



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

By

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Dept of Naval, Ocean & Marine Eng.*

2  **DECARBONIZING SHIPPING**
ND **VIRTUAL FORUM**
APRIL 27, 2021

06:00 AM MIAMI | 12:00 HAMBURG

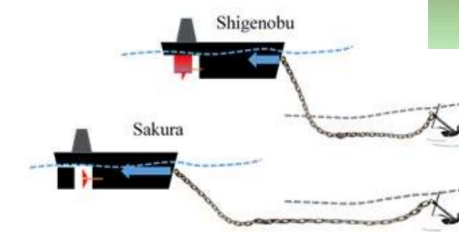
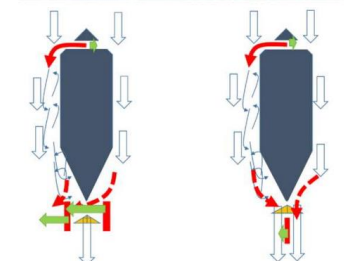
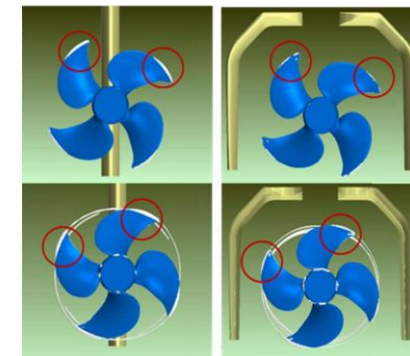
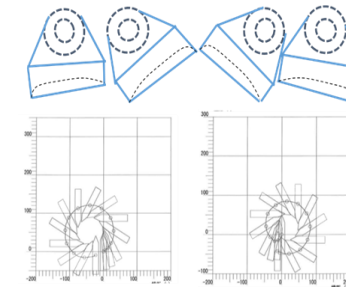
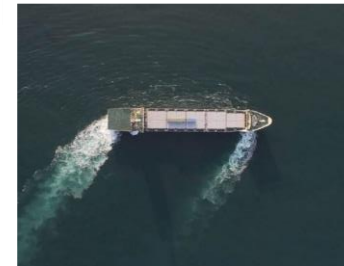
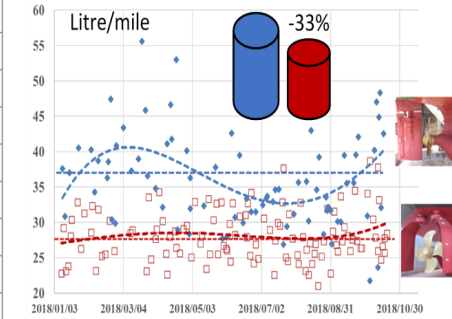
What is A GATE RUDDER SYSTEM (GRS) ?

- 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 motion control capability.



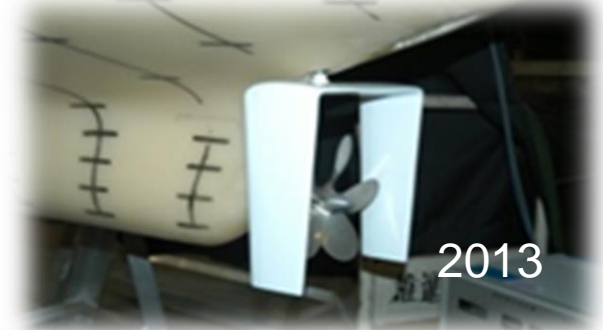
What are the advantages of A GATE RUDDER SYSTEM (GRS) ?

- 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 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



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 400TEU Japanese Container vessel “**Shigenobu**” through the R&D project sponsored by Nippon Foundation and a Japanese Consortium in 2017. The comparison of performance with her sister ship “**Sakura**” was well above the predictions.



First GRS application in Japan

- First application of the GRS was on a new build 400TEU Container vessel SHIGENOBU in 2017
- SHIGENOBU is the sister ship of SAKURA with the same size and engine power but with conventional (flap) rudder built in 2016
- As part of an R&D programme sponsored by Nippon Foundation and the Japanese Consortium the performance of both vessels were compared in speed trials in 2017 and later on through continuous performance monitoring in-service

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

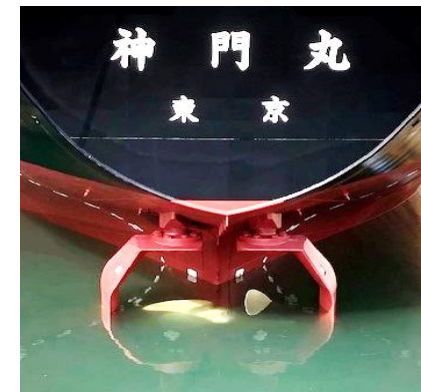


SAKURA			
Length overall	L _{OA}	(m)	111.4
Length between perpendiculars	L _{BP}	(m)	
Breadth	B	(m)	17.8
Draught (midship)	T	(m)	5.24
Displacement	Δ	(ton)	
Service Speed	V _S	knots	15.5
Rudder			CR



So far, GRS APPLICATIONS

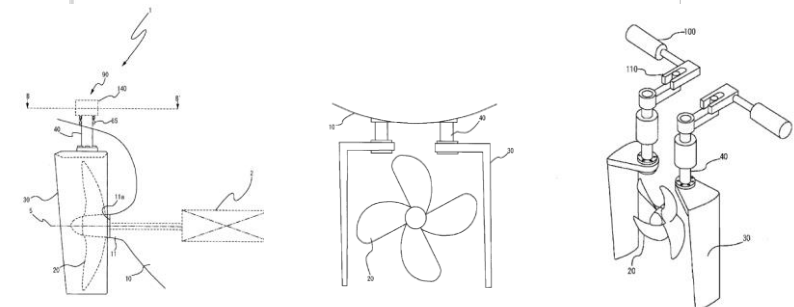
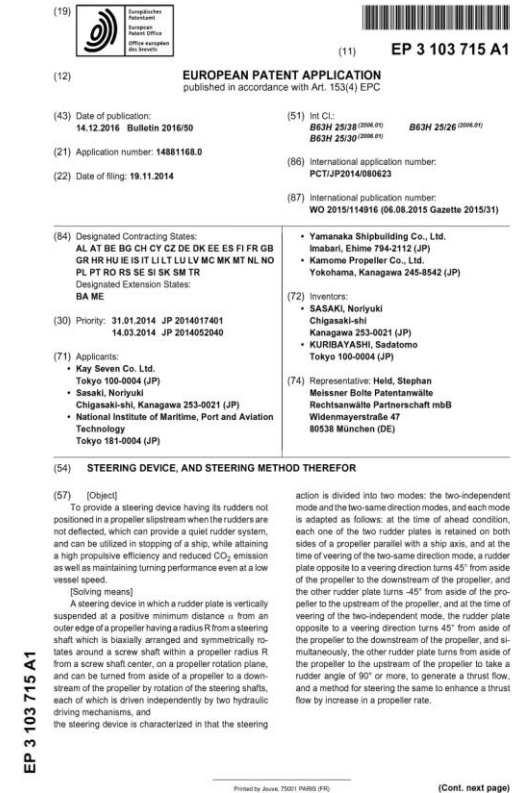
	SHIGENOBU (1 st Application, 2017)	KOHSIN MARU (2 nd Application, 2020)	SHINMON MARU (3 rd Application, 2020)
Type of ship	Container (400 TEU)	General cargo (509 GT)	General Cargo (499 GT)
Lpp	101.9	69	72
B	17.8	12	12
T	5.24	4.11	4.13
C_B	0.67	0.70	0.70
Design Vs	14.5	13	13
Fn (Lpp)	0.2436	0.267	0.267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



