

HENRIK SCHMIDT

PROFESSOR OF MECHANICAL & OCEAN ENGINEERING

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Henrik Schmidt is Professor of Mechanical & Ocean Engineering at the Massachusetts Institute of Technology. He received his MS degree from The Technical University of Denmark in 1974, and his PhD. from the same institution in 1978. From 1978 to 1982 he worked as a Research Fellow at Risoe National Laboratory in Denmark. From 1982 to 1987 he worked as Scientist and Senior Scientist at the NATO SACLANT ASW Research Centre in Italy. He has been on the MIT faculty since 1987. He has served as Associate Director of Research at the MIT Sea Grant College Program from 1989-2002, and as Associate Department Head 1994-2002. He served as Acting Department Head of Ocean Engineering between 1/1/00 to 6/30/00 and from 9/01/02 to 12/31/04. Professor Schmidt is a consultant to several DOD contractors as well as to major companies in the seismic exploration sector.

Professor Schmidt's research has focused on underwater acoustic propagation and signal processing, in particular on the interaction of sound in the ocean with seismic waves in the ocean bottom and the Arctic ice cover. His work has been of theoretical, numerical and experimental nature. He has been Principal Investigator in two Arctic ice station experiments, and Chief Scientist for several recent, major experiments in coastal environments. He has developed numerically efficient numerical algorithms for propagation of acoustic and seismic waves in the ocean and solid earth environment, including the SAFARI code and its successor OASES which is used as a reference propagation model in more than 100 institutions around the world, including all US Navy laboratories and most major universities involved in underwater acoustics and seismic research. The OASES code is also used extensively by several private DOD contractors as part of their sonar processing, and by the oil exploration community. In recent years Professor Schmidt has been pioneering the development of new underwater acoustic sensing concepts for networks of small Autonomous Underwater Vehicles (AUV). Thus, in collaboration with SACLANT Undersea Research Centre he is exploring the possibility of using AUVs for measuring the three-dimensional acoustic scattering from the seabed to detect and identify buried objects, with application to mine countermeasures and environmental management in the littoral ocean. Also, he has been leading the development of a synergy of ocean acoustic tomography and direct sampling by autonomous underwater vehicles for observation and forecasting of ocean processes on multiple scales.

Prof. Schmidt's current principal fields of interest include: Pioneering the development of new underwater acoustic sensing concepts for networks of small Autonomous Underwater Vehicles (AUV). For example, exploring the possibility of using AUVs for measuring the three-dimensional acoustic scattering from the seabed to detect and identify buried objects, with application to mine countermeasures and environmental management in the littoral ocean. Leading the development of a synergy of ocean acoustic tomography and direct sampling by autonomous underwater vehicles for observation and forecasting of ocean processes on multiple scales. Lead-PI for the multi-

institutional PLUSNet team currently developing a distributed, autonomous acoustic sensing concept, under the ONR Undersea Persistent Surveillance Program.

Professor Schmidt has authored many articles on underwater acoustics, seismics and signal processing, and has co-authored a textbook on computational ocean acoustics. He is a Fellow of the Acoustical Society of America (ASA). He served as Chairman of the ASA Technical Committee on Underwater Acoustics from 1991 to 1994 and he was an elected member of the Executive Council of ASA from 2000-2003. He also served on CORE, Ocean Observatories Steering Committee between 2000 & 2004, and the NSF ORION Cyber infrastructure Steering Committee from 2006 to 2008. Prof. Schmidt was the Lead PI on the ONR Undersea Persistent Surveillance Program during 2005-2007. He was awarded the Pioneers of Underwater Acoustics Medal by the ASA in 2005.

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Education:

Ph.D.	Technical University of Denmark	1978
M.Sc.	Technical University of Denmark	1974

Selected MIT Appointments and Service:

Associate Professor	1987-1994
Professor of Ocean Engineering	1994-2004
Professor of Mechanical and Ocean Engineering	2005-present
Associate Department Head of Ocean Engineering	1994-2005
Acting Department Head of Ocean Engineering	1/1/00-6/30/00 9/01/02-12/31/04
M.I.T. Sea Grant Program Associate Research Director	1989-2002
MIT/WHOI Joint Program	1988-1997
Joint Committee for Applied Ocean Science and Engineering	1998-2002
OE Graduate admissions committee	1989-1997
MIT Ocean Engineering Review Committee	2002-2003
Chair, MIT/WHOI Joint Program –	
Joint Committee for Applied Ocean Science and Engineering	2005-2008
ME Admissions Committee	2005-present
ME Research Council	2005-2007

Selected Honors and Awards:

Fellow, Acoustical Society of America	1989
Doherty Professorship in Ocean Utilization	1990-1993
Chair, ASA Technical Committee on Underwater Acoustics	1991-1994
Chief Scientist for Acoustics, ONR Sea Ice Mechanics Initiative	1994
Chief Scientist ONR Frontal Dynamics PRIMER	1996
Chief Scientist GOATS '98 experiment	1998
Executive Council, Acoustical Society of America	2000-2003
Lead PI ONR Undersea Persistent Surveillance Program	2005-2007
Pioneers of Underwater Acoustics Medal, ASA	2005

Selected External Professional Service

Acoustical Society of America, Technical Council	1991-1994
Acoustical Society of America, Executive Council	2000-2003
AIP, Advisory Committee on Computing in Science & Engineering	2000-2003
CORE, Ocean Observatories Steering Committee	2000-2004
NSF ORION Cyber infrastructure Steering Committee	2006-2008

Publications of Henrik Schmidt

Professor Schmidt, together with his research group and collaborators, has published over 77 peer-reviewed archival journal publications; over 96 conference proceedings papers, and is a co-inventor on two issued U.S. Patents. Professor Schmidt has mentored 15 S.M. and 26 Ph.D. theses as well as several postdoctoral associates. A list of Archival Refereed Journal Articles is provided below in chronological order:

1. Krenk, S., and Schmidt, H., "Vibration of an elastic circular plate on an elastic half space. A direct approach," *Journ. Appl. Mech.*, Vol. 48, no. 1, pp. 161-168, 1981.
2. Schmidt, H., and Krenk, S., "Asymmetric vibration of a circular elastic plate on an elastic half space." *Int. Journal of Solids and Structures*, Vol. 18, no. 2, pp. 91-105, 1982.
3. Krenk, S., and Schmidt, H., "Elastic Wave Scattering by a Circular Crack," *Phil. Trans. R. Soc. Lond.*, A308, pp. 167-198, 1982.
4. Schmidt, H., and Jensen, F.B., "An efficient numerical solution technique for wave propagation in horizontally stratified environments," *Comp. and Math. with Appl.*, 11, pp. 699-715, 1985.
5. Schmidt, H., and Jensen, F.B., "A full wave solution for propagation in multi-layered viscoelastic media with application to gaussian beam reflection at fluid/solid interfaces." *J. Acoust. Soc. Am.*, 77 (3), pp. 813-825, 1985.
6. Schmidt, H., and Glattetre, J., "A fast field model for three-dimensional wave propagation in stratified environments based on the global matrix method." *J. Acoust. Soc. Am.*, 78 (6), 2404-2114, 1985.
7. Schmidt, H., and Tango, G., "Efficient global matrix approach to the computation of synthetic seismograms," *Geophys. J. R. Astr. Soc.*, 84, 331-359, 1986.
8. Kuperman, W.A., W., and Schmidt, H., "Rough surface elastic wave scattering in a horizontally stratified ocean," *J. Acoust. Soc. Am.*, 79, pp. 1767-1777, 1986.
9. Jensen, F.B., and Schmidt, H., "Subcritical penetration of beams into sediments," *J. Acoust. Soc. Am.*, 83 (2), pp. 571-579, 1987.
10. Baggeroer, A.B., Kuperman, W.A., and Schmidt, H., "Matched field processing" Source localization in correlated noise as an optimum parameter estimation problem," *J. Acoust. Soc. Am.*, 83 (2), pp. 571-587, 1988.
11. Schmidt, H., and Kuperman, W.A., "Estimation of surface noise source level from low-frequency seismo-acoustic ambient noise measurements," *J. Acoust. Soc. Am.*, 84 (6), pp. 2153-2162, 1988.

12. Kuperman, W.A., and Schmidt, H., 'Self-consistent perturbation approach to rough surface scattering in stratified elastic media,' J. Acoust. Soc. Am., 86, pp. 1511-1522, 1989.
13. Schmidt, H., Baggeroer, A.B., Kuperman, W.A., and Scheer, E.K., "Environmentally tolerant beamforming for high resolution matched field processing: Deterministic mismatch," J. Acoust. Soc. Am., 88, pp. 1851-1862, 1990.
14. Gerstoft P., and Schmidt, H., "A boundary element approach to ocean seismo-acoustic facet reverberation," J. Acoust. Soc. Am., 89, pp. 1629-1642, 1991.
15. Miller and Schmidt, H., "Observation and inversion of seismo-acoustic waves in a complex Arctic ice environment," J. Acoust. Soc. Am., 89, pp. 1668-1685, 1991.
16. Rolt, K. and Schmidt, H., "Azimuthal ambiguities in synthetic aperture sonar and synthetic aperture radar imagery," IEEE J. Oceanic Eng., 17 (1). Pp. 73-79, 1992.
17. Collins, M., Kuperman, W.A., and Schmidt, H., "Nonlinear inversion for ocean bottom properties," J. Acoust. Soc. Am., 92 (5), pp. 2770-2783, November 1992.
18. Schmidt, H., "Numerically stable global matrix approach to radiation and scattering from spherically stratified shells." J. Acoust. Soc. Am., 94 (4), pp. 2420-2430, 1993.
19. J-Y Liu, Schmidt, H., and Kuperman, W.A., "Effect of a rough sea bed on the spectral composition of deep ocean infrasonic ambient noise," J. Acoust. Soc. Am., 93 (2), pp. 753-769, 1993.**
20. Ricks, D. and Schmidt, H., "A numerically stable global matrix method for cylindrically layered shells excited by ring forces," J. Acoust. Soc. Am., 95, (6), pp. 3339-3349, 1994. **
21. Kurkjian, A., Coates, R.T., White, J.E., and Schmidt, H., "Finite difference and frequency-wavenumber modeling of seismic monopole sensors in fluid-filled boreholes," Geophysics, 59 (7), pp. 1053-1064, 1994.
22. LePage, K., and Schmidt, H., "Modeling of low frequency transmission loss in the Central Arctic," J. Acoust. Soc. Am., 96 (3), pp. 1783-1795, 1994. **
23. Goh, J.T. and Schmidt, H., "Validity of spectral theories for weakly range-dependent ocean environments—Numerical results," J. Acoust. Soc. Am., 95 (2), pp. 727-732, 1994. **
24. Rolt, K. and Schmidt, H., "Effects of refraction on synthetic aperture sonar imaging," J. Acoust. Soc. Am., 95 (6), pp. 3424-3429, 1994. **
25. Rolt, K., Schmidt, H., and Rolt, G.H., "Commentary on 'Effects of propagation on the operation of a synthetic aperture sonar' [J. Acoust. Soc. Am., 82 (4) , 1403-1408, Oct. 1987]," J. Acoust. Soc. Am., 96 (4), pp. 469-475, 1994.**

26. Schmidt, H., and Kuperman, W.A., 'Spectral and modal representations of the Doppler shifted field in ocean waveguides,' J. Acoust. Soc. Am., 96(4) 386-395, 1994.
27. Livingston, E. and Schmidt, H., "A comparison of the conventional, the minimum variance, and the multiple constraint matched field processors," J. Comp. Acoust., 2(3), 217-229, 1994.
28. Schmidt, H., and Kuperman, W.A., "Spectral representations of rough interface reverberation in stratified ocean waveguides," J. Acoust. Soc. Am., 97(4), 2199-2209, 1995.
29. Bondaryk, J., and Schmidt, H., "Array processing for the analysis of stiffened, fluid-loaded, cylindrical shells," J. Acoust. Soc. Am., 97(2), 1067-1077, 1995. **
30. Schmidt, H., Seong, W., and Goh, J.T., "Spectral super-element approach to range-dependent ocean acoustic modeling," J. Acoust. Soc. Am., 98(1), 465-472, 1995. **
31. Kapoor, T. and Schmidt, H., "Spherical coordinate Green's function for ring tractions in a solid unbounded medium," J. Acoust. Soc. Am., 98(5), 2783-2791, 1995. **
32. LePage, K., and Schmidt, H., "Analysis of spatial reverberation statistics in the Central Arctic," J. Acoust. Soc. Am., 99(4), 2033-2047, 1996. **
33. Bondaryk, J. and Schmidt, H., "Hybrid processing structure for the analysis of scattering from stiffened, fluid-loaded, cylindrical shells," J. Acoust. Soc. Am., 99(4), 2176-2187, 1996. **
34. Goh, J.T. and Schmidt, H., "A hybrid coupled waveguide integration approach to range-dependent seismo-acoustic modeling," J. Acoust. Soc. Am., 100(3):1409-1420, 1996 **
35. Elisseeff, P., and Schmidt, H., "Acoustic propagation through a low Mach number, stratified flow," J. Acoust. Soc. Am., 101:1936-1944, Apr. 1997 **
36. Kapoor, T., and Schmidt, H., "Acoustic scattering from a three-dimensional protuberance on a thin, infinite, submerged elastic plate," J. Acoust. Soc. Am., 102(1):256-265, July 1997. **
37. Kapoor, T., and Schmidt, H., "Matched Field evaluation of acoustic scattering from rough Arctic ice," J. Acoust. Soc. Am., 102(2):865-876, August 1997. **
38. Goh, J.T., Schmidt, H., P. Gerstoft and W. Seong, " Benchmarks for validating range-dependent seismo-acoustic propagation codes," IEEE Journal of Oceanic Engineering, 22(2) ,1997. **
39. Tracey, B., and Schmidt, H., "Seismo-acoustic field statistics in shallow water," IEEE Journal of Oceanic Engineering, 22(2):317-331,1997. **

40. Cederberg, R.J., Collins, M., Schmidt, H., Siegmann W.L., "Rational operators for filtering," J. Acoust. Soc. Am., 101(5):.02518-2523, 1997.
41. Dudko, Y., Schmidt, H., von der Heydt, K., Scheer, E., "Edge wave observation using remote seismoacoustic sensing of ice events in the Arctic," J. of Geophy. Res., 103(C10):21775-21781, 1998. **
42. Elisseeff, P., Schmidt, H., Johnson, M., Herold, D., Chapman, N.R., and McDonald, M.M. "Acoustic tomography of a coastal front in Haro Strait, British Columbia", J. Acoust. Soc. Am.,106(2):169-184,1999. **
43. Schmidt, H., and Lee, J.Y., "Physics of 3-D scattering from rippled seabeds and buried targets in shallow water," J. Acoust. Soc. Am, 105(3):1605-1617,1999. **
44. Tracey, B. and Schmidt, H., "A self-consistent theory for seabed volume scattering," J. Acoust. Soc. Am., 106 (5):.2524-2534 , 1999. **
45. Maguer, A., Bovio, E., Fox, W.L., Pouliquen, E., and Schmidt, H., "Mechanisms for subcritical penetration into a sandy bottom: Experimental and modeling results," J. Acoust. Soc. Am, 107(3): 1215, 2000.
46. Maguer, E. Bovio, W.L Fox, and H. Schmidt. "In situ estimation of sediment sound speed and critical angle," J. Acoust. Soc. Am J. Acoust. Soc. Am., 108 (3) Pt.1:.987-996, Sept. 2000.
47. K. LePage and H. Schmidt. "Spectral integral representations of volume scattering in sediments in layered waveguides," J. Acoust. Soc. Am., 108 (4); 1557-1567, October 2000
48. M. D. Collins, H. Schmidt, and W. L. Siegmann, "An Energy-Conserving Spectral Solution," J. Acoust. Soc. Am. 107(4), 1964--1966 (2000).
49. LePage, K., Schmidt, H. "Bistatic synthetic aperture imaging of proud and buried targets from an AUV". IEEE Journal of Oceanic Engineering 27(3) pp. 471-483, 2002.
50. J. R. Edwards, H. Schmidt and K. LePage, "Bistatic synthetic aperture target detection and imaging with an AUV". IEEE Journal of Oceanic Engineering 26(4) pp. 690-699, 2001. **
51. LePage, K., Schmidt, H. "Spectral integral representations of monostatic backscattering from threedimensional distributions of sediment volume inhomogeneities". Journal of the Acoustical Society of America, 113(2), 789-799, 2003.
52. Tesei, A., Lim, R., Maguer, A., Fox, W.L.J., Schmidt, H. "Measurements of acoustic scattering from partially and completely buried spherical shells". Journal of the Acoustical Society of America 112(5), 1817-1830, 2002.

53. Elisseeff, P., Schmidt, H., Xu, W. "Ocean acoustic tomography as a data assimilation problem". IEEE Journal of Oceanic Engineering, Vol. 27, No. 2, pp275-282, 2002. **
54. Xu, W., Schmidt, H. "System-orthogonal functions for sound velocity profile perturbation". IEEE Journal of Oceanic Engineering, Vol.31, No.1, pp.156-169, January 2006.
55. M. Montanari, J.R. Edwards, and H. Schmidt. "Autonomous Underwater Vehicle-based Concurrent Detection and Classification Concept Using Higher-order Spectral Analysis," IEEE Journal of Oceanic Engineering, Vol.31, No.1, pp.188-199, January 2006. **
56. Xu, W., Baggeroer, A.B., Schmidt, H., "Performance Analysis for Matched-Field Source Localization: Simulations and Experimental Results", IEEE Journal of Oceanic Engineering, Vol. 31, No. 2, pp. 325-344, April 2006.
57. Eickstedt, D.P., Benjamin, M.R., Schmidt, H., Leonard, J.J., "Adaptive Tracking of Underwater Targets with Autonomous Sensor Networks", submitted for publication in US Navy Journal of Underwater Acoustics, 2006. **
58. Lucifredi, I., Schmidt, H., "Subcritical scattering from buried elastic shells", J. Acoust. Soc. Am. 120 (6), pp. 3566-3583, December 2006. **
59. Eickstedt, D.P., Benjamin, M.R., Wang, D., Schmidt, H., "Behavior Based Adaptive Control for Autonomous Oceanographic Sampling", in Proc. 2007 IEEE Int. Conf. on Robotics and Automation, Rome, Italy, pp. 4245-4250, April 2007. **
60. Benjamin, M.R., Battle, D., Eickstedt, D.P., Schmidt, H., Balasuriya, A., "Autonomous Control of an Autonomous Underwater Vehicle Towing a Vector Sensor Array", in Proc. 2007 IEEE Int. Conf. on Robotics and Automation, Rome, Italy, pp. 4562-4569, April 2007.
61. A. Balasuriya, H. Schmidt, M.B. Benjamin, "Integrated sensing, modeling, and control in undersea sensor networks (A)", J. Acoust. Soc. Am. 123 3007 (2008)
62. H. Schmidt, K.D. LePage, "Propagation, scattering and reverberation in an ice-covered Arctic ocean (A)", J. Acoust. Soc. Am. 123 2989 (2008)
63. K. Cockrell, H. Schmidt, "Source localization and tracking in a waveguide via sequential bayesian estimation (A)" J. Acoust. Soc. Am. 123 3339 (2008) **
64. Wang, D., Lermusiaux, P. F. J. *, Haley, P. J., Eickstedt, D., Leslie, W. G., Schmidt, H., "Acoustically Focused Adaptive Sampling and On-board Routing for Marine Rapid Environmental Assessment", Journal of Marine Systems, 78(S1), S393-S407. 2009. **
65. W. Luo and H. Schmidt, "Three-Dimensional Propagation and Scattering around a Conical Seamount," J. Acoust. Soc. of Am., 125(1), 52-65, 2009 **

66. H. Schmidt, D.P. Eickstedt, A.P. Balasuriya, D. Battle, M.R. Benjamin, Nested Autonomy – A Concept of Operations for Distributed, Undersea Acoustic Surveillance, U.S. Navy Journal of Underwater Acoustics (Secret, NoForn), 2009.
67. A.J. Poulsen, D. P. Eickstedt, and H. Schmidt, “Stabilized target bearing estimation and tracking for AUVs with towed hydrophone arrays,” U.S. Navy Journal of Underwater Acoustics, 2009 [in press, refereed].
68. M. R. Benjamin, H. Schmidt, P. Newman and J.J. Leonard, Nested Autonomy for Unmanned Marine Vehicles with MOOS-IvP, Journal of Field Robotics 27(6), 834–875 (2010)
69. K. L. Cockrell, H. Schmidt, “Robust passive range estimation using the waveguide invariant” J. Acoust. Soc. Am., 127, pp. 2780-2789 (May 2010)**
70. K. L. Cockrell , H. Schmidt, “A relationship between the waveguide invariant and wavenumber integration” J. Acoust. Soc. Am., 128, pp. EL63-EL68 (July 2010)**
71. T. Schneider and H. Schmidt, “Unified command and control for heterogeneous marine sensing networks.” Journal of Field Robotics, 27: 876–889, 2010. **
72. K. L. Cockrell , H. Schmidt, “A modal WKB approach to calculating the waveguide invariant for non-ideal waveguides”, J. Acoust. Soc. Am. , 130, 72-84 (2011). **
73. S. Petillo, H. Schmidt, and A. Balasuriya, "Constructing a Distributed AUV Network for Underwater Plume-Tracking Operations,” International Journal of Distributed Sensor Networks, vol. 2012, Article ID 191235, 2012.**
74. K. L. Cockrell and H. Schmidt, "Calculating the waveguide invariant for non-ideal waveguides" (2011) **
75. T. Schneider and H. Schmidt, “Model-based Adaptive Behavior Framework for Optimal Acoustic Communication and Sensing by Marine Robots”, Submitted to IEEE J. Oceanic Eng., (2011).**
76. S. Petillo and H. Schmidt, “Exploiting Adaptive and Collaborative AUV Autonomy for Detection and Characterization of Internal Waves”, Submitted to IEEE J. Oceanic Eng., (2011).**
77. R. Lum and H. Schmidt, “Integrated Perception, Modeling and Control for Bistatic Sonar Tracking by Autonomous Underwater Vehicles”, Submitted to IEEE J. Oceanic Eng., (2011).**