Copy No. _____

Defence Research and Development Canada
Recherche et d�veloppement pour la d�fense Canada

DEFENCE R&D DÉFENSE

TOTEM Projector Suite Calibrations

Richard A.G. Fleming

Defence R&D Canada – Atlantic

Technical Memorandum

DRDC Atlantic TM 2007-095

November 2007

Canada

This page intentionally left blank.

TOTEM Projector Suite Calibrations

Richard A.G. Fleming

Defence R&D Canada – Atlantic

Technical Memorandum
DRDC Atlantic TM 2007-095

November 2007

Principal Author

Original signed by Richard A.G. Fleming

Richard A.G. Fleming

Approved by

Original signed by David Hazen

David Hazen

Section Head / Technology Demonstration

Approved for release by

Original signed by Dr. J.L. Kennedy

Dr. J.L. Kennedy

A/Chair, Document Review Panel

Abstract

The TOwed Torpedo Emulator (TOTEM) system was recently developed under contract from Defence Research and Development Canada - Atlantic (DRDC Atlantic) by Ultra Electronics Maritime Systems Incorporated (UEMS) and Brooke Ocean Technology (BOT) to provide a towable system for producing acoustic signatures to emulate those of torpedoes. TOTEM emulates torpedo signatures from a suite of four different underwater sound projectors and is capable of projecting sound omnidirectionally from 120 Hz to 10 kHz and directionally from 20 kHz to 32 kHz. TOTEM was successfully trialed in October of 2006, but there remained a requirement for complete characterization of the transmitting voltage responses and directivity patterns of projectors installed in the tow-body. In March 2007, transmitting voltage responses and directivity patterns at various depths and orientations were measured at the Acoustic Calibration Barge (ACB). Results showed that the in-situ transmitting voltage response (TVR) of the omnidirectional projectors was generally 3 to 6 dB below expected performance, except in the 240 Hz to 350 Hz band. There were no marked changes noted as a result of changing depth. These response curves' shapes showed good agreement with finite element design models, except for resonance frequency shifts due to inter-projector interaction. There was also a 10 dB drop in output at 430 Hz. This drop in expected performance was shown to be caused by interactions within the tow-body.

Résumé

Le simulateur de torpilles remorqué (TOTEM) a été mis au point dernièrement par Ultra Electronics Maritime Systems Incorporated (UEMS) et Brooke Ocean Technology (BOT) en vertu d'un contrat de Recherche et développement pour la défense Canada – Atlantique (RDDC Atlantique) pour la fourniture d'un système remorquable en vue de la production de signatures acoustiques émulant les signatures de torpilles. Le système TOTEM émule les signatures de torpilles à l'aide d'une série de quatre projecteurs acoustiques sous-marins et peut assurer une projection acoustique omnidirective de 120 Hz à 10 kHz, ainsi qu'une projection acoustique directive de 20 kHz à 32 kHz. Il a été mis à l'essai avec succès en octobre 2006, mais il reste une exigence pour compléter la définition des caractéristiques des réponses en tension d'émission et les diagrammes de directivité des projecteurs installés dans le corps remorqué. En mars 2007, les réponses en tension d'émission et les diagrammes de directivité à diverses profondeurs et à diverses orientations ont été mesurés au chaland d'étalonnage acoustique. Les résultats ont montré que les réponses en tension d'émission sur place des projecteurs omnidirectifs étaient en règle générale de 3 à 6 dB au-dessous du rendement attendu, sauf dans la bande de 240 Hz à 350 Hz. Il n'y a pas eu d'écart marqué en raison de la variation de la profondeur. Les formes des courbes de réponse ont montré une bonne concordance avec les modèles de conception des éléments finis, sauf en ce qui concerne les déplacements de fréquences de résonance attribuables à l'interaction entre les projecteurs. Il y a aussi eu une chute de 10 dB dans la sortie à 430 Hz. On a montré que cette chute du rendement attendu a été causée par les interactions à l'intérieur du corps remorqué.

This page intentionally left blank.

Executive summary

TOTEM Projector Suite Calibrations:

R.A.G. Fleming; DRDC Atlantic TM 2007-095; Defence R&D Canada – Atlantic; November 2007.

Introduction: The Towed Torpedo Emulator (TOTEM) system was developed at DRDC Atlantic to provide a low-cost alternative for evaluation of shipbourne torpedo detection systems. TOTEM is composed of a specially modified rigid-hull inflatable boat (RHIB), winch system, RHIB-mounted control system and tow-body. The tow-body contains a suite of four acoustic projectors that provide realistic torpedo sound signatures. After the system was constructed and trialled, a full projector suite calibration was carried out at DRDC Atlantic's Acoustic Calibration Barge (ACB) in Bedford Basin. This calibration consisted of transmitting voltage responses and directivity pattern measurements at various depths, in both horizontal and vertical tow-body orientations.

Results: TOTEM's acoustic projector suite showed general shape agreement with finite element design predictions. Transmitting voltage response only met or exceeded expectations in the 240 Hz to 350 Hz band. The remainder of the 120 Hz to 10 kHz response was on the order of 3 to 6 dB (with a 12 dB dip at 430 Hz for LF2 and a 5 dB drop for LF1) below modelled predictions mainly due to inter-projector and tow-body interactions. However, the projectors' output is considered wholly adequate for future employment of the TOTEM system. Beampatterns showed little low frequency deviation from omnidirectional. Beampatterns at higher frequencies showed the expected negative impact as wavelengths approached characteristic tow-body component lengths resulting in lowered output and increased directivity. There was no significant variation in performance with changes in depth.

Significance: TOTEM's acoustic performance is shown to be near the design goals. Knowledge of the true acoustic source levels from TOTEM will allow accurate experiments and trials to be carried out especially with regard to pre- and post-trial acoustic modelling.

Future plans: It is anticipated that TOTEM will be given further at-sea performance testing, and potentially demonstrated against a naval ship in 2008. This at-sea performance testing is to include broadband measurements to evaluate the system response with respect to the presented discrete projector calibrations.

Sommaire

TOTEM Projector Suite Calibrations:

R.A.G. Fleming; DRDC Atlantic TM 2007-095; R & D pour la défense Canada – Atlantique; Novembre 2007.

Introduction ou contexte: Le simulateur de torpilles remorqué (TOTEM) a été mis au point à RDDC Atlantique comme solution de rechange peu onéreuse pour l'évaluation des systèmes de détection de torpilles embarqués. Il se compose d'un canot pneumatique à coque rigide modifiée spécialement, d'un treuil, d'un système de commande installé dans le canot pneumatique à coque rigide et d'un corps remorqué. Le corps remorqué contient une série de quatre projecteurs acoustiques qui fournissent des signatures acoustiques de torpilles réalistes. Une fois le système construit et mis à l'essai, un étalonnage complet de la série de projecteurs a été effectué au chaland d'étalonnage acoustique de RDDC Atlantique, dans le bassin Bedford. L'étalonnage a consisté en mesures des réponses en tension d'émission et des diagrammes de directivité à diverses profondeurs dans les deux orientations du corps remorqué (horizontale et verticale).

Résultats: La série de projecteurs acoustiques du système TOTEM a montré une concordance de forme générale avec les prédictions de la conception des éléments finis. Les réponses en tension d'émission ont atteint ou dépassé les attentes uniquement dans la bande de 240 Hz à 350 Hz. Le reste des réponses de 120 Hz à 10 kHz était de l'ordre de 3 à 6 dB (avec baisse de 12 dB à 430 Hz pour la LF2 et baisse de 5 dB pour la LF1) au-dessous des prédictions modélisées, principalement à cause des interactions du corps remorqué et entre les projecteurs. Toutefois, le rendement des projecteurs est considéré comme tout à fait adéquat en vue d'un emploi futur du système TOTEM. Les diagrammes des faisceaux ont fait état d'un faible écart aux basses fréquences par rapport au diagramme omnidirectif; aux fréquences supérieures, ils ont montré l'impact négatif attendu à mesure que la longueur d'onde approchait des longueurs caractéristiques d'éléments du corps remorqué, ce qui a donné un résultat plus faible et une directivité accrue. Il n'y a pas eu d'écart significatif de rendement aux différentes profondeurs.

Importance: On a montré que le rendement acoustique du système TOTEM se rapproche des objectifs de conception. Une connaissance des véritables niveaux de source acoustique du système TOTEM permettra de mener des expériences et des essais précis, surtout en ce qui concerne la modélisation acoustique antérieure et postérieure aux essais.

Perspectives: On s'attend à ce que le système TOTEM fasse l'objet d'autres essais de rendement en mer et éventuellement d'une démonstration par rapport à un navire de guerre en 2008. L'essai de rendement en mer doit comprendre des mesures large bande dans le but d'évaluer la réponse du système en ce qui concerne les étalonnages des projecteurs discrets présentés.

Table of contents

List of figures

List of tables

Acknowledgements

I wish to thank Richard Johnson and David Doucette for the untiring efforts during these calibrations. I wish also to acknowledge James Crawford of UEMS for some of the TOTEM projector images he provided.

1 Introduction

1.1 TOTEM

The TOwed Torpedo EMulator (TOTEM) system was developed at DRDC Atlantic to provide a torpedo defence testing tool for the Multi-Sensor Torpedo Detection Classification and Location Technology Demonstration Project. It is hoped that ultimately this system might be utilized by the Canadian Navy for testing and training. The system is aimed at providing a flexible source so that a myriad of known torpedo acoustic signatures can be produced at realistic levels so that navy crews can practice defending against torpedo threats without the cost associated with conventional anti-torpedo trials [1, 2]. This system is comprised of a high speed rigid hulled inflatable boat (RHIB), control unit, winch assembly and acoustic source tow-body. The system was designed to transmit omnidirectionally from 120 Hz – 10 kHz and directionally from 20 kHz to 32 kHz.

