DYNAMIC POSITIONING CONFERENCE
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THRUSTERS

Systematic Approach to Develop an Optimized Nozzle Design for Up to Date and Future Demands

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Schottel

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DUCTED PROPELLER

SYSTEMATIC APPROACH TO DEVELOP AN OPTIMIZED NOZZLE DESIGN FOR UP TO DATE AND FUTURE DEMANDS

Müller, Tweddell, Glas 10.10.2017

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02 Nozzle Optimization

- Optimization Technique / Approach
- Market Study / Predesign
- Parameterization
- Design Process / Tools
- Model Tests

03 Results

04 Integrated Anode Concept

Content

01 Introduction

02 Nozzle Optimization

Optimization Technique / Approach

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04 Integrated Anode Concept

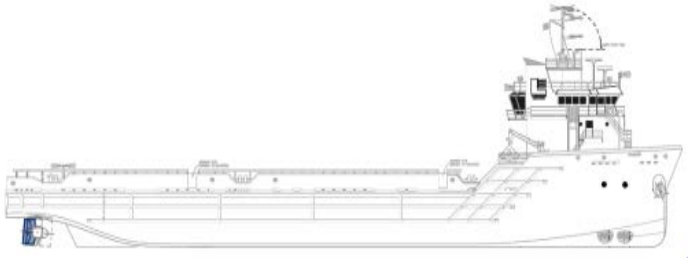
01 Introduction
>> Background

Principal use:

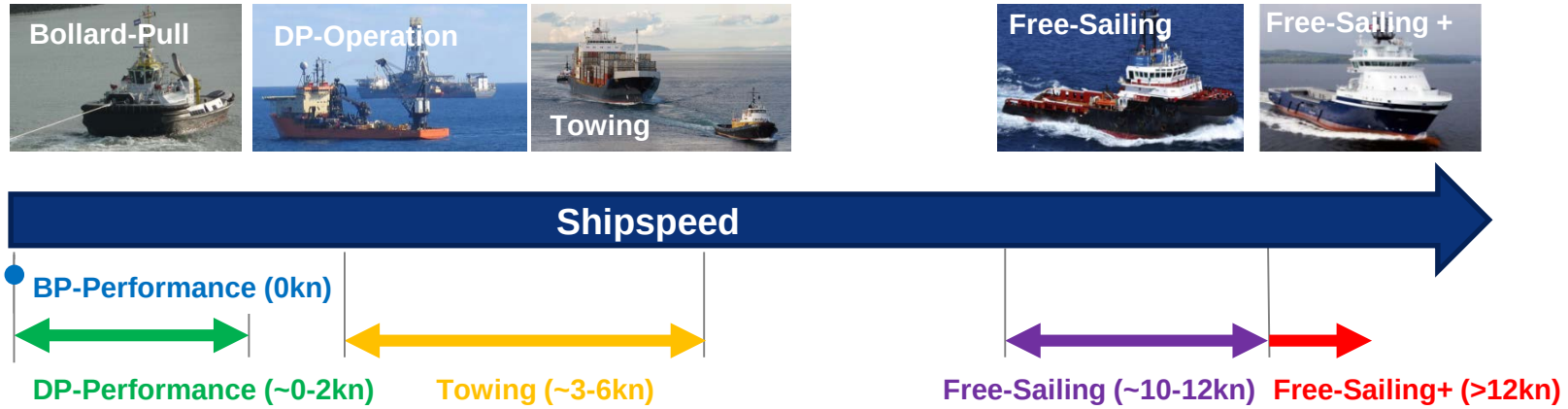
Nozzle used to increase thrust at low speed operation

Performance:

highly dependant on nozzle profile

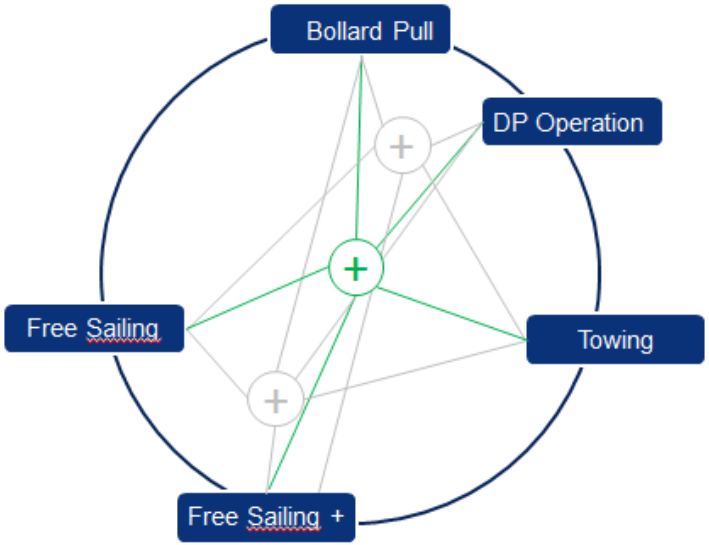


01 Introduction
>>Application Requirements



01 Introduction
>> New Development >>Objectives

New development, design objective:



High-Speed Optimized Nozzle

Main Operating Speed: *>10kn*

Goal: *- Efficient @ higher Speeds*
- high DP-Thrust

Compromise Design → **New Development**

01 Introduction
>> New Development >>Objectives

Requirements for the new compromise duct:

- suitable for a wide range of various applications
- identical bollard pull as standard nozzle *WAG19A-mod*
- improved free running performance (fuel economy)
- minimized space for installation

…which nozzle design???

