GATERS – Gate Rudder System as a Retrofit for the Next Generation Propulsion and Steering of Ships

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GATE RUDDER SYSTEM (GRS)

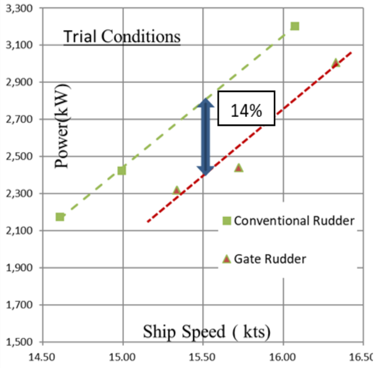
- Classical single-rudder behind the propeller arrangement is replaced by twin-rudder blades with asymmetric cross-sections which are positioned either side of the propeller

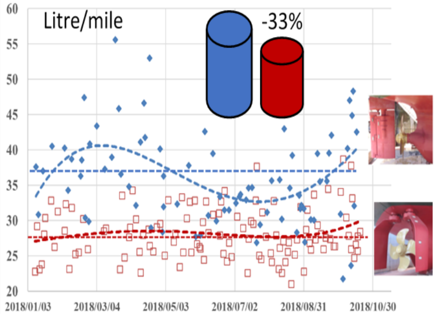
- The Gate Rudder System, therefore, takes advantage of additional thrust generated by the two rudder blades, in contrast to the additional resistance resulted by the conventional rudder

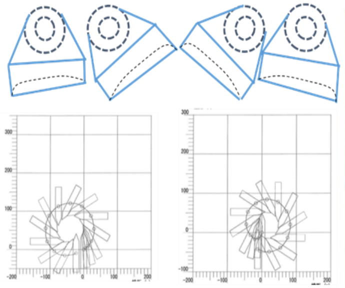
- Each rudder blade can be controlled individually to affect the direction of the propeller's slipstream (i.e. to vector) and hence to steer the vessel with increased manoeuvring and steering control capability.

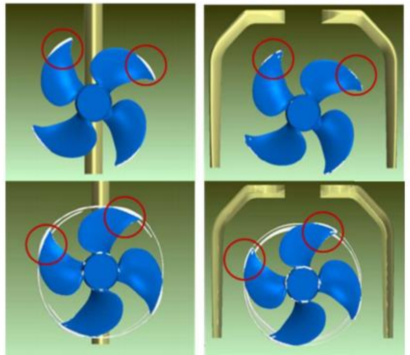
Advantages of GATE RUDDER SYSTEM (GRS)

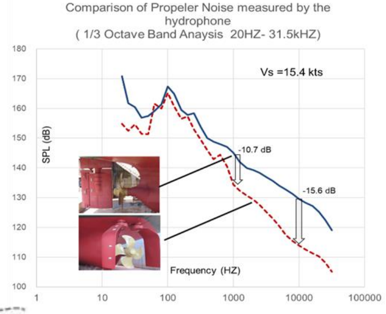
- Remarkable fuel saving (up to 14% in trials), especially in-service and rough weather (up to 30%)
- Reduced vessel motions (in yawing and rolling) in waves
- Improved steerability and manoeuvring (especially in harbours) without stern thrusters
- Reduced propeller loading and hence less vibration and Underwater Radiated Noise (URN)
- Low wash wake due to hull waves & propeller slipstream
- Shorter ship length or more space at aft compared to the vessel with a conventional rudder behind the propeller
- Effective use of the bow thrusters at higher ship speeds
- Reduced risk of running anchor

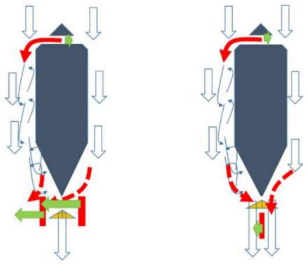


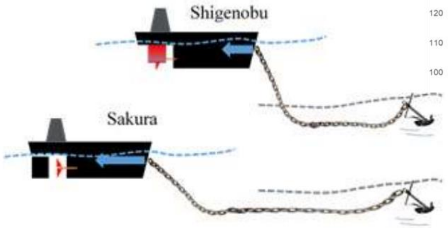












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A brief history of GATE RUDDER SYSTEM (GRS)

- GRS had its origin in “**Frame Rudder**” proposed and tested by *Mr Sadamoto Kuribayashi* of Kuribayashi Steam Co Ltd, Japan in 2011.

- Frame Rudder was tested and further improved by R&D conducted in NMRI of Japan by *Dr Noriyuki* Sasaki and this led to the 1st (Japanese) patent for the early version of GRS with a single rudder stock [# JP 2014-73815 A]

- Further R&D work in Japan and the UK at the Newcastle and Strathclyde Universities led by Dr Sasaki as the Visiting Professor resulted in the current shape of the GRS with two separate rudder stocks and the 2nd (European) Patent [# EP 3103715 A1]

- GRS was first applied on a Japanese coastal container vessel called “**Shigenobu**” through a demonstration project conducted by a Japanese Industry Consortium and sponsored by Nippon Foundation in 2017.

First GRS application in Japan

- **Shigenobu** is a new built 400TEU container ship having the world's first GRS fitted on her.
- Shigenobu has a sister ship **Sakura** with the same size and engine power but with conventional (flap) rudder built in 2016
- As part of the demonstration project the performance of these ships were compared in power-speed trials in 2017 and later on through continuous performance monitoring in-service.
- Comparative results were remarkably in favour of Shigenobu as will be shown in later slides

SHIGENOBU			
Length overall	L_{OA}	(m)	111.40
Length between perpendiculars	L_{BP}	(m)	
Breadth	B	(m)	17.80
Draught (midship)	T	(m)	5.24
Displacement	Δ	(ton)	
Service Speed	V_S	knots	15.5
Rudder			GR

SAKURA			
Length overall	L_{OA}	(m)	111.4
Length between perpendiculars	L_{BP}	(m)	
Breadth	B	(m)	17.8
Draught (midship)	T	(m)	5.24
Displacement	Δ	(ton)	
Service Speed	V_S	knots	15.5
Rudder			CR

Later GRS APPLICATIONS *(so far)*

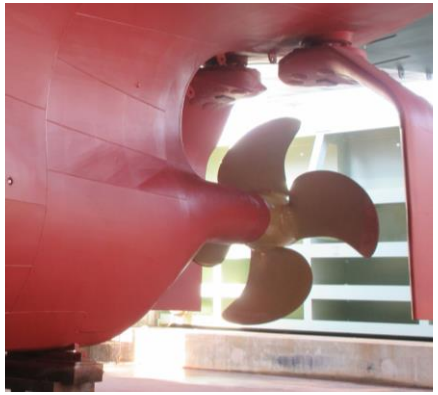
	SHIGENOBU (1st Application, 2017)	KOHSIN MARU (2nd Application, 2020)	SHINMON MARU (3rd Application, 2020)
Type of ship	Container (400 TEU)	General cargo (509 GT)	General Cargo (499 GT)
Lpp	101.9	69	72
B	17.8	12	12
T	5.24	4.11	4.13
C_B	0.67	0.70	0.70
Design Vs	14.5	13	13
Fn (Lpp)	0.2436	0.267	0.267
L/B	5.72	5.75	5.75
Stern shape	V shape	Stern bulb	V shape

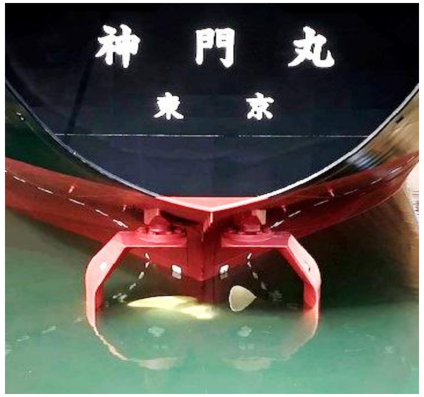
2 more ships are in order in Japan for 2022:

- A new larger container (max size of a coastal ship)
- A new "Training Ship"

Investigations underway:

- 2 Fishing vessels
- Medium size LNG s
- 20K DWT Bulk Carrier





April 2022 delivery (image)

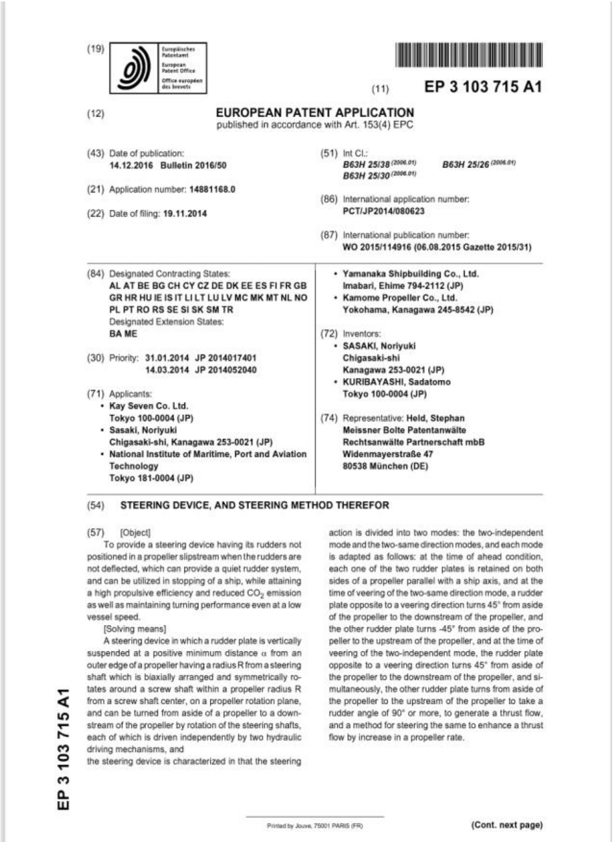
Current commercial status of GRS

- 5 members ofJapanese Industry Consortium (JC) involving Kay Seven Co., Ltd., (Kuribayashi Steam Co Ltd); Dr. Noriyuki Sasaki, National Institute of Maritime (Port and Aviation Technology), Yamanaka Shipbuilding Co., Ltd. and Kamome Propeller Co., Ltd owns the Gate Rudder Patent **(European Patent: EP 3103715)**

- Further R&D and promotion activities in the University of Strathclyde (Glasgow) attracted Wartsila Propulsion to purchase the commercial license from the JC to use the Gate Rudder technology protected by the Licensed Patent in 2020

- GATERS Project funding was granted by the EC (H2020) and the GATERS Project Consortium signed **sub-license agreement** with Wartsila Netherlands BV in 2020 for commercial for commercial applications. Hence:

"GATERS has an official sub-licence agreement with Wartsila Netherlands BV to utilise the Gate Rudder Patent (EP 3103715) at specific retrofit projects of vessels sizes below 15,000. DWT. GATERS is sponsored by the EC H2020 Programme (ID: 860337) with the aims and objectives independent of Wartsila Netherlands BV"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(54) STEERING DEVICE, AND STEERING METHOD THEREFOR

(57) [Object]
To provide a steering device having its rudders not positioned in a propeller slipstream when the rudders are not deflected, which can provide a quiet rudder system, and can be utilized in stopping of a ship, while attaining a high propulsive efficiency and reduced CO_2 emission as well as maintaining turning performance even at a low vessel speed.
[Solving means]
A steering device in which a rudder plate is vertically suspended at a positive minimum distance α from an outer edge of a propeller having a radius R from a steering shaft which is biaxially arranged and symmetrically rotates around a screw shaft within a propeller radius R from a screw shaft center, on a propeller rotation plane, and can be turned from aside of a propeller to a downstream of the propeller by rotation of the steering shafts, each of which is driven independently by two hydraulic driving mechanisms, and
the steering device is characterized in that the steering action is divided into two modes: the two-independent mode and the two-same direction modes, and each mode is adapted as follows: at the time of ahead condition, each one of the two rudder plates is retained on both sides of a propeller parallel with a ship axis, and at the time of veering of the two-same direction mode, a rudder plate opposite to a veering direction turns 45° from aside of the propeller to the downstream of the propeller, and the other rudder plate turns -45° from aside of the propeller to the upstream of the propeller, and at the time of veering of the two-independent mode, the rudder plate opposite to a veering direction turns 45° from aside of the propeller to the downstream of the propeller, and simultaneously, the other rudder plate turns from aside of the propeller to the upstream of the propeller to take a rudder angle of 90° or more, to generate a thrust flow, and a method for steering the same to enhance a thrust flow by increase in a propeller rate.

