ROUGH SEAS AND SMALL PASSENGER FERRIES THE DAMEN 3717 SWATH SOLUTION

Rik Vrugt, Sovereign Marine Services NV, Belgium
Piet Hein Noordenbos, Damen Shipyards BV, The Netherlands
Ed Dudson, Nigel Gee and Associates Ltd, UK

SUMMARY

This paper outlines the philosophy behind the selection of the SWATH hull form for the Province of Zeeland ferry between Vlissingen and Breskens. The Damen 3717 SWATH is currently under construction at the Schelde Yard of Damen Shipyards and this paper describes the work undertaken in the detail design of the vessel. Chapter 1 describes the essential project requirements, whilst chapter 2 goes into more detail on the actual design of the SWATH vessels. Chapter 3 relates to the construction of the SWATH vessels.

AUTHORS' BIOGRAPHIES

Rik E Vrugt has a cum laude B.Sc degree in Marine Engineering, and started his career with a reputable Dutch naval architect and marine engineering consultancy firm in 1977, and was involved in the design and engineering of numerous special floating equipment for the Eastern Scheldt barrier project, various double ended diesel electric Ro/Ro ferries for different Dutch inland water routes, as well as aluminium catamaran ferries for abroad.

He founded the maritime consultancy Sovereign Marine Services NV (SMS) in 1992 and the company operates from Belgium. SMS' major clients include shipping companies, government organisations and operators.

He was Project Manager for the Provinciale Stoomboot Diensten (PSD) of the Province of Zeeland on two new building projects at the Royal Schelde Yard in Vlissingen and was also involved in various modifications of older ferries.

Furthermore, he was Project Manager during the design and engineering, construction and delivery of two azipod driven diesel electric ice breakers, built in Finland, and three special Ro/Ro paper carriers built in Germany which sail on the Zeebrugge – Gothenburg route.

Rik E Vrugt has been involved in the Province of Zeeland's passenger and bicycle fast ferry project since 1998. He was in charge of the contract negotiations with Damen Shipyards. At present, he is the Project Manager for the SWATH project on behalf of the Province of Zeeland.

Piet Hein Noordenbos has a B.Sc degree in Naval Architecture and Shipbuilding, and he served in the Dutch Navy as junior officer on a Mine Sweeper and later joined the design department of the Navy for several years before joining Damen Shipyards. In 1971 he designed Damen's first high speed craft, the Poly Cat, a seagoing pilot/crewboat with a speed of 33 knots. At Damen he has always been engaged in designing and marketing High Speed Craft.

Amongst numerous other projects, he was the Project Manager for cooperation with Bollinger Shipyard Inc. using Damen's design for their successful Coast Guard 82-foot patrol boats, the Barracuda class.

Since 1999 he has been Product Director of Damen's Fast Ferry activities.

In his spare time he sails an International Yngling Class keelboat and has several positions in the class organisation.

Ed Dudson graduated from the University of Southampton in 1990 and joined Nigel Gee and Associates the same year where he has worked continuously, with the exception of a year's sabbatical at Marintek Sintef Group in Trondheim, Norway. He is Director of Ship Design and also, the Project Manager on the Damen SWATH for Nigel Gee and Associates Ltd. Ed Dudson is a Chartered Engineer and Member of the Royal Institute of Naval Architects.

NOMENCLATURE

BV	Bureau Veritas
DSG	Damen Shipyards, Gorinchem, The Netherlands
NGA	Nigel Gee and Associates Ltd., UK
SMS	Sovereign Marine Services NV, Belgium
PZ	Province of Zeeland, The Netherlands
PSD	Provinciale Stoomboot Diensten, The Netherlands

1.0 INTRODUCTION

The Damen 3717 SWATH is a 37m single strut SWATH designed to operate between Vlissingen and Breskens in the Western Schelde. The vessel has been designed for ease of maintenance and has a diesel electric propulsion plant to avoid the necessity of maintenance in the floaters. The vessel is constructed from high tensile steel grade AH36 for the hull and the superstructure is constructed from aluminium alloy. The vessel is classed to Bureau Veritas High Speed Rules, with The Netherlands Shipping Inspectorate the national authority. A computer rendering of the vessel can be seen in Figure 1. Principal particulars of the vessel are presented in Table 1.