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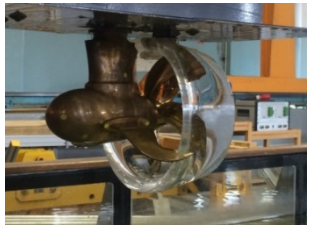
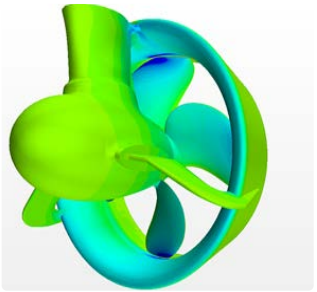
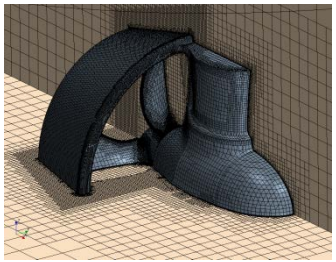
Optimization Technique

Traditional:
Modeltest, Experiments



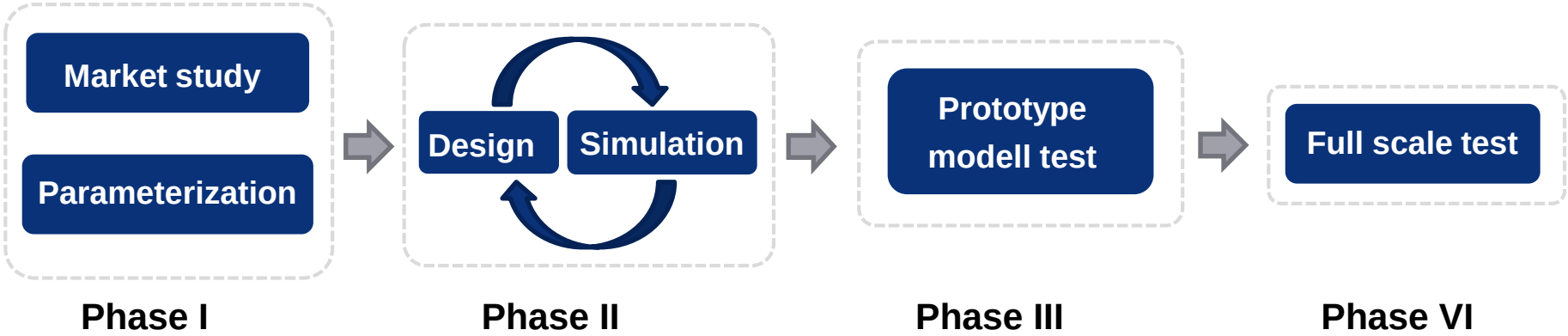
Virtual Product Development:
Computer Simulations,
„Virtual Experiments“





02 Nozzle Optimization
>> Approach

Virtual Product Development:



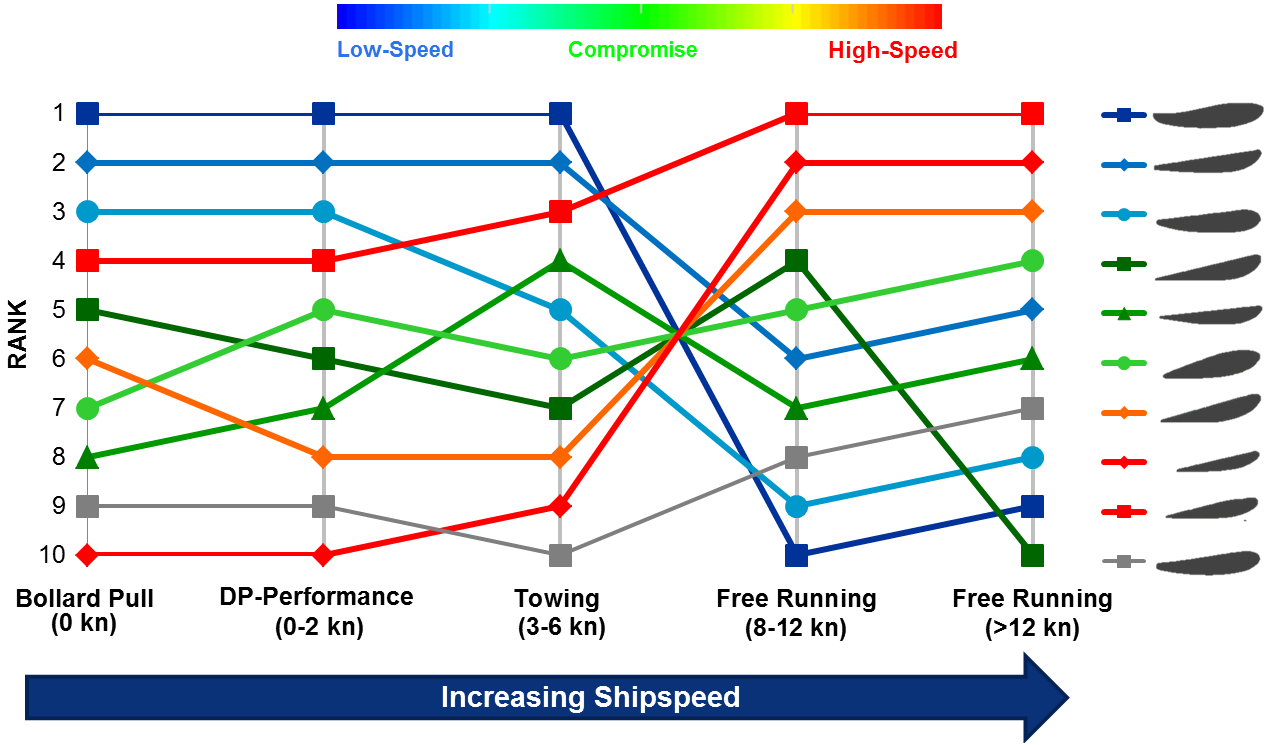
Phase I: Suitable selection of nozzle geometries / parametriziation

