

Vibraciones  
y Ruidos



*Vibration & Noise*

*Engineering  
Solutions*

Soluciones  
de Ingeniería

# SILENT SHIPS



The solution for those Owners worried with  
the Protection of the HEALTH & COMFORT  
of Passengers, Crews and Environment!



TÉCNICAS Y SERVICIOS DE INGENIERÍA, S.L.

# The Target: Compliance with the Current Regulatory Framework

The improvement of work conditions and health protection of passengers and seafarers of all type of ships, as well as the environmental protection of the residential areas closest to the harbours and the Marine Life, has been the reason and leitmotiv of **European Commission Regulatory Framework**. The corresponding Directives have been translated as Local Laws to all Member States.



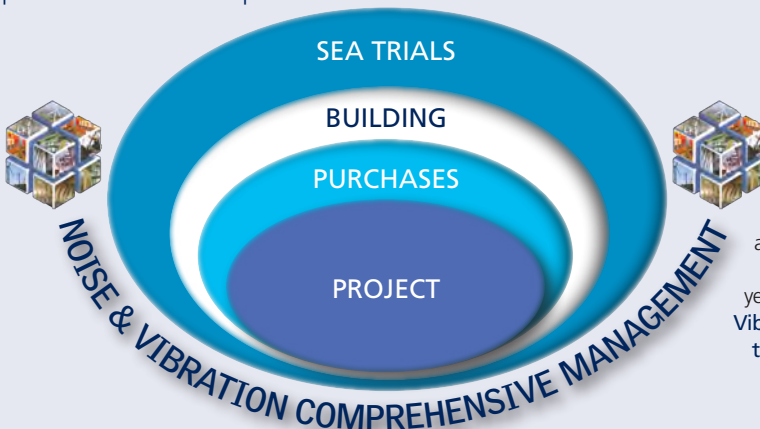
-  **DIRECTIVE 2003/10/EC**  
Improvement of work conditions and health protection of passengers and seafarers of all type of ships.
-  **DIRECTIVE 2006/56/EC**  
Environmental protection of the residential areas close to the harbours.
-  **DIRECTIVE 2008/56/EC**  
Marine Life Protection.

## The Challenge: To Design and Build "SILENT SHIP"

Within this trend, the **REDUCTION OF THE UNDERWATER RADIATED NOISE** for all type of ships is the most remarkable novelty and the most difficult **CHALLENGE** that the Shipbuilding Industry has ever faced.

## The Engineering Tool

The Proven Tool to achieve not only Noise & Vibration Comfort Class Notation but also the compliance with URN Requirements.



Developed by TSI and based on its own experience over 40 years Solving Noise & Vibration problems in the fields of Marine and Industry.

# THE METHODOLOGY

APPLYING PREVENTIVE N&V CONTROL TECHNIQUES FROM THE EARLIEST STAGES OF THE PROJECT UNTIL THE SEA TRIAL TEST!

## PRELIMINARY ANALYSIS OF DESIGN

**Assessment, from the Noise and Vibration point of view of:**

Specification, Structural Design, Original Noise Insulation, Suitability of specified Machinery, etc.



## SENSITIZATION OF SUPPLIERS

**Specific Acoustical & Dynamic Requirements for:**

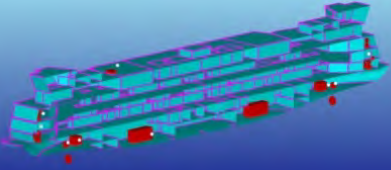
Main Noise & Vibration Sources:  
Main & Auxiliary Machinery, Propeller, Thrusters, HVAC and Ventilation Systems, etc.

Accommodation panels and certified damping properties of the noise insulation materials.

F.A.T and dedicated tests must be required for validations.