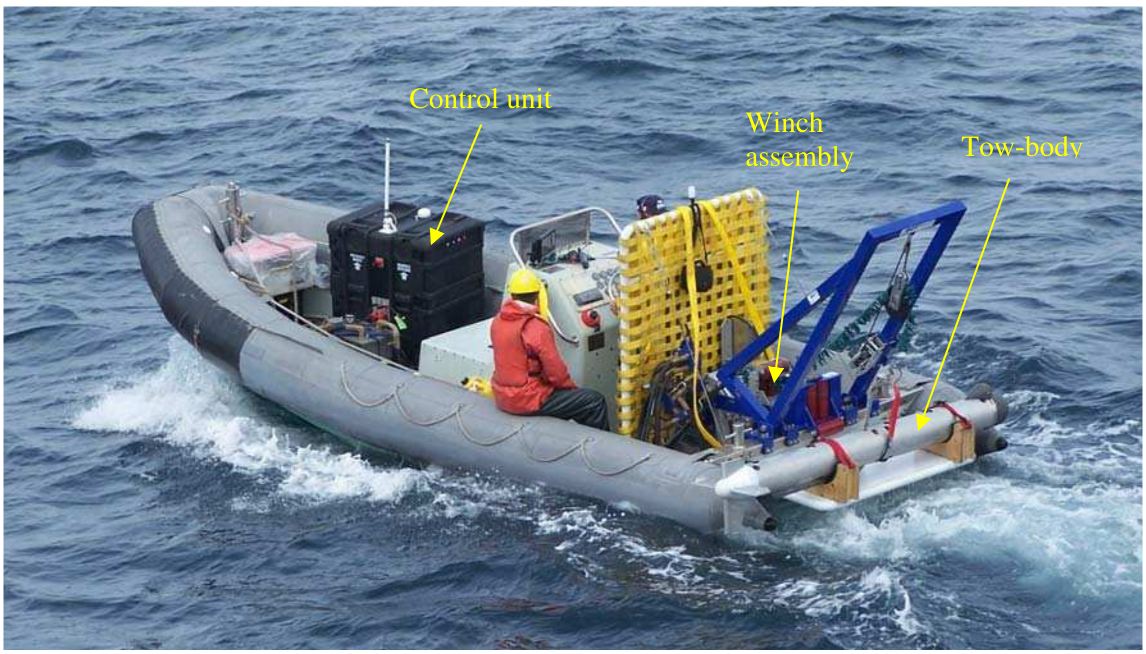

Figure 1 TOTEM system during sea trials.

1.2 TOTEM Tow-body

The TOTEM tow-body is 2.08 meters long, 0.23 meters in diameter, weighs 136 kg (in air) and is designed to be towed at speeds up to 20 knots at depths to 40 meters. The tow-body contains four acoustic projectors in order to cover the 120 Hz to 10 kHz band and the 20 kHz to 32 kHz band. The two low frequency projectors are bender-based Modular Projector System (MPS) units [3], while the mid-frequency unit is a sphere and the high frequency unit is a forward projecting hemisphere. Low frequency unit 1 (LF1) is composed of twenty-four 13.5 cm diameter benders wired in parallel and spaced 25mm center-to-center. LF1 was designed to resonate at 400 Hz and cover the 120-400 Hz frequency band. Low frequency unit 2 (LF2) is composed of two 13.5 cm diameter benders wired in parallel and spaced 100 mm center-to-center. LF2 was designed to resonate at 940 Hz and cover the 400-1200 Hz band. The mid-frequency unit (MF) is a sphere designed to operate omnidirectionally over the 1.2 kHz -10 kHz band. The forward-firing hemispherical high frequency (HF) projector transmits over the 20 kHz- 32 kHz band and is designed to emulate the active sonar of a torpedo. Also in the tow-body is a water-tight stainless steel cylinder which contains a local system control processor, power amplifier and the matching circuits for the various projectors, monitor hydrophone and other non-acoustic sensors for heading, roll, pitch, and depth characterization. In order to evaluate the tow-body's projector suite performance against the design goals, a full set of calibrations was carried out at DRDC Atlantic's Acoustic Calibration Barge (ACB).

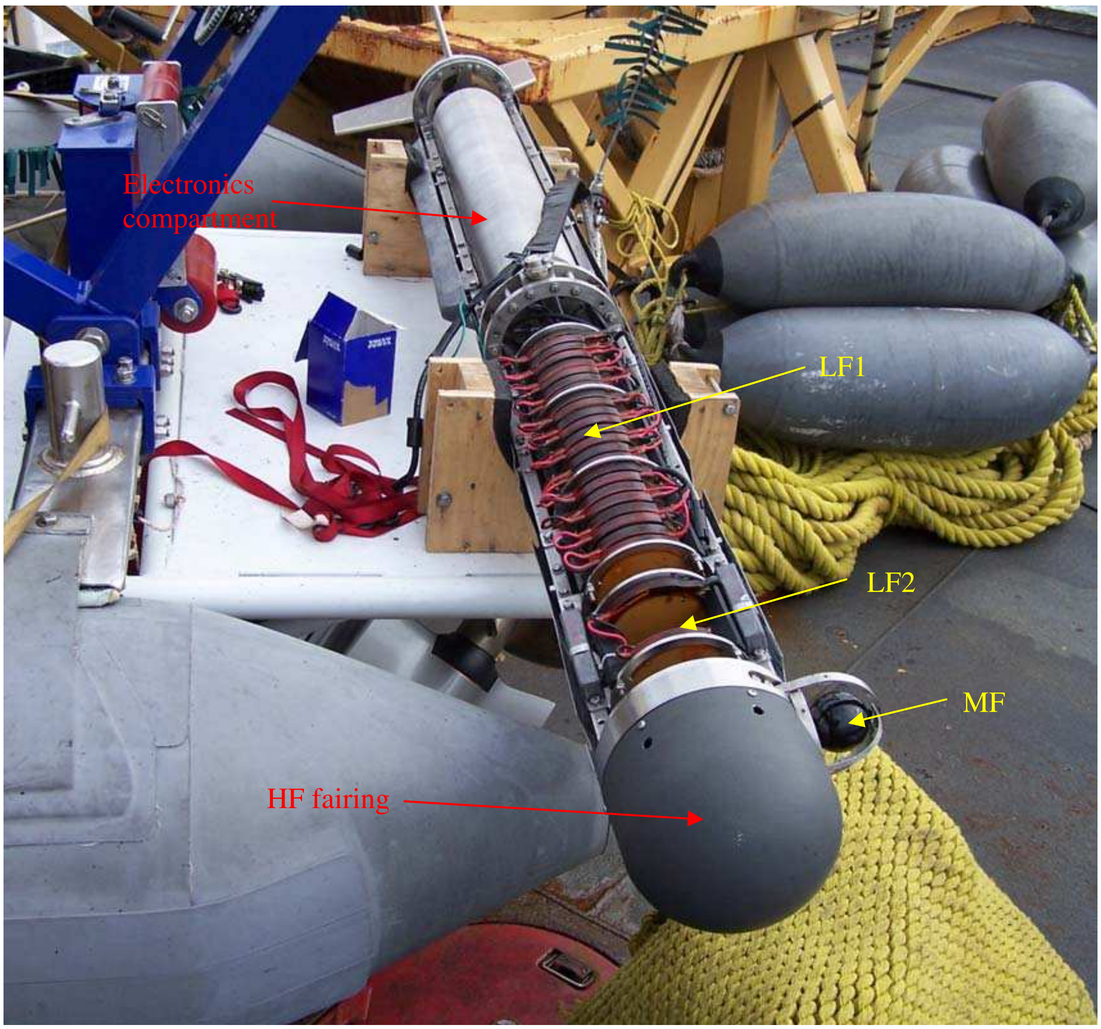

Figure 2 TOTEM tow-body with starboard body panels removed.

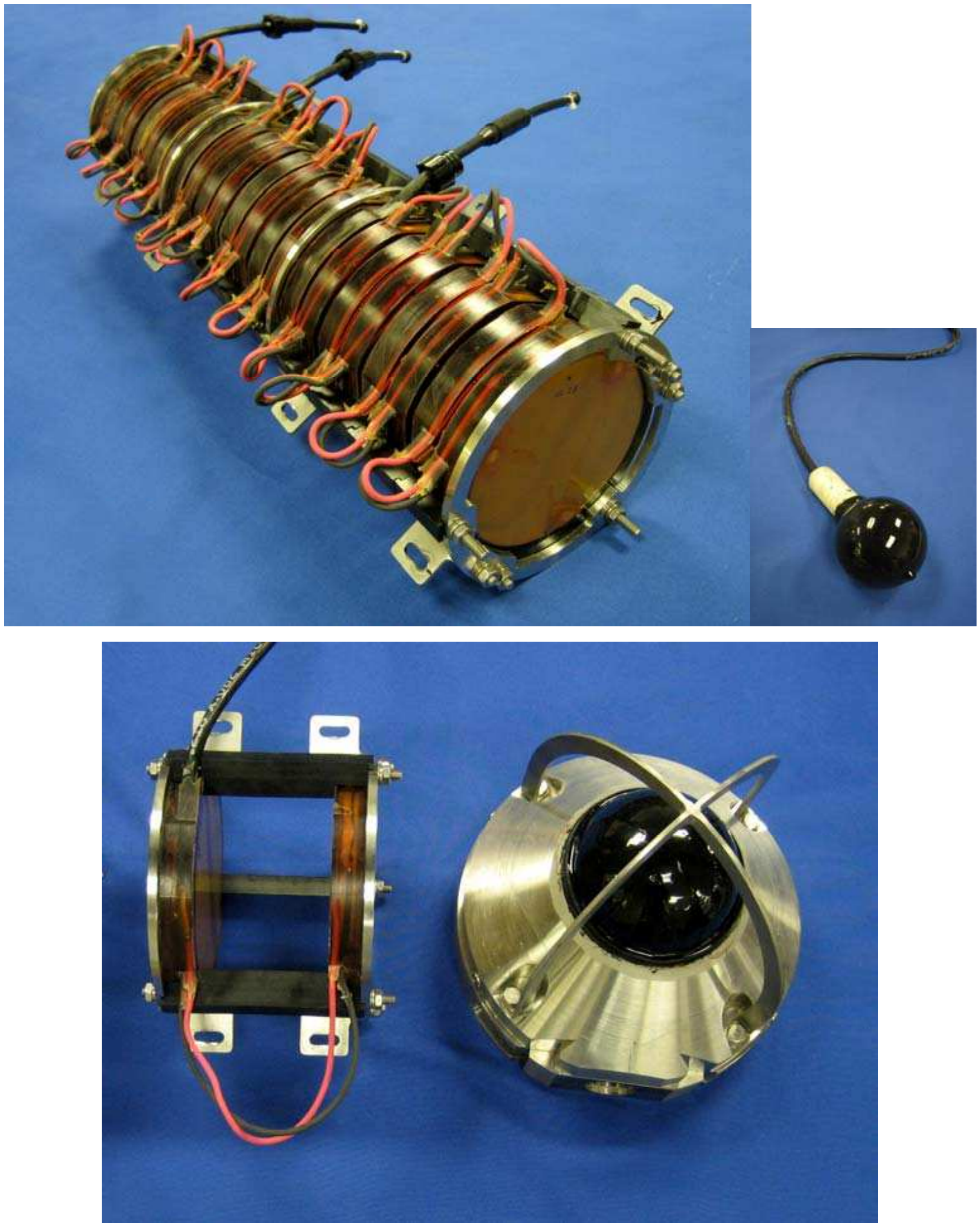

Figure 3 TOTEM projectors (Clockwise from top left: LF1, MF, HF, LF2).

