Shipping Noise :
Regulation and Technical Issues

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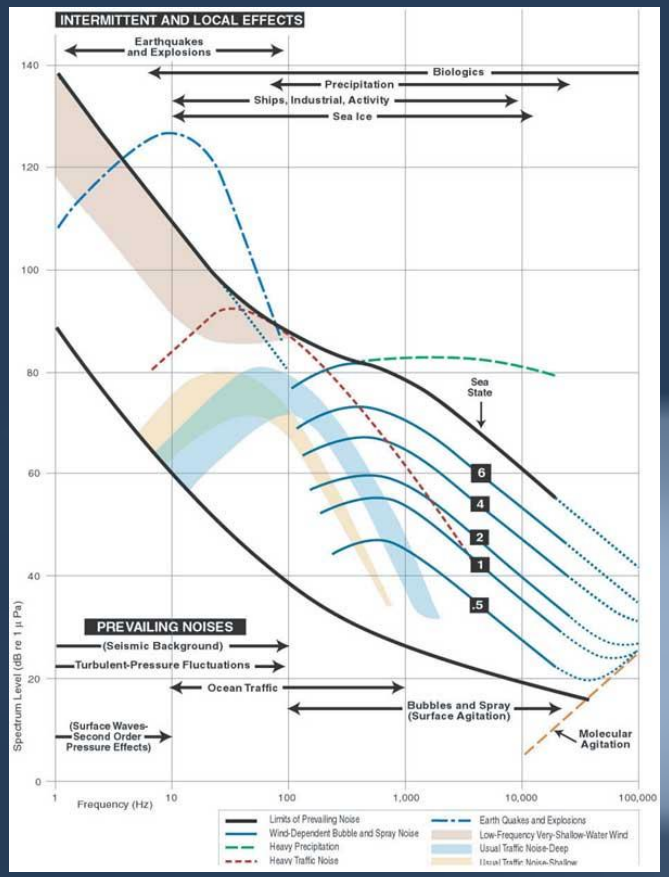
Contents

- Background
- Regulation Issues
  - International Regulations
  - Standard and Technical Issues
- Technical Issues
  - Noise Reduction Techniques (general)
  - Korea Research Program on Ship Noise
- Conclusion

BACKGROUND

- Ocean Ambient Noise
  - Nature-made noise.

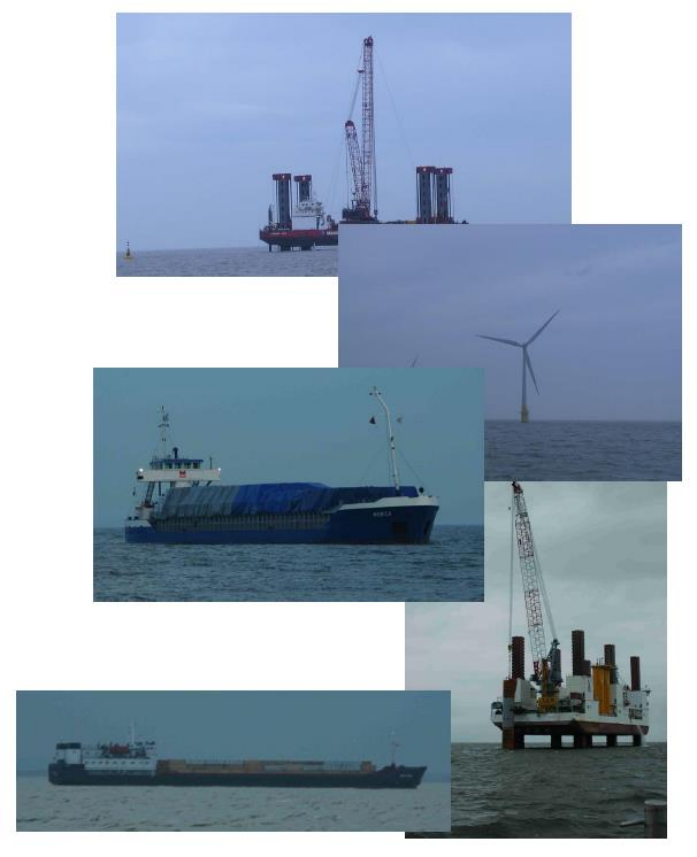
- Wenz (1962)
- seismic (LF)
- “distant” shipping
- rain
- waves
  - depends on sea state and wind speed
- biological
  - snapping shrimp, mammals, etc



BACKGROUND (Cont.)

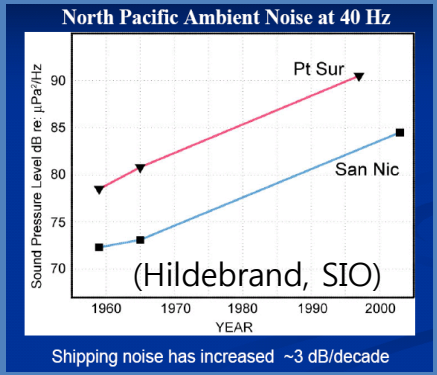
- Anthropogenic Noise
  - Man-made noise.