## SIMULATION: N&V CALCULATIONS



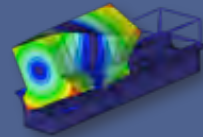
## NOISE, VIBRATION & URN ACCEPTANCE



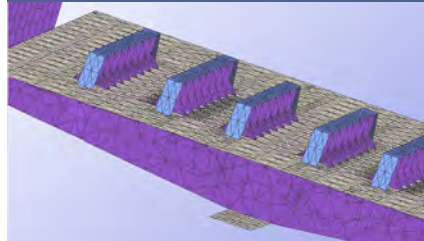
## SEA TRIAL TESTS



## Double resilient bedframe Calculation



## Ship foundation Mobility Calculation



## Experimental ODS

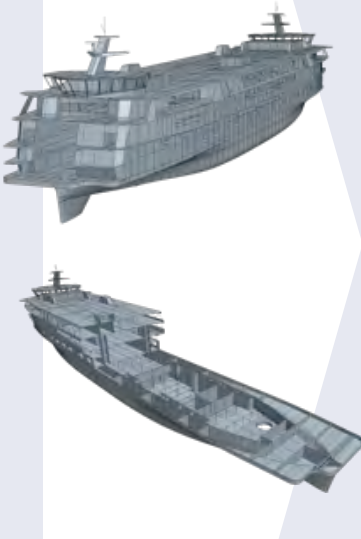


## FAT FACTORY ACCEPTANCE TESTS

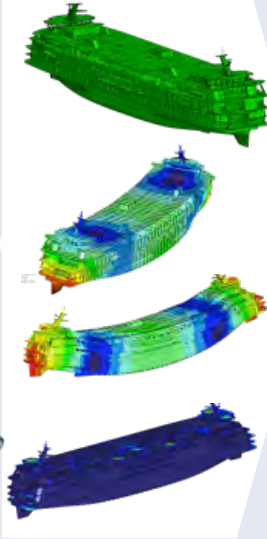
# SIMULATION: N&V CALCULATIONS

## VIBRATION PREDICTION CALCULATIONS

### Mathematical Model



### Forced Response



### ADVANTAGES

#### ► To Avoid

Global and Local Resonance problems. So, non desirable vibration levels.

#### ► To Know

The Expected Vibration Levels at each space at the early stage of the Project.

#### ► To Apply

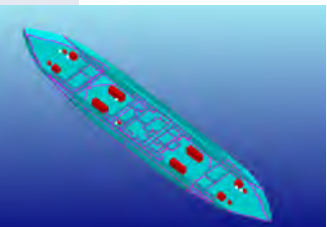
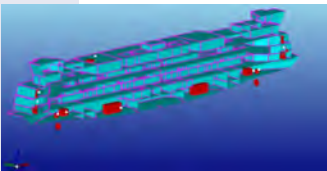
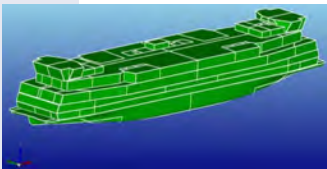
If required, the structural modifications at the locations affected, at the earliest design stage.

#### ► To Guarantee

The compliance with Contractual Limits and the **COMPLIANCE** with Regulation and Directives.

## NOISE PREDICTION CALCULATIONS. SEA MODEL

### SEA Model



### ADVANTAGES

#### ► To Guarantee

The Compliance with the Standard New IMO MSC 337(91) and / or the Comfort Noise Limits required by Specification

#### ► To Know

The Expected Noise Levels at each space of the ship at the early stage of the Project.

#### ► To Apply

The "proper noise insulation solutions" in the "right partitions", and only attending to the "type of noise: Airborne or Structural" causing the deviation.

#### ► To Optimise

The "NOISE INSULATION WEIGHT" and "COST".

Unlike other statistical approaches...