Phase II: determine optimal nozzle design with computer simulations

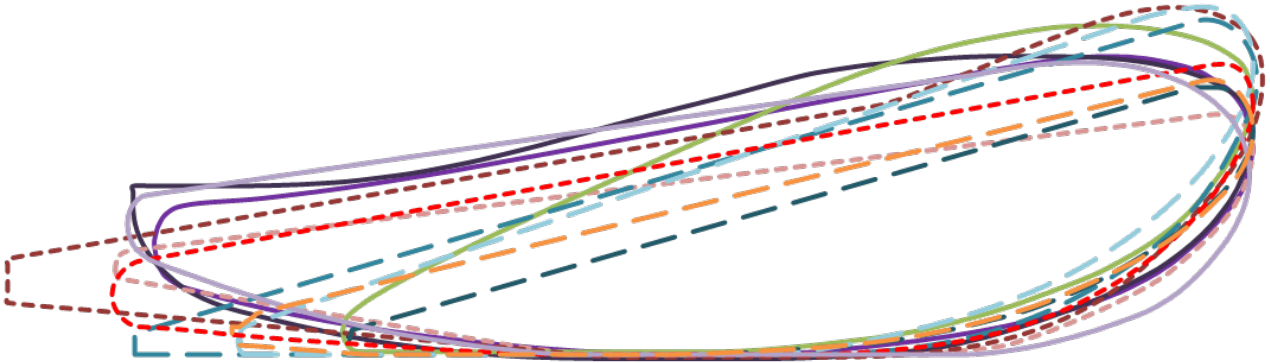
Phase III: verify optimized performance in model test

Phase VI: check full scale performance

02 Nozzle Optimization
>>Nozzle >>Market-analysis >>Results

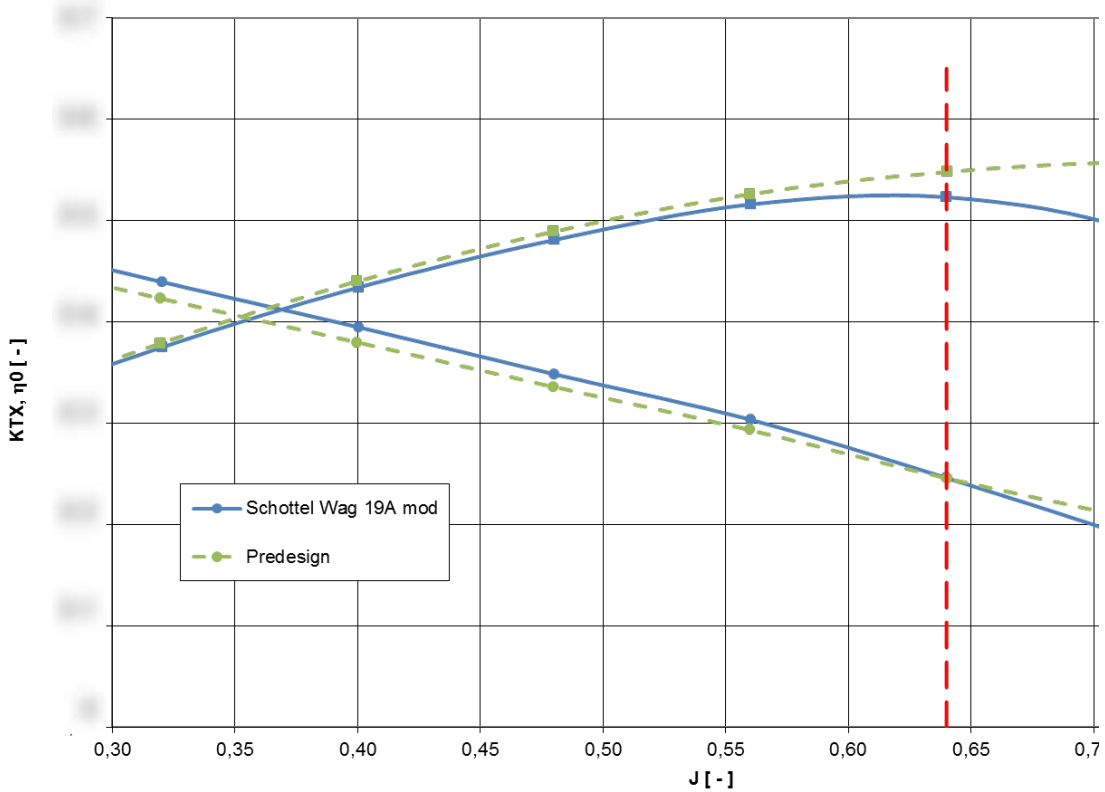


02 Nozzle Optimization
>> PreDesign Check >> PSV



- **Higher speed /Compromise optimized ducts**
  - moderate openening-angles,
    integrated cylindrical part for propeller, small diffusor
  - L/D =0.4 .. 0.45
  - Propellerplane x/L= 0.55 .. 0.7

02 Nozzle Optimization
>> PreDesign Check - Model Based



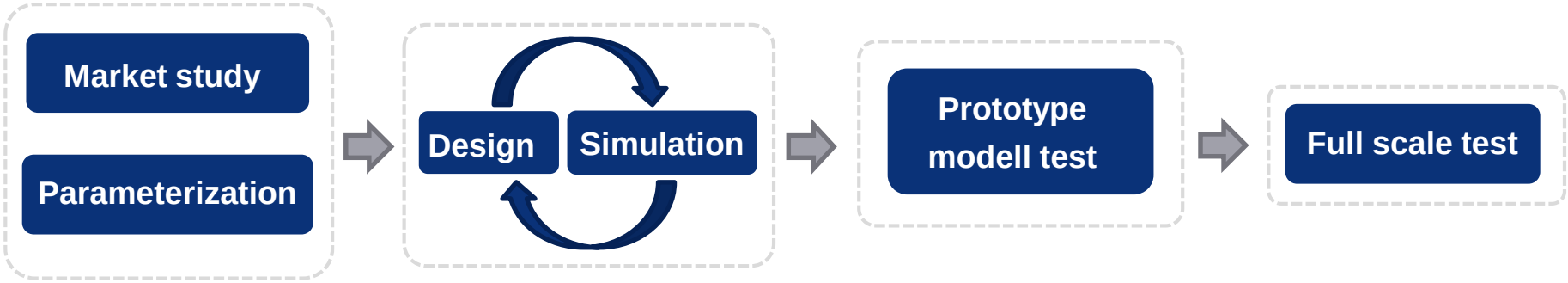
Predesign
(high-speed optimized nozzle)

