SWATH Technology
Advanced SWATH Design Methods

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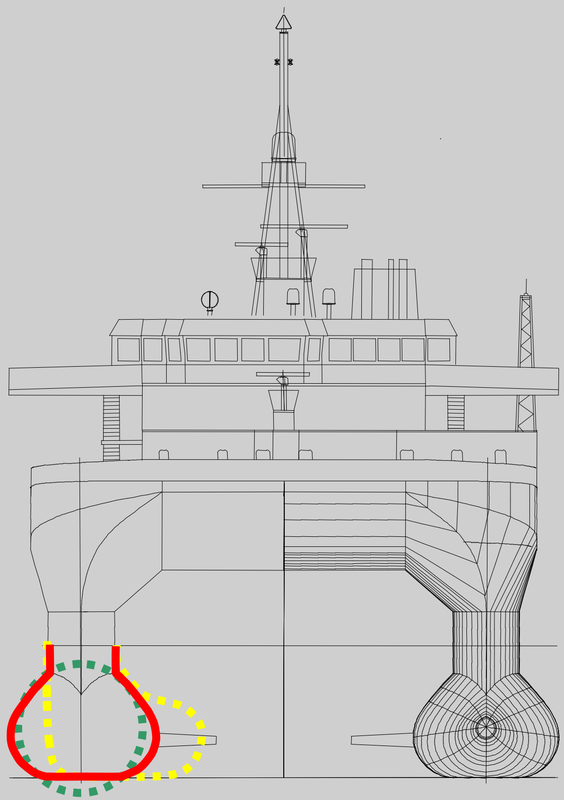
Agenda

1. SWATH technology: advantages/limitations
2. SWATH design: special features
3. OptiSWATH: Hydrodynamic optimization of SWATH vessels
4. Design examples
   a) Research and Trials SWATH „Planet“
   b) Fast Offshore Patrol SWATH
5. Conclusions
6. Literature

SWATH technology



Front view research and trials ship “Planet”

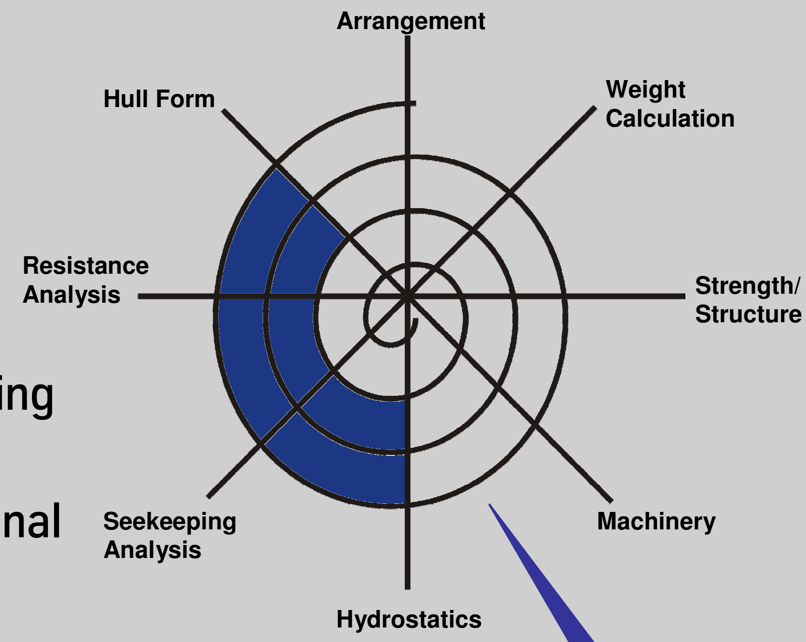
- Small Waterplane Area Twin Hull
- Two submerged floaters are connected by slender struts to a platform well above the waterline
- Stable platform even in higher sea states. Low motions, accelerations and add. resistance in waves
- Large deck space area
- Due to the increased wetted surface power demand is higher compared to a monohull
- Limited deadweight capacity; changes in deadweight generate significant change in draught and trim
- Military and civil applications: research vessels, offshore patrol vessels, pilot tenders, station vessels, yachts, …

SWATH design

Features of SWATH design:

- A limited number of SWATH vessels has been build, experience is quite little; first principle approaches are required
- Weight optimization required. Lightweight structures by intensive FEM-analysis and intelligent material selection
- Thin struts and cramped floaters require focus on coordination of machinery & outfitting equipment
- Compared to most monohull designs additional hydrodynamic aspects are to be considered (increased resistance, Munk's moment, seakeeping behaviour, fin activity)

Design spiral



To address the hydrodynamic aspects of SWATH design special tools for analysis and optimization are required in order to develop competitive designs

OptiSWATH: Objectives of the Joint Research Project

- Development of a practical design tool
- Implementation of proven codes for resistance and seakeeping analysis for SWATH vessels
- Consideration of foils within the analysis programs
- Automatic generation of sound hull forms by parameter variation
- Hull form optimization with respect to resistance and seakeeping behaviour (multi-objective optimization)
- Test and validation of the implemented codes

Partners:

FRIENDSHIP Systems:	Engineering and Consulting, Potsdam/Germany
HSVA:	Model Basin, Hamburg/Germany
MTG Marinetechnik:	Engineering and Consulting, Hamburg/Germany
TKMS/Nordseewerke:	Shipyard, Emden/Germany

