly for the SME part of the consortium, to demonstrate their know-how in lightweight constructions. This part of the LASS project is expected to require resources, mainly during 2007.