2 TOTEM Transducer Calibration Set-up

Calibrations of the TOTEM transducers were embarked upon in order to confirm the performance of the transducers when mounted in the tow-body. Full calibrations of the projector suite aboard the Towed Torpedo EMulator (TOTEM) were carried out at the Acoustic Calibration Barge (ACB) facility which belongs to Defence Research and Development Canada – Atlantic (DRDC Atlantic). The ACB is moored in 43 meters of water in Bedford Basin, near Halifax, Nova Scotia. The ACB has a suite of traceable hydrophone and projector standards as well as an array of amplification and data acquisition hardware and software. This facility is capable of acoustic calibration of hydrophones and projectors from 300 Hz to 200 kHz. This facility is equipped with both 300 pound and 7.5 ton electronically controlled rotating stations for generating beam pattern and directivity index data.

The tow-body was attached to the ACB's 300 lb. station for all testing. Calibrations of the TOTEM projectors included transmitting voltage responses of each of the projectors as well as beam patterns both with the tow-body mounted vertically and horizontally at selected frequencies.

The horizontal orientation consisted of simply hanging the tow-body by its towing bridle and lashing the tow-body bow and stern such that the tow-body was level (see Fig. 4 and 5). Transmitting voltage responses and beam patterns for each of the projectors were measured. Since the TOTEM's projectors are the forward half of the tow-body, a slight offset in the horizontal beam patterns was created as a result of this non-concentric beam pattern measurement. Table 1 provides this offset calculation based on spherical spreading transmission loss. For the vertical aspect measurements, a jig was made that rigidly held the aft end of the vertically oriented tow-body to the 300 lb station. (see Fig 6.).

Projector	Acoustic center to tow-bridal distance (m)	Computed endfire-to-broadside transmission loss scaling factor (dB)
LF1	0.42	-0.37
LF2	0.84	-0.76
MF	1.00	-0.92
HF	1.12	-1.06

Table 1 Endfire horizontal aspect projector output offset due to non-concentricity.

Measurements of each projector included directivity pattern and transmitting voltage response (TVR) at depths of 10m, 15m, 20m and 25m. In all measurements, a B&K 8106 reference hydrophone (serial number 5372006) was suspended 10m from the centerline of the rotating station at the same depth as the tow-body.

On a later date, projector LF1 was calibrated without being installed in the tow-body to qualify the inter-projector effects seen in the initial testing.

Figure 4 Tow-body on 300 lb. station for horizontal aspect characterization.

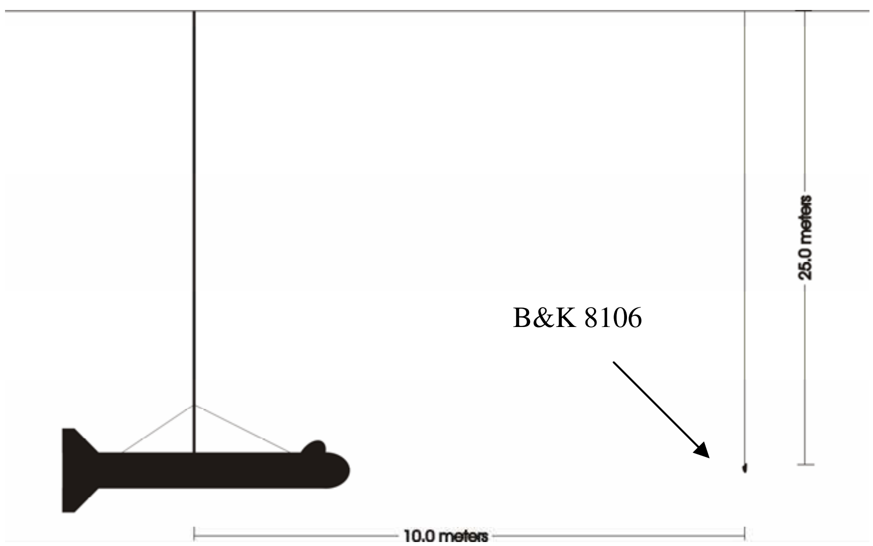

Figure 5 Details of tow-body configured in horizontal orientation (here shown bow-aspect (endfire) with respect to hydrophone at depth of 25m).

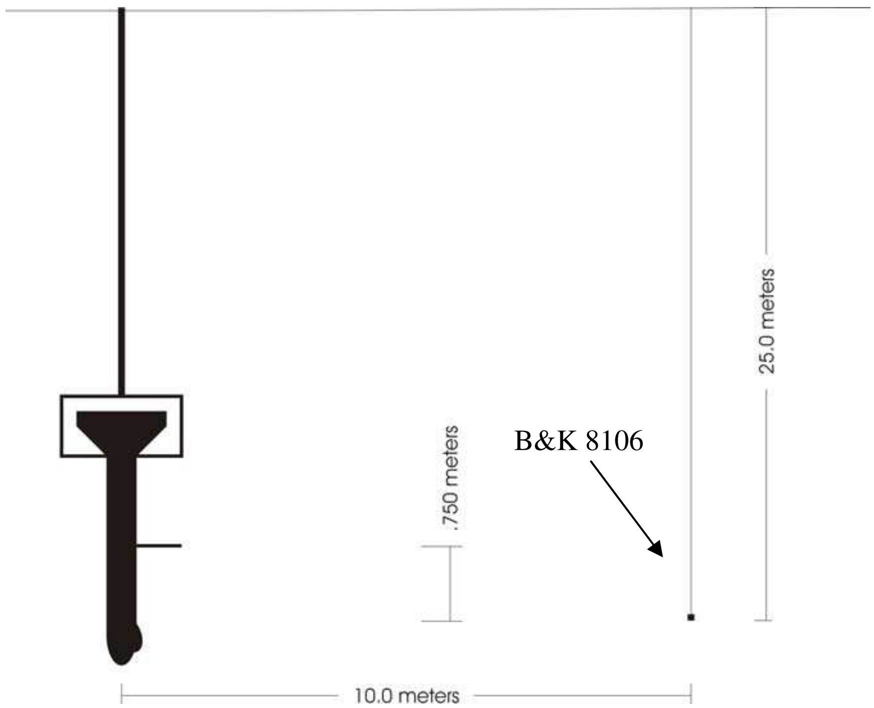

Figure 6 Details of tow-body configured in vertical orientation (shown at depth of 25m).

3 TOTEM Transducer Calibration Results

The four transducers in the tow-body were initially designed using the Model to Analyze the Vibration and Acoustic Radiation of Transducers (MAVART) finite element program [4]. However, each transducer was modelled in a free-field condition and therefore did not take into account inter- transducer effects or tow-body interactions. The composite TVR comparison of broadside response of the three omnidirectional projectors with modelled responses is shown in Figure 7. All three projectors generally fell slightly short of the predicted behaviour. Marked deviation from modelling occurred near the first resonance frequency of LF1. Here output from LF1 was 5 dB below expected and LF2 showed a 12 dB drop at the same frequency. This indicates a substantial inter-transducer effect which is most likely due the proximity of these two projectors (see Fig. 8) and the fact that each is comprised of identical MPS elements arranged along the same axis. A second possible LF2 – MF interaction can be seen near 1200 Hz. A later calibration of LF1 unmounted from the TOTEM tow-body showed its performance was comparable to modelled results.

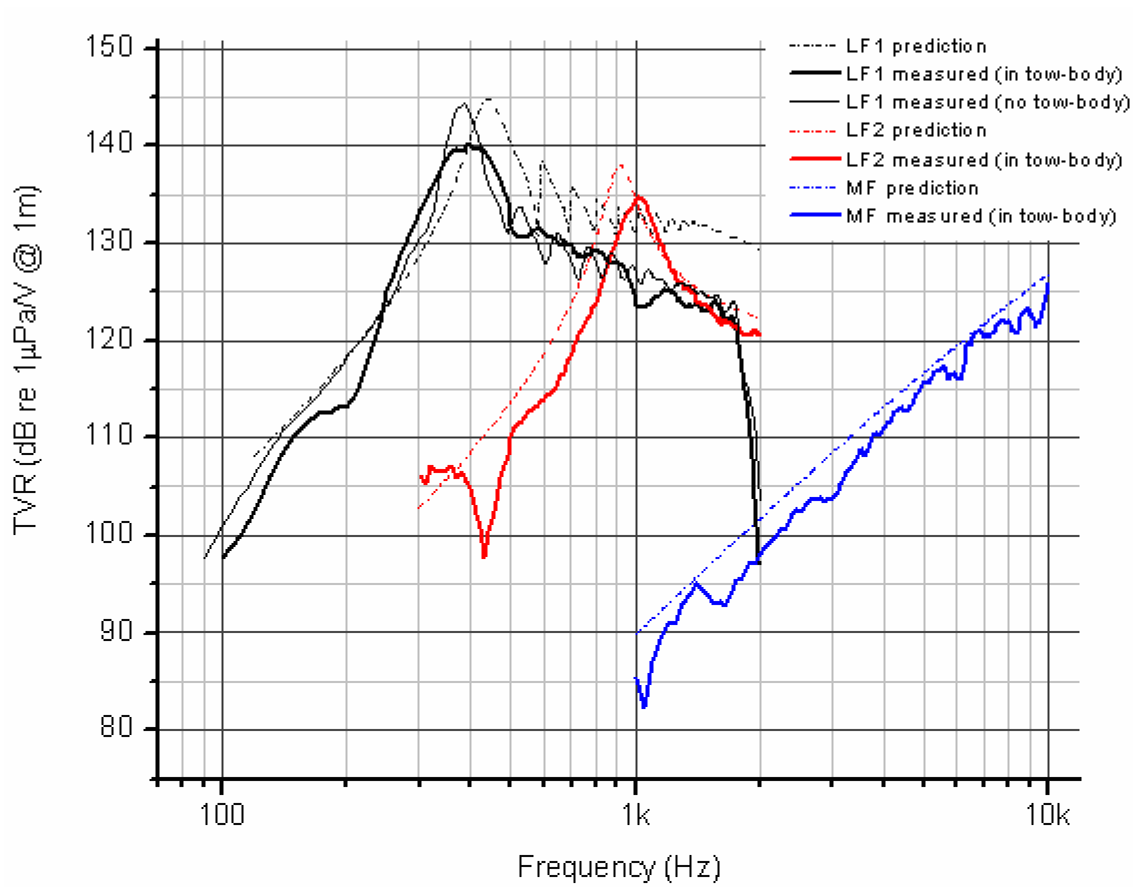

Figure 7 Composite broadside TVR's of LF1, LF2 and MF transducers at a depth of 25 meters.

