

THE POTENTIAL FOR THE USE OF A NOVEL CRAFT, PACSCAT (PARTIAL AIR CUSHION SUPPORTED CATAMARAN), IN INLAND EUROPEAN WATERWAYS.

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ABSTRACT

A new type of high-speed cargo vessel could soon be taking some of the burden from our roads. The Partial Air Cushion Supported Catamaran, or PACSCAT, is being developed with the aid of funding from the EU Growth programme. With rapid growth in freight logistics markets throughout Europe, and an already congested land-based infrastructure, expansion of waterborne modes is considered essential. It is expected that PACSCAT vessels will play a major role in achieving this goal. The high speed, low wash, variable draught vessel is designed for operations on the Rhine and Danube rivers. At a design speed of around 20kt (37 km/hr), the vessel will be capable of making the 2,200 km trip from Constanza to Passau in three days as opposed to the current journey time of seven days by barge, thus competing directly with road transport. The payload capacity will be in the order of 2000 t, which is equivalent to around 45 truckloads. The vessel draught can be adjusted from 2.5m to as low as 1.5m in order to cope with shallow conditions and air draught can be similarly altered to allow for bridge height limitations. The air cushion is contained between the sidehulls and end seals, and is generated by installed lift fans. This reduces the propulsion power requirements and the wash generated, which is especially important in operations along waterways. It will be designed to operate utilising existing berthing/loading facilities. This paper reports the results of the current EU funded project which is developing the concept for operations on inland European waterways. However, the concept is equally applicable to short sea operations, possibly with a river transit as part of the route to avoid unnecessary transshipment of cargo between seagoing and river craft. A number of military applications are also under investigation.

INTRODUCTION

A safe and environmentally acceptable maritime transport system is important for the entire European Community. The volume of maritime transport in European waters is increasing as a consequence of limitations on the expansion of land-based modes. There is clearly an incentive to move freight from roads to water, on account of both spare capacity and reduced environmental burden potentially offered by water-borne modes. This is illustrated by the many recent European initiatives which explore opportunities for short sea shipping. However, these studies largely ignore the potential for growth of freight transport using inland waterways and, as a

consequence, ignore the greater reduction in the environmental burden that could be achieved. Increasing levels of freight movements within the EU have already led to major congestion on road systems with consequent increases in economic costs and environmental pollution. Demands for freight transportation are expected to increase by around 50% over the next ten years and it is difficult to see how road transport can absorb this.

Attempts to transfer freight from road to rail systems have not been very successful to date, mainly because of the lack of priority given to rail freight transport in relation to passenger carrying services. The EC has estimated (Ref 1) that the average speed of freight

trains within the EU is only 16 km/hr and such trains carried only 14% of the EU's total freight tonnage. Subsequently, the EC drew up a transport policy (Ref 2) that identifies the potential for the development of "waterway branches" to enhance this form of intermodal transport.

European waterways provide an alternative to road systems. River barges, each loaded with several thousand tonnes of payload, already carry a significant proportion of the total EU freight tonnage. However, the speed of such barges is restricted typically to a maximum of 18 km/hr, by propulsion power demands and the need to limit disturbance caused by the height of the generated waves (wash). Consequently, freight delivery times achieved by barges are substantially longer than those by road transport. Despite this, container transport in Germany by inland vessels has grown over recent years as shown in Fig 1.

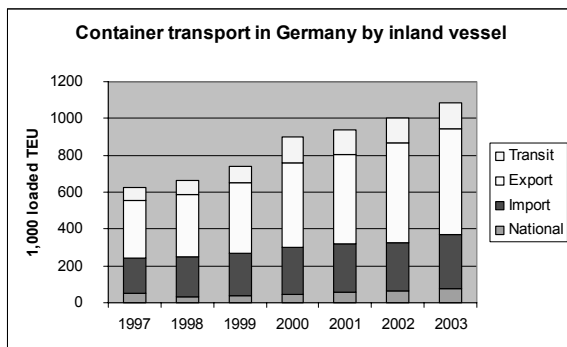


Fig 1: Growth of Container Transport in Germany by Inland Vessels.

(Source: DESTATIS: Verkehr, FS 8, R4)

Doubling the speed of river barges would offer a significant alternative to trucks, attract more freight to waterways and thereby help reduce road congestion.

Exploratory studies have shown that more freight would be attracted to the waterways if shorter delivery times could be offered. However, if similar heavy payloads are to be carried at higher speeds, different types of hull-form will be needed in order to avoid the problems associated with large increases in power demands and wash heights.

