How Monitoring Systems can improve ship management and maintenance

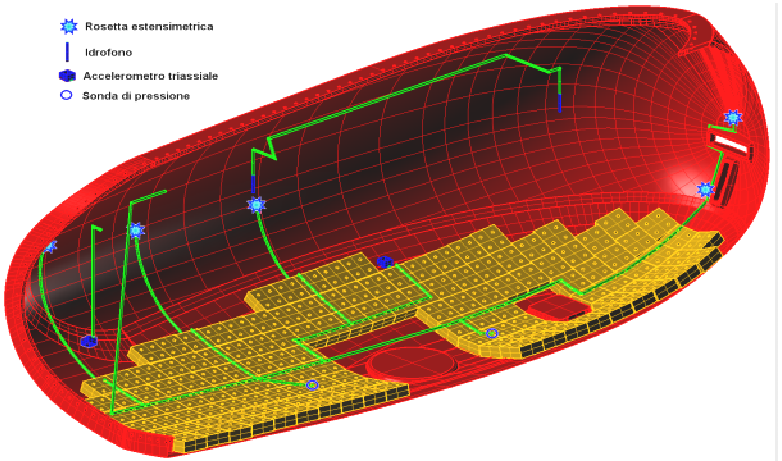
Napoli, 27/09/2018

Development, design, on-board installation, commissioning, management and data analysis of Monitoring Systems:

- in structural, acoustics, energetic or electric field
- for short- or long-term monitoring
- standard o customised

Main targets of a monitoring system:

- ✓ *assessment* of ship design and plant/structures "as built"
- ✓ *assessment* of ship operations and management
- ✓ *surveillance* of ship performance and structure
- ✓ *detection* of potential risks related to structure and and to cargo integrity and safety
- ✓ *feedback* on innovative/alternative solutions
- ✓ *resolution* of disputes with suppliers
- ✓ *data collection* to improve design of future ships
- ✓ *data collection* for basic and applied research
- ✓ *assessment* of critical issues and countermeasures identification
- ✓ *acquisition* of additional class notations by Registry

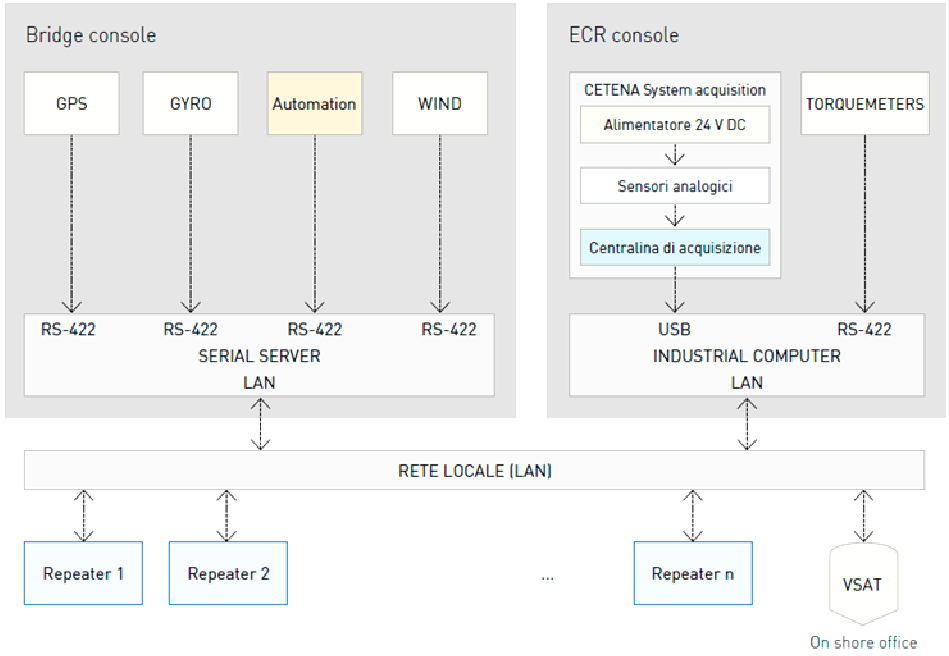


Fuel efficiency

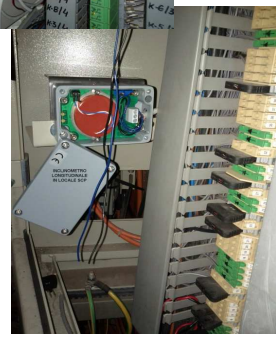
Monitoring systems

PM&OTE - Performance Monitoring & Optimum Trim Estimator

- monitoring propulsive performances
- assessment of ship management in a fuel consumption perspective
- EEOI calculation in SEEMP perspective
- assessment of retrofit (re-blading, silicon paints, appendages, etc)
- dynamic trim optimisation: 2-4 % fuel saving
- performance index visualisation
- route optimisation with weather forecast



- ✓ Low installation impact
- ✓ Interface with: torquemeters, flowmeters, ship automation and navigation systems, wave radar
- ✓ Acquisition of dedicated sensors (high-precision inclinometers) to monitor dynamic trim



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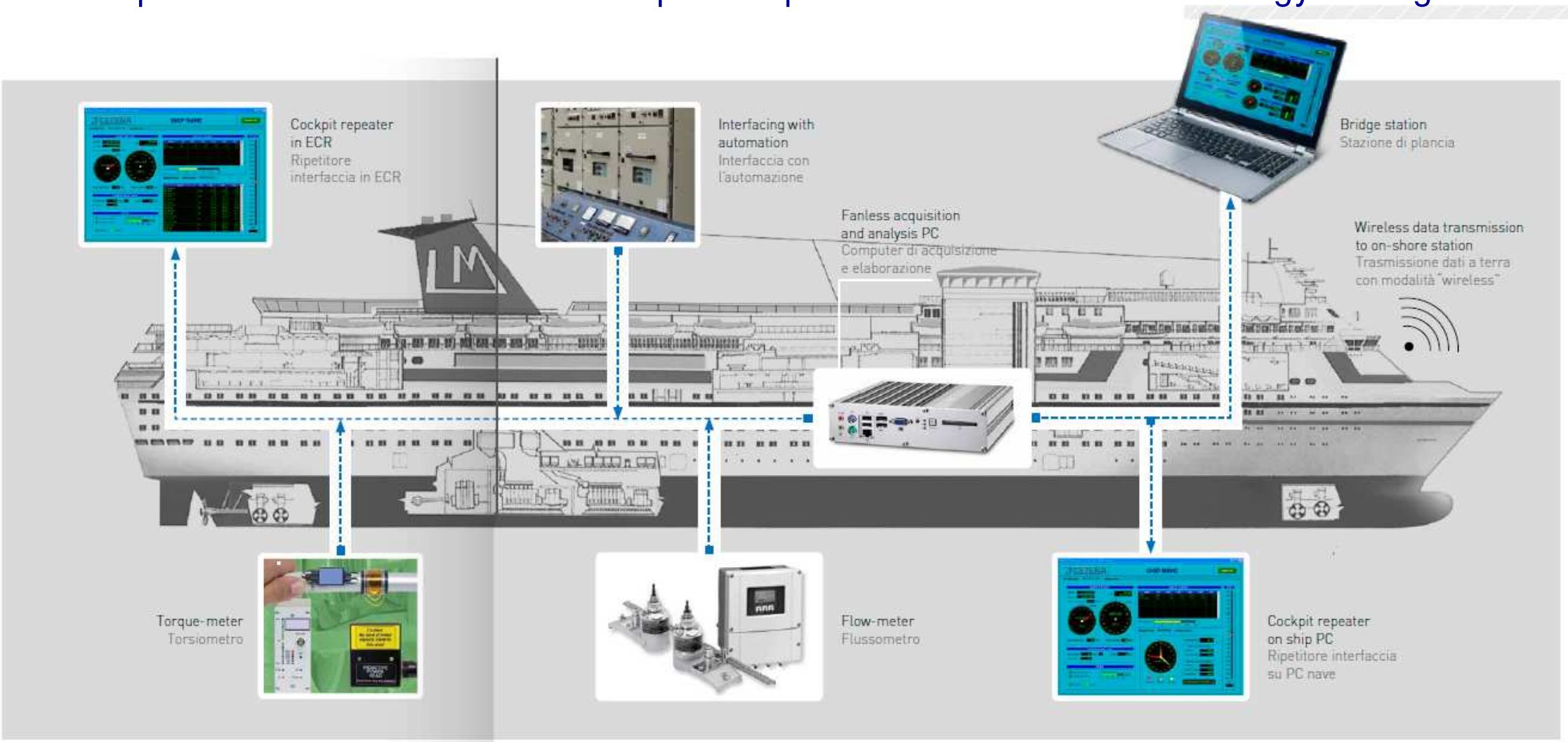
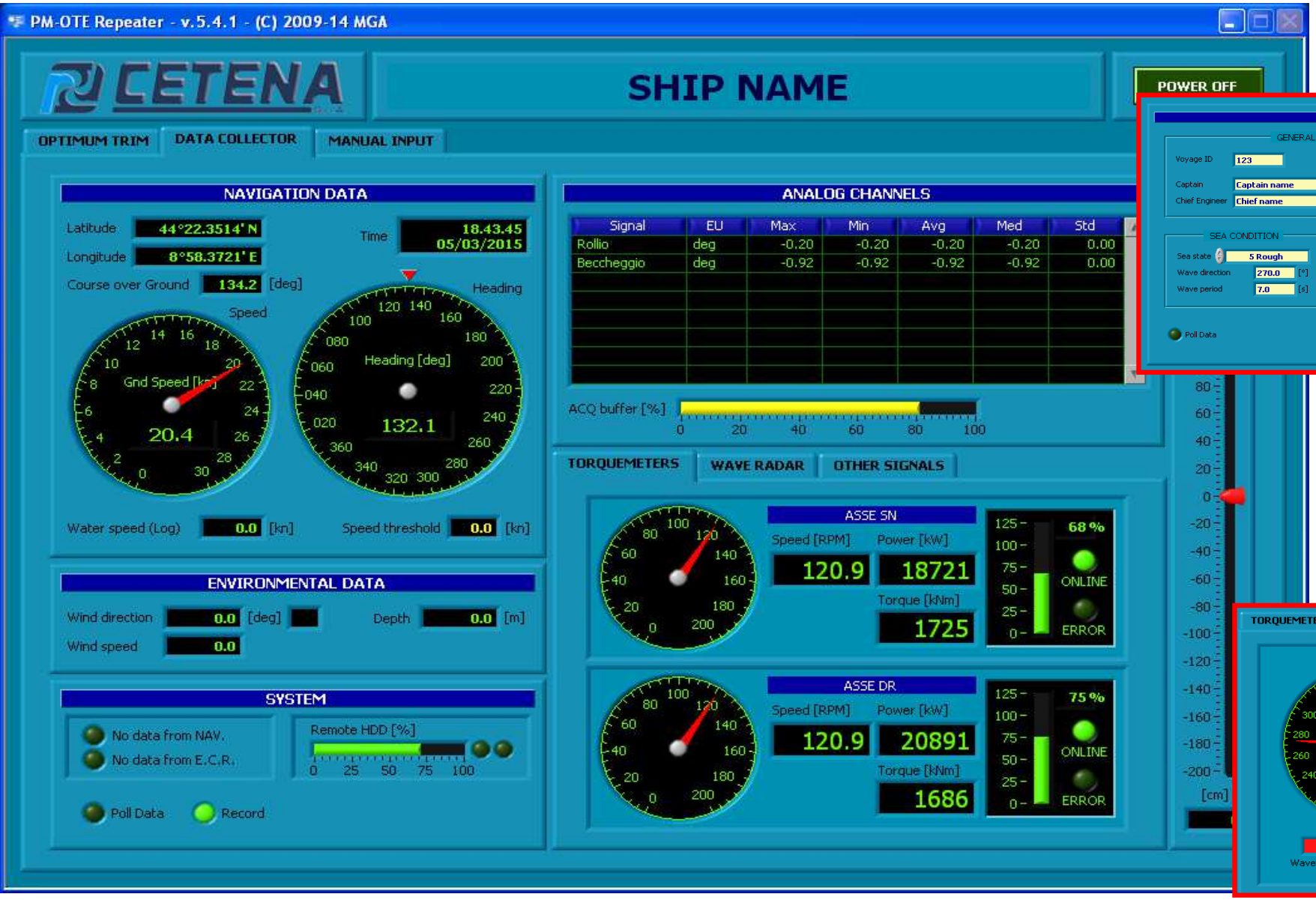
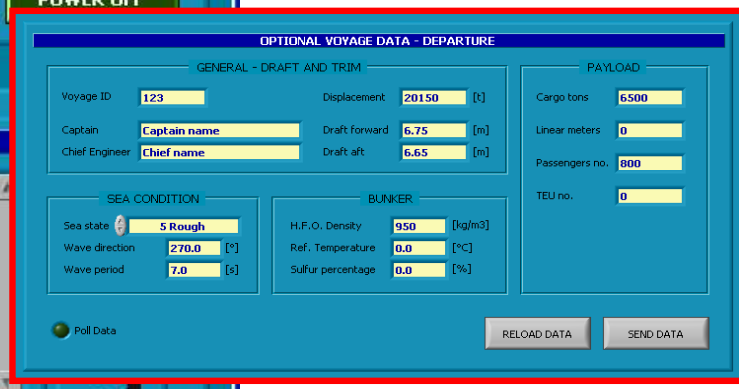
Integration with on board systems:

- acquisition of signals and information through ship net
- cockpit available to Officers on all ship's computers and on onshore to Energy Manager



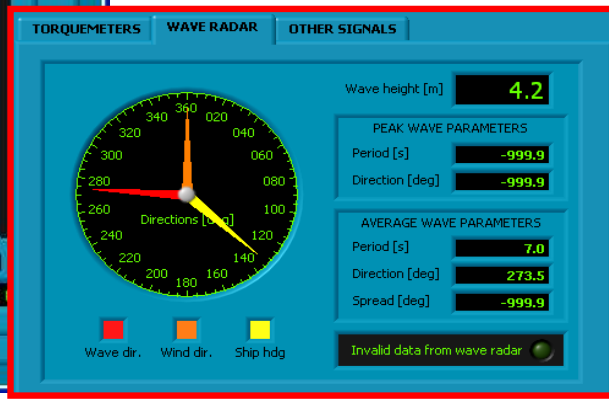
Cockpit available to Officers on all ship's computers and on onshore to Energy Manager





Manual input data

Sea state data



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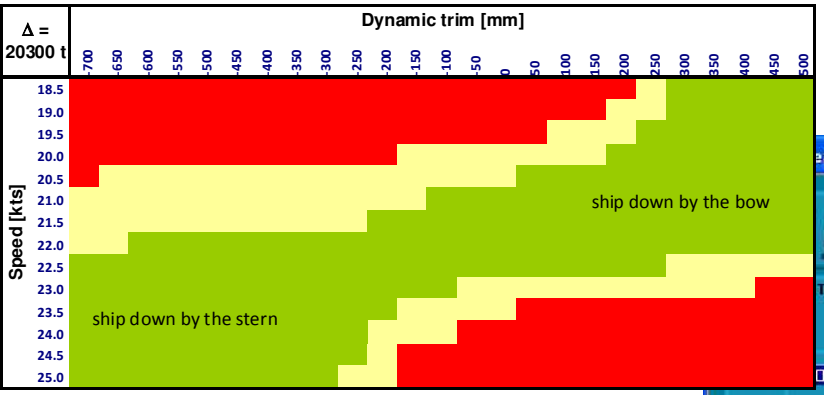
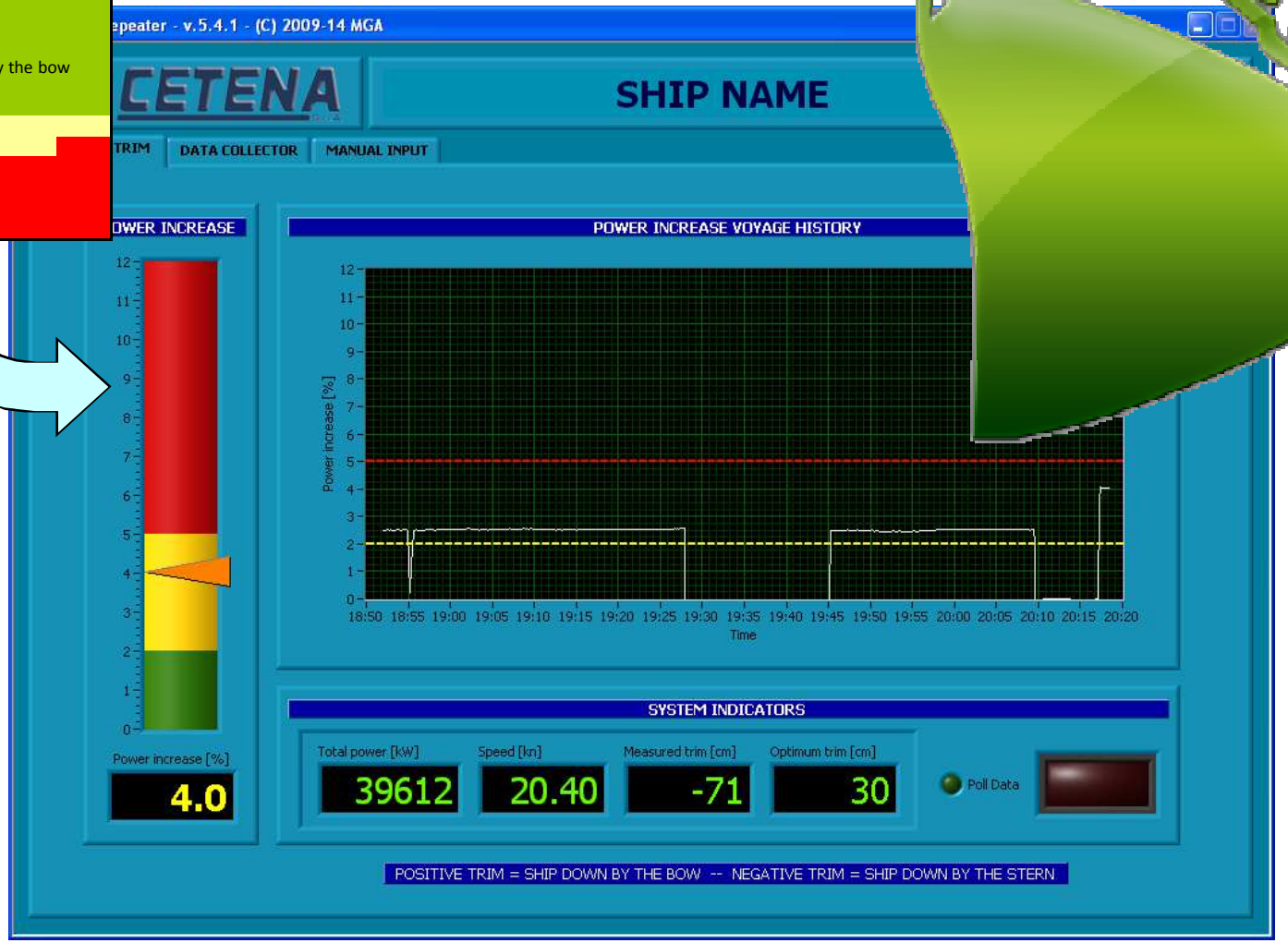
Dynamic Trim optimisation as a function of ship speed and displacement



Embedded info on % of fuel saved as a function of speed, trim and dispacement



The ***DSS*** shows how to trim the ship to save how much fuel

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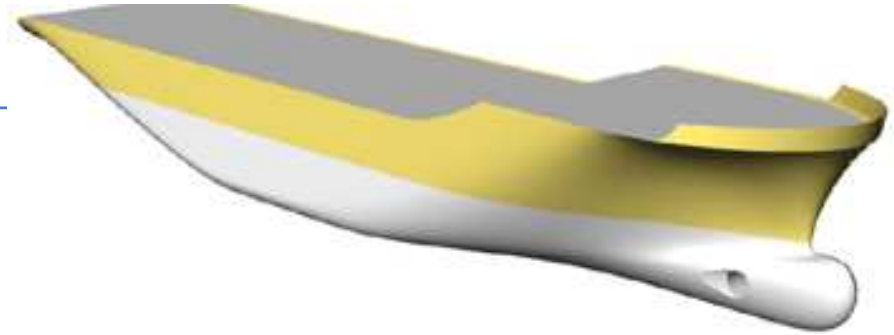
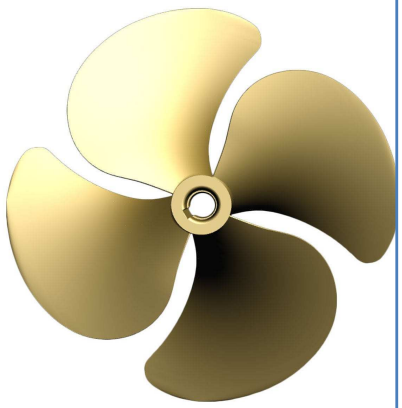
Basic hull and propeller performance indicators



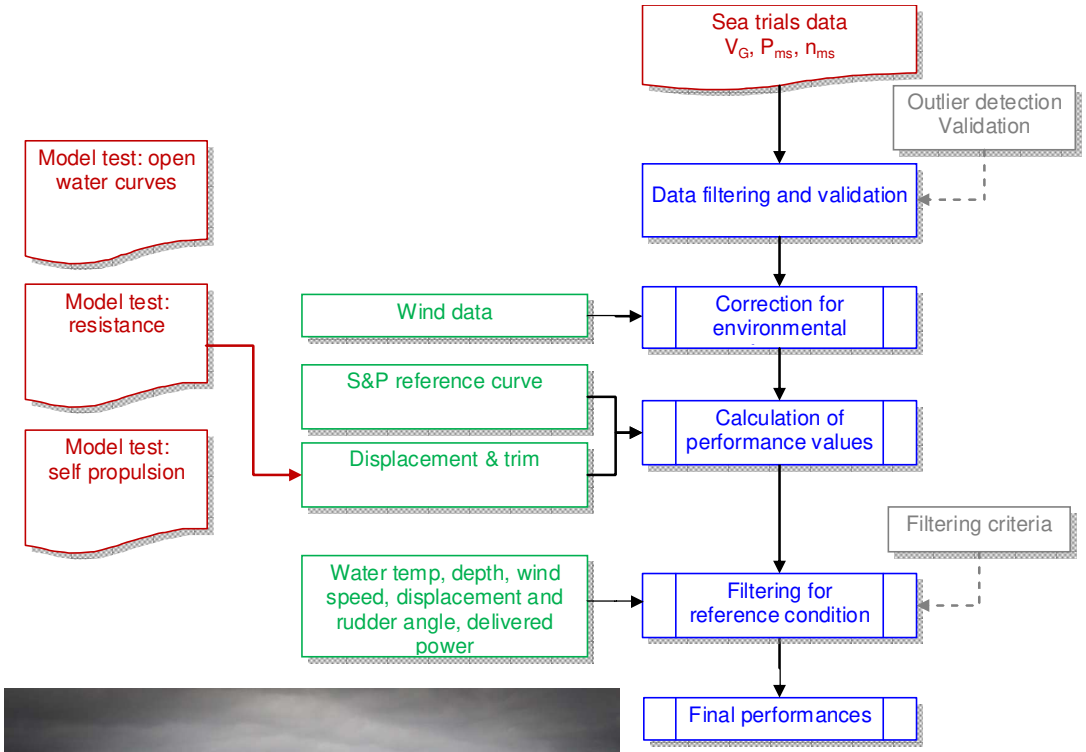
Hull and propeller performance refers to the relationship between the condition of a ship's underwater hull and propeller and the power required to move the ship through water at a given speed. Measurements of changes in ship specific hull and propeller performance over time make it possible to indicate the impact of hull and propeller maintenance, repair and retrofit activities on the overall energy efficiency of the ship in question.