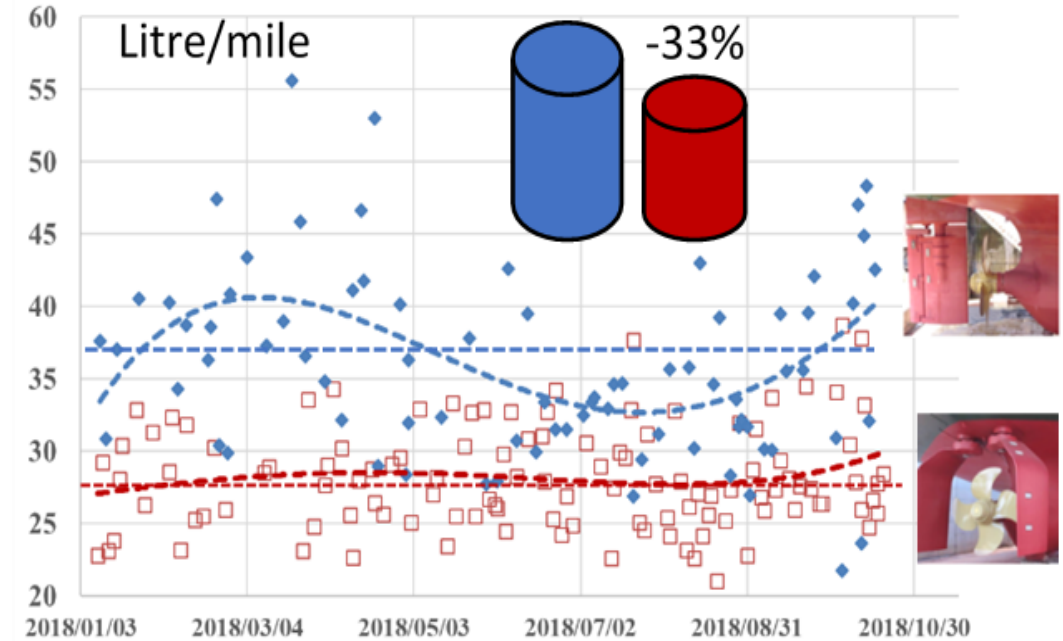
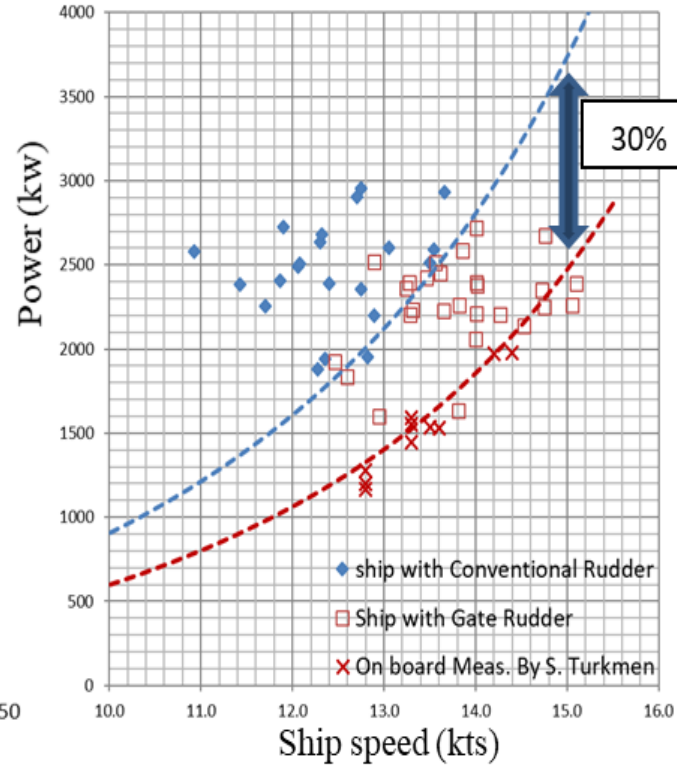
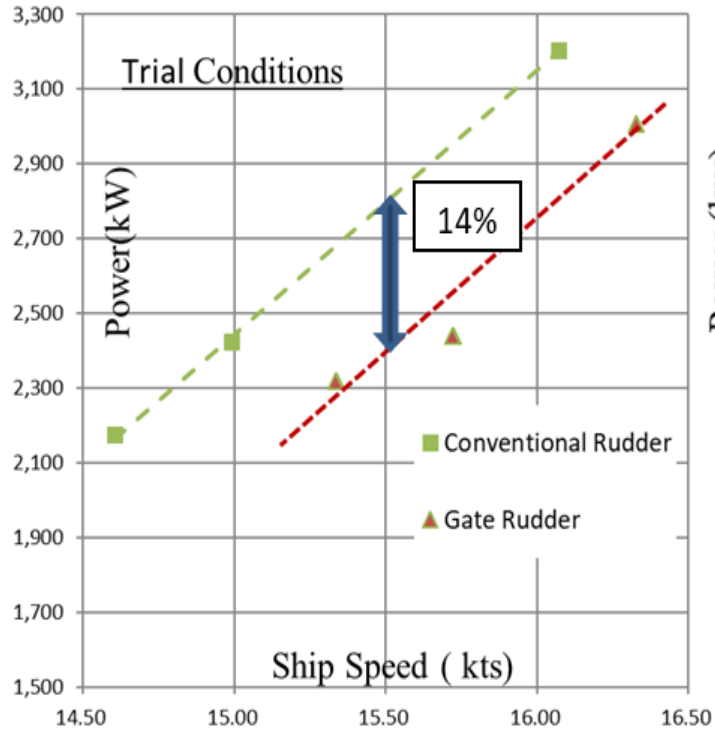
Current commercial status of GRS

- A Japanese Consortium (JC) involving Kay Seven Co., Ltd., (Kuribayashi Steam Co Ltd); Mr. 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) and Visiting Prof Noriyuki Sasaki 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) in December 2019 and the GATERS Consortium signed sub-license agreement with Wartsila Netherlands BV in 2021 on behalf of the Patent Holders 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”



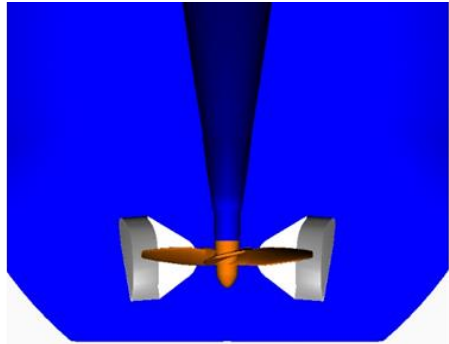
Fuel saving advantage of GRS



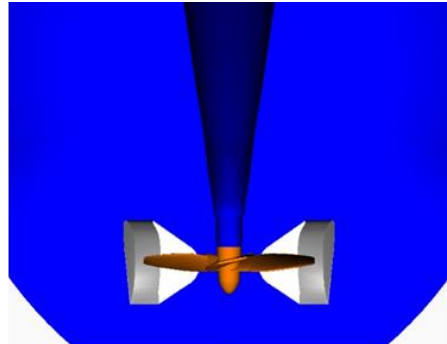
Trials (calm water) and in-service (including rough weather) powering performance comparisons of two sister ships: one with Gate rudder system, other with Conventional flap-rudder system

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

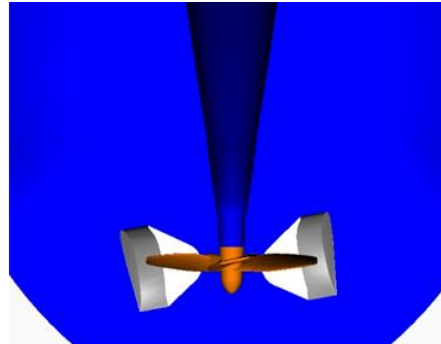
Manouverability advantage of GRS



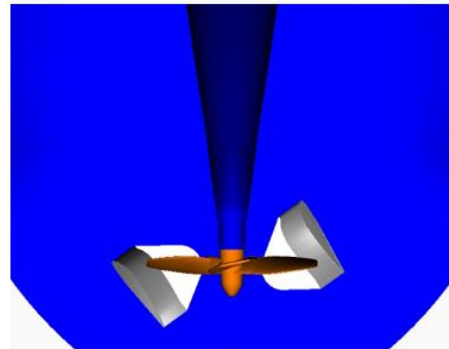
Navigation (economy mode)
Rudder angle +3 ~ +5 deg.