EP 3 103 715 A1

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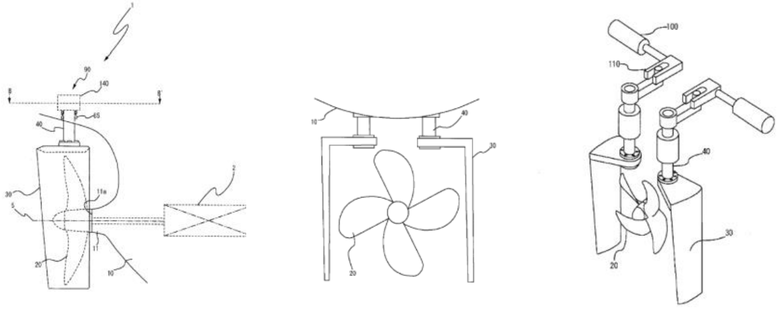
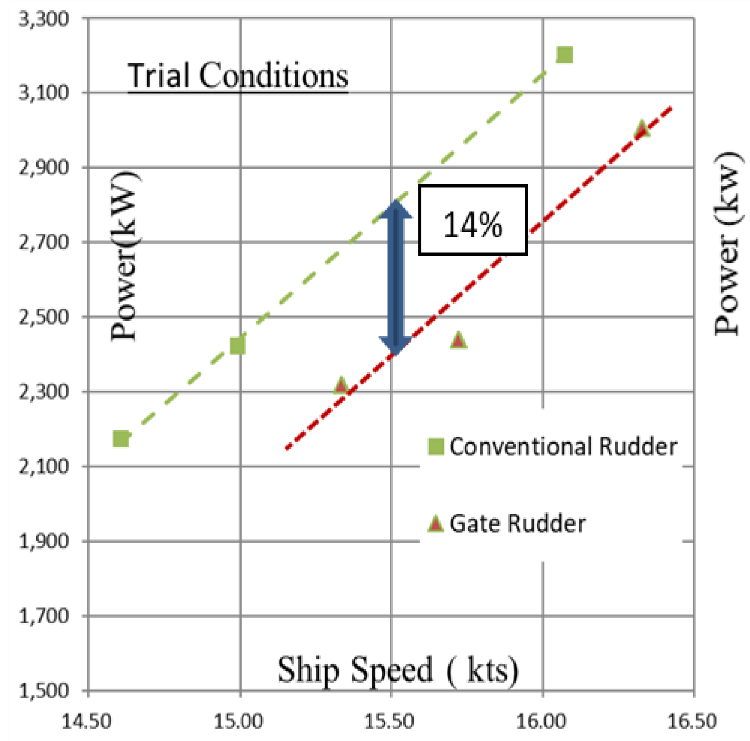
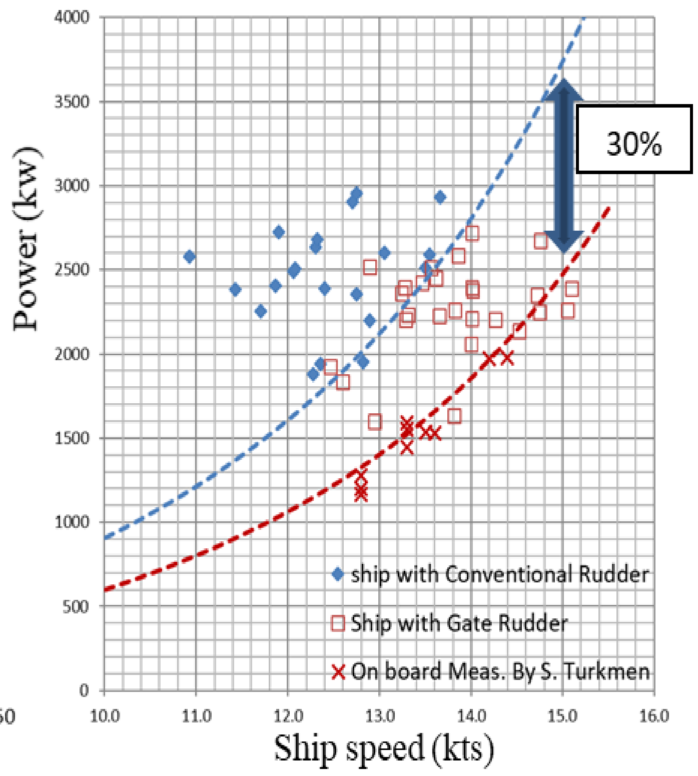
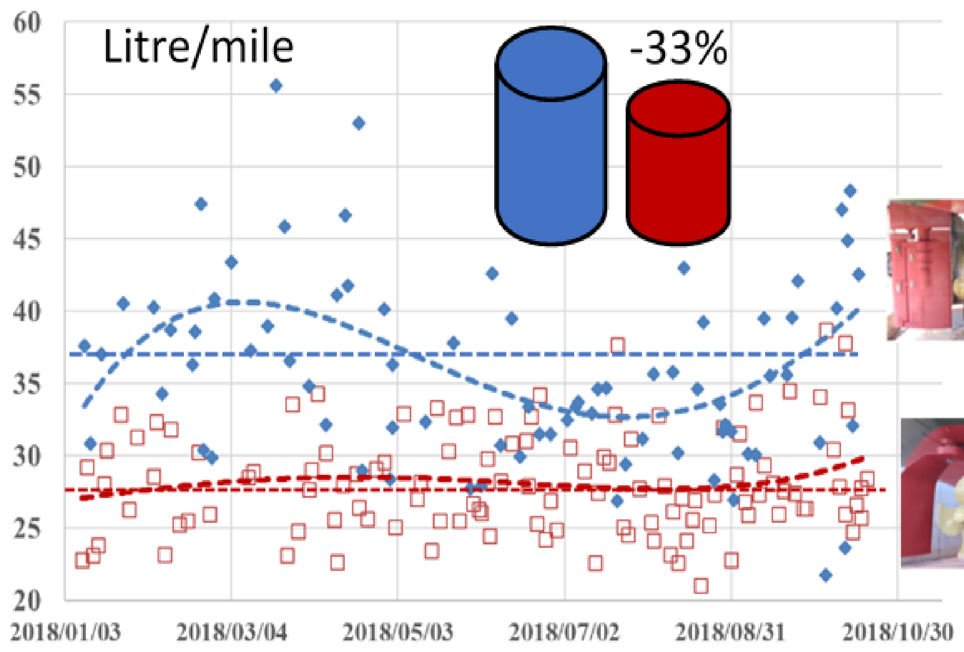
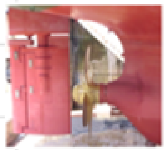


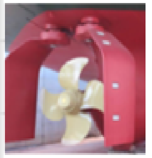
Recalling advantages of GRS – Energy saving







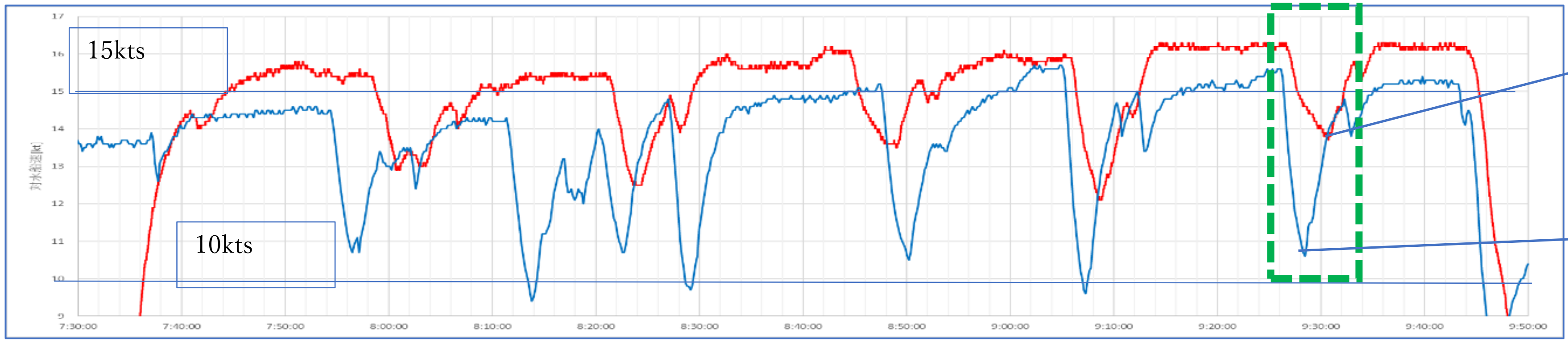


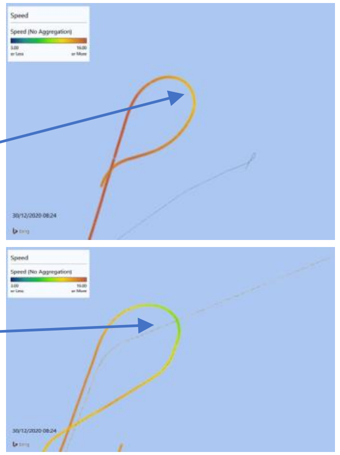


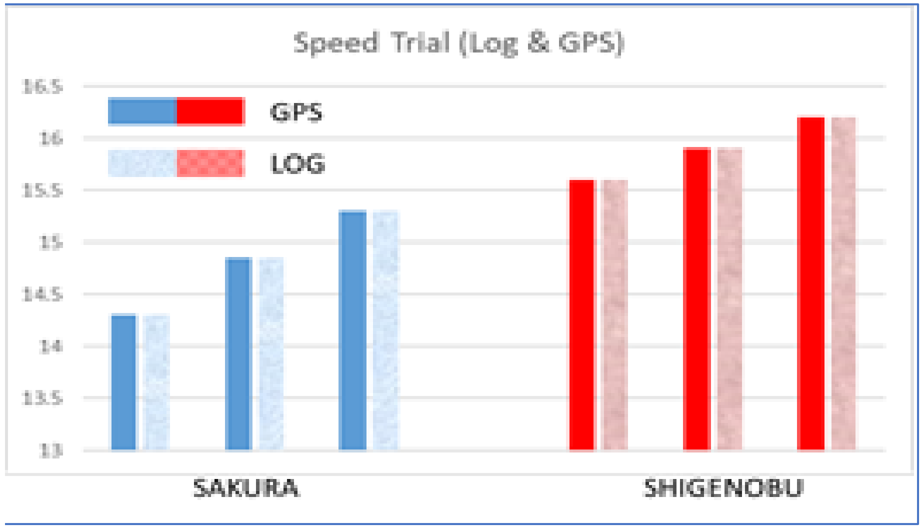
Trials (calm water) and in-service (including rough weather) powering performance comparisons of two sister ships: one ***Shigenobu*** with Gate rudder system **vs.** ***Sakura*** with Conventional flap-rudder system

In-service fuel consumption comparisons of two sister ships, ***Shigenobu*** with GRS (red) vs**.** ***Sakura*** with CRS (blue)

Recalling advantages of GRS – Energy saving

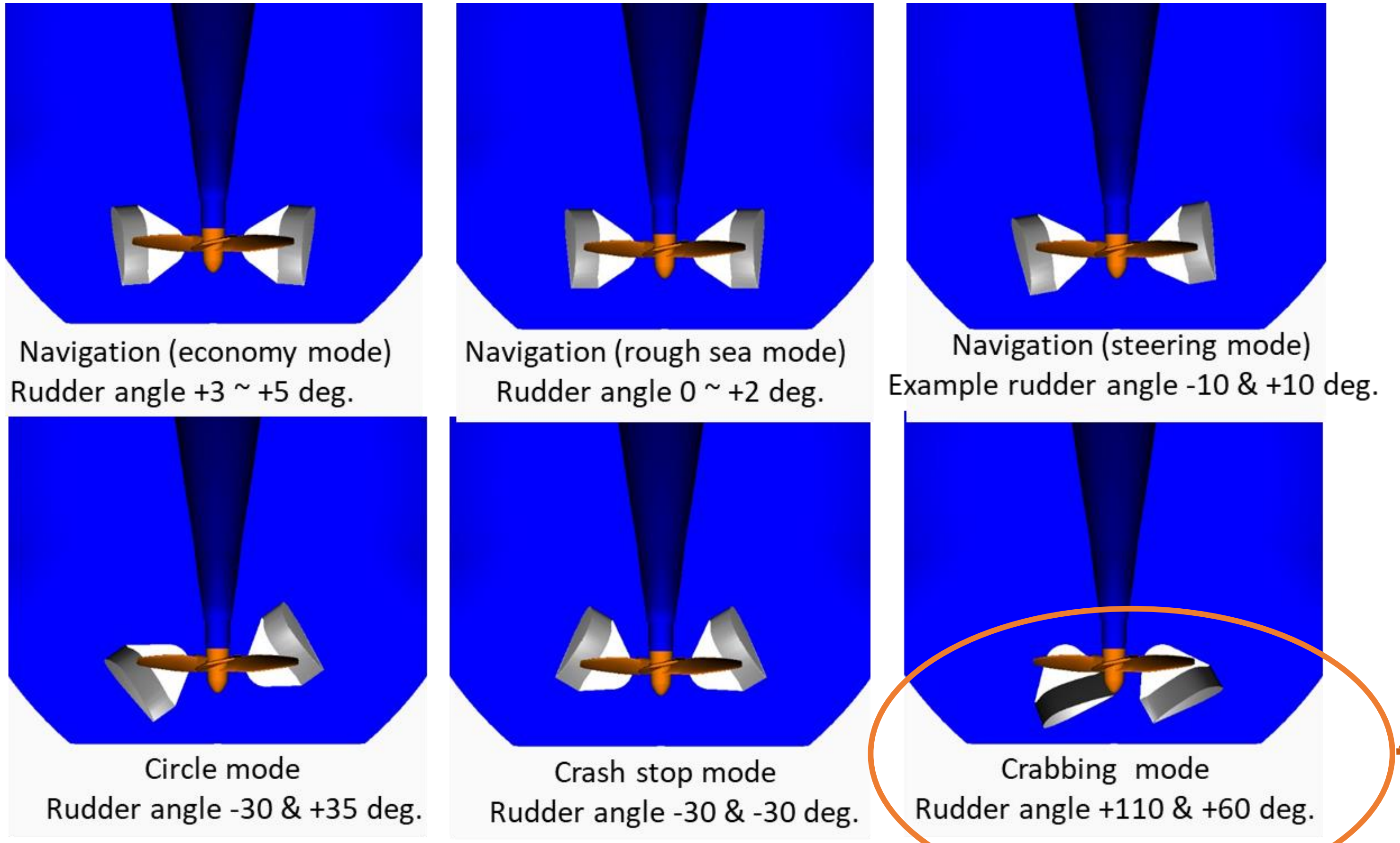






Joint sea trials on the same track **in 2020** with ***Sakura (CRS) and Shigenobu (GRS)*** at the same Engine RPMs for three different engine loading conditions indicated 18% power reduction for Shigenobu which is relatively higher than the individual sea trial conducted **in 2017** but further confirming the superior energy saving advantage of GRS

