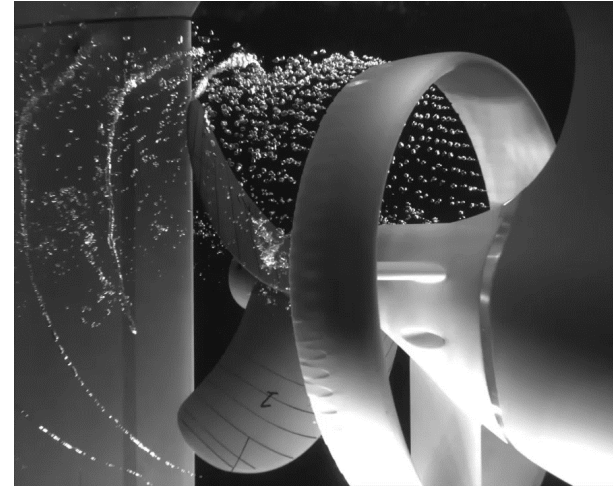
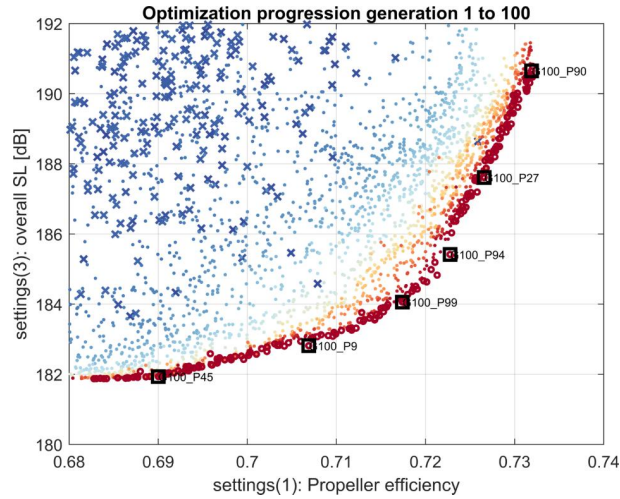




Reducing ship URN by propeller design and air injection and its effect on energy efficiency



Johan Bosschers, Evert-Jan Foeth,
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URN workshop, Antwerp, Belgium, 15th December 2025
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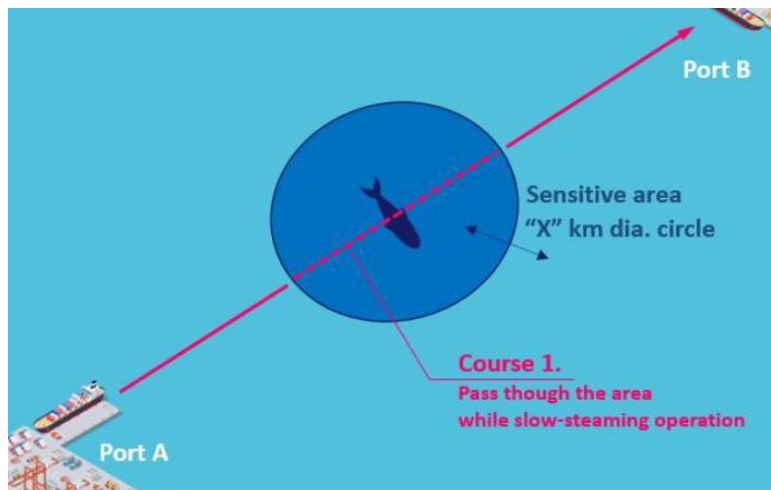


- Advanced propeller design and comparison with speed reduction
- Future directions and initiatives
- Air injection systems to reduce cavitation and machinery noise

Study #1: slow down or quieter propeller?