- **Performance check**

➢ Based on thrust load idendity
➢ Assessment of efficiency improvement

02 Nozzle Optimization
>> PHASE I

Virtual Product Development:



Phase I: Suitable selection of nozzle geometries / parametriziation ✓

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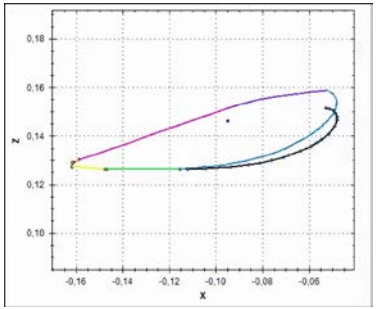
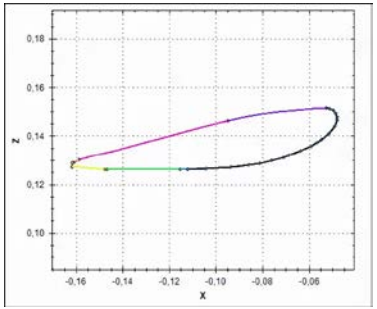
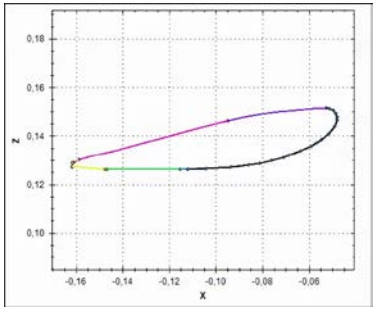
02 Nozzle Optimization
>> Parametrization



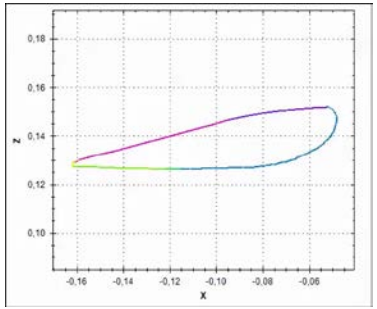
Opening angle



Radius Leading edge

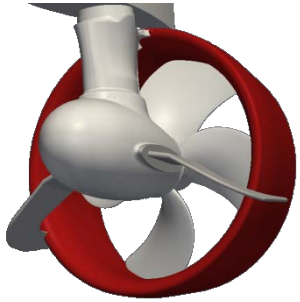


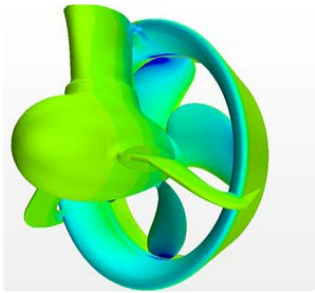
Inflow contour



Diffusor geoemetry

02 Optimization-Workflow
>> Applied Tools

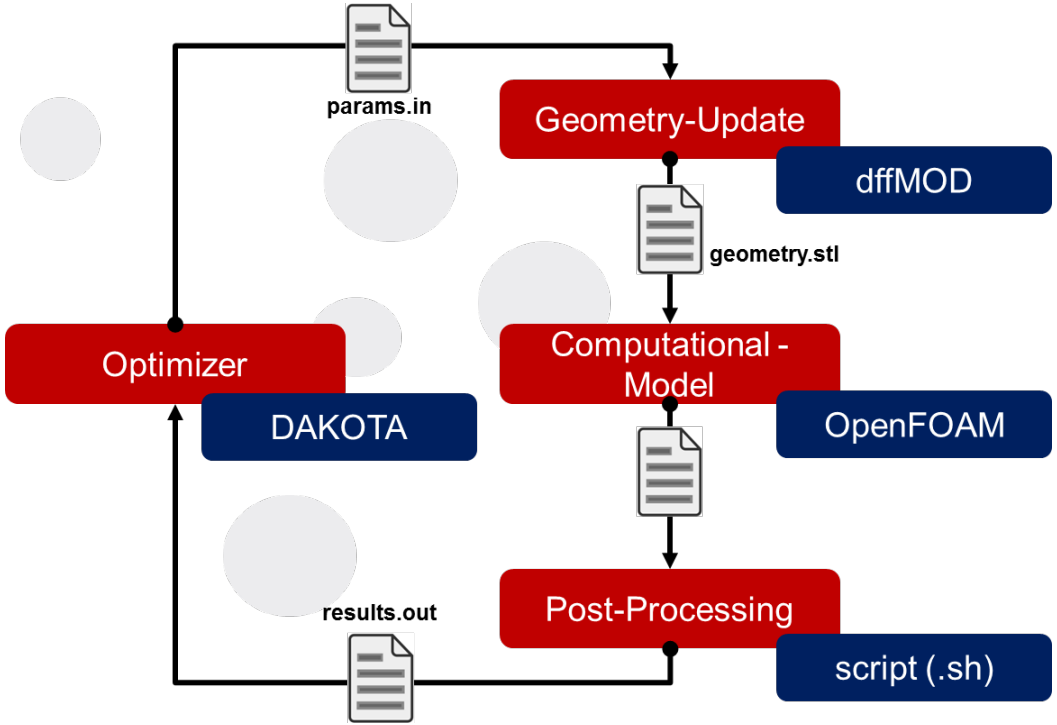




Geometry Update → CFD Calculation → Optimizer → Geometry Update

Optimization setup:	*Genetic algorithm*
Input variables:	*5 parameters*
Design objective:	*Maximize BP- & FR-performance*

