References

- ECO Lines
Selected References – ECO Lines
Container Vessels
ECO Lines - CV 21,000 TEU

SITUATION AND CRITICAL ISSUE

CV 21k TEU – ECO Lines optimization competition

For the optimization of their new CV 21k TEU fleet, an Asian shipping company contracted DNVGL and a competitor. The party providing the best performing hull lines was to be rewarded with the classification services for six vessels.

DNV GL SOLUTION

- DNV GL applied their advanced AIS analysis and expertise to suggest the client a most appropriate operational profile which was well received.
- By means of the well established ECO Lines hull and propulsion optimization service, DNV GL commenced the optimization by a dense sampling of the design space of abt. 30,000 design to ensure full coverage.
- In subsequent formal optimization phases the 21k TEU hull form was developed to arrive at optimum wave, viscous and propulsion performance.
- Full assessment by advanced CFD power prediction.

VALUE DELIVERED

- DNV GL provided an AIS based operational profile for optimization and later comparison.
- MARIN model tests demonstrated that DNV GL outperformed the competitor’s design in power consumption by 5 to 10% across the operational profile! At a fuel price of 300 USD/t, 220 days @ sea and 6 ships this amounts to yearly savings of more than 5 mio USD/y, leading to ROI of less than one month.

For more information please contact: Karsten.Hochkirch@dnvgl.com
For the new HHI/UASC 14k TEU CV class a formal hull form optimization was carried out in tight cooperation with HHI. Five mutually weighted operational points in the draft range 11.7 to 16 m covering the speed range 15 to 22 kn were considered.

**SITUATION AND CRITICAL ISSUE**

**ECO Lines - CV 14,000 TEU optimization study**

Starting from an excellent performing initial HHI design a formal parametric optimization was conducted in three major phases:

- Review of the propulsion concept by HHI
- The first focusing on the general hull form characteristics (abt. 35k designs generated and analyzed).
- In phase II a fully viscous aftbody optimization was enforced optimizing the aftbody/skeg geometry and wake characteristic.

**DNV GL SOLUTION**

**VALUE DELIVERED**

- According best CFD prediction following was attained:
  - overall performance gain of the above measures of up to 4%  
  - increased stability yielding an increased container intake  
  - uncritical seakeeping behavior and low added resistance in seaways

For more information please contact: Karsten.Hochkirch@dnvgl.com

564-01
SITUATION AND CRITICAL ISSUE
A service to improve the starting point of a new design

DNV GL undertook a study on main dimensions for a new 11k/12k container vessel project to find out, what is the best main dimensions for this type and size of vessel. The purpose was to minimize the costs per transported container for a given operational profile and a specific “cargo mix”.

DNV GL SOLUTION
- Select no. of bays, rows and tiers to arrive at the targeted ship size.
- Perform the loop over select main dimensions, estimate light ship weight and centre of gravity, predict speed-power and assess stability for a range of different container weights (8t/TEU to 16t/TEU).
- Calculate average power according to specified operating speed-draught profile. Calculate average number of loaded containers for specified “cargo mix”.
- Determine Costs Per Thousand Container Miles for the CPTCM-tool for decision support.

VALUE DELIVERED
- The owner gains insight into the interdependencies between main dimensions and power consumption for the specified operational speed-draught profile.
- The owner gains insight into the interdependencies between stability and cargo intake for the specified “cargo mix”.
- Decision support either to go for a more specialized vessel or for a more robust and flexible design.

For more information please contact: eco.maritime@dnvgl.com
ECO Lines – CV 9,600 TEU

SITUATION AND CRITICAL ISSUE

CV 9600TEU – Hull and propulsion optimization

9600TEU container vessel to be optimized for an operational speed and draft matrix. Design competition between DNV GL, the Shipyard and the model test basin.

DNV GL SOLUTION

- Full ECO-Lines Project
- Hull shape optimization
- Viscous aftbody optimization
- Propeller optimization

VALUE DELIVERED

- DNV GL's team won the competition!
- Significant improvements of about 3.4% over the whole operational profile were achieved

For more information please contact: Karsten.Hochkirch@dnvgl.com
Tankers
Starting from a well-known tanker design the propulsion was to be improved as far as possible. Besides of the decision for a g-type engine and a bigger propeller taken by the yard the shape of the aft-body was free to be optimized allowing asymmetric shape.