Figure 1 : Computer Rendering

Length Overall	37.4	m
Length Waterline	33.9	m
Beam Overall	17.0	m
Draught (Design)	4.2	m
Displacement (Design)	400.0	tonnes
Deadweight (Design)	37.0	tonnes
Main Engines	2 x MTU 12V4000 2 x 1560 kW	
Propulsion Motors	4 x INDAR 660 kW	
Maximum Speed	16.5	knots
Service Speed	14.5	knots
Maximum Wave Height	2.5	m

Table 1 : Principal Particulars

1.1 PROJECT BACKGROUND

The PSD have been carrying out ferry services on the Western Scheldt since around 1850. Today's Ro/Ro ferries operate on two different routes, Vlissingen – Breskens and Kruiningen – Perkpolder.

In mid-1996, the Dutch Government in The Hague took the decision to build a tunnel under the Western Scheldt known as the 'Westerschelde Oever Verbinding' (WOV) project.

When the newly constructed tunnel connecting 'Walcheren' with 'Zeeuws Vlaanderen' comes into service in March 2003, these PSD Ro/Ro ferry services will become redundant.

Due to the fact that the tunnel is positioned more or less in between the existing ferry service routes, in mid-1996 the Province of Zeeland (PZ) committed themselves to providing a suitable 'passenger and bicycle fast ferry' service on the Vlissingen – Breskens route which would be operated by a private operator.

In mid-2001, the PZ opted to directly procure two SWATH vessels which would give them the possibility of having a bare boat charter for concession periods of six years to a private operator.

As a result, a yard pre-selection and evaluation was carried out in accordance with European directives. Tender documents consisting of a tender outline specification and concept contract were made by SMS on behalf of the PZ. This was followed by a tender evaluation at the end of 2001.

The contract negotiations with Damen Shipyards (DSG) commenced at the beginning of 2002. This resulted in a final Shipbuilding Contract and Building Specification which were prepared by SMS, in cooperation with DSG, and a contract award between the PZ and DSG on March 26, 2002.

1.2 PROJECT APPROACH

All parties involved had already realised during the contract negotiation phase that this SWATH project would be a unique one and a highly demanding challenge. In addition, as of today, there are no other similar SWATH vessels presently in operation worldwide which have to comply with the same operational demands, severe weather conditions and a number of very important and stringent requirements.

Therefore, it was agreed by all parties to make this a joint project, incorporating each others knowledge and experience to the full extent.

To date, this rather unique approach has already resulted in a fruitful and efficient cooperation and joint team effort between Damen Shipyards with their consultant Nigel Gee and Associates on the one side and Sovereign Marine Services on the other.

1.3 PRINCIPAL REASONS FOR SELECTING A SWATH DESIGN VESSEL

In 1992, MARDOC, a naval architect and marine engineering consultancy firm in The Netherlands had already carried out a dedicated study for the PZ on the different design possibilities for smaller ferries on the specific route Vlissingen – Breskens.

In order to prevent seasickness, the limitation of the vertical accelerations was considered as being the main reason for selecting small type vessels of the SWATH design suitable for the safe and comfortable transport of passengers.

It was concluded that with the wind, tidal and wave conditions, and the significant wave height for Beaufort 9 conditions in this part of the Western Scheldt, a small single hull vessel of approx. 50 m length would not be able to comply with the vertical accelerations limits. The same applied to catamaran type vessels.

In order to build up confidence amongst passengers and without compromising the design philosophy and operational requirements, it is of the utmost importance that passengers do not become seasick during crossings in bad weather conditions. Seasickness could result in a negative opinion of the new operator and could also possibly jeopardize the project's existence.

1.4 PRIMARY SERVICE REQUIREMENTS

The SWATH vessels have to be designed and constructed for an all year round service taking passengers and bicycles on the Vlissingen – Breskens route. The different route possibilities are shown in Figure 2.