Recalling advantages of GRS – Manoeuvrability

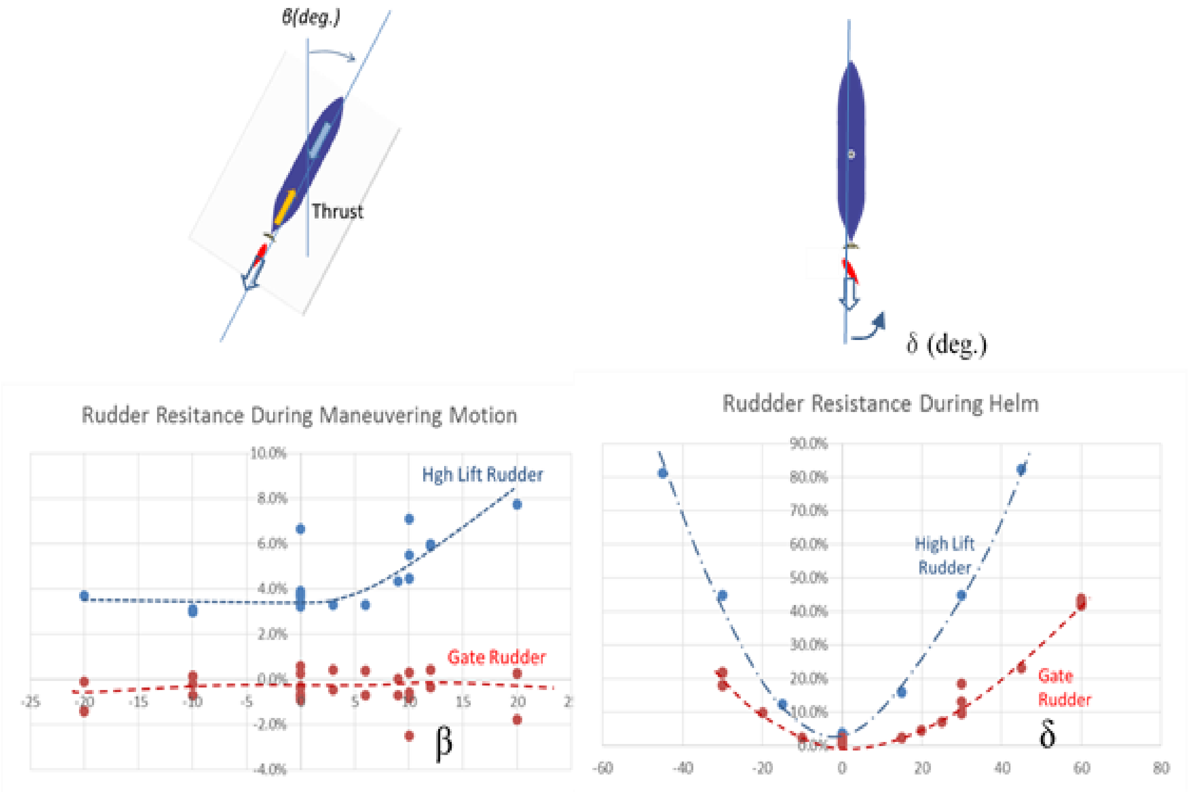


Manoeuvring modes of Gate Rudders System

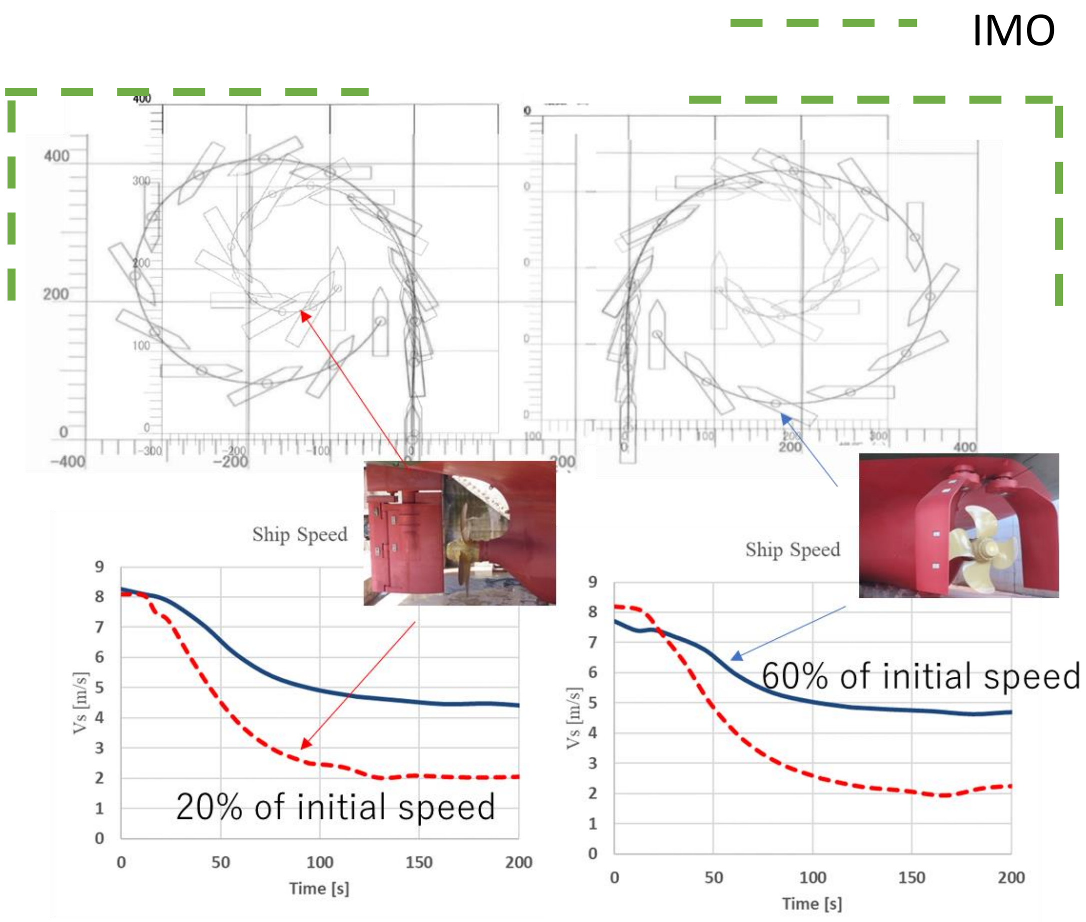
Pivot turn and Crabbing

Crabbing

Recalling advantages of GRS – Manoeuvrability

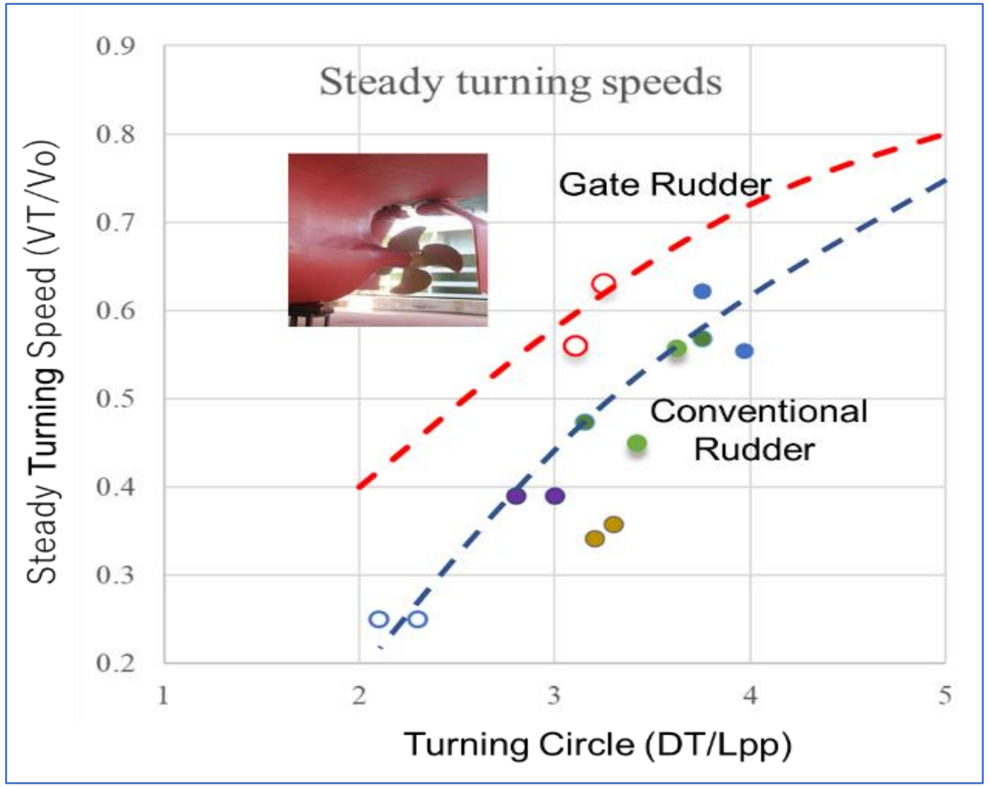


Comparison of rudder resistance (% Thrust) due to manoeuvring for conventional rudder and GRS.