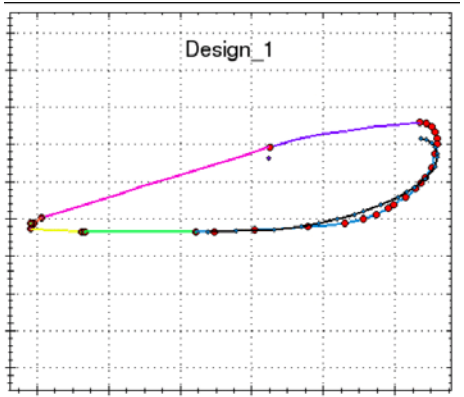
02 Optimization-Workflow
>> Applied Tools



02 Nozzle Optimization
>> Examined Designs

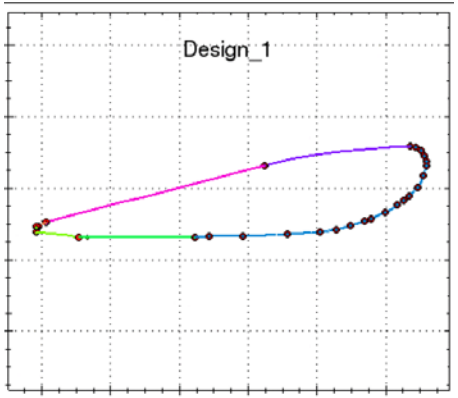
Examined Designs:

1. step:



Inflow Optimization
(150 designs)

2. step:



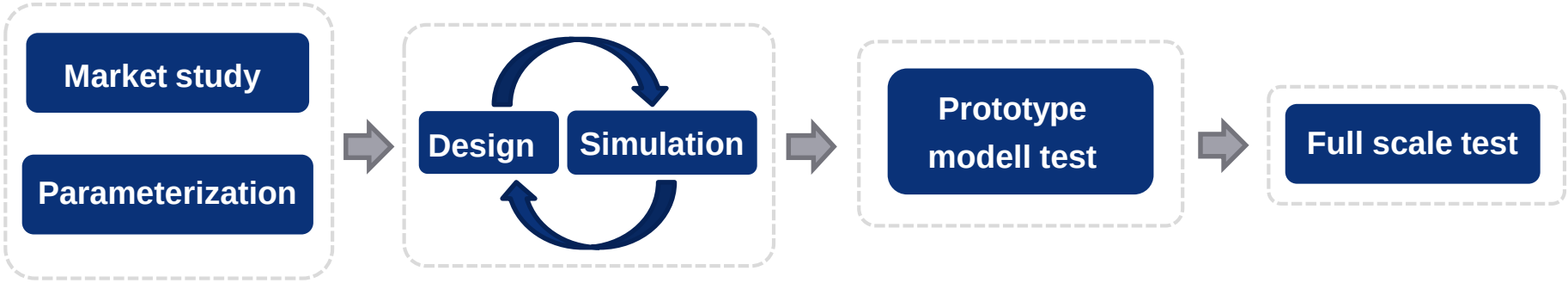
Diffusor Optimization
(79 designs)

Optimized Design:

Maximized
BP- & FR-performance

02 Nozzle Optimization
>> PHASE II

Virtual Product Development:



Phase I: Suitable selection of nozzle geometries / parametriziation ✓

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02 Nozzle Optimization
>> Modeltest

Modeltests with the optimized nozzle:

SVA-Potsdam

SRP 510 with optimized nozzle

Towing Tank

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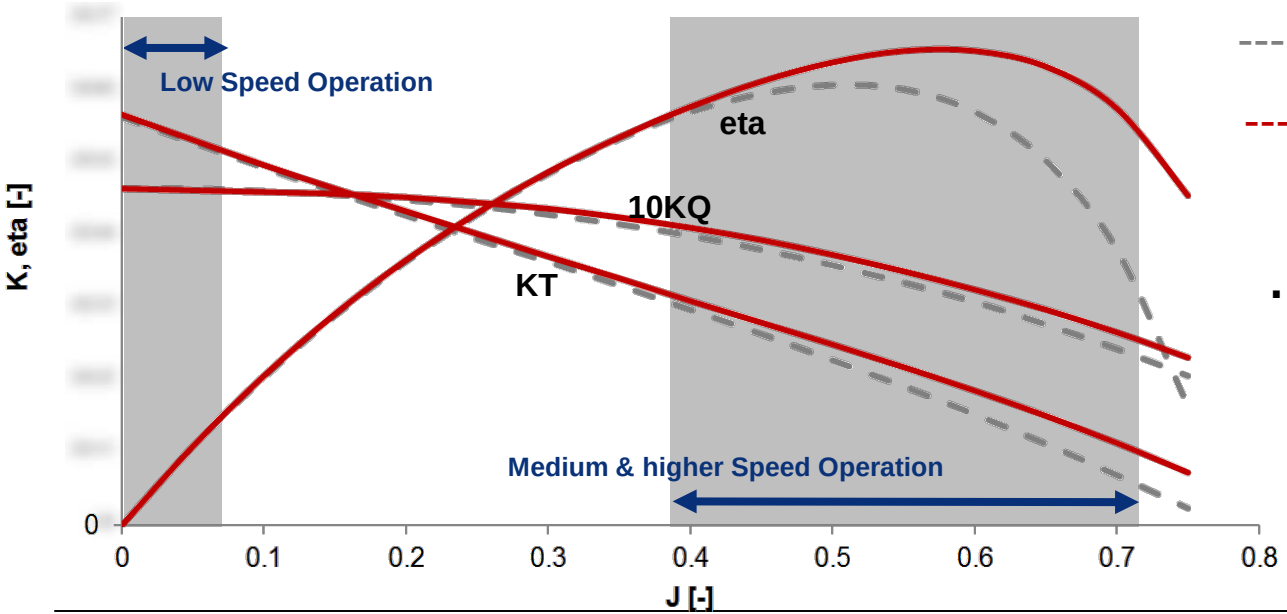
04 Integrated Anode Concept