...We only apply the right materials needed in the most effective partitions

**REDUCTION**

**COSTS**

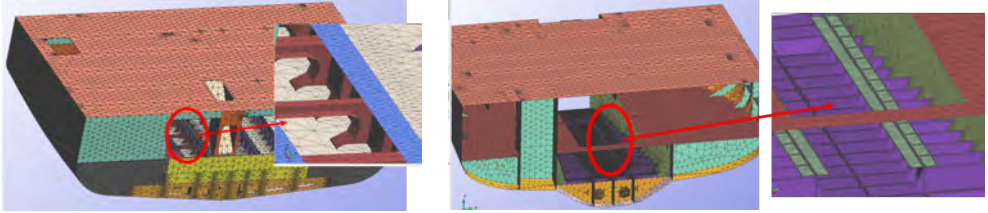
**LIGHT WEIGHT**

**FUEL CONSUMPTION**

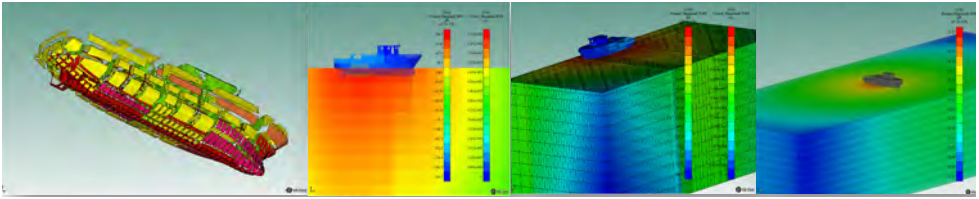
Very significant with regard to other "cheaper studies" based only on "statistical approaches" and with high impact on the Stability and the Operating Costs during the entire life-cycle of the ship.

## UNDERWATER RADIATED NOISE CALCULATIONS FEM+BEM+SEA MODEL

### Mobility of Machinery Foundations



### Underwater Radiated Noise Calculations



## FAT-FACTORY ACCEPTANCE TESTS

### DEDICATED DYNAMIC EXPERIMENTAL ACCEPTANCE TESTS



Focused on verifying the Compliance with the contractual Requirements of the Suppliers of the main Noise, Vibration and Underwater Radiated Noise sources!



TSI has been involved in the FAT of the common Main Supplies in the Vendor Lists of most of the Specifications of "Silent Ships".

## SEA TRIAL TESTS

- ▶ Noise Levels on board,
- ▶ Vibration Levels on board,
- ▶ Noise Insulation Index,
- ▶ Noise Radiated to the harbour,
- ▶ URN Underwater Radiated Noise
- ▶ Bollard Pull,
- ▶ Manoeuvring Tests....



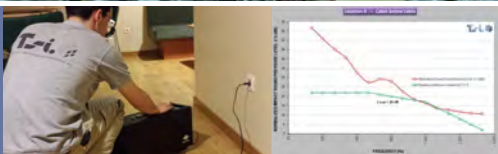
FOR OTHER DEDICATED TESTS,  
PLEASE SEE OUR WEBSITE  
OR THE YOUTUBE VIDEO  
"TSI -DEDICATED SERVICE TO THE  
MARINE SECTOR".



NOISE & VIBRATION MEASUREMENTS ACCORDING TO SPECIFICATION OR COMFORT CRITERIA



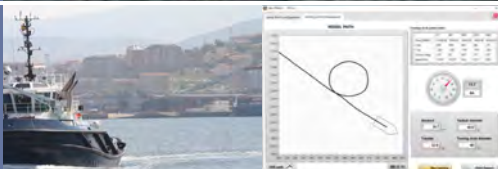
ON SITE MEASUREMENTS OF NOISE REDUCTION INDEX ( $R_w$ ) BETWEEN LOCALS OF THE SHIP ACCORDING TO STANDARD AND COMFORT CLASS NOTATIONS



IMPACT NOISE INSULATION TESTS



MEASUREMENT OF NOISE RADIATED BY THE SHIP TO HARBOUR. IDENTIFICATION OF DEVIATIONS.



MANEUVERING TESTS.



SHIP PERFORMANCE: POWER AND SHIP'S SPEED MEASUREMENTS.

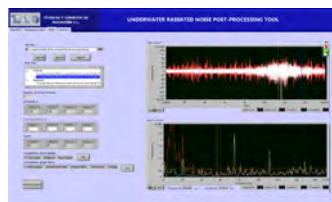


URN - UNDERWATER RADIATED NOISE MEASUREMENTS



## Everywhere and on Deep and Shallow water!

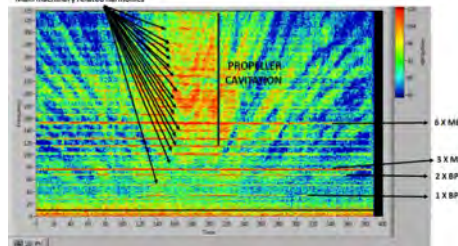
According to the most recent URN Measurement Procedure developed in the framework of AQUO Project (FP7-GA N° 314227) and implemented in the New voluntary URN Class Notation NR 614 of BUREAU VERITAS.