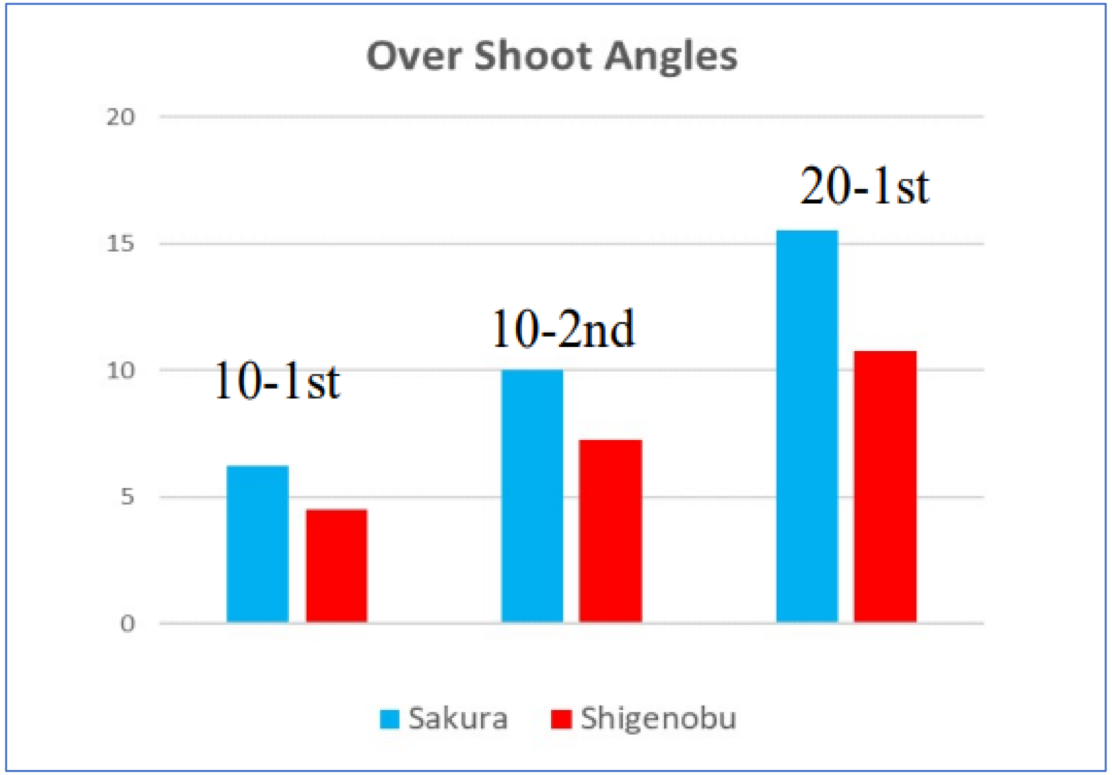


Full-Scale 35^0 Circle Test for Ship with conventional (flap) rudder and GRS

Recalling advantages of GRS – Manoeuvrability

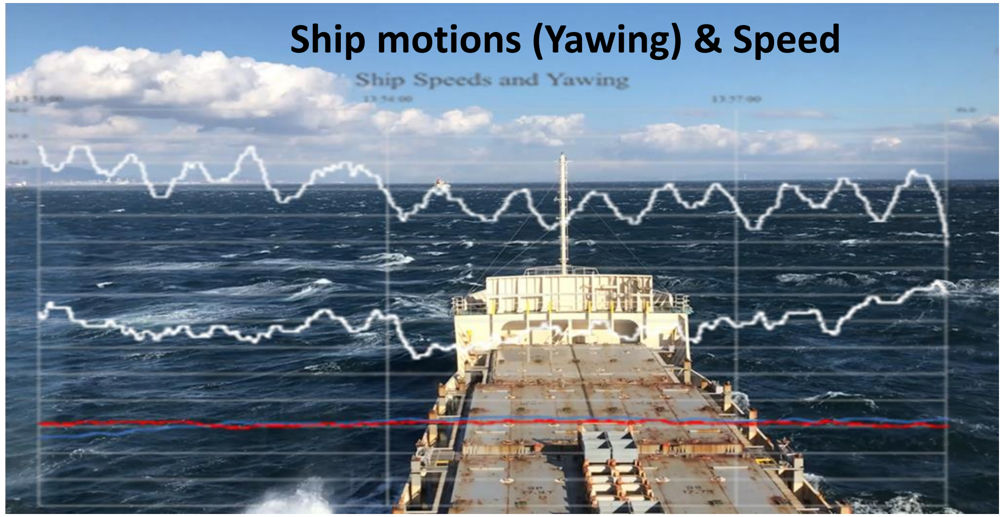


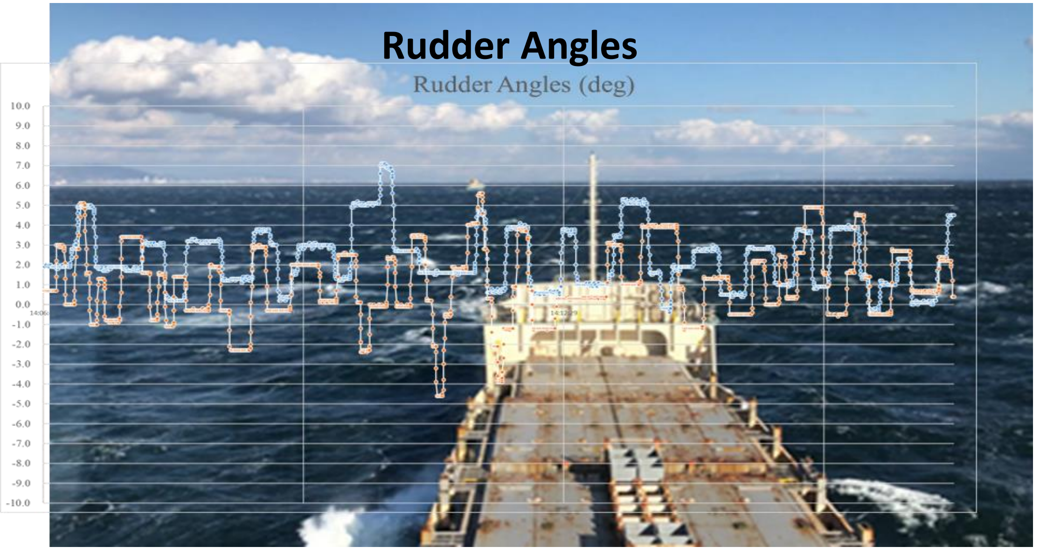
Comparative steady turning speeds

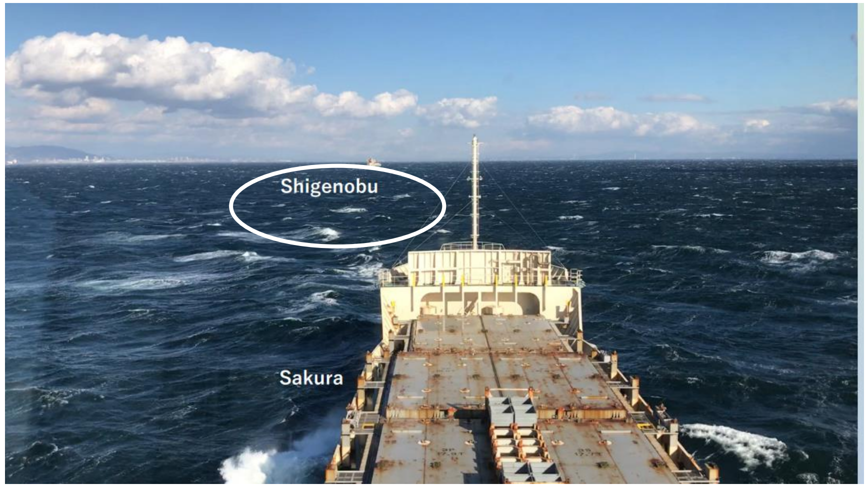


Comparative over shoot angles of *Sakura (GRS)* and *Shigenobu (CRS)* Based on trials

Recalling advantages of GRS – Seakeeping







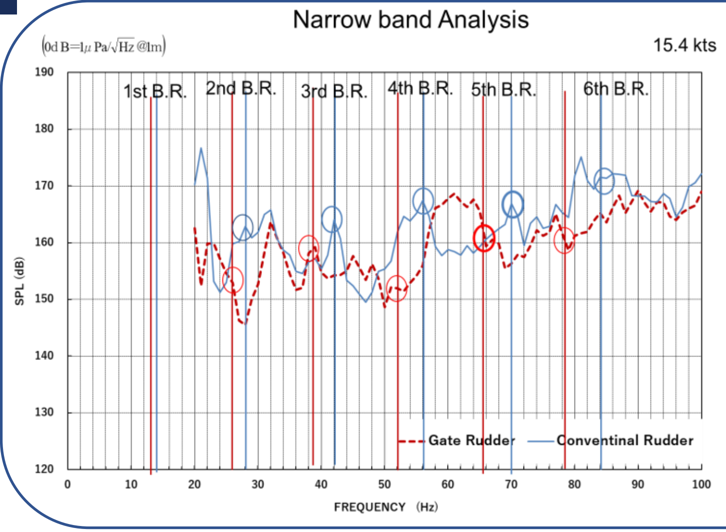
Sea conditions:
Wind speed: 12-24 knots
Wave height: 1.5 – 2.0m
Direction 250-270^0
Period: 30 sec

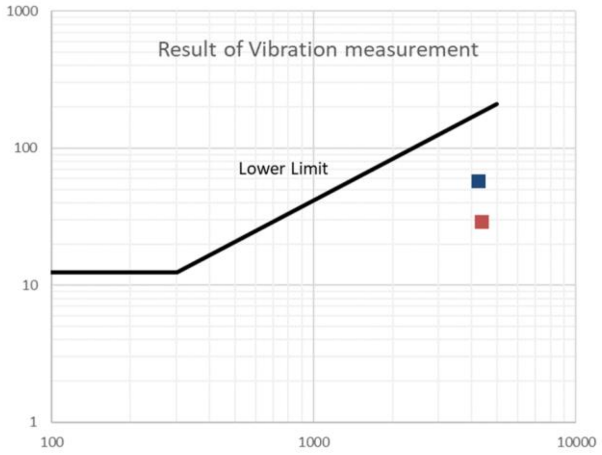
Rolling motion recorded on inclinometer:

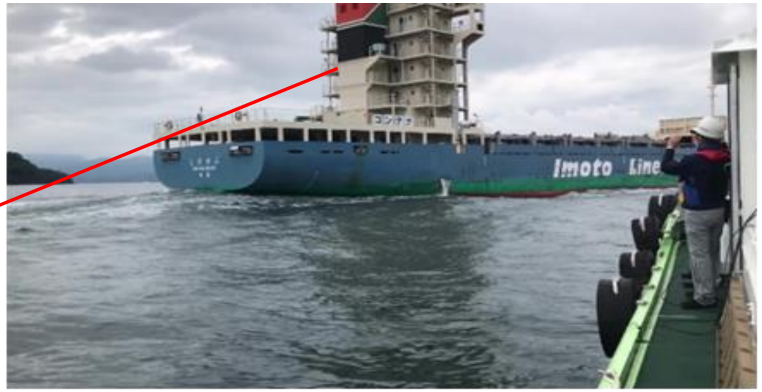
SAKURA → 3-5^0
SHIGENBOU → 1-3^0

Comparison of time history yawing motions in (almost) side-by-side trials with *SAKURA (CRS)* and *SHIGENOBU (GRS)*

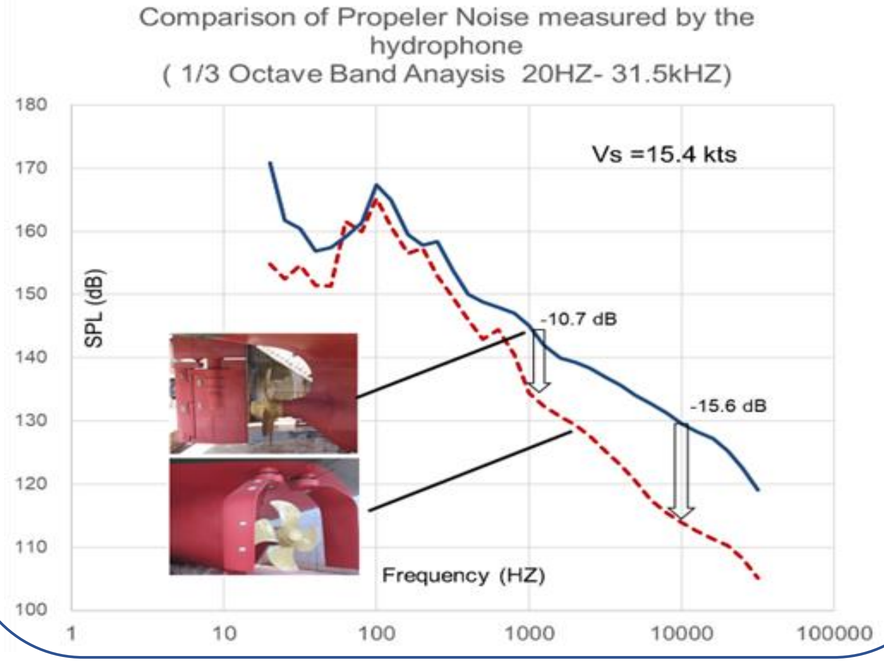
Recalling advantages of GRS – Noise and Vibration



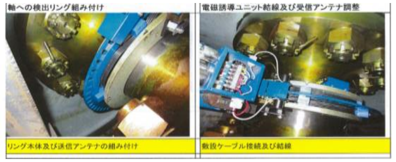




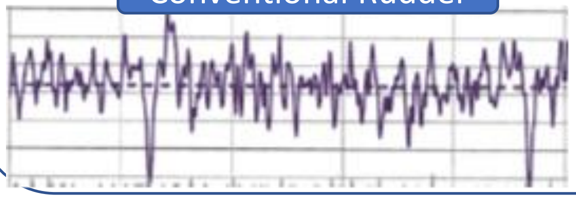
Local vibration reduction : abt.1/2



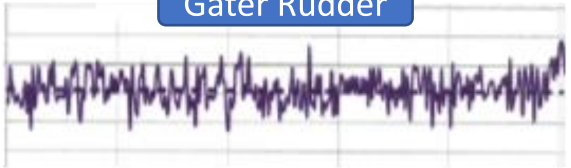
Same torquemeter



Conventional Rudder



Gater Rudder



Torque fluctuation reduction : abt.1/3

Propeller UR noise reduction : abt -10 ～15dB

The EC-H2020 Project

GATERS

GATE Rudder System as a Retrofit for the Next Generation Propulsion and Steering of Ships

Motivations for GATERS Project

- The proposal responded to the EC’s H2020 “Innovation Action” call under the heading “***Retrofit Solutions and Next Generation Propulsion for Waterborne Transport***” (ID: LC-MG-1-8-2019).

- Although there was one new ship application of GRS (***“Shigenobu”***), ***there was/is no current application of the Gate Rudder System as a “retrofit” device***, and hence it is proposed in GATERS for the first time and this, in fact, was the primary motivation of the GATERS proposal.

- GATERS, therefore, addressed the call text explicitly “***to develop and demonstrate to TRL6 and higher innovative, cost-effective retrofit solution for marine shipping which will provide substantial improvements regarding environmental impacts and life cycle cost***”.

- Recent IMO requirement for introducing the attained ***Energy Efficiency Existing Ship Index (EEXI)*** for ships of 400 GT and above, is the further complementary motivation of the GATERS project.

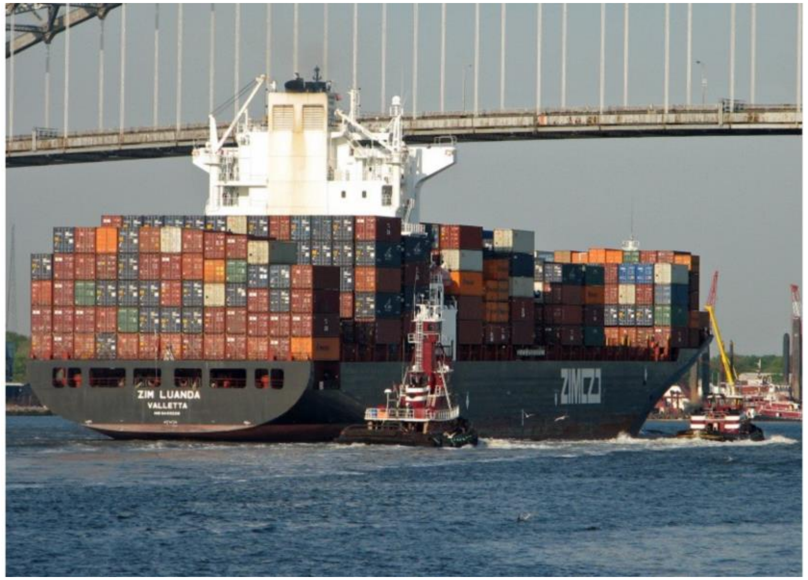
GATERS – Aims

- To bring together 18 technology experts and prime stakeholders, including the patent holder, to demonstrate and exploit the benefits of this system by two main deliverables:

➢ **To demonstrate the GR system for the European <u>short sea shipping</u> operations by installing and operating on a target coastal vessel.**

➢ **To explore the GR system, conceptually, for the <u>oceangoing shipping</u> operations, including fleet level.**

- Hence to demonstrate if the Gate Rudder System can be the next generation propulsion and steering system for the waterborne transport.

