SHIP EFFICIENCY 2017
by STG
6th International Conference
Hamburg, 25 – 26 September 2017

Presentation on:

Fuel efficient tanker design

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The German Society for Maritime Technology
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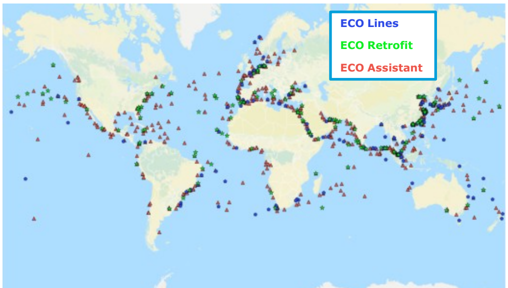


1,000+ vessels optimized:

Savings	per day	overall
CO_2 [t]	7,900	7.7 Mio
Fuel [t]	2,600	2.5 Mio
Costs* [$]	0.52 Mio	750 Mio

MARITIME

Fuel Efficient Tanker Design

Yesterdays ideas – tomorrow's savings

Ship Efficiency Conference, Dr. Karsten Hochkirch, DNV GL

Hamburg, 2017-09-26

*) assuming an average fuel price of 300 $/ton

Maritime Advisory in DNV GL

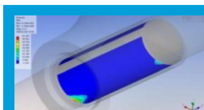
Shipping Advisory

Concept Advisory

Structures

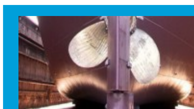
Noise & vibration

Hydrodynamics



Mechanical & Systems Eng.

Safety, Risk & Reliability



Lifecycle Management

Agenda

1. **Today's design tools**
2. **Yesterday's ideas**
3. **Tomorrow's savings**

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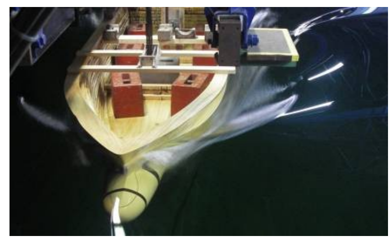
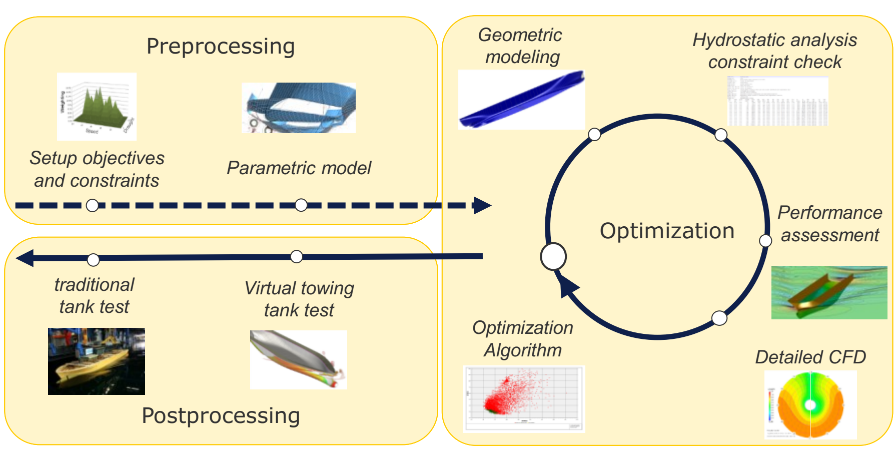
Hull lines development – traditional way

- Open drawer
- Select similar ship
- Adjust dimensions
- Some selected CFD
- Modeltesting
  - Bossing
  - Rudder configuration
  - Propeller position
- Done!