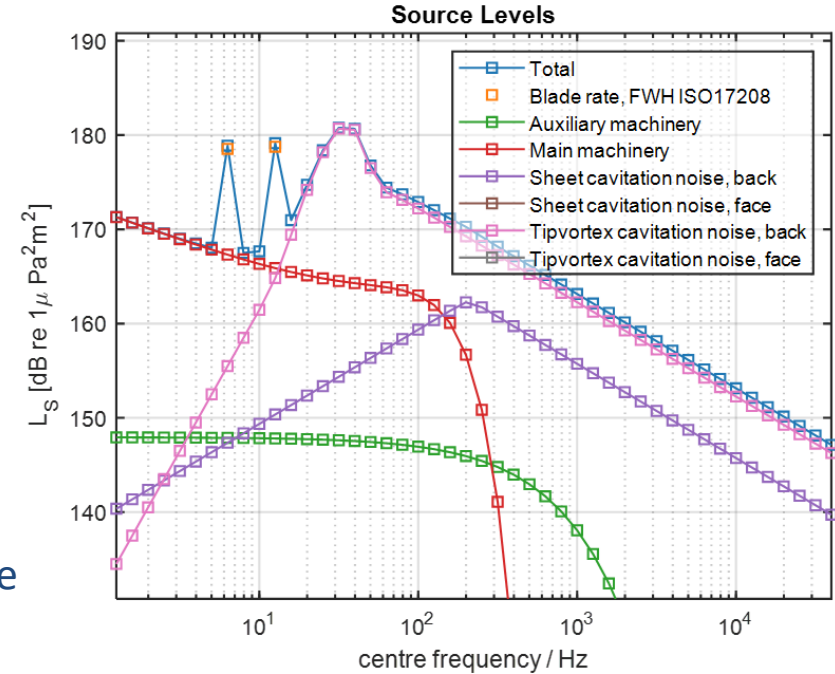


- Inspired by IMO SDC9-INF-11 (Japan, 2022)
- Scenario: URN limits during part of journey of container vessel
 - Prescribed time of arrival
- What requires less fuel for journey: slowing down or quieter propeller design?

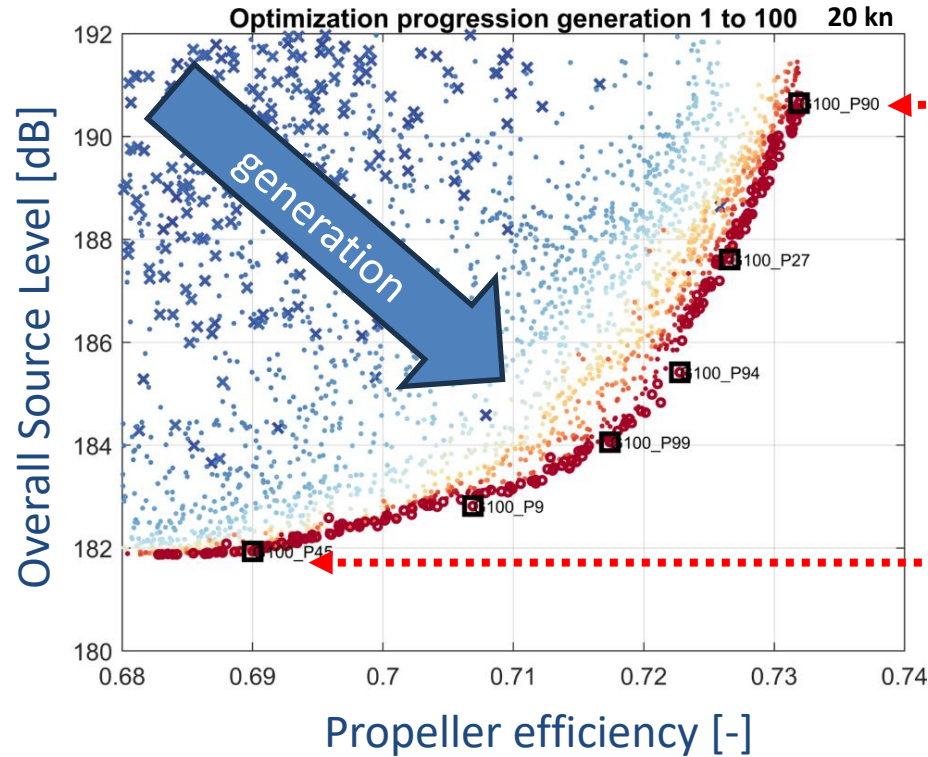


- Some inputs:
 - 270 m container vessel
 - 18 knots average service speed
 - URN limit selected such that reference propeller needs to slow down to 14.5 kn
- Study sponsored by NL Ministry of Infrastructure and Water Management