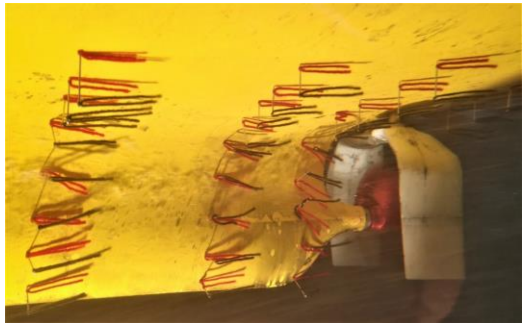


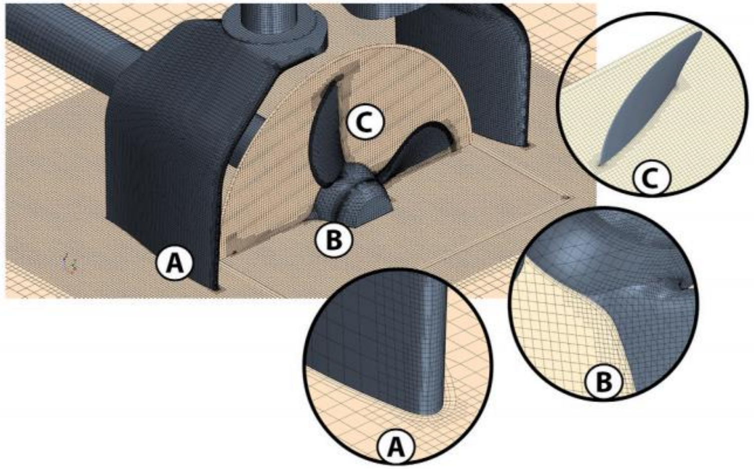
GATERS – Objectives

1. To investigate technical challenges of the Gate Rudder System (GRS) and **to establish the best practice of application as a retrofit** by using a combination of the computational, experimental and full-scale procedures.

2. To design a retrofit GRS at a detailed level, **to manufacture and install on the coastal target cargo vessel. Hence, to demonstrate the effectiveness of the GRS** by sea trials and voyage monitoring as well as its impact on the existing IMO regulations (i.e. EEDI, EEOI, EEXI and Minimum power requirements) and the Life Cycle Cost (LCC).

3. **To assess the overall impact of the retrofit GRS applications** to major ship types for the European SSS operations and the Oceangoing Shipping (OS) operations on the existing (IMO) regulations and Life Cycle Cost (LCC) for both individual vessels as well as the fleet-level services.





GATERS – Partners

Participant No.	Participant organisation name	Acronym	Country
1 (Coordinator)	UNIVERSITY OF STRATHCLYDE	UoS	UK
2	HAMBURGISCHE SCHIFFBAU- VERSUCHSANSTALT GMBH	HSVA	DE
3	BUREAU VERITAS MARINE & OFFSHORE REGISTRE INTERNATIONAL DE CLASSIFICATION DE NAVIRES ET DE PLATEFORMES OFFSHORE	BV	FR
4	GLAFCOS MARINE EPE	GME	EL
5	CONSIGLIO NAZIONALE DELLE RICERCHE	CNR	IT
6	HIDROTEKNIK YAT GEMI DENIZ YAPILARI TASARIM TEKNOLOJILERI SANAYI VE TICARET LIMITED SIRKETI	HYD	TR
7	ISTANBUL TEKNIK UNIVERSITESI	ITU	TR

GATERS – Partners (continued)

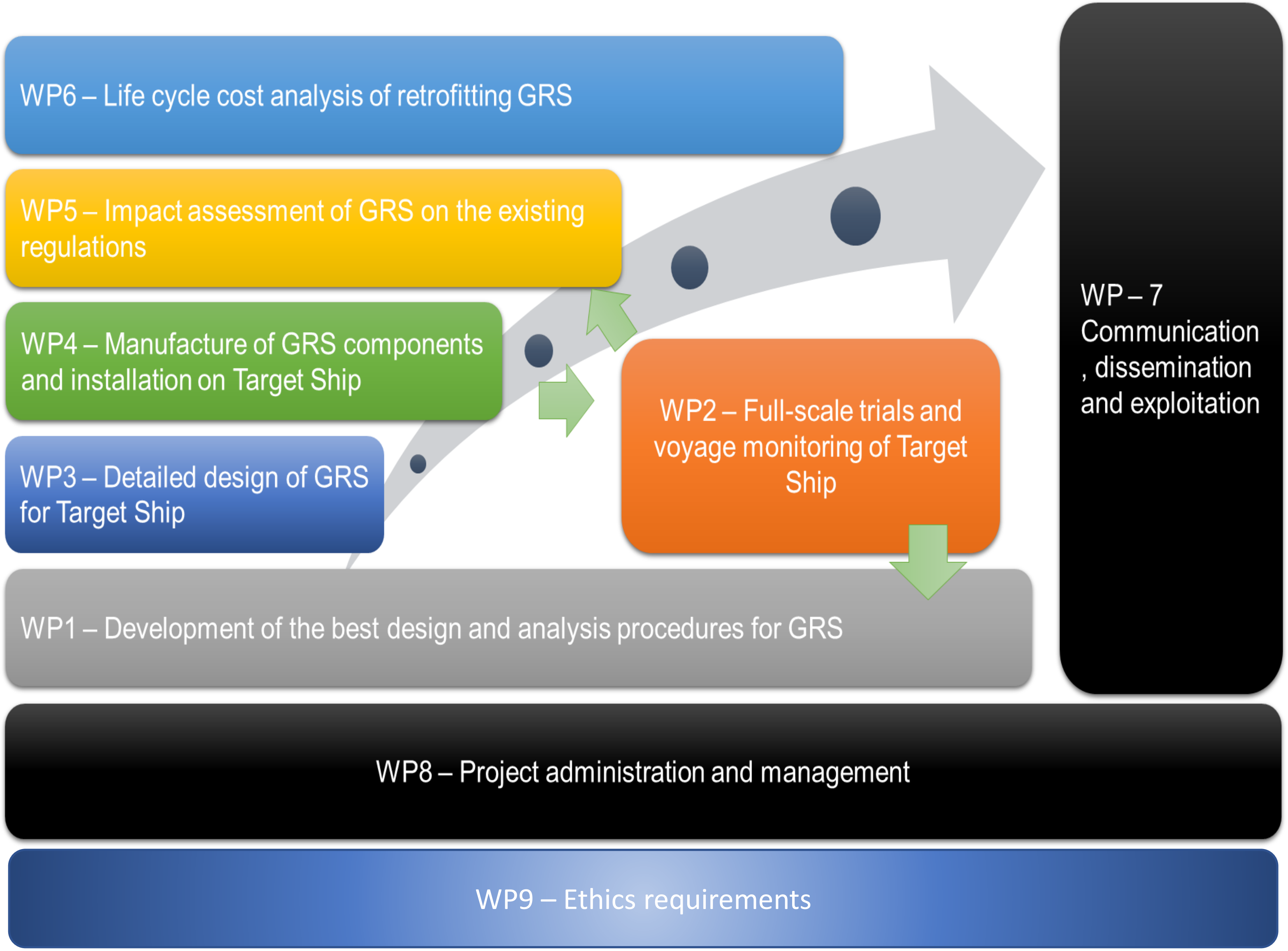
Participant No.	Participant organisation name	Acronym	Country
8	TWI LIMITED	TWI	UK
9	NAVAL ARCHITECTURAL SERVICES LIMITED	NAS	MT
10	CAPA DENIZCILIK NAKLIYAT SANAYI VETICARET LIMITED SIRKETI	CAPA	TR
11	SINTEF OCEAN AS	SINTEF	NO
12	DANAOS SHIPPING COMPANY LIMITED	DANAOS	CY
13	STONE MARINE PROPULSION LIMITED	SMP	UK
14	GURDESAN GEMI MAKINA SANAYI VE TICARET ANONIM SIRKETI	GURD	TR
15	UNIVERSITY OF NEWCASTLE UPON TYNE	UNEW	UK
16	STAR BULK SHIP MANAGEMENT CO. (CYPRUS) LTD	STARB	CY
17	INFORMA UK LTD (LLOYD'S LIST INTELLIGENCE)	LLI	UK
18	CETENA S.P.A.	CETENA	IT

GATERS – Methodology

- **Phase-1 (Feb'21 - Feb'22):** "Development of the best procedures for the design, manufacturing and retrofitting of the GRS" – *Critical design parts of the works to achieve the retrofitting of the GRS for the target cargo vessel will be completed.*

- **Phase-2 (Feb'22 - Feb'23):** "Detailed design, manufacturing and application of the GRS retrofitting on the target ship as well as its demonstration and further procedure development" – *Retrofitting on Sept'22*

- **Phase-3 (Feb'23 – Feb'24):** "Impact of the GRS retrofitting on the existing and forthcoming regulations and life cycle cost for the European SSS operations and the Oceangoing Shipping operations" – *An overall impact assessment of the GRS retrofitting for the major ship types at a fleet level will be conducted in this phase.*



Target vessel – MV ERGE To be retrofitted with GRS

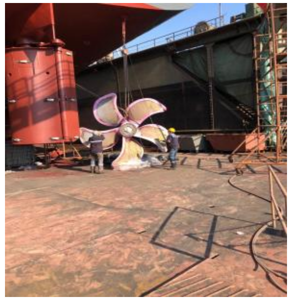
- **M/V ERGE** (IMO No: 9508603) 5650 DWT (2993GT) General Cargo ship, built in Weihai PRC and delivered in 2011.

- She operates in European Coastal waters, Black Sea, Red Sea and North African waters

- **M/V ERGE** is owned by **CAPA Denizcilik** and she has sister vessel M/V ERLE with conventional flap rudder

Parameter	MV Erge				
	Symbol	Units	Ballast Load	Design Load	Full Load
Length overall	L_{OA}	(m)	89.95		
Length between perpendiculars	L_{BP}	(m)	84.95		
Breadth	B	(m)	15.4		
Draught (midship)	T	(m)	3.3	5.6	6.45
Draught (AP)	T_A	(m)	3.8	5.6	6.45
Draught (FP)	T_F	(m)	2.8	5.6	6.45
Displacement	Δ	(ton)	3607	6339	7241
Block coefficient	C_B		0.818	0.827	0.84
Prismatic coefficient	C_P		0.823	0.829	0.843
Midship area coefficient	C_M		0.994	0.997	0.997
Waterplane area coefficient	C_{WP}		0.854	0.916	0.944
Longitudinal centre of buoyancy	LCB	(m) (+ fwd)	46.866	45.85	43.025
Longitudinal centre of floatation	LCF	(m) (+ fwd)	46.246	39.748	39.863
Longitudinal centre of gravity	LCG	(m) (+ fwd)	46.903	45.91	43.036
Verticle centre of gravity	VCG	(m)	3.23	5.4	6.095
Speed	V_S	knots	12		







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GATERS – Duration, Funding & CDE [Communication, Dissemination & Exploitation] Activities

GATERS

GATERS Duration and Effort

Project elapsed duration [months]	Project person efforts [months]
36	694

GATERS Funding

Total Project Fund [EUR]	**EU Contribution** [EUR]	**Industry Contribution** [EUR]
5,878,364.25	**4,999,509.98**	**878,854.27**

GATERS - Innovation and IP Management Board (IPMB)

Project Members	GME	HYD	SMP	TWI	UoS

GATERS - Communication, Dissemination and Exploitation Board (CDEB)

Project Members	CAPA	GME	HYD	SMP	TWI	UNEW	UoS

GATERS - Industry Advisory Board (IAB) and representatives

Member Institution / Company	Royal Caribbean Cruise Ltd	Wartsila Netherlands BV	Hellenic Tankers Co Ltd	Oscar Propulsion Ltd	Kuribayashi Steam Co Ltd	Shell Int'l Trad & Co Ltd	KOSDER

Most recent member

Progress on GATERS Project so far

- Project was officially started in February 2021 with a kick-off meeting held on 24th of February

- Project website was launched as well as other CDE activities have been underway including social media interfaces

www.gatersproject.com

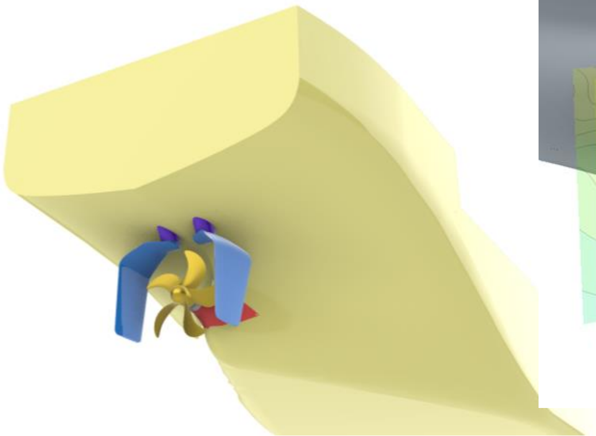
European Commission | CORDIS
EU research results

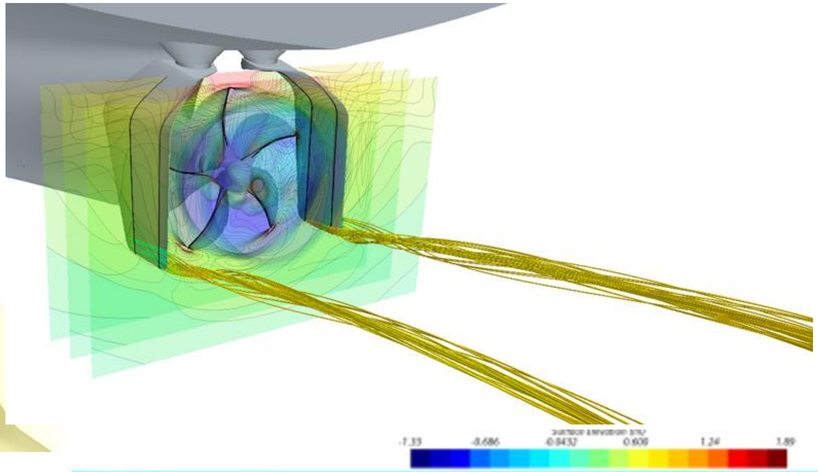
- www.gatersproject.com
- https://cordis.europa.eu/project/id/860337
- https://twitter.com/gatersproject
- https://www.linkedin.com/company/gatersproject
- https://www.youtube.com/channel/UCh0n9ruJt75bS64Js4vQEFw
- Contact (Coordinator): Prof Mehmet Atlar (mehmet.atlar@strath.ac.uk)