In general, increasing speed leads to more efficient use of vessels insofar as a higher freight throughput can be achieved (i.e. it is possible to "work the vessels harder"). Whilst the existence of high-speed vessels is a prerequisite for the creation of a solution for maritime high-speed transport, it does not constitute the whole of the solution. If freighters are subject to disruption of services due to insufficient water depth over even a short section of route, then a large part of the advantage of high cruising speed is lost. Unless those problems are addressed and solved, it will not be possible to create an efficient

and cost-effective solution for freight transport on inland waterways. The PACSCAT concept offers a potential solution by exploiting an extra-lift (reduced-draught) mode to avoid restrictions posed by sections of limited water depth. Furthermore, it does not suffer from the 'squat' phenomenon which exacerbates the problem of limited water depth for conventional barges.

An EU funded CRAFT exploratory project was completed in 2001 (Ref 3), involving three organisations which are all now members of the PACSCAT consortium. The project performed a market/technical feasibility analysis and novelty investigation for the PACSCAT concept. It considered potential routes along river and canal waterways and generally reached very positive conclusions, but found that efficient deployment of PACSCAT vessels would only be viable at present on primary river systems. Use on canals was not recommended due to prevailing speed restrictions. Although there was significant prior art in the general field of partial air cushion support, detailed aspects of the proposed design were patentable. The study also highlighted the need for further work to refine the cost and performance parameters.

1. THE EU PACSCAT PROJECT

A successful proposal to undertake the further work identified by the CRAFT project was made to the European Community to be funded under the Growth Programme (1998-2002) and the new PACSCAT project started in November 2002. The following Partners formed a consortium to undertake specific tasks within their own areas of expertise:

- The University of Southampton (UoS)
- Independent Maritime Assessment Associates Ltd (IMAA)
- Witt & Sohn AG (Witt)
- Checkmate Avon Ltd (Avon)
- Wärtsilä Propulsion Netherlands BV (Wärtsilä)
- Marinetechniek South Ltd (MTS)
- Germanischer Lloyd AG (GL)
- Europäisches Entwicklungszentrum für Binnen und Küstenschiffahrt (VBD)
- MDS Transmodal Ltd (MDS)
- Sovtransavto Deutschland GmbH (SOV)
- CETEC Consultancy Ltd (now White Young Green Consulting Ltd - WYGC)
- Shipbuilders and Shiprepairers Association (SSA)
- Maritime Simulation Rotterdam BV (MSR)
- Institut für Seeverkehrswirtschaft und Logistik (ISL)

The overall objective was to identify commercial opportunities for which the PACSCAT concept could be exploited, to develop appropriate designs and to

complete the project with a cost/benefit exercise to demonstrate the economic advantages that could be achieved.

The current PACSCAT project comprises the following activities, which are described in more detail below:

Market assessment, Specification, Performance modelling, Operations assessment, Detailed design, Cost-effectiveness appraisal, Commercialisation planning and Dissemination of PACSCAT achievements to a wide range of operators and other actors.

2. MARKET NEEDS AND SPECIFICATION

The first part of the project was to carry out a market assessment, exploring specific waterway logistics markets and wider replication markets, based on the work completed in the CRAFT project. This was undertaken by ISL with contributions from SOV and MDS.

A review of the geographical features and man-made restrictions likely to influence the higher speed operation of barge-like vessels on main European waterways has been carried out. The main emphasis has been concentrated on the large, free flowing rivers such as the lower Rhine and the Danube where speed and size can be used with best advantage. However, it has been noted that the depths on these rivers is often quite low and can alter considerably and rapidly over short times. Hence, vessels operating in such scenarios should have a low draught and the concept of varying the draught on demand (that is, by employing air cushion lift) could be a significant advantage. Locks on the Rhine, Danube and major canals in Belgium and the Netherlands can generally accept vessels 22.8m wide and 135m in length and new PACSCAT designs should make best allowance of these dimensions.

Over recent years there has been a decrease in the number of conventional barges, particularly on the Rhine. Compared to thousands of existing ships the number of new builds is very small, but a number of new vessels have been introduced. Since most new ships are tankers or large dry cargo barges optimised for container cargo, no shortage of container tonnage exists. Such vessels have often been of increased size and facilities have been modified to accommodate these. Container barges are mostly owned privately and chartered to liner operators. Capacities range from 200 to 400 TEU in new ships.