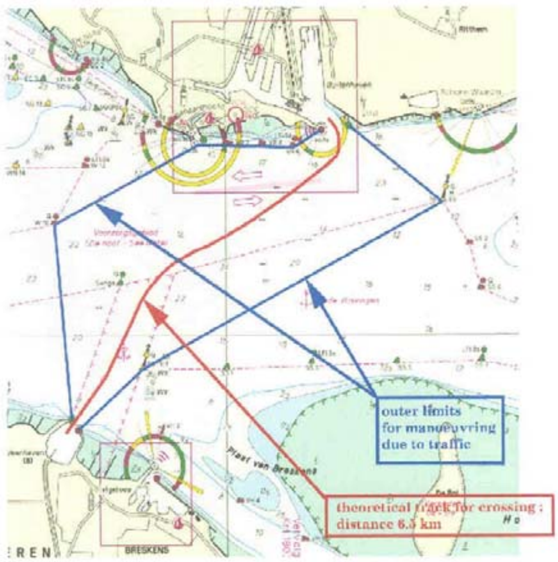

Figure 2: Vlissingen – Breskens Route

The theoretical distance of the Vlissingen – Breskens crossing is approx. 6.5 km.

The fast ferry services will be operational all year, from 0600 hours to 2300 hours based on a seven day week. The SWATH vessels will be designed for a maximum number of 7,000 operational hours on an annual basis with a total lifetime of 30 years.

The Western Scheldt river is the approach to several major ports in Southern Holland and to the Port of Antwerp. It is used by many seagoing as well as inland vessels. The Western Scheldt is an estuary with strong tidal currents, many sandbanks and shallow water areas.

1.5 CONDITIONS OF THE PROVINCE OF ZEELAND

Since the award of contract, PZ is no longer involved in the day to day activities of the project, having appointed SMS to deal with all matters on their behalf.

However, PZ has laid down certain conditions which should remain in force for the entire duration of the project. These are :

- The project has to fulfil the requirements of the Contract and the Building Specification.
- The scheduled delivery times of the SWATH vessels have to be met. Delivery of the first vessel is scheduled to be delivered on December 31, 2003 and the second vessel on February 28,2004.
- The project has to remain within the budget.

1.6 DESIGN PHILOSOPHY AND OPERATIONAL REQUIREMENTS

To summarize, PZ's design philosophy with its operational requirements is as follows :

- To provide maximum safety of the passengers and crew.
- To ensure a high degree of operational reliability of the SWATH vessel's service, its installations, systems and equipment in order to maintain an 'out of service' and/or maintenance time of the vessel's target figure of approx. 1% of the total trips on an annual basis according to the time schedule. However, bad weather conditions such as heavy fog, ice and heavy storms are <u>not</u> included.
- To provide an acceptable comfort for passengers and crew during sailing in adverse weather conditions up to Beaufort 9.
- The operational services should be possible throughout the year and based upon the primary service requirements as described above.

- To ensure ease of operation, use and maintenance of systems, installations and/or equipment and simple to operate systems and installations.

- To minimize environmental risks.

- To install as few sea water systems as possible.

- To provide full and complete information and documentation on installations, systems, components and equipment for use by the PZ and/or the operator.

- To provide a modern designed passenger accommodation with facilities of a good quality ‘economy class’ level.

- The SWATH vessel’s only ‘design’ limitation and restriction is a maximum draft of 4.5 m to limit the annual maintenance dredging at both landing stages.

1.7 ESSENTIAL DESIGN CRITERIA & REQUIREMENTS

Based upon their long experience with the PSD ferries and furthermore in relation to the above described design philosophy, the PZ concluded that the following design criteria and requirements would be essential in the design and engineering, construction, delivery and operation of the SWATH vessels :

- The design should be based upon the logistic and physical constraints of the SWATH vessels, the intended fast ferry service and the particular sailing route on the Western Scheldt between Vlissingen and Breskens as far as it relates to the SWATH vessel design concept.

- The SWATH vessels will be used as a means of public transport for the short distance transportation of passengers, commuters, and all types of bicycle and moped vehicles permitted on the public roads of The Netherlands.

- The SWATH vessels should be suitable to sail on the Vlissingen - Breskens route. Furthermore, it will be the yard's responsibility that the SWATH vessels intending to be used fulfil the prescribed topics with regard to all technical and operational requirements, infrastructure, climatological and environmental conditions applicable to the Western Scheldt area and, in particular, to the sailing route between Vlissingen and Breskens.

- To ensure a high degree of manoeuvrability of the SWATH vessels.