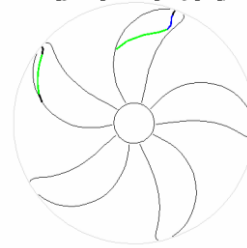
- Ship wake field computed by computational fluid dynamics
- Propeller analysis tools
 - Boundary element method PROCAL
 - Semi-empirical methods for URN source levels
 - Cavitating tip vortex noise (ETV model)
 - Sheet cavitation noise
 - PIANO machinery noise model
- Automated propeller design tool
 - PROPART
 - Goal: produce thrust at minimum torque and minimum URN source level
 - Constraints: strength, erosion, rotation rate, diameter



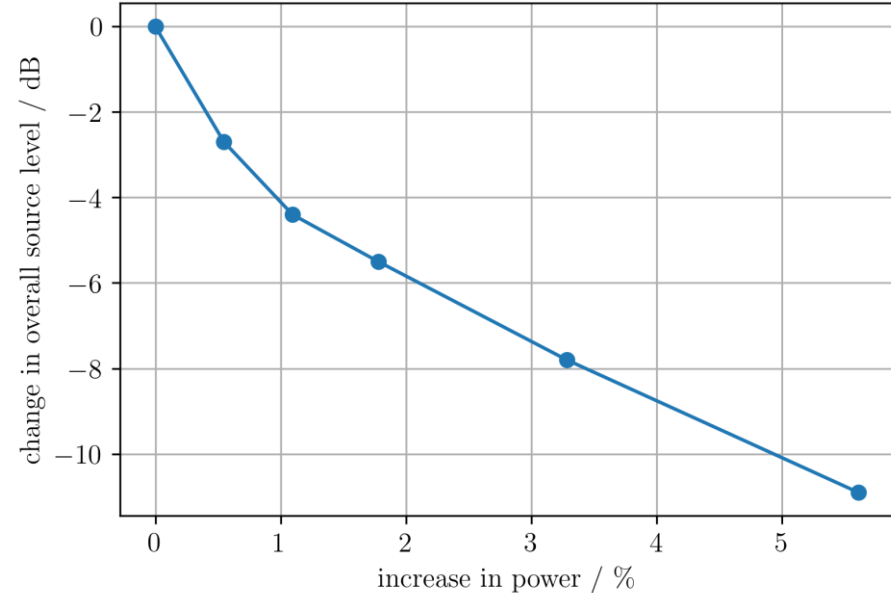
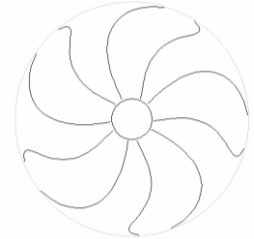
Propeller design study: URN versus efficiency