OptiSWATH: Network of Competencies

Techn. Coordination

Nordseewerke

Software Development

- Parametric modelling
- Hyd. optimization
- Framework

FRIENDSHIP SYSTEMS

- CFD
- ν-Shallo

HSVA

- Seakeeping
- SEDOS

MTG

Test and Validation

HSVA

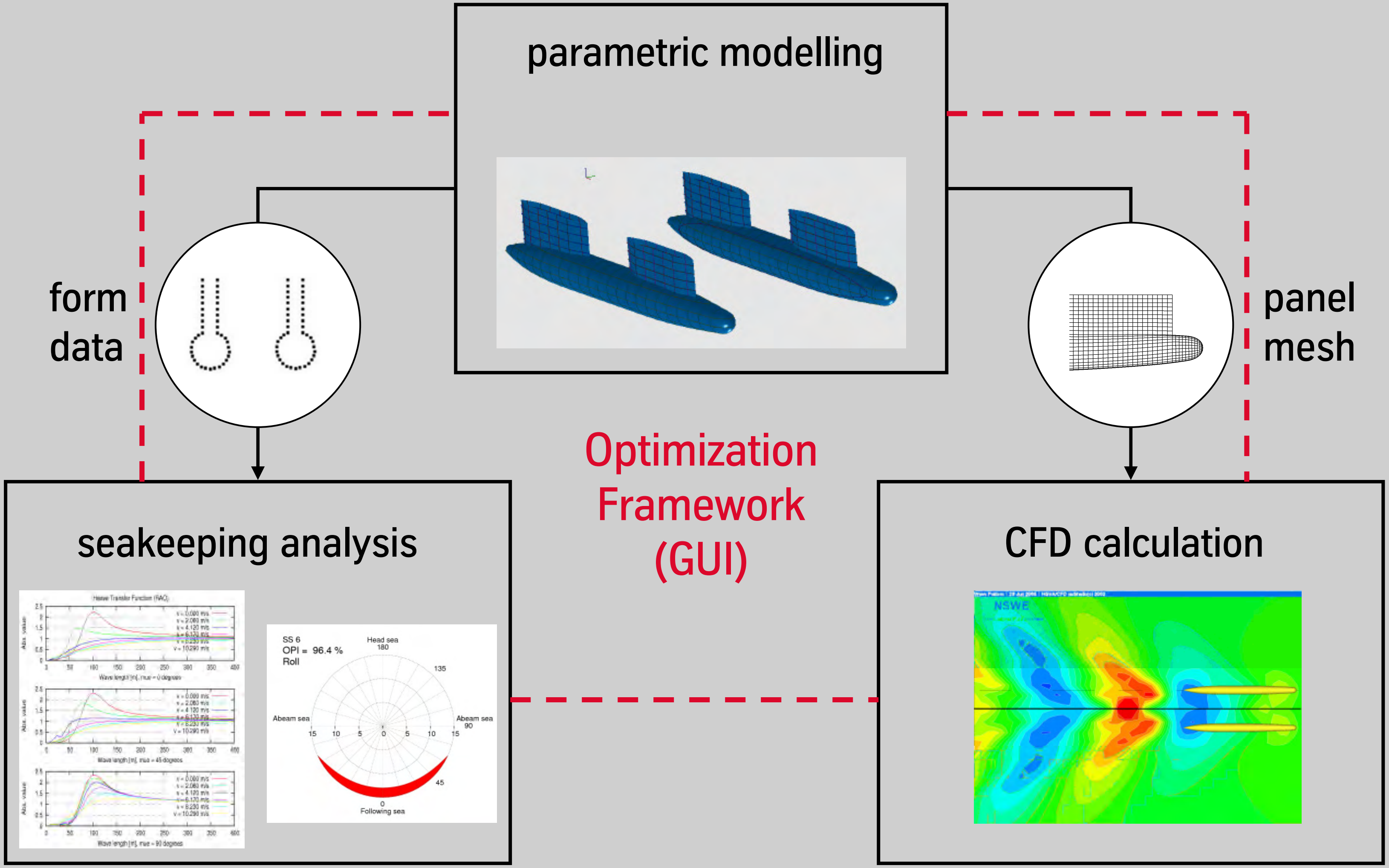
MTG

Nordseewerke

Designtool:

OptiSWATH

OptiSWATH: Program Layout

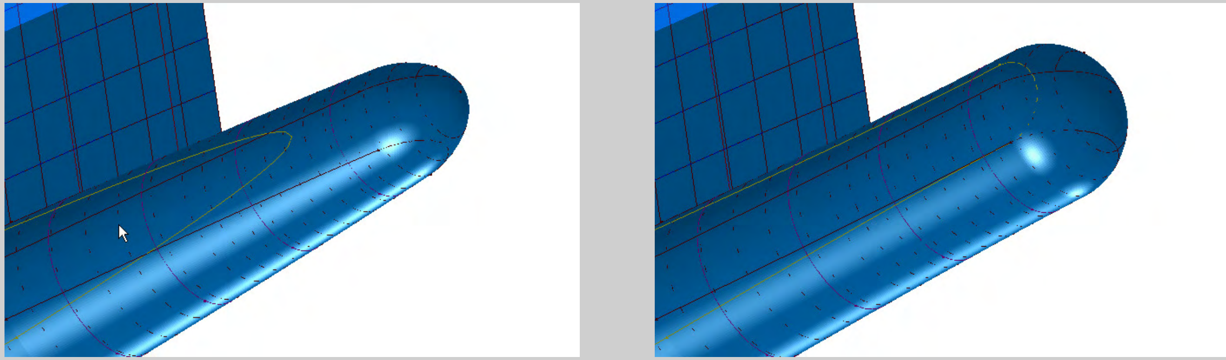


OptiSWATH: Parametric Modelling I

- Parametric modeling as basis for systematic hull form variation and formal optimization
- Hull form description by a set of design parameters:

  - main particulars like length or beam
  - complex form parameters like tangent angles or area coefficients of curves (e.g. sectional area curve)

- Parametric description and automatic fairing of the hulls with FRIENDSHIP-Modeller



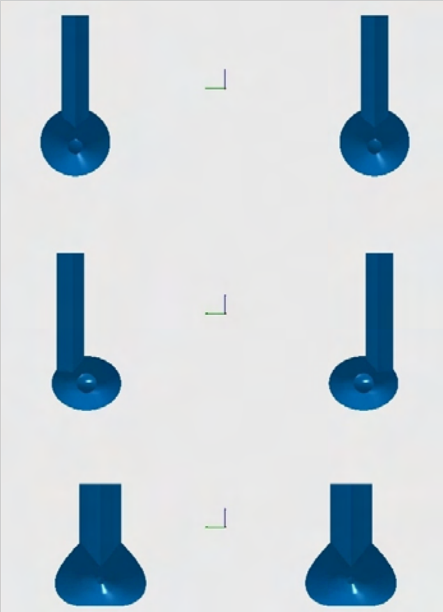
Parametric variation of a SWATH's bow shape by changing two parameters (diameter and position of the forward frame)

OptiSWATH: Parametric Modelling II

Circular shape

Golf club

Elephant foot



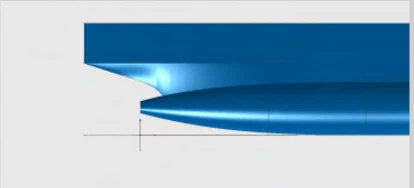
Examples of possible midship sections

Twin strut

Single strut

Examples of strut variations

Stern variant



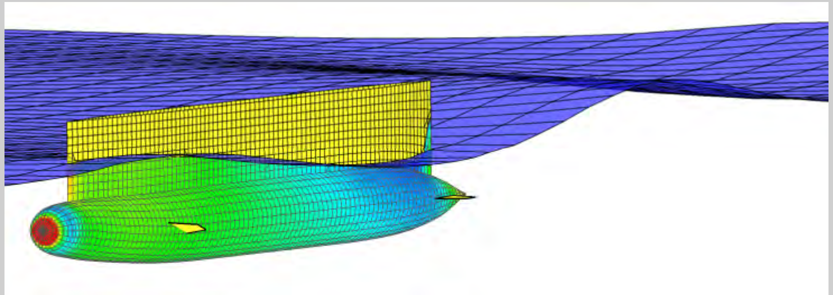
Example of an alternative stern design

OptiSWATH: Hydrodynamic Analysis Codes I

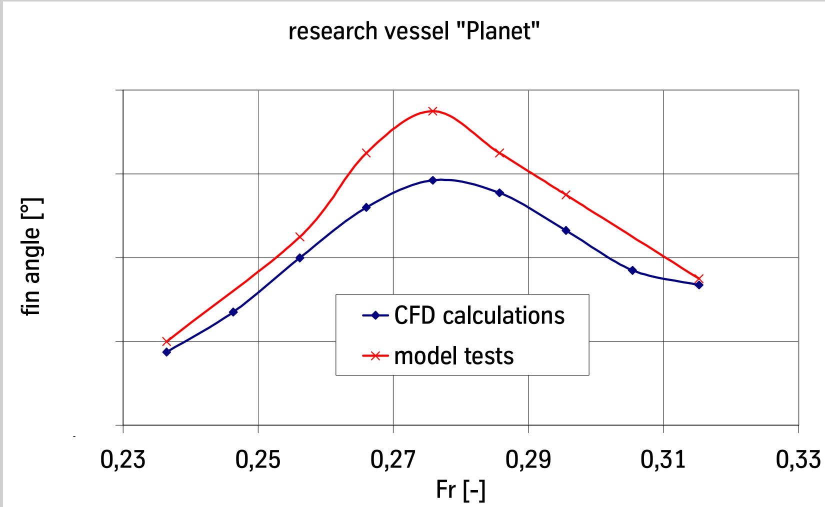
Comp. Fluid Dynamics (CFD)

Code: ν – Shallo SWATH

- Non-linear potential flow code
- Wave resistance
- Wave pattern and pressure distribution
- Trim and sinkage
- Lifting line theory to consider foils