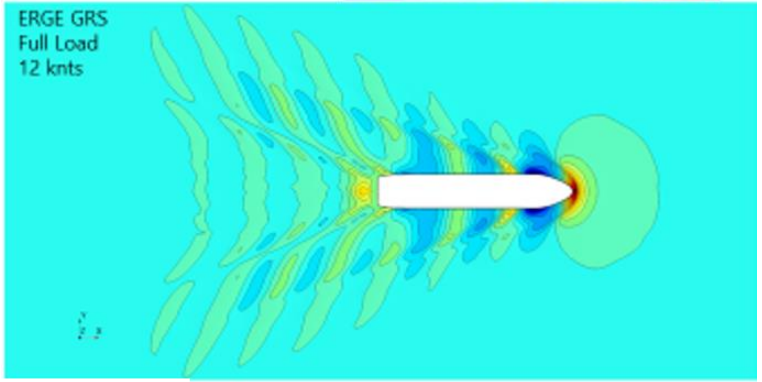
Progress on GATERS Project so far
(continued)

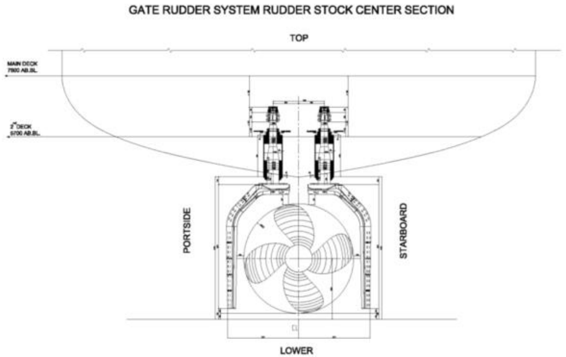
Active WP's

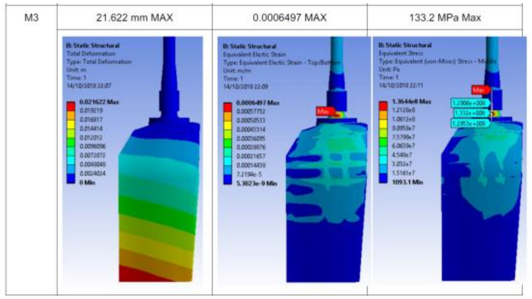
- **WP1** (Best retrofitting procedure development & Preliminary Gate Rudder Design including CFD and model testing tasks);
- **WP2** (Target Vessel Sea Trials & Performance Monitoring System installation and data collection task);
- **WP3 / WP4** (Detailed design / Manufacturing preparation tasks, resp.)
- **WP7** (Communication, Dissemination and Exploitation activities tasks);
- **WP8** (Day-to-day management tasks)







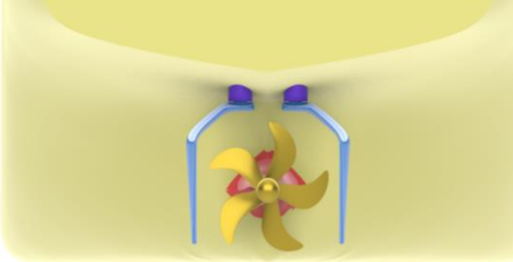


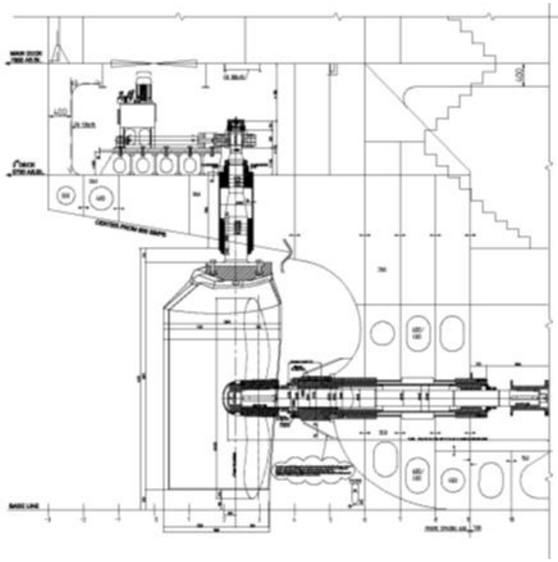


Progress on GATERS Project so far
(continued)

WP 1 - Activities

- Preliminary design of GRS for MV ERGE has been completed using low (empirical) and hi-fidelity (CFD) tools as well as the full-scale performance data
- Initial model tests with 3.6m model at ITU Towing Tank has been completed to support the GRS system Design
- Detail design of the GRS (rudder blades, steering gear machinery, Autopilot selection, shaft and propeller) for manufacturing purposes are underway
- Class-approval talks with Bureau Veritas has been initiated
- Futuristic GRS blade design using “composite” materials is also being investigated for large ship applications to save weight increase
- Scale effects in powering, manoeuvring and seakeeping predictions are being rigorously investigated using different scale model tests (e.g. 3.6m ; 6.0m and 10m models) in three different institutions (ITU-Istanbul; CNR-Rome; and HSVA-Hamburg) and alternative CFD tools.


Progress on GATERS Project so far *(continued)*

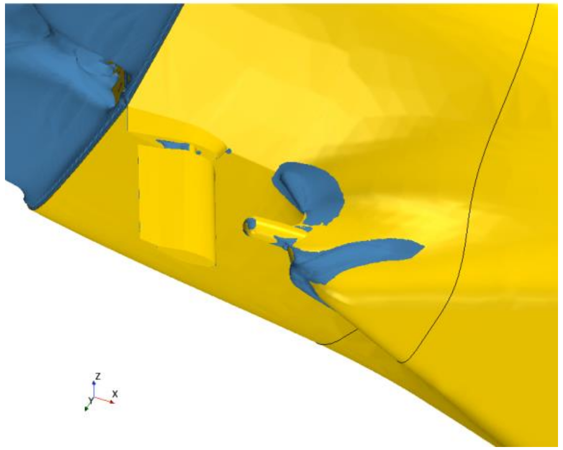
M/V ERGE				Loaded	Ballast
Scale	λ			23.7	
Length overall	L_{OA}	(m)	89.95	3.795	
Length between perpendiculars	L_{BP}	(m)	84.95	3.584	
Breadth	B	(m)	15.40	0.650	
Design Draught (midship)	T	(m)	6.46	0.273	0.139
Displacement	Δ	(ton)	7280	0.547	0.263
Service Speed	V_S	Knots - m/s	12.0	1.27	
Rudder Type			GRS-CRS	GRS-CRS	

Loaded Condition (ITU, Ata Nutku Towing Tank)

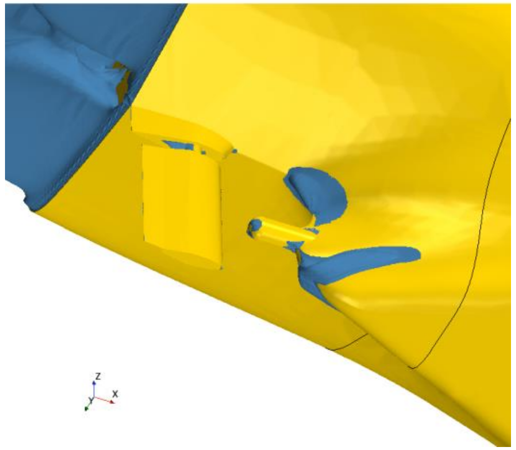
Ballast Condition (ITU, Ata Nutku Towing Tank)

CFD Predictions for MV ERGE in ITU model test scale (Lpp = 3.6m)

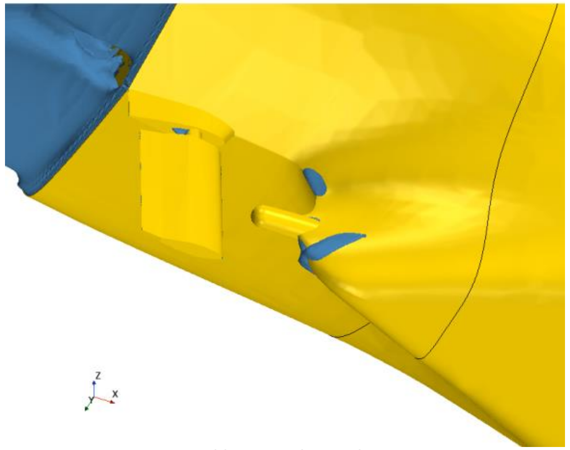
Progress on GATERS Project so far
(continued)



3.6 m Model

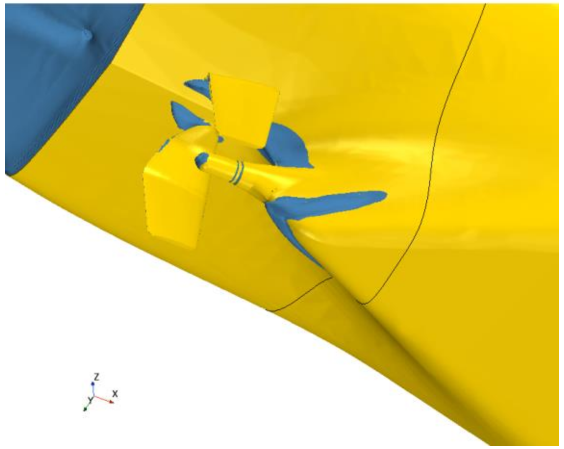


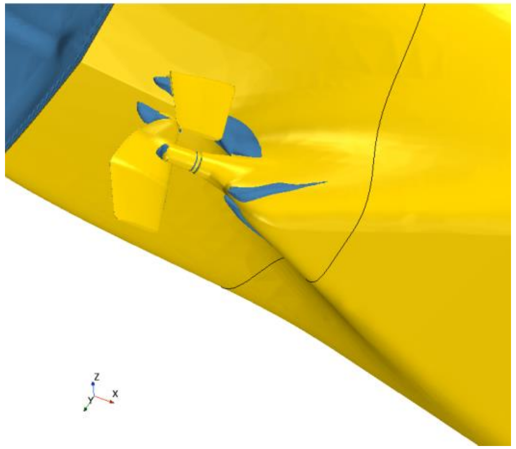
6.0 m Model

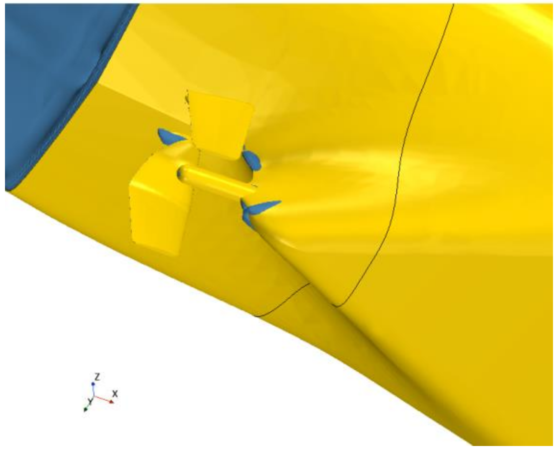


Full Scale ship

Conventional Rudder case



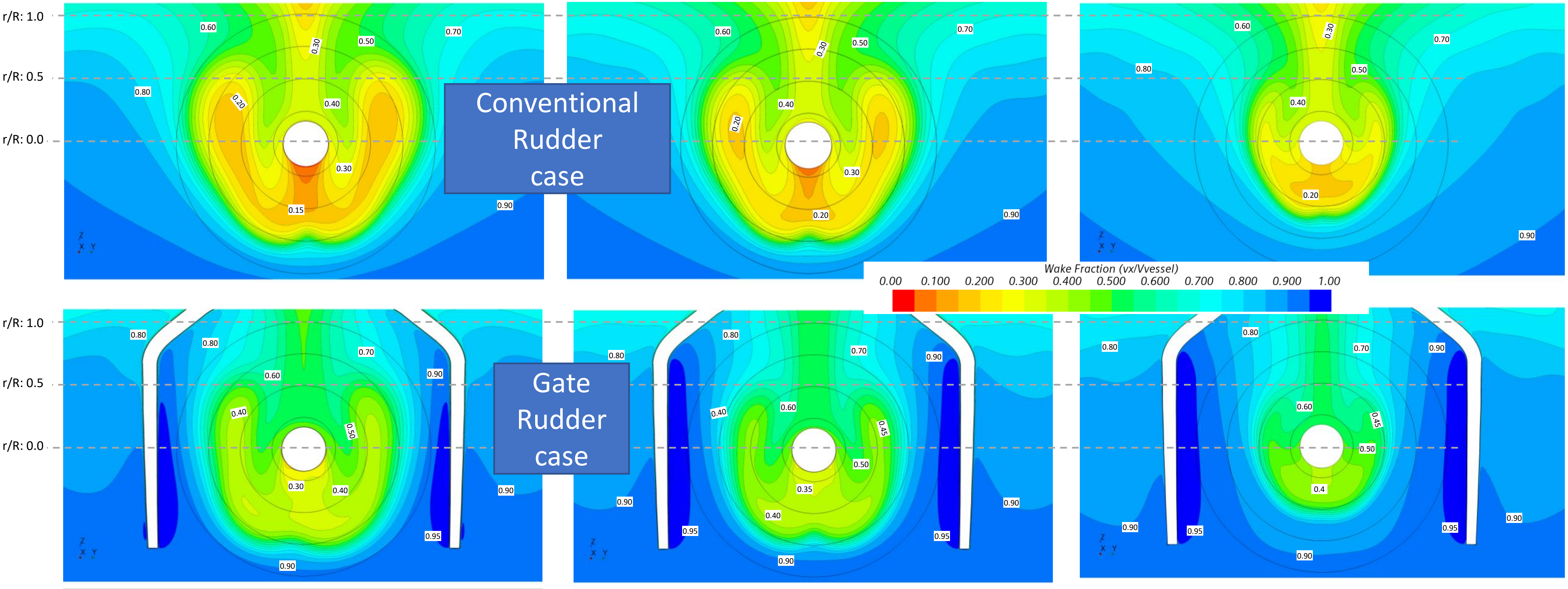




Gate Rudder case

CFD Predictions of separation in towing condition (loaded draft)