Most efficient

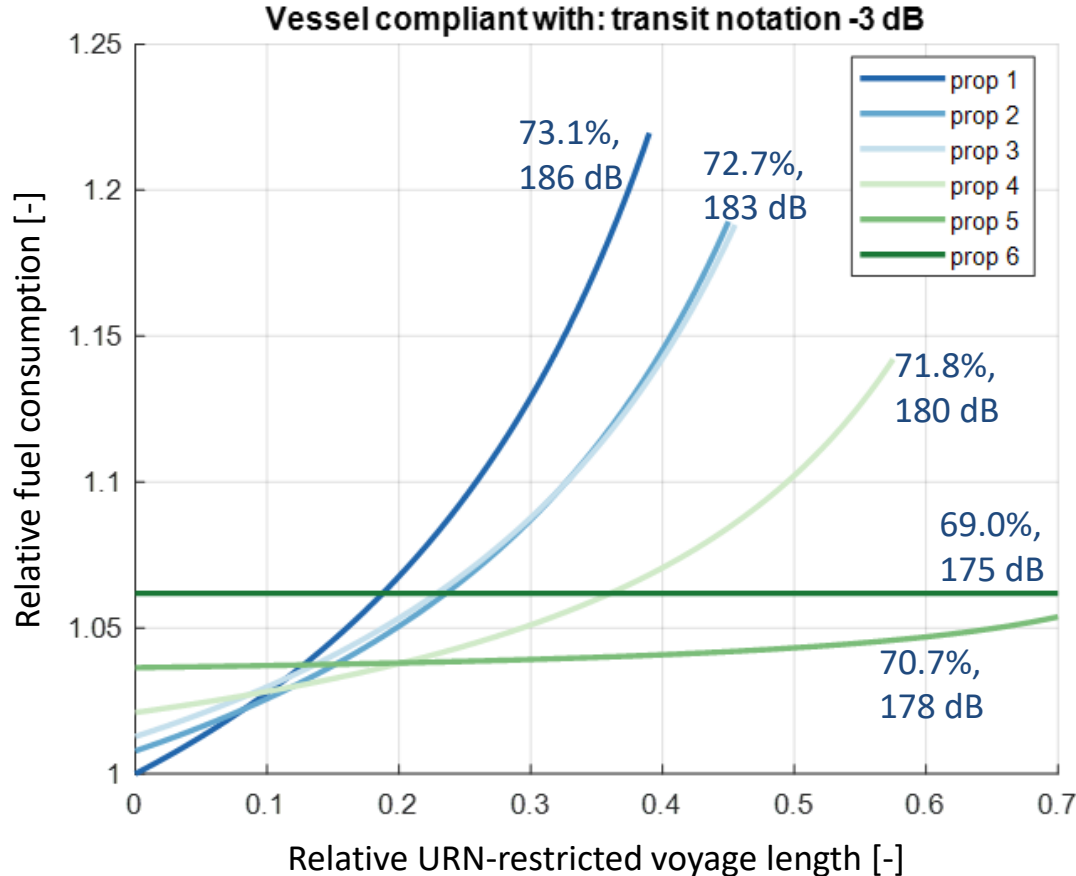


Most quiet (only tip vortex cavity)



18 kn

Fuel consumption vs URN-restricted voyage length



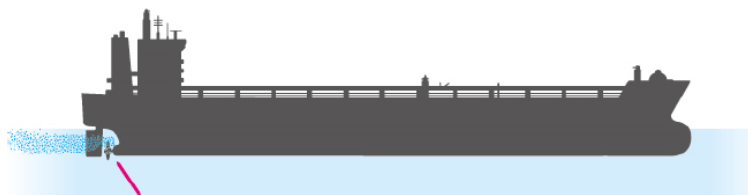
- Quieter propeller requires less fuel than high-efficiency propeller when URN limit applies >10 % of voyage

- **“Masker”**: air injection around the hull to reduce machinery noise



Masker belts positioned around the hull

- **“Prairie”**: air injection into propeller disc to reduce cavitation noise



Bubbles injected in propeller inflow

Potential gain in energy efficiency if combined with:

- Air lubrication system



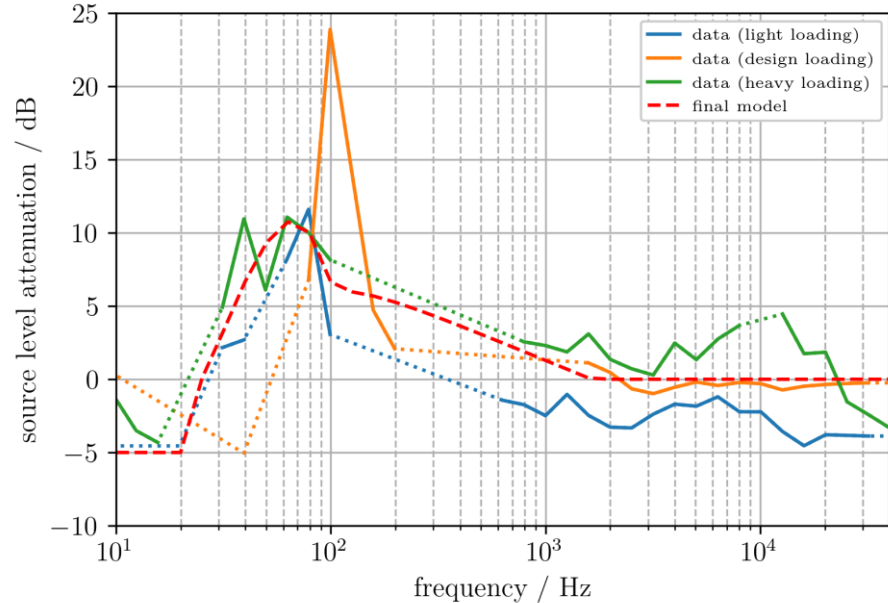
~5-10 % net fuel saving

- Pre-swirl fins and ducts



Becker Mewis duct twisted
(~3-8 % power saving)

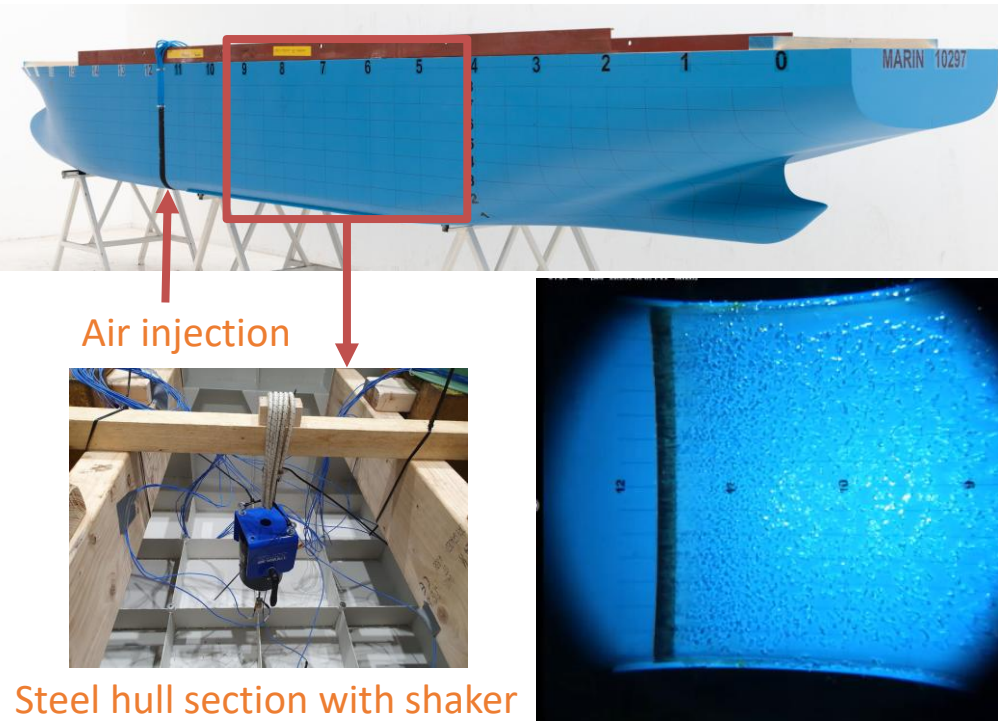
- Scale model tests performed in MARIN's Depressurised Wave Basin



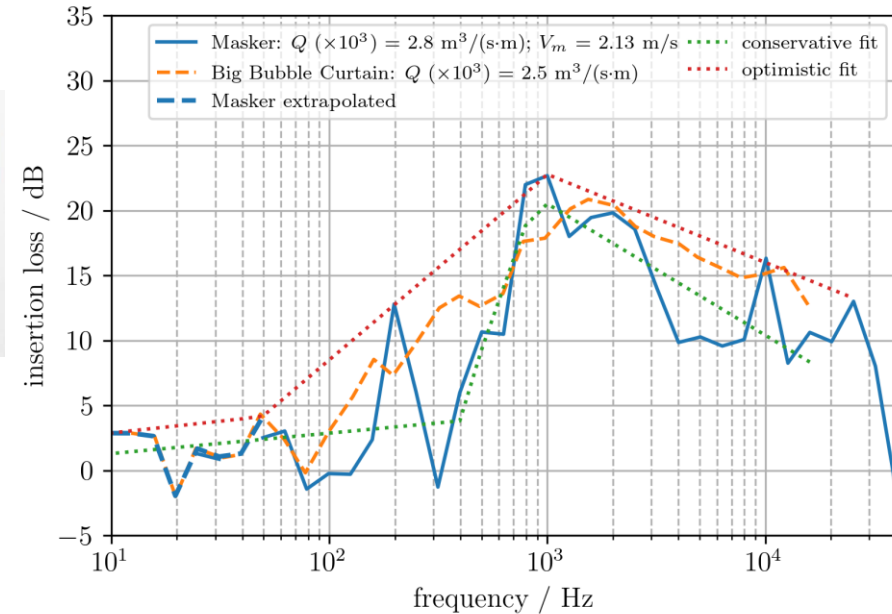
- Maximum reduction in source level varies between 10 dB and 24 dB
- Increase in source level at very low frequencies

Masker system: reduce machinery noise

- Scale model tests performed in MARIN's Depressurised Wave Basin



Air injection

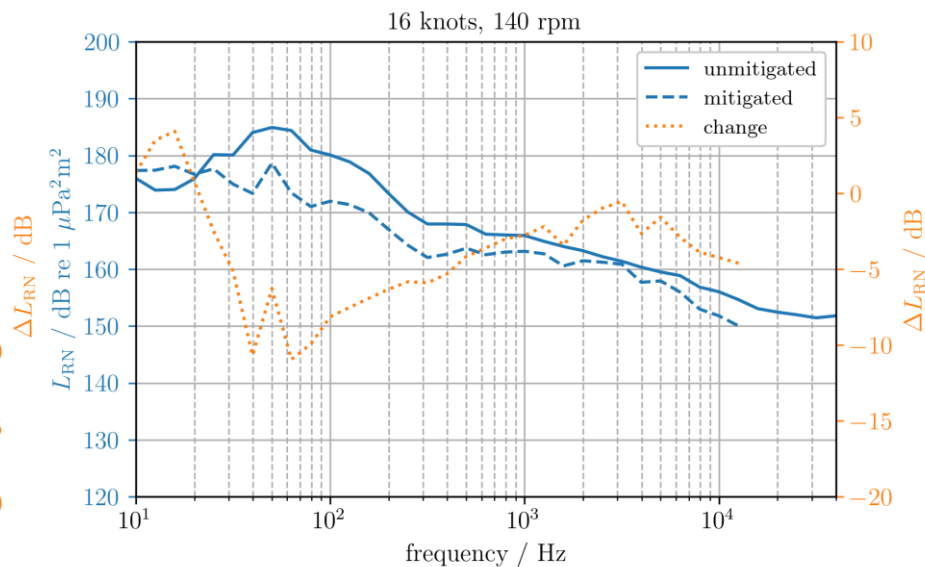
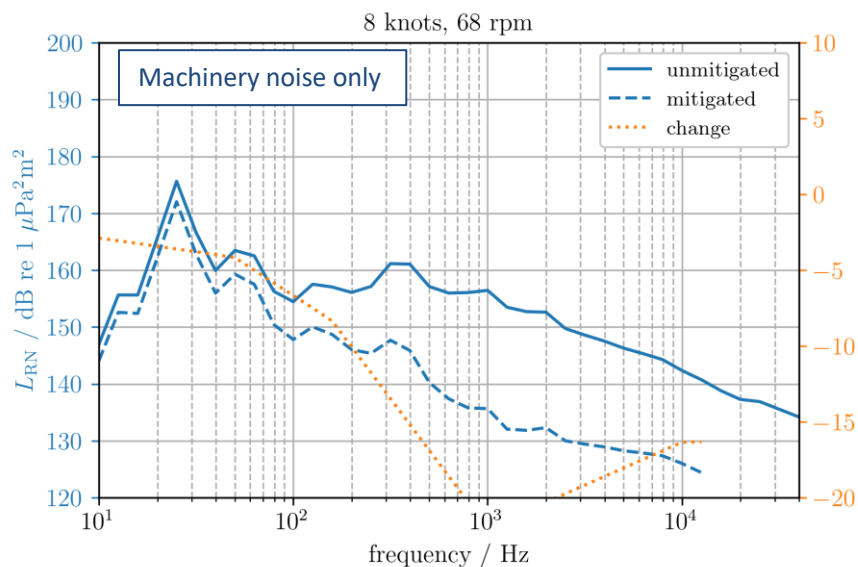