Wave contour and pressure distribution on the hull



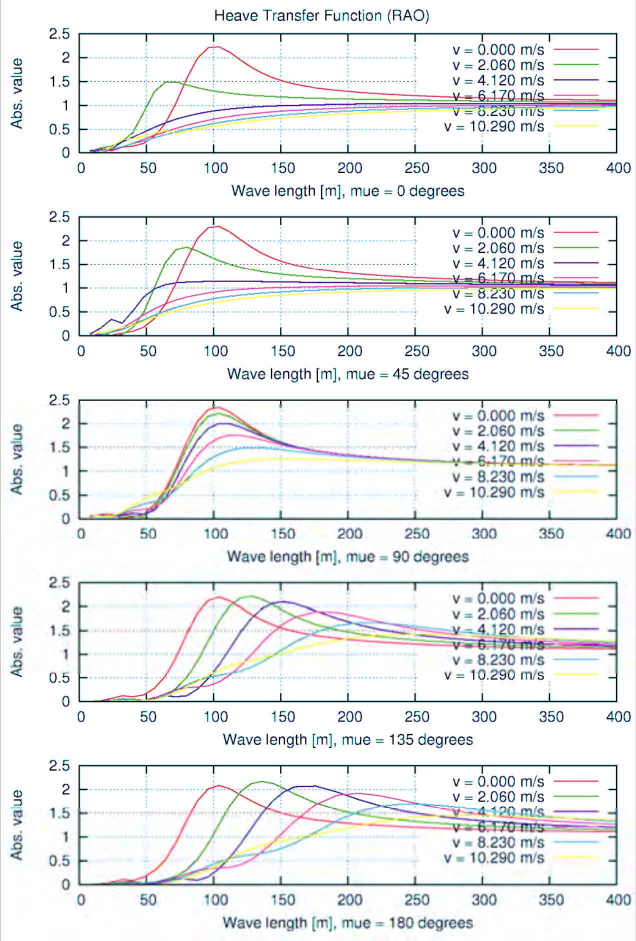
Fin angles calculated and measured

OptiSWATH: Hydrodynamic Analysis Codes II

Seakeeping Analysis

Code: SEDOS

- Linear strip method
- Transfer functions
- Significant motions, velocities and accelerations
- Operability index (OPI)
- Seakeeping performance index (SPI)

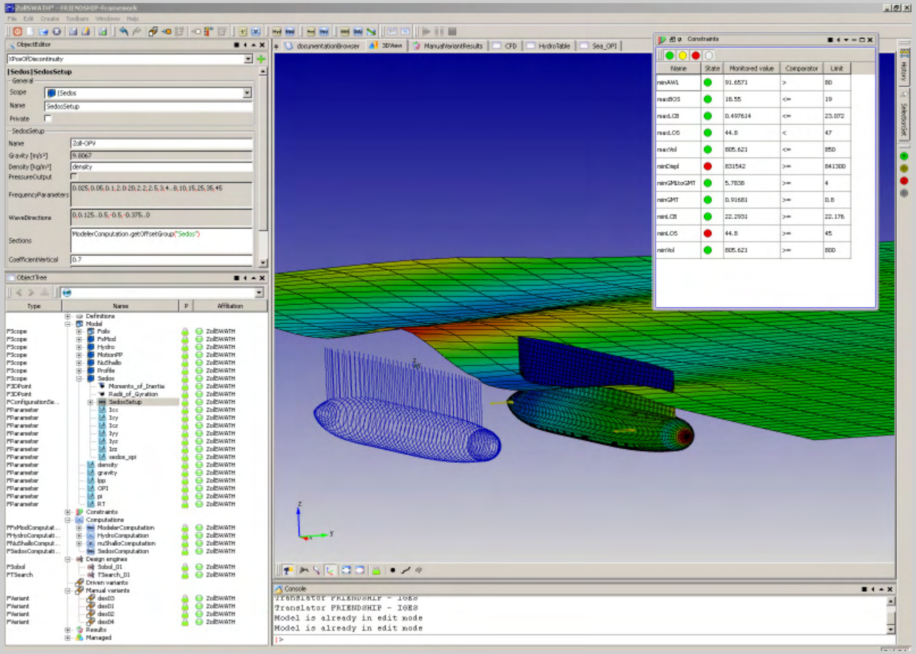


Transfer functions for heave motion as function of speed and heading

OptiSWATH: Optimization Framework

FRIENDSHIP-Framework

- Controller for implemented programs (FRIENDSHIP-Modeller, ν – Shallo, SEDOS)
- Graphical user interface (GUI)
- Design variant management
- Optimization algorithms
- Constraint management



Snapshot of the OptiSWATH-framework

Design Examples:

1. Research and trials SWATH Class 751: „Planet“

Research-SWATH

L_{OA} abt.	73,00 m
B	27,20 m
v	15,00 kn
Disp.	3.500 t

2. Fast Offshore Patrol SWATH

SWATH-OPV

L_{OA} abt.	49,35 m
B	19,00 m
v	20,00 kn
Disp.	900 t

Research SWATH „Planet“: Main Particulars

Main particulars:	
Lenght over all	73,0 m
Beam (under water)	27,2 m
Beam main deck	25,0 m
Draught	6,8 m
Displacement	3500 t
Speed	15 kn
Endurance (at 15 kn)	5000 nm
Crew	25 pers.
Scientists	20 pers.

Research SWATH „Planet“: Tasks and Requirements

Customer:

- German Navy

Main tasks:

- Exploration of the naval environment
- Trials with naval equipment such as torpedoes, decoys, jammers and sonar arrays
- Basic research for acoustic underwater detection and communication

Main requirements:

- Low acoustic signature
- Stable platform in most weather conditions allowing to conduct research work