- Shipping
- Geophysical surveying
- Drilling, piling, dredging
- Explosions
- Underwater vehicles
- SONAR
- Acoustic communication and positioning transducers
- Echo sounders



BACKGROUND (Cont.)

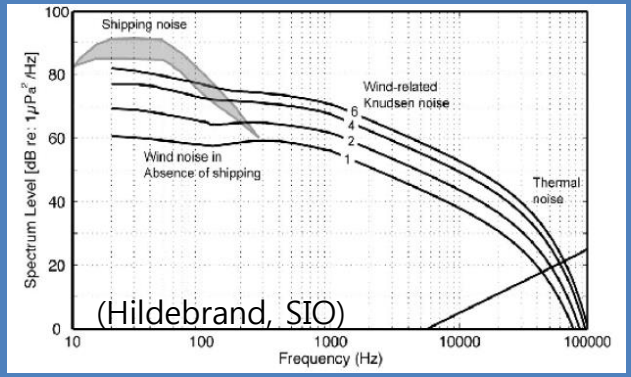
- Why Shipping Noises?

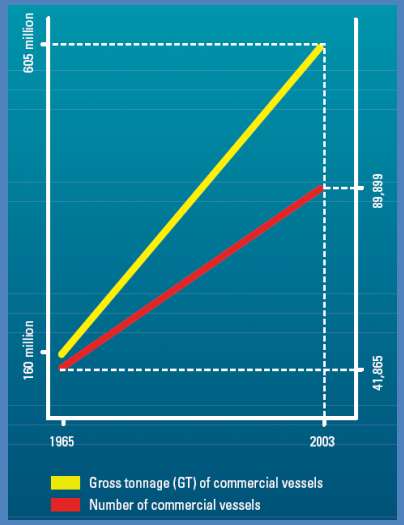


Increase in underwater background noise

6dB/decade

Shipping v.s Natural Noise



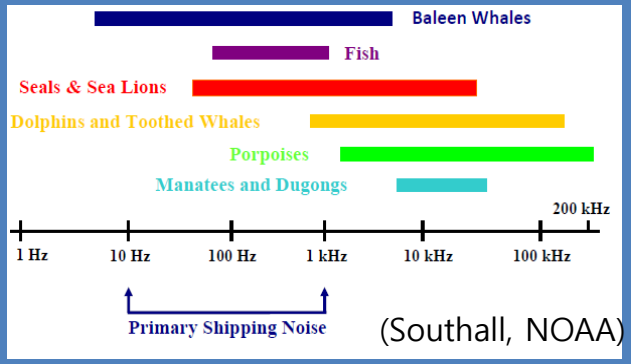


No. of Commercial Ships
40K (1965)
90K (2003)

GT of Commercial Ships
180million GT(1965)
605million GT(2003)

Future?
Two times increase expected in 2030's

Marine Mammals Vocal Frequency



REGULATION ISSUES

UN

- **The United Nations Convention on Law of the Sea (UNCLOS)**
- The Particularly Sensitive Sea Areas (PSSA) resolution of the IMO
- The International Convention for the Prevention of Pollution from Ships

USA

- **Marine Mammal Protection Act (MMPA)**
- Endangered Species Act(ESA)
- National Environmental Policy Act (NEPA)

EU

- **ACCOBAMS / ASCOBANS / OSPAR (*)**
- DTI Offshore Petroleum Activities Regulations 2001 (PON 14)
- Licenses/consents granted by DEFRA for offshore activities

* ACCOBAMS : Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Area
* ASCOBANS : Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas
* OSPAR : Convention for the Protection of the Marine Environment of the North-East Atlantic

REGULATION ISSUES (Cont.)

Past

- Broad regulation for marine environment protection
- Strict shipping noise regulations **NOT** exist.

Present

- **Non-mandatory** to shipping noise reduction
- Guidelines for the reduction of underwater noise from commercial shipping (IMO, 2014)