- Maximum reduction in received noise level >20 dB
- Larger reduction expected for 'closed' bubble layer

Application case: M/V Overseas Harriette



- 173 m bulk cargo ship, URN sea trial data, Arveson & Vendittis (2000), JASA107(1):
 - Change in radiated noise level between -10 and +3 dB at 16 knots
 - Overall reduction (summed over all frequencies) between 2 and 5 dB
- Combined effect on propulsive performance:
 - Air in propeller disc leads to reduction in thrust of 3-4 % and decrease in efficiency of 1-2 %
 - Additional power requirements are estimated to be modest



- Modern propeller design method shows trade-off between efficiency and URN for optimal propeller designs (1 % efficiency loss for 3-5 dB URN reduction)
 - Improvement in both can be obtained with respect to old designs
 - For URN restricted area, quieter propeller leads to reduction in total fuel consumption compared to slowing down, assuming fixed arrival time
 - **Future work:** combined optimisation of hull and propeller design
- Air injection leads to substantial reduction of machinery and propeller cavitation URN for a tanker:
 - Maximum URN reduction ~20 dB (Masker) and 10-24 dB (Prairie)
 - 1-2 % efficiency loss. Can be minimised through system design optimisation
 - Can be used to minimise efficiency loss in propeller design
 - **Future work:** combination with proven energy saving devices (air lubrication systems, pre-swirl stators)

- E.-J. Foeth, “Trade-off between URN and GHG in propeller design”, MARIN Report 77002-2-RD, March 2025: [77002-2-RD.pdf](#)
- T. Lloyd et al., “Mitigation of ship underwater radiated sound by propeller optimisation and bubble injection”, SATURN deliverable D4.3, January 2024: [Results | Saturn Project](#)
- T. Lloyd, F.H. Lafeber, J. Bosschers, “Ship URN mitigation by air injection: model-scale experiments and application to full-scale measurement data”, Eighth International Symposium on Marine Propulsors, smp’24, Berlin, Germany, March 2024: [Ship URN Mitigation by Air Injection: Model-scale Experiments and Application to Full-Scale Measurement Data](#)
- F. dos Santos et al., “Effect of speed reduction on underwater radiated noise of ships sailing on the Dutch North Sea”, MARIN Report 77002-3-RD, March 2025: [77002-3-RD.pdf](#)



Fleet-scale baselining

Decision-making support

Voluntary
certification



Policy input

Collective
Action for
Lower
Marine noise



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