A questionnaire was also circulated to ports and terminals along the Rhine. This has helped to identify current and likely changes in port facilities such as berth sizing, water depth and container loading arrangements. The number of containers

shipped by existing operators through such ports has been identified and the typical weight of a standard TEU calculated.

Operating regulations on the rivers were also examined, particularly with regard to the introduction of higher speed vessels. The "Rheinschiffsuntersuchungsordnung" was recently supplemented by a new chapter 22b concerning fast ships. More interesting is the introductory definition of fast ships being able to make more than 40 km/h. Such vessels will require to have better control, operating and safety standards.

The Danube has a length of 2850 km and is - after the Volga - the second longest river in Europe. Its catchments area comprises 817,000 km² and flows through all major landscape forms of Central and Eastern Europe. The Danube crosses the countries Germany, Austria, Slovakia, Hungary, Croatia, Serbia, Bulgaria, Romania, Moldavia and Ukraine. The population of the 13 countries in the catchment area totals 83 million people and the 10 states along its banks make it the most international river worldwide. Many of them live directly in one of the big Danube cities (e.g. Vienna, Bratislava, Budapest, Belgrade) or at one of its tributaries (such as Munich, Zagreb, Sofia, or Bucharest).



Fig 2: The River Danube

The actual water level in the Danube varies with the flow in the river. The water depth in the river is given, referring to one of the following reference levels: LNRL (Low Navigation and Regulation Level) and HNWL (High Navigable Water Level). LNRL is the water level exceeded during 94% of the ice-free time based on a period of 40 years (between 1944 and 1983) of monitored discharges. This level has been adopted as the reference level to define the minimum available water depth in the navigation channel (Fig 3). HNWL is the water level that is exceeded during 1% of the ice-free time based on observations period of 40 years (between 1924 and 1963). The minimum air draft under the bridges and high voltage cables will be expressed in meters above HNWL. The Danube discharge is at the highest level around May-July and the lowest level in October-November.

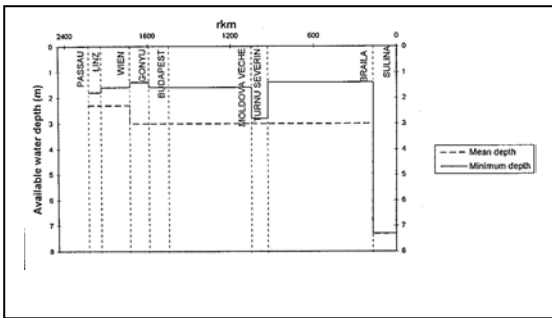


Fig 3: Predicted water levels on the River Danube

To take maximum advantage of the freight opportunities, a route on the River Danube between Constanza and Passau was chosen for more detailed study. A passage time of 3 days was calculated, including a generous allowance for those stretches of the river where the full speed could not be maintained. Based on the information collated and with additional contributions from IMAA, GL and VBD, the following initial specification for the Danube river freighter was selected:

Length overall	135.0m
Beam moulded	22.8m
Operating draught	1.6m
(reducing to 1.4m with maximum lift)	
Static draught	2.5m
Air height	5.5m

A similar route on the River Rhine between Rotterdam and Duisburg was also chosen for more detailed study. An artist's impression of a container freighter is shown in Fig 4.

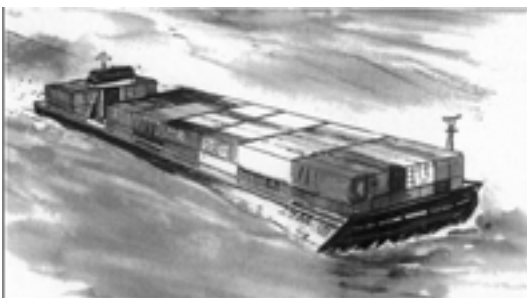


Fig 4: Artists impression of the PACSCAT vessel

3. PERFORMANCE MODELLING

A series of generic tests were carried out by the University of Southampton and by VBD at their tank testing facility at Duisburg, using models with variable geometry. IMAA coordinated the development of the test programme and assisted with the testing.

From the test results, the University of Southampton developed a numerical model for the PACSCAT vessel to use for performance predictions for the final configuration. This work will be presented to the FAST 2005 conference separately (Ref 4).

It was originally intended to carry out large-scale open water testing in order to determine the manoeuvring characteristics of the proposed vessel but this information was determined during the testing at the VBD tank, sufficient to provide the base data for the simulation work carried out by MSR that is described later in the paper.

