



JOB MEMO

TO: Justin Morgan
COMPANY: Glosten
FROM: Ray Fischer
DATE: Dec. 7, 2004
SUBJECT: **AARV - Preliminary Sonar Self-Noise Analysis**
CC:

0.0 EXECUTIVE SUMMARY

This report addresses some of the preliminary information relative to the platform noise¹ (or sonar self-noise²) evaluation for the Alaska Regional Research Vessel (ARRV). The sonar system of concern is Kongsberg EM 30, operating at 30,000 Hz. The limiting depth for this system is 5,000m. The system is currently located at approximately Frame 40 on a deployable centerboard. The centerboard is forward of the gensets (approximately 7m) and within 3 m of various pumps and boiler equipment.

NCE is suggesting a goal of 44 dB// μ Pa/Hz, for the vessel underway at 12 knots. This is based on operating in Sea State 4.

The propeller design is not fixed at this point. Given the planned treatment of the gensets, at 12 knots the platform noise would likely be dominated by propeller (Z-drive) induced noise. Therefore, NCE has just reverse engineered a “radiated goal” for the propellers at this point.

Currently all machinery, including pumps and piping, within 5m of the sonar centerboard should be isolation mounted. The gensets are very close to the sonar and the path from the gensets forward may require additional treatment, such as damping.

¹ Platform noise is the noise induced by the vessel's machinery and propulsors as measured by an omni-directional hydrophone placed at the location of the sonar system.

² Sonar self-noise is similar to 'platform' noise except that omni-directional hydrophone is replaced by the actual sonar system and accounts for sonar system properties such as array gain, signal-to-noise ratio, and directivity.

1.0 INTRODUCTION

Estimates of the ship's platform noise are presented, which is the level measured by an omni-directional hydrophone placed at the location of the sonar receiver array. The platform noise estimate does not account for sonar system array gains, sensitivity or system processing.

Operation at 12 knots is assumed. Operation of the bow thruster is not considered. Radiation near-field (non-propagating) effects are excluded. Propeller and machinery induced noise transmitted over the hull grazing path is typically of primary concern. Based on previous experience [1-4], the internal airborne noise in a compartment does not contribute significantly to the platform noise. Unless very high airborne noise is expected in tanks or compartments local to the sonar, this path can and is generally be neglected. On most vessels, structureborne noise transmitted along the tank top to the sonar location is less important than the hull grazing, fluidborne path. The most critical path generally involves direct radiation into the water near the machinery spaces and transmission at hull grazing.

Flow noise generated by the sonar dome or cover plate is the responsibility of each sonar vendor and is assumed to not be a factor.

The ship's mission is to conduct general-purpose oceanographic research. The principal characteristics of this steel hulled vessel are as follows:

TABLE 1-1: SHIP PRINCIPAL CHARACTERISTICS

Length Overall	236 ft
Waterline Length	210 ft
Beam	52 ft
Full Load Draft	28 ft
Displacement	3114 LT

The ship is driven by a diesel/electric propulsion system, with DC motors driving fixed pitch Z-drive propulsors. Critical equipment is listed in Table 1-2.

TABLE 1-2: EQUIPMENT PARAMETERS

(3) MTU 16V4000 Prop. Diesels, 1800 kW @1800 rpm
(1) MTU 8V4000 Prop. Diesel, 900 kW @1800
(2) Schottel type SRP 3030 FP

The hull vibration levels are taken from the Designer Noise prediction carried out for the radiated noise analysis [5]. Empirical methods were used to predict the coupling between the predicted hull vibration levels and the underwater radiates noise.

2.0 SELF-NOISE ANALYSIS

NCE suggests the allowable platform noise be set equal to Sea State 4 noise. This is equivalent to 44 dB//1 μ Pa/ \sqrt Hz at 30,000. This level tracks with levels set for other vessels such as AGOR 26.

The analysis traces two sources. The sources are the isolation mounted propulsion gensets and the propellers. The path is 'hull grazing', which consists of the noise from the source propagating along the hull to the sonars.

The predicted hull vibration levels are taken from the Designer Noise prediction utilized to predict the far-field radiated noise [5].

3.0 SOURCE LEVELS

The above mount propulsion diesel vibration data is taken from vendor provided measurements. These measurements only extend to 8,000 Hz. The vibration above 8 kHz is assumed to fall off at 6 dB per octave.

TABLE 3-1: PROPULSION DIESEL FOUNDATION VIBRATION LEVELS

OB frequency, Hz	30,000
MTU. Diesel	116

Three diesels are assumed to be operating.

No propeller information is available at this point so not source levels are predicted for the propulsors.

4.0 PLATFORM NOISE ESTIMATES

The two possible contributors are the propulsion diesels and propellers. The noise is transmitted over the hull grazing path. This model is addressed in the following sections.

4.1 PROPELLER INDUCED PLATFORM NOISE

The propeller-radiated noise is attenuated as it is transmitted forward to the sonar location. The propeller-induced noise is typically attenuated by 32 log (d/d₀) along

the hull grazing path [1]. Assuming a distance of 32.5 m between the array and the propeller, this transmission loss would amount to 48 dB.