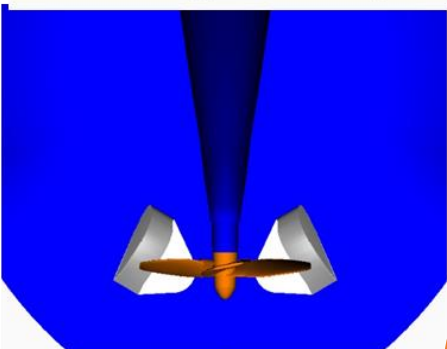
Navigation (rough sea mode)
Rudder angle 0 ~ +2 deg.



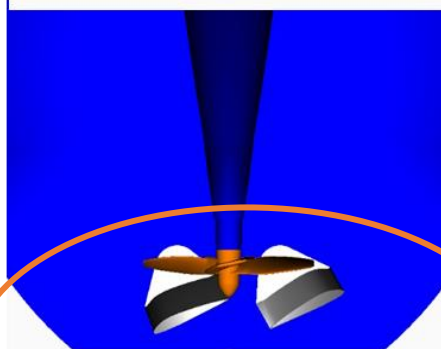
Navigation (steering mode)
Example rudder angle -10 & +10 deg.



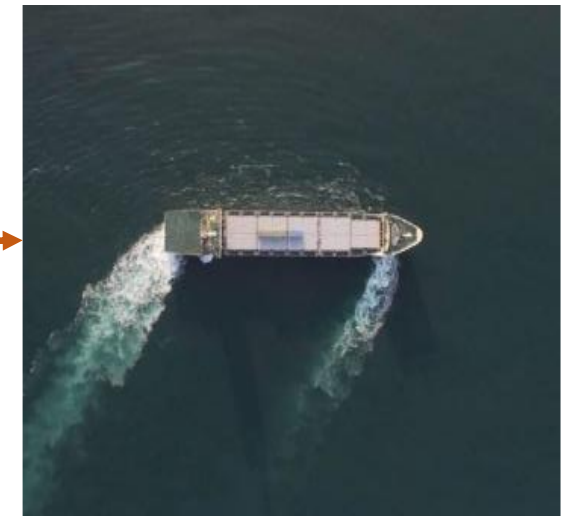
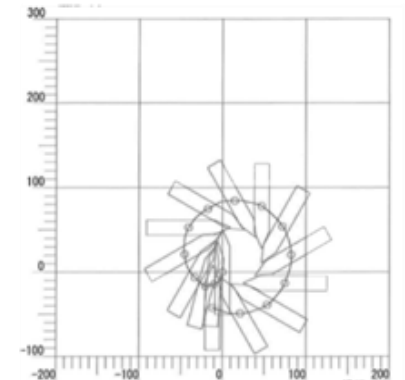
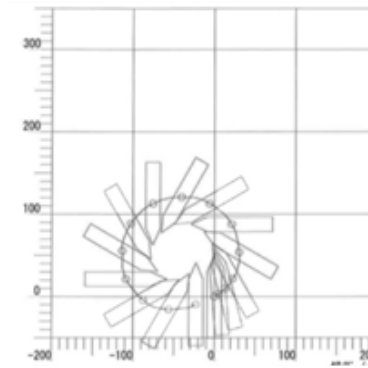
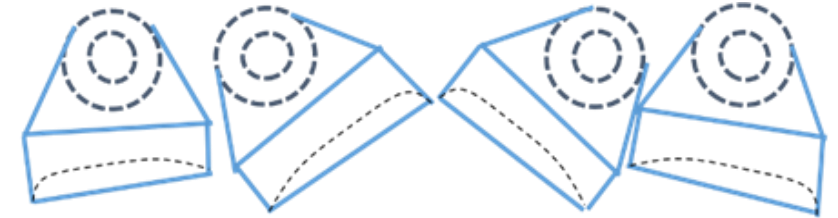
Circle mode
Rudder angle -30 & +35 deg.



Crash stop mode
Rudder angle -30 & -30 deg.



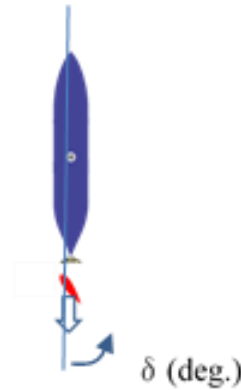
Crabbing mode
Rudder angle +110 & +60 deg.