03 Results
>> Performance >>Open Water Test

SDV45 „SCHOTTEL VarioDuct“
increased performance proofed in Open Water Tests



--- WAG19A-mod

--- SDV45

… identical bollard pull

and increased free sailing efficiency

03 Results
>> Performance >>Open Water Test

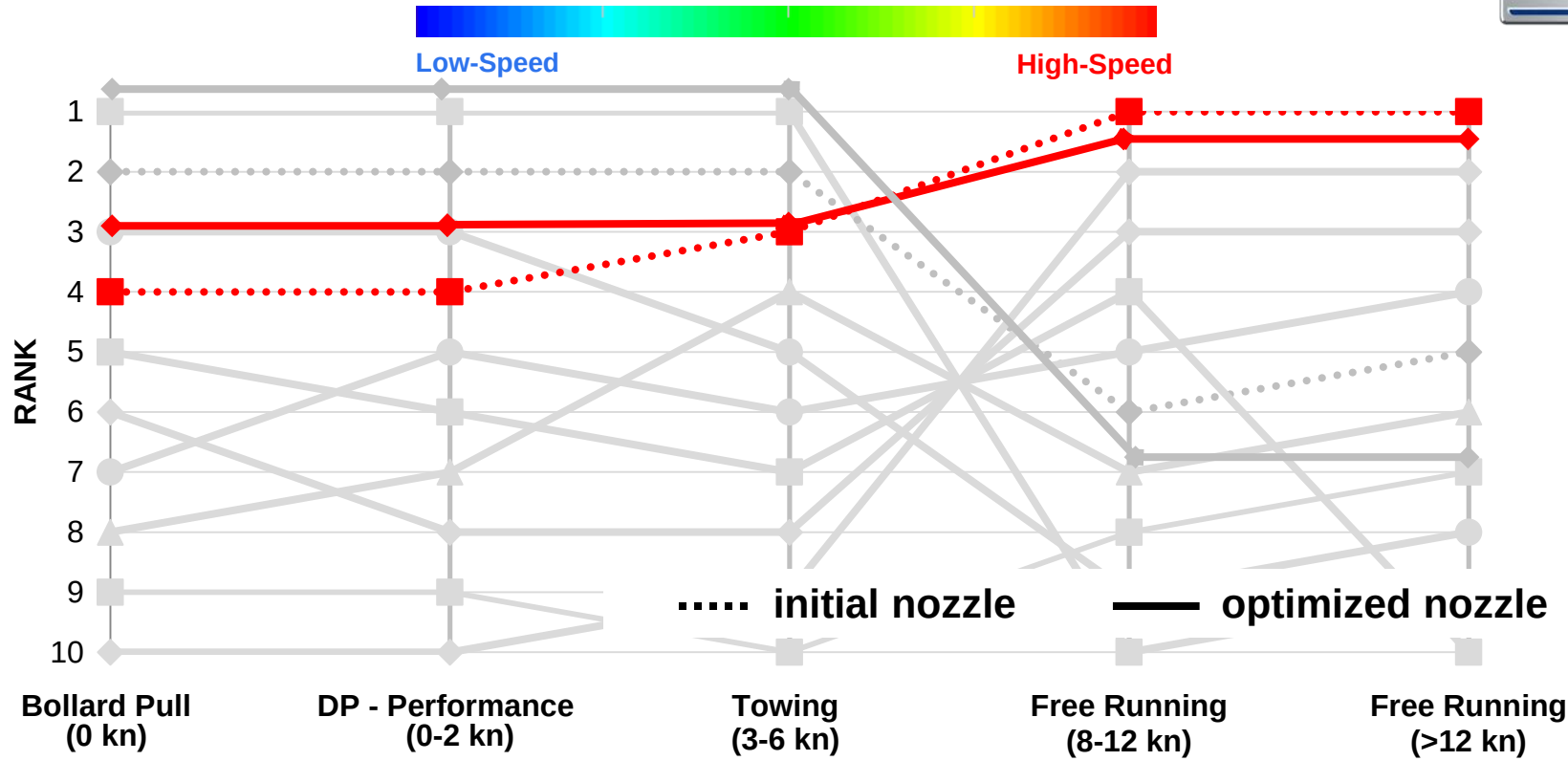
SDV45 „SCHOTTEL **V**ario**D**uct“
increased performance proofed in Open Water Tests

	Offshore Supply Vessel (Free-running-design, SRP430 FP, 1600kW, D_P=2.3m)	
nozzle	WAG19A-mod	SDV45
DP-thrust (1kn) [t]	47.1 (100%)	48.5 (+3%)
max. vessel speed [kn]	14.8 (100%)	15.1 (+0.3kn)
power @ 14.8kn [kW]	1571 (100%)	1410 (-10.2%)