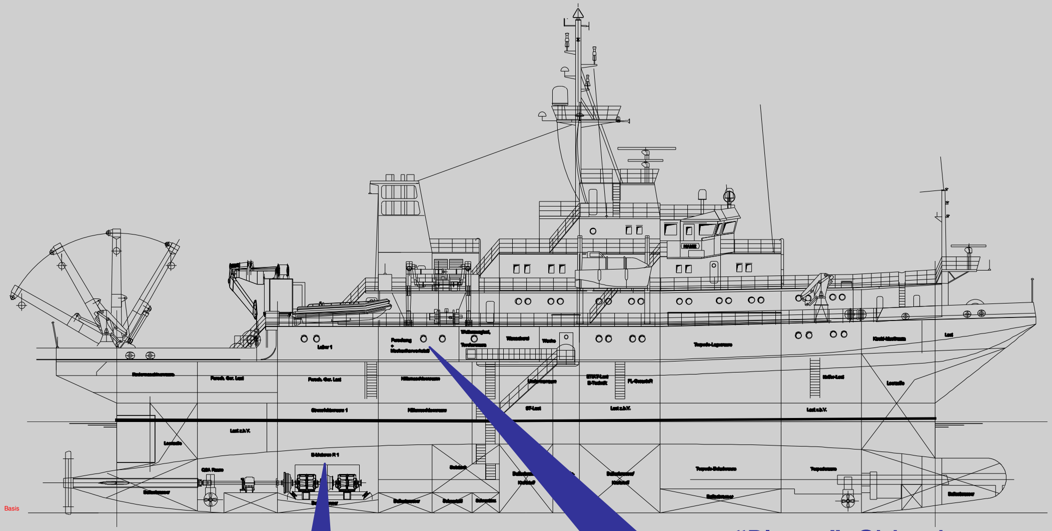
Research SWATH „Planet“: Hydrodynamics

Main features:

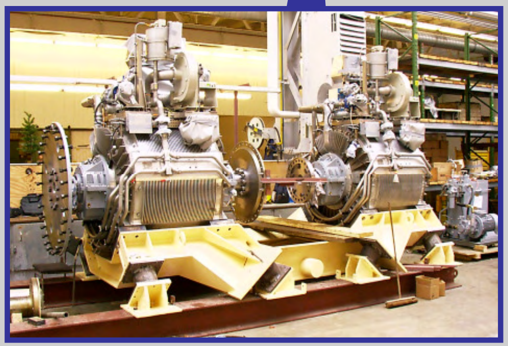
- “Elephant foot” section for high damping behaviour
- Two active (fwd) and four passive (aft) fins
- Seakeeping behaviour*:
  sign. roll angle: 4.8°
  sign. pitch angle: 4.4°
  sign. accel. (a_z): 1,0 m/s² ≈ 0,1g

*Max. values of all headings (worst cases) from model tests with $H_{1/3}$ = 3.5 m and v=13 kn (fins active and passive). Sign. values calculated as two times the measured root mean square (rms) value.

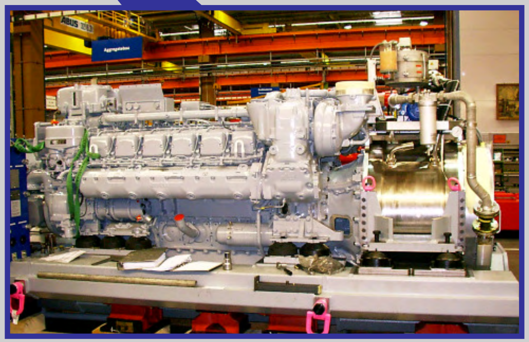
Research SWATH „Planet“: Machinery Overview