- **Variations looked at < 10**



Today's design tools – DNV GL's unique optimization process



Optimization of a LEG carrier – multi-objective optimization

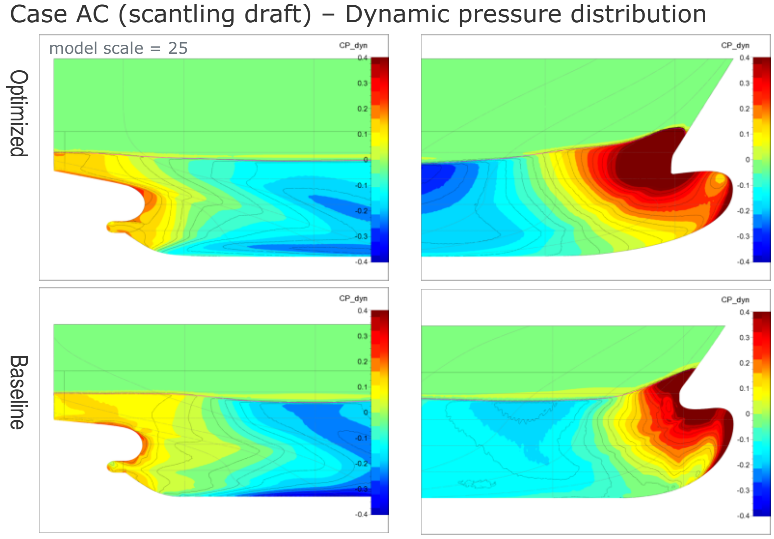
Case **AC** (Scantling) weighted by 25%
- Draft : 9.50 m
- Speed: 14.3 kn

Case **BB** (Design) weighted by 50%
- Draft: 7.50 m
- Speed: 15.3 kn

Case **CA** (Ballast) weighted by 25%
- Draft aft: 6.50 m
- Draft fwd: 4.50 m
- Speed: 15.8 kn