Future

- **Mandatory regulation possible** for quiet ocean

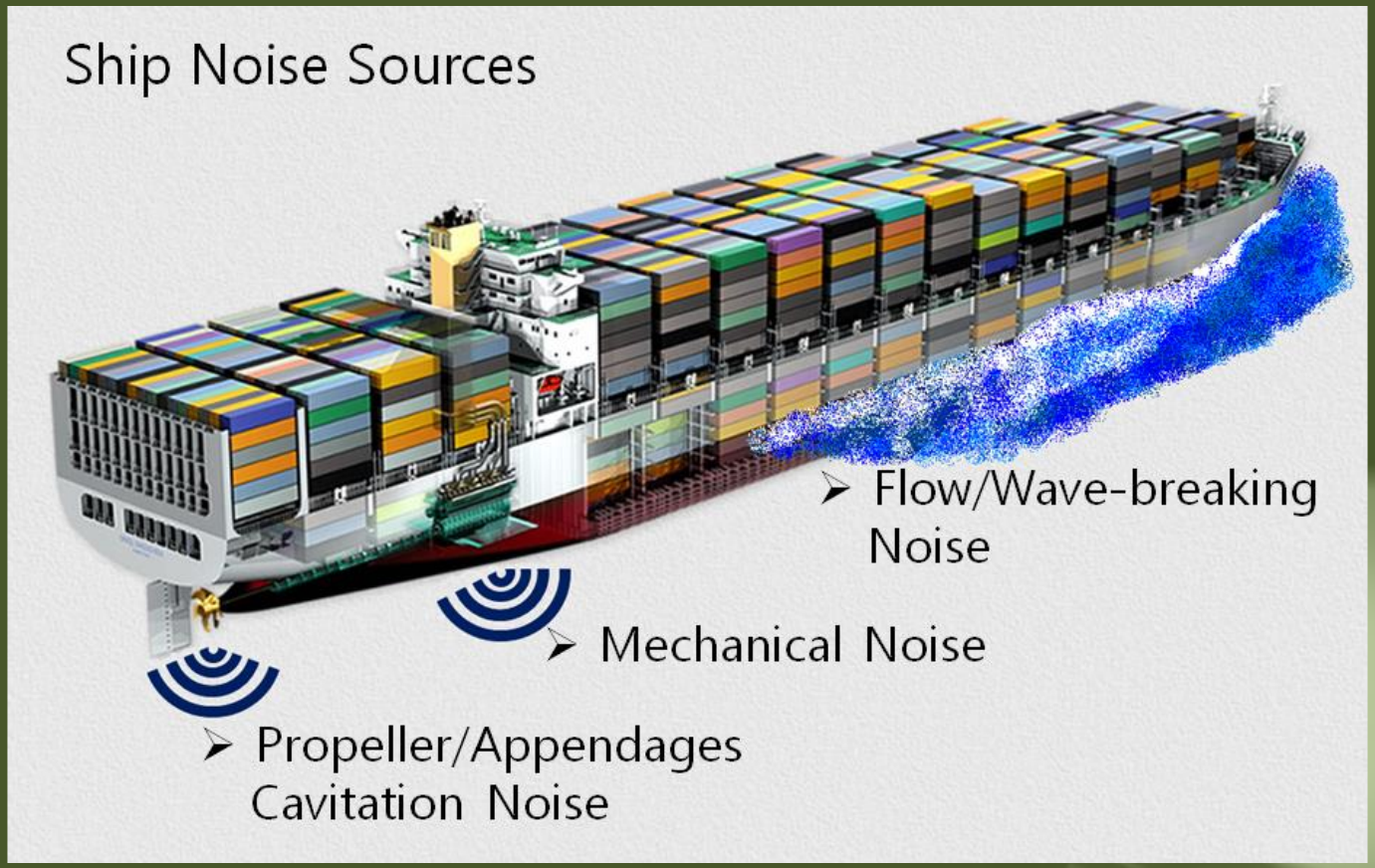
STANDARD ISSUES

- ISO
  - ISO/PAS 17208-1:2012
    - ACOUSTICS-Quantities and procedures for description and measurement of underwater sound from ships Part 1 : General requirements for measurements in deep water
  - New Work Item Proposals related with measurements in deep/shallow waters

- ITTC (International Towing Tank Conference)
  - ITTC – Recommended Guidelines : Underwater Noise from Ships, Full Scale Measurement
  - ITTC – Recommended Guidelines : Model Scale Noise Measurements