- To ensure a high degree of reliability of all installations, systems, machinery, outfit and equipment.

- To ensure a high degree of redundancy of essential systems as requested by the Class, Regulatory Bodies or as specified in the Building Specification.

- To provide failsafe systems and installations as requested by the Class, Regulatory Bodies or as specified in the Building Specification.

- Foolproof control automation systems will be designed and provided, for smooth operation by the operator, and will be in accordance with good seamanship operation and practice.

- To provide a dual propulsion installation and a dual steering/manoeuvring control installation.

- To provide a redundant diesel electric network for the propulsion system based upon 720 volts AC, 60 Hz and a fully separate redundant auxiliary electric network based upon 400 volts AC, 50 Hz.

- During a black-out of one of the auxiliary diesel generator sets supplying the 400 volts network, safe operation and continuation of sailing with the propulsion system will remain possible.

- To provide maximum all round visibility for the crew in the wheelhouse.

- As far as possible and practicable, the layout of spaces, entrances, stairs, railings, hand-grips, instructions and signs (visual and acoustic) etc. will be provided to serve normal as well as handicapped persons in the best possible way.

- The operation of each SWATH vessel will be performed by a minimum crew complement of four crew members.

- The noise and vibration requirements will comply with the levels as indicated in the Building Specification which simultaneously covers the requirements of the Regulatory Bodies.

- To properly deal with the specific comfort requirements as described hereinafter.

- To take the special environmental requirements into account as described hereinafter.

- Selection of all equipment and materials by the yard will be subject to approval and taken in strict consultation with the PZ’s representatives.

- In principle, all drawings and information will be subject to approval.

- Comprehensive model testing will form an integrated part of the principal design and engineering loop.

- Comprehensive testing will be performed during a) the factory acceptance tests of all main machinery and components; b) during the harbour acceptance tests; and c) finally, during the sea trials.

- Finally, to use comprehensive standards for a) machinery systems and installations; b) hydraulic installations; and c) electrical installations to ensure the lifetime requirement of 30 years as much as possible.

1.8 COMFORT REQUIREMENTS

For the comfort of the passengers and crew, the SWATH vessels will be able to handle the following conditions :

- Sailing (at reduced speed) on the Western Scheldt up to Beaufort 9 weather conditions.

- During these conditions, the vertical acceleration midship will be maximum 1.00 m/s5 (significant single amplitude), which is a reduced acceleration level in relation to the requirements specified in ISO Standard 2631/3-1985, "Evaluation of human exposure to whole-body vibration".

- The SWATH design vessel type with its specific hull shape, principal dimensions and sailing characteristics will be designed by the yard in such a way that these vertical acceleration limits will be met.

- The air gap between the underside of the cross deck construction and the water will be very carefully designed and determined by the yard in order to prevent slamming problems during all sailing conditions.

  The yard will prove through model tests that these vertical acceleration limits and air gap requirements can be achieved and will not be exceeded.

1.9 SPECIAL ENVIRONMENTAL REQUIREMENTS

The design of the SWATH vessels will need to incorporate the following special environmental requirements, some of which are in addition to the present rules and regulations, and requirements of the Regulatory Bodies :

- Marine Gas Oil (MGO) will comply with the requirement that the sulphur content will not exceed 0.2% maximum.

- Diesel combustion during the complete power range will be smokeless as far as possible.

- The NOx emission levels of the exhaust gases will comply with the latest IMO recommendations for 'Proposal for New Ships'.

- Furthermore, the SWATH vessel's machinery installations and systems will be arranged in such a way that no discharge overboard will be necessary in the Western Scheldt. This requirement does not pertain to sea water and rain water on decks and superstructures.

  However, adequate provisions will be provided for discharge of waste, garbage, sludge, sewage etc. to the shore in Vlissingen.

- Environmentally friendly cooling media will be used for the AC compressor units and systems.

- The application of environmentally friendly paint systems.

- A bilge water collecting tank will be installed for zero dumping of contaminated deck-wash water in way of the bicycle and moped area on the main deck.