“Planet”: Side view



PM propulsion motor

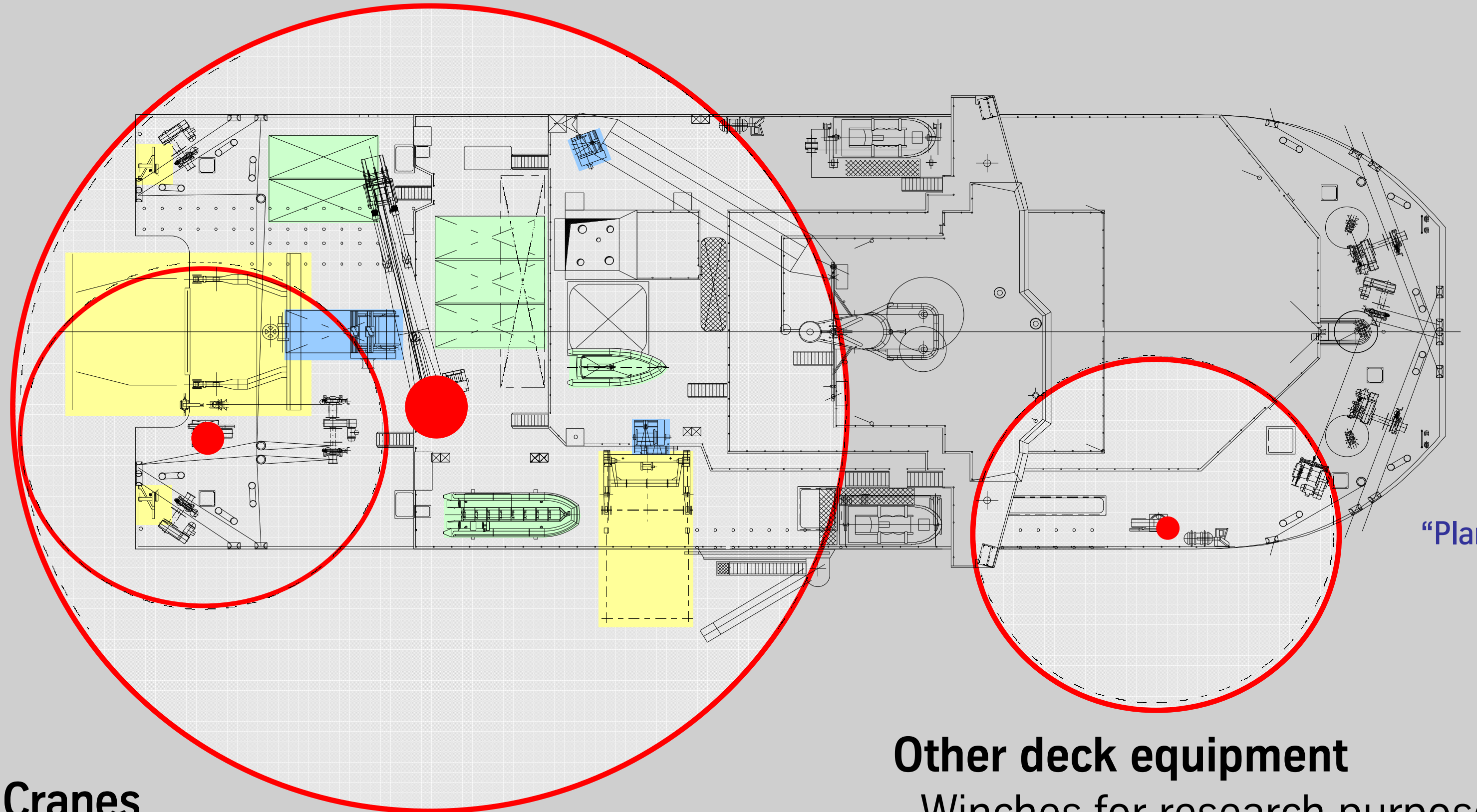


PM generator set

- All Electric Ship (AES)
- 2 x 2 PM propulsion motors each 1040 kW at 150 rpm (main and booster engine)
- 2 PM generator sets 1250 kW each driven by MTU 12V396
- 2 PM generator sets 1700 kW each driven by MTU 16V396
- Double-elastic mounting
- Dynamic positioning system with 4 thrusters each 350 kW

PM = permanent magnet excited machines

Research SWATH „Planet“: Equipment I

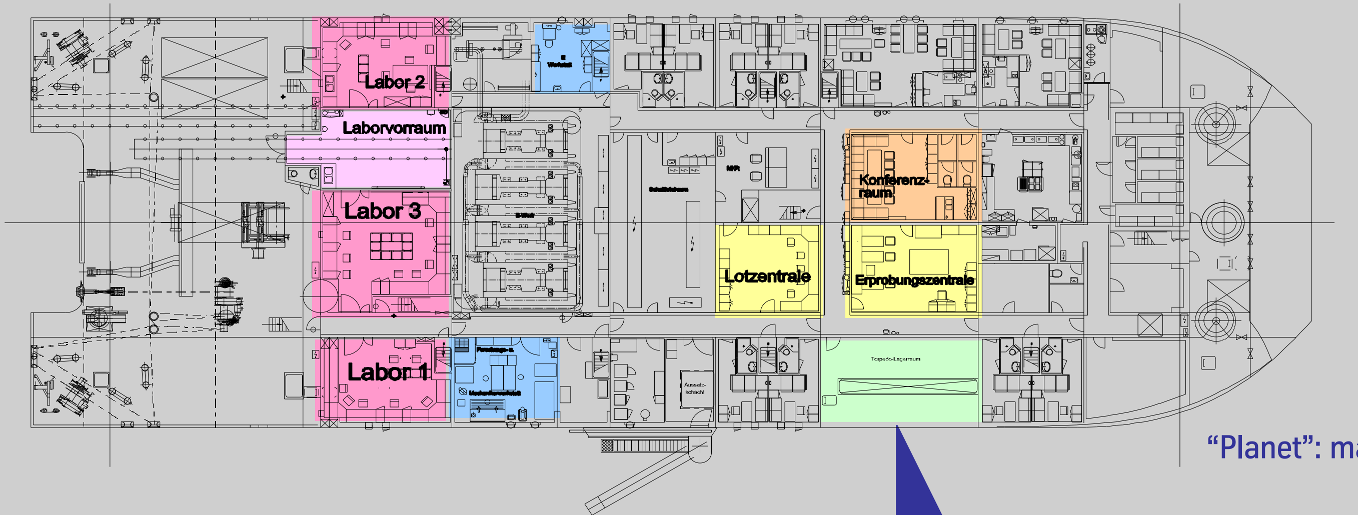


“Planet”: top view

Cranes
- Main crane 12 t, 23 m outreach
- 2 auxiliary cranes 2,7 t each
- Stern- and side gallows

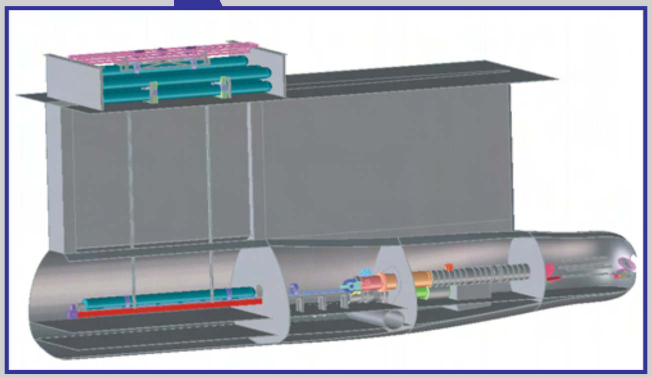
Other deck equipment
- Winches for research purposes
- 2 rescue boats
- 1 speed boat, 1 work boat
- Space for 5 x 20’ containers

Research SWATH „Planet“: Equipment II



“Planet”: main deck

- 3 Laboratories
- 1 electrical and mechanical workshop each
- 2 Research centers
- 1 Conference room



Torpedo test equipment

Design Examples:

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L_{OA} abt.	49,35 m
B	19,00 m
v	20,00 kn
Disp.	900 t

SWATH-OPV: Main Particulars

Main particulars:

Lenght over all	abt. 49,35 m
Beam (under water)	18,55 m
Beam main deck	19,00 m
Draught	4,55 m
Displacement	abt. 900 t
Speed	20 kn
Endurance (at 14 kn)	2300 nm
Crew	13+8 pers.