Progress on GATERS Project so far
(continued)



M/V Erge
- 3.6 m
- Full Load
- Star CCM+

CRS V_X/V_S: 0.361
GRS V_X/V_S: 0.534

M/V Erge
- 6.0 m

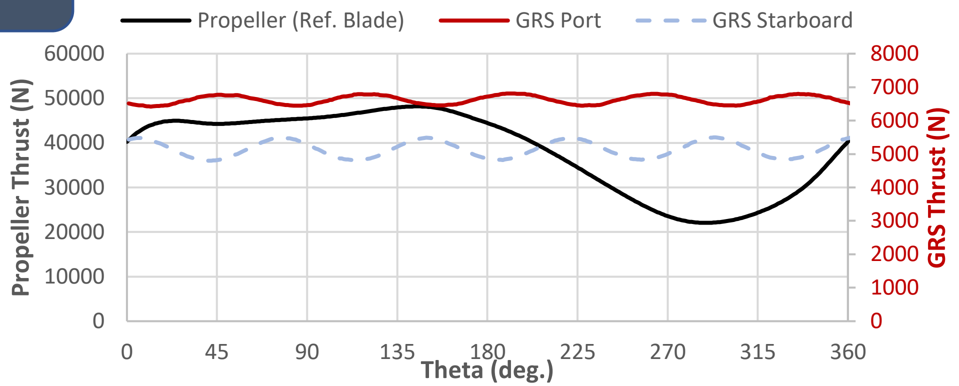
CRS V_X/V_S: 0.348
GRS V_X/V_S: 0.604

M/V Erge
- Full Scale
- Full Load
- Star CCM+

CRS V_X/V_S: 0.541
GRS V_X/V_S: 0.709

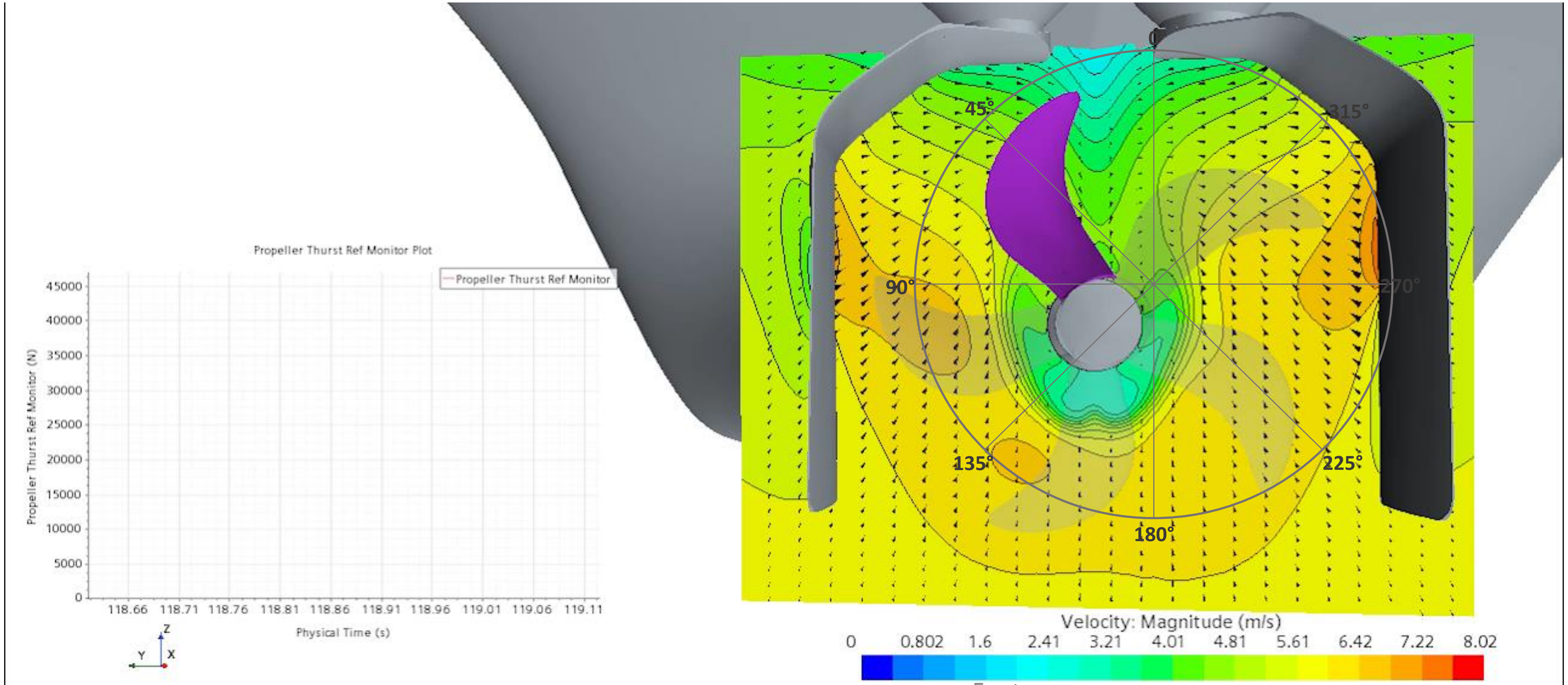
CFD Predictions of Nominal Wake at different scales

Progress on GATERS Project so far
(continued)



A reference blade load according to its position is given on the table.

Also, the dynamic load change can observed the video below. As can be seen on the dynamic table, the same propeller load profile repeats itself during each turn. It shows that the solution has been converged.



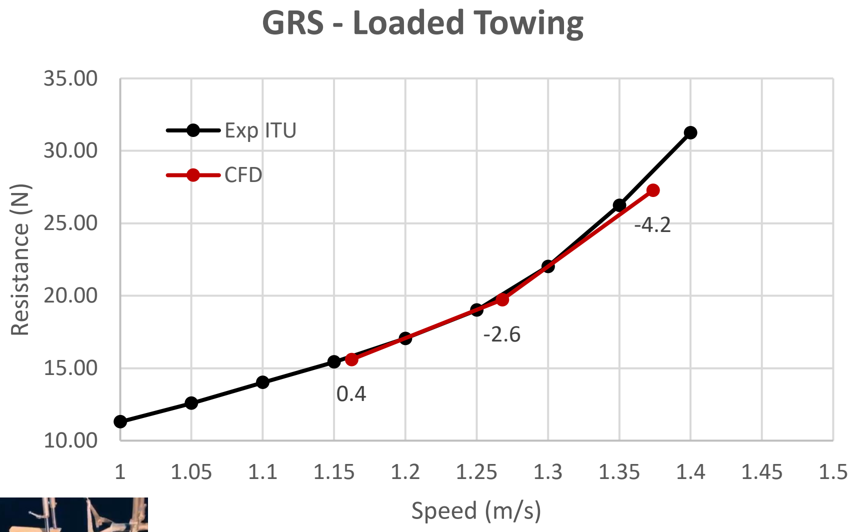
CFD prediction for time dependent Thrust Loading on propeller and rudder blades

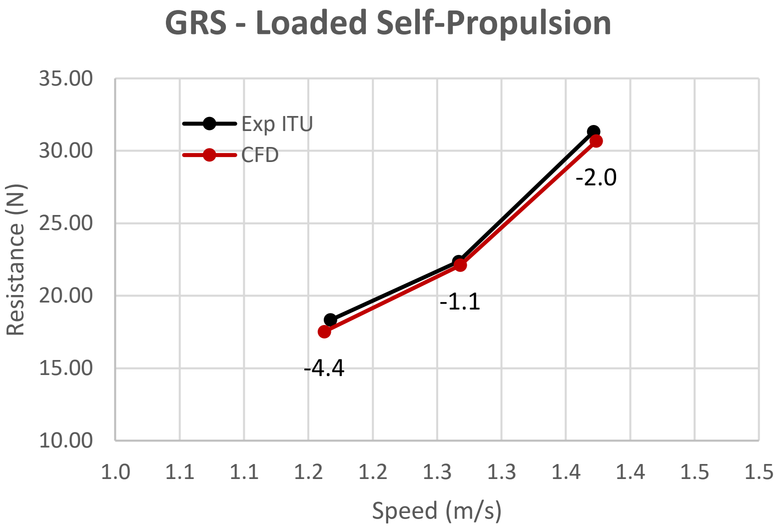
Progress on GATERS Project so far *(continued)*

V_M	11 kn	Loaded EFD	CFD	Diff %
Naked	Towing	15.90	15.71	-1.2
CRS	R_{Towing}	16.47	15.79	-4.1
	R_{SP}	21.44	19.09	-11.0
GRS	R_{Towing}	15.54	15.60	0.4
	R_{SP}	18.31	17.51	-4.4

V_M	12 kn	Loaded EFD	CFD	Diff %
Naked	R_{Towing}	20.36	19.60	-3.7
CRS	R_{Towing}	20.90	19.89	-4.9
	R_{SP}	26.19	24.00	-8.4
GRS	R_{Towing}	20.26	19.72	-2.6
	R_{SP}	22.35	22.10	-1.1

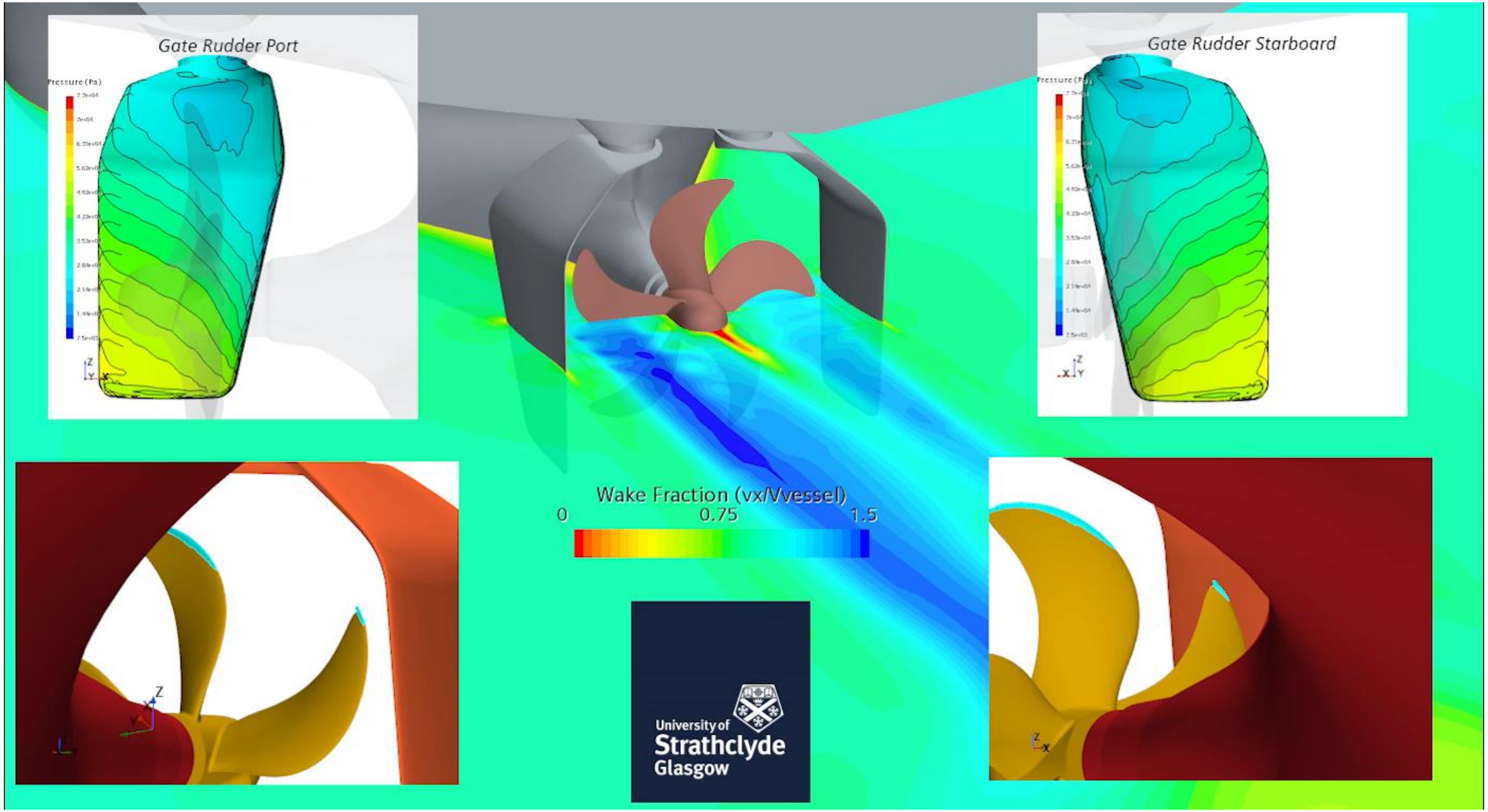
V_M	13 kn	Loaded EFD	CFD	Diff %
Naked	R_{Towing}	29.09	0.00	
CRS	R_{Towing}	27.20	27.45	0.9
	R_{SP}	36.15	33.80	-6.5
GRS	R_{Towing}	28.46	27.26	-4.2
	R_{SP}	31.30	30.66	-2.0