DNV GL SOLUTION

- DNVGL’s Asymmetric aft ship optimization was applied to the tanker design.
- This service uses a RANSE simulation with a coupled potential solver for the propeller. This makes it possible to directly compute the propulsion efficiencies of the propeller vessel combination. Driven by a state of the art optimization techniques it leads to the optimal asymmetric aft ship.

VALUE DELIVERED

- Aft ship with more than 3 % decreased propulsion power compared to the original tanker design.

For more information please contact: karsten.hochkirch@dnvgl.com
SITUATION AND CRITICAL ISSUE

8500 dwt Tanker – formal hull lines optimization

For the development of a new 8500 dwt tanker fleet, the ship owner required the best hydrodynamic solution for a given constraint set.

DNV GL SOLUTION

- DNV GL’s team ECO-Lines service was applied to optimize the hull form of the new tanker class.
- The service included an assessment of design potentials including discussion, design exploration and a final optimization.
- Hydrostatic and machinery constraints as well as the cargo tank arrangement were considered.
- A dense sampling of the design space of more than 25000 designs ensured a robust minimum of thrust power.

VALUE DELIVERED

- Starting from a baseline design the hull was optimized with respect to resistance and propulsion.
- The optimized hull featured:
  - Increased displacement of 150t
  - KMT and XCB unchanged
  - Delivered power decreased 22% @Design Draft
  - Delivered power decreased 12% @Ballast Draft
- Faired hull was delivered to the customer.

For more information please contact: Karsten.Hochkirch@dnvgl.com
ECO Lines – 12k m³ LEG Carrier

SITUATION AND CRITICAL ISSUE

Optimization of a 12,000 m³ LEG carrier

For a new series of LEG carriers the hull form was to be optimized for an operational speed and draft matrix. Full lines optimization including viscous aft body was applied. For comparability baseline and optimized design were measured at model basin.

DNV GL SOLUTION

- Assessment of the optimization potential
- Full ECO-Lines hull shape optimization
- Optimization focused on three drafts
- Comprehensive set of constraints and hardpoints in due to LNG-arrangement considered
- Tank tests for baseline and optimized design conducted at SVA Potsdam

VALUE DELIVERED

- Initial potential analysis to trigger optimization decision
- Optimized hull shape delivered as finally faired geometry
- Significant gains across the whole operational mix
- Scantling condition exceeding 11.5%
- Design condition exceeding 14.5%
- Ballast condition about 7.0%

For more information please contact: Karsten.Hochkirch@dnvgl.com
General cargo
ECO Lines - 36,500 dwt bulker

SITUATION AND CRITICAL ISSUE

Hull line optimisation for a new series of Lakes-max bulkers

The fundamental design philosophy was “design for flexibility”, giving owners high flexibility to adapt to changing operational scenarios in the future. The general layout was then designed balancing loading flexibility, stability and outstanding hydrodynamics.

DNV GL SOLUTION

- A dedicated **formal hull lines optimization** was carried out in close cooperation with Cyprus based Intership Navigation (Owner) and Shanghai Odely Marine Engineering (Design office).
- **Constraints** for displacement, **stability**, required cargo capacity and machinery space were evaluated for each design.
- About **35 000 Designs** were generated driven by state of the art **high performance optimization algorithms** to select the most favored design.

VALUE DELIVERED

- “ [...] in fact, the results show no savings by the PID, which very much speaks for your very good hull optimisation. [...] we will not further consider any PID (except rudder bulb) and will keep the well designed aft body undisturbed by any interferences.”

For more information please contact: juryk.henrichs@dnvgl.com

> 25% gain
SITUATION AND CRITICAL ISSUE

Optimization of hydrodynamic performance
Improving hydrodynamic performance of a bulk carrier series

DNV GL SOLUTION

- ECO-Solutions for:
  - global performance optimization
  - viscous aft body optimization
  - Design and ballast condition
  - Propeller design

VALUE DELIVERED

- optimized hull lines delivered
- model tests at CSSRC weighted savings abt. 2.85.% from model tests with stock propeller
- further savings from propeller design
- total weighted savings: 4.3%

For more information please contact: Karsten.Hochkirch@dnvgl.com
Cruise liners
Yachts
Optimization of a modern cruise liner

For a new cruise liner the Meyer ship yard tried to push the current state of the art further in order to make its offer to ship owners even more attractive. DNV GL was contracted to optimize the design for the operational conditions.

