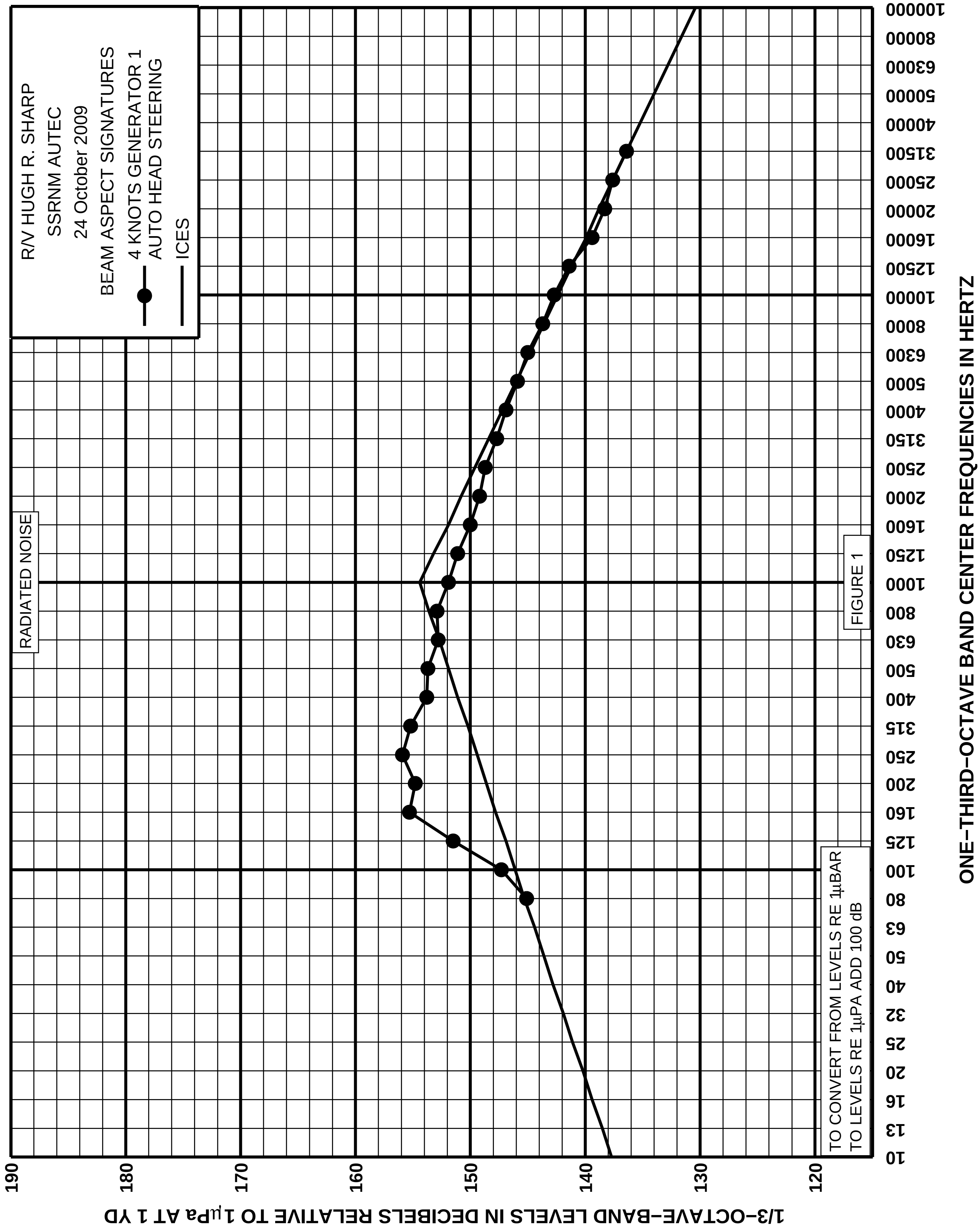
R/V HUGH R. SHARP
SURFACE SHIP RADIATED NOISE MEASUREMENT (SSRNM)
RANGED AT ATLANTIC UNDERSEA TEST AND EVALUATION CENTER
24 OCTOBER 2009

An underwater acoustical trial was conducted on R/V *Hugh R. Sharp* on 23/24 October 2009 at the Atlantic Undersea Test and Evaluation Center (AUTEC) in the Tongue of the Ocean, Bahamas. The testing used the measurement processes of the Surface Ship Radiated Noise Measurement (SSRNM) program with some modification in line with a draft of Grade B of AMERICAN NATIONAL STANDARD, Quantities and Procedures for Description and Measurement of Underwater Sound from Ships. Thirty two test runs were conducted at speeds from DIW to 9 knots past a vertical string of hydrophones suspended from the stern of the R/V *Ranger*. Beam aspect data used an integration window covering +/- 30 degrees about CPA of the dominant noise source location. A nominal 180-yard CPA was used for the beam aspect runs. Ship speed was set by using a specified shaft rpm. Data were not corrected for any image interference effects. The attached Testing Information Appendix provides informational characteristics from the testing.

Weather conditions were marginal for measuring a quiet ship. Background noise limited the frequency range to approximately 100 Hz to 32 kHz that ship noise could be extracted from the ambient noise conditions. Wind speed was 6 to 18 knots with seas 2 to 5 feet. Background noise in the 1000 Hz one-third octave band ranged from 82 to 89 dB. The test site was free from shipping interference for most of the evaluation.

Two methods of steering the ship were used to attain a straight line course depending on ship speed. At 6 knots and slower speeds auto heading was used. This method provided satisfactory control at slow speeds. In this mode the Z drive thrust of each unit was angled towards the center line of the ship at various degrees to keep the ship head automatically pointing at the desired angle. Generally at speeds of 6 knots the Z drive thrust was angled inboard on each shaft by 30 degrees while at 4 knots the angle increased to approximately 45 degrees. At higher speeds auto pilot was used. This method kept the Z drive thrust parallel for both units. Propeller cavitation was detected for the entire run when in auto heading mode with cavitation "burst" increases as thrust headings changed, however in auto pilot mode steady state propeller cavitation was lower with significantly evident cavitations bursts when ever there was a course correction to keep the ship on the desired track (embedded recording at 8 knots in auto pilot). Attempts were made to operate the ship in auto pilot at speeds below 7 knots, however steerage was insufficient to maintain the ship on a straight line. Likewise an attempt was made to utilize asynchronous (one Z drive thrusting dead ahead and the other providing steerage) auto pilot or auto heading however the wind and seas prevented this lineup from maintaining a straight line course.

Figures 1 through 10 provide 1/3-octave band measurements of ship radiated noise at the various conditions measured compared to a recommended noise limit derived from that presented in the International Council for the Exploration of the Sea (ICES) report No. 209 of May 1995. Figure 11 is a record of the background noise measurements taken during the acoustic trial. Table 1 provides the tonals detected at the various speeds. Source identification was made based on the character of the tone and mechanical description of the ship machinery. Figures 12 through 14 provide LOFARgram presentations of selected measurement conditions. This presentation shows tones as dark lines at the frequency detected as a function of time. The most significant tonal components were provided by the upper and lower drive train gear mesh. The imbedded recording demonstrates the "whine" at 7 knots.


R/V HUGH R. SHARP
SSRNM AUTEC
24 October 2009
BEAM ASPECT SIGNATURES
4 KNOTS GENERATOR 1
AUTO HEAD STEERING
ICES
RADIATED NOISE
FIGURE 1
TO CONVERT FROM LEVELS RE 1µBAR
TO LEVELS RE 1µPA ADD 100 dB
ONE–THIRD–OCTAVE BAND CENTER FREQUENCIES IN HERTZ
1/3–OCTAVE–BAND LEVELS IN DECIBELS RELATIVE TO 1µPa AT 1 YD
10 13 16 20 25 32 40 50 63 80 100 125 160 200 250 315 400 500 630 800 1000 1250 1600 2000 2500 3150 4000 5000 6300 8000 10000 12500 16000 20000 25000 31500 40000 50000 63000 80000 100000
120 130 140 150 160 170 180 190