Technical Issues

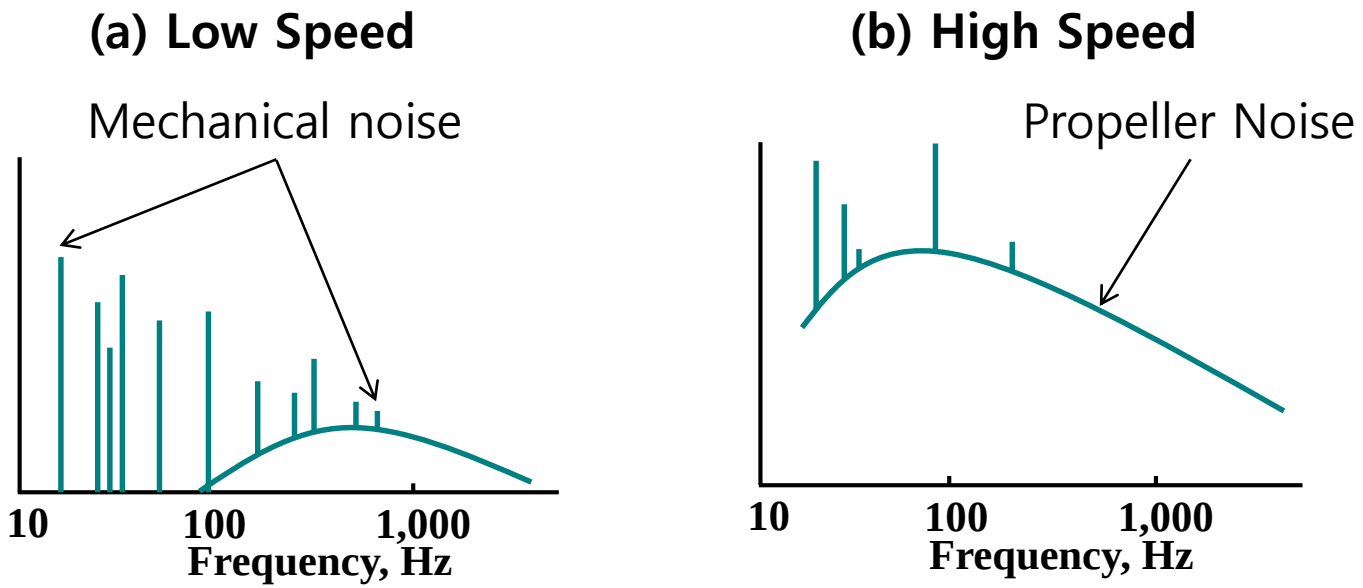
Ship Noise Sources



Ship Noise Sources (Cont.)

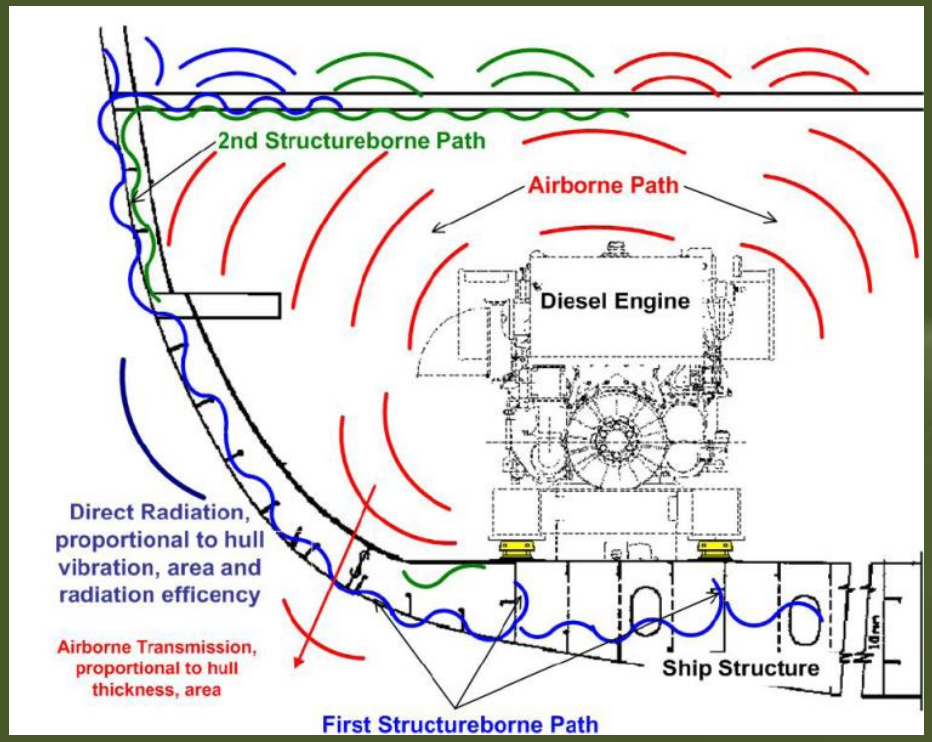
- At low speed, **Mechanical noises** are dominant.
- At high speed, **Propeller cavitation noises** are dominant.

Typical Ship Noise Spectrum



Noise Reduction Techniques – Mechanical Noise

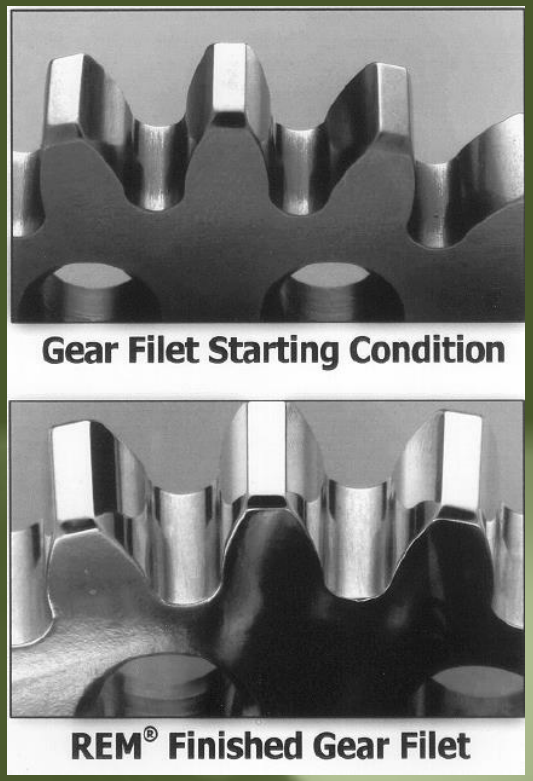
- Noise source elimination (limited methods)
- Transmission path treatments (more practical methods)



Noise Reduction Techniques – Mechanical Noise (Cont.)

- Noise Source Treatment

Electrical Powered Propulsion (POD)



Low-noise Reduction Gear

Noise Reduction Techniques – Mechanical Noise (Cont.)