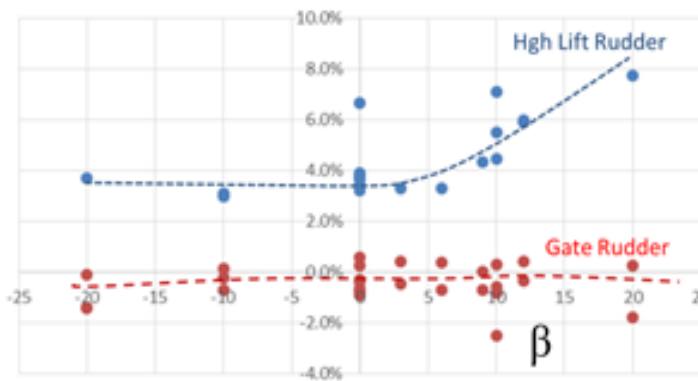
Crabbing mode

Manoeuvring modes with GRS

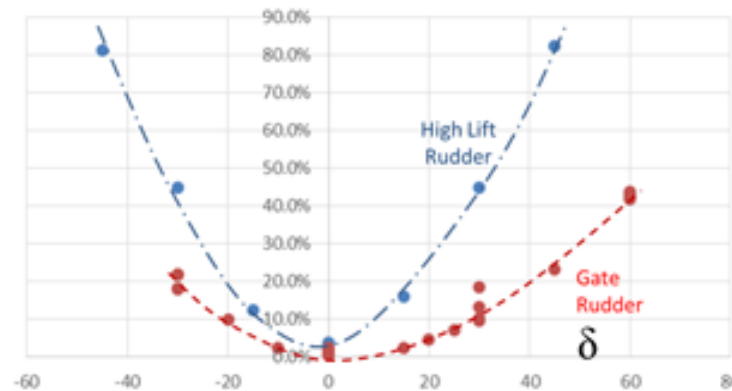
Manouverability advantage of GRS



Rudder Resistance During Maneuvering Motion

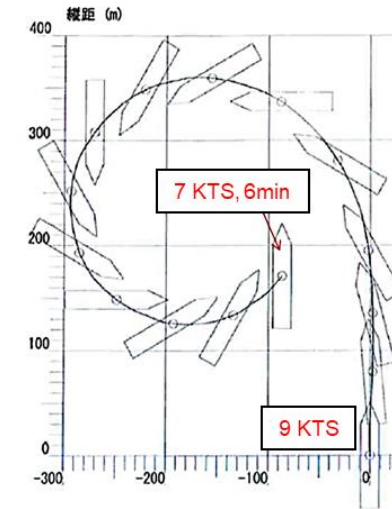


Rudder Resistance During Helm

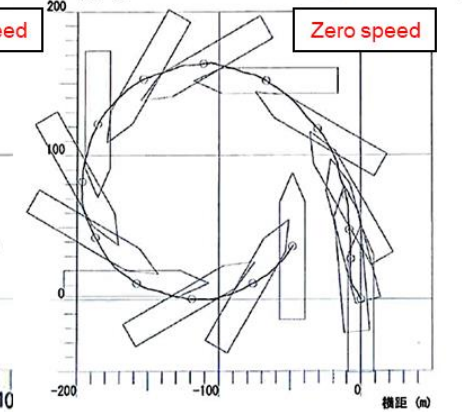
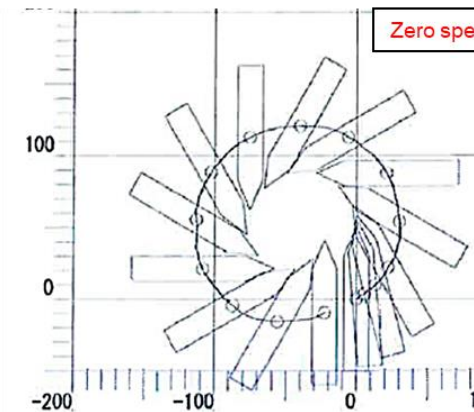
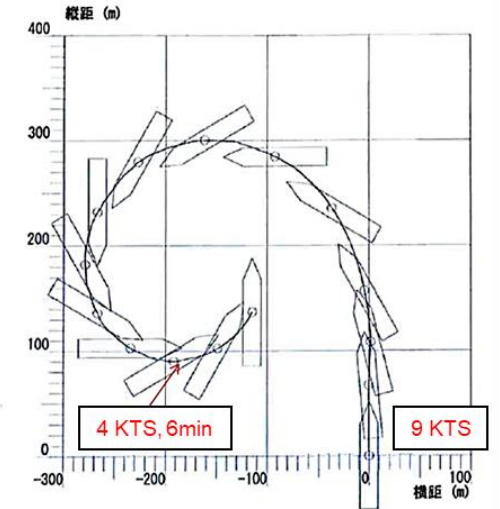


Comparison of rudder resistance (% Thrust) due to manoeuvring for conventional rudder and GRS.

Gate Rudder

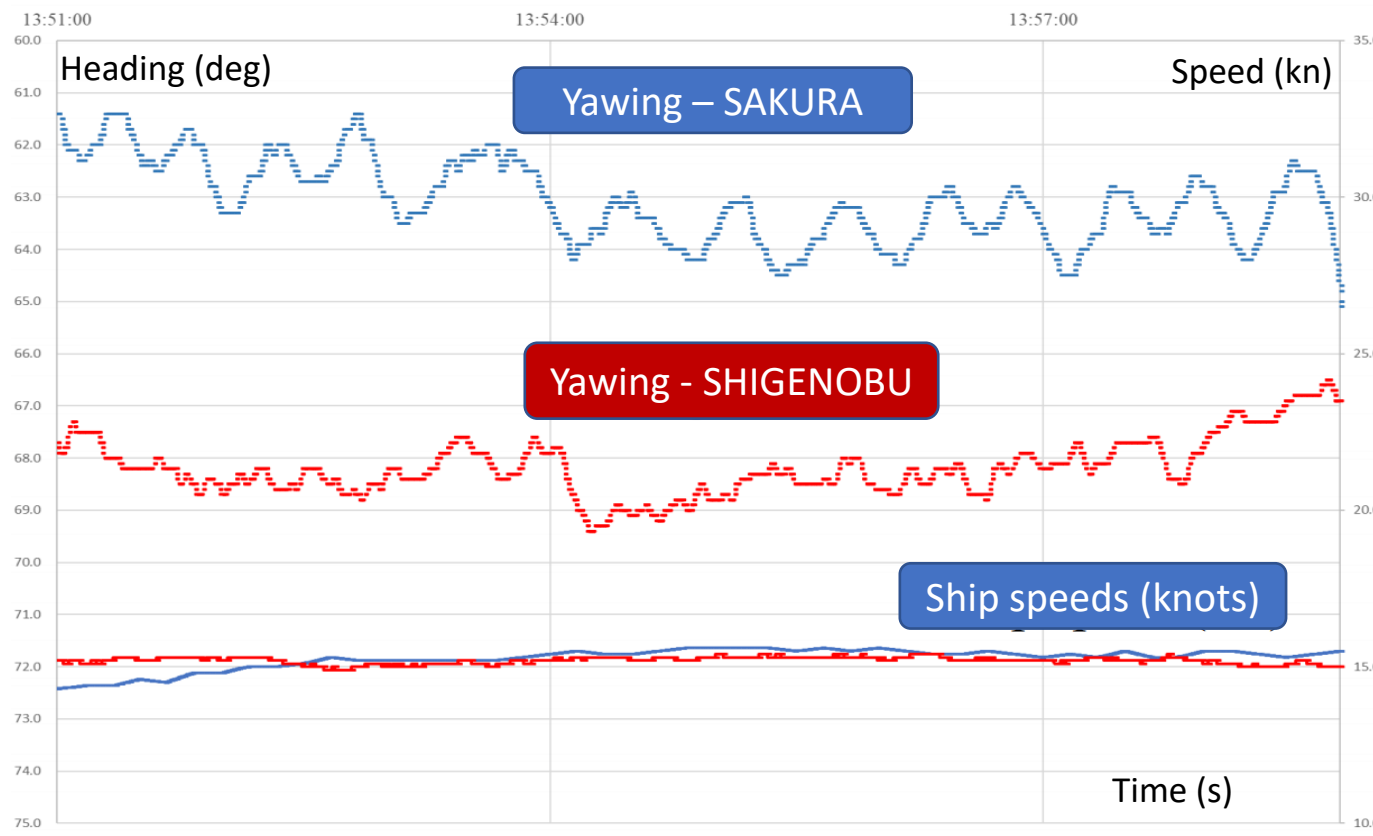


Flap Rudder



Full-Scale 35° Circle Test (Low Speed and Zero Speed) for Ship with conventional (flap) rudder and GRS

Seakeeping advantage of GRS



Sea conditions:

Wind speed: 12-24 knots

Wave height: 1.5 – 2.0m

Direction 250-270°

Period: 30 sec

Rolling motion recorded on inclinometer:

SAKURA → 3-5°

SHIGENBOU → 1-3°

Comparison of time history yawing motions recorded in (almost) side-by-side trials with SAKURA (CR) and SHIGENOBU (GRS) containerships

Motivations for GATERS Project



- The proposal responded to the 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 TRL 6 and higher innovative, cost-effective retrofit solution for marine shipping which will provide substantial improvements regarding environmental impacts and life cycle cost”***.
- Recent IMO proposal for introducing the attained ***Energy Efficiency Existing Ship Index (EEXI)*** for ships of 400 GT and above



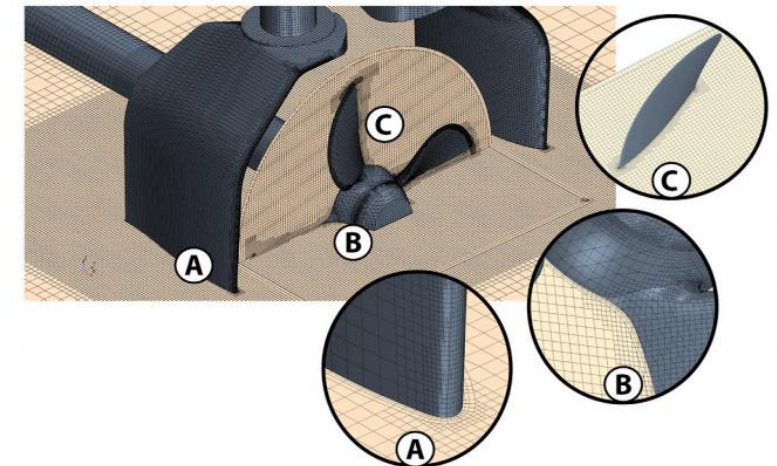
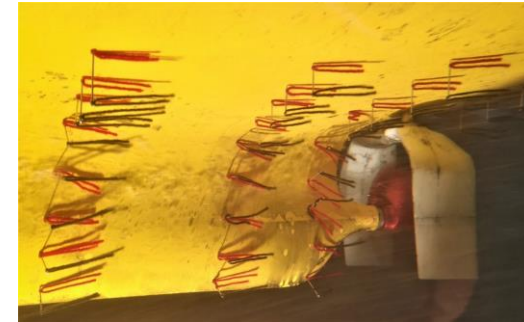
GATERS – Aims

- 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 short sea shipping operations by installing and operating on a target coastal vessel.
 - To explore the GR system, conceptually, for the oceangoing shipping 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.