**DNV GL SOLUTION**

- DNV GL’s team ECO-Lines service was applied
- This includes parametric modeling of the ship hull shape and subsequent hydrodynamic analysis
- A substantial set of boundary conditions to conform with the design constraints made this project exceptionally complex

**VALUE DELIVERED**

- While maintaining the already outstanding performance of the hull at the design condition, a substantial improvement of almost 5% could be identified for the slower operating modes by taking advantage of a radically different bulb shape

For more information please contact: Karsten.Hochkirch@dnvg.com
ECO Lines – 240 Pax Expedition Cruise Liner

SITUATION AND CRITICAL ISSUE

Hull line optimization for two 240 Passenger Expedition Cruiser

Due to polar operations bunker cost are second highest operating costs for this type of cruise vessel. DNV GL was contracted by the owner to explore and utilize the hydrodynamic savings potential.

DNV GL SOLUTION

- A dedicated **formal hull lines optimization** using state of the art optimization and analysis techniques was carried out in three steps.
  - Exploration of the savings potential and definition of hard points and constraints
  - Global optimization to exploit this potential for valid designs with respect to GAP and stability
  - Fine tuning of the design to further improve stern slamming behavior
- A **close cooperation with owner and yard** was key to make the full savings potential accessible.

VALUE DELIVERED

- **> 10%** saving in average over the defined operational profile by hull form optimization leading to a **ROI of less than 6 months**.

For more information please contact: juryk.henrichs@dnvgl.com
German shipyard Blohm & Voss was developing a new 80m type yacht as semi custom platform. The most efficient hydrodynamic solution for a hull form under the given constraints and requirements was searched for.

**SITUATION AND CRITICAL ISSUE**

Hull Lines Optimization of an 80m Type Yacht

**DVN GL SOLUTION**

- A dedicated **parametric model** was implemented in order to cope with the comprehensive requirements for a super-yacht vessel such as room requirements and stability.
- About **18 000 Designs** were generated driven by state of the art **high performance optimization algorithms** to find the best possible design.
- Improvements of 5.5% were found for the optimized design over the defined operational profile.

**VALUE DELIVERED**

- Final hull form fulfilling all nine hard points, stability, and buoyancy requirements. Displacement was also increased by 47 tons.

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Ferries
SITUATION AND CRITICAL ISSUE
Hydrodynamic analysis of a catamaran ferry for lake Bodensee

For economical and ecological considerations the Bodensee-Schiffsbetriebe GmbH wanted to reduce the operational speed of their existing catamaran ferry from 40 km/h to 32 km/h. DNVGL was to identify possible hydrodynamic improvements wrt. the reduced speed.

DNV GL SOLUTION

- **RANSE CFD calculations** have been carried out to assess the speed-power characteristic of the hull as well as the wave pattern and flow details.
- **Expert review of** the hydrodynamic shaft-line and appendage design has been carried out in order to identify possible improvements.
- **Design of a new propeller optimized for operation at the new target speed**, but allowing a maximum speed close to the design speed.

VALUE DELIVERED

- Besides a better understanding of the hull performance over the speed range some easy-to-adopt improvements to the shaft line and appendage design were delivered as well as an optimized propeller design with a considerable reduction in fuel consumption at the new target speed.

For more information please contact: karsten.hochkirch@dnvgl.com
ECO Lines – Alaska Ferry

SITUATION AND CRITICAL ISSUE

Hull Lines Development of an Alaska Ferry

For the Alaska Marina Highway a replacement for one Ferry was planned. DNVGL was contracted to develop the hull lines for best hydrodynamic performance.

DNV GL SOLUTION

- A particular parametric model was implemented according to customers recommendation including the specified constraints and hard points for the ferry design.
- About 18 000 Designs were generated driven by state of the art high performance optimization algorithms to find the best possible design.
- A best design was chosen for the operational profile defined by the customer.

VALUE DELIVERED

- The optimized hull form with three different bow proposals “optimum”, “wide bow” and “slim bow” was delivered to the customer.
- The weighted resistance reduction of the finally selected hull form variant compared to the baseline was 20%.

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Navy
ECO Lines – Semi-planing navy vessel

SITUATION AND CRITICAL ISSUE

Optimization of a semiplaning hull

In order to provide a more competitive offer for a series of semiplaning boats the shipyard wanted to reduce the powering requirement in order to fit a smaller sized engine.