Performance indicators (PI)	Definition
Dry-docking performance: Determining the effectiveness of the dry-docking ("repair" and/or retrofit activities)	Change in hull and propeller performance following present out-docking (evaluation period) as compared with the average from previous out-dockings (reference periods).
In-service performance: Determine the effectiveness of the underwater hull and propeller solution (including any maintenance activities that have occurred over the course of the full dry-docking interval)	Average change in hull and propeller performance from a period following out-docking (reference period) to the end of dry-docking interval (evaluation period).
Maintenance trigger: Trigger underwater hull and propeller maintenance, including propeller and/or hull inspection	Change in hull and propeller performance from the start of the dry-docking interval (reference period) to a moving average at a given point in time (evaluation period).
Maintenance effect: Determine the effectiveness of a specific maintenance event, including any propeller and/or hull cleaning	Change in hull and propeller performance from before (reference period) to after a maintenance event (evaluation period).

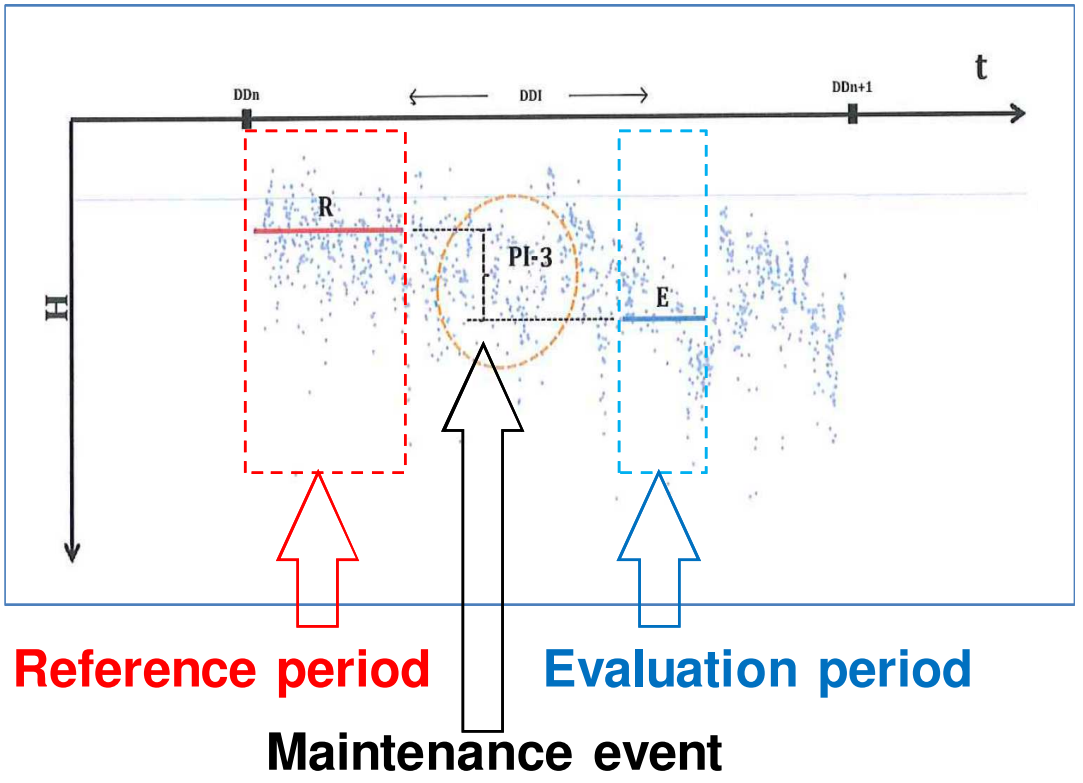


Basic hull and propeller performance indicators:

- acquired power/speed data are corrected to be referred to standard environmental conditions (ISO 19030 / ISO 15016)



- corrected data are comparable
- performance indicators can be built



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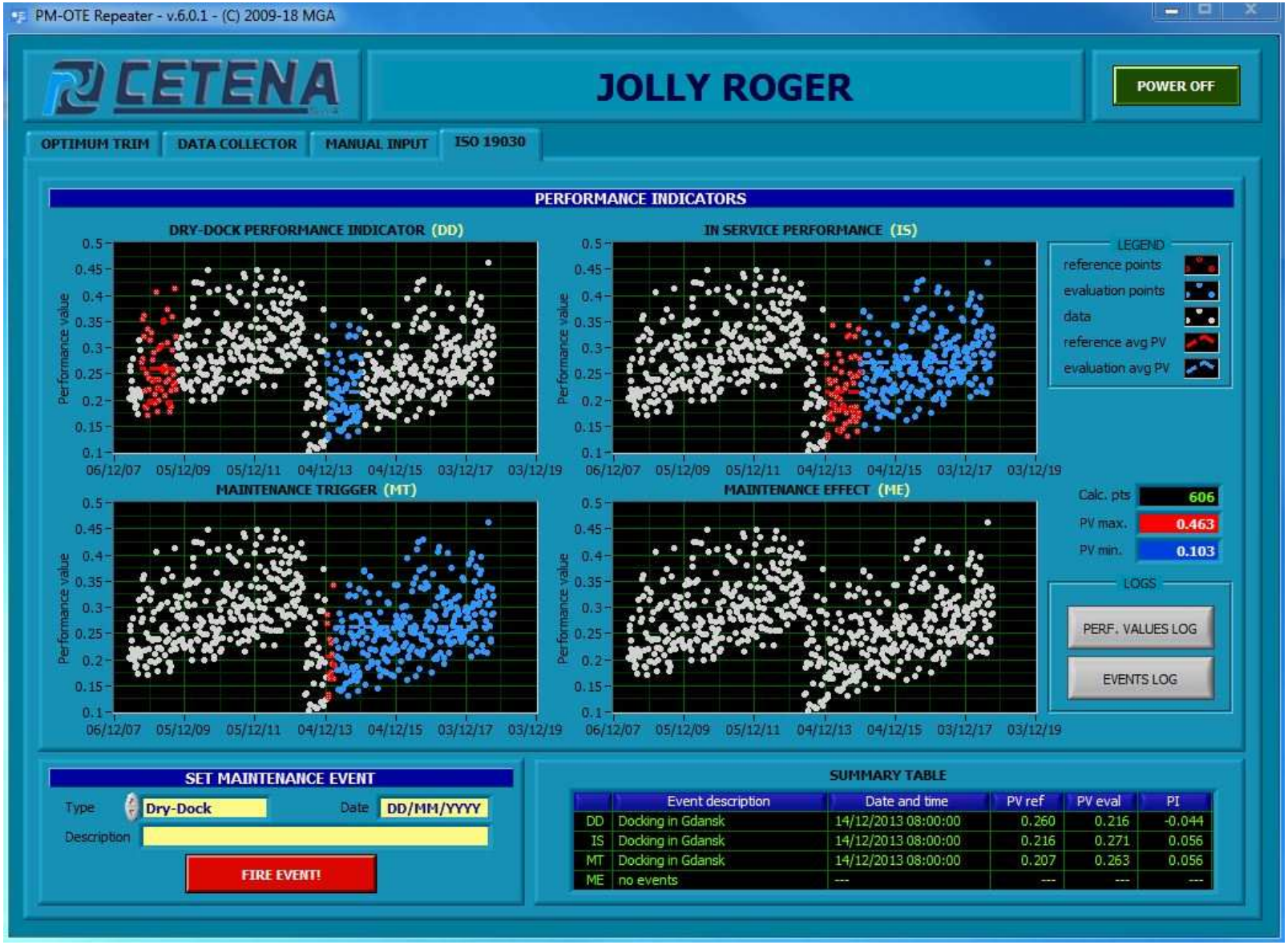
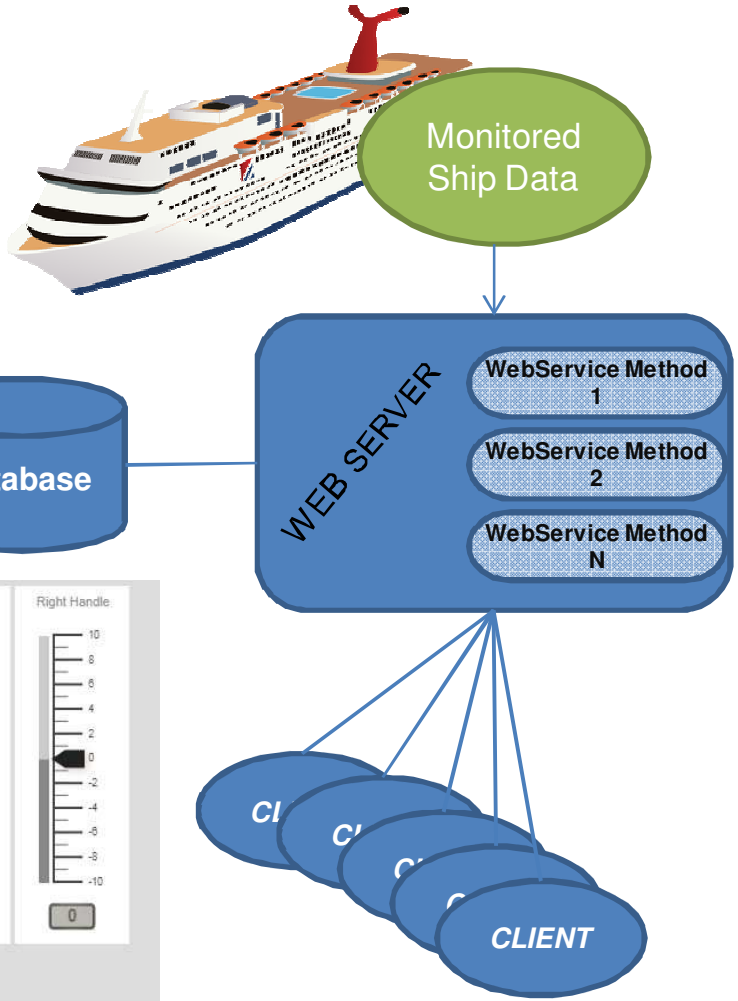
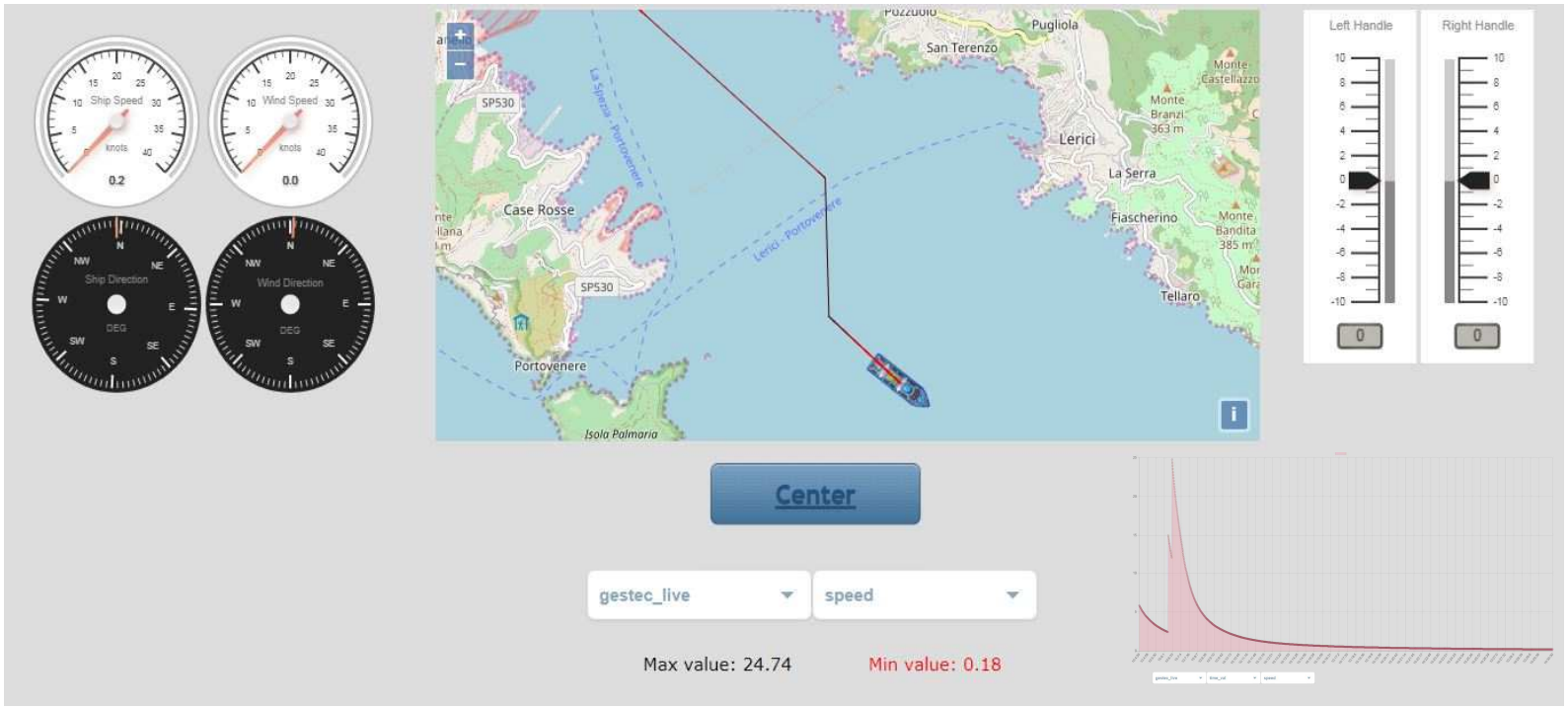
On-line basic hull and propeller performance indicators