4. OPERATIONAL APPRAISAL

The regulations that apply to the design and operation of a PACSCAT vessel were identified for both the Danube and the Rhine to ensure that subsequent design work was carried out to the appropriate requirements. Also an initial assessment of the potential impact on the environment was made, considering exhaust emissions, wash and noise. Information was gathered from a wide range of sources and the final documentation contained inputs from UoS, GL, ISL, MDS and SOV. A significant part of this work was a safety assessment carried out by MSR at their simulator facility in Rotterdam. Models of PACSCAT vessels were prepared based on the results of the hydrodynamic testing and then operated by experienced river captains in a wide variety of predicted hazardous situations. The simulator model for PACSCAT is shown in Fig 5 and an example of hazard is shown in Fig 6.

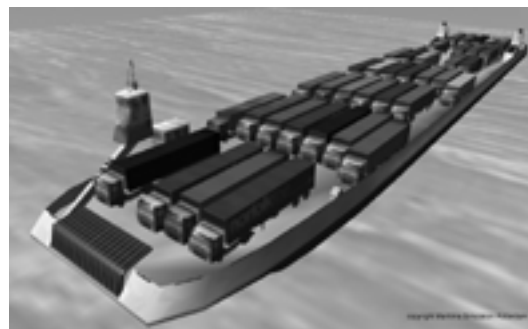


Fig 5: Front view of the PACSCAT river freighter

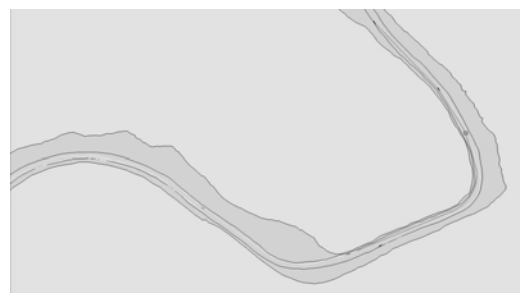


Fig 6: Sharp bend on the Danube

When the simulation was running, a typical view of the waterway was seen as shown in Fig 7.



Fig 7: *General view of the simulation model*

Operations assessment included risk assessment and human factors for PACSCAT craft operation, and definition of operating envelopes compliant with regulatory limits. The results gave a good overview of the potential problems of operating a PACSCAT vessel at approximately twice the speed of conventional barges and the actions necessary to ensure safety. It will not pose a hazard due to its good manoeuvring characteristics at high speed.

5. DESIGN

Detailed design of a PACSCAT river freighter was developed in accordance with the specification and performance assessment

This is the area where the diversity of expertise of the members of the Consortium made a very significant contribution towards the project. IMAA were responsible for co-ordinating the design process, with specialist knowledge from the manufacturers involved.

WYGC designed the hull structure based on the rules previously identified and using techniques that minimised the hull weight. Their work was reviewed by GL to ensure that the final result was a practical solution and suitable for submission to building yards for a capital cost estimate. A typical cross section for the PACSCAT vessel is shown in Fig 8.

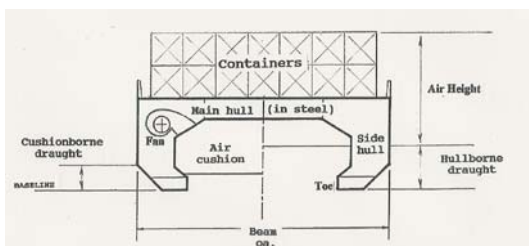


Fig 8: *Cross section of the PACSCAT freighter*

Checkmate Avon have wide experience in the design of seals for hovercraft and other cushion vehicles and were able to provide good advice on the construction of suitable bow and stern seals for this particular application. Similarly, they were able to advise on the capital costs and maintenance involved.

The propulsors and propulsion machinery was specified by Wärtsilä Propulsion, based on the powering requirements determined from the hydrodynamic testing and generated realistic estimates of capital and operating costs as well as levels of exhaust and noise emissions.

Witt & Sohn proposed a suitable fan arrangement for the lift system based on the pressure required and the seal leakage predicted by Checkmate Avon.

MSR recommended the navigational equipment based on the results of the hazard simulation.

The final design arrangement for the Danube river freighter is shown in Fig 9 (at the end of the paper).

6. COST/BENEFIT AND EXPLOITATION

As a result of the wide range of specialists involved in the design of the prototype PACSCAT, the final design arrangement shown in Fig 9 is as close to a working design as possible. Estimates of capital and operating costs are sufficiently accurate to enable potential users to consider the benefits of the PACSCAT vessel and the opportunities to integrate it into their operations.