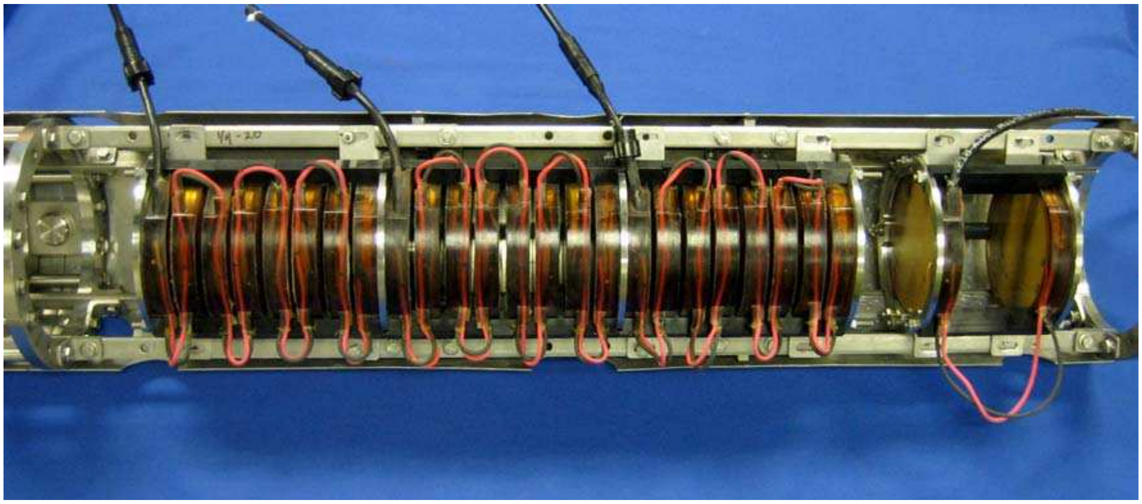

Figure 8 LF1 and LF2 mounted in the TOTEM chassis.

Representative results of the directivity and TVR measurements of the TOTEM projectors are broken down into the following LF1, LF2, MF and HF subsections. Two sets of TVR measurements were taken: endfire with the HF transducer end of the tow-body aimed at the reference hydrophone and broadside with the long axis of the tow-body perpendicular to the hydrophone.

Of note in the TVR of LF1 at 10m is an apparent discontinuity at 400 Hz (see Fig.9). This was due to a windowing limitation brought about by the shallow measurement depth. The ACB's TRANSCAL program shifted measurement points from the third received wave sample to the second (necessary to prevent the system from sampling the first surface reflection). The second wave was too early in the pulsed waveform to permit the projector from going to full power thereby skewing the TVR levels at and below this frequency at this water depth. The deeper measurements did not exhibit this unusual artifact.

3.1 LF1

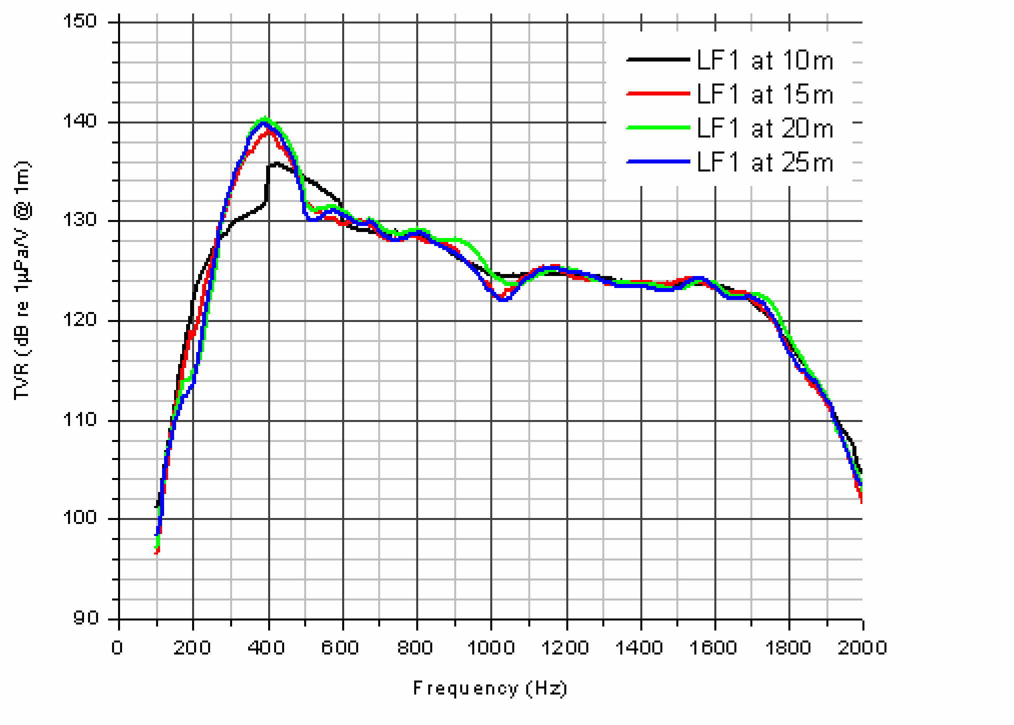

Figure 9 LF1 measured broadside TVR's.

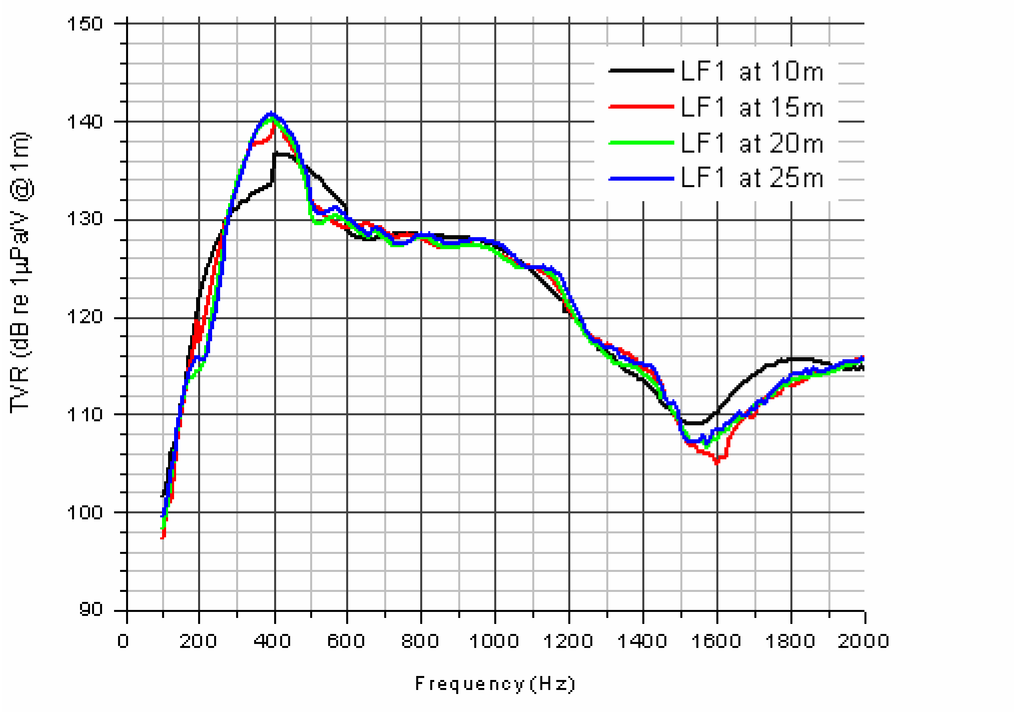

Figure 10 LF1 measured endfire TVR's.

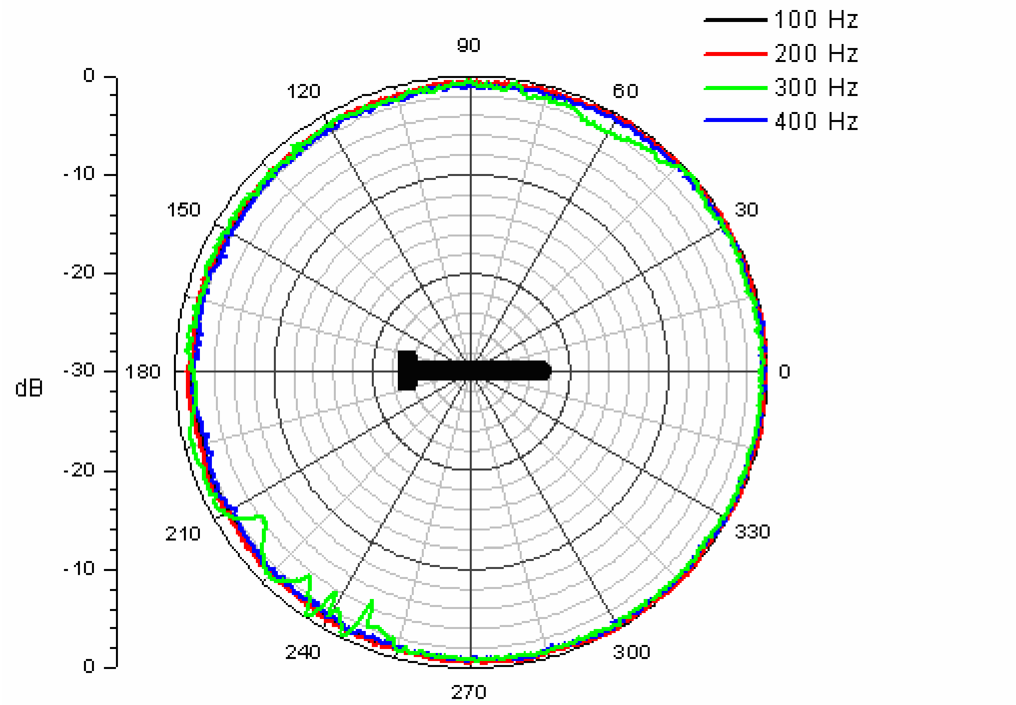

Figure 11 LF1 horizontal aspect beam patterns at a depth of 25 meters.