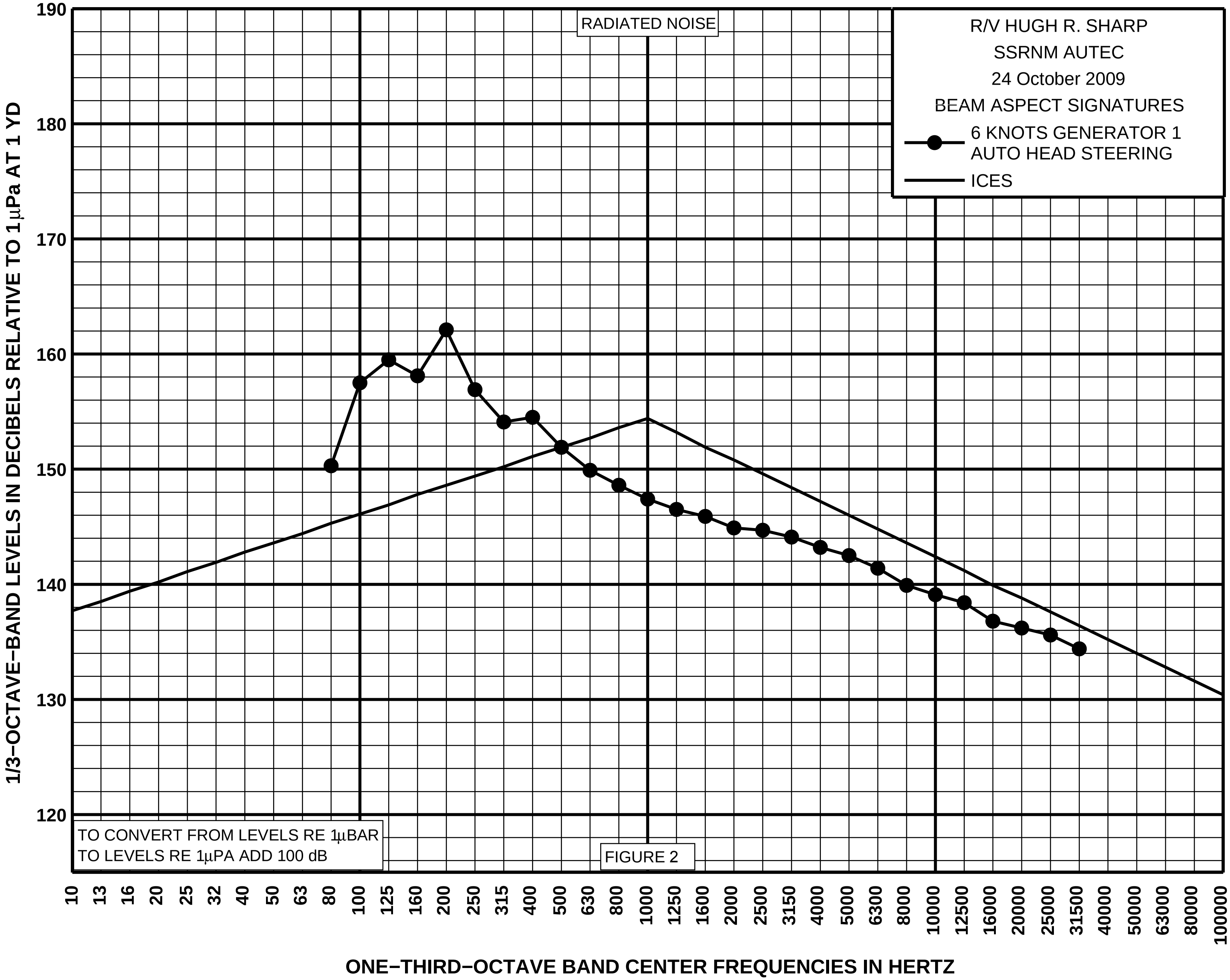
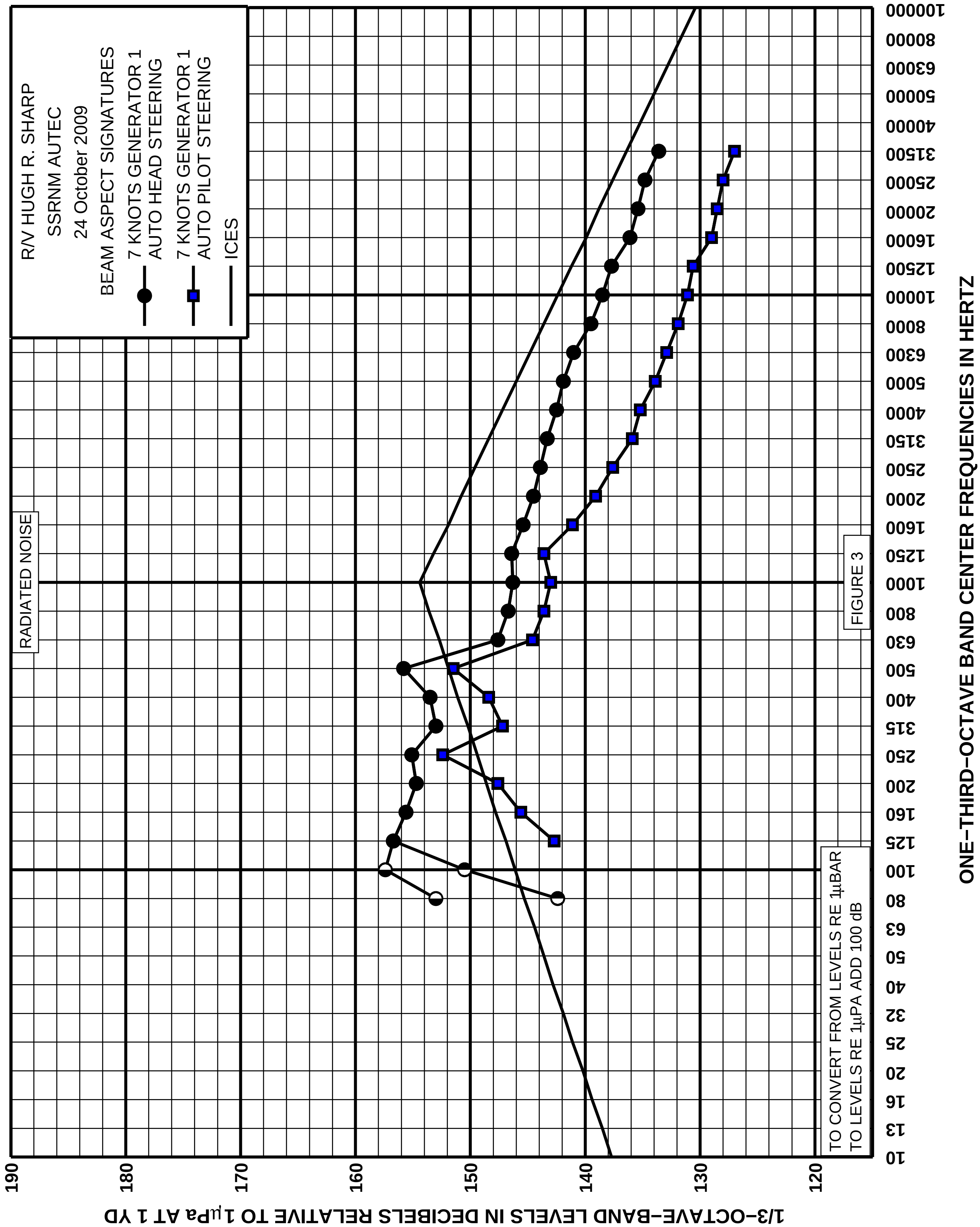
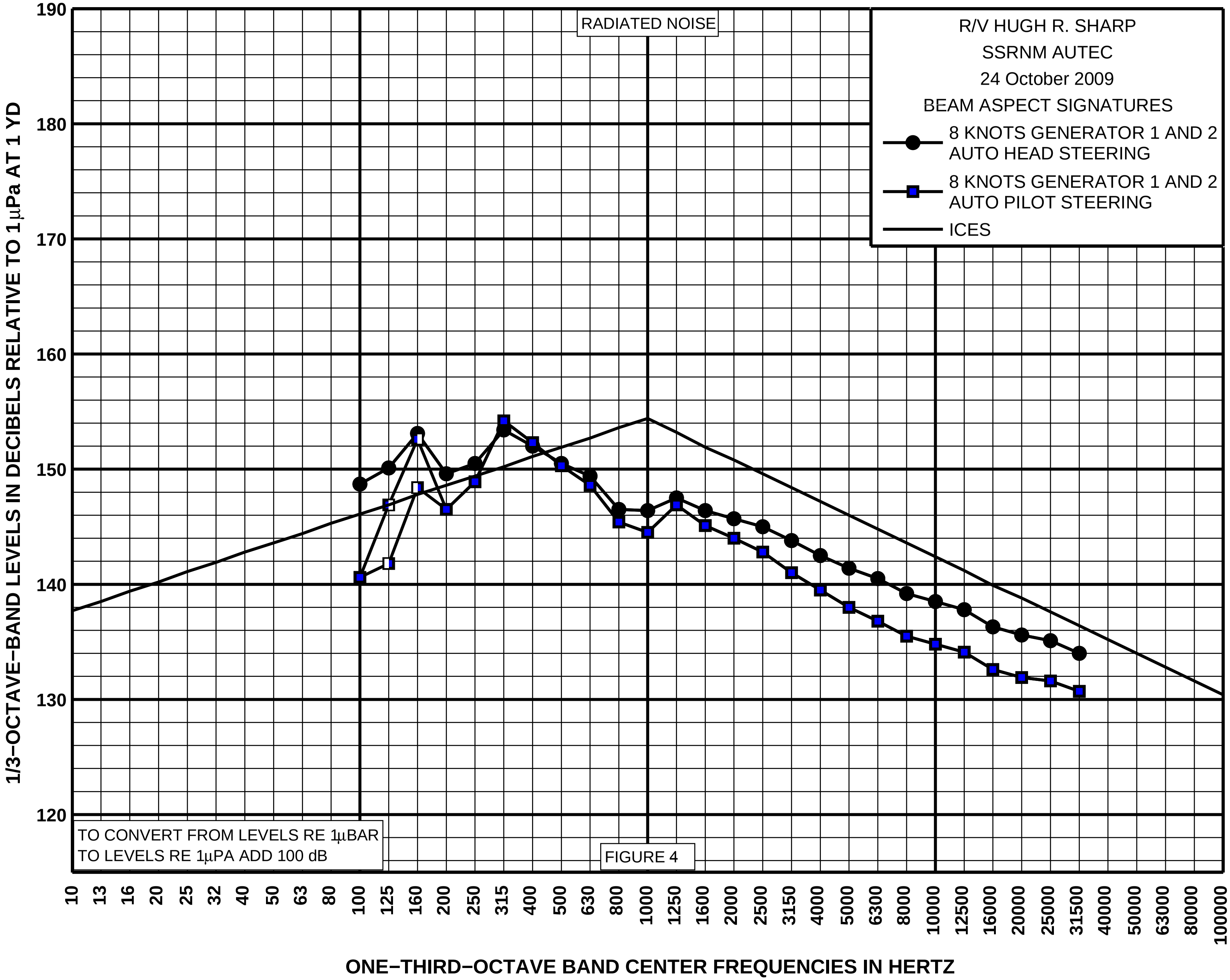
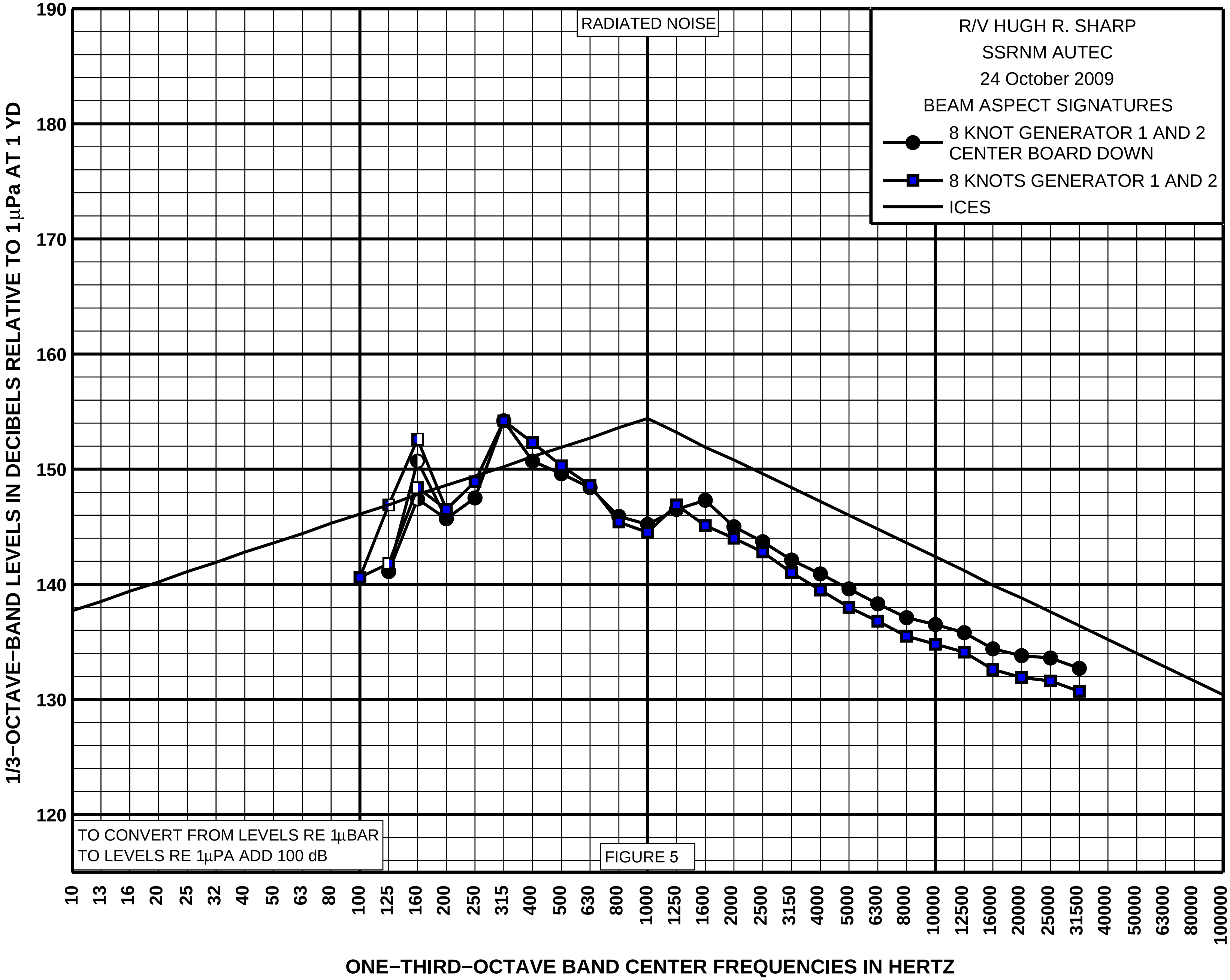

