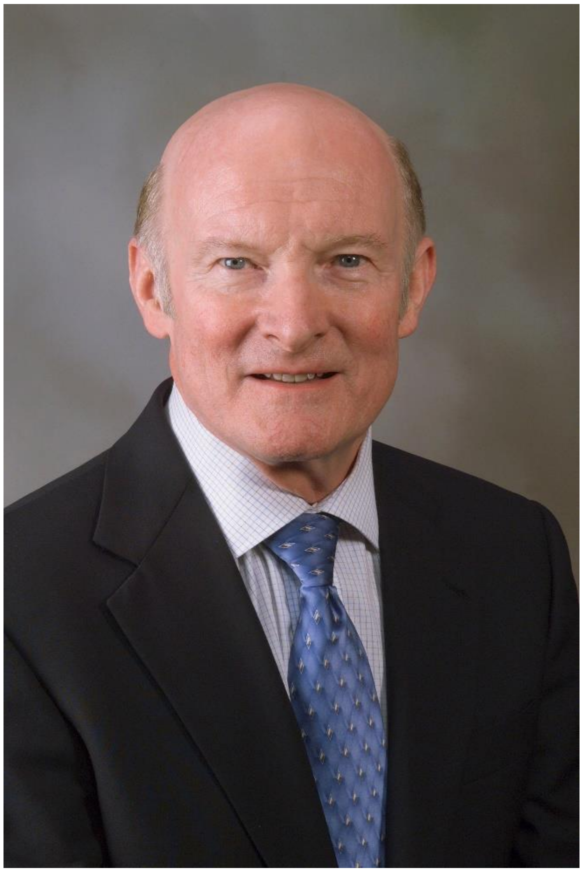
HALL OF FAME

A Pioneer of Computer-Based Ship Structural Design

Professor Owen F. Hughes



Dr Owen F. Hughes was professor of Ship Structures, Department of Aerospace and Ocean Engineering, Virginia Tech, Blacksburg, VA. He was recognized internationally as a pioneer in the field of first-principles structural design, having been one of the first to achieve a synthesis of finite element analysis, ultimate strength analysis and mathematical optimization. In doing so, he made several fundamental contributions in all three of these areas. His book Ship Structural Design [1], published in 1983, embodies an entirely new approach for ship structural design, as indicated by its subtitle: A Rationally-Based, Computer-Aided Optimization Approach. He also implemented the method in a computer program called MAESTRO [2] (Method for Analysis, Evaluation and Structural Optimization). MAESTRO is now used by navies, by structural safety authorities, and by structural designers and shipyards in Europe, North America, Asia, and Australia. In addition to his textbook, Professor Hughes is the author or co-author of over 60 journal articles and conference papers. Dr Hughes has been NAVSEA Research Professor at the US Naval Academy, chairman of the SNAME Panel on Design Procedures and Philosophy, and chairman of the International Ship Structures Congress (ISSC) Committee on Computer-Aided Design. His education includes PhD (Naval Architecture), University of New South Wales, 1970; MS (Naval Architecture), MIT, 1963; and BS (Naval Arch.), MIT, 1961.

Professor Owen Hughes was born in Chicago, Illinois on November 7, 1939. The first-born child in a family of three children, Owen developed a love for the sea at a young age, becoming a Sea Scout and raising money for a Ship to Ship and Ship to Shore radio. This experience ultimately saved Owen's life a year later when his Sea Scouts boat and team were caught in a violent storm on Lake Michigan. With his boat sinking, Owen was able to radio for help and was ultimately rescued by a nearby Yugoslavian tanker!

After attending a private liberal high school where he excelled in math and competitive diving, Owen went on to a midwestern liberal arts college. However, soon after his second year, Owen realized that he wanted to be a naval architect and applied to the Massachusetts Institute of Technology (MIT). Owen was one of the few transfer students accepted into MIT and his hard work and dedication even earned him a scholarship.

In 1962 Owen was doing a Ph.D. at Massachusetts Institute of Technology (MIT). He had just joined Opus Dei, a relatively young (founded in 1928) but already a worldwide association of the Catholic Church (for more information see, opusdei.org) and was living in a student residence run by Opus Dei. The previous year his roommate, Ron Woodhead, had been a lecturer (assistant professor) on a one-year sabbatical leave from the University of New South Wales (UNSW) in Sydney, Australia. In January of 1963 he wrote to say that his university was establishing a Department of Naval Architecture – the first in Australia – and asked if Owen was interested in applying. At about the same time Owen learned that Opus Dei had been invited to establish a 'College' (student residence) at that same university! The coincidence was too much to ignore. He applied to UNSW and was appointed as a senior tutor. So Owen gave up his MIT Ph.D. (his friends thought he was crazy) and went to UNSW.

Owen began teaching there full time and had two part-time 'jobs': getting his Ph.D. and helping to establish 'Warrane College' as it was eventually named. Both of these tasks took seven years! When the College was opened in 1970, Owen became the dean of studies where he was responsible for organizing the program of tutorials for students.

In 1970 Owen attended his first International Ship Structures Congress (ISSC) in Tokyo (the fourth ISSC). Since there was no one else from Australia he became the Australian correspondent. The ISSC had a big effect on Owen as he met (or at least mingled with) nearly all of the world's experts in ship structures, strongly confirming his decision to change over to that field (his Ph.D. was in fluid mechanics).

But the real reason for Owen's decision was that he could see that there were exciting developments in four synergistic areas: (1) finite element analysis (FEA) – in this area Owen had a wise and experienced guide: Ron Woodhead, his former MIT roommate and now close friend and colleague, was one of the developers of frame analysis, the civil engineering precursor to FEA; (2) computers – they were still bulky and expensive, but it was computers that had made frame analysis feasible, and it was clear to everyone that they would grow in power and shrink in size and cost, and already they were the reason for the feasibility and rapid development of FEA; (3) steadily improving knowledge about the modes of structural failure, especially buckling and fatigue, so that we could quantitatively evaluate the health (safety) of a structure, and thereby move beyond a 'code' or 'rule-based' method of structural design; and (4) emerging methods of mathematical optimization, through which the process of structural design could be given explicit goals, and an 'autopilot' that would direct the process towards those goals (thus also moving away from a rule-based prescriptive approach). The synergism was obvious and, being only one person and a novice at that, Owen was sure that some much stronger entity (navy, shipyard, classification society, etc.) would completely eclipse whatever small results he might produce. But Owen saw the potential of an exciting and fun challenge and he persisted with his ideas regardless. This proved to be a wise decision as he was very fortunate to meet and join with many other young researchers who also saw the synergy and shared his feelings.

In June 1972 Owen went on his first sabbatical leave, doing research at University College London (UCL), which had special expertise in ship structures, having inherited the professors and curricula of the Royal Corps of Naval Constructors. The University of Newcastle was another well-established center of ship structures, and while at UCL Owen visited Newcastle, mainly to get to know Professor John Caldwell, who had been a visiting professor at MIT teaching ship structures while Owen was a graduate student there. His teaching was superb, and now that Owen had chosen ship structures, he wanted to re-establish contact.

To Owen, the most important professional body was the ISSC. Compared to, for example, medicine or law, the ship structure community is a small world, and the ISSC (with less than 200 members) makes it both collegial and focused. It was founded in 1960 and consists of a Standing Committee and 15 specialist committees. It meets every three years, and during the intervening period each committee meets three or four times and prepares a report on recent developments in their special area. The fifth congress met at Hamburg in 1973, and Owen was appointed as a member of the Structural Optimization Committee.

In 1973, Owen received a grant from the Australian Navy to develop an indigenous ship structural evaluation and design capability. Funded by this grant, Owen was joined by a postdoctoral fellow, Farrokh Mistree, and together they developed RANSAP for ship structural analysis and SLIP2 (sequential linear programming – second order) to optimize ship structures. The two programs were merged into the automated ship structural evaluation system (AUSEVAL).

In February 1976 Owen began his second sabbatical, teaching ship structures at MIT. That semester was when Owen first met Vedran Žanić, a research associate at MIT who shared exactly the same views about the four synergistic areas mentioned above. While at MIT, Vedran and Owen began to develop the next generation of a ship structural optimization system, SHIPOPT[3]. The cornerstone of SHIPOPT is its special "design-oriented" FEM, which uses large specially developed elements, each of which corresponds to a principal structural member in a ship such as a stiffened panel or a keel girder. Instead of using the general-purpose elements in more general programs, such as NASTRAN or SESAM, these special elements reduce the complexity of the model. Owen worked on the stress analysis and the failure evaluation modules, while Vedran simplified the linearization procedure in SHIPOPT and reorganized the SLIP2 optimizer into a faster 'modified dual' form. In August they attended the sixth ISSC, which was held right there in Boston.

About the same time Owen was contacted by Professor Michael McCormick of the US Naval Academy, who was the editor of the Ocean Engineering series of books published by John Wiley & Sons. He invited him to write a book on ship structures. The book, Ship Structural

Design (SSD) [1] published by John Wiley and Sons Ltd in 1983, was considered as one of the best ship structural textbooks at the time, and was translated into Chinese and Russian.

In 1976, Owen and Farrokh obtained a grant from the American Bureau of Shipping (ABS) to support the further development of SHIPOPT. Vedran was also involved in the SHIPOPT project, and in March of 1979 came to UNSW. For the next five months, the team worked on the documentation of the code, their paper for Journal of Ship Research (Hughes, et.al. 1980[4]) and on the benchmark example based on the SD14 general cargo ship. In August, the team attended the seventh ISSC in Paris. From 1979 to 1981 Owen made many visits to ABS, working with John Mahowald. Together they wrote a paper on SHIPOPT that they presented at the SNAME Annual Meeting in November of 1981. Unfortunately, ABS did not want to go any further with SHIPOPT because it was a design tool, and at that time classification societies engaged only in plan approval and not in anything that would constitute structural design. So, Owen became the sole developer of the software and coined a new name from its various parts: Modelling, Analysis, Evaluation and Structural Optimization, or MAESTRO. MAESTRO is a computer program for rationally based optimum design of large, complex thin-walled structures. In essence, MAESTRO is a synthesis of finite element analysis, failure (or limit state) analysis and mathematical optimization, all of which is smoothly integrated under a graphical interface. MAESTRO accommodates non-linear failure modes and large complex structural geometries. It can therefore be used for virtually all large structures including cargo ships (tankers, bulk carriers, and containerships), high speed multi-hull and monohull vessels, surface combatants, aircraft carriers, submarines, and floating offshore facilities. The theoretical basis for MAESTRO is provided in Ship Structural Design. The MAESTRO system incorporates interfaces with hull and arrangements surface models and CAD models in formats routinely used in concept and preliminary design. For this reason, MAESTRO provides a structural design facility that can be applied as early as concept design and used to support decisions regarding light ship weight objectives and overall naval architecture impacts of the structural design.

From January to May of 1983 Owen was a visiting professor at the US Naval Academy, and was involved in editing the final galley proofs of SSD. Each week he would give the midshipmen a new chapter; sets of weird legal-sized pages with scribbled corrections, that would eventually become part of the book that finally appeared later that year. While living in Annapolis, Owen got to know the naval architects at Giannotti & Associates (G&A), among them Tobin McNatt. With G&A, Owen was able to reach an agreement where they would provide the marketing, distribution and user support for MAESTRO. This partnership proved successful, especially in regard to the US Naval Sea Systems Command (NAVSEA) in Washington.

Lloyd's Register (LR) also expressed an interest in MAESTRO, and Ieuan Phillips of LR came to Sydney in August 1985 bringing a 'blindfold test' for MAESTRO –data from a ship that had suffered an unexpected structural failure. The team made the MAESTRO model and imposed the loads, and Owen was happy to see that MAESTRO correctly diagnosed the problem.

During the same time in the United Kingdom, Robert Dow, who at that time was in charge of ship structures at the UK Naval Research Centre at Rosyth, Scotland, applied MAESTRO to numerous UK MOD Naval vessels, including composite minehunters and conventional monohull and trimaran designs. He was then and still is a staunch supporter and user of MAESTRO. Bob Dow is now professor in the School of Marine Science and Technology at the University of Newcastle, where he has applied MAESTRO to search and rescue craft research for the Royal National Lifeboat Institution (RNLI), as well as for graduate research and teaching.

In 1985, Dr. John Adamchak, a structural expert at US Navy's principal research lab for surface ships (the David Taylor Research Center) began to collaborate with Owen in the use of MAESTRO for the US Navy. Together, they implemented US Navy limit state design criteria into MAESTRO. At that time George Washington University (in Washington DC) was providing Master's degree courses for the naval architects and engineers at DTRC. The Navy wanted Owen to teach ship structures there, so GWU appointed him as a distinguished visiting professor. So in September of 1985, Owen took leave from UNSW and taught for one semester at DTRC.

In December 1986, Professor Raphael Haftka of the Department of Aerospace and Ocean Engineering at Virginia Tech (VT) invited Owen to give a seminar there. Soon after, Owen was offered an appointment as a full professor. It was a difficult decision for Owen to leave Sydney, but there were two other factors that affected his decision: his parents were getting very elderly and needed him to be closer, and Tobin McNatt and his colleagues had told Owen that if MAESTRO was to be successful he needed to be closer to the users and the technical support team. So, after 25 years in Sydney, Owen returned to the United States on 4 July 1988.

Owen's first semester at Virginia Tech was off-campus; Virginia Tech provides a Master's degree program for the Naval Sea Systems Command, so he lived in Washington DC and taught ship structures until the end of 1988. By that time Ross–McNatt had a branch in Washington and they provided an office for him. It was during that time that Owen began to discuss the use of MAESTRO by the Canadian Navy and developed a working relationship with Merv Norwood of Martec Ltd. in Halifax. Martec would be an important development partner for MAESTRO.

Also, in 1988 John Wiley & Sons sold the last copy of Ship Structural Design. They knew they had saturated the reference book market, so they declined another printing. In such a case the copyright reverts to the author. Because Owen had always intended the book's audience to have been students, and knowing SNAME's charitable policy on student prices, Owen generously donated the copyright to them.

In an earlier visit to John Caldwell at the University of Newcastle, Owen met Philip Thompson, who for his Ph.D. had developed a very elegant finite element for representing stiffened panels. Together, the two of them worked to integrate Philip's finite element system into MAESTRO.

In 1990 the US Navy arranged with VT for Owen to work at DTRC, putting Navy structural criteria into MAESTRO and making other improvements.

As part of its agreement with the US Navy, VT provided Master's courses to the US Naval Surface Warfare Center (NSWC) at Dahlgren, VA. In the fall semester of 1993 Owen was part of a group of engineering professors who taught at NSWC once a week.

In 1994 the VT Provost told the dean of engineering that as an economic measure, the ocean engineering Master's program was going to be canceled. Fortunately, Owen and the other professors had already begun to transition the program to the Internet, allowing students the ability to playback recorded lectures from any location and at any time. As a result of this, in the next three years the number of OE Masters students jumped from 15 to 75 and was still growing. Owen also received letters of support, pointing out that the OE course was one of very few in the nation; it was a vital national asset. Owen was one of a few full professors who spent lots of time with undergraduates. His dedication, kindness and compassion were echoed by colleagues and many students. He also mentored a number of PhD and MS students, and continued research on ultimate strength and optimization. [10-25]

In 1994 the MAESTRO team began discussions with the senior management of the Classification Society Bureau Veritas (BV), in Paris, including Dominique Béghin, who was the scientific director of the Marine Branch. Over the next two years Dominique made several visits to Stevensville and to VT to assess MAESTRO, and Tobin made several visits to BV. In 1996, at Dominique's recommendation, BV decided to use MAESTRO as the basis for their first version of VeriSTAR. Over the next three years the MAESTRO team made many visits to BV including working on-site to collaborate in developing the MAESTRO component of BV's VeriStar software. VeriStar was subsequently released for use by BV clients worldwide.

In a similar development, during this time, Owen and the MAESTRO team engaged with the American Bureau of Shipping (ABS) and formed a collaboration to utilize MAESTRO as a component of the ABS SafeHull ship structural assessment software.

In 1997, during the thirteenth ISSC meeting in Trondheim, Owen and Jeom Paik, a professor at Pusan National University (PNU) known for his research on the ultimate strength of ship structures, collaborated to incorporate Jeom's ultimate-strength computer programs ALPS/ULSAP[8] and ALPS/HULL[9] into MAESTRO[8][9]. In 2010, Owen published the second edition of SSD with Prof. Jeom Kee Paik, titled *Ship Structural Design and Analysis* [7].

MAESTRO has been applied as a structural design, analysis and optimization toolset in many U.S. Navy research programs such as the DARPA Maritech program and the National Shipbuilding Research Program (NSRP). Likewise the U.S. Navy and its U.S. based shipbuilders have used MAESTRO for design, assessment, and optimization of many ship classes including the DDG 1000 Zumwalt Class, Littoral Combat Ship Freedom and Independence Classes, and recently to design and optimize the U.S. Navy's FFG(X) by Fincantieri Marinette Marine. Similarly, the U.S. Coast Guard has applied MAESTRO for in-service structural engineering of many classes of their patrol vessels and cutters.

Owen retired as a Professor (Emeritus) after teaching for 50 years – 25 at UNSW and 25 at VT. He attended 15 ISSC congresses over the course of his long and distinguished career.

Professor Hughes demonstrated exceptional vision and creativity when during the 1970's he recognized the opportunity to change the technical approach used for ship structural design and proceeded to lead the development of methods and computer-based tools to make these innovations available to the real-world of ship design. Throughout his life Professor Hughes also remained committed to his faith and life's work with Opus Dei, a worldwide association of the Catholic Church, to his love and devotion to teaching, and to his unflagging work to cultivate and bring to fruition his vision for applying a rationally-based approach to the complex task of ship and floating structures design.

References:

1. Hughes, O. F., Ship Structural Design: A Rationally-based, Computer-aided Optimization Approach, John Wiley and Sons Ltd, 1983
2. MAESTRO Version 11.12. (2020). Program documentation, MAESTRO Marine LLC., Maryland, http://www.maestromarine.com.
3. Hughes, O.F., Janava, R.T. and Wood, W.A., SHIPOPT-A CAD system for rationally based ship structural design and optimization, in Computer Applications in the Automation of Shipyard Operation and Ship Design IV, ICCAS 1982, Rogers, D.F., Nehrling, B.C. and Kuo, C. (Eds), Noth Holland, Amsterdam, 1982.
4. Hughes, O F, Mistree, F and Zanic, V. 1980. A practical method for the rational design of ship structures. *J Ship Res.*, 24(2): 101–113.
5. F. Mistree, O. F. Hughes and H. B. Phuoc, "An Optimization Method for the Design of Large, Highly Constrained, Complex Systems", Engineering Optimization, 5(3), 1981, 141-144.
6. O. F. Hughes, "Computer-Aided Optimum Structural Design of Tension Leg Platforms", CADMO '86, International Conference on Computer-Aided Design in Marine and Offshore Industries, 1986.
7. Hughes, O.F. and Paik, JK. 2010. *Ship structural analysis and design*, New Jersey: The Society of Naval Architects and Marine Engineers.
8. ALPS/ULSAP. Ultimate strength analysis of plates and stiffened panels under combined biaxial compression /tension, edge shear and lateral loads. MAESTRO Marine LLC.
9. ALPS/HULL. Hull girder progressive ultimate strength analysis. MAESTRO Marine LLC
10. Hughes, O. F., “Two First Principles Structural Designs of a Fast Ferry – All Aluminum and All-Composite,” Proceedings of FAST 97 Conference, Sydney, Australia, June 1997.
11. “Elastic Tripping of Asymmetric Stiffeners”, O.F. Hughes and M. Ma, Computers and Structures, Vol. 60. No. 3, pp. 369-389, 1996.
12. “Inelastic Analysis of Panel Collapse by Stiffener Buckling”, M. Ma, and O.F. Hughes and Computers and Structures, Vol. 61. No. pp. 107-117, 1996.
13. “Lateral Distortional Buckling of Monosymmetric I-Beams under Distributed Vertical Load”, M. Ma and O.F. Hughes, Thin-Walled Structures, Vol. 26, No. 2, pp123-145, 1996.
14. “Lateral Distortional Buckling of Monosymmetric I-Beams under a Concentrated Load”, O. F. Hughes and M. Ma, Journal of Structural Engineering, Oct. 1996, Vol 122, No. 10.
15. Hughes, O.F., Ghosh, B. and Chen, Y. “Improved Prediction of Simultaneous Local and Overall Buckling of Stiffened Panels.” Thin-Walled Structures, 42, (2004): 827-856.
16. Improved prediction of simultaneous local and overall buckling of stiffened panels, Thin-Walled Structures 42(6):827-856 · June 2004
17. Analytical Solution for the Ultimate Strength of Metal-faced Elastomer-cored Sandwich Panels under In-plane Edge Compression and Lateral Pressure
18. “Tripping Analysis and Design Consideration of Permanent Means of Access Structure”, M. Ma, B.S. Jang and O.F. Hughes, Proceedings of the OMAE 2011, Rotterdam, Netherlands
19. “Permanent Means of Access Structural Design using Multi-objective Optimization”, M. Ma, and O.F. Hughes, Proceedings of the OMAE 2011, Rotterdam, Netherlands
20. “Applying Sectional Seakeeping Loads to Full Ship Structural Models Using Quadratic Programming”, Ming Ma, Owen Hughes, Chengbi Zhao, Proceedings of the International Conference of Maritime Technology, 2012

21. "Ultimate strength based stiffened panel design using multi-objective optimization methods and its application to ship structures", Ming Ma, Owen Hughes, Jeom Kee Paik, Proceedings of PRADS 2013.
22. "Applying strip theory based linear seakeeping loads to 3d full ship finite element models", Chengbi Zhao, Ming Ma, Owen Hughes, Proceedings of the OMAE 2013, Nantes, France.
23. "A practical method to apply hull girder sectional loads to full-ship 3D finite-element models using quadratic programming", Ming Ma, Chengbi Zhao, Owen Hughes, *Ships and Offshore Structures*, April, 2013
24. "Applications of Vector Evaluated Genetic Algorithm (VEGA) in Ultimate Limit State Based Ship Structural Design", Owen Hughes, Ming Ma, Jeom Kee Paik, Proceedings of the OMAE 2014 , San Francisco, USA
25. "Ultimate limit state based ship structural design using multi-objective discrete particle swarm optimization", Ming Ma, Owen Hughes, Tobin McNatt, Proceedings of the OMAE 2015, St. Johns, Canada