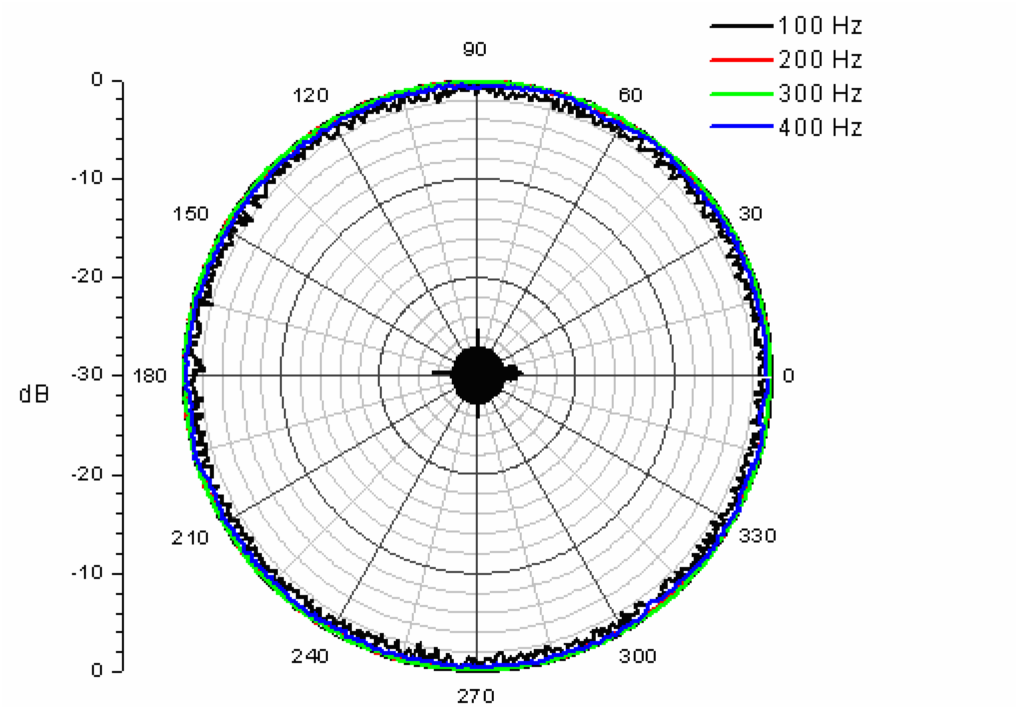

Figure 12 LF1 vertical aspect beam patterns at a depth of 25 meters.

3.2 LF2

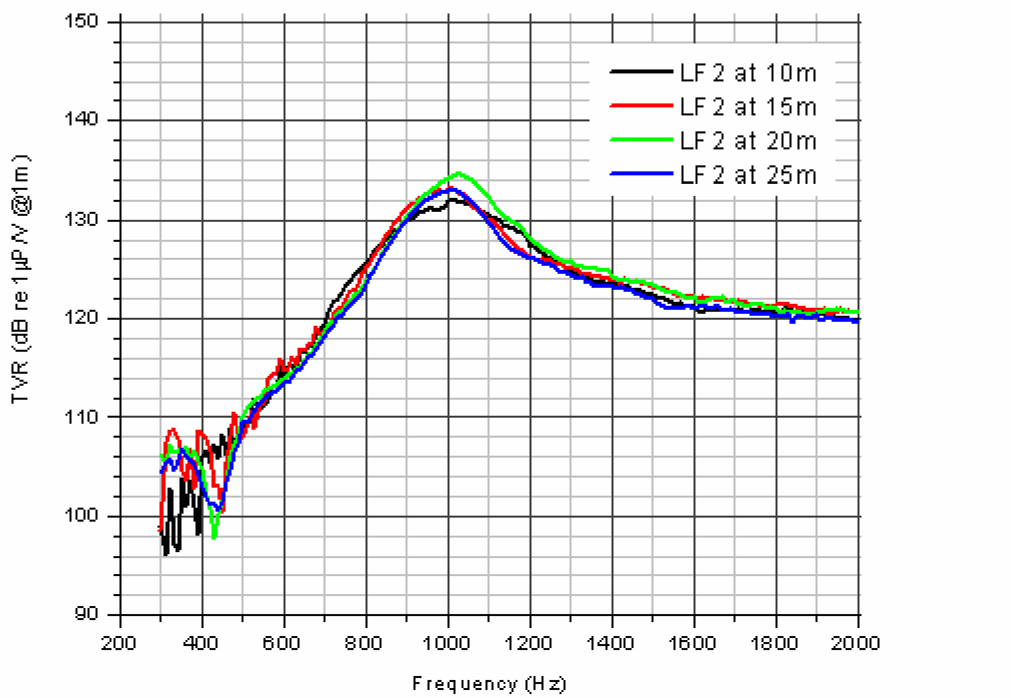

Figure 13 LF2 measured broadside TVR's.

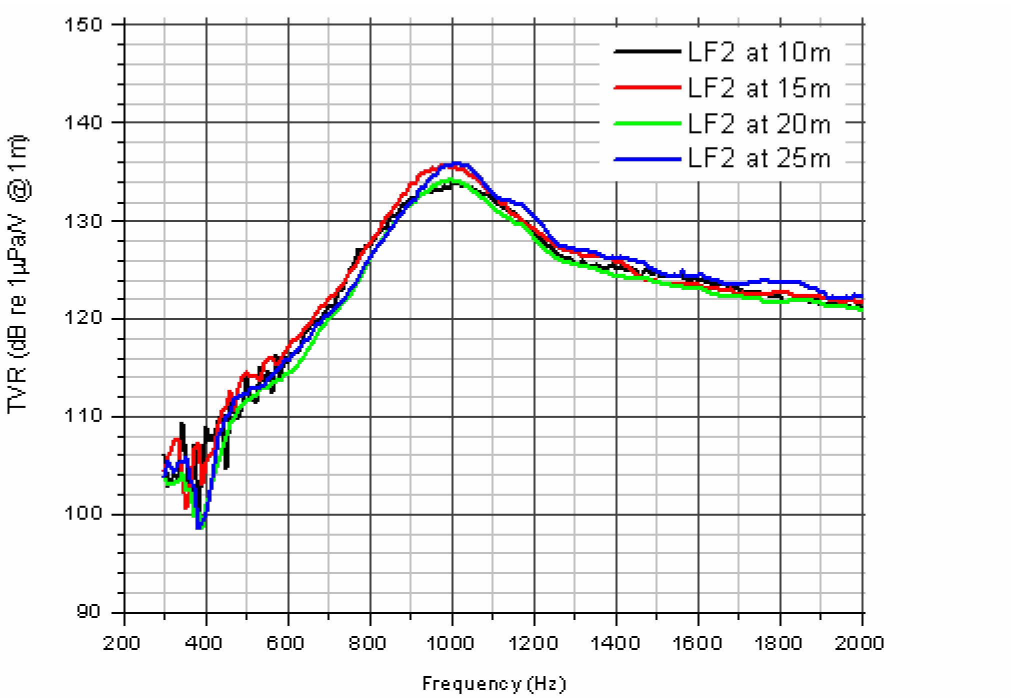

Figure 14 LF2 measured endfire TVR's.

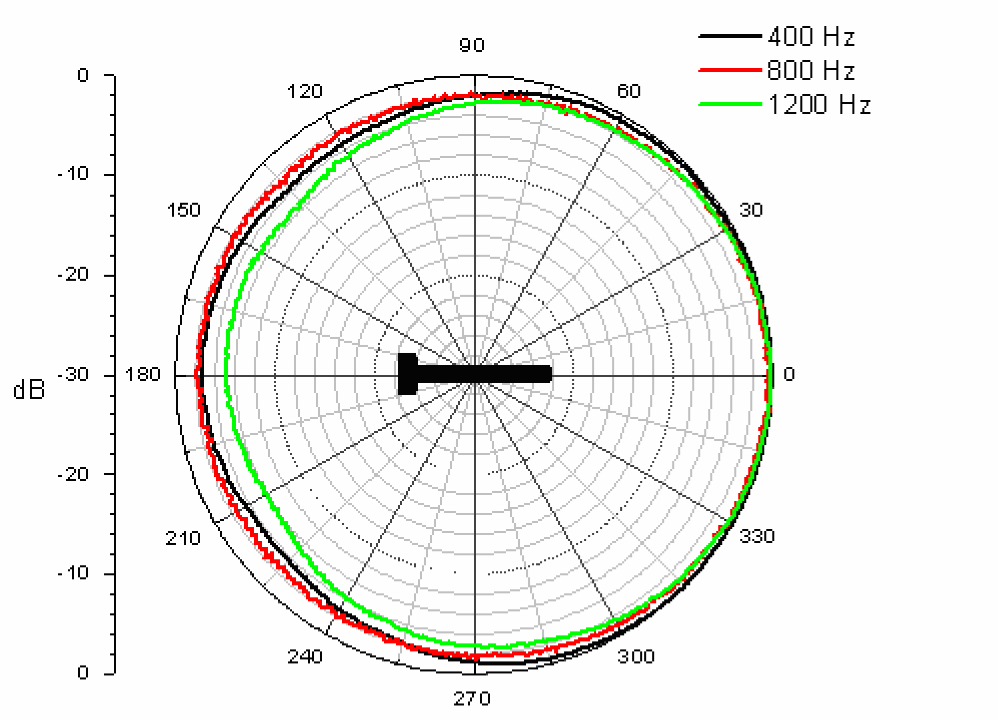

Figure 15 LF2 horizontal aspect beam patterns at a depth of 25 meters.

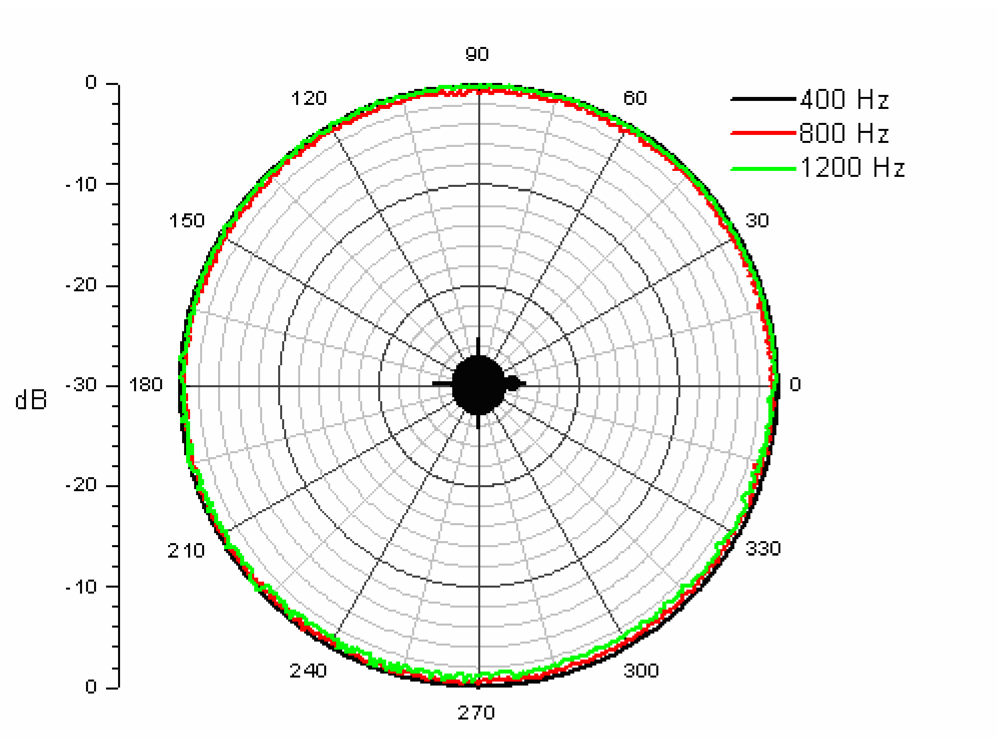

Figure 16 LF2 vertical aspect beam patterns at a depth of 25 meters.

3.3 MF

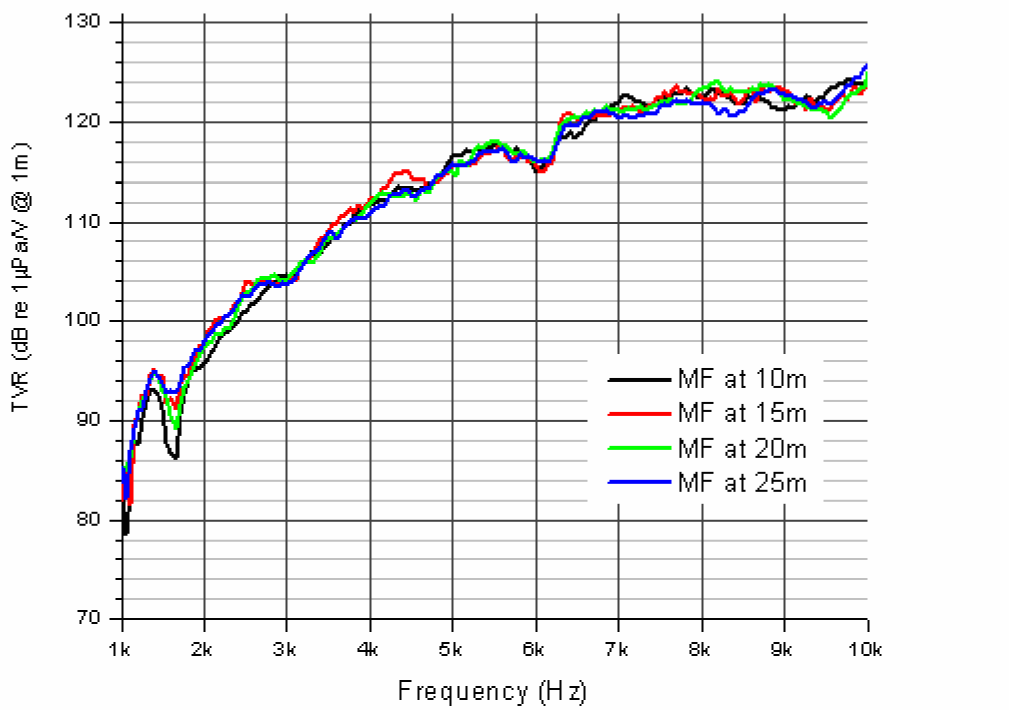

Figure 17 MF measured broadside TVR.

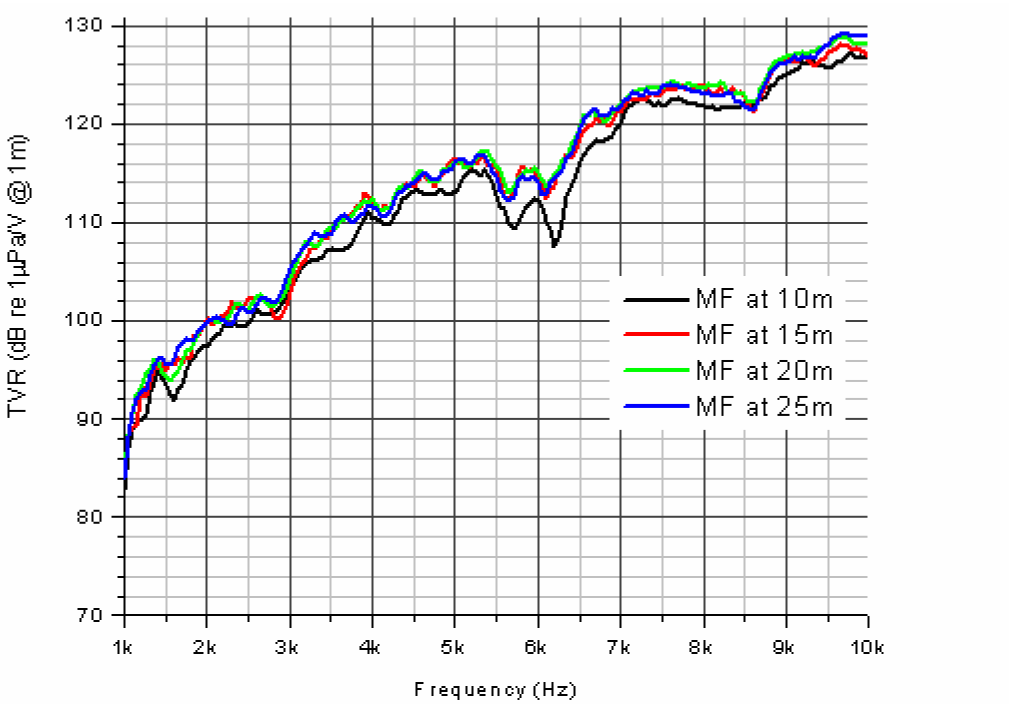

Figure 18 MF measured endfire TVR's.

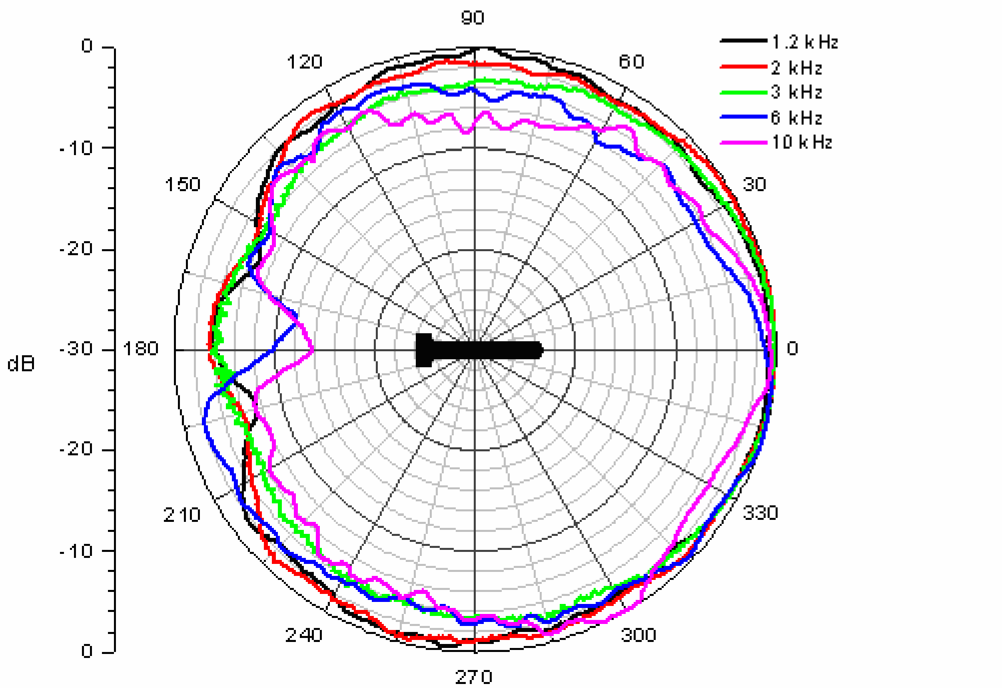

Figure 19 MF horizontal aspect beam patterns at a depth of 25 meters.

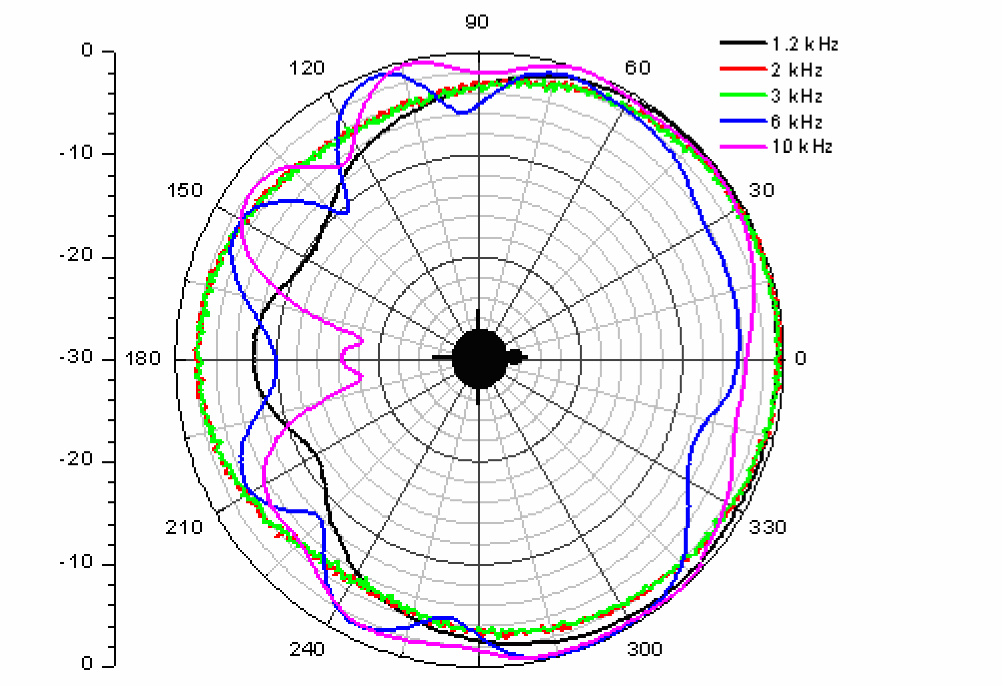

Figure 20 MF vertical aspect beam patterns at a depth of 25 meters.

3.4 HF

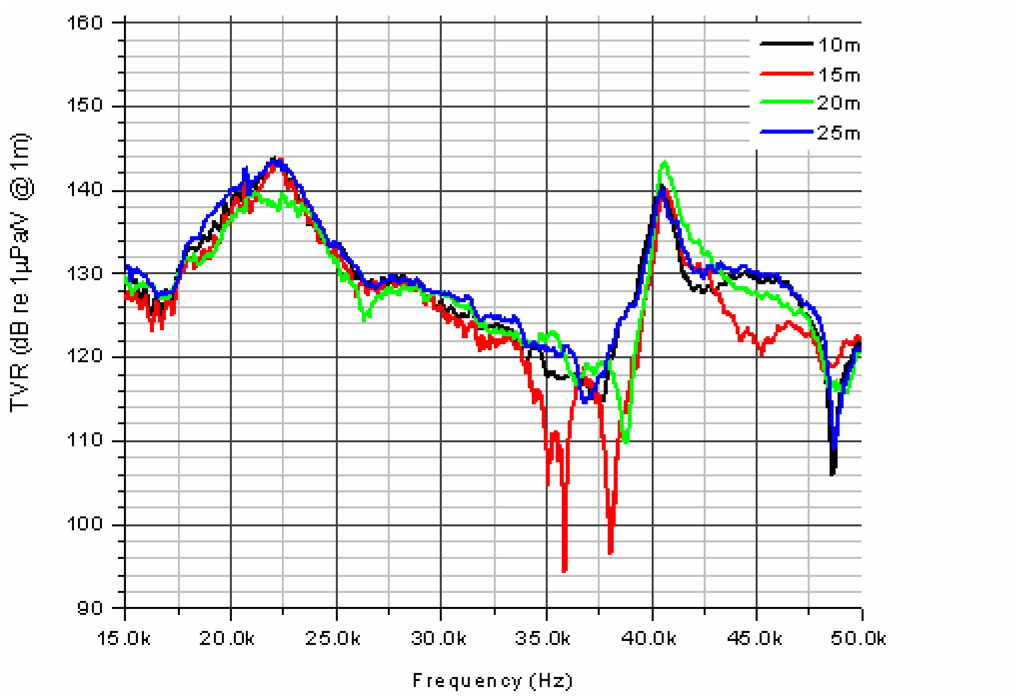

Figure 21 HF measured broadside TVR's.

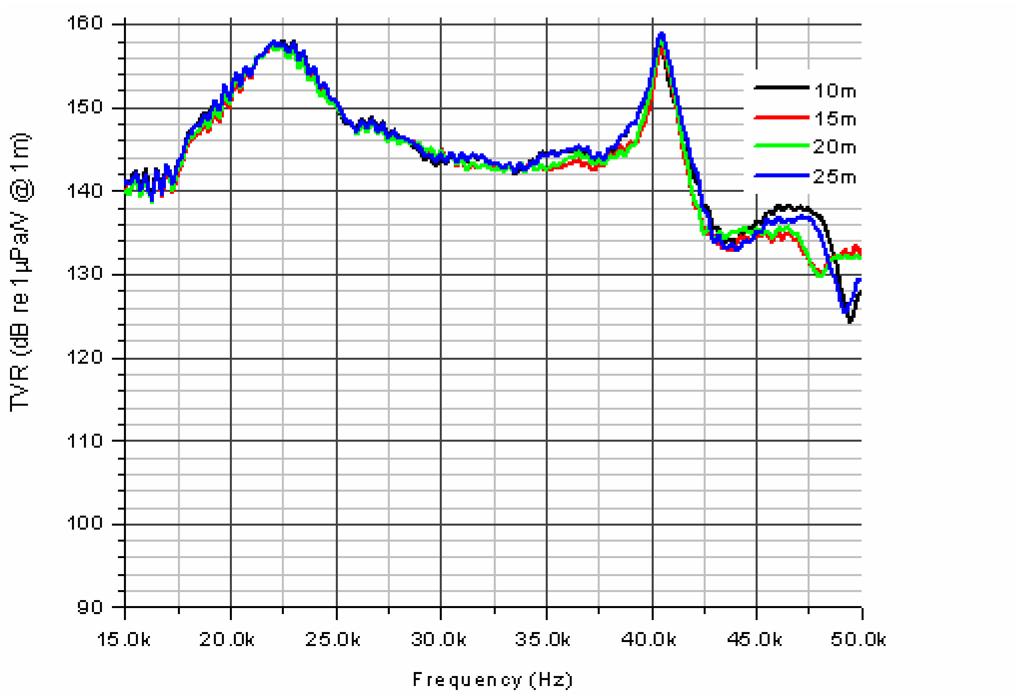

Figure 22 HF measured endfire TVR's.

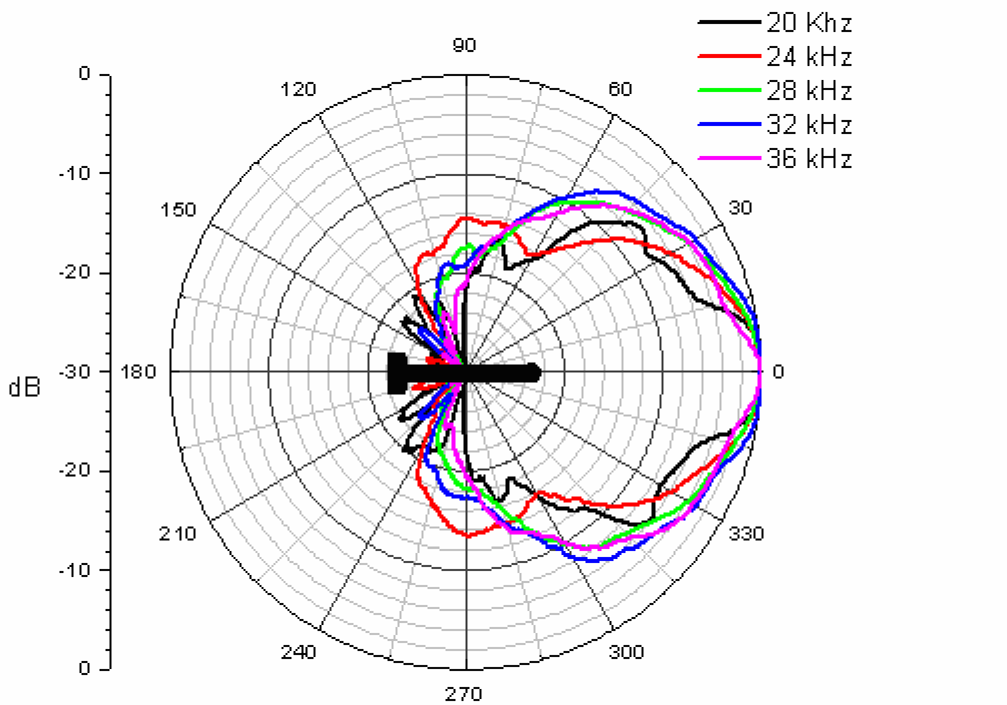

Figure 23 HF horizontal aspect beam patterns at a depth of 25 meters.

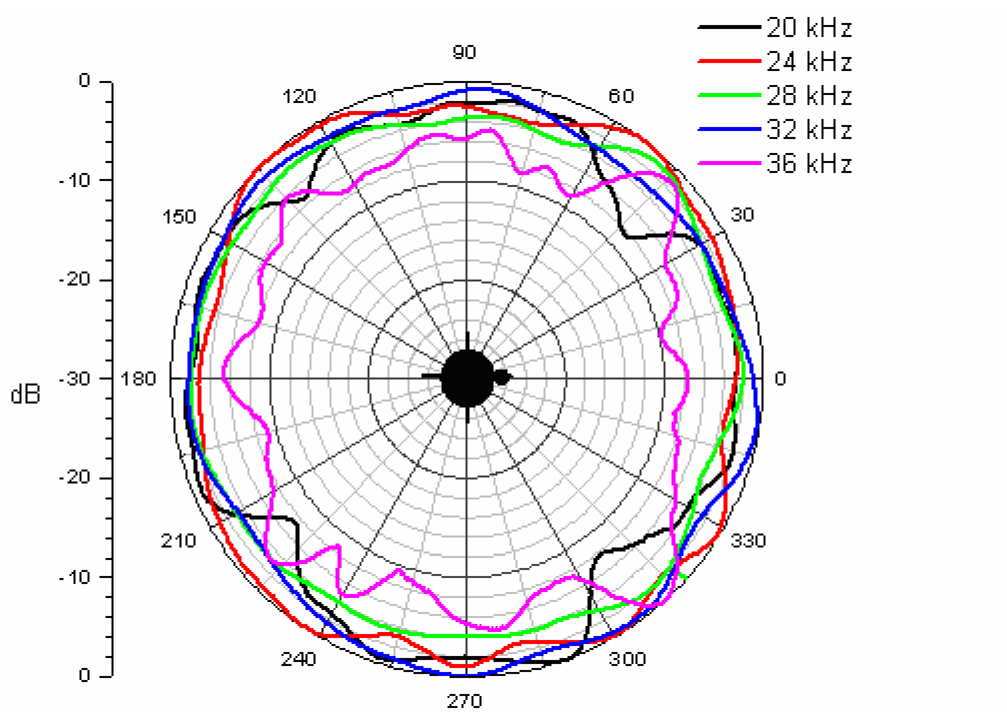

Figure 24 HF vertical aspect beam patterns at a depth of 25 meters.

4 Summary

The TOTEM suite of projectors was fully calibrated and shown to perform satisfactorily. In order for the TOTEM system to more closely approach the original source level goals, additional drive voltage levels will be required especially at 430 Hz and 1200 Hz. Any subsequent required voltage level changes are dependent of the frequency crossover points for LF1, LF2 and MF and therefore subject to further investigation. In addition to this, full system broadband response measurements will be carried out on a subsequent sea-trial to evaluate how the waveform/projector crossover filtering affects transmission frequency response.

No significant variation in performance was noted at the various measurement depths. This observation bodes well for establishing a broad operational depth envelope for TOTEM.

The 3-6 dB lower TVR than was predicted is not particularly surprising given the proximity of all of the projectors and the presence of the electronics compartment in the tow-body. Since the tow-body is a complex acoustical environment it would be prohibitively problematic to more accurately finite element model.

The calibration process went smoothly although rigging and deployment of this unit for measurement (especially in the vertical orientation) required care to prevent damage to the HF and MF projectors.

As a result of these TVR and directivity calibrations on TOTEM's projectors, there now exists the capability for modelling the expected received signals both pre- and post-trial.

References

[1] Trevorrow M. and Fleming R., The Towed Torpedo Emulator (TOTEM) System, MTS-IEEE Oceans 2007, SL2007-224 (2007).

[2] Smart D. and Keast A., System Design Document for the Towed Torpedo Emulator, DRDC Atlantic Contract Report, CR 2006-112 (Limited Distribution), (2006).

[3] Crawford J., Armstrong B., and Fleming R., The Towed Torpedo Emulator (TOTEM): A Modular Projector System (MPS) Success Story, Proceedings of UDT Europe 2007, Naples Italy, 5-7 June 2007.

[4] Skiba E.L., McMahon G.W., and Wozniak Z., Examples Manual for Program MAVART, DREA Contract Report, CR/95/416, (1995).

List of symbols/abbreviations/acronyms/initialisms

DRDC	Defence Research and Development Canada
TOTEM	TOwed Torpedo EMulator
UEMS	Ultra Electronics Maritime Systems
BOT	Brooke Ocean Technologies
ACB	Acoustic Calibration Barge
dB	decibel
Hz	hertz
TVR	transmitting voltage response
RHIB	rigid hull inflatable boat
LF1	Low frequency transducer 1
LF2	Low frequency transducer 2
MF	Medium frequency transducer
B&K	Bruel and Kjaer
MAVART	Model to analyze the vibration and acoustic radiation of transducers

This page intentionally left blank.

Distribution list

Document No.: DRDC Atlantic TM 2007-095

LIST PART 1: Internal Distribution by Centre:

5 DRDC Atlantic Library
1 Richard Fleming
1 Mark Trevorrow
1 David Hazen
1 Erin MacNeil
1 Jim Theriault
1 David Hopkin

11 TOTAL LIST PART 1

LIST PART 2: External Distribution by DRDKIM

1 DRDKIM
1 James Crawford
Ultra Electronic Maritime Systems Incorporated
40 Atlantic Street, Dartmouth, NS B2Y 4N2
1 Bruce Armstrong
GeoSpectrum Technologies Incorporated
30 Bel Ayr Avenue, Dartmouth, NS B2W 2E1
1 Steven Hughes, DSTM, NDHQ Ottawa,
101 Colonel By Dr., Ottawa, ON K1A 0K2
1 W.H. Hunter, DMSS 7-2, NDHQ Ottawa,
101 Colonel By Dr., Ottawa, ON K1A 0K2
1 LCdr A. Penny, DMRS 5-2, NDHQ Ottawa,
101 Colonel By Dr., Ottawa, ON K1A 0K2
1 LCdr S. Bernier, CFMWC

7 TOTAL LIST PART 2

18 TOTAL COPIES REQUIRED

This page intentionally left blank.

DOCUMENT CONTROL DATA

(Security classification of title, body of abstract and indexing annotation must be entered when the overall document is classified)

1. ORIGINATOR (The name and address of the organization preparing the document. Organizations for whom the document was prepared, e.g. Centre sponsoring a contractor's report, or tasking agency, are entered in section 8.) Defence R&D Canada Atlantic 9 Grove Street P.O. Box 1012 Dartmouth, Nova Scotia B2Y 3Z7	2. SECURITY CLASSIFICATION (Overall security classification of the document including special warning terms if applicable.) Unclassified

3. TITLE (The complete document title as indicated on the title page. Its classification should be indicated by the appropriate abbreviation (S, C, R or U) in parentheses after the title.)

TOTEM Projector Suite Calibrations:

4. AUTHORS (last name, followed by initials – ranks, titles, etc. not to be used)

Richard A.G. Fleming

5. DATE OF PUBLICATION (Month and year of publication of document.) November 2007	6a. NO. OF PAGES (Total containing information, including Annexes, Appendices, etc.) 31	6b. NO. OF REFS (Total cited in document.) 4

7. DESCRIPTIVE NOTES (The category of the document, e.g. technical report, technical note or memorandum. If appropriate, enter the type of report, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.)

Technical Memorandum

8. SPONSORING ACTIVITY (The name of the department project office or laboratory sponsoring the research and development – include address.)

Defence R&D Canada Atlantic
9 Grove Street
P.O. Box 1012
Dartmouth, Nova Scotia B2Y 3Z7

9a. PROJECT OR GRANT NO. (If appropriate, the applicable research and development project or grant number under which the document was written. Please specify whether project or grant.)	9b. CONTRACT NO. (If appropriate, the applicable number under which the document was written.)
10a. ORIGINATOR'S DOCUMENT NUMBER (The official document number by which the document is identified by the originating activity. This number must be unique to this document.) DRDC Atlantic TM 2007-095	10b. OTHER DOCUMENT NO(s). (Any other numbers which may be assigned this document either by the originator or by the sponsor.)

11. DOCUMENT AVAILABILITY (Any limitations on further dissemination of the document, other than those imposed by security classification.)

(X) Unlimited distribution
( ) Defence departments and defence contractors; further distribution only as approved
( ) Defence departments and Canadian defence contractors; further distribution only as approved
( ) Government departments and agencies; further distribution only as approved
( ) Defence departments; further distribution only as approved
( ) Other (please specify):

12. DOCUMENT ANNOUNCEMENT (Any limitation to the bibliographic announcement of this document. This will normally correspond to the Document Availability (11). However, where further distribution (beyond the audience specified in (11) is possible, a wider announcement audience may be selected.))

13. ABSTRACT (A brief and factual summary of the document. It may also appear elsewhere in the body of the document itself. It is highly desirable that the abstract of classified documents be unclassified. Each paragraph of the abstract shall begin with an indication of the security classification of the information in the paragraph (unless the document itself is unclassified) represented as (S), (C), (R), or (U). It is not necessary to include here abstracts in both official languages unless the text is bilingual.)

The TOwed Torpedo Emulator (TOTEM) system was recently developed under contract from Defence Research and Development Canada Atlantic (DRDC Atlantic) by Ultra Electronics Maritime Systems Incorporated (UEMS) and Brooke Ocean Technology (BOT) to provide a towable system for producing acoustic signatures to emulate those of torpedoes. TOTEM emulates torpedo signatures from a suite of four different underwater sound projectors and is capable of projecting sound omnidirectionally from 120 Hz to 10 kHz and directionally from 20 kHz to 32 kHz. TOTEM was successfully trialed in October of 2006, but there remained a requirement for complete characterization of the transmitting voltage responses and directivity patterns of projectors installed in the tow-body. In March 2007, transmitting voltage responses and directivity patterns at various depths and orientations were measured at the Acoustic Calibration Barge (ACB). Results showed that the in-situ transmitting voltage response (TVR) of the omnidirectional projectors was generally 3 to 6 dB below expected performance, except in the 240 Hz to 350 Hz band. There were no marked changes noted as a result of changing depth. These response curves' shapes showed good agreement with finite element design models, except for resonance frequency shifts due to inter-projector interaction. There was also a 10 dB drop in output at 430 Hz. This drop in expected performance was shown to be caused by interactions within the tow-body.

Le simulateur de torpilles remorqué (TOTEM) a été mis au point dernièrement par Ultra Electronics Maritime Systems Incorporated (UEMS) et Brooke Ocean Technology (BOT) en vertu d'un contrat de Recherche et développement pour la défense Canada – Atlantique (RDDC Atlantique) pour la fourniture d'un système remorquable en vue de la production de signatures acoustiques émulant les signatures de torpilles. Le système TOTEM émule les signatures de torpilles à l'aide d'une série de quatre projecteurs acoustiques sous-marins et peut assurer une projection acoustique omnidirective de 120 Hz à 10 kHz, ainsi qu'une projection acoustique directive de 20 kHz à 32 kHz. Il a été mis à l'essai avec succès en octobre 2006, mais il reste une exigence pour compléter la définition des caractéristiques des réponses en tension d'émission et les diagrammes de directivité des projecteurs installés dans le corps remorqué. En mars 2007, les réponses en tension d'émission et les diagrammes de directivité à diverses profondeurs et à diverses orientations ont été mesurés au chaland d'étalonnage acoustique. Les résultats ont montré que les réponses en tension d'émission sur place des projecteurs omnidirectifs étaient en règle générale de 3 à 6 dB au-dessous du rendement attendu, sauf dans la bande de 240 Hz à 350 Hz. Il n'y a pas eu d'écart marqué en raison de la variation de la profondeur. Les formes des courbes de réponse ont montré une bonne concordance avec les modèles de conception des éléments finis, sauf en ce qui concerne les déplacements de fréquences de résonance attribuables à l'interaction entre les projecteurs. Il y a aussi eu une chute de 10 dB dans la sortie à 430 Hz. On a montré que cette chute du rendement attendu a été causée par les interactions à l'intérieur du corps remorqué.

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (Technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus, e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)

torpedo, emulator, MPS }

This page intentionally left blank.

Defence R&D Canada

Canada's leader in defence
and National Security
Science and Technology

R & D pour la défense Canada

Chef de file au Canada en matière
de science et de technologie pour
la défense et la sécurité nationale

DEFENCE DÉFENSE

www.drdc-rddc.gc.ca