1.10 WIND, TIDE & WAVE INFORMATION

The Beaufort 9 weather conditions on the intended sailing route are an aggregate of the worst possible combination of wind, tide, current and waves and are defined as follows :

- Maximum wind speed at the Cadzant measuring station 22 m/s
- Maximum significant wave heights (from top to trough) of 1/3 of the highest waves over the year 2.5 m equivalent to 2.75 m at the Wielingen measuring station
- Maximum river current + tide current
- Maximum current velocity of Western Scheldt river water outside the harbour 3.5 knots
- High water tide
- Low water tide

The following summary of wind and wave information has been based upon Rijkswaterstaat's data bank :

1/ Beaufort 9 condition :

- Wind speed 22 m/s
- Significant wave height of 2.5 m
- Zero up-crossing period of 5 - 7 seconds
- Peak period of approx. 8 seconds
- A swell from the North with a period of 10 to 14 seconds max.
- A worst wind condition from W - NW

2/ Beaufort 6/7 condition :

- Wind speed 14 m/s
- Significant wave height of 1.45 m
- Zero up-crossing period of 5 - 7 seconds
- A swell from the North with a period of 10 to 14 seconds max.
- A worst wind condition from W - NW

1.11 CLASS NOTATION

The SWATH vessels will comply with the following Bureau Veritas rules and regulations for the classification of ships as a seagoing ship with the following Class Notation :

I + Hull + MACH
Light Ship / SWATH / Fast Passenger Ferry (NL)
Coastal Area
AUT-UMS
In Water Survey

Note : The navigation notation 'coastal area' is assigned to ships intended to operate only within 20 nautical miles from the shore and with a maximum sailing time of six hours from a port of refuge or safe sheltered anchorage. This complies with the intended Vlissingen - Breskens service route.

With regard to the national requirements of the Regulatory Bodies, the SWATH vessels will comply with the following regulations of The Netherlands Shipping Inspectorate for Inland Waterway Vessels :

"Binnenschepenbesluit" (BSB) (Regulations for Inland Waterway Vessels) published in 1987 (Staatsblad nr. 466), and its amendments, published in 1994, (Staatsblad nr. 915). The SWATH vessels will, in particular, fully comply with the requirements as specified in NSI's 'Bijlage V' (Annex V), applicable to ferries for 'zone 2'. (Staatsblad nr. 915).

2.0 VESSEL DESIGN

The SWATH vessel is designed to carry 50 bicycles plus 20 mopeds plus 5 handicapped persons mopeds, or a total of 75 bicycles. In addition, the vessel will be able to carry 181 passengers including space for 5 wheelchairs. The vessel is bow loading, and bicycles and mopeds will be stored on the main deck whilst passengers will be seated on the upper deck.

A general arrangement is shown in Figure 3.

Inherent in its design, the SWATH vessel has excellent seakeeping capabilities. In this vessel the seakeeping has been enhanced with the installation of 4 active fins. The route between Vlissingen and Breskens can be very rough and the comfort requirements of the specification are extremely high. The vertical acceleration limit in a significant wave height of 2.5m is 0.05g RMS. In order to verify the seakeeping of the vessel an extensive series of model tests were conducted at MARIN.