… identical bollard pull

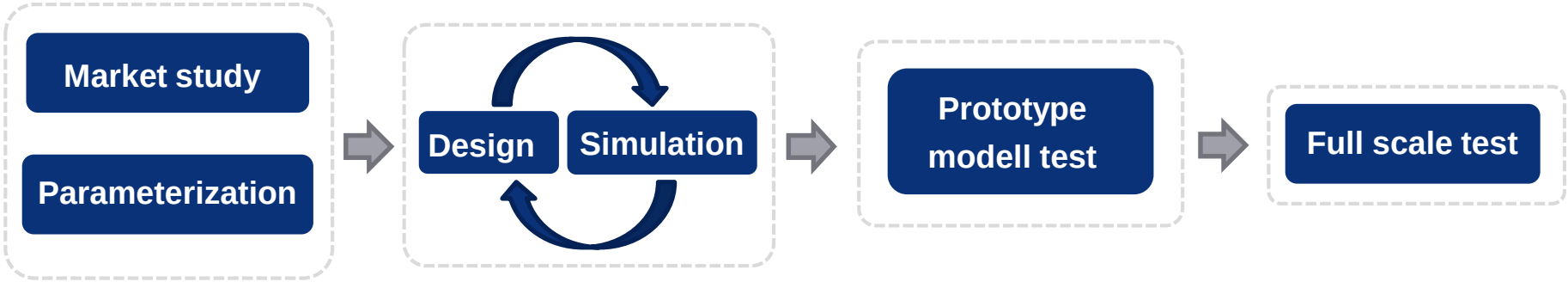
and increased free sailing efficiency

03 Results
>> Nozzle >>Performance



03 Results
>> PHASE III

Virtual Product Development:



Phase I: Suitable selection of nozzle geometries / parametriziation ✓

Phase II: determine optimal nozzle design with computer simulations ✓

Phase III: verify optimized performance in model test ✓

Phase VI: check full scale performance

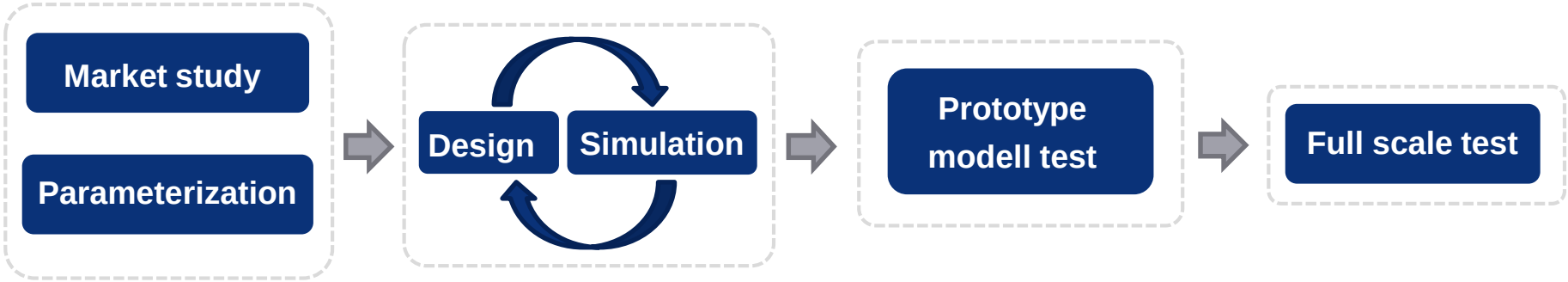
03 Results
>> SDV45

Bollard Pull Test: Harbout Tug - Geta Coast Guard

Speed Trial: Escort Tug - Dux

03 Results
>> PHASE IV

Virtual Product Development:



Phase I: Suitable selection of nozzle geometries / parametriziation ✓

Phase II: determine optimal nozzle design with computer simulations ✓

Phase III: verify optimized performance in model test ✓

Phase VI: check full scale performance ✓

03 Results
>> SDV45

SDV45 „SCHOTTEL **V**ario**D**uct“

…combines great bollard pull capacities
with excellent free sailing efficiency
at minimized installation space

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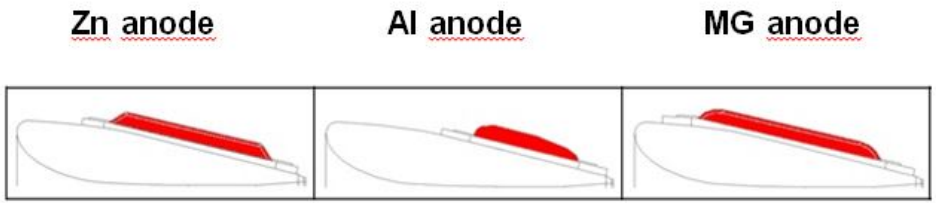
04 Integrated Anode Concept
>> Invention