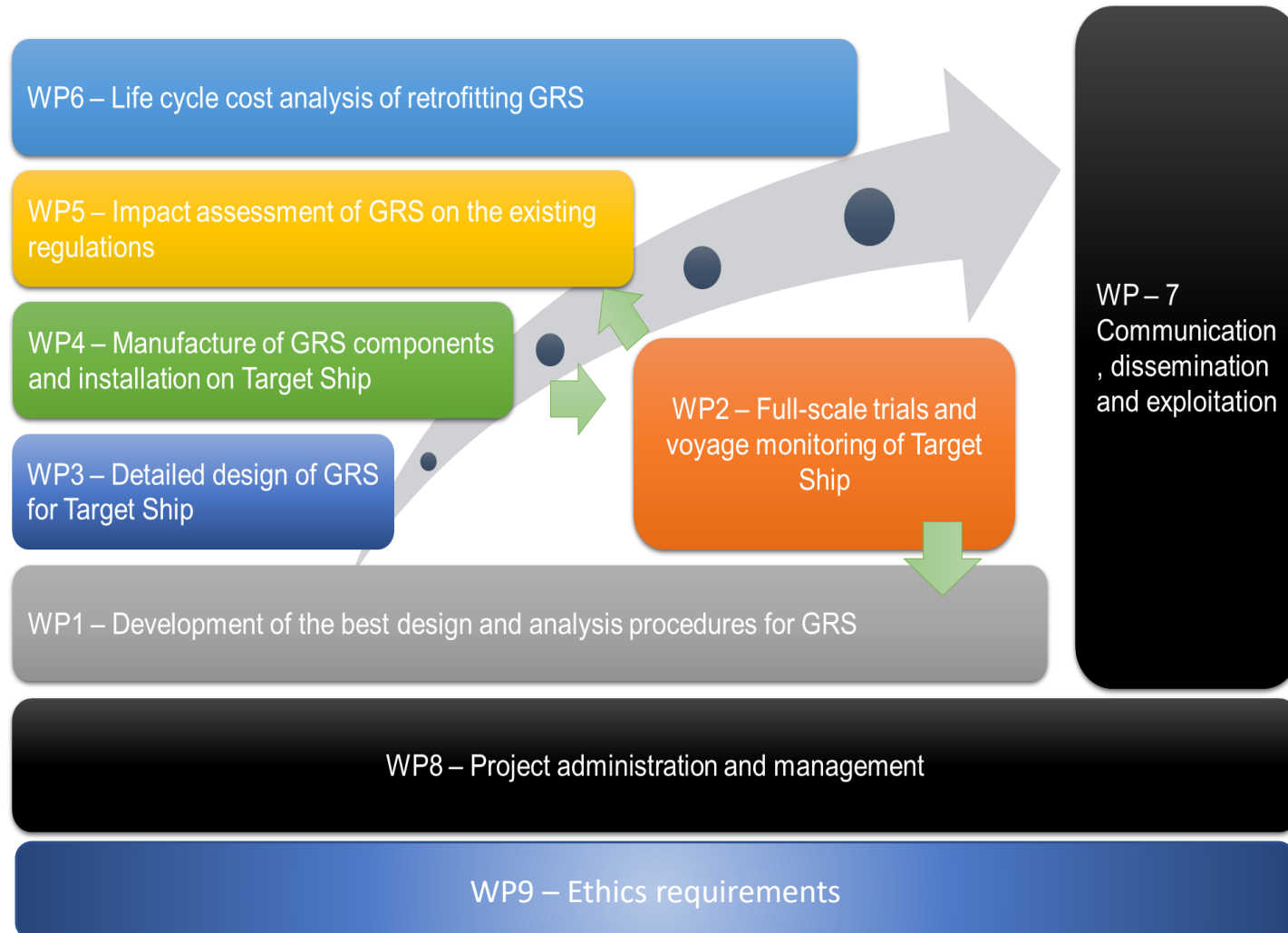


GATERS – Objectives

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 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.



- **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.*



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 TEKNİK UNIVERSITESI	ITU	TR

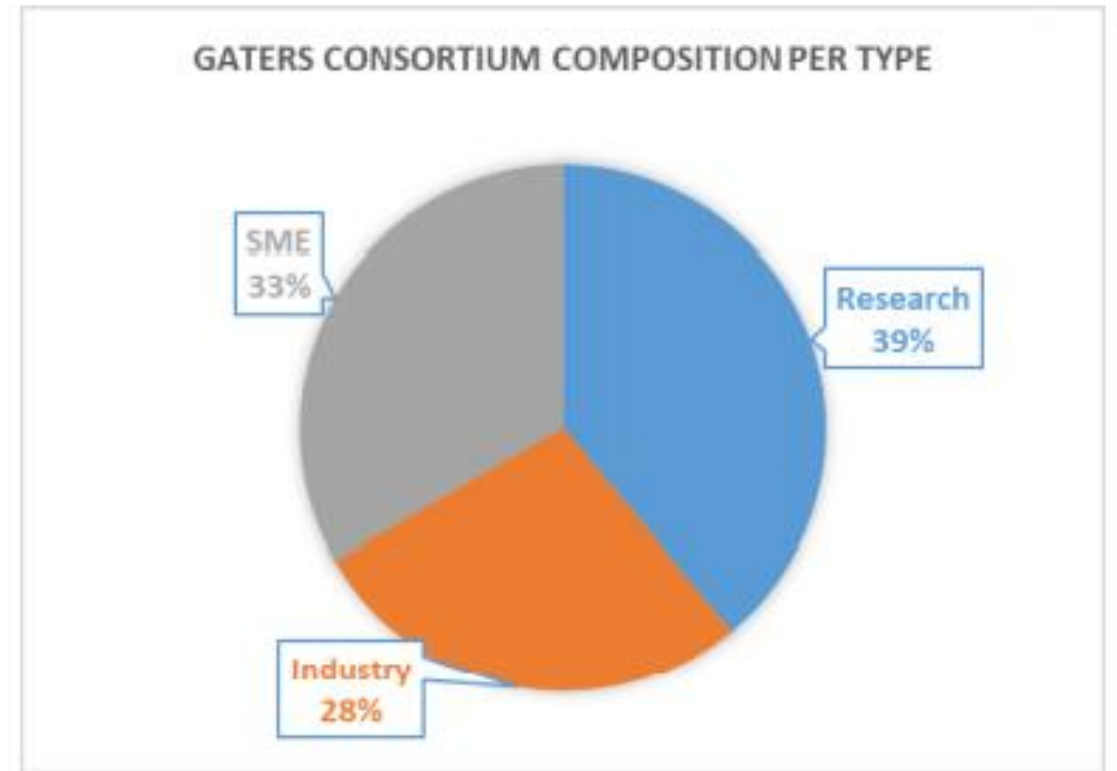
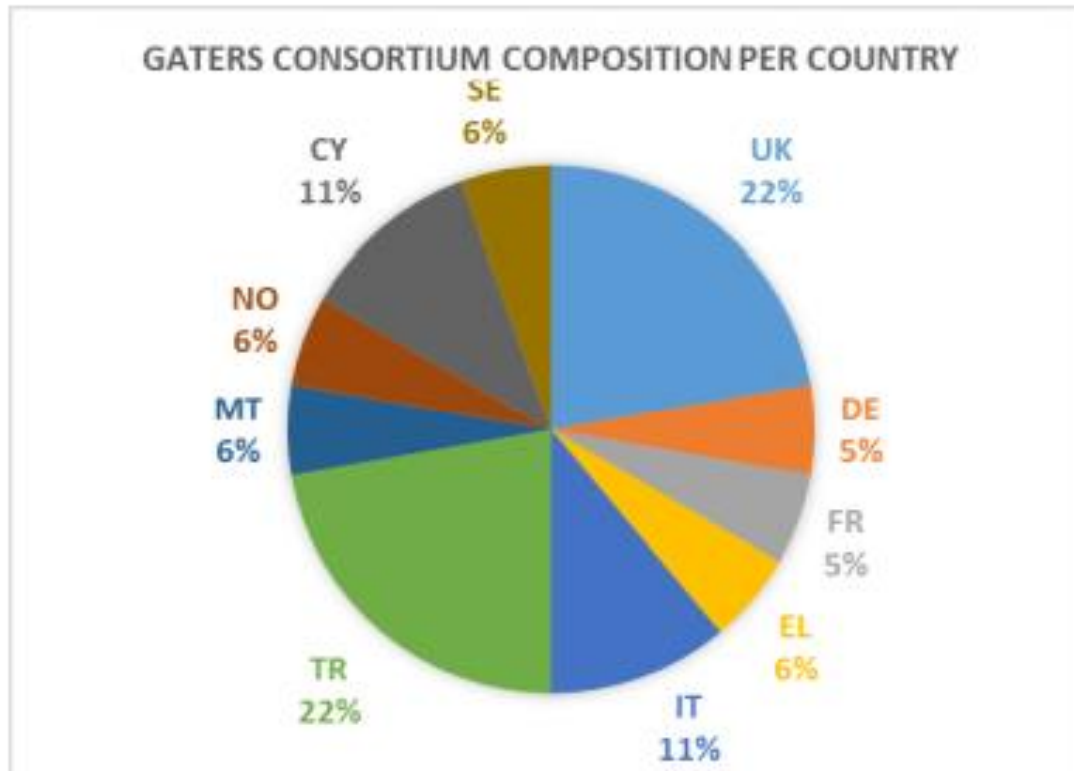