RADIATED NOISE
R/V HUGH R. SHARP
SSRNM AUTEC
24 October 2009
BEAM ASPECT SIGNATURES
6 KNOTS GENERATOR 1
AUTO HEAD STEERING
ICES
1/3−OCTAVE−BAND LEVELS IN DECIBELS RELATIVE TO 1 µPa AT 1 YD
190
180
170
160
150
140
130
120
10 13 16 20 25 32 40 50 63 80 100 125 160 200 250 315 400 500 630 800 1000 1250 1600 2000 2500 3150 4000 5000 6300 8000 10000 12500 16000 20000 25000 31500 40000 50000 63000 80000 100000
ONE−THIRD−OCTAVE BAND CENTER FREQUENCIES IN HERTZ
TO CONVERT FROM LEVELS RE 1µBAR
TO LEVELS RE 1µPA ADD 100 dB

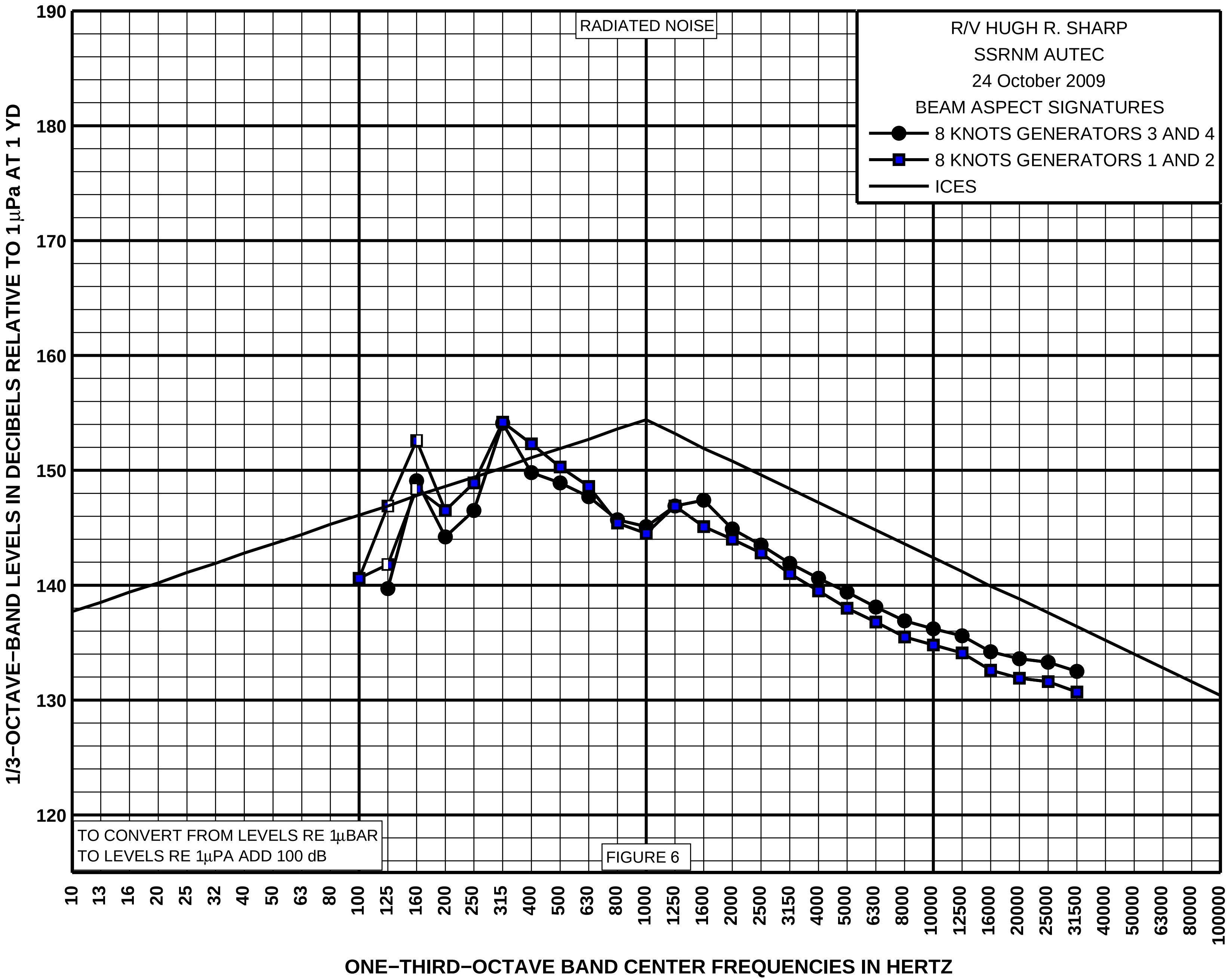
FIGURE 2

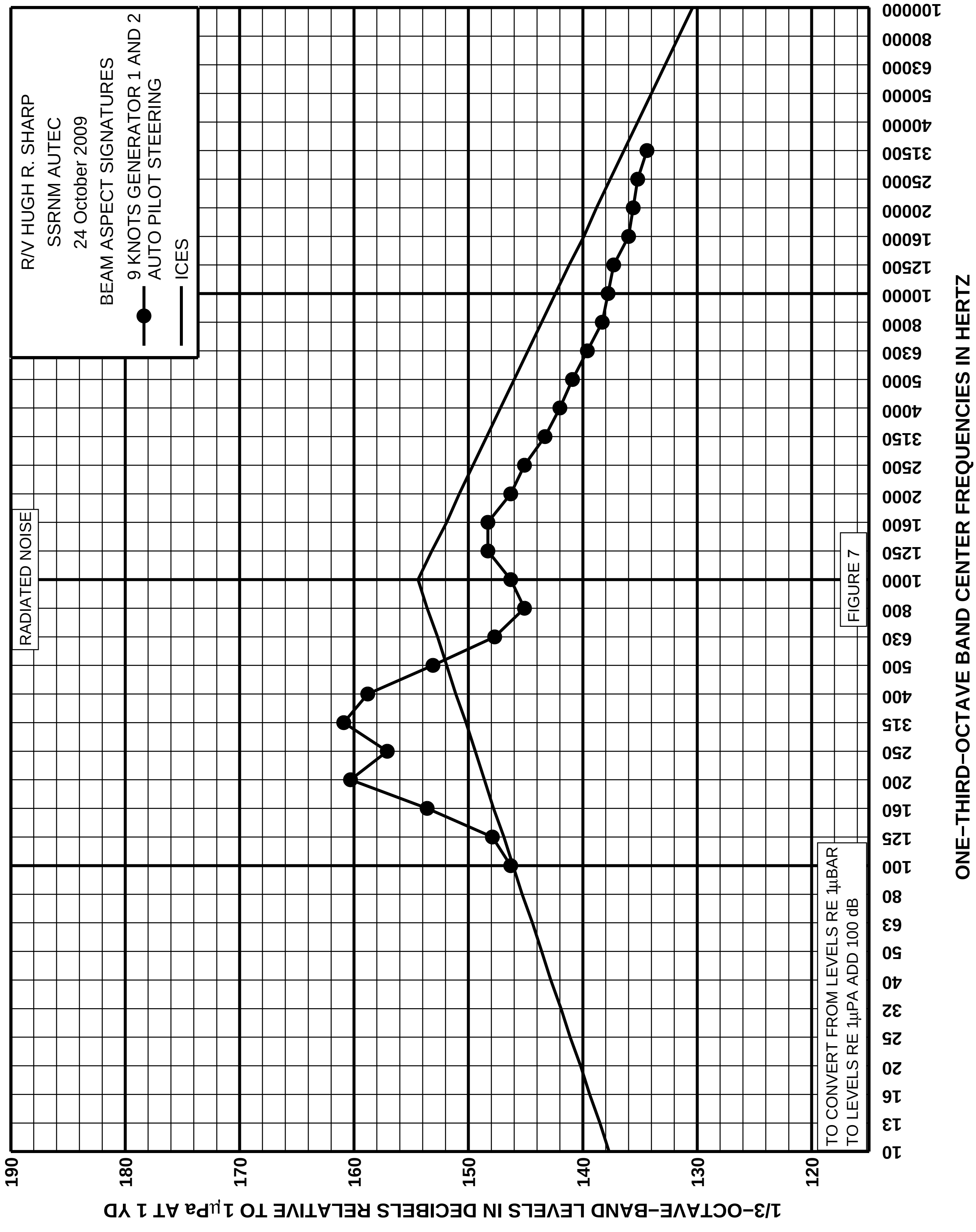


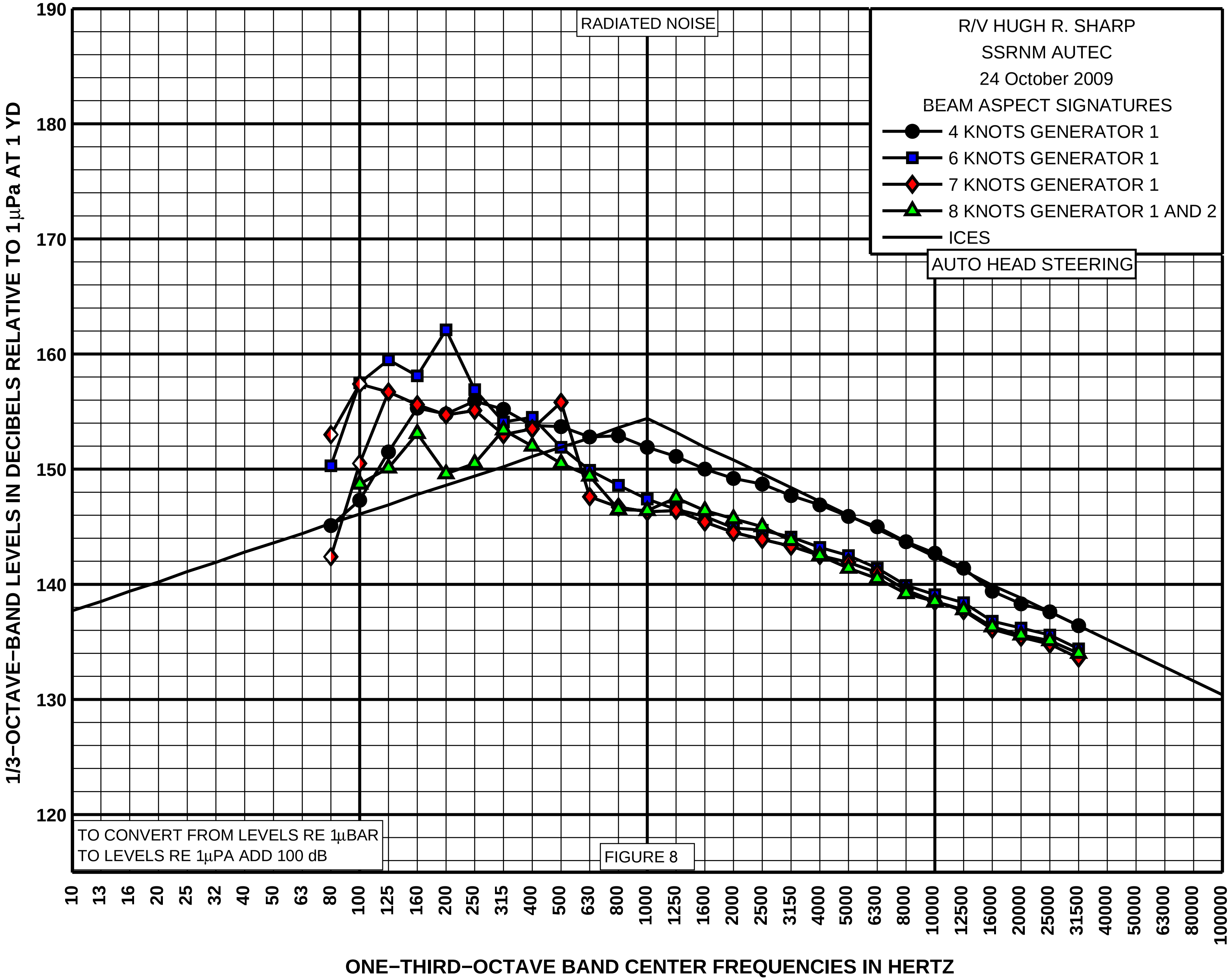
R/V HUGH R. SHARP
SSRNM AUTEC
24 October 2009
BEAM ASPECT SIGNATURES
7 KNOTS GENERATOR 1 AUTO HEAD STEERING
7 KNOTS GENERATOR 1 AUTO PILOT STEERING
ICES
RADIATED NOISE
FIGURE 3
TO CONVERT FROM LEVELS RE 1μBAR TO LEVELS RE 1μPA ADD 100 dB
1/3–OCTAVE–BAND LEVELS IN DECIBELS RELATIVE TO 1μPa AT 1 YD
ONE–THIRD–OCTAVE BAND CENTER FREQUENCIES IN HERTZ
190 180 170 160 150 140 130 120
10 13 16 20 25 32 40 50 63 80 100 125 160 200 250 315 400 500 630 800 1000 1250 1600 2000 2500 3150 4000 5000 6300 8000 10000 12500 16000 20000 25000 31500 40000 50000 63000 80000 100000