- Mount/Foundation
  - For vibration isolation
  - Active method : effective to high freq. vibration
  - Passive method : effective low freq. vibration

Two-stage Genset Isolation System(NOAA FRV)

Vibration Isolator

Noise Reduction Techniques – Mechanical Noise (Cont.)

- Acoustic Insulation (air-borne noise)

Acoustic Insulation Wall

Acoustic Insulation Box

Noise Reduction Techniques – Mechanical Noise (Cont.)

- Pipes/HVAC Noise Reduction

Piping Isolation

Fuel Oil Pump Isolation & Acoustic Filter

Piping Hangers

HVAC

Noise Reduction Techniques – Mechanical Noise (Cont.)

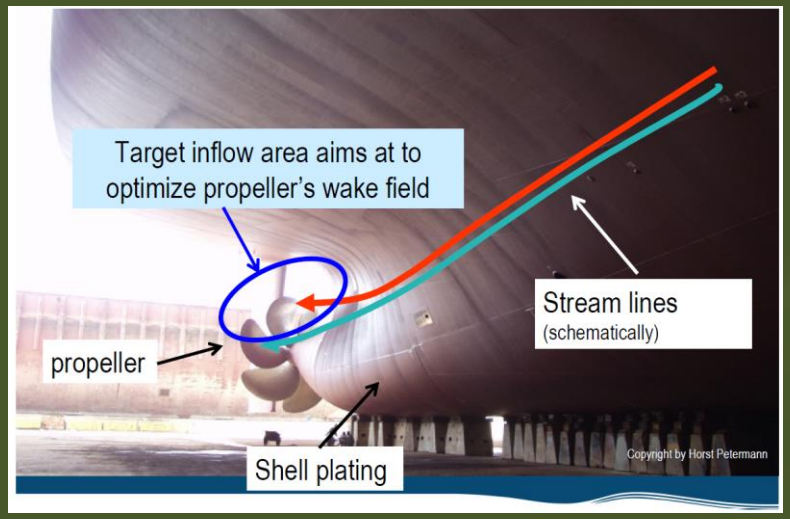
- Hull Damping

Spray-on Damping

Damping Tile

Noise Reduction Techniques – Cavitation Noise

- Wake Improvement
  - Reducing Propeller Cavitation



Hull Form / Appendages

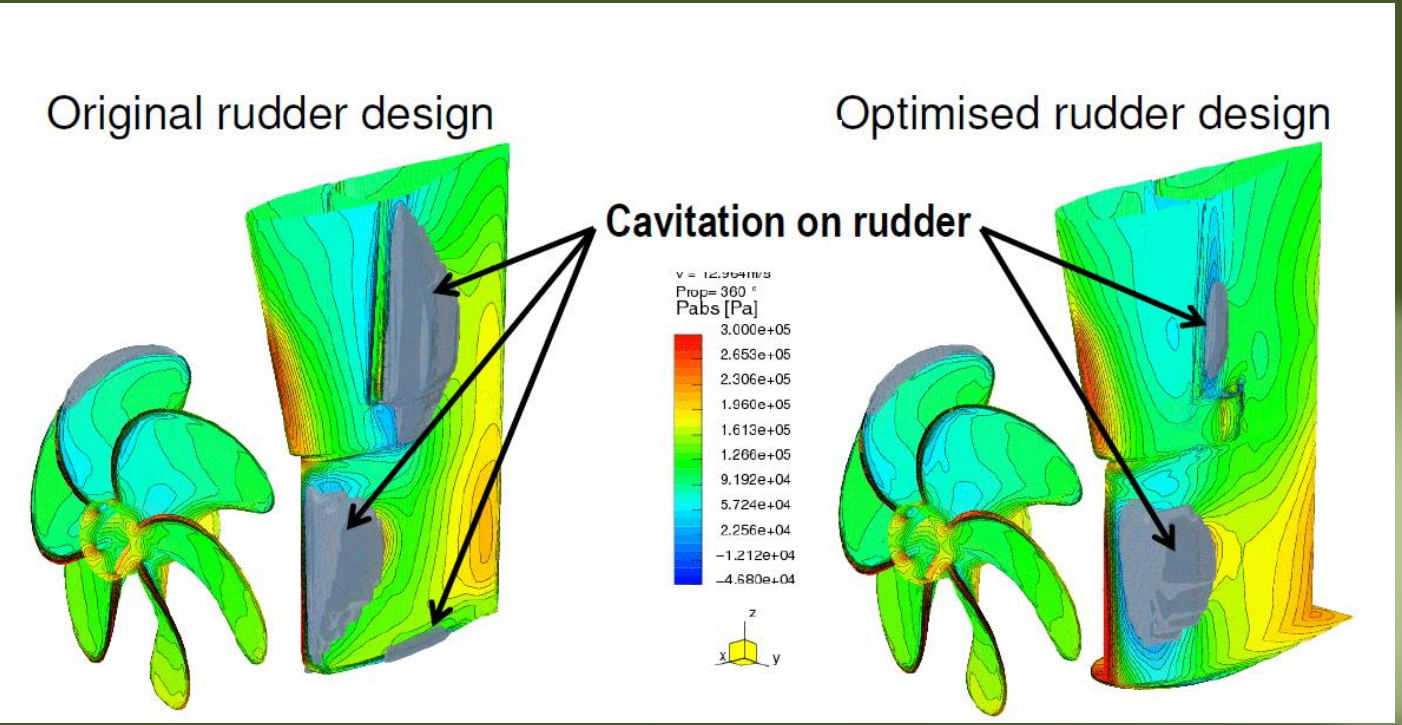
Duct / Nozzle

Noise Reduction Techniques – Cavitation Noise (Cont.)