GATERS – Partners (continued)

Participant No.	Participant organisation name	Acronym	Country
8	TWI LIMITED	TWI	UK
9	NAVAL ARCHITECTURAL SERVICES LIMITED	NAS	MT
10	CAPA DENİZCİLİK NAKLIYAT SANAYİ VETİCARET LİMİTED SİRKETİ	CAPA	TR
11	SINTEF OCEAN AS	SINTEF	NO
12	DANAOS SHIPPING COMPANY LİMİTED	DANAOS	CY
13	STONE MARINE PROPULSION LİMİTED	SMP	UK
14	GURDESAN GEMİ MAKİNA SANAYİ VE TİCARET ANONİM SİRKETİ	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

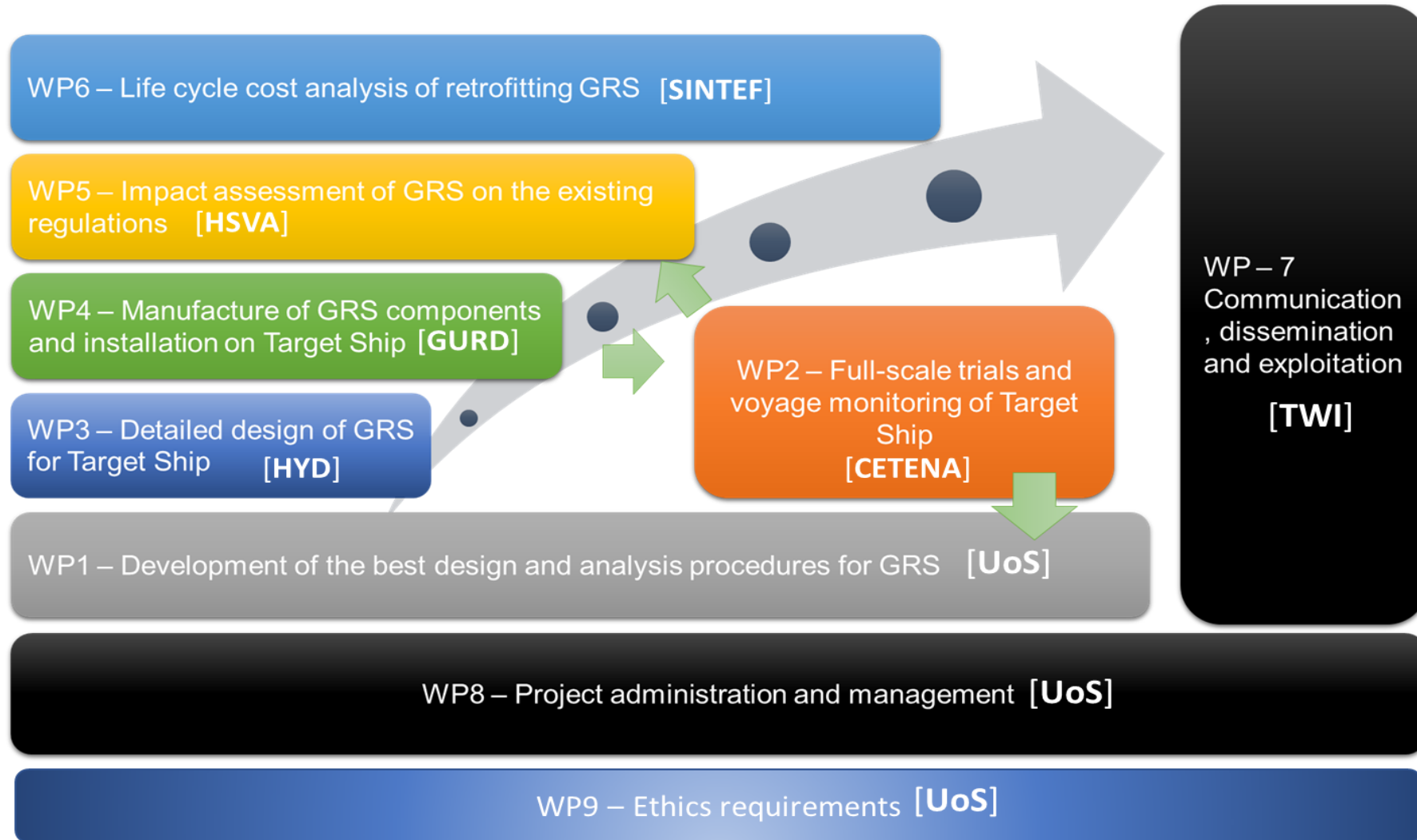


GATERS – Partners background summary



Distribution of GATERS Partners' background by Country (Left) & Type (Left)

GATERS – Work Packages

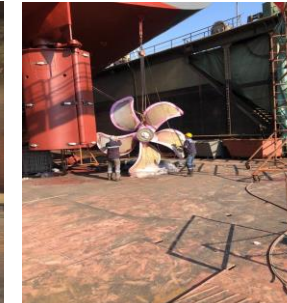


Schematic of GATERS Work Breakdown Structure in terms of Work Packages(WP) and associated leaders (WPL)