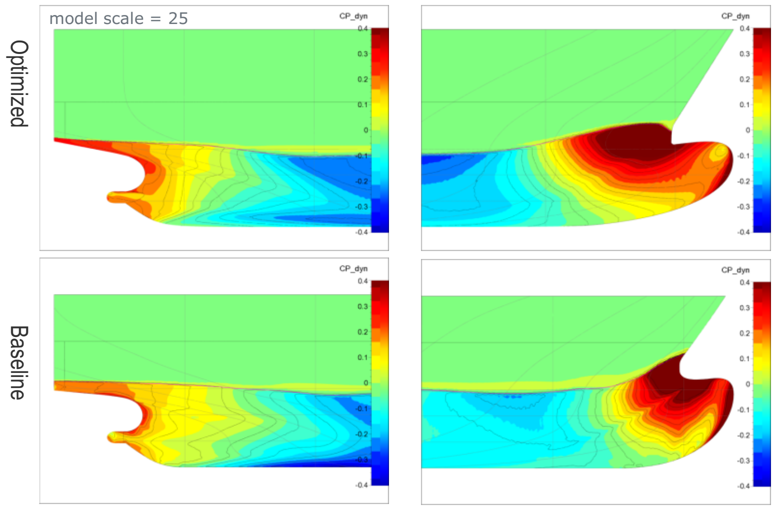
LEG Tanker – Baseline & Optimized

Case AC (scantling draft) – Dynamic pressure distribution



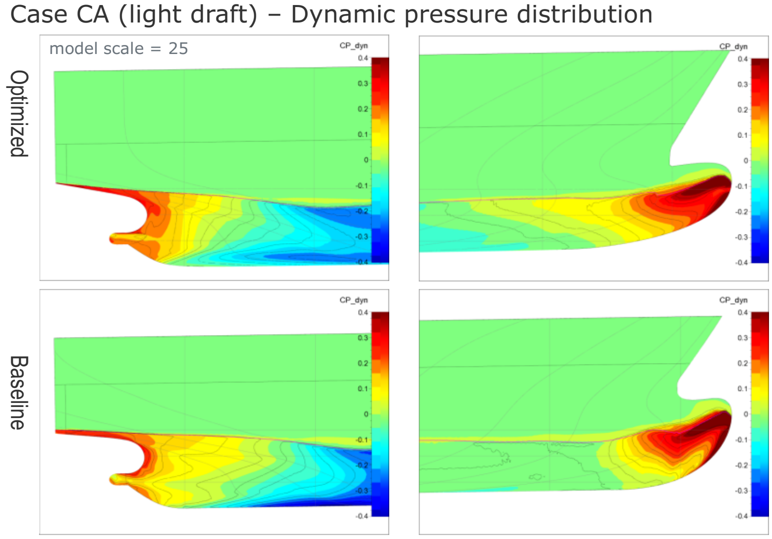
LEG Tanker – Baseline & Optimized

Case BB (design draft) – Dynamic pressure distribution



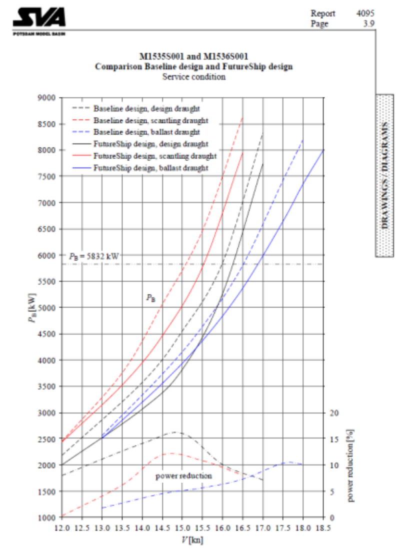
LEG Tanker – Baseline & Optimized

Case CA (light draft) – Dynamic pressure distribution

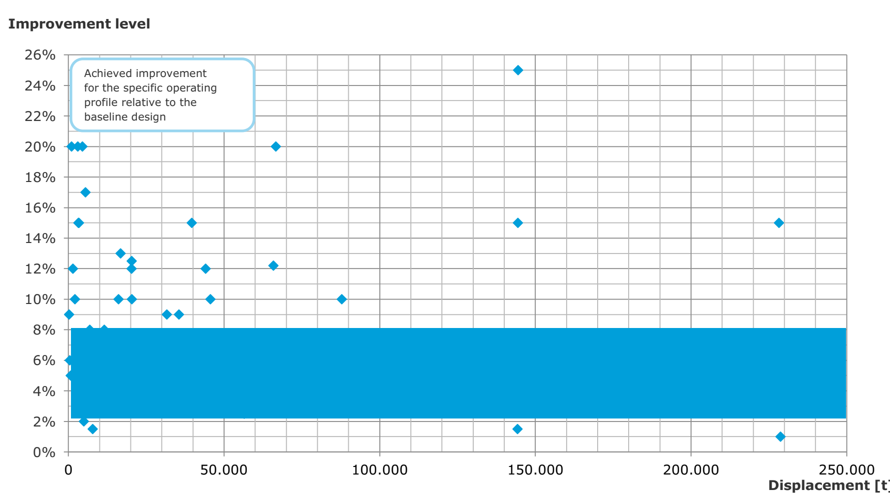


LEG Tanker – Results

Case	Relative total resistance Optimized / Baseline	Achieved Improvement	Weight
AC (scantling)	84.0%	16.0%	25%
BB (design)	82.9%	17.1%	50%
CA (ballast)	95.3%	4.7%	25%
Weighted total improvement in RT [%]		13.7%	



Benefit of hull lines optimizations for various ship types



Fuel Efficient Tanker Design

Motivation

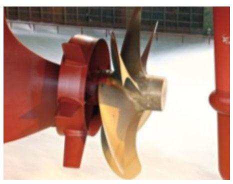
Ship type		RoPax Ferry	14000 TEU ULCV	Gas Tanker	76k Bulker
Lpp / B / T	m	**200 / 27 / 13.0**	**397 / 56.4 / 16.5**	**145/21.6/9.5**	**225x32.2x14.5**
Speed	kn	**25**	**26**	**16.5**	**14.5**
Displacement	t	**80,000**	**240,000**		**76,000**
Installed power	kW	37,000	54,000	6,000	8,500
Service condition (75%)	kW	**27,750**	**40,500**	**4,500**	**6,375**
Time at sea	days/year	200	250	250	220
	h/year	4800	6000	6000	5280
Engine	Fuel type	IFO380	IFO380	IFO380	IFO380
Fuel oil price	$/t	325	325	325	325
Specific fuel consumption	kg/kWh	0.175	0.175	0.175	0.175
Sludge	%	1.5%	1.5%	1.5%	1.5%
Savings					
Assumed improvement	%	**5.0%**	**4.0%**	**11.0%**	**5.0%**
Fuel oil savings	t/day	5.9	6.9	2.1	1.4
Fuel savings	t/year	1183.0	1726.5	527.5	298.9
Reduced investment in main engine	$	301,327	351,820	107,501	69,224
Annual savings per vessel	**$/year**	**384,469**	**561,117**	**171,453**	**97,156**
Annual savings for a fleet of	**5**	**1,922,347**	**2,805,587**	**857,263**	**485,782**
Emmisions saved per year (approx.)					
Carbon dioxide (CO_2)	t/year	**3,903.8**	**5,697.5**	**1,740.9**	**986.5**
SO_2	t/year	**94.64**	**138.12**	**42.20**	**23.92**
NOx	t/year	**99.90**	**145.80**	**44.55**	**25.25**