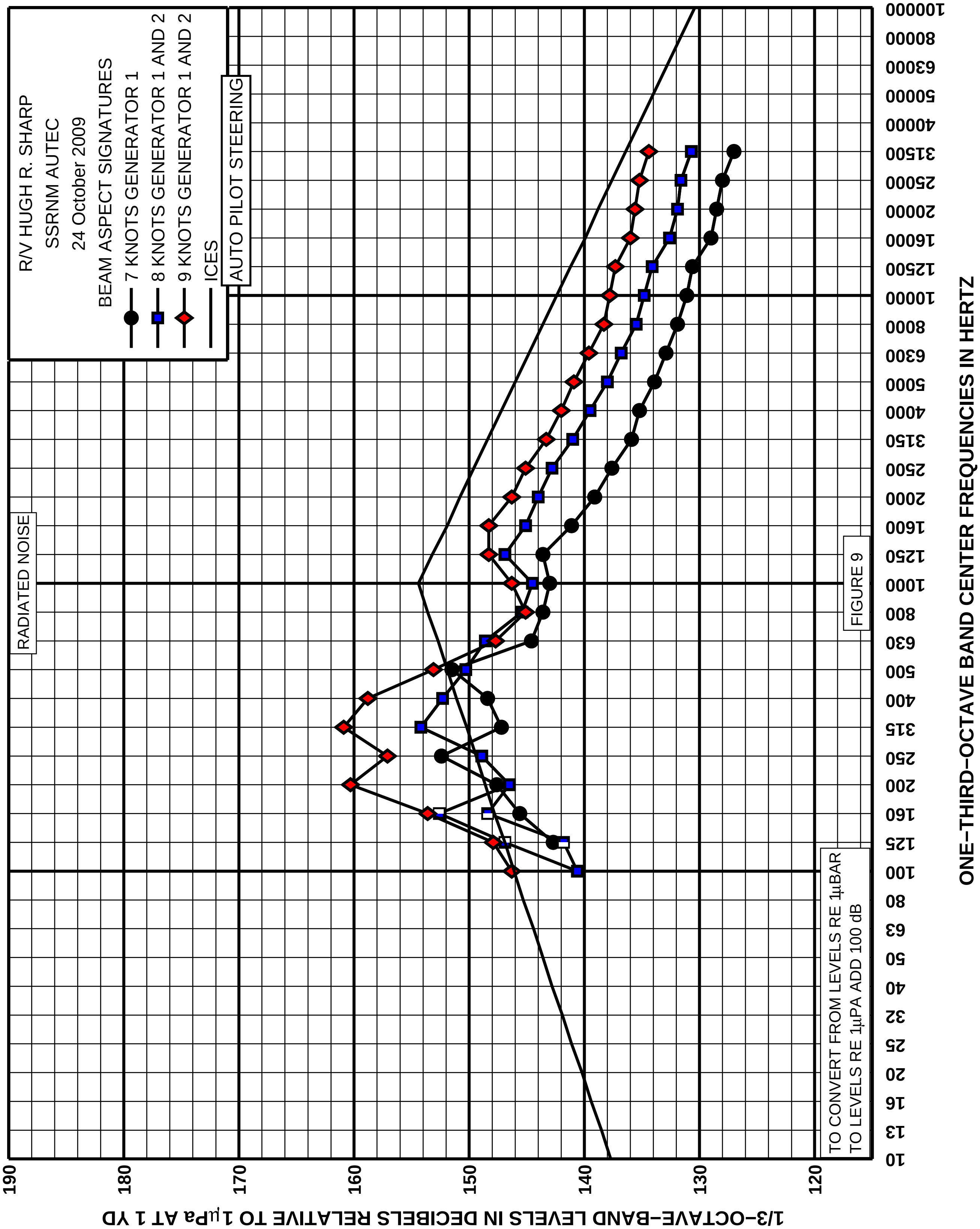

RADIATED NOISE
R/V HUGH R. SHARP
SSRNM AUTEC
24 October 2009
BEAM ASPECT SIGNATURES
8 KNOTS GENERATOR 1 AND 2 AUTO HEAD STEERING
8 KNOTS GENERATOR 1 AND 2 AUTO PILOT STEERING
ICES
1/3−OCTAVE−BAND LEVELS IN DECIBELS RELATIVE TO 1 μPa AT 1 YD
190
180
170
160
150
140
130
120
TO CONVERT FROM LEVELS RE 1μBAR
TO LEVELS RE 1μPA ADD 100 dB
FIGURE 4
10 13 16 20 25 32 40 50 63 80 100 125 160 200 250 315 400 500 630 800 1000 1250 1600 2000 2500 3150 4000 5000 6300 8000 10000 12500 16000 20000 25000 31500 40000 50000 63000 80000 100000
ONE−THIRD−OCTAVE BAND CENTER FREQUENCIES IN HERTZ


RADIATED NOISE
R/V HUGH R. SHARP
SSRNM AUTEC
24 October 2009
BEAM ASPECT SIGNATURES
8 KNOT GENERATOR 1 AND 2 CENTER BOARD DOWN
8 KNOTS GENERATOR 1 AND 2
ICES
1/3−OCTAVE−BAND LEVELS IN DECIBELS RELATIVE TO 1 μPa AT 1 YD
190
180
170
160
150
140
130
120
10 13 16 20 25 32 40 50 63 80 100 125 160 200 250 315 400 500 630 800 1000 1250 1600 2000 2500 3150 4000 5000 6300 8000 10000 12500 16000 20000 25000 31500 40000 50000 63000 80000 100000
ONE−THIRD−OCTAVE BAND CENTER FREQUENCIES IN HERTZ
TO CONVERT FROM LEVELS RE 1μBAR TO LEVELS RE 1μPA ADD 100 dB
FIGURE 5


RADIATED NOISE
R/V HUGH R. SHARP
SSRNM AUTEC
24 October 2009
BEAM ASPECT SIGNATURES
8 KNOTS GENERATORS 3 AND 4
8 KNOTS GENERATORS 1 AND 2
ICES
1/3–OCTAVE–BAND LEVELS IN DECIBELS RELATIVE TO 1 µPa AT 1 YD
190
180
170
160
150
140
130
120
TO CONVERT FROM LEVELS RE 1µBAR
TO LEVELS RE 1µPA ADD 100 dB
FIGURE 6
10 13 16 20 25 32 40 50 63 80 100 125 160 200 250 315 400 500 630 800 1000 1250 1600 2000 2500 3150 4000 5000 6300 8000 10000 12500 16000 20000 25000 31500 40000 50000 63000 80000 100000
ONE–THIRD–OCTAVE BAND CENTER FREQUENCIES IN HERTZ


R/V HUGH R. SHARP
SSRNM AUTEC
24 October 2009
BEAM ASPECT SIGNATURES
9 KNOTS GENERATOR 1 AND 2
AUTO PILOT STEERING
ICES
RADIATED NOISE
FIGURE 7
TO CONVERT FROM LEVELS RE 1μBAR
TO LEVELS RE 1μPA ADD 100 dB
ONE–THIRD–OCTAVE BAND CENTER FREQUENCIES IN HERTZ
1/3–OCTAVE–BAND LEVELS IN DECIBELS RELATIVE TO 1 μPa AT 1 YD
10
13
16
20
25
32
40
50
63
80
100
125
160
200
250
315
400
500
630
800
1000
1250
1600
2000
2500
3150
4000
5000
6300
8000
10000
12500
16000
20000
25000
31500
40000
50000
63000
80000
100000
120
130
140
150
160
170
180
190


RADIATED NOISE
R/V HUGH R. SHARP
SSRNM AUTEC
24 October 2009
BEAM ASPECT SIGNATURES
4 KNOTS GENERATOR 1
6 KNOTS GENERATOR 1
7 KNOTS GENERATOR 1
8 KNOTS GENERATOR 1 AND 2
ICES
AUTO HEAD STEERING
TO CONVERT FROM LEVELS RE 1μBAR
TO LEVELS RE 1μPA ADD 100 dB
FIGURE 8
1/3−OCTAVE−BAND LEVELS IN DECIBELS RELATIVE TO 1μPa AT 1 YD
ONE−THIRD−OCTAVE BAND CENTER FREQUENCIES IN HERTZ
190
180
170
160
150
140
130
120
10
13
16
20
25
32
40
50
63
80
100
125
160
200
250
315
400
500
630
800
1000
1250
1600
2000
2500
3150
4000
5000
6300
8000
10000
12500
16000
20000
25000
31500
40000
50000
63000
80000
100000


R/V HUGH R. SHARP
SSRNM AUTEC
24 October 2009
BEAM ASPECT SIGNATURES
7 KNOTS GENERATOR 1
8 KNOTS GENERATOR 1 AND 2
9 KNOTS GENERATOR 1 AND 2
ICES
AUTO PILOT STEERING
RADIATED NOISE
FIGURE 9
TO CONVERT FROM LEVELS RE 1μBAR
TO LEVELS RE 1μPA ADD 100 dB
ONE–THIRD–OCTAVE BAND CENTER FREQUENCIES IN HERTZ
1/3–OCTAVE–BAND LEVELS IN DECIBELS RELATIVE TO 1μPa AT 1 YD
10 13 16 20 25 32 40 50 63 80 100 125 160 200 250 315 400 500 630 800 1000 1250 1600 2000 2500 3150 4000 5000 6300 8000 10000 12500 16000 20000 25000 31500 40000 50000 63000 80000 100000
120 130 140 150 160 170 180 190