Target vessel – MV ERGE To be retrofitted with GRS

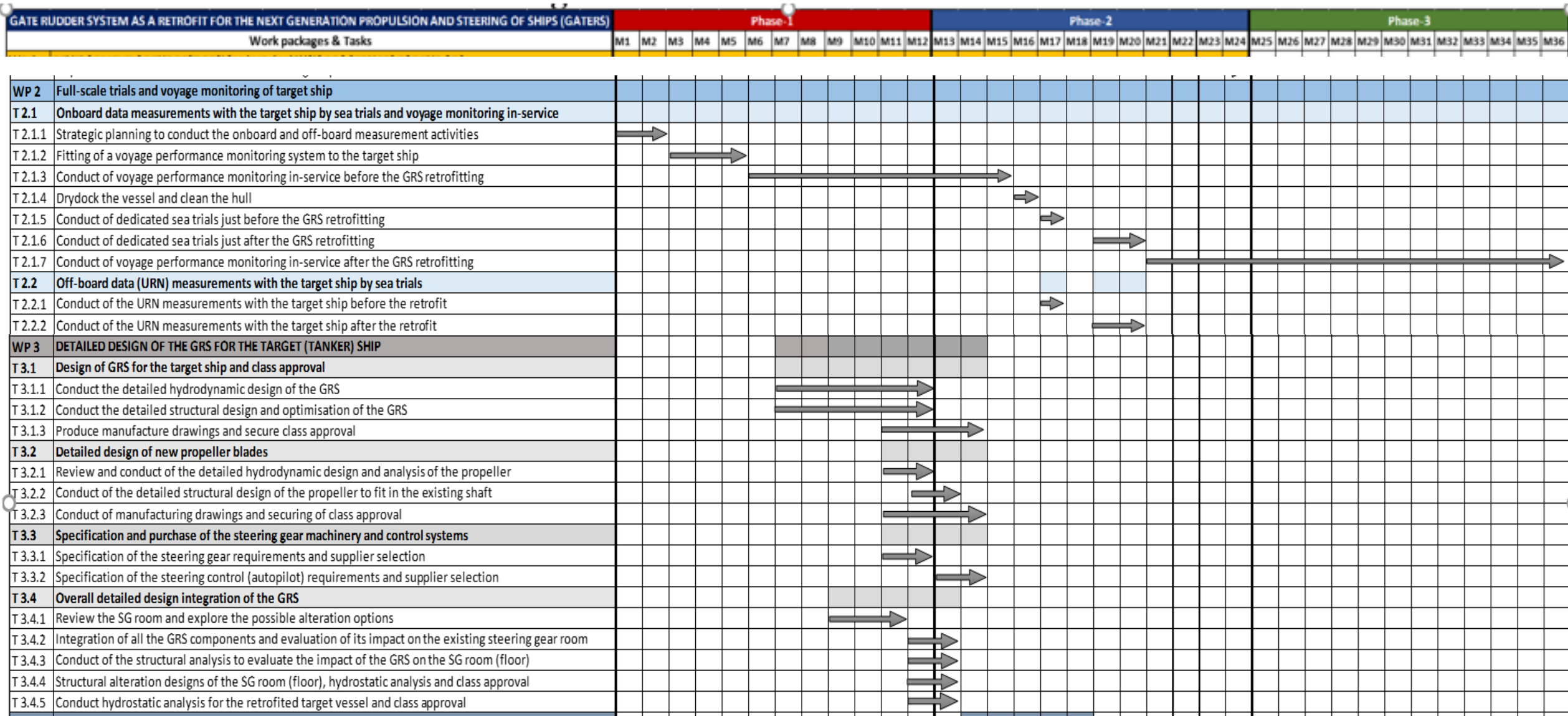
- MV ERGE (IMO No: 9508603) 5650 DWT (2993GT) General Cargo ship, built in Weihai PRC and delivered in 2011.
- She operates in European Coastal waters, Black Sea, Red Sea and North African waters
- She is owned by partner CAPA and she has sister vessel MV ERLE with conventional flap rudder

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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WP 3 – DETAILED DESIGN OF GRS FOR TARGET SHIP



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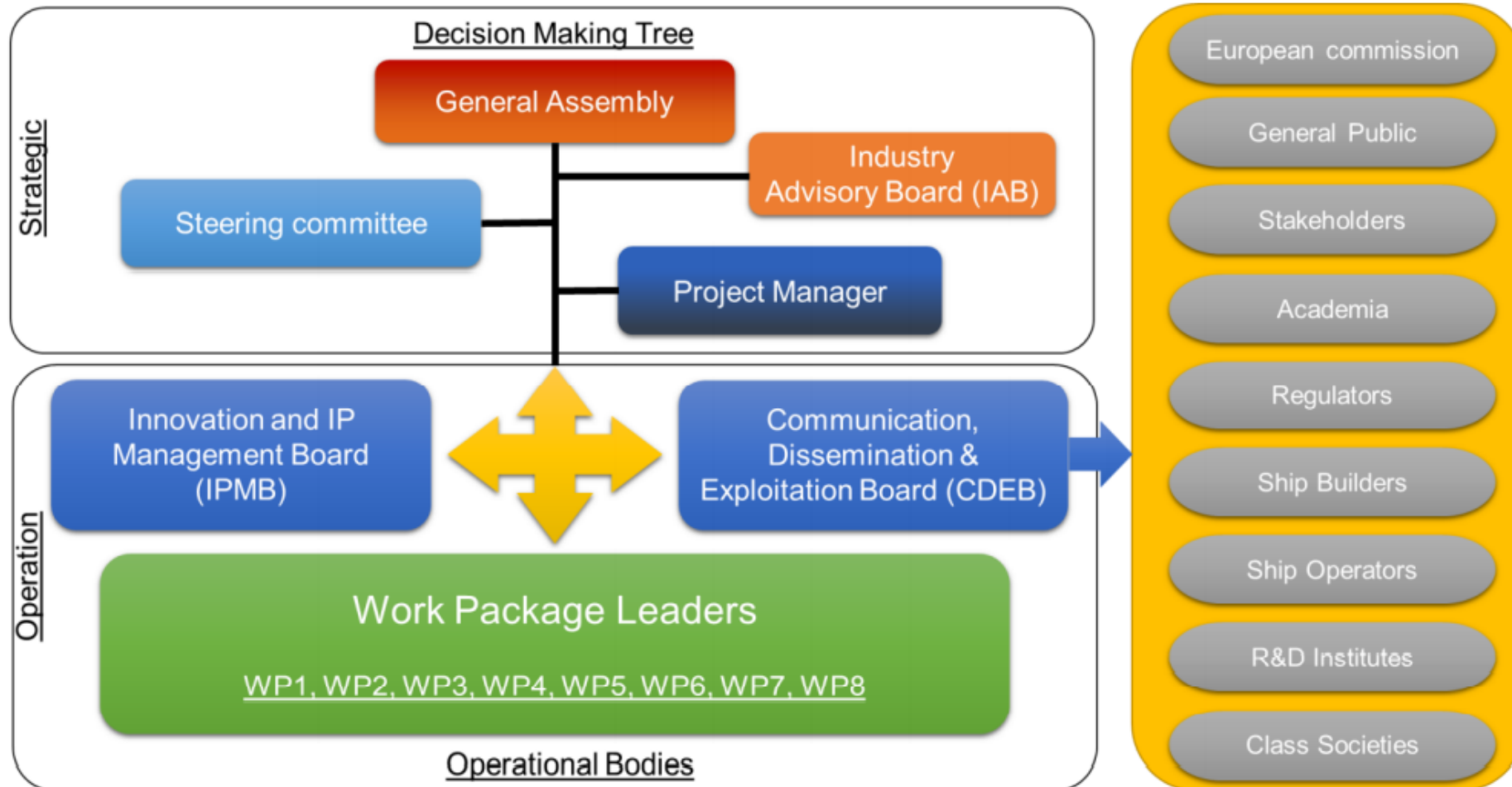
WP7 – COMMUNICATION, DISSEMINATION & EXPLOITATION ACTIVITIES