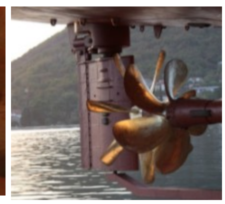
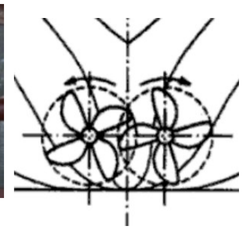
Agenda

1. Today's design tools
2. **Yesterday's ideas**
3. Tomorrow's savings

Rotational losses

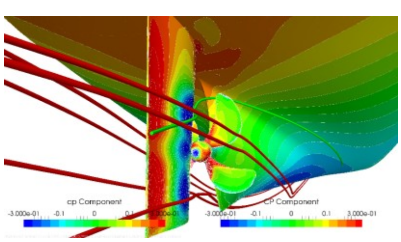
- Since engineers have understood the nature of "rotative" propulsion it is known that a part of the energy is left behind as rotation in the flow field.
- pre-rotation or pre-swirl in front of or equalization behind the propeller saves propulsive energy.
- Several measures and devices were introduced to produce pre-swirl or reuse the rotating flow behind the propeller.
- Most of the ideas that are practically used are based on ducts or fins.

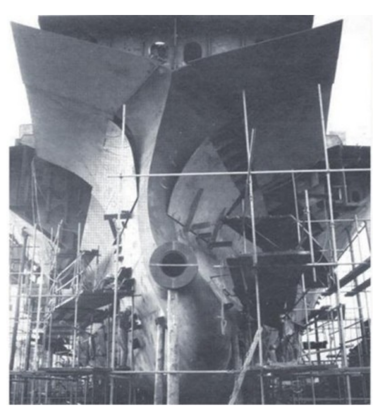


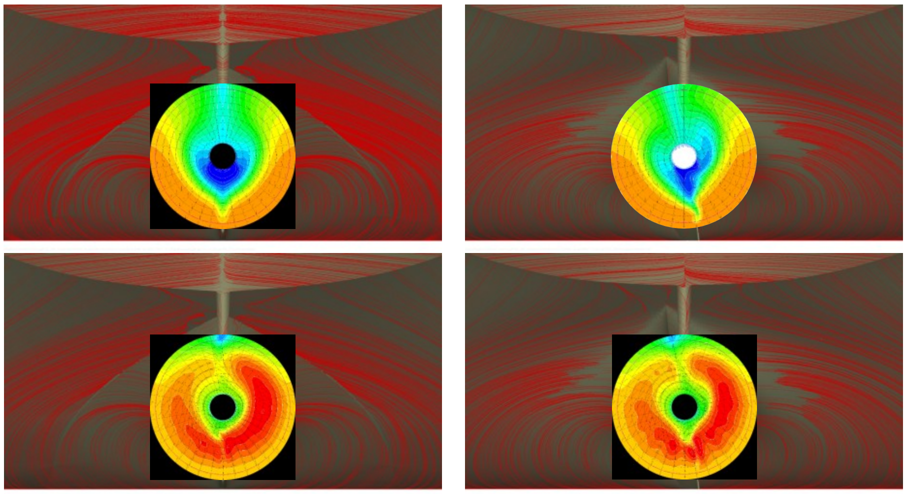
Yesterday's ideas…

- Nönnecke pioneering in the 60's
- Asymmetrical aft ship





Symmetry vs. Asymmetry



Fuel Efficient Tanker Design

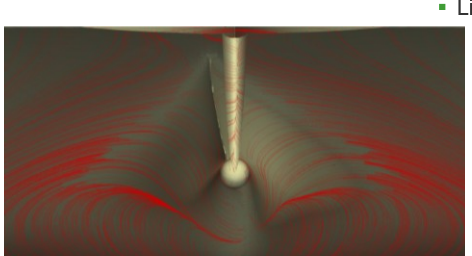
Asymmetric stern

Pros

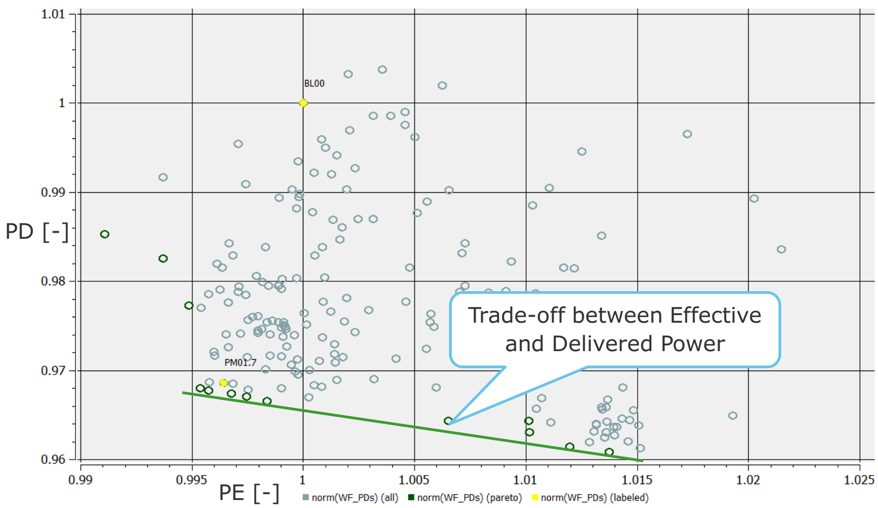
- Introduces pre swirl (similar to fins)
- Improves propulsive efficiency
- No appended devices, better structural integrity

Cons

- More complex to build
- Optimization and analysis is more complex
- Model tests or advanced CFD methods are required
- Traditional design is unlikely to yield optimum
- Likely increase in Resistance



Optimization – PD / PE



Asymmetric Aft Ship Optimization for a 38,000 dwt Tanker

Agenda

1. Today's design tools
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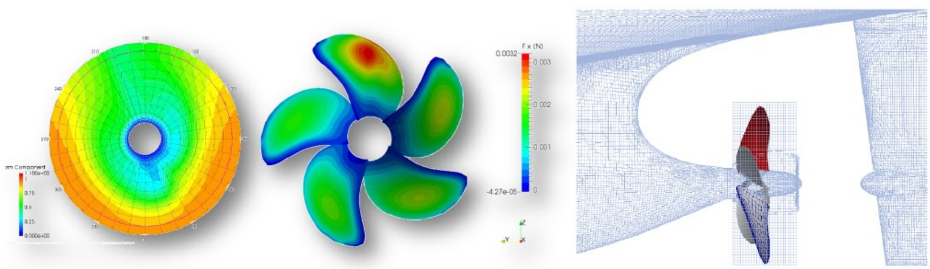
Fuel Efficient Tanker Design

New design tools

Combining

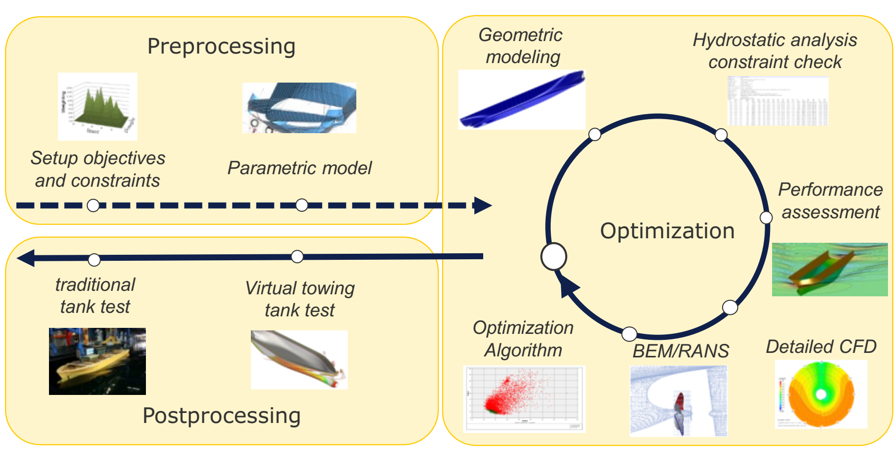
- state of the art Propeller computation tool
- Viscous RANS analysis

Gives a perfect team to deliver best accuracy + good response time



Fuel Efficient Tanker Design

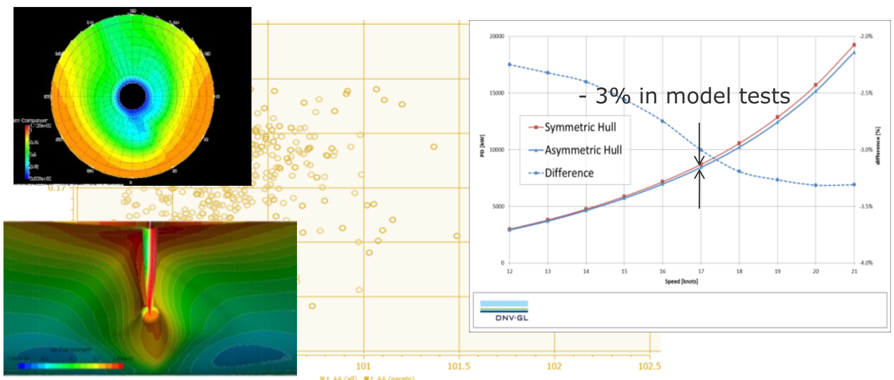
Today's design tools – DNV GL's unique optimization process