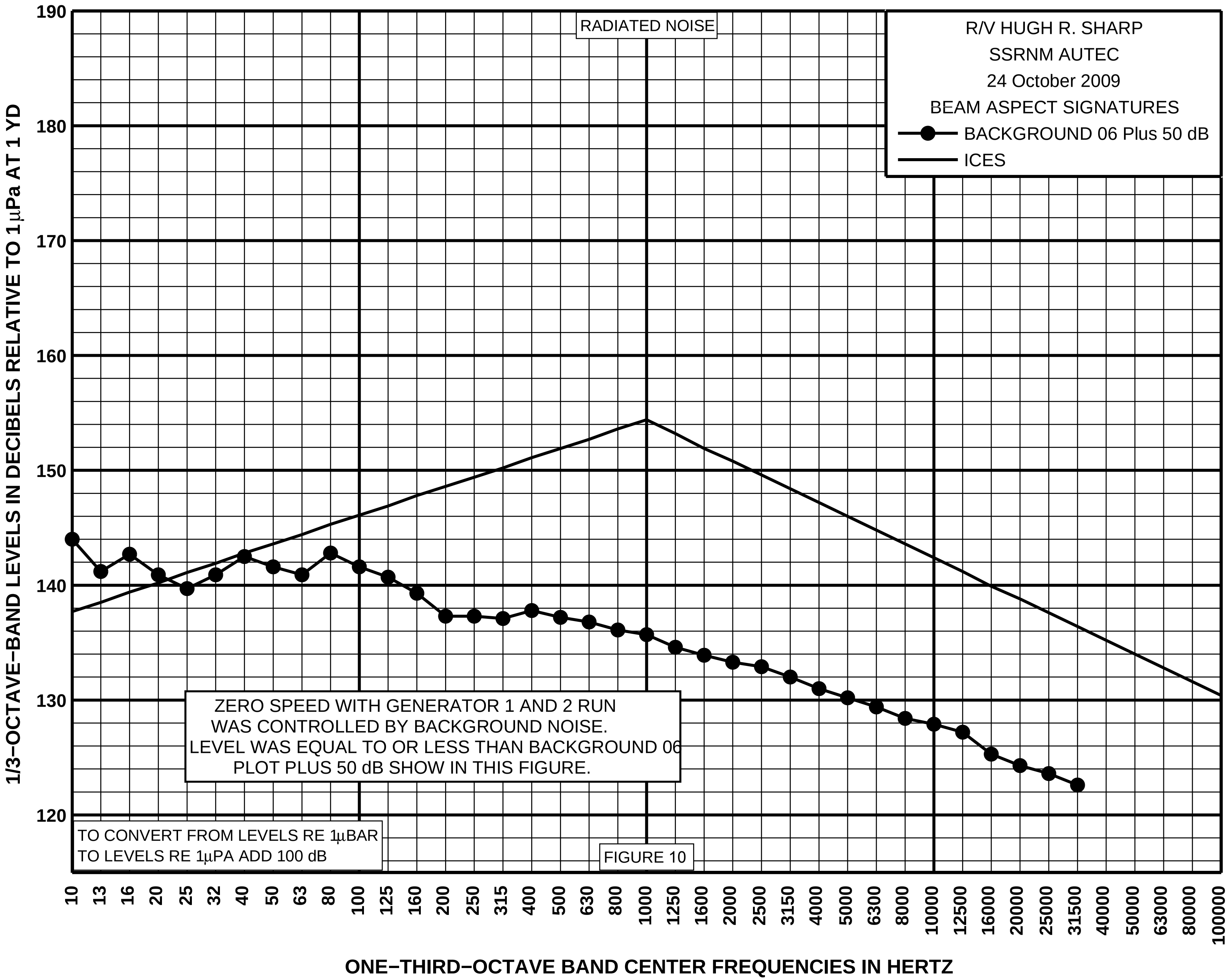

RADIATED NOISE
R/V HUGH R. SHARP
SSRNM AUTEC
24 October 2009
BEAM ASPECT SIGNATURES
BACKGROUND 06 Plus 50 dB
ICES
ZERO SPEED WITH GENERATOR 1 AND 2 RUN
WAS CONTROLLED BY BACKGROUND NOISE.
LEVEL WAS EQUAL TO OR LESS THAN BACKGROUND 06
PLOT PLUS 50 dB SHOW IN THIS FIGURE.
TO CONVERT FROM LEVELS RE 1µBAR
TO LEVELS RE 1µPA ADD 100 dB
1/3−OCTAVE−BAND LEVELS IN DECIBELS RELATIVE TO 1µPa AT 1 YD
190
180
170
160
150
140
130
120
10 13 16 20 25 32 40 50 63 80 100 125 160 200 250 315 400 500 630 800 1000 1250 1600 2000 2500 3150 4000 5000 6300 8000 10000 12500 16000 20000 25000 31500 40000 50000 63000 80000 100000
ONE−THIRD−OCTAVE BAND CENTER FREQUENCIES IN HERTZ

FIGURE 10

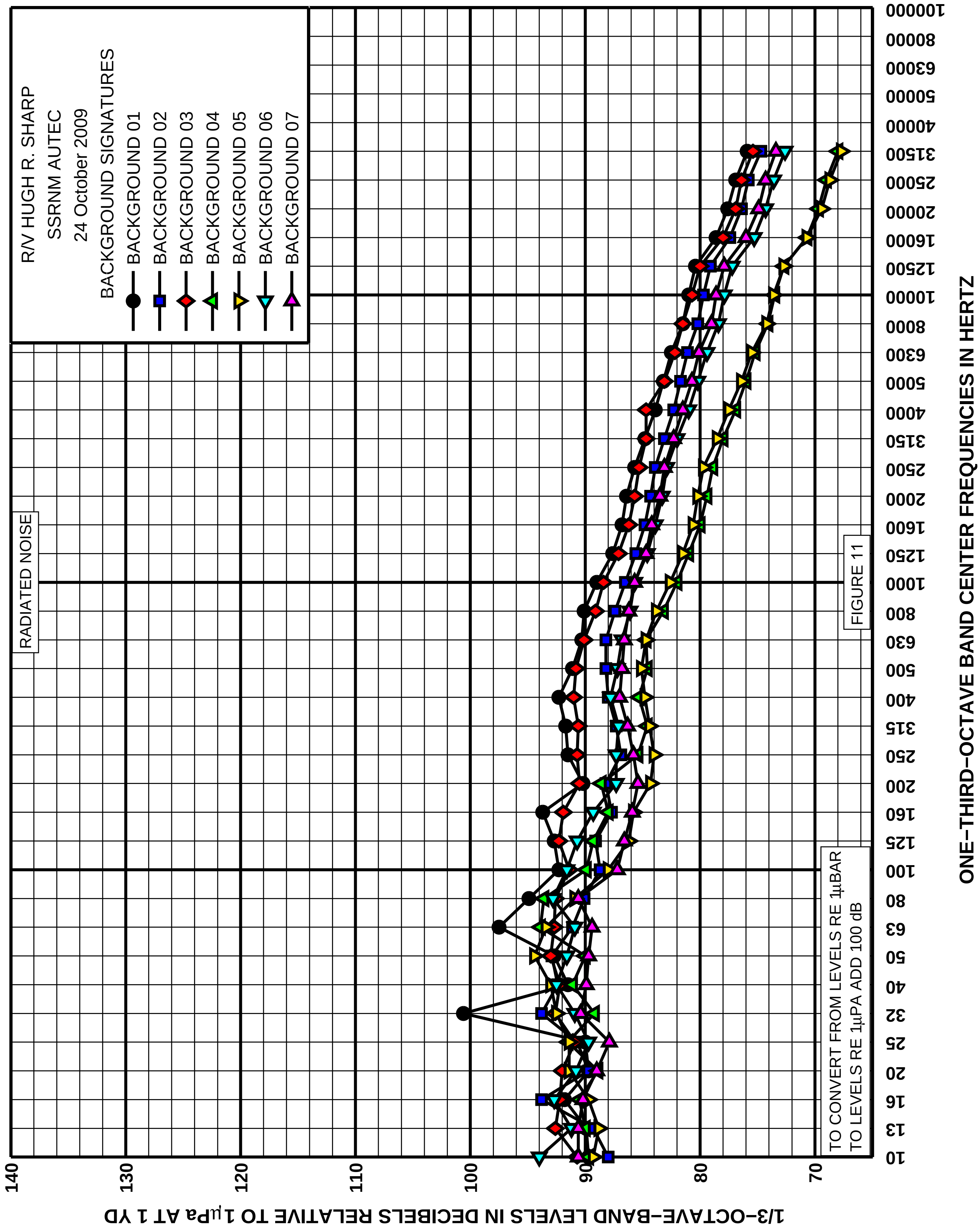

R/V HUGH R. SHARP
SSRNM AUTEC
24 October 2009
BACKGROUND SIGNATURES
BACKGROUND 01
BACKGROUND 02
BACKGROUND 03
BACKGROUND 04
BACKGROUND 05
BACKGROUND 06
BACKGROUND 07
RADIATED NOISE
FIGURE 11
TO CONVERT FROM LEVELS RE 1μBAR
TO LEVELS RE 1μPA ADD 100 dB
1/3–OCTAVE–BAND LEVELS IN DECIBELS RELATIVE TO 1μPa AT 1 YD
ONE–THIRD–OCTAVE BAND CENTER FREQUENCIES IN HERTZ
140
130
120
110
100
90
80
70
10
13
16
20
25
32
40
50
63
80
100
125
160
200
250
315
400
500
630
800
1000
1250
1600
2000
2500
3150
4000
5000
6300
8000
10000
12500
16000
20000
25000
31500
40000
50000
63000
80000
100000

TABLE 1.

R/V HUGH R. SHARP SURFACE SHIP RADIATED NOISE MEASUREMENT PROGRAM Range: AUTEC Date: 24-Oct-09 DATA SUMMARY SHEET TABULATED SOURCE LEVELS IN dB // 1microPa at 1 yard												
Possible Sources:	**4 KNOTS ~150 SRPM Generator 1**		**6 KNOTS ~192 SRPM Generator 1**		**7 KNOTS ~224 SRPM Generator 1**		**8 KNOTS ~256 SRPM Gen 1 and 2**		**8 KNOTS ~256 SRPM Gen 3 and 4**		**9 KNOTS ~288 SRPM Gen 1 and 2**	
	FREQ	**LEVEL**	**FREQ**	**LEVEL**	**FREQ**	**LEVEL**	**FREQ**	**LEVEL**	**FREQ**	**LEVEL**	**FREQ**	**LEVEL**
Diesel Generators									30	144		
Diesel Generators									60	- /139		
Diesel Generators									75	144/137		
Z Drive Lower Gear Mesh	88	146/ -			129	137	157	149	164	148	183	159
Diesel Generators									90	- /137		
Diesel Generators									135	137		
Z Drive Upper Gear Mesh	163	151	215	159	237	145/151	298	146	302	147		
2x Z Drive Lower Gear Mesh									324	147		
3x Z Drive Lower Gear Mesh					386	140						
									492	- /138		
2x Z Drive Upper Gear Mesh			430	145	485	148	581	140	602	139		
3x Z Drive Upper Gear Mesh	484	145										
4x Z Drive Lower Gear Mesh											748	135/ -
							Numerous Gear Mesh Harmonics 817 - 1510 Hz 132 - 137 dB					