WP8 – PROJECT ADMINISTRATION & MANAGEMENT

WP9 – ETHICS REQUIREMENTS

GATE RUDDER SYSTEM AS A RETROFIT FOR THE NEXT GENERATION PROPULSION AND STEERING OF SHIPS (GATERS)			Phase-1												Phase-2												Phase-3												
Work packages & Tasks			M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24	M25	M26	M27	M28	M29	M30	M31	M32	M33	M34	M35	M36	
WP 7	COMMUNICATION, DISSEMINATION AND EXPLOITATION ACTIVITIES																																						
T 7.1	Strategic planning, coordination and organisation																																						
T 7.2	Project communication activities																																						
T 7.3	Project dissemination activities																																						
T 7.3	Project exploitation activities																																						
WP 8	PROJECT ADMINISTRATION AND MANAGEMENT																																						
T 8.1	Administrative and financial management																																						
T 8.2	Scientific and technological management																																						
MS	PROJECT MILESTONES													MS1		MS2				MS3		MS4												MS5				MS6	
GATE RUDDER SYSTEM AS A RETROFIT FOR THE NEXT GENERATION PROPULSION AND STEERING OF SHIPS (GATERS)			M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24	M25	M26	M27	M28	M29	M30	M31	M32	M33	M34	M35	M36	

GATERS – Management structure



GATERS – Management, Communication, Dissemination & Exploitation Activities Support Boards

GATERS - Innovation and IP Management Board (IPMB)

Project Members	GME	HYD	SMP	TWI	UoS
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GATERS - Communication, Dissemination and Exploitation Board (CDEB)

Project Members	CAPA	GME	HYD	SMP	TWI	UNEW	UoS
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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 & Shipping Co Ltd
Member’s Representative	Dr Tor E Svensen	Dr Elias Boletis	Dr Christos Vervenitos	Mr David Taylor	Mr Hirohisa Inada	Mr James Cocks

GATERS – Financial

Project fund

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

Project cost breakdown

Personal cost [EUR]	Travel, Equipment & Other cost [EUR]	Indirect cost (25% Flat rate) [EUR]	Total cost [EUR]
3,131,085.40	1,571,606.00	1,175,672.85	5,878,364.25

Project time and effort

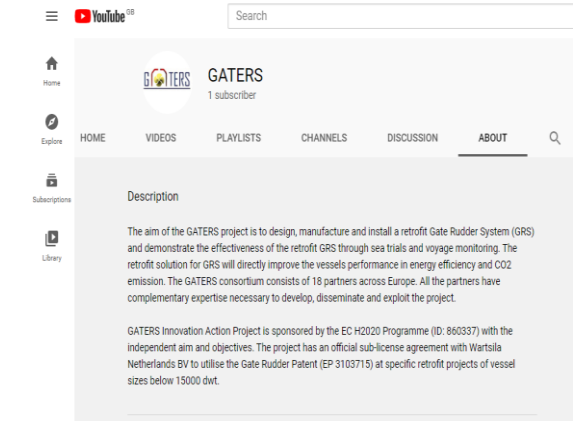
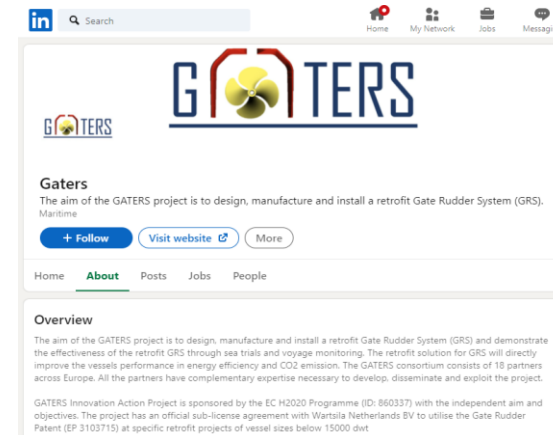
Project elapsed duration [months]	Project person efforts [months]
36	694

Progress on GATERS Project so far



www.gatersproject.com

- 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
- **WP1** (Preliminary Gate Rudder Design; Model testing and CFD modelling procedure development tasks); **WP2** (Target Vessel Trials and Monitoring System installation and data collection task); **WP7** (Communication, Dissemination and Exploitation activities tasks); **WP8** (Day-to-day management tasks) are underway
- First two critical milestones (MS1 and MS2) are to complete the model tests and confirm the design of the GRS for MV ERGE on M12 and 14, respectively.



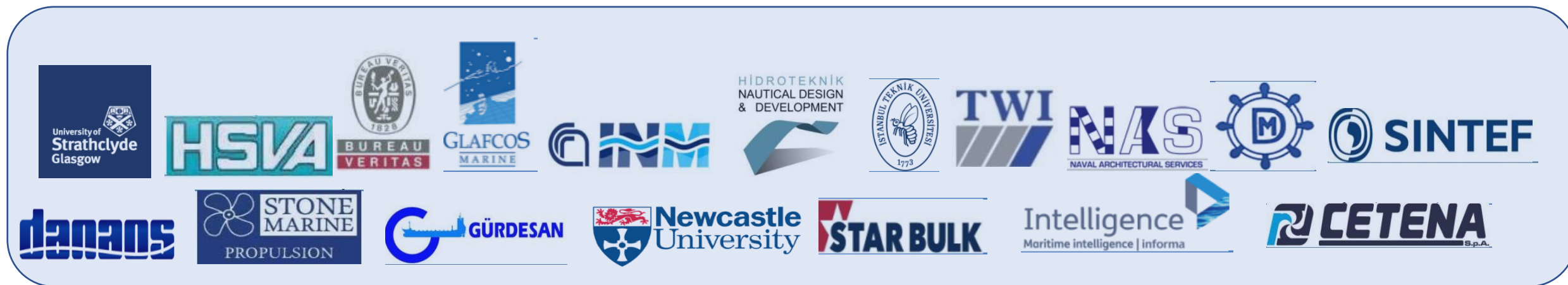


THANK YOU

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on behalf of the GATERS Consortium



GATERS Project - Summary

- **Project number:** 860337
- **Project Acronym:** GATERS
- **Project title:** GATE Rudder System as a Retrofit for the Next Generation Propulsion and Steering of Ships
- **Call (part) ID:** H2020-MG-2019-Two-Stages
- **Topic:** LC-MG-1-8-2019 (Retrofit Solutions and Next Generation Propulsion for Waterborne Transport)
- **Fixed EC Keywords:** Maritime, Low emission technology in transport
- **Free keywords:** Novel propulsion and manoeuvring system; Retrofit technology; Short sea shipping operations; Oceangoing shipping operations; Generic and flexible propulsion system; IMO requirements for Emission
- **Starting Date:** 1 February 2021
- **Duration:** 36M
- **Funding:** 5.894,822.5 M EUR (total); 4,999,510.0M ER (EU requested)
- **Call (part) ID:** H2020-MG-2019-TwoStages
- **Partners no:** 18 (11 Industry + 4 Research Institutes + 3 Universities)
- **Country no:** 9
- **Partners :** UoS(UK); HSVA(DE); BV(FR); GME(GR); CNR(I); HYD(TR); ITU (TR); TWI (UK); NAS (MT); CAPA(TR); SINTEF(NO); DANAOS(CYP); SMP(UK); GURD(TR); UNEW(UK); STARB(CYP); LLI(UK); CETENA(I)
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