The propeller noise is also attenuated by any barrier effect associated with the hull. For this vessel, the propeller is located above the baseline and behind the hull; thus, the hull provides an effective barrier. However, to be conservative, a value of only 3 dB has been assumed for this barrier. Using techniques presented in [6], the losses could be as high as 10 dB.

At 30,000 Hz, the allowable propeller source level (for one propeller) transmitted along the hull grazing path is:

$$L_{\text{prop grazing}} = 44 + 48 + 3 - 3 = 92 \text{ dB re } 1\mu\text{Pa/Hz } 30,000 \text{ Hz}$$

The goal for the propeller would be on the order of 92 dB re 1 μ Pa/Hz 30,000 Hz.

4.2 MACHINERY INDUCED PLATFORM NOISE

Machinery induced platform noise can be transmitted over three paths. Usually the dominant path is vibration transmitted directly to the hull in the area of the machinery and radiated locally. Secondary paths are 1) structureborne vibrations transmitted forward along the hull to the sonar and re-radiation from the hull next to the sonar and 2) airborne noise from machinery spaces transmitted into the water and to the sonar along the hull grazing path. The later two are insignificant compared to the first path listed. SNAME methods were used to determine the vibration levels on the hull.

Vibrations are transmitted from the feet of machinery, through the mounts and to the foundation and ultimately to the hull plate below the foundation. These vibrations radiate into the fluid in the vicinity of the machinery. The radiated noise, adjusted by the directivity pattern of the ribbed hull, is transmitted along hull grazing to the sonar.

This model accounts for vibration transmitted from the foundation down to the hull plating in the machinery space. The coupling of the hull vibration and water is provided by the radiation transfer function. This radiation transfer function accounts for frame size and spacing, plates thickness, and radiation pattern to hull grazing. The received noise at the sonar is attenuated by hull grazing effects.

Again Designer Noise does not predict beyond 8 kHz. ABased on past experience, the hull vibration is expected to decrease at 5 dB/octave. The hull vibration levels local to the propulsion diesel as predicted by Design Noise and resulting platform noise are as follows:

Genset Induced Platform Noise			Comment
Hull vibration	83.0	La dB re 1 micorG, 30 k TOB	93 dB predicted by designer noise for 8 k Hz
Unit rad Xfer fn	40.0	Chandi calc and spirit of texas	
10 log 4 pi	-11.0	dB	
rad area	15.0	m ²	
area adj	11.8	dB	
U/W source lvl	123.8	Lp dB re 1 microPa, TOB	
hull grazing dist	7.0	d, m	
hull grazing loss	-21.1	25 log (d)	use value between 20 and 32
Platform noise, TOB	102.6	Lp dB re 1 microPa, TOB	
Platform noise SL	64.2	Lp dB re 1 microPa/Hz	
Goal	44		
Delta	20.2		

The machinery-induced noise is attenuated by $25 \log (d/d_0)$ along the hull grazing path forward and down to the sonar, where 'd' is the distance from the radiating area of interest to the array.

The predicted level induced by the gensets is above the goal of 44 dB//microPa/Hz. However this prediction does not account for any baffling between the hull and the lowered centerboard. This baffling effect would be significant at this frequency. Pending additional analysis, damping may be need on the hull plate to reduce the contribution of the gensets.

Given the potential problem with the genset induced noise and the location of multiple pumps, compressors and a boiler in the immediate vicinity of the centerboard it will necessary to isolation mount this equipment and ensure any piping in the area is resiliently supported, especially steam piping.

5.0 SUMMARY

The sonar self-noise goals may be exceeded due to noise transmitted from the gensets. This path will require additional review as the design progresses.

REFERENCES

1. Dan Nelson, Anthony Galaitsis, Rafal Mlawski, & Dave Whitemore, "Diagnostic Tests on SPIRIT OF TEXAS In Support of T-AGS 39/40 Sonar Self-Noise Analysis,' BBN Report No. 6441, Feb. 1987.
2. Larry E. Wittig and Raymond W. Fischer, "Noise Predictions at the T-AGS SASS Sonar - Alternative Mounting System Analysis," BBN TM 873, April 1985.
3. Dan Nelson & Dwight Davis, " SASS Sonar System Performance Prediction for T-AGS 39," BBN Report 6872, June 1988.
4. Ray Fischer, "SEA BEAM System Preliminary Performance Prediction - Antarctic Research Vessel," AARC Job Memo, April 16, 1990.
5. J. Spense, R. Fischer, L. Boroditsky. "ARRV Airborne Noise and Underwater Radiated Noise Prediction Report," NCE TM 2004-038, Oct. 2004.
6. Kurt Yankaskas and Tom Slotwinski, "Acoustic Characteristics of T-AGOS 19 Class SWATH Ships, Naval Engineering Journal, 107(3), May 1995.