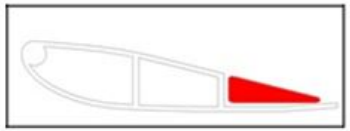
The real life …

… a picture is worth a thousand words

04 Integrated Anode Concept
>> Invention

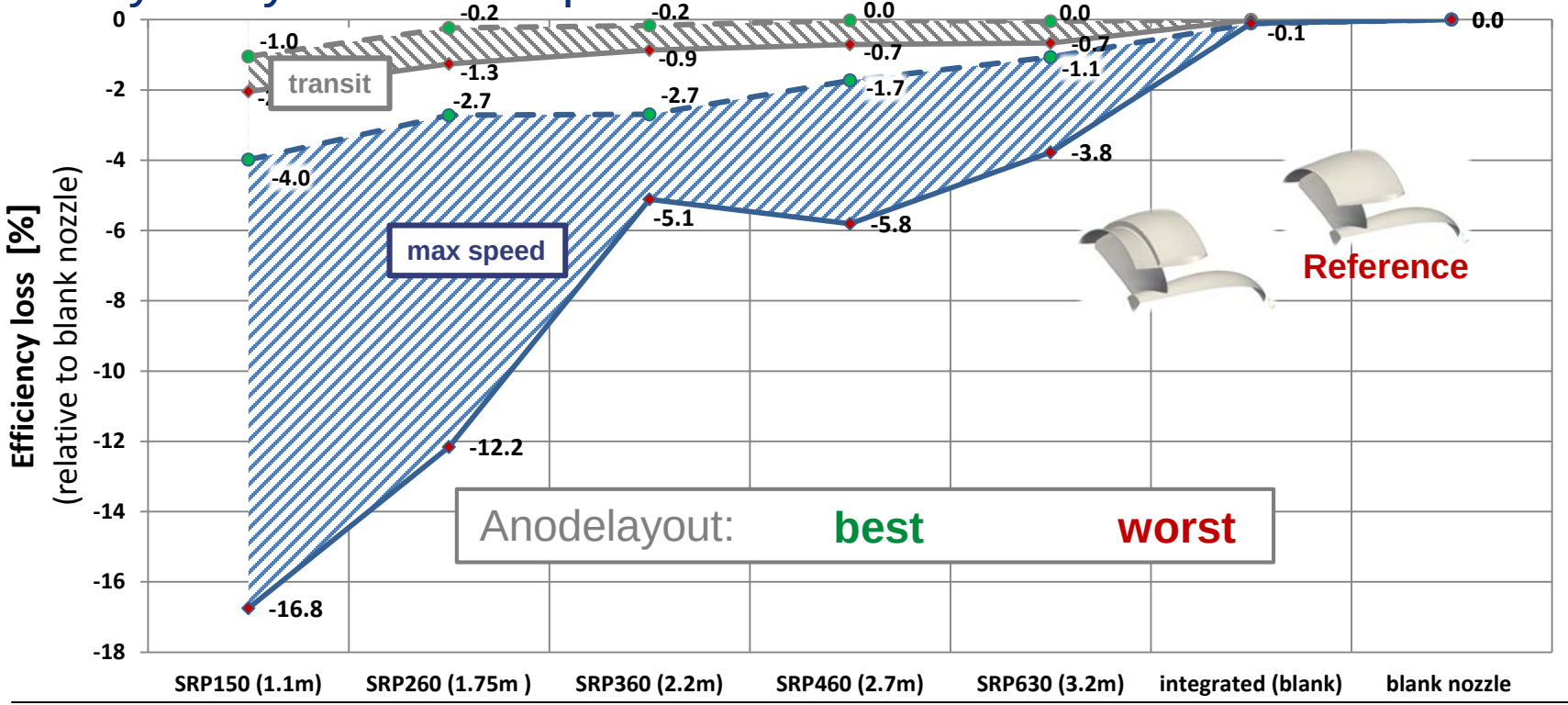
The invention …





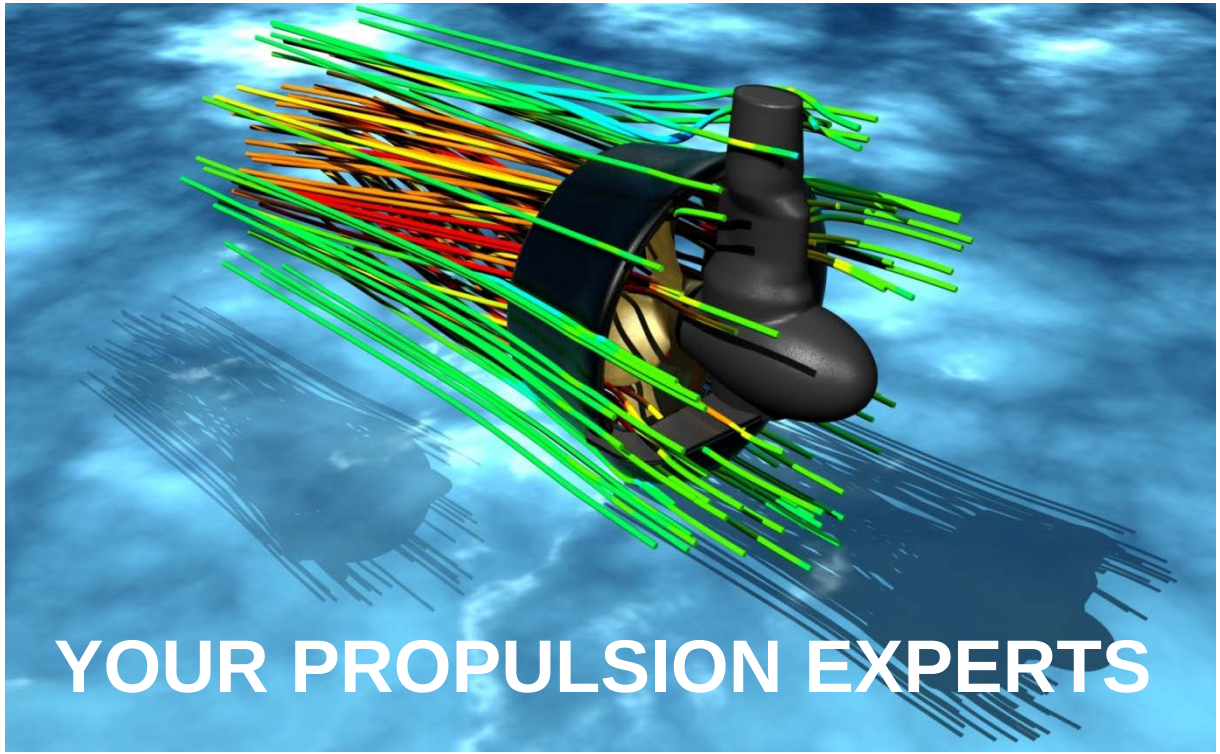
… a picture is worth a thousand words

04 Integrated Anode Concept
>> Hydrodynamic Comparison >> OWC



04 Integrated Anode Concept
>> Advantages

- **less thruster weight**
- **increased hydrodynamic efficiency:** higher speed , less fuel consumption
- **reduced risk** of anode damage
- **minimum installation space**
- **increased protection time:** up to **5 years** and more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