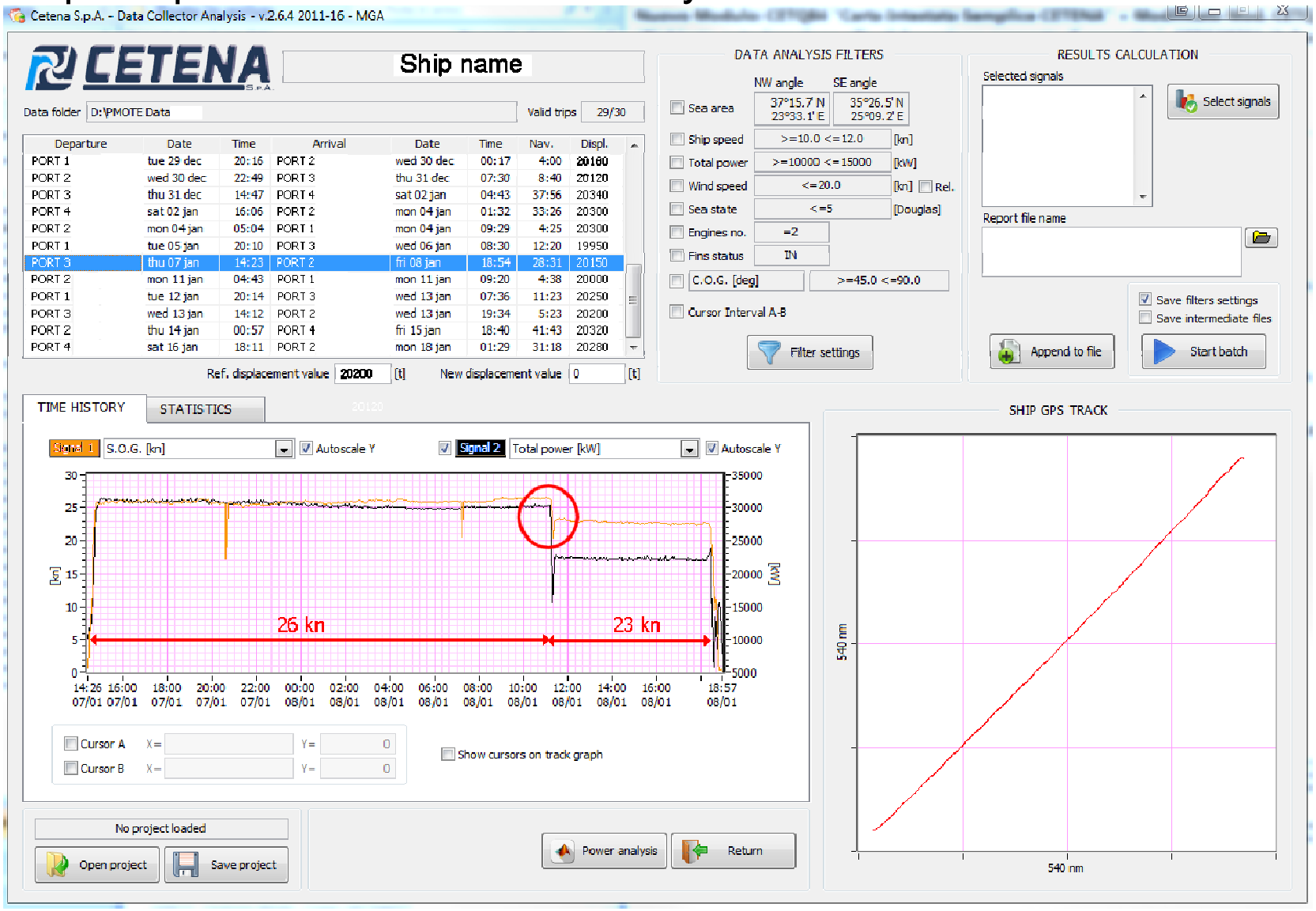
On-line visualisation and analysis of ship performance

- Real-Time map
- Ship position, route, performance data
- Reconfigurable real-time updated gauges
- Colour-indication of performance / KPI on route

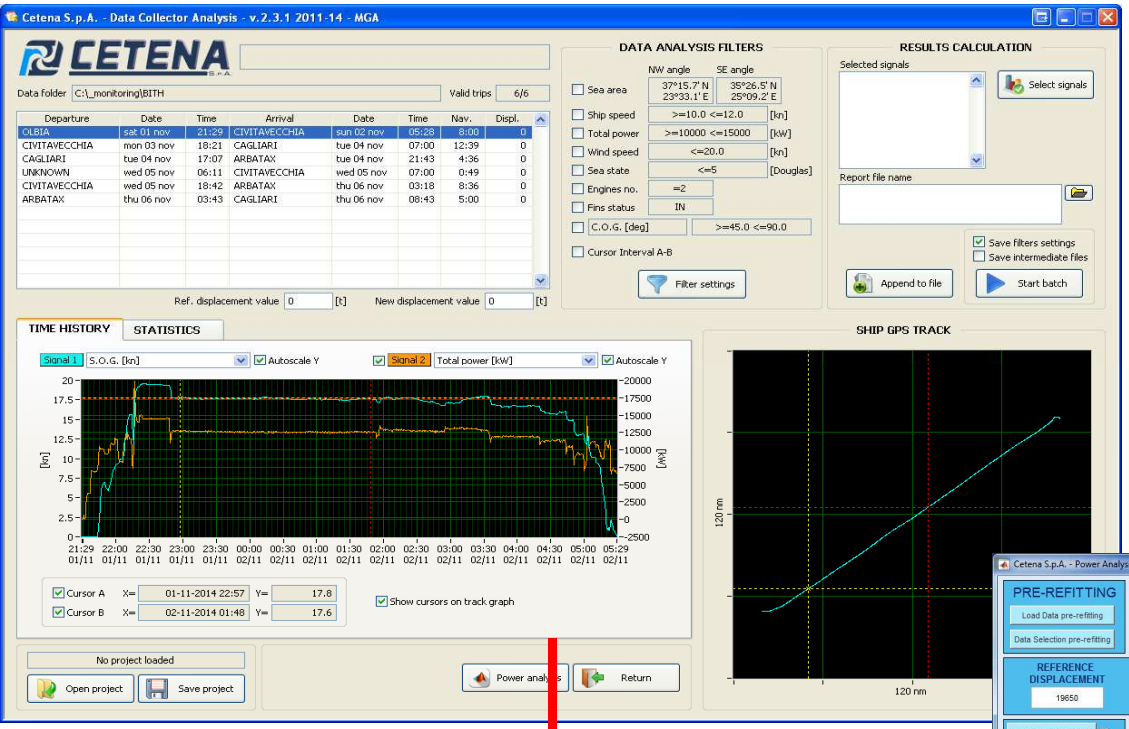


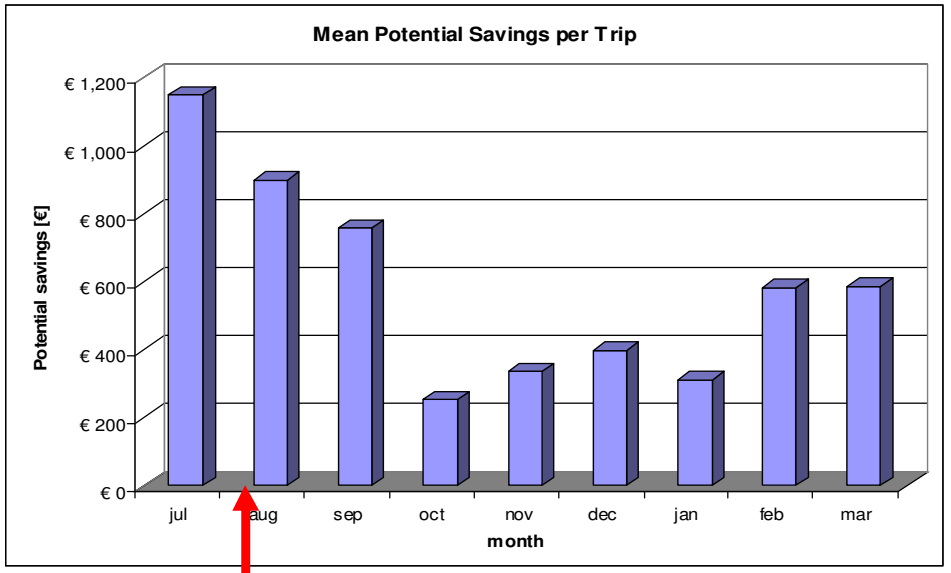


How the ship is operated? Is the actual way the best one?



Off-line deep Analysis of monitored data

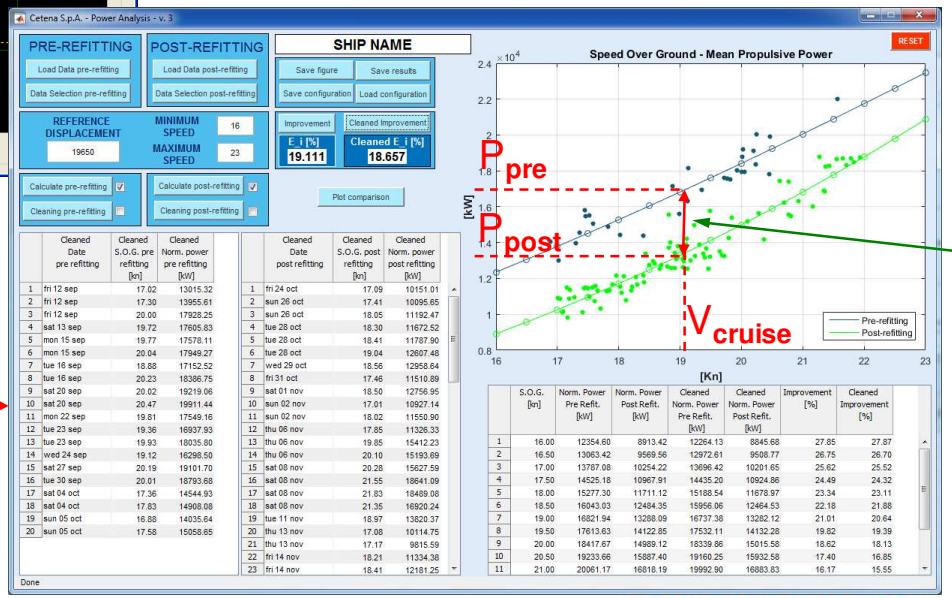




Optimum Trim activation

Retrofit assessment

Ship management assessment



Power/fuel saving

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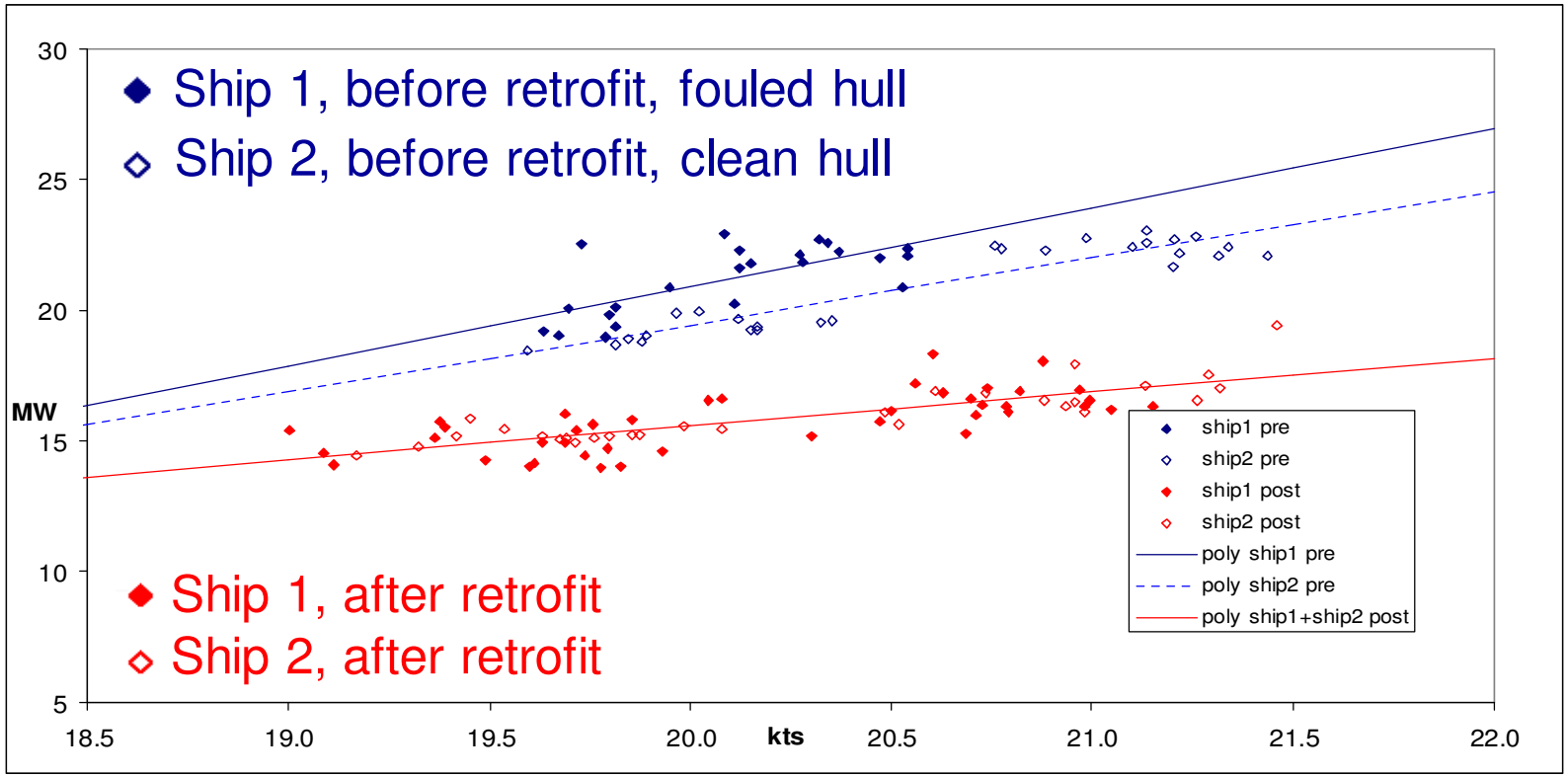
Retrofit assessment (re-blading, appendages, silicon painting, …)

- Acquisition and recording of propulsive performances in the short-medium term before and after the retrofit.
- Assessment and measurement of retrofit effectiveness

Re-blading and hull cleaning on two sister ships



SHIP 1			
Speed kts	Power [kW] before	after	R %
19.5	19410	14921	23.13
20	20918	15573	25.55
20.5	22427	16226	27.65
21	23935	16878	29.48
		EI	26.5%

SHIP 2			
Speed kts	PB kW	PA kW	R %
19.5	18177	14921	17.92
20	19453	15573	19.95
20.5	20729	16226	21.72
21	22005	16878	23.30
		EI	20.8%

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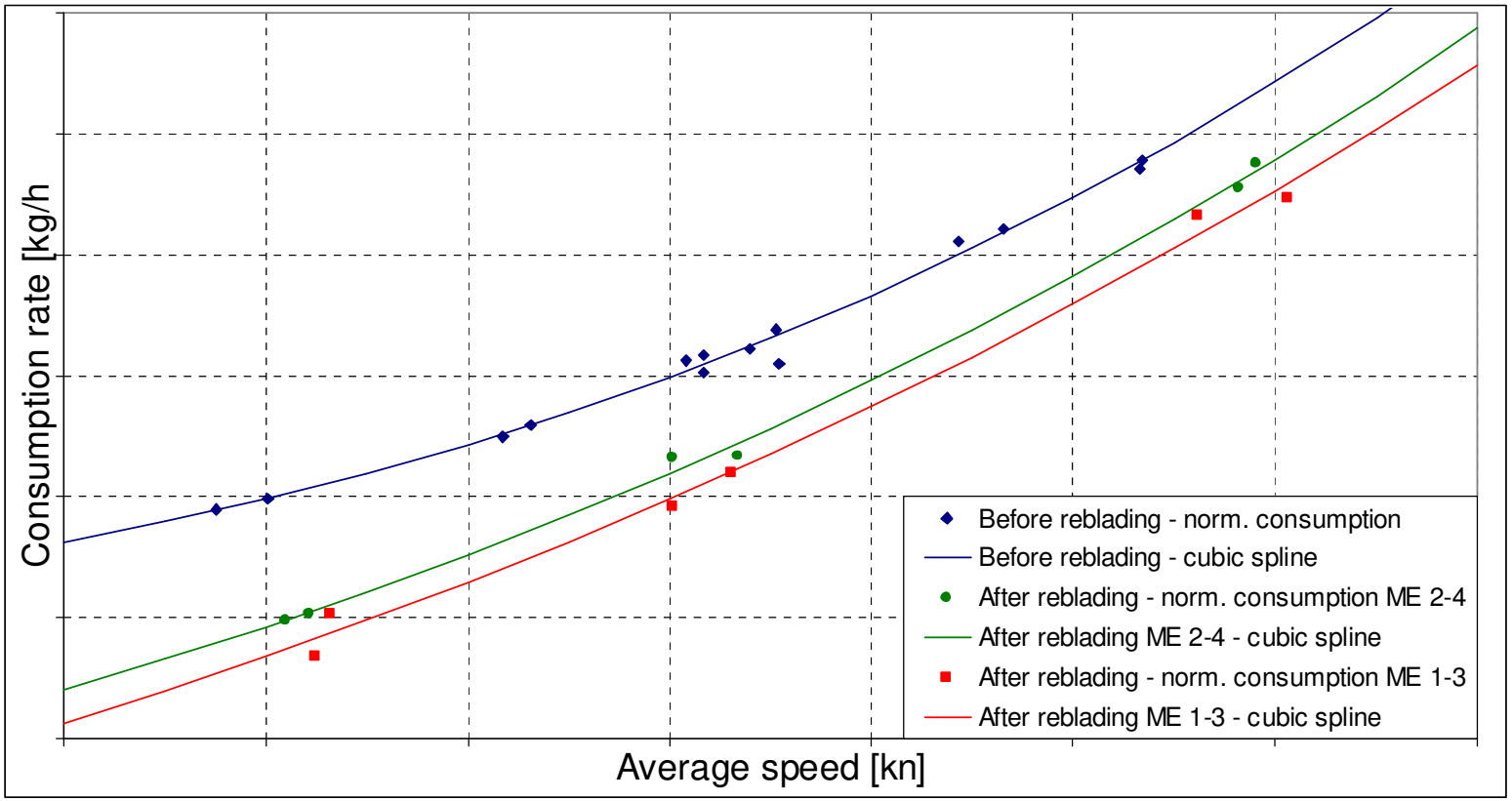
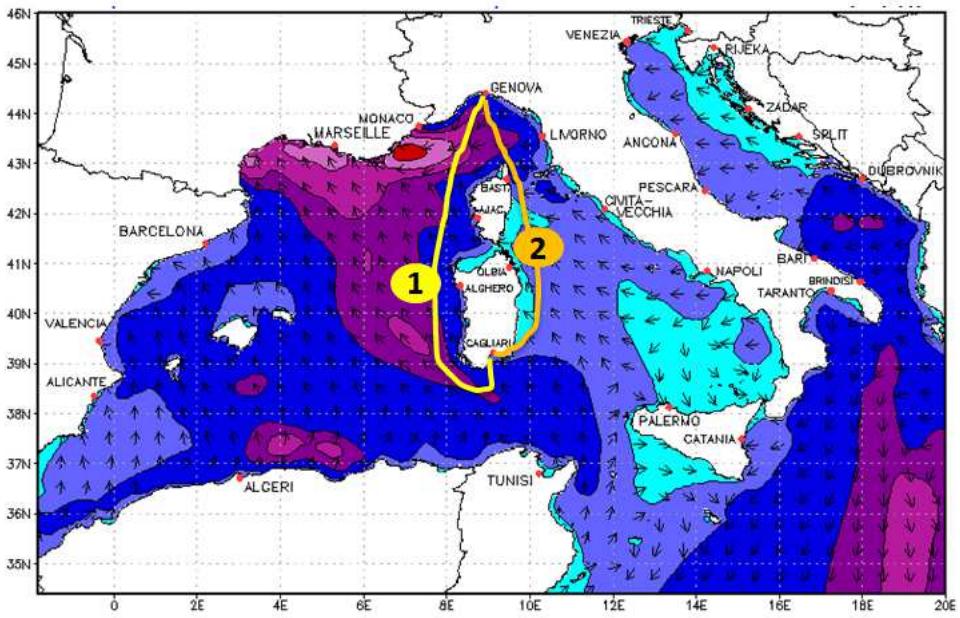
Assessment of re-blading and engine overhauling effect on fuel consumption



- Dedicated sea trials before reblading (4 ME running) and after (2 ME running)
- after reblading ME 2-4 (none overhauled): 11,5%
- after reblading ME 1-3 (one overhauled): 14%

An automated module can help Master to save fuel:

- best route depending on weather condition
- best engine configuration for each sub-trip along the route



Stating the main voyage data:

- ATD: actual time at departure
- ETA: estimated time at arrival
- Ship power generation configurations
- Max allowed speed with sea state
- Voyage waypoints

The sailing assistant provides information on minimal consumption route and on power (engine) configuration to be set for each trip in order to optimize the overall fuel consumption and fulfilling the ETA required.

PM&OTE - Sailing assistant, CONFIGURATION CONSOLE.vi

SAILING ASSISTANT CONFIGURATION CONSOLE

VOYAGES CONFIGURATION

AVAILABLE VOYAGES

#	Voyage	trips	distance [nm]	time [h:m]
1	VADO LIGURE - CIVITAVECCHIA	8	209.9	00:00
2	TARRAGONA - VADO LIGURE	8	377.7	00:00

SCHEDULING

ETA advance

02:20

VADO LIGURE - CIVITAVECCHIA

Actual Time at Departure

ATD 17/09/2018 @ 10:01

Expected Time at Arrival

ETA 18/09/2018 @ 10:01

18/09/2018 @ 12:21

Sailing time [h] 24:00

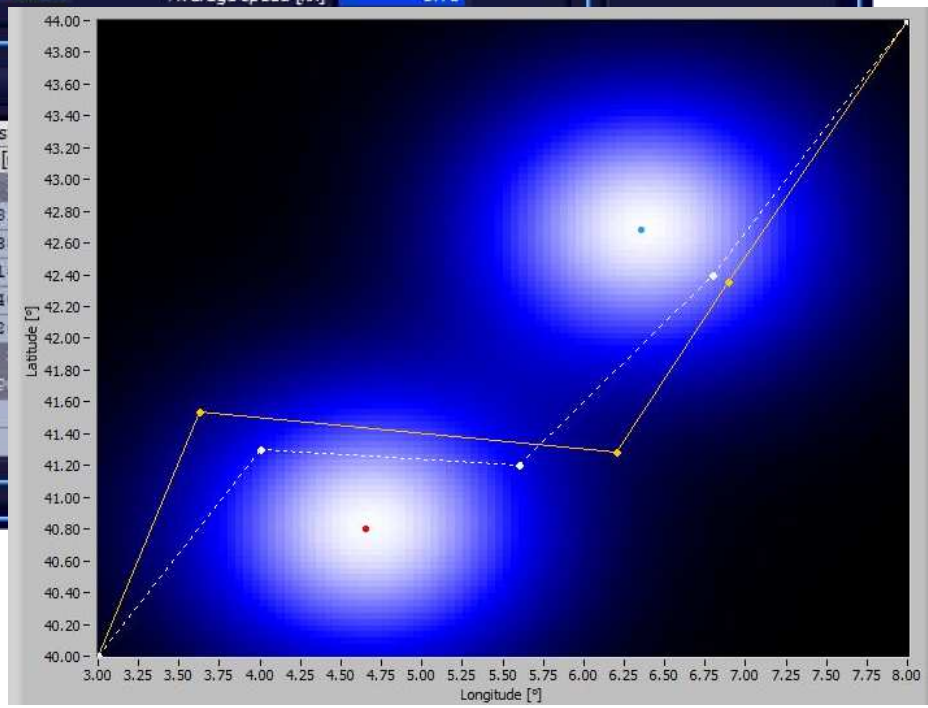
Voyage extension [nm] 209.92

Average speed [kn] 8.75

SAILING ASSISTANT

VOYAGE TRIPS' DETAILS

#	Latitude	Longitude	name	start time	speed [kn]	time [h:m]	dis
1	44° 16' 0.12" N	8° 28' 0.12" E	PORTO VADO LIGURE	17/09/2018 10:01	2.00	01:40	
2	44° 13' 48.00" N	8° 31' 30.00" E		17/09/2018 11:41	9.38	08:43	8
3	43° 4' 59.88" N	9° 33' 0.00" E		17/09/2018 20:25	9.38	04:07	3
4	42° 31' 0.12" N	9° 58' 0.12" E		18/09/2018 00:32	9.38	01:42	1
5	42° 27' 0.00" N	10° 19' 0.12" E		18/09/2018 02:14	9.38	04:16	4
6	42° 7' 0.12" N	11° 5' 60.00" E		18/09/2018 06:31	9.38	02:49	2
7	42° 3' 42.12" N	11° 41' 30.12" E	TSS IN	18/09/2018 09:20	5.00	00:40	
8	42° 6' 27.00" N	11° 44' 6.00" E	TSS INBOUND	18/09/2018 10:01	END	VOYAGE	P



Sailing assistant allows to get a fuel-optimized route starting from the initial route chosen by crew

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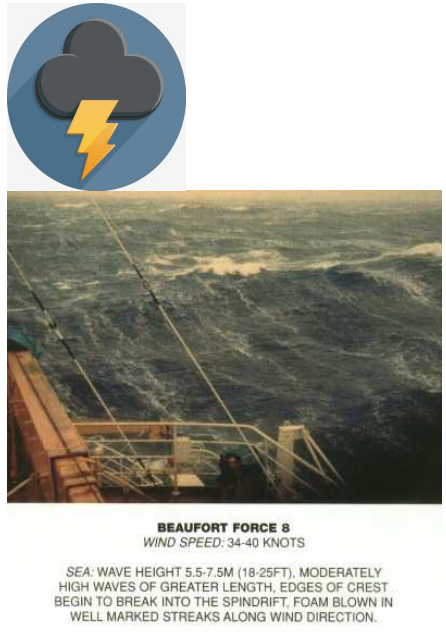
BEAUFORT FORCE 3
WIND SPEED: 7-10 KNOTS

SEA: WAVE HEIGHT .6-1M (2-3FT), LARGE WAVELETS, CRESTS BEGIN TO BREAK, ANY FOAM HAS GLASSY APPEARANCE, SCATTERED WHITECAPS

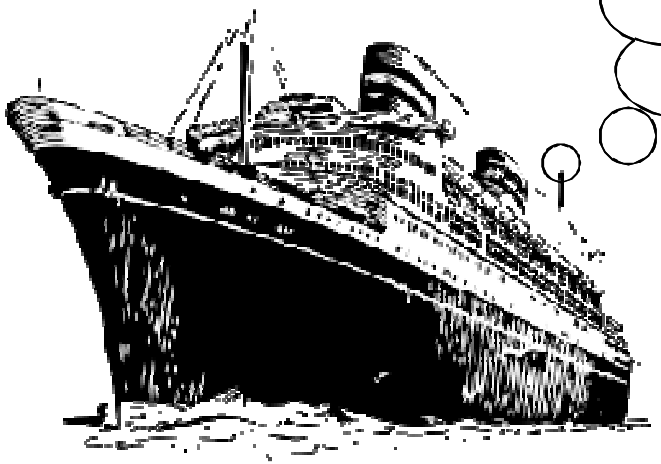
BEAUFORT FORCE 7
WIND SPEED: 28-33 KNOTS

SEA: WAVE HEIGHT 4-5.5M (13.5-19 FT), SEA HEAPS UP, WHITE FOAM FROM BREAKING WAVES BEGINS TO BE BLOWN IN STREAKS ALONG THE WIND DIRECTION



BEAUFORT FORCE 8
WIND SPEED: 34-40 KNOTS

SEA: WAVE HEIGHT 5.5-7.5M (18-25FT), MODERATELY HIGH WAVES OF GREATER LENGTH, EDGES OF CREST BEGIN TO BREAK INTO THE SPINDRIFT, FOAM BLOWN IN WELL MARKED STREAKS ALONG WIND DIRECTION.



Which weather can be expected during navigation?

- **Wave radar**
  - High accuracy
  - Reduced range prediction
  - High installation costs
- **Weather forecast service**
  - Good accuracy
  - High range prediction
  - Reduced costs

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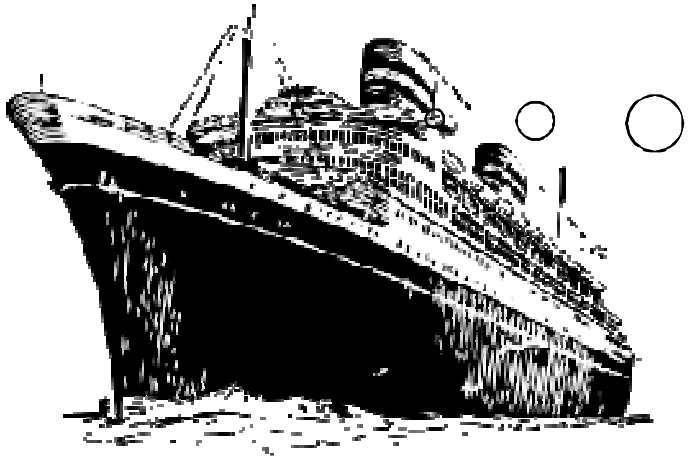
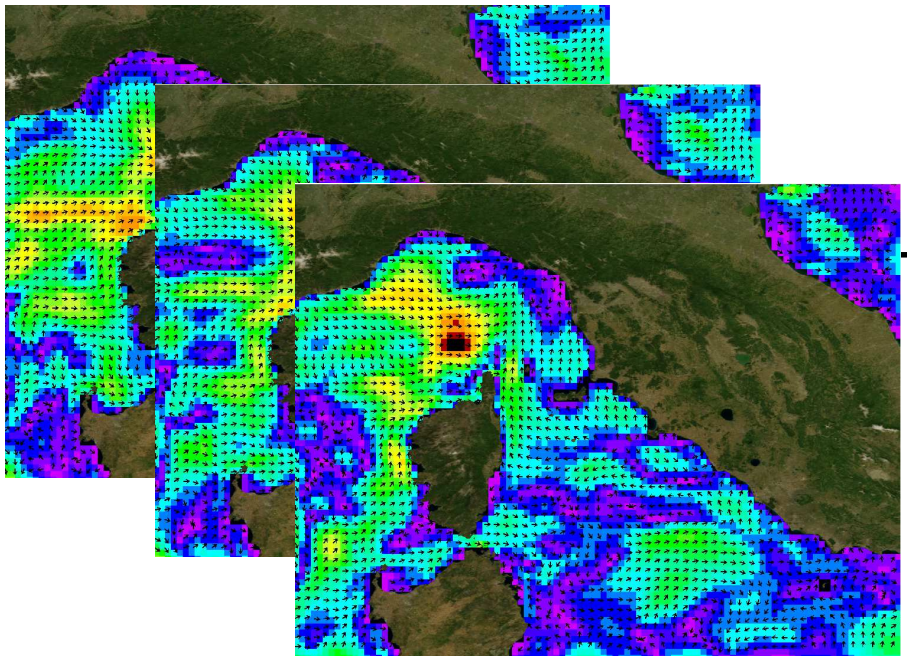
CETENA is currently developing a Virtual Weather Station aimed to:

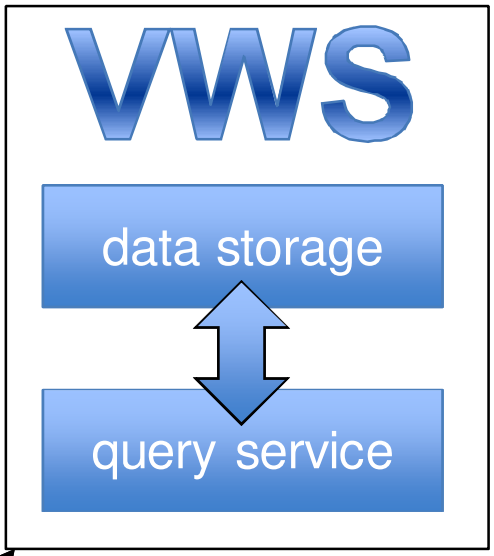
- **Collect weather condition data,** characterized by
  - 1 hour averaging
  - Reduced spatial resolution
  - Different kind of data, such as current, wave, temperature, wind
- **Provide a query service for different kind of applications:**
  - Sailing assistance (performance and safety)
  - Voyage prediction
  - Post-process analysis

The accuracy of this kind of data has already been checked during international cooperative research project



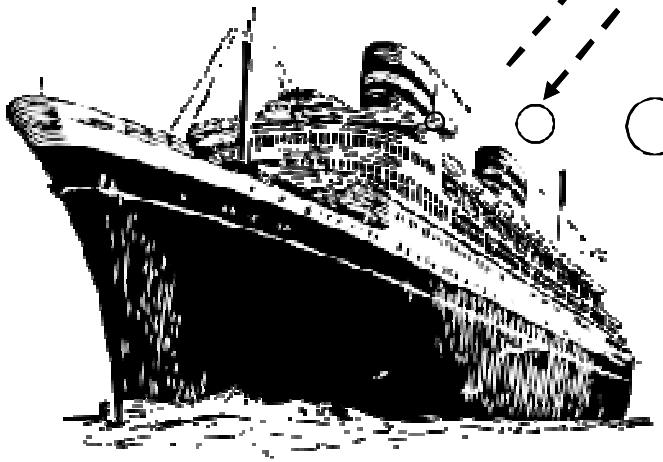
Which weather can be expected during navigation?





request

reply



Which weather can be expected during navigation?

Ship monitoring effects on ship management

1. Monitoring of current sailing condition in real time
2. Analysis of ship performances depending on: crew, season, route, operating condition
3. Real time evaluation of maintenance effects on ship performances, stating the KPI prescribed by international standards
4. Improvement of the usual maintenance planning stating the monitored performances
5. Fuel consumption reduction through route optimization
6. Optimisation of structural maintenance and reduction of insurance costs

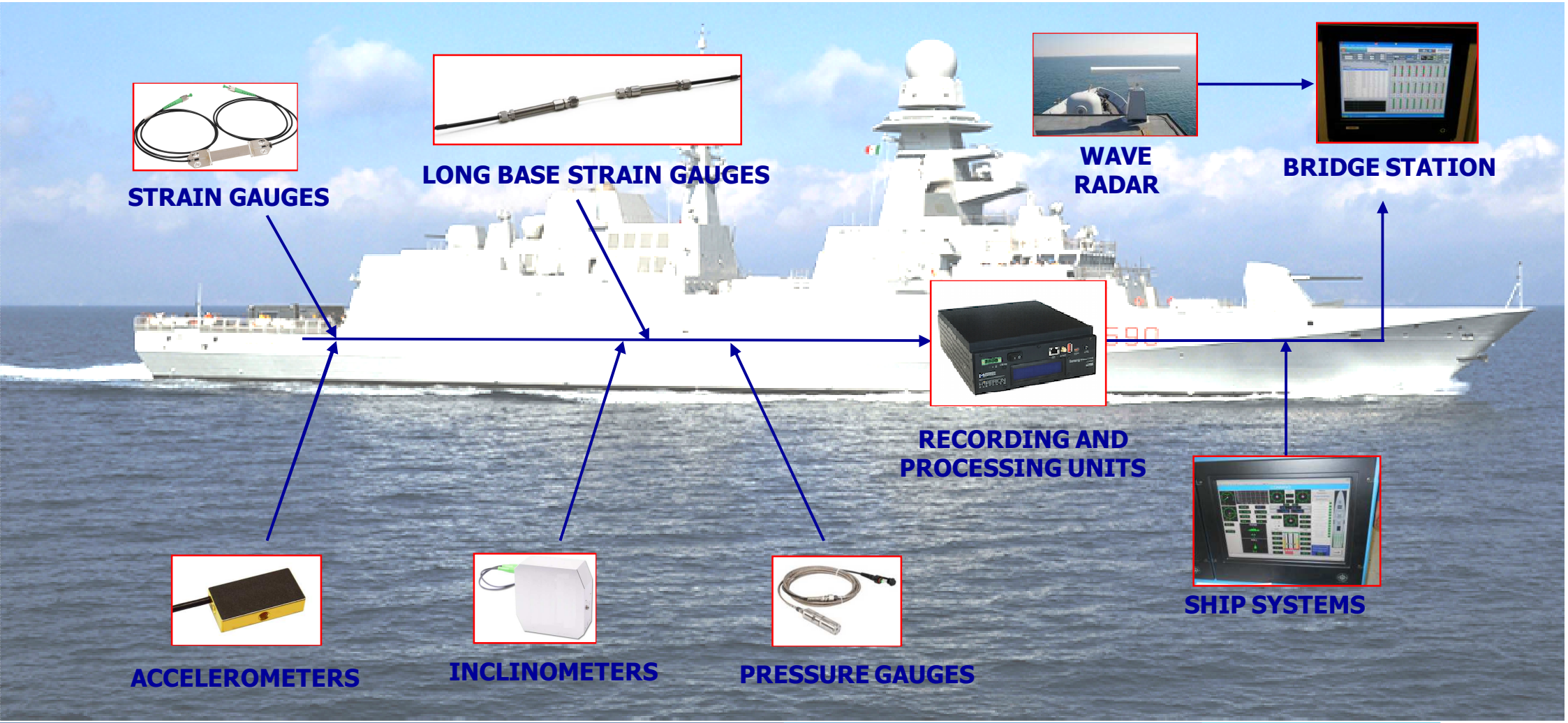
Green ship means…

…spend money?

Not always!

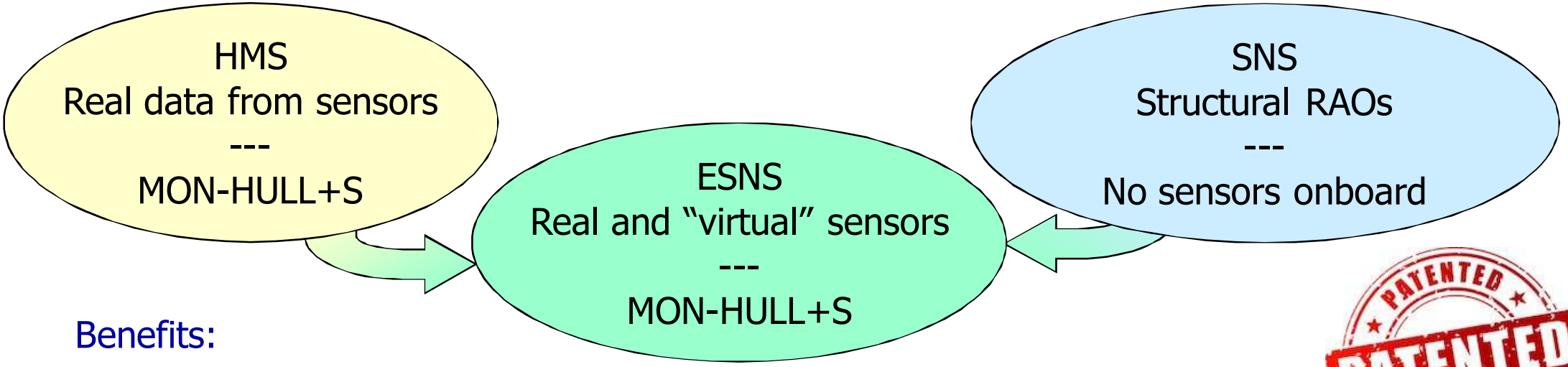
HMS - Hull Monitoring System based on Fiber Optic Technology

- developed for Navy ships and merchant ships, including ATEX environment
- RINA Type Approval certified, suitable for MON-HULL additional Class notation
- Sensor costs comparable with traditional ones



Enhanced Safe Navigation System

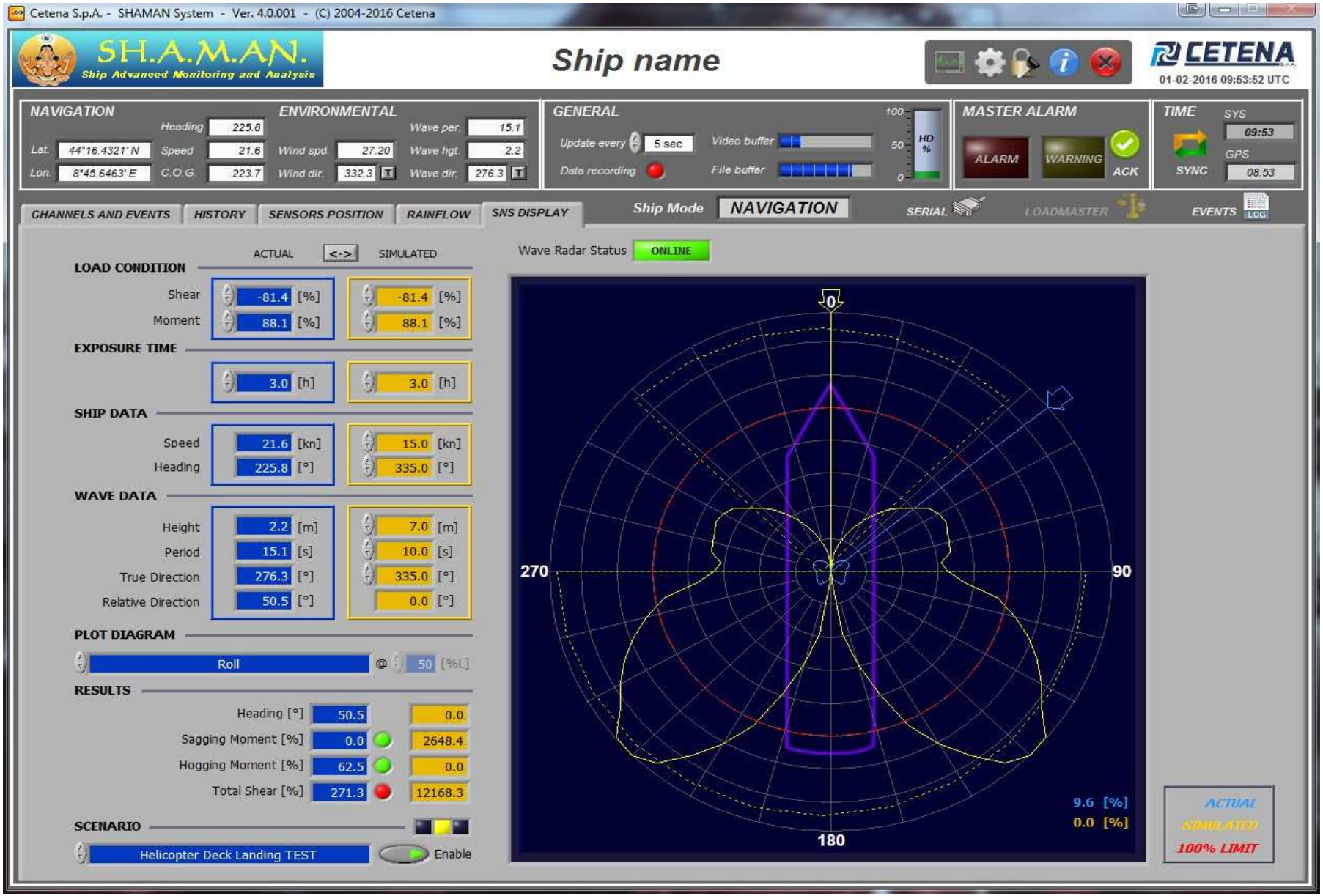
- Hybrid systems using few sensors and FEM/CFD model results for higher accuracy and enhanced decision support system;



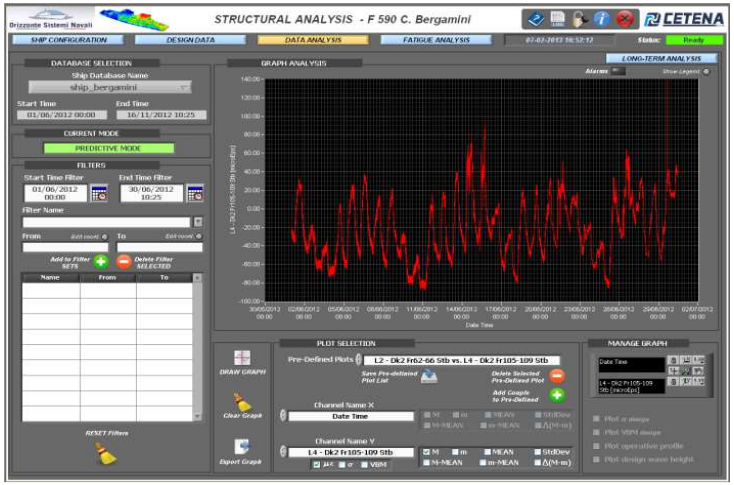
Benefits:

- Joins benefits from HMS (real data) and from SNS (provisional tool)
- Virtual sensors (no cables);
- Ship motions and loads forecast tuned by using sensors data: higher accuracy (local and global effects);
- Ship operating windows widened;
- Operating Envelope Diagrams aid in ship operations (landing / take off, operations at sea, …): more support to Master decision.

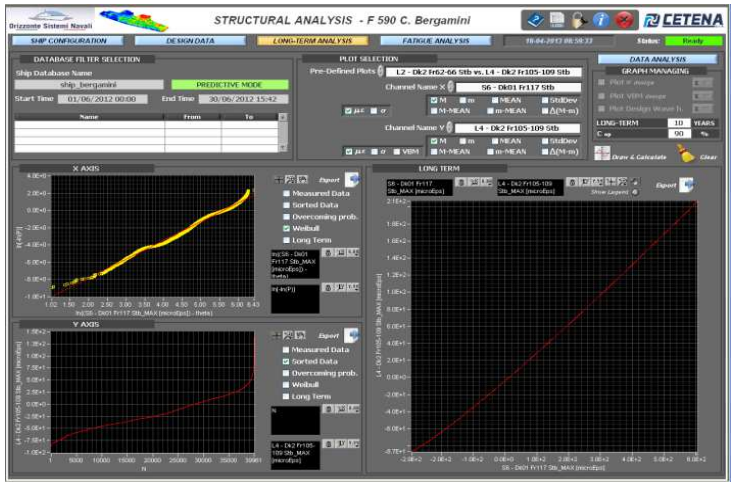
Operating Envelope Diagrams



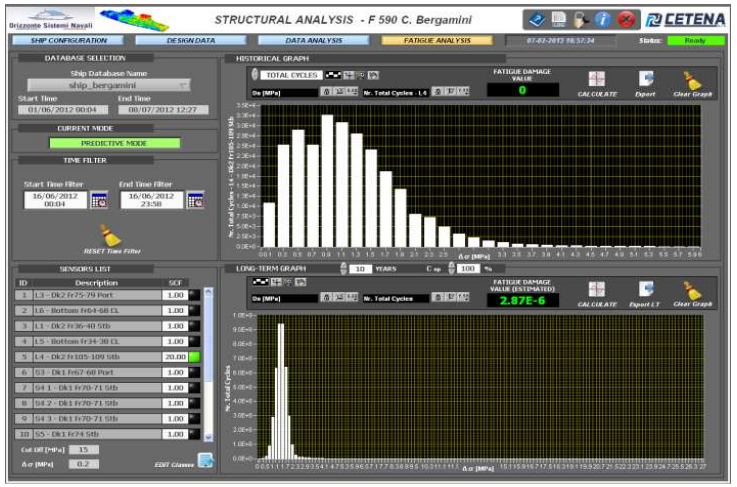
Post-processing of data recorded by Sh.A.M.An. Hull Monitoring System



- ✓ Data-Base archive
- ✓ time histories plot
- ✓ data filtering
- ✓ operative profile assessment



- ✓ long term statistical extrapolation
- ✓ highest expectable loads estimation



- ✓ elapsed and long term forecasted fatigue life
- ✓ estimate effects on fatigue life by vessel use, detail geometry/surface

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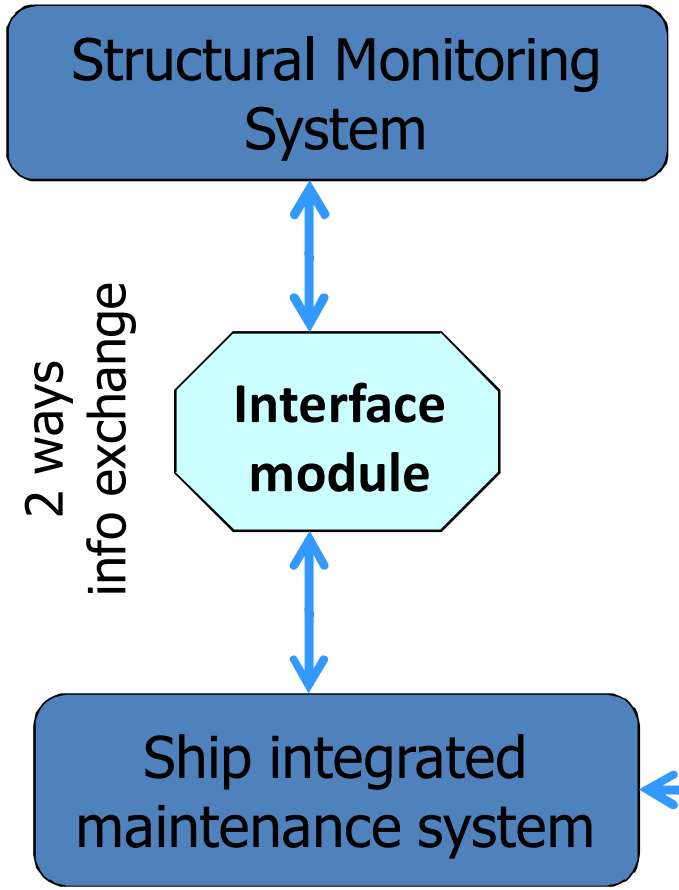
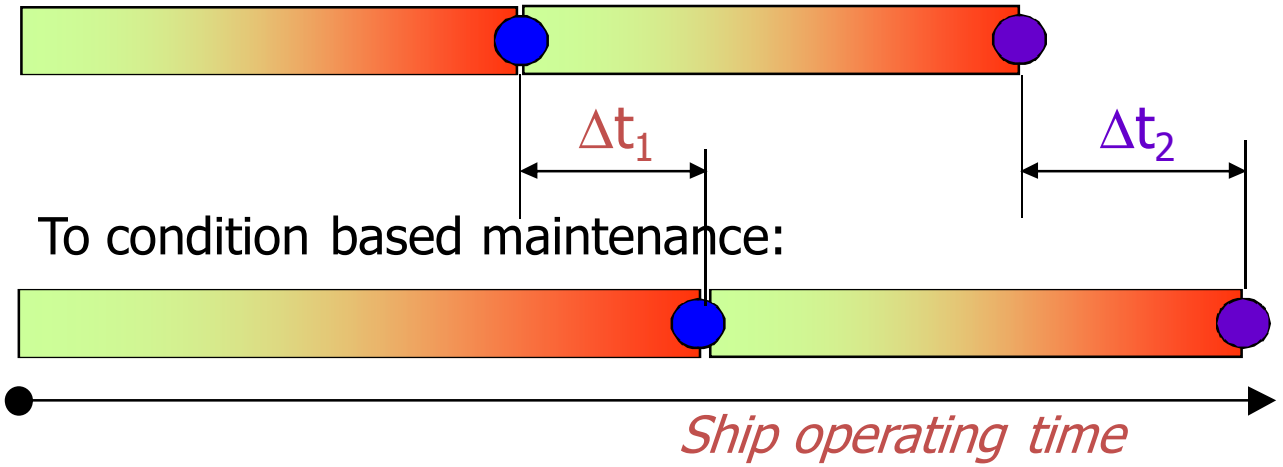
If integrated with the on-board maintenance suite, the Sh.A.M.An. System can allow to extend the CBM concept to ship structures.



From traditionally scheduled maintenance:



Maintenance tasks

- local / global inspections
- structure repair
- cargo inspection
- system maintenance

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Thanks for your kind attention.

CETENA SpA
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