Fuel Efficient Tanker Design

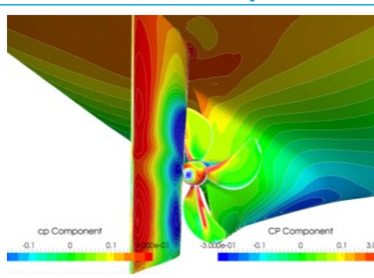
3% decrease of power found for a container feeder vessel

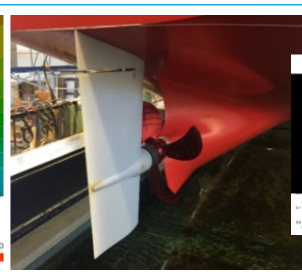
- In a recent project, a 3000 TEU container carrier was tuned to achieve minimum power consumption. Starting from a well optimized symmetric baseline design the additional freedom for an asymmetric aft ship design achieved a **propulsion power reduction** of **3%** as confirmed by the model test.

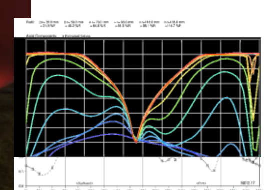


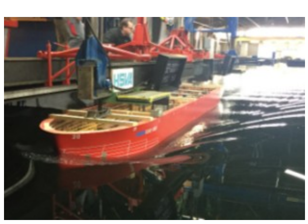
Fuel Efficient Tanker Design

3.8 % decrease of power found for a tanker vessel







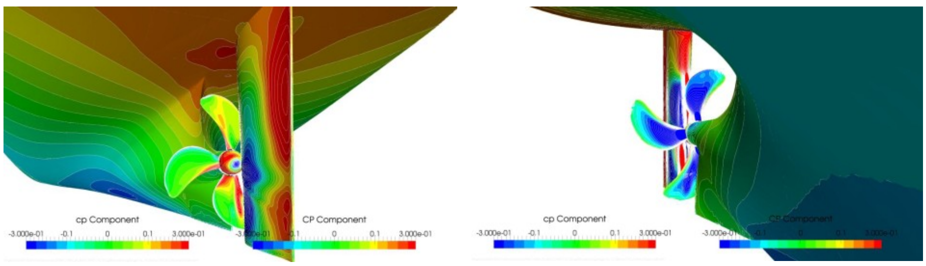


- Allowing asymmetric stern shapes in the optimization for a well designed 38k dwt tanker yielded an some 3.4% and 3.8% improvement on performance in ballast and design condition, respectively.

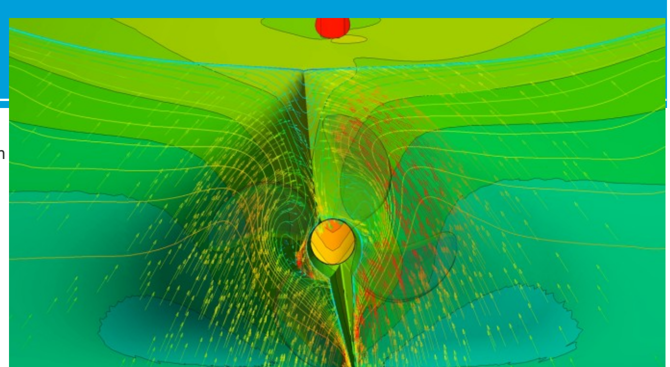
Fuel Efficient Tanker Design

Conclusion

- Combining advanced CFD technology with formal parametric optimization the great idea of the asymmetric aft body can be driven to its maximum potential.
- The asymmetric stern allows further improvement of propulsive efficiency exploiting similar effects as pre-swirl devices, albeit with much higher structural robustness.
- Predicted improvements were confirmed in model tests.
- Gains are expected to be higher for Tankers and Bulkers than for Containerships.



Thank you.



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