CFD Predictions vs ITU Model test results

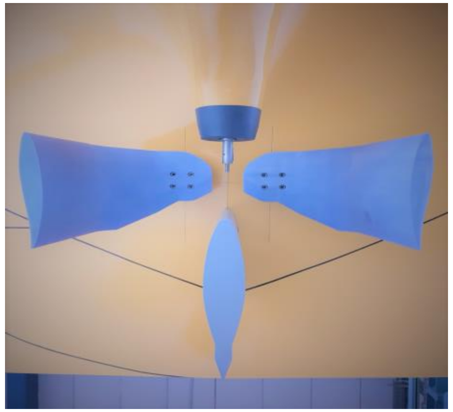
Progress on GATERS Project so far *(continued)*



CFD predictions including cavitation Modelling

Progress on GATERS Project so far *(continued)*



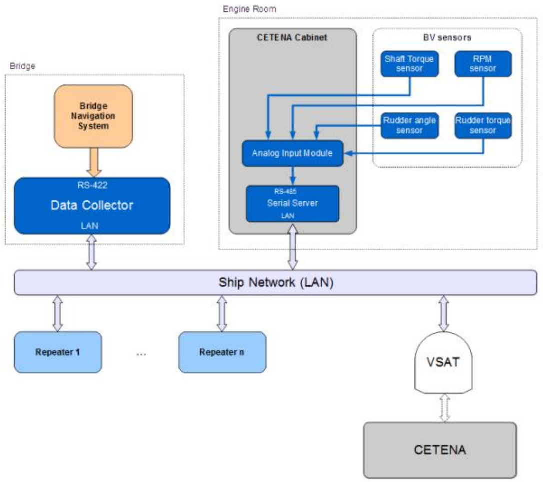
SHIGENOBU			
Length overall	L_{OA}	(m)	111.40
Length between perpendiculars	L_{BP}	(m)	106.40
Breadth	B	(m)	17.80
Design Draught (midship)	T	(m)	5.24
Displacement	Δ	(ton)	4794
Service Speed	V_S	knots	15.5
Rudder			GRS

Large size container model tests (λ = 10.94; Lpp = 9.72m; Dp = 0.3m) conducted at HSVA on October 2021

Progress on GATERS Project so far
(continued)

WP 2 - Activities

- **Ship performance** data collection and monitoring system onboard MV ERGE installed to record Speed-Power; Fuel Consumption & Environment data on late September 2021
- **Performance monitoring "in-service"** started in October 2021 and will continue until the end of the project
- **Dedicated "sea-trials"** in calm water for Speed-Power; Vibrations / Cavitation / Underwater Radiated Noise and Manoeuvring are scheduled before and after the Gate Rudder retrofitting to be conducted in Marmara Sea for August/September 2022



Long term monitoring system cockpit that will be installed on board

CETENA

this case both the two HFO tanks must be empty in order to avoid heeling, and the consequent displacement, trim and range must be considered.

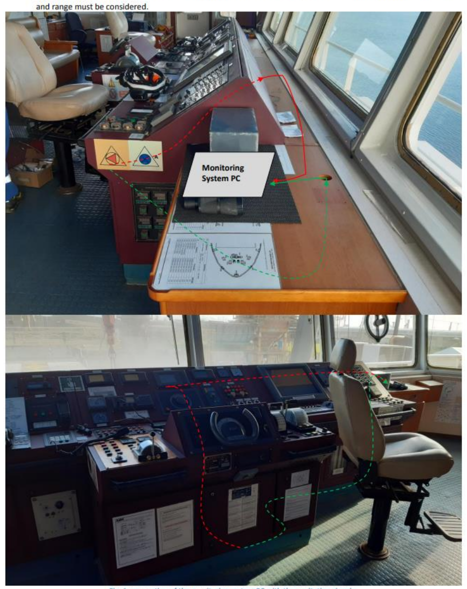


Fig. 1: connection of the monitoring system PC with the navitation signals

CETENA

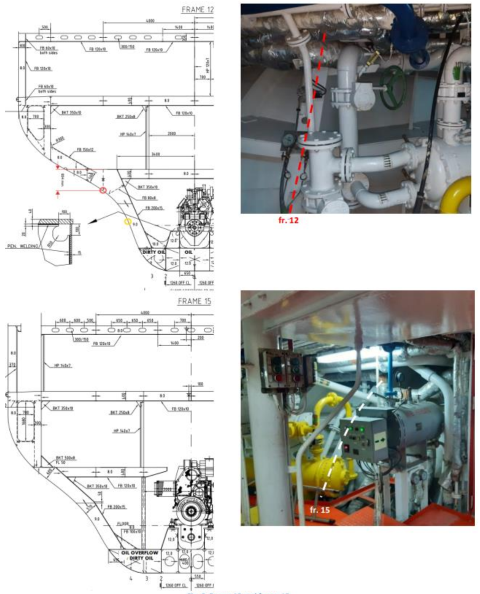


Fig. 6: Frame 12 and frame 15

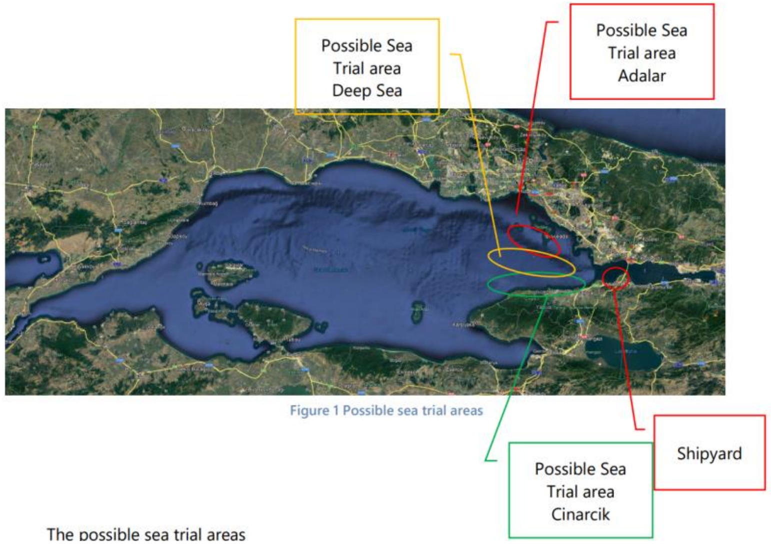


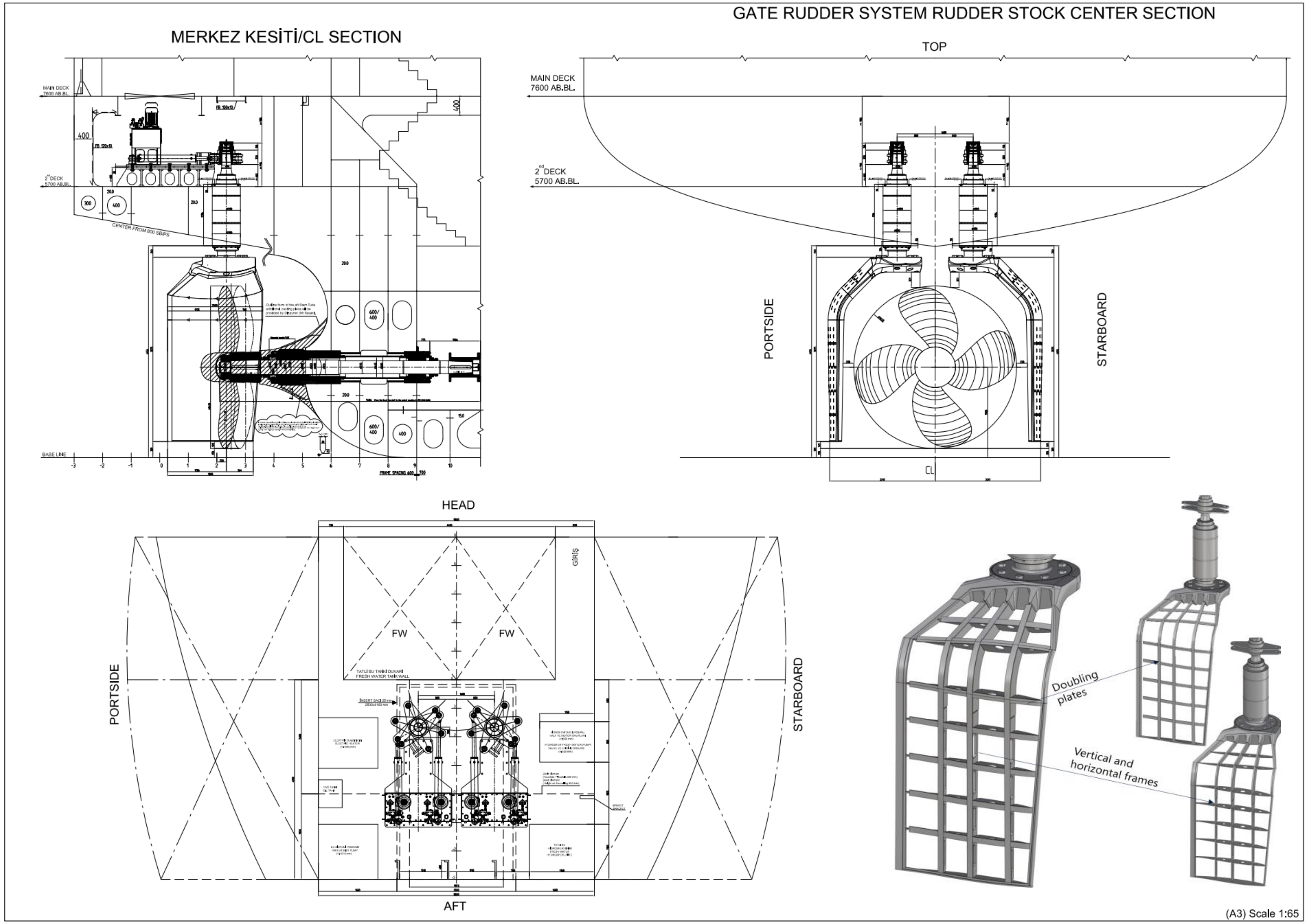
Figure 1 Possible sea trial areas

The possible sea trial areas

Progress on GATERS Project so far
(continued)

WP 3 / WP4 - Activities

- **Detailed design** activity tasks involving GRS components (i.e. GR Blades, Shafting, Propeller, modifications to aft end, Steering Gear Machinery; Autopilot selection etc) have been underway
- **Negotiations with Class Society** (Bureau Veritas) for the approval of modifications have been started
- **Manufacturing GRS components,** removal of CRS and installation GRS - related preparation activities are being arranged



GATERS - Summary

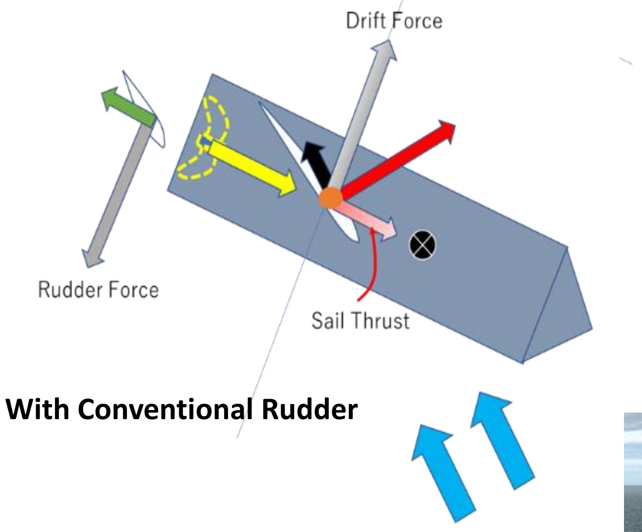
- **GRS provides such a significant amount of power-saving and associated GHG reduction** that cannot be achieved by any other solitary (single) energy-saving device (ESD) for propulsion currently available in the market.

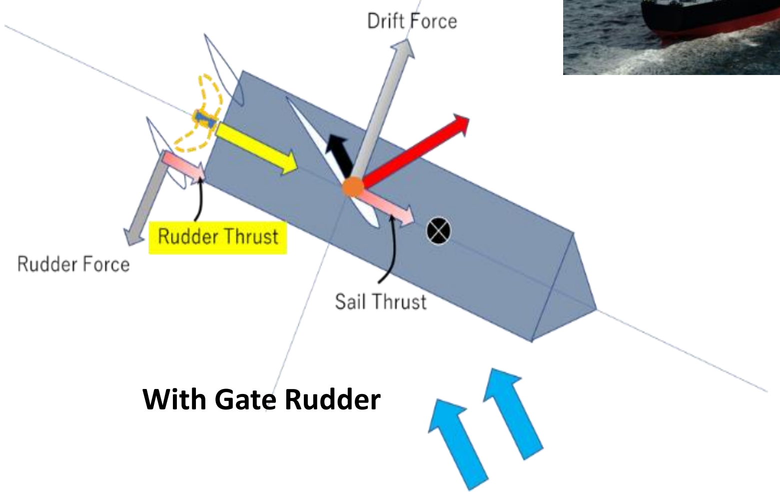
- GRS is a generic and **complementary ESD** that can be easily combined with other energy-saving technologies without any conflict.

- For example, new engine and fuel technologies, fuel cells, hybrid systems, waste heat recovery and renewable energy based technologies **(in particular Wind Assisted propulsion)** can take the great advantage of GRS.

- **Slow-steaming** may be well recognised cost-effective way of reducing GHG with **the risk of poor seakeeping/manoeuvring in waves**. This risk can be removed by the use of GRS with the reduced power requirement.

- GATERS focuses on "**Retrofit**" type GHG reduction measure which complements IMO's most recent requirement, "**Short term technical measure of EEXI" for existing ships, due to come in force on January 2023.**





University of Strathclyde Glasgow

OCTOBER 19
4TH GREENTECH IN SHIPPING VIRTUAL FORUM

THANK YOU

on behalf of the GATERS Consortium

GATERS

mehmet.atlar@strath.ac.uk
www.strath.ac.uk/naome/