- Low-noise Propeller Design
  - Delaying cavitation inception
- Air / Water / Particle Injections
  - Reducing cavitation

Noise Reduction Techniques – Cavitation Noise (Cont.)

- Rudder Design
  - Reducing rudder cavitation

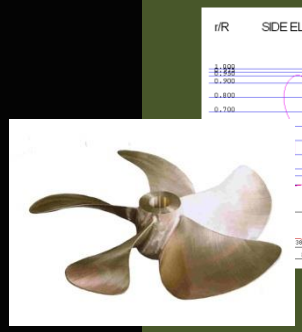


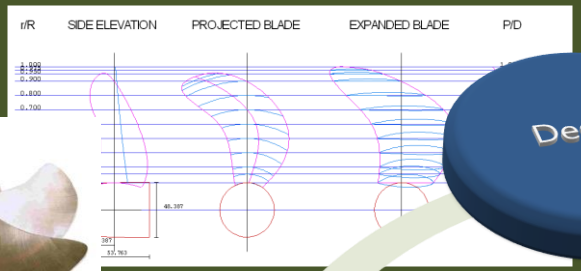
Korea Research Program

- Propeller Noise Research Program
  - Funded by MOTIE (Ministry of Trade, Industry and Energy)
  - Periods : 2013-2018 (5years)
  - Participants :

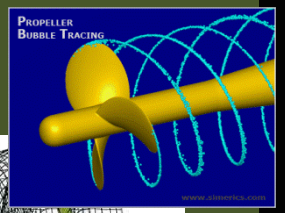
KRISO, Pusan National University, CNU, KOSHIPA (Korea Offshore & Shipbuilding Association), HYUNDAI HEAVY INDUSTRIES CO.,LTD., DSME, stx Shipbuilding, HANJIN HEAVY INDUSTRIES & CONSTRUCTION CO.,LTD., TMS TOTAL MARINE SERVICES

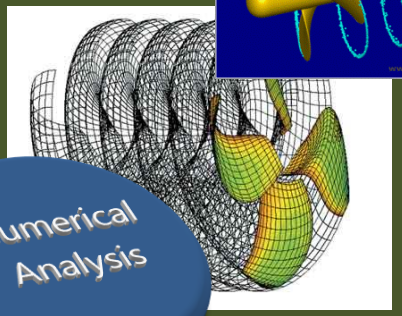
Korea Research Program (Cont.)