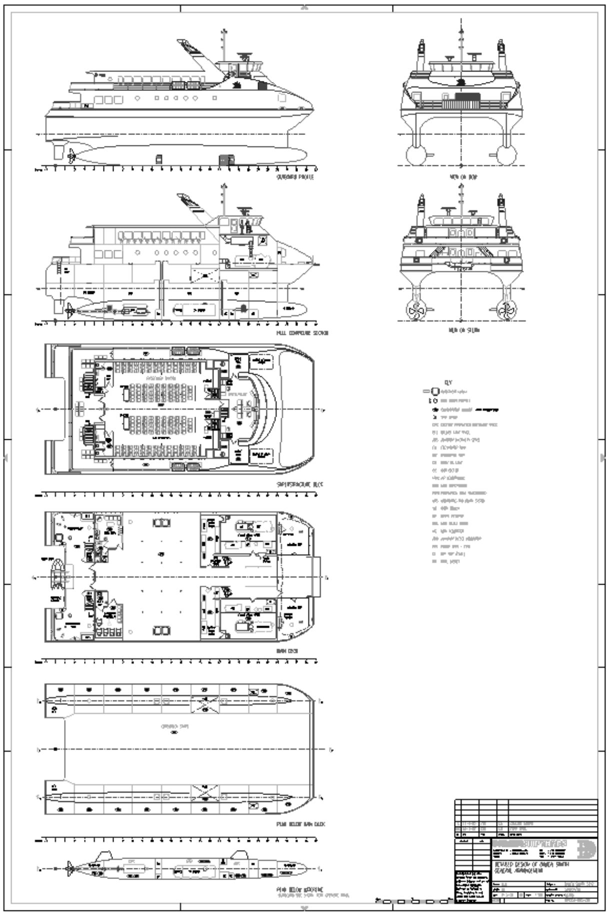

Figure 3 : General Arrangement

The Western Schelde is highly corrosive and the PZ specifically requested that no sea water systems were to be installed in the vessel. All machinery cooling is performed using box coolers. To prevent marine growth and corrosion in the box cooler chests, the chests are fitted with copper anodes.

The low GM_L and GM_T of the SWATH vessel make it necessary to have a ballast system capable of correcting for changes in load and centres of load. This is particularly necessary with a bow loading arrangement. The main ballast system on this vessel is a fresh water system consisting of four ballast tanks, one at each corner of the floaters. This ballast system is able to correct for vessel heel and trim at any loading condition; however, since it is a fixed mass system it cannot correct for changes in displacement. With the exception of loading and unloading, the operation of the vessel is expected to be at a reasonably constant displacement and, therefore, the fresh water ballast system should be sufficient. As a precaution, the vessel is also fitted with two composite sea water ballast tanks, one in each floater, to correct for significant changes in displacement if necessary.

The design of the SWATH vessel has been very challenging and the most difficult aspects are discussed in more detail in the following chapters :-

2.2 STRUCTURAL DESIGN

During the pre-tender stage, the owner (PZ) required the yards to offer an aluminium hull and superstructure. After studying the rigorous requirements, DSG and NGA requested to offer an alternative for the hull in high tensile steel. Designer and Builder felt that this combination would have better resistance against fatigue and impact / damages during the numerous landings.

Royal Schelde's experience with the Royal Netherlands Navy's frigates was positive with regard to the use of high tensile steel and added significantly to this decision. Another influence on the decision to use steel was the excellent experience in Hawaii with the cruise vessel, *Navatek I*.

The materials selected are summarised in Table 2:

Material	0.2% proof stress unwelded (MPa)	0.2% proof stress welded (MPa)	E (GPa)
5083 – H116 (Sheet & Plate)	215	125	69
6082 – T6 (Extrusions)	240	115	69
AH36 High Tensile Steel	355	355	200

Table 2 : Materials for Construction

2.2.1 Design Loads

With regard to the design loads on the hull, the building team studied the different Classification Societies' requirements as well as the experience gained by MARIN on SWATH research projects for the Royal Netherlands Navy and others. The design bending moments that were derived from Classification Society rules differed so much that it was decided that, during model testing, the model would be fitted with transverse beams to measure the different forces. The direct measurements comprised of:

- The bending moment at the centreline (2 strain gauges in each beam);
- The vertical sheer (2 times 2 strain gauges on top/below each beam);
- The horizontal sheer (2 times 2 strain gauges fore/aft in each beam);
- The torsion along the longitudinal axis of each beam.

The measurements were combined into:

- The total roll bending moment (around a point in the CL at 6.88 m above keel);
- The total vertical sheer force (along the CL cut);
- The total pitch moment (around a point at frame 10, 6.88 m above the keel);
- The total longitudinal sheer (along the CL cut).

The individual beams were calibrated prior to the tests. In-situ tests with the model floating in the water confirmed the roll bending moment.

The load measurement continued, during all seakeeping and manoeuvring tests at MARIN, and proved to be a valuable investment as the highest forces were measured at zero speed with beam waves. The magnitude of the force is very sensitive to the wave period and in the resonant situation the so-called "Moonpool" effect occurs resulting in the horizontal bending moment increasing to twice that experienced in any other operational condition.

The arrangement of the force measurements is shown in Figure 4.

Figure 4: Model Setup

BV also performed 3D hydrodynamic calculations in order to gain extra insight into the design loads. Their work demonstrated not only that the maximum bending moment is always in beam seas at zero speed, but also that the magnitude of the bending moment is highly tuned to wave period and wave spreading. BV utilised a detailed wave study of the area of operation from Alkyon combined with the model tests and their hydrodynamic calculations to arrive at the final design bending moments.