SWATH-OPV: Tasks and Requirements

Customer:

- German Federal Customs Authority

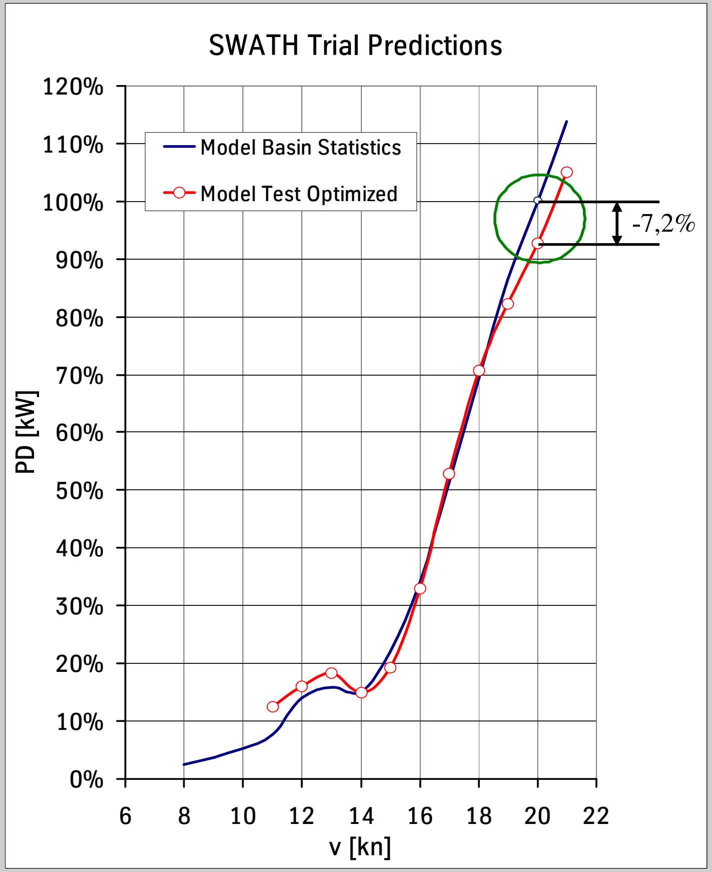
Main tasks:

- Surveillance and protection of the German territorial waters as integral part of of the German Coast Guard
- Boarding and rescue operations
- Patrol area: Southern North Sea / German Bight

Main requirements:

- Reduction of downtime due to bad weather conditions
- Reduction of crew fatigue in higher sea states
- Maximum speed of 20 kn (calm water)

SWATH-OPV: Hydrodynamics I



Trials prediction of optimized hull versus model basin statistic

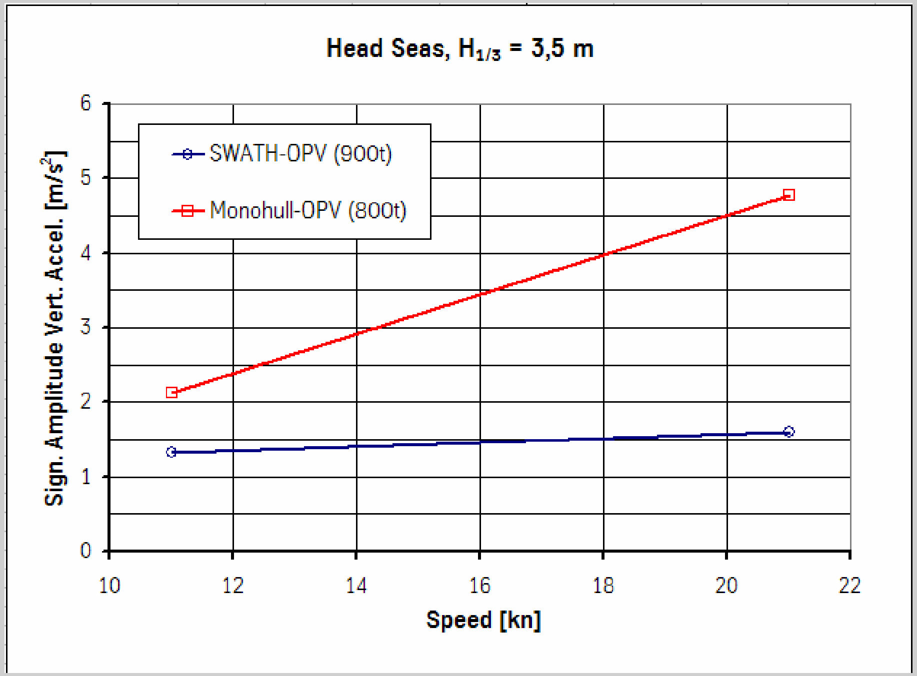
OptiSWATH was used in design process:

- To optimize hull form with respect to lowest resistance at maximum speed.

  A reduction of more than 7% in power demand compared to a statistical power prognosis of a well known model basin could be achieved.

- To check all design variants with respect to customer given seakeeping criteria.