Design



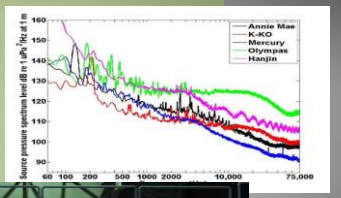


Numerical Analysis

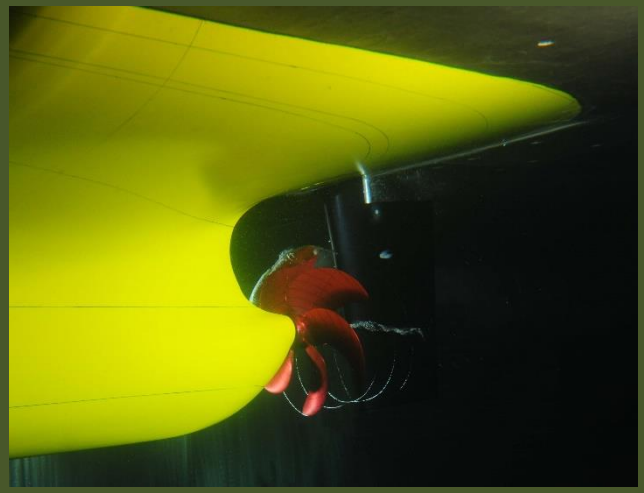
Noise Research

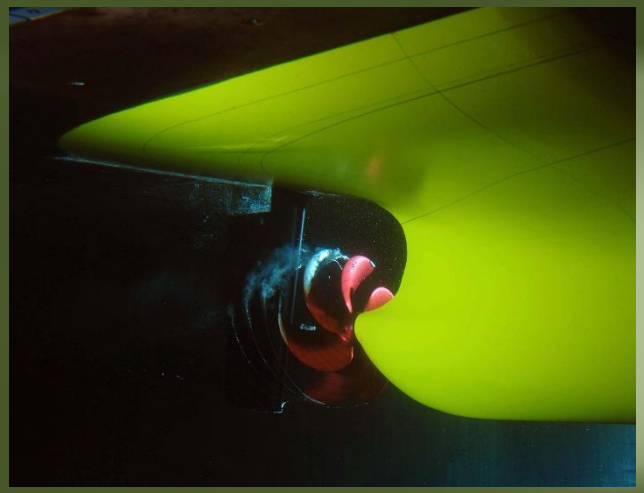
Full-scale Test

Model Test

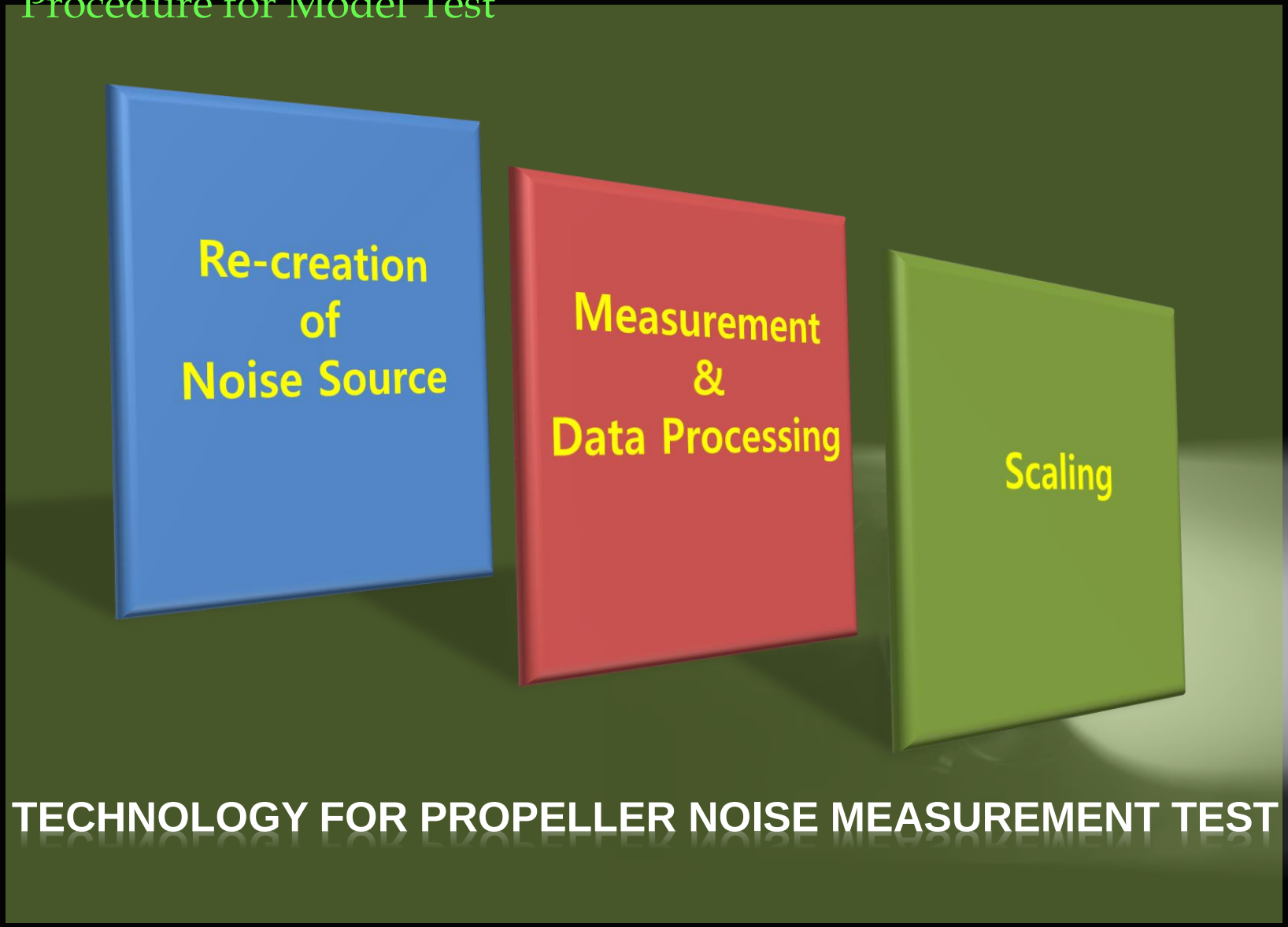


Model Test Facility – Cavitation Tunnel





Procedure for Model Test



Test Condition Setups (Re-creation of Noise Source)

- Same propeller working conditions as predicted for the full scale ships.
  - Torque identity method from the results of a self-propulsion test
  - Propeller operating conditions were determined
    - Thrust coefficient, K_T
    - Cavitation number
      - 0.7R above the propeller centerline
      - Consider stern wave height (based on T.T test results)
    - Tunnel flow speed at the test section: 7~8m/s (commercial), 10~15m/s (military)
    - Model propeller rotation speed: 35~45 rps

$$K_T = \frac{T}{\rho n^2 D^4}$$

$$\sigma_n = \frac{P_0 - P_v}{1/2 \rho n^2 D^2}$$

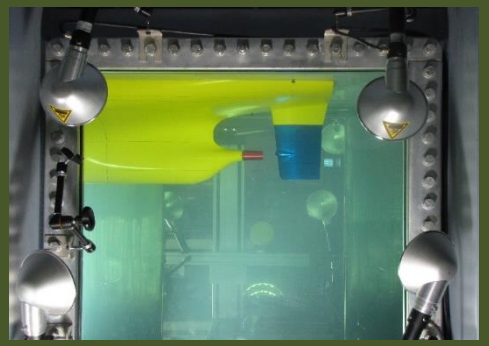
- Other condition : Dissolved air content normally, 60% ~ 70%