The appraisal of cost-effectiveness will then be based on actual yard cost modelling for construction and realistic operating cost estimates, providing a sound basis for exploitation of the PACSCAT concept. An important part of this part of the project will be to compare the impact of a fleet of PACSCAT vessels with comparable road transport in order to demonstrate the opportunity to move freight from the European road network and the contribution this could make towards the EC transport policy.

MDS will lead this part of the project with inputs from ISL and SOV. The overall project and its conclusions will be presented to a workshop being arranged by SSA. The intention is to disseminate the findings widely and give an opportunity for the results to be discussed with important companies involved in freight transport, leading to enhanced opportunities for the introduction of the PACSCAT concept.

These results will underpin an exploitation plan based on solid market knowledge. An evaluation of the impacts of such exploitation (e.g. on modal shift from roads to water and the resulting environmental

benefits) will also be performed, to illustrate how PACSCAT can contribute to major European policy objectives.

CONCLUSIONS

At the end of the 30-month project, a range of designs for a full-scale PACSCAT vessel configuration will have been developed, suited to specific priority freight routes. Detailed assessments will offer assurance of safety, environmental performance and compliance with relevant regulations. Capital and operating cost estimates will also have been generated, allowing potential operators to assess the cost-effectiveness of a PACSCAT freighter to a high level of confidence.

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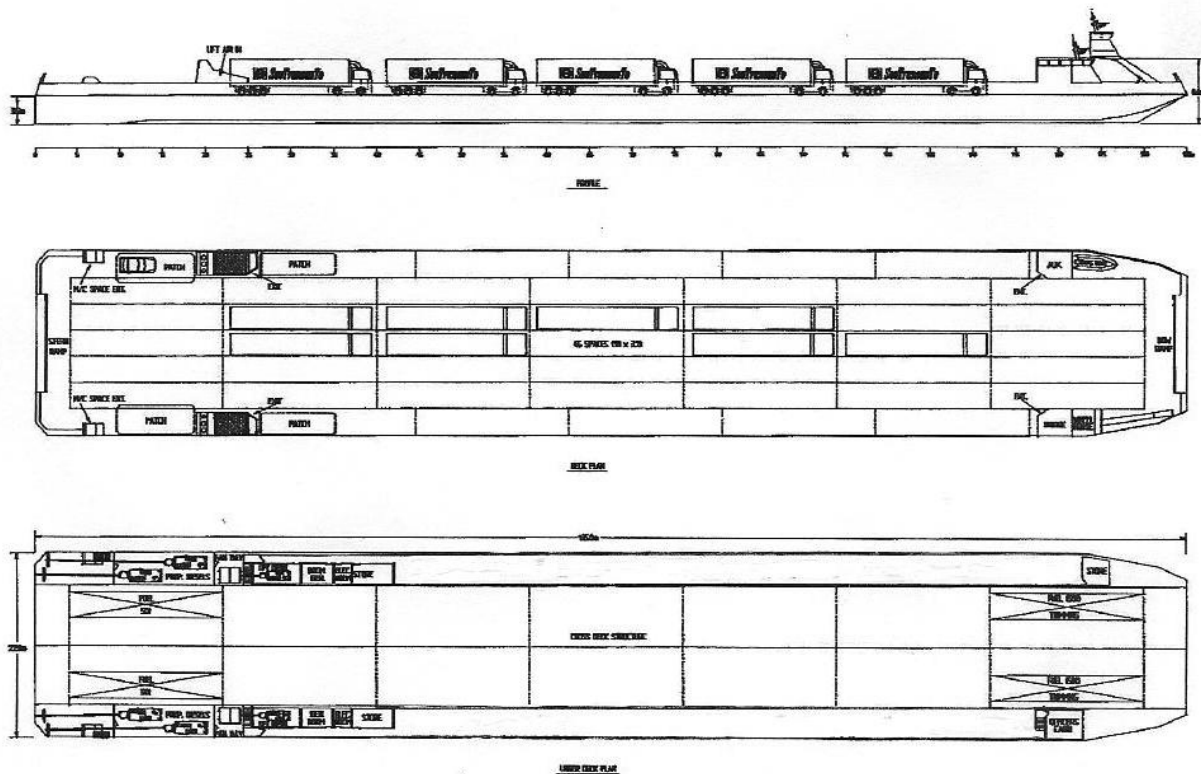


Fig 9: General Arrangement of the PACSCAT river freighter