SWATH-OPV: Hydrodynamics II

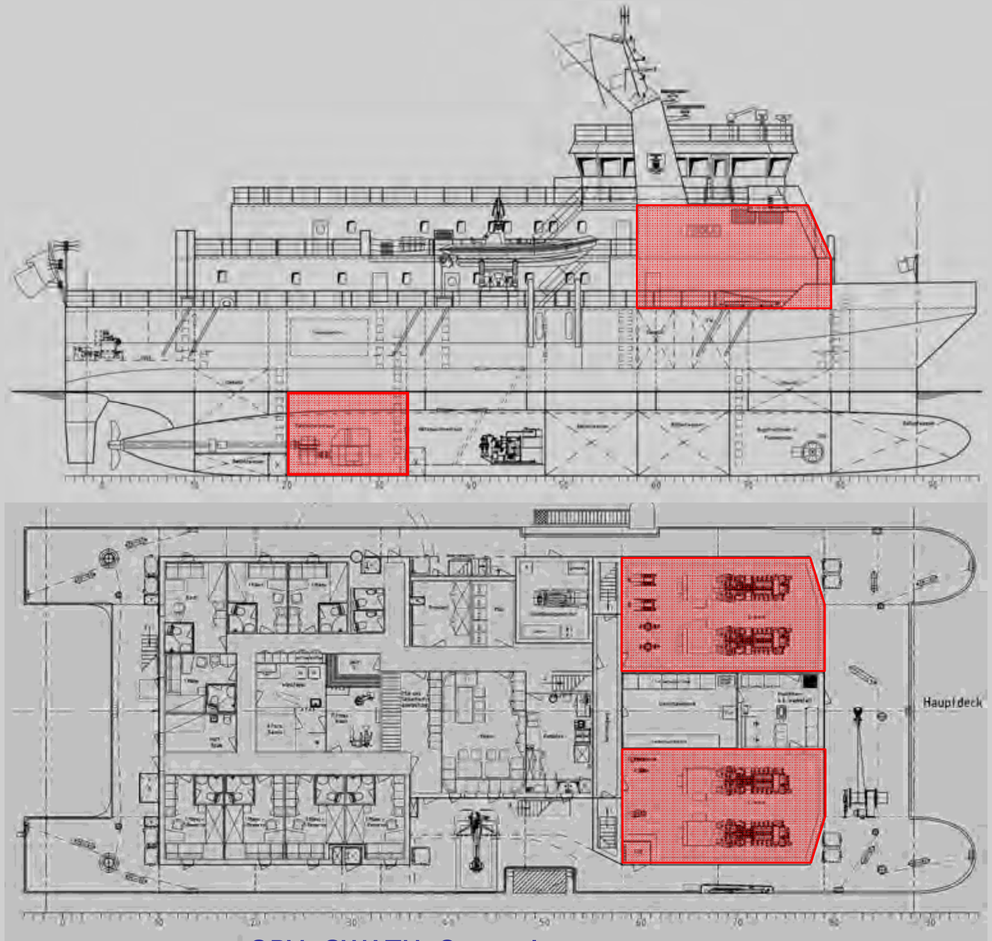


Comparison of vertical accelerations on the bridge for a SWATH and a 800t monohull OPV from published data [4]

Seakeeping behaviour compared to 800 t monohull:

- At cruising speed of 14 kn: about 50% reduced vertical accelerations in head seas
- At higher speeds vertical accelerations up to 2/3 lower
- Roll motions of SWATH about 75% lower than for monohull
- Speed reduction (forced and voluntarily) for SWATH much lower

SWATH-OPV: Machinery Overview



OPV- SWATH: General arrangement
side view (top) and main deck (bottom)

- All Electric Ship (AES)
- 2 async. propulsion motors each abt. 3800 kW at 1800 rpm
- 4 generator sets 2200 kW each driven by MTU 16V4000
- Power plant on main deck; advantageous in service and maintenance
- Dismounting of each single generator set possible through front hatches
- Bow thruster 300 kW
- Four active fins (fwd and aft)

SWATH-OPV: Outfitting

OPV- SWATH: General arrangement of
1. superstructure deck (top) and main deck (bottom)

Accommodation:
- 13 single cabins with bathroom
- 4 double cabins with bathroom

Public rooms:
- Mess room, recreation rooms
- Office and conference room

Other rooms:
- Galley, laundry, provision rooms
- Treatment room
- Mission control center
(on bridge deck)

Boats:
- 8,50m RIB boat, speed 30 kn
- 1 Rescue boat

Boarding Platform

Conclusion

- Advantages as well as the limitations of SWATH technology were presented
- It was shown that SWATH design requires experienced shipyards with advanced design software
- OptiSWATH, a newly developed, integrated design and optimization tool for SWATH vessels, was introduced
- Using OptiSWATH customized SWATH designs with regard to speed and seakeeping behaviour in specified sea climates can be developed
- Design features of a low speed research vessel, the Nordseewerke built SWATH ship “Planet”, were presented
- A high-speed application for SWATH vessels was shown by introducing Nordseewerke’s Fast Offshore Patrol SWATH

Literature

[1] Kennell, C. (1992) „ SWATH ships“, Technical and Research Bulletin No 7-5, The Society of Naval Architects and Marine Engineers

[2] Braun, M., Hollung, A. (2004)„ Forschungs- und Erprobungsschiff Planet an das BWB übergeben“, Schiff & Hafen Vol. 12/2004

[3] Richardt, T., Wetterling, P. (2006) „OptiSWATH – a new way towards optimum SWATH design“, HANSA International Maritime Journal, Vol. 09/2006

[4] NN (2003) „Typschiff einer Serie von Patrouillenbooten an BGS übergeben“, Schiff & Hafen Vol. 02/2003

The End

Thank you for your attention