The final design bending moments were derived from the following input variables :

- Displacement	415 tonnes
- Speed	0 to 16.5 knots
- Wave height Hs	2,5 m
- Wave frequency Tp	6 sec
- Spectrum Pearson Moskovitz	
- Crossing time	20 min
- Duration storm	3 hrs
- Spreading effect of head waves	30 degrees
- Wind direction	from bow- to stern-quartering

2.3 STABILITY

The stability of the SWATH vessel is to be approved according to the inland waterways regulations of NSI. These rules are typically used for the approval of large monohulls and are not particularly applicable to a multi-hulled vessel, and definitely not to a SWATH vessel. During the tender stage, the damage stability requirements were such that the vessel had to withstand a two compartment side damage of a minimum length of 7.5m. Furthermore, the rules state that no deck edge immersion is permitted after damage. These requirements immediately ruled out a twin strut arrangement, and even with a single strut solution, a large number of compartments required filling with foam in order to ensure that the vessel met the requirements. Detailed discussions with NSI have resulted in a change to the stability regulations for this particular SWATH vessel in which the required damaged length has been reduced to 4.0m.

This has allowed the removal of the foam from void compartments. However, in order to ensure that there is no deck edge immersion, a counter flooding system has been designed, in which one of the sea water ballast tanks is flooded to reduce the vessel's residual heel angle.

2.4 MACHINERY

PZ's specification for the machinery is very demanding :-

"The vessel's propulsion is diesel electric to create maximum propulsion flexibility and redundancy. Propulsion is via two fixed pitch propellers each powered by a double motor asynchronous induction cage motor. No gearbox is permitted between the motor and propeller. The diesel generator sets and all switchboards are positioned on the main deck as shown on the general arrangement."

The reasons behind the machinery selection are clear since it virtually eliminates the need for the crew to perform maintenance tasks in the very restrictive space of the floaters. The impact for the designer, however, is significant.

The use of diesel electric reduces the efficiency of the propulsion system.

The use of electric motors without reduction gears results in a trade-off between propeller efficiency and motor weight. The optimum propeller revolutions are around 300 rpm. The final motor was selected with a speed of 350 rpm. This speed gave a good balance between the installed weight of the motor and the efficiency of the propeller.

An indication of the impact of the machinery design on the vessel can be seen when looking at the weights. The total installed power on the vessel is 3120 kW and the total weight of the propulsion machinery installation is 72 tonnes.

3.0 SELECTION OF BUILDING PLACE

During the first six months, the building team worked from the offices in Southampton (NGA) and in Gorinchem (Damen Shipyards). From there, the initial design, and the discussions with Bureau Veritas and the sub-contractors were undertaken, as well as the supervision of the extensive tank tests performed by MARIN. As soon as the worst bending moment was derived from the model tests and confirmed by BV's hydrodynamic calculations, NGA started to prepare the final hull construction drawings. After approval by BV and SMS, the drawings were converted into a modern 3D-CAD/CAM system at Royal Schelde.

3.1 THE CONSTRUCTION OF THE FIRST SWATH

For the construction, Damen selected Royal Schelde to build the complete hull and superstructure, and to perform all outfitting.

3.1.1 Introduction to Royal Schelde

Royal Schelde was founded in 1875 as a Netherlands Shipbuilding Company and has been a Dutch Government owned company for the past decades, specializing in the building of surface naval vessels and complicated commercial ships.

Recent developments have culminated in the takeover of the Royal Schelde Group by the privately owned Damen Shipyards Group in the year 2000.

The almost 400 merchant and naval vessels Royal Schelde has built have brought us the technology, experience and expertise to build today the ships for tomorrow.

Because of the restrictions at the original premises at Vlissingen, Schelde Naval Shipbuilding has and will continue to invest in modern and up-to-date production facilities at Vlissingen East. This has been of great significance in opening the window to a new and wider shipbuilding market. In the near future, all Schelde Naval Shipbuilding will take place at this location.