**DNV GL SOLUTION**

- Parametric modelling of the specific hull shape and detailed CFD analysis for the baseline design
- Assessment of all design constraints, e.g. volume, stability, hard points
- Formal optimization to achieve sensible reduction if powering requirement
- Detailed CFD analysis for the finally selected design.

**VALUE DELIVERED**

- The final design featured a power consumption which allowed to reduce the required engine power without sacrificing the speed requirement
- This allowed the shipyard to provide a more attractive offer to the client.

For more information please contact: karsten.hochkirch@dnvgl.com
**ECO Lines – Frigate F125**

**SITUATION AND CRITICAL ISSUE**

**Exploration Study for a Frigate**

For the German Navy, a design exploration study for a frigate F125 was carried out in cooperation with Blohm & Voss Shipyard

Objective: Optimize fuel consumption during operation while maintaining displacement and stability in calm water and in waves

**DNV GL SOLUTION**

- Operational profile consisting of 4 weighted combinations of speed and draft was considered
- 27,000 design variants considered

**VALUE DELIVERED**

- minor change in beam allowed to utilize a significant fuel savings of 5-7%, while maintaining the required

For more information please contact: Karsten.Hochkirch@dnvgl.com
CFD study – Frigate hull extension

SITUATION AND CRITICAL ISSUE

Retrofit study for hull extension of the F123 frigate

Hydrodynamic exploration of hull extension for German frigate F123 was carried out together with Blohm & Voss Shipyards. Installation of a towed array sonar required and extension of the existing frigate to provide sufficient space.

DNV GL SOLUTION

- Consideration of speed 18 kn and speed 30 kn
- ~10,000 variants of new aftbody investigated with fully parametric geometry model and 3d potential flow simulations and semi-empirical consideration of viscous effects
  - Influence of individual form parameters investigated
  - Extensive design data base created

VALUE DELIVERED

- Based on the design knowledge gained, we recommended detailed geometry with:
  - Significantly improved stability
  - Improved hydrodynamic performance

For more information please contact: Karsten.Hochkirch@dnvgl.com
Misc
SITUATION AND CRITICAL ISSUE

Hull line optimisation for new Ocean Research Vessel

Glosten Associates was aiming for the most efficient hull for their new ORV design for Xiamen University in China. Main dimensions and power consumption were optimized during the project. In addition bubble sweep down was optimized as a key parameter to extend the operational range of the vessel.

DNV GL SOLUTION

- A dedicated parametric model was implemented in close cooperation with The Glosten Associates and used in an automatic optimization process.

- Constraints for displacement, intact and damage stability, required space for thrusters machinery research instruments and workspace were evaluated for each design.

- About 15 000 Designs were generated by state of the art high performance optimization algorithms to select the most favored design.

VALUE DELIVERED

- Most suitable main dimensions were identified. Final hull form guarantees a low bubble sweep down and an optimized propulsion power demand fulfilling all required hydrostatic properties, hard points and spaces requirements.

For more information please contact: karsten.hochkirch@dnvgl.com
ECO Lines – Offshore tug

SITUATION AND CRITICAL ISSUE

Hydrodynamic optimization of an offshore tug

The design of the shipyard did not perform to contract specifications even after a modified hull was investigated.

DNV GL was contracted to improve the performance to attain contract conditions.

DNV GL SOLUTION

- By means of a formal optimization of the forebody shape a large number of design alternatives have been developed and a promising candidate identified.

VALUE DELIVERED

- The model test of DNV GL’s team design proposal confirmed a saving of about 20% propulsion power at the design speed.
- The contract condition of the shipyard could conveniently be met.

For more information please contact: Karsten.Hochkirch@dnvgl.com
Twin skeg – Rudder Optimization

For the development of a new ULCV the customer wanted the most efficient design possible. DNV GL was contracted to optimize the rudder design. Included was also an extensive analysis of the performance for different rudder and head box combinations.

DNV GL SOLUTION

- DNV GL’s ECO-Solutions service was applied to optimize and design the rudder blade of a ULCV for optimal performance while maintaining the maneuvering and cavitation properties.
- Subsequently an extensive CFD study was carried out to investigate the performance of the rudder in combination with different head box geometries.

VALUE DELIVERED

- With the new rudder design only a gain of close to 1% in total resistance could be realized.
- The CFD study revealed a significant influence of the head box design on the resistance of the vessel. It also revealed a very beneficial head box design as provided by DNV GL.

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