The Elmer A. Sperry Award 2006

FOR ADVANCING THE ART OF TRANSPORTATION

The Elmer A. Sperry Award

The Elmer A. Sperry Award shall be given in recognition of a distinguished engineering contribution which, through application, proved in actual service, has advanced the art of transportation whether by land, sea or air.

In the words of Edmondo Quattrocchi, sculptor of the Elmer A. Sperry Medal:

"This Sperry medal symbolizes the struggle of man's mind against the forces of nature. The horse represents the primitive state of uncontrolled power. This, as suggested by the clouds and celestial fragments, is essentially the same in all the elements. The Gyroscope, superimposed on these, represents the bringing of this power under control for man's purposes."

Presentation of

The Elmer A. Sperry Award for 2006

to

ANTONY JAMESON

in recognition of his seminal and continuing contributions to the modern design of aircraft through his numerous algorithmic innovations and through the development of the FLO, SYN, and AIRPLANE series of computational fluid dynamics codes.

by

The Elmer A. Sperry Board of Award
under the sponsorship of the:

American Society of Mechanical Engineers
Institute of Electrical and Electronics Engineers
Society of Automotive Engineers
Society of Naval Architects and Marine Engineers
American Institute of Aeronautics and Astronautics
American Society of Civil Engineers

at the
45th AIAA Aerospace Sciences Meeting and Exhibit
Reno, Nevada

9 January 2007

Antony Jameson

Antony Jameson has authored or co-authored 300 scientific papers in a wide range of subject areas, including both control theory and aerodynamics, and is the principal developer of the well known series of `FLO' and 'SYN' codes, which have been used throughout the aerospace industry. He was born in Gillingham, Kent in 1934. Much of his early childhood was spent in India where his father was stationed as a British army officer. He first attended school at St. Edwards, Simla. Subsequently he was educated at Mowden School and Winchester College. He served as a lieutenant in the British Army in 1953-1955, and was sent to Malaya. On coming out of the army he worked in the compressor design section of Bristol Aero-Engines in the summer of 1955, before studying engineering at Trinity Hall, Cambridge University, graduating with first class honors in 1958. Subsequently he stayed on at Cambridge to obtain a Ph.D. in Magnetohydrodynamics, and he was a Research Fellow of Trinity Hall from 1960-1963.

On leaving Cambridge he worked as an economist for the Trades Union Congress in 1964-1965. He then became chief mathematician at Hawker Siddeley Dynamics in Coventry. In 1966 he joined the Aerodynamics Section of the Grumman Aerospace Corporation in Bethpage, New York. In this period his work was largely directed toward the application of automatic control theory to stability augmentation systems. Starting in 1970, he began to concentrate on the problem of predicting transonic flow. Existing numerical methods were not equal to the task, and it was clear that new methods would have to be developed. At that time limitations in computer capabilities also precluded any attempt to calculate the flow past a complete aircraft, but useful efforts could be made for simpler configurations such as airfoils and wings.

In 1972 he moved to the Courant Institute of Mathematical Sciences at New York University, where he continued his work on transonic flow. In 1974 he was appointed professor of Computer Science at New York University. He joined Princeton University in 1980, and in 1982 he was appointed James S. McDonnell Distinguished University Professor of Aerospace Engineering. He was director of the University's program in Applied and Computational Mathematics from 1986 to 1988. During that decade Antony Jameson devised a variety of new schemes for solving the Euler and Navier-Stokes equations for inviscid and viscous compressible flows, and wrote a series of computer programs which have been widely used throughout the aircraft industry. He and his co-workers were finally able to realize their goal of calculating the flow past a complete aircraft in 1985, using his new finite element method. Subsequently, he re-focused his research on the problem of shape optimization for aerodynamic design.

Antony Jameson

In 1980 he received the NASA Medal for Exceptional Scientific Achievement in recognition of his earlier work on transonic potential flow. In 1986 he was appointed an honorary professor of North Western Polytechnic University in Xian, China. In 1988 he received the Gold Medal of the British Royal Aeronautical Society for his outstanding contribution to the development of methods for the calculation of transonic flow over real aircraft configurations. In 1991 he was elected a fellow of the American Institute of Aeronautics and Astronautics, and he was also elected an honorary fellow of Trinity Hall, Cambridge, and in 1992 was a W. R. Sears Distinguished Lecturer at Cornell University. In 1993, he was selected to receive the American Institute of Aeronautics and Astronautics Fluid Dynamics Award in recognition of numerous contributions to computational fluid dynamics and the development of many widely used computer programs which have immeasurably improved the capability to analyze and understand complex flows.

Antony Jameson was elected a fellow of the British Royal Society for Improving Natural Knowledge in 1995, and that same year was selected by ASME to receive The Spirit of St. Louis Medal for numerous outstanding contributions to computational fluid dynamics and for the development of many widely used computer programs that have immeasurably improved understanding of complex flow fields and have become dominant tools for aerodynamic design. In 1996 he was selected to receive the Theodorsen Lectureship Award from ICASE/NASA, Langley. In 1997 he was elected as a foreign associate to the National Academy of Engineering. He was awarded the degree Docteur Honoris Causa from the University of Paris in 2001, and in 2002 he received the degree Docteur Honoris Causa from Uppsala University. Both these degrees were in Applied Mathematics. In 2004 he became a fellow of the Royal Aeronautical Society. In 2005 he was elected a fellow of the Royal Academy of Engineering, and also received the US Association of Computational Mechanics Fluid Dynamics award. A special symposium in his honor was held in 2006 at the World Congress of Computational Mechanics in Los Angeles.

THE ACHIEVEMENT

Antony Jameson's career has spanned more than three decades and numerous scientific fields, including aeronautical engineering, fluid dynamics, applied mathematics, numerical analysis, computer science, control theory and magnetohydrodynamics. He has woven together a deep understanding of mathematical principles and a clear grasp of technical issues and requirements in the fields of air, space and sea transportation to form a tangible body of highly efficient algorithms that have often anticipated and have always taken advantage of advanced computer architectures and new software capabilities. His numerous innovations have been successively implemented into increasingly comprehensive and robust computer codes that have at each stage of their development been core elements of standard computational tools for aircraft design.

SOLUTION OF THE TRANSONIC POTENTIAL FLOW EQUATION

Antony Jameson began working on computational aerodynamic design in 1970 when he was an employee of the Grumman Aerospace Corporation, having previously worked on control theory. The first programs he wrote, FLO1 and SYN1, were for ideal two-dimensional flow. These programs were written for the IBM 1130 machine, which was about the size of a refrigerator and had only a few thousand words of memory. They took between 5 and 10 minutes to calculate the pressure around an airfoil (FLO1), or calculate the shape of an airfoil given the pressure distribution (SYN1). FLO1 and SYN1 codes are still functional and now run on a laptop in about 1/50th of a second. Figure 1 shows a direct calculation of the pressure coefficients along the surface of a NACA0012 airfoil calculated by FLO1. The SYN1 code solved the inverse problem by finding an airfoil profile that corresponds to a specific targeted pressure distribution. An example is shown in Figure 2.

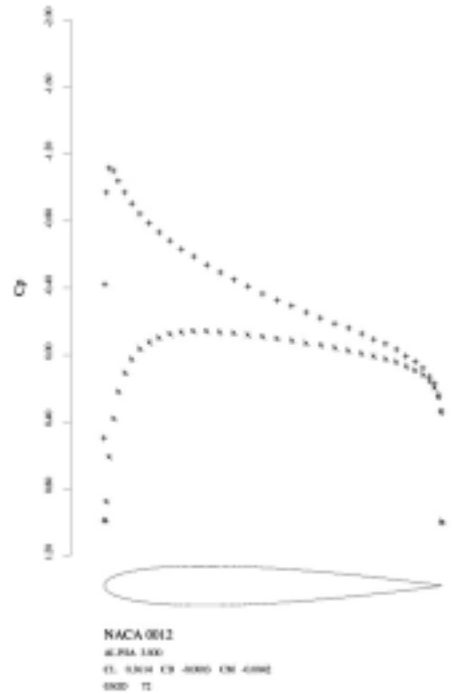


Figure 1. Direct calculation of flow past a NACA0012 airfoil by FL02.

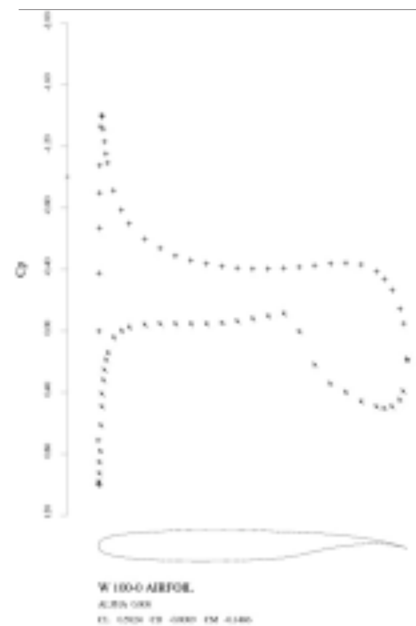


Figure 2. Inverse calculation, recovering the Whitcomb airfoil.

Although these were never used for design at Grumman, they were the first steps towards the development of methods to calculate transonic flow, which was the major challenge at the time and continued to be a driving force for the development of computational fluid dynamics (CFD) through 1990. For commercial aircraft, range optimization mandates that the cruising speed be increased until the onset of significant drag due to the formation of shock waves. Consequently, the best cruising speed is in the transonic regime. For military aircraft, the high drag associated with high-G maneuvers forces them to be performed in the transonic regime. In 1970, Murman and Cole (AIAA J., Vol. 12, 1974) demonstrated that solutions for steady transonic flows could be computed by switching from central differencing in the subsonic zone to up-wind differencing in the subsonic zone. Murman and Cole's method solved the transonic small disturbance equation. Jameson realized the same idea could be applied to solving the full transonic potential flow equations for general geometries, and initiated development at Grumman of codes to calculate transonic flows past both airfoils and axisymmetric bodies (FLO 6 and FLO 7).

In 1972 Jameson moved to the Courant Institute of Mathematical Sciences and began working with Paul Garabedian and his research group. Soon afterwards he presented the rotated difference scheme for transonic potential flow, and applied it to axisymmetric transonic flow, and to flow past a yawed wing, which was then being advocated by R.T. Jones as the most efficient solution for supersonic transport aircraft.

With the rotated difference scheme, Jameson not only generalized Murman and Cole's type-dependent difference scheme to devise an upwind scheme aligned with the local flow direction in the supersonic zone. He also analyzed the relaxation method and showed that it is necessary to introduce a proper blend of mixed space-time derivatives to guarantee convergence. This was the reason that it proved to be very robust. It subsequently provided the basis for the FLO 22 code that was developed together with David Caughey to predict transonic flow past swept wings. FLO 22 was immediately put to use at McDonnell-Douglas, and a simplified in-core version is still in use at Boeing-Long Beach today. Figure 3 shows recent results using FLO 22 on the calculation of transonic flow over the wing of a proposed aircraft to fly into the Martian atmosphere.

The computer listing of FLO 22, which was published in the mid 1970's, has been available worldwide and provided the computational platform of choice for the transonic aerodynamic design of many civil and military aircraft in the 1980's, such as the Canadair Challenger, Douglas C17 and Northrop B2.

Jameson and Caughey, however, were not completely satisfied with FLO 22 because it relied on an analytic transformation of the equations to a curvilinear coordinate system, and it

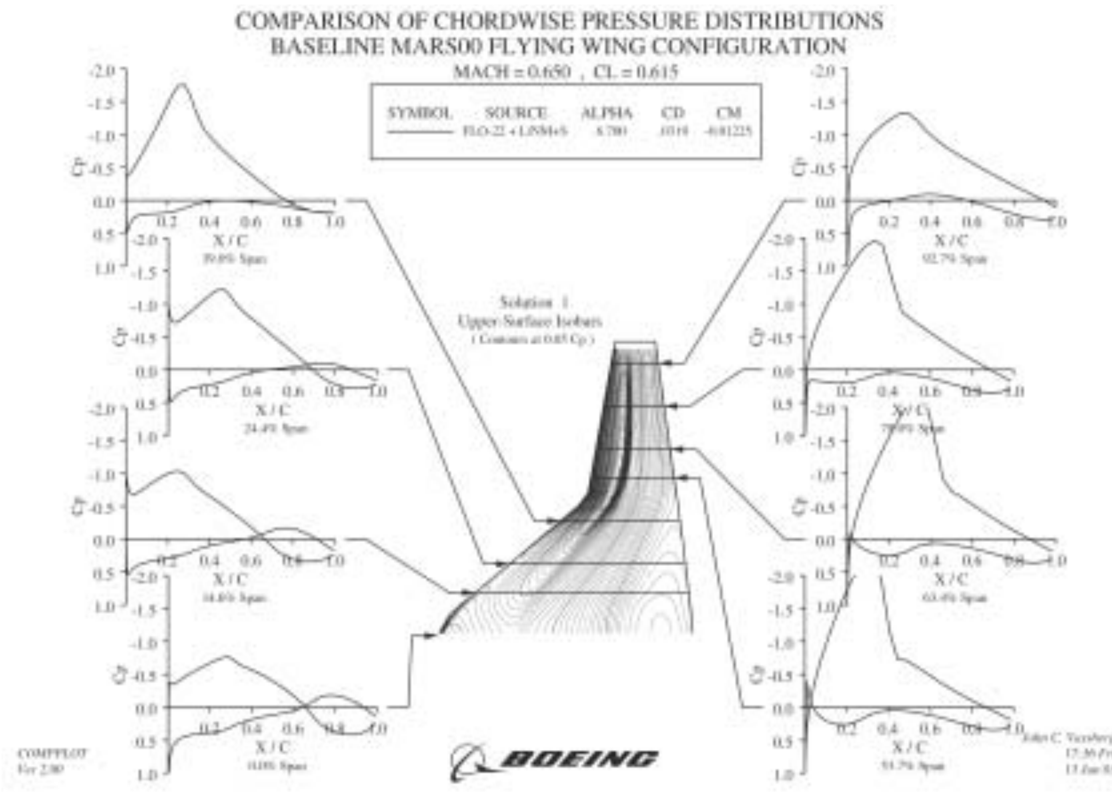


Figure 3. Pressure distribution over the wing of a Mars Lander using FLO22.

appeared impossible to extend it to treat general geometries. They embarked on the development of a new method that could be used on arbitrary meshes, and it was embodied in the codes FLO 27 (specialized to swept wings), and FLO 28 and 30 (specialized to wing-bodies with C-H and C-O mesh topologies). While it was initially presented as a finite volume method, it was actually a finite element method with isoparametric trilinear elements derived from the Bateman variational principle. Computational complexity was reduced by the use of a one-point integration scheme, and recoupling terms were added to suppress the "hour glass" instability later recognized by the finite element community. Jameson had already shown how the rotated difference scheme could be reformulated to treat the potential flow equation in conservation form, in order to ensure proper shock jump conditions, by adding explicit artificial diffusive terms, and Jameson and Caughey used the same technique to stabilize their new method in the supersonic zone.

This method could have been used to calculate flows over complete configurations if a suitable mesh generation method had been available. Boeing evaluated it in 1978, and subsequently combined FLO 28 with a boundary layer analysis method due to Douglas McLean in the Boeing A488 software. This was the workhorse for wing analysis at Boeing over a fifteen-year period which saw the development of the Boeing 757, 767 and 777 aircraft.

Concurrently, while he was at the Courant Institute, Jameson developed a method which solves the fully conservative potential flow equation by a multigrid alternating direction method, and wrote the FLO 36 code with which he was eventually able to obtain converged solutions in 3-10 multigrid cycles.

EULER AND NAVIER-STOKES SOLVERS

By the 1980's, advances in computer hardware had made it feasible to solve the full Euler equations using software which could be cost effective in industrial use. The idea of directly discretizing the conservation laws to produce a finite volume scheme had been introduced by MacCormack, but most of the early flow solvers tended to exhibit strong pre- or post-shock oscillations and would not converge to a steady state. By this time Jameson had moved to Princeton University, and was concentrating on a major effort to develop a fully satisfactory method to solve the Euler equations. He had been experimenting with Euler solvers since 1976 when he tested an unpublished code EUL1, using a semi implicit "Z" scheme. This was effective, but hard to apply to general geometries. Stemming from a collaboration with Wolfgang Schmidt at Dornier in Germany, a new scheme evolved which used a Runge-Kutta time stepping method and dissipative terms consisting of a blend of second and fourth differences controlled by the pressure gradient, leading to the Jameson-Schmidt-Turkel paper which was published in 1981. This was the first Euler method which both cleanly captured shocks without oscillations, and also reliably converged to a steady state. It was embodied in FLO 57 which was used world wide, and was the precursor of many other programs, such as NASA's TLNS 3D, Lockheed's TEAM and Dornier's Ikarus codes.

At that time it was widely believed that in order to improve the efficiency of both time accurate and steady state calculations, it would be necessary to introduce an implicit scheme to allow the use of larger time steps. However, the coupled nonlinear equations of an implicit scheme have essentially the same complexity as the steady state problem, forcing recourse to some combination of linearization, factorization and inner iterations within each time step. Jameson believed that the necessary efficiency would be achieved with well-designed explicit schemes. These had the advantages of flexibility and simplicity, and being readily amenable to vectorization on the new vector computers such as the Cray, and parallelization for the parallel computers that could be expected to emerge in the future.

In order to accelerate steady state calculations FLO 57 used both a variable local time step with a fixed CFL number, and enthalpy damping. In 1981 Jameson introduced residual averaging, a technique that was later widely adopted, and enabled the permissible time step to be doubled. Then in 1983 he introduced the (now) classical full approximation multigrid time stepping scheme, which yielded a dramatic reduction in the computational cost of Euler solutions, and remains standard practice worldwide. He first applied it to a cell-centered finite volume scheme, using, apparently for the first time, an agglomeration method to generate the coarse grids. Next he applied it to a cell-vertex scheme, leading to another widely distributed code FLO 67, which typically converged in about 25 cycles.

His focus now switched to the problem of calculating flows past arbitrarily complex geometric configurations. The aircraft industry clearly needed the capability to calculate flows over complete aircraft. The problem of generating body-fitted hexahedral meshes which could include features such as nacelle-pylon-wing combinations and winglets appeared then to be (and remains) extremely difficult. This motivated a switch to the use of unstructured meshes. After surrounding the aircraft by a cloud of points, one could draw on a well-known technique in computer science, DeLaunay triangulation, to connect them into tetrahedra. During 1984 he embarked on an intensive study of discretization techniques on triangular and tetrahedral meshes, and tested cell centered, vertex centered and edge or face centered schemes, reaching the conclusion that a vertex centered scheme was the most promising. This scheme could be regarded as a Galerkin finite element method with some simplifications, but it had an equivalent representation as a finite volume method. Using standard finite element assembly methods would lead to massive memory requirements, but Jameson realized that one could use face-based and edged-based loops to calculate the discretization coefficients on the fly. This effort culminated in the development during 1985, jointly with Timothy Baker and Nigel Weatherill, of the Airplane code, which was finally able to calculate the flow past a complete aircraft (figure 4).

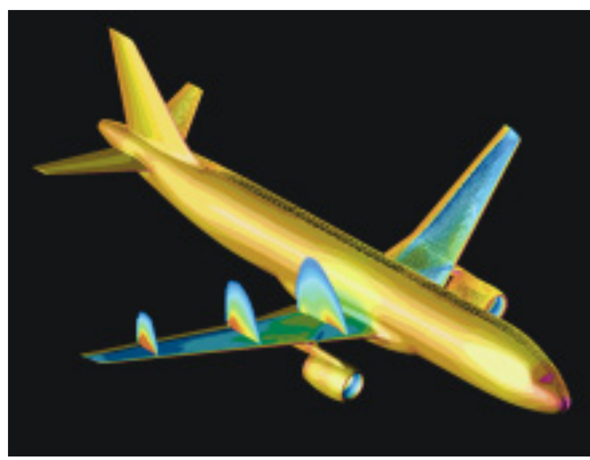


Figure 4 Computed pressure distribution about an Airbus A320. On the right side of the picture the detailed surface triangulation is visible.

The Airplane code enabled John Vassberg at McDonnell Douglas, who also added significant improvements to the software, to redesign the pylon-wing fairing of the MD11 in order to meet the range requirements of their airline customers (Figure 5). It was also heavily used in the NASA Supersonic Transport Program, and continues to be used at the present time. Current versions use a multigrid algorithm, stemming from joint work with Dimitri Mavriplis which led to his thesis. They also support parallel operations on multiple central processing units. This enables an airplane calculation on a mesh with two million cells to be performed in less than one minute. Figures 6 and 7 show flow simulations from the Airplane code of some commercial aircraft in transonic flight.

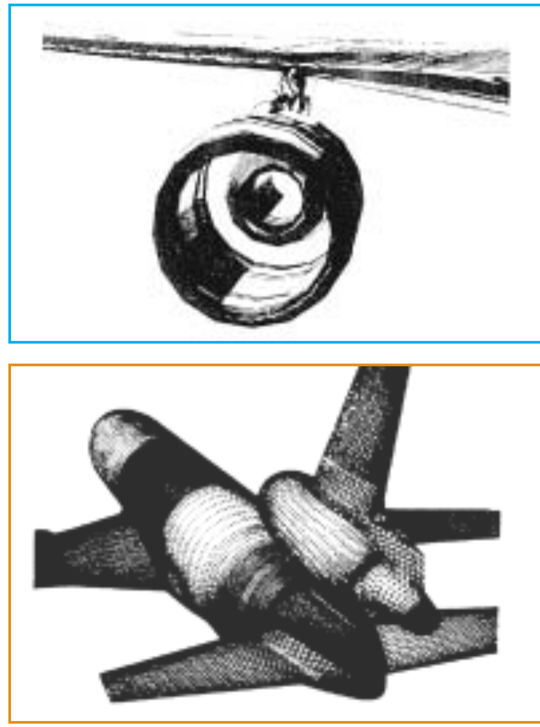


Figure 5 MD11 Wing-Pylon-Nacelle and surface triangulation of the entire aircraft.

Figure 6. Pressure contours for the Boeing 747-200.

Figure 7. Density contours for the MD-11.

Concurrently with his development of software for unstructured meshes, Jameson continued to work on improved algorithms. The cell-centered multigrid scheme was perfected in the 2D and 3D Euler solvers FLO 82 and FLO 87. In 1984, working with Peter Lax, Jameson derived general conditions for the construction of total variation diminishing (TVD) schemes, and he also devised a symmetric TVD scheme, published in the *American Mathematical Society (AMS) Lectures in Applied Mathematics, Vol. 22,* which closely resembles the scheme later published by H. Yee. With Seokkwan Yoon, he developed the widely used LU-SGS algorithm to speed up convergence to a steady state. Returning to this idea in 2001, Jameson and Caughey were able to obtain converged Euler solutions in three multigrid cycles with a fully nonlinear implementation of the SGS scheme.

In the period 1985-1990 Antony Jameson collaborated with Luigi Martinelli in the extension of the Euler solvers to treat the Reynolds averaged Navier Stokes (RANS) equations. They developed alternative cell-vertex and cell-centered solvers, FLO 97 and FLO107. In the course of this work they also perfected modified Runge Kutta (MRK) time stepping schemes which use a separate treatment of the convective and diffusive terms to extend the stability region. The MRK5-3 scheme has proved to be a very powerful driver for multigrid solvers. FLO 107 was later extended to treat multiblock grids by J. Farmer, L. Martinelli and A. Jameson, and to execute on a parallel computer with the participation of J. Alonso and J. Reuther. Farmer and Martinelli also modified FLO 67 and FLO 97 to calculate incompressible flows with free surfaces and applied them to predict the wave resistance of ship hulls. Martinelli and Cowles made a similar conversion of the multiblock FLO 107 code which was subsequently used to predict the performance of the Alinghi America's Cup Yacht. Stemming from his thesis under Jameson's supervision, Feng Liu also modified the solvers to treat blade passages in turbomachinery for both rotors and stators. Another adaptation of Jameson's FLO 87 software, undertaken with R.Y. Cen, F. Liu and J.P. Ostriker, was one of the first simulations of the evolution of the universe. ("The Universe in a Box: Thermal Effects in the Standard Cold Dark Matter Scenario").

In 1991 Jameson introduced the concept of dual time stepping to calculate unsteady flows, with multigrid inner iterations. This method has proven successful in turbomachinery simulations, and is currently used in Stanford University's SUmb code, which evolved from FLO107MB and F. Liu's turbomachinery code TURBO 90, and has been applied to calculate the end-to-end flow through an entire jet engine.

In the period 1991-1994 Jameson also developed a more rigorous theoretical basis for the JST scheme, based on the concept of local extremum diminishing (LED) schemes, a generalization of the TVD concept, and devised alternative discretization methods (the SLIP and CUSP schemes) which have proved to be accurate and robust in practice, and are now the default options in current versions of the software codes.

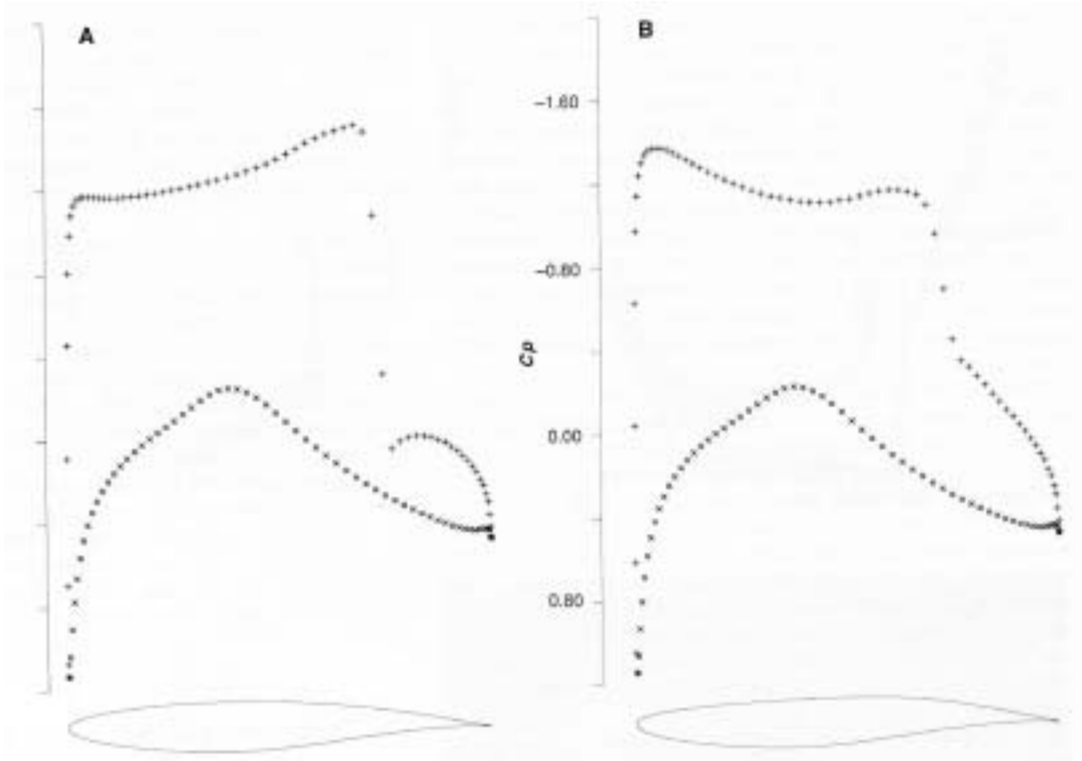


Figure 8. Redesign of the RAE2822 airfoil by means of control theory to reduce its shock-induced pressure drag. (A) Initial profile. Drag coefficient of 0.0175. (B) Redesigned profile after five cycles. Drag coefficient of 0.0018.

OPTIMUM AERODYNAMIC SHAPE DESIGN

The successful development of these codes still left an open challenge: the effective use of CFD for design ultimately requires another level of software which can guide the designer in the search for improved aerodynamic shapes on the basis of the predicted performance. In 1988 Prof. Jameson felt that CFD predictions had reached a level of reliability and credibility where one could seriously tackle this issue, and he redirected the central focus of his research. Instead of asking how air flows around a wing, he asked what the optimal shape should be to control the flow of air around it. This led to the realization that one could combine CFD with control theory to calculate optimum shapes, obtaining the derivative of a performance measure such as the drag with respect to the shape via the solution of an adjoint problem. An early example of this published in Science in 1989, is reproduced in Figure 8, which shows the redesign of the RAE2822 airfoil to minimize the drag coefficient, subject to the constraints that the lift coefficient is held constant at approximately 1.0 and the thickness is not reduced. An almost shock-free profile was obtained in five cycles.

During the last decade Antony Jameson's shape optimization method has been extended both to three dimensional design and to higher fidelity Euler models of inviscid flow (SYN 88) and Reynolds averaged Navier Stokes (RANS) models of compressible flow (SYN 107), with contributions from Martinelli, Vassberg, Reuther and Alonso. It has been perfected to the point where optimum designs can be determined with a computational cost of two to ten flow calculations. Jameson's approach is distinguished from most other optimization methods in treating the geometry as a free surface defined by the mesh points. SYN107 typically uses more than 4000 design variables. Smoothness is enforced by the use of a Sobolev gradient which prevents the surface points from moving in an uncoordinated way. Otherwise it could be necessary to introduce additional curvature constraints.

The software can be used to determine optimum shapes in both transonic and supersonic flow. When it is used to minimize the drag at a given transonic flight condition, it routinely produces a shock-free shape. The search for shock-free airfoils was the focus of intensive effort in the period of the sixties and seventies. A remarkable outcome of Jameson's research has been the demonstration that shock-free shapes do not need to resemble the standard supercritical airfoils: almost any shape can be made shock-free at a given design point by very small modifications. Shock-free designs, however, tend to break down to an undesirable double shock pattern below the design point. To prevent this the software has been extended to support multi-point design.

The optimization method has also proven to be very effective at solving the inverse problem of finding a shape which produces a desired target pressure distribution. Whenever the target corresponds to a realizable shape, it is recovered exactly. Otherwise a shape is found that brings the pressure distribution as close as possible to the target.

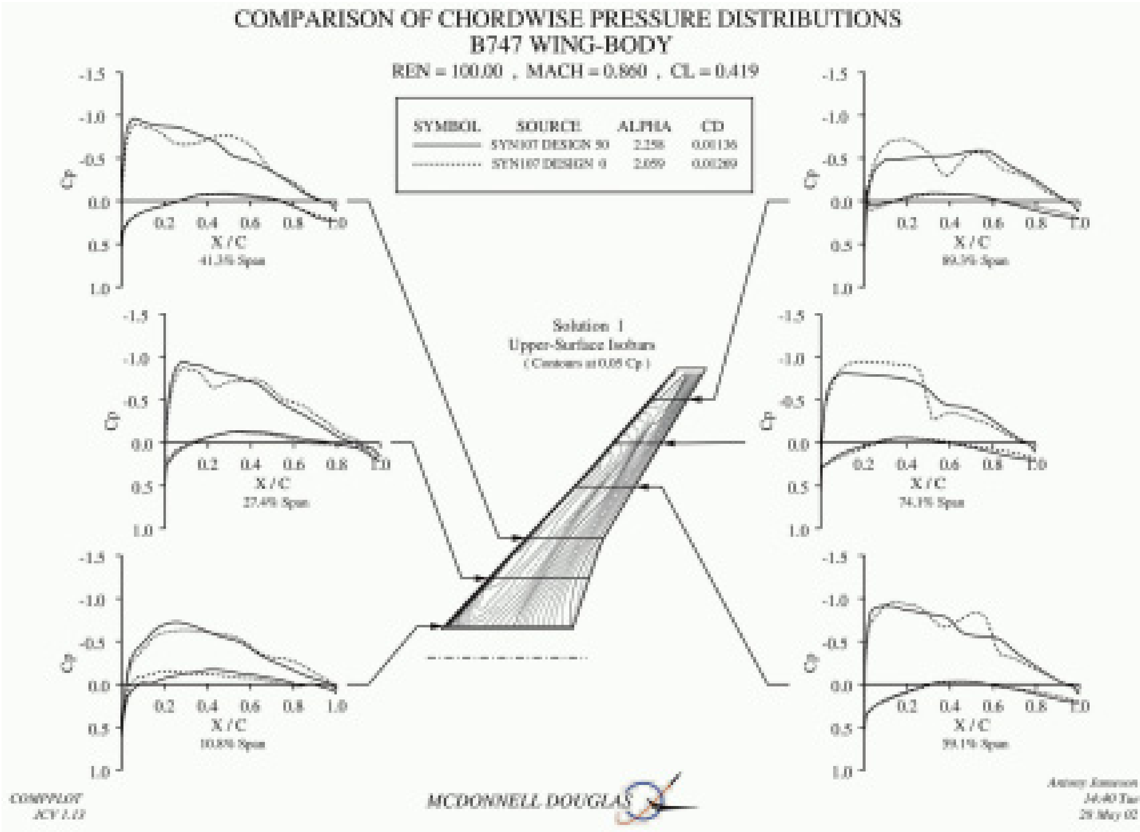


Figure 9. Comparison of Chordwise pressure distributions on a 747 wing-body before and after redesign, Re=100 million, Mach=0.86, CL-0.42.

Figures 9 and 10 show the results of Navier-Stokes redesigns of the Boeing 747 wing at its present cruising Mach number of 0.86 and also at a higher Mach number of 0.90. These calculations are for the wing fuselage combination with wing shape changes restricted to the wing. At Mach 0.86 the drag coefficient is reduced from 126.9 counts (0.01269) to 113.6 (0.01136) counts, a reduction of 5% of the total drag of the aircraft. At Mach 0.9, it is reduced from 181.9 counts to 129.3 counts, a 30% reduction in drag. Thus, the redesigned wing has about the same drag at Mach 0.9 as the original wing at Mach 0.86, suggesting the potential for a significant increase in the cruise Mach number, provided the other problems, such as engine integration, can all be solved.

This design methodology has been extended to unstructured grids with the new Synplane software and used to redesign the Falcon Business Jet in the cruise condition. Figure 11