Photographs of the two yards are shown in Figures 5 & 6

Figure 5 : Vlissigen Centre

Figure 6 : Vlissingen East

3.1 THE WEIGHT ISSUE

It is well known that the SWATH design is very critical on weight and the position of that weight. It is, therefore, important to control all the weights and margins that suppliers offer. The use of thin steel plates for construction made the rolling tolerance one of the most critical points. We therefore selected steel mills that use so-called plus tolerance and we purchased plate thicknesses just below the nominal thickness. The following part of the steel order shows the very positive result in the last column.

3.3 STEEL SPECIFICATION FOR 2 x DAMEN SWATH 3717's

Continuously hot-rolled plates in the quality Grade AH36 High Tensile Steel, will be delivered with approval and certificate according to EN 10204-3.1C of Bureau Veritas (BV).

The plates to be rolled with a tolerance on the thickness of –0/+0.52 mm (the mill will try to reach an average thickness tolerance of –0/+0.4 mm).

All materials have to be delivered shot blasted SA 2½ and preserved with SIGMA Weld MC, dry layer 19-26 μ. The plates of items 10, 20 and 40 to be coated with Red Sigma Weld MC and the plates of the item 30 with Grey.

<u>Marking:</u>
Order-No. xxxxx + article no. if feasible on separate plates or on the packet.

BV markings to be clearly indicated.

Note: The different colours have been chosen to prevent mistakes in selecting the right plate for the correct position. Table 3 details the steel plate ordered and thicknesses received.

Item	**Art. No.**	**Colour Preser-vation**	**Length x**	**Width x**	**Thickness/mm** *Ordered*	*nominal*	*received*
10	201 – plate 1	Red	8200	1735	3.7	4.0	4.05
20	201 – plate 2	Red	8200	1735	3.8	4.0	4.12
30	201 – plate 3	Grey	8200	1735	4.3	4.5	4.60
40	201 – plate 6	Red	8200	1735	5.7	6.0	6.00

Table 3 : Details of Steel Orders

Upon delivery to the yard, all steel plates were weighed and the thickness of the plates checked. The thicker plates are positioned lower in the hulls and in areas of higher stress, whilst the thinner plates are placed on the main deck or used for brackets.

4.0 ASSEMBLY AND TRANSPORT OF THE SWATH

The building team decided to build the SWATH in sections to enable maximum pre-outfitting of each section. The lower part of the hull will be built in steel jigs to control the fairness and alignment to a very high degree. A photograph of the jig is shown in Figure 7.

Figure 7 : Steel Jig for Construction of Floaters

Figure 8 shows the different sections for each side and the superstructure.

Sections 1601 and 1701 are built in aluminium using Hydro Marine aluminium panels with friction stir welded connections. These sections are built over the complete width and connected to the hull with triclad aluminium steel connection strips.

Sections 1201/02 contain the electric propulsion motor and the aft stabilizing fins, both of which will be installed before the sections are welded together.

Sections 1301/02 contain the GRP sea water ballast tanks.

Sections 1401/02 contain the forward stabilizing fins as well as the box coolers.

Sections 1101/02 and 1501/02 contain the fresh water ballast tanks.

Sections 1103 to 1403 contain the small equipment, pumps etc.

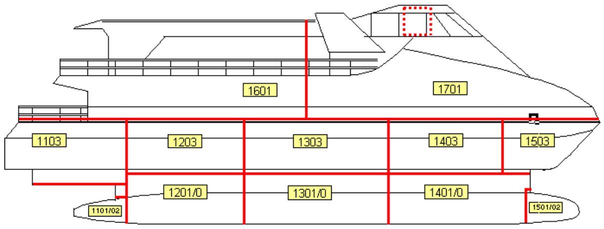

Figure 8 : Section Plan

The sections will be outfitted and built together in the assembly hall after painting both inside and outside with a Sigma paint system.

5.0 CONCLUSION

The determination of the design loads is critical in proceeding with the design of the SWATH. It is clear to the building team that the best way to proceed is to obtain early confirmation of the wave environment in which the vessel will operate and then to perform model tests with force measurement in combination with hydrodynamic calculations. This will allow the designer to finalise the scantlings for the vessel at an early stage in the design process.

The first hull is due to be launched in September 2003 and the SWATH vessel will commence operation in early 2004.

The building team will be proud to show you around on the SWATH vessels on the pleasant trip from Vlissingen to Breskens and back.