Measurement & Data Processing

Propeller & Background Noise Measurement

$$Ls(f) = Lm(f) + T.F \quad [dB\ re\ 1uPa\ @1m]$$

Propeller → Bare hub



- Propeller noise measurement
- Test condition
  - ✓ Flow speed
  - ✓ Propeller rotation rate
  - ✓ Tunnel ambient pressure
  - ✓ Air content

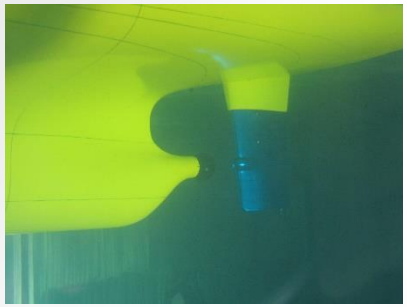
- Background noise measurement
- Check the validity of measured results
- Same test condition
  - ✓ Flow speed
  - ✓ Shaft rotation rate
  - ✓ Tunnel ambient pressure
  - ✓ Air content

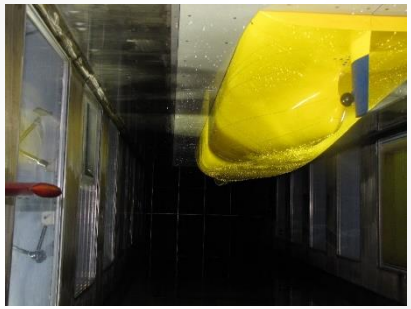
Validity Check

Criterion : 6dB or 10dB

Transfer Function Measurement

Ls(f) = Lm(f) + T.F [dB re 1uPa @1m]





Transfer function

=

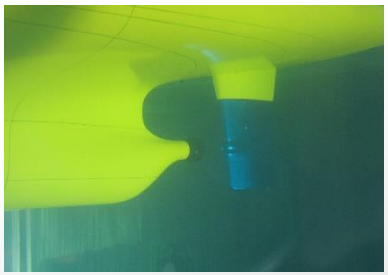
Wall reverberation effect ✚ **Transmission Loss**

Model-scale Source Level

$$Ls(f) = Lm(f) + T.F \quad [dB\ re\ 1uPa\ @1m]$$

Lm(f)

T.F (f)



$$\frac{Ls_1(f) + Ls_2(f) + Ls_3(f) + Ls_4(f) + \cdots}{\text{No. of Measuring system}} = Ls(f)$$

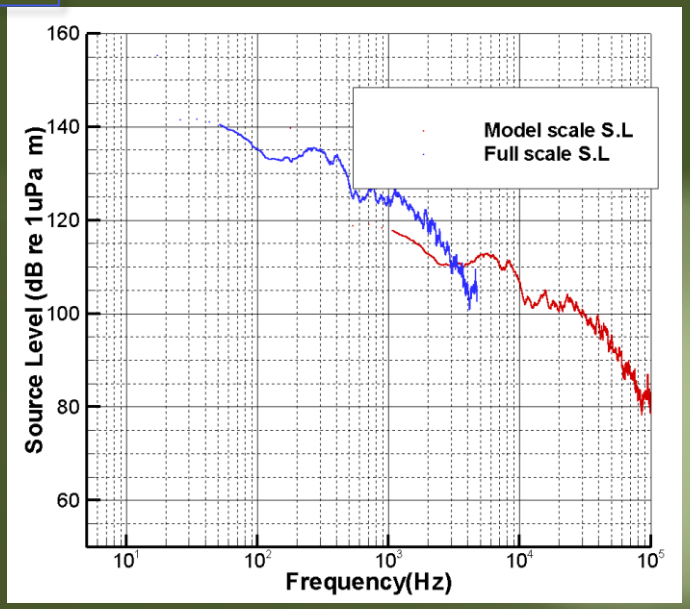
Source Level

Scaling to Full-scale Source Level

$$\frac{P_S^{\,2}}{P_M^{\,2}} = \left(\frac{r_M D_S}{r_S D_M}\right)^2 \left(\frac{\rho_S}{\rho_M}\right)^2 \left(\frac{n_S D_S}{n_M D_M}\right)^4 \qquad \frac{f_S}{f_M} = \frac{n_S}{n_M}$$

ITTC '87

Model scale source level



Full scale source level

Conclusion

- The shipping noise reduction might be not an option for the protection of marine environment.
- A regulation can be enacted by International Maritime Organization.
- Shipping industries and ship yards are sensitive to IMO regulation.
- There are different views on shipping noise regulation.
- Regardless of regulations, noise reduction techniques should be prepared for the future.

Q&A

Thank You