Port/starboard aspect

3 Hz bandwidth measurement for frequencies below 6400 Hz

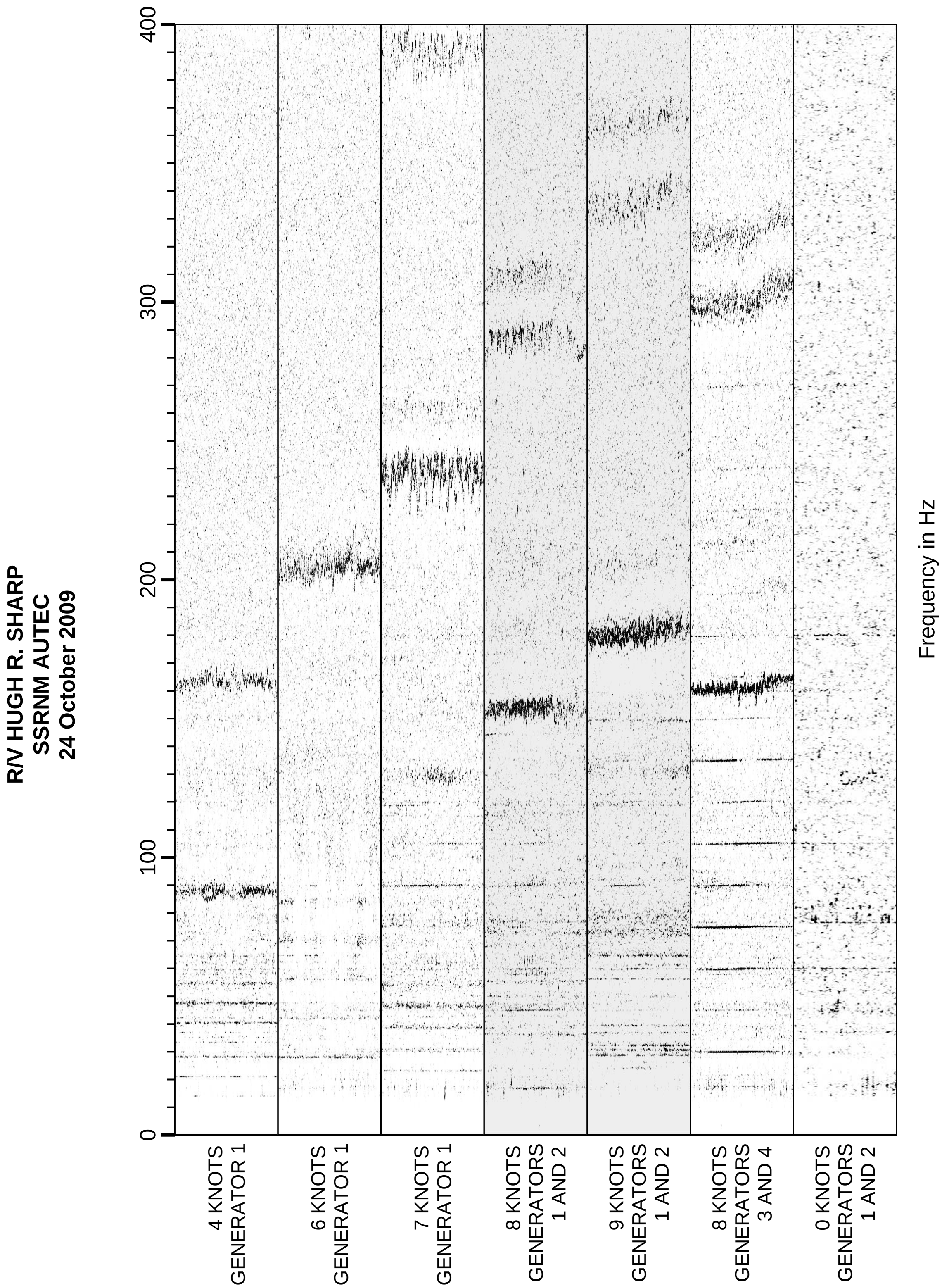

R/V HUGH R. SHARP
SSRNM AUTEC
24 October 2009
0
100
200
300
400
4 KNOTS GENERATOR 1
6 KNOTS GENERATOR 1
7 KNOTS GENERATOR 1
8 KNOTS GENERATORS 1 AND 2
9 KNOTS GENERATORS 1 AND 2
8 KNOTS GENERATORS 3 AND 4
0 KNOTS GENERATORS 1 AND 2
Frequency in Hz