### FUNCTIONALITIES:

- ▶ Adapted for BV NR614 Post-Processing
- ▶ Post-processing according to DNV and ANSI/ASA also available
- ▶ Any input of TL.
- ▶ Indicate what 1/3 octave band levels are background noise affected.
- ▶ Visualization of the results of all runs.
- ▶ Direct computation and visualization of the final URN signature.
- ▶ Directivity diagrams.
- ▶ Spectrograms to identify sources

Main machinery related harmonics



TSI- URN Database with over 48 "underwater footprints" of a wide variety of ships.

# Recent References of SILENT Ships

Applying the most innovative technologies to get the Compliance with the strictest Noise & Vibration and Underwater Radiated Noise Requirements.



2014

FRV "Dr. Fridtjof Nansen"  
A. GONDAN



2013

FRV "BIPO"  
ARMÓN-Vigo



2013

ARMÓN  
Vigo



2011

ARMÓN  
Vigo



2010

FRV "Ramón Margalef"  
ARMÓN-Vigo



2007

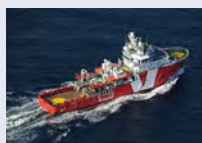
FRV "Sarmiento de Gamboa"  
C.N. Freire



2007

FRV "Miguel Oliver"

# Other References of SILENT Ships





# When TSI takes care of the "Noise & Vibrations" of your Ship, these are the Experimental Results...

- Maximum Vibration Level at Passengers Areas: 0,6 mm/s-rms / Limit 2,5 mm/s-rms.
- Maximum Noise Levels at Passenger Areas: 52,8 dB (A) / Limit 58 dB (A)

**LaNaval**  
CONSTRUCCIONES NAVALES DEL NORTE



- Noise & Vibration Levels in COMPLIANCE with Comfort Class Notation PCAC 2.2 Lloyd Register
- Mechanical Vibration of Human Exposure to Whole Body in COMPLIANCE with ISO 2631-1:1997 "
- Crew Noise & Vibration Exposure Levels in COMPLIANCE with ARBO Regulation (Dutch Labour HSE Regulation) and Directive 2002/44/EC and Directive 2003/10/EC.

- Maximum Vibration Level at Accommodation Areas: 1,3 mm/s-rms / Limit 4,0 mm/s-rms.
- Maximum Noise Levels at Accommodation Areas: 61,0 dB (A) / Limit 61dB (A)

**ZAMAKONA**  
YARDS



- Noise & Vibration Levels in COMPLIANCE with Comfort Class Notation COMF-VIB3 and COMF-NOISE3- BV
- Crew Noise Exposure Levels in COMPLIANCE with REAL DECRETO DE RUIDO 286/2006 (Spanish Regulation) and Directive 2003/10/EC.

- Maximum Vibration Level: 0.7 mm/s-rms
- Noise: Cabin 37,6 dB (A) . Machinery Room: 87,0 dB (A)

**ARMON**



- Noise Radiated to the Harbour: In COMPLIANCE with Directive 2002/49/EC.
- UNDERWATER RADIATED NOISE: In COMPLIANCE with ICES N°209, according to BV-NR 614

- Maximum Vibration Level at Accommodation Areas: 0,4 mm/s-rms / Limit 3,5 mm/s-rms.
- Maximum Noise Levels at Accommodation Areas: 48 dB (A) / Limit 55 dB (A)

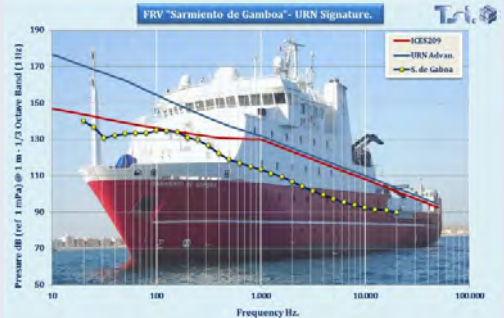
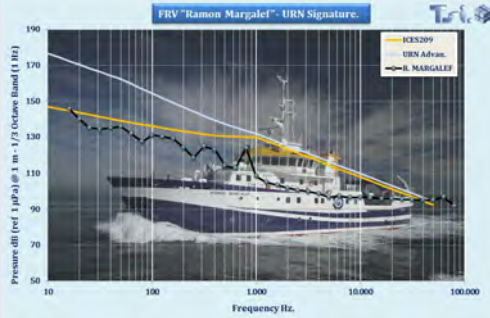
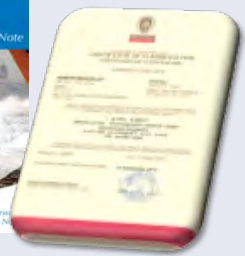
**ASTILLEROS GONDAN**  
SHIPBUILDERS



- Noise & Vibration Levels in compliance with DNV CONF-(C2)V(2)
- Noise Radiated to the Harbour in compliance with 2006/56/EC

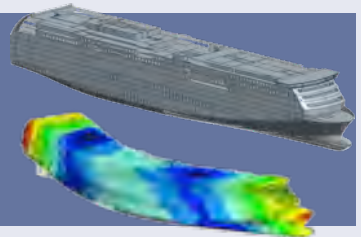
# URN Certified Results

Certification should be convenient!

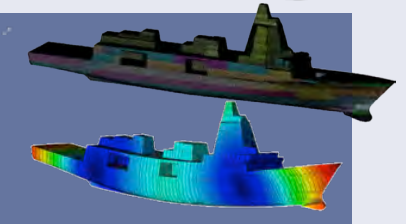


## Projects in progress

**LaNaval**  
CONSTRUCCIONES NAVALES DEL NORTE



**Navantia**



## The Company

Your right partner for  
**"Noise & Vibration  
 Engineering  
 Solutions"** in Marine,  
 Power Generation &  
 Industry

**TSI - Técnicas y Servicios de Ingeniería, S.L.**, specialized company in **Vibration & Noise Measurement, Analysis and Control, Condition Base Maintenance (CBM), Failures Consultancy, Dynamic Analysis; Theoretical and Experimental and Condition Monitoring Systems;** gather more than 2.800 references of these applications for national and foreign Civilian and Military Shipyards.

**The Services of TSi**, accredited by DNV, UKAS, RVA and DMA, had permitted delivery all type of Ships: Passengers, Luxury Yachts, LNG's, Fishing Research Vessels, Merchant s and Fishing Vessels; in compliance with the most strictly Comfort, Radiated External Noise and Underwater Radiated Noise Requirements, usually required by current Regulations: IMO, ILO, Comfort Class Notations, and ICES 209.



# "Acoustical Retrofitting for Ships in Service"

"The effective tool based on 40 years of experience solving noise and vibration problems on board ships".

"Who is acoustically designing the most "Silent Ships" ...



SHIP IN SERVICE

...can help you to achieve the **COMPLIANCE** of your vessels with the Directive 2003/10/EC "on the minimum health safety requirements regarding the exposure of the workers to the risks arising from noise"

TSI is ISO certified (ISO 9001:2008) and has the recognition and accreditation of international entities, **DNV, UKAS, RvA**, for the following issues: "Specialized services of engineering and consultancy in Vibrations and Noises and related training. Carrying out of dynamic tests: Measurements, Analysis and Control. Sales of Vibrations Monitoring Systems and Technical Service. Building Technical Assistance".

TSI is authorized by **BUREAU VERITAS** to perform Noise and Vibration Measurements to obtain the corresponding "COMFORT CLASS Notation" in accordance with that established in their rule: "Classification of Steel Ships, Part E, Chapter 6 Comfort on Board".

And it is also certified by **BUREAU VERITAS** to carry out and report on underwater radiated noise measurement on ships classed with **BUREAU VERITAS** within the scope of Bureau Veritas Rule Note NR 614 – Underwater Radiated Noise.

TSI is approved as **service supplier** to perform Comfort Class measurements for **DNV GL**. And it has authorization to carry out Under Water Radiated Noise in accordance with its rule **DNV GL Silent class notation**.

TSI has authorisation from **DMA – DANISH MARITIME AUTHORITIES** to carry out Noise and Vibration measurements and studies on vessels.



Your right Partner to achieve  
**SILENT SHIPS**  
and so, **Quiet Oceans**



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