Figure 12

R/V HUGH R. SHARP
SSRNM AUTEC
24 October 2009

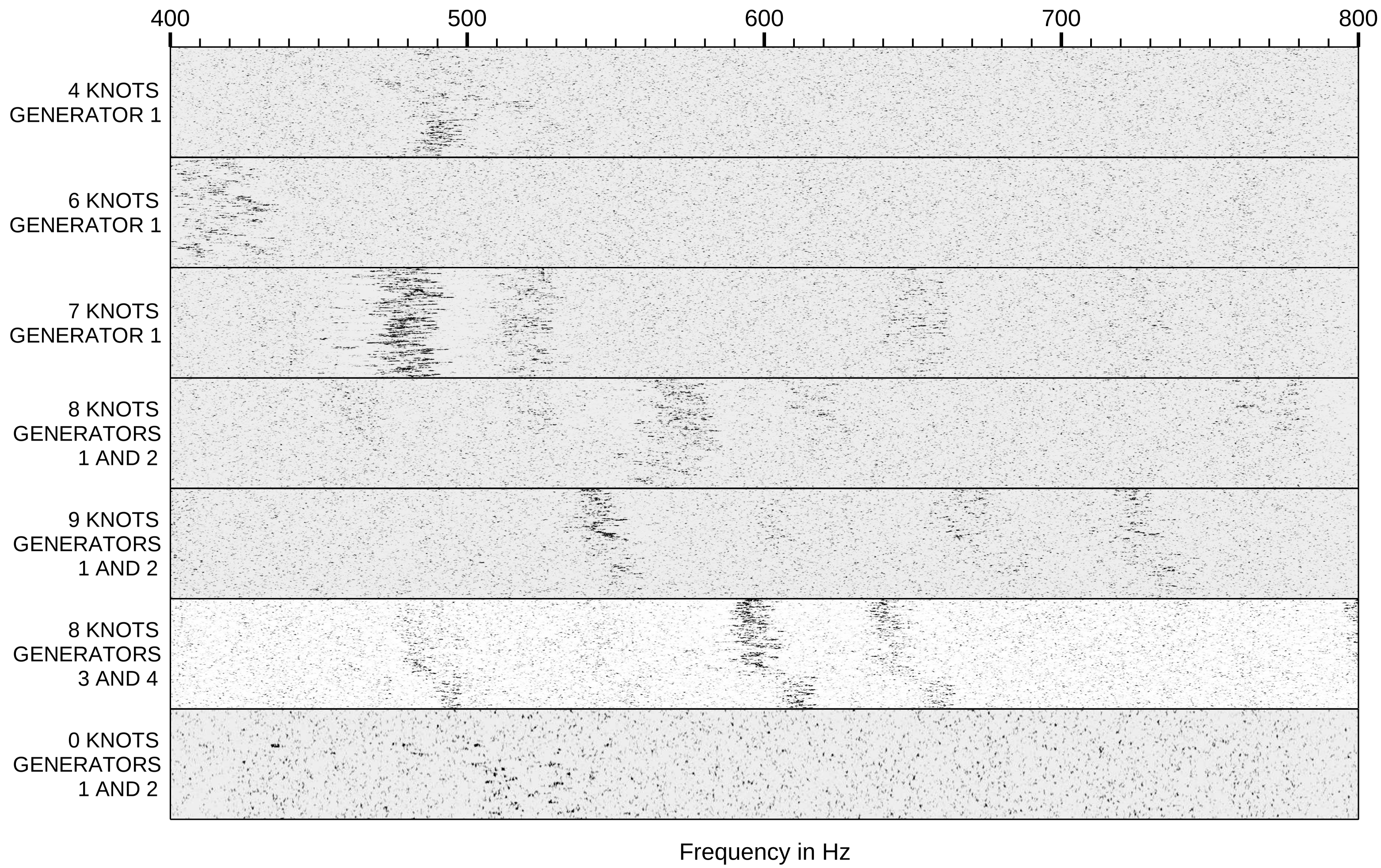


Figure 13

R/V HUGH R. SHARP
SSRNM AUTEC
24 October 2009

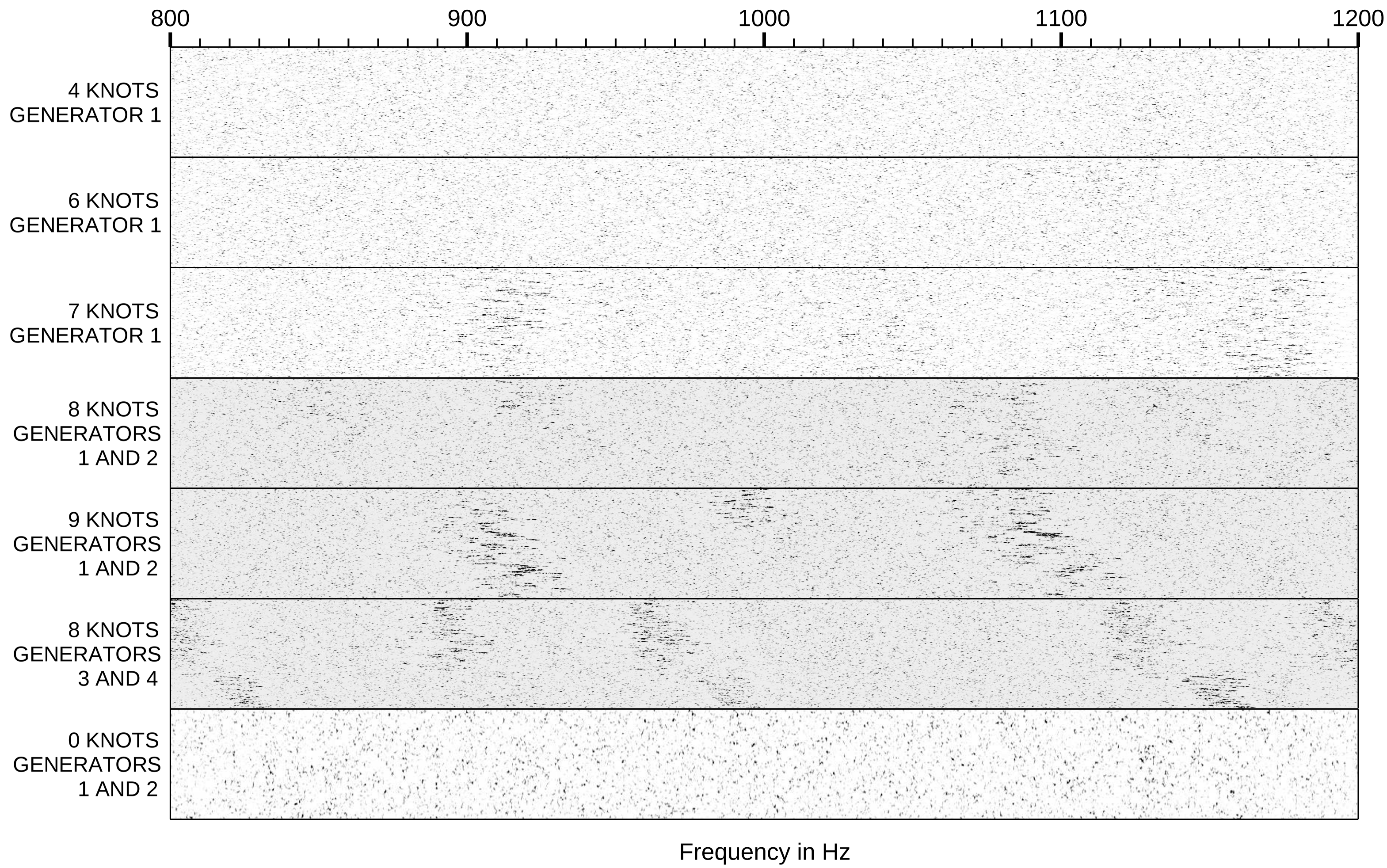
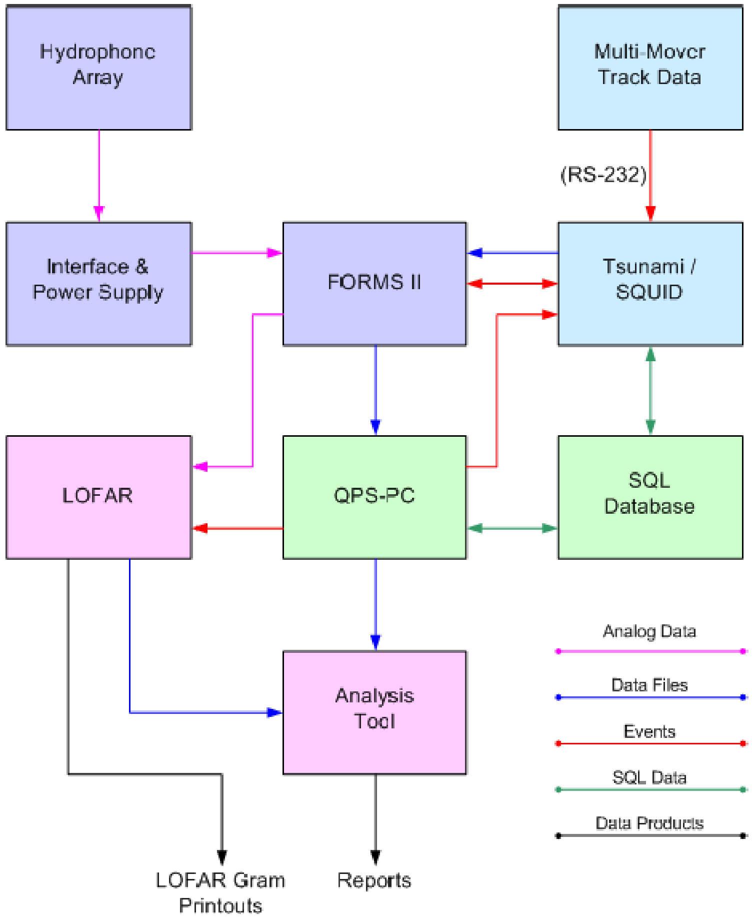


Figure 14

Testing Information Appendix

ID#	INFORMATION TYPE	INFORMATION FROM OWNER
1.	Ship characteristics	
1.1.	Name / classification	R/V SHARP
1.2.	Reason for the measurements	Periodic recheck
1.3.	Shipyard and year constructed	Dakota Creek Industries, 2005
1.4.	Dimensions	-
1.4.2.	Length	146 feet
1.4.3.	Beam	32 feet
1.4.4.	Draft	8' 10" (light) to 9' 8" (heavy)
1.4.5.	Tonnage	550 long tons
1.4.6.	Ballast conditions	Not Available
1.5.	Propulsion characteristics	ASI Robicon Motor with Schottel Z-Drive
1.5.1.	Power source	Cummins, CMA 455; KTA 19 D(M)
1.5.2.	Drive train	Diesel Electric; Port & Stbd Z-Drives
1.5.4.	Number of propulsor blades	5
1.5.5.	Turns per knot	32 utilized
1.5.6.	Modifications to propulsion line since the last measurement.	New brushes put in both Z-drive motors (May 2009) and new bearing at rear of starboard drive motor (August 2009)
1.5.7.	Known problems or concerns that may affect underwater sound levels	Small cavitation pitting and slight mechanical damage. A 500 Hz tone found in self noise monitor around 2 years ago. The source was never identified.
1.5.8.	Condition of the hull, last time the hull and propellers were cleaned.	The hull was cleaned at last shipyard period in May 2007.
2.	Testing characteristics	
2.1.	ANSI/ASA S12.64 Measurement Grade	Grade B
2.1.1.	Mitigations / deviations	Less than desired ambient
2.2.	Location / environment	Atlantic Undersea Test and Evaluation Center (AUTEC) Bahamas Islands
2.2.1.	Date	23/24 October 2009
2.2.2.	Latitude / longitude	24 deg 52 Min N / 77 Deg 49Min W
2.2.3.	Nominal environmental conditions	Winds and seas caused low frequency contamination
2.2.3.1.	Wave height / sea state / wind / rain	2-5 Feet / State 3/4 Sea / Winds 6-18 Knots
2.2.3.2.	Vessel traffic	Minimal – one contact during 9 knot runs
2.2.3.3.	Bottom depth / bottom type	4000 Feet
2.3.	Measurement system	US Navy Surface Ship Radiated Noise Measurement (SSRNM) FORMS Portable System
2.3.1.	Suspension system description / diagram	Compliant surface tether
2.3.2.	Hydrophone depths	324 / 474 / 524 Feet
2.3.3.	Hydrophone type / model / directionality / nominal sensitivity	ITC Model 8201 Low Noise Differential Output Hydrophone/ omnidirectional below 40KHz / nominal -158 dB//1V/uPa
2.3.4.	System component description and diagram	See Attachment
2.3.5.	Factory calibration details (performed by, dates and certificates)	See Attachment
2.3.6.	Field calibration methods and results	In situ electrical calibration
2.4.	Testing scenario	US Navy SSRNM Type modified to provide +/- 30 degree horizontal integration window
2.4.1.	Nominal CPA	180 Yards
2.4.2.	Selection of center of integration window	Integration about the Acoustical Center
2.4.3.	Maneuvering geometry	Figure 8 maneuvering

SSRNM System bock diagram:



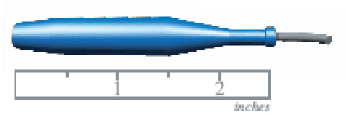
Typical SSRNM Array Hydrophone Characteristics:

Model ITC-8201

Low Noise Differential Output Hydrophone

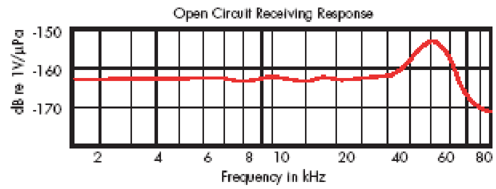
Model ITC-8201

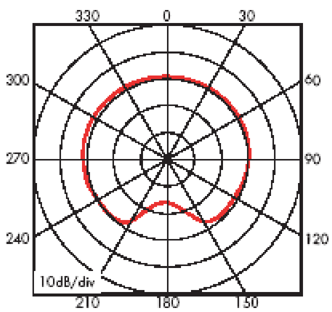
The Model ITC-8201 has a differential output with a very low noise preamplifier. Although polyurethane encapsulated, this hydrophone maintains its low frequency roll-off over long-term deployments through an improved internal insulation technique. It can drive cable lengths up to 2,500 feet.



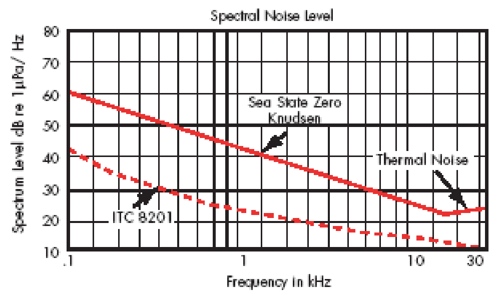
Specifications (Nominal)

Midband OCV dB/v/μPa	-158 dB//1V/μPa
Midband Beam Pattern Shape	Omnidirectional
Usable Frequency Range	.01 - 65
Preamplifier Type	Single in/Single out, Voltage
Depth	900 meters





Directivity Pattern at 50.0 kHz



International Transducer Corporation

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ww.itc-transducers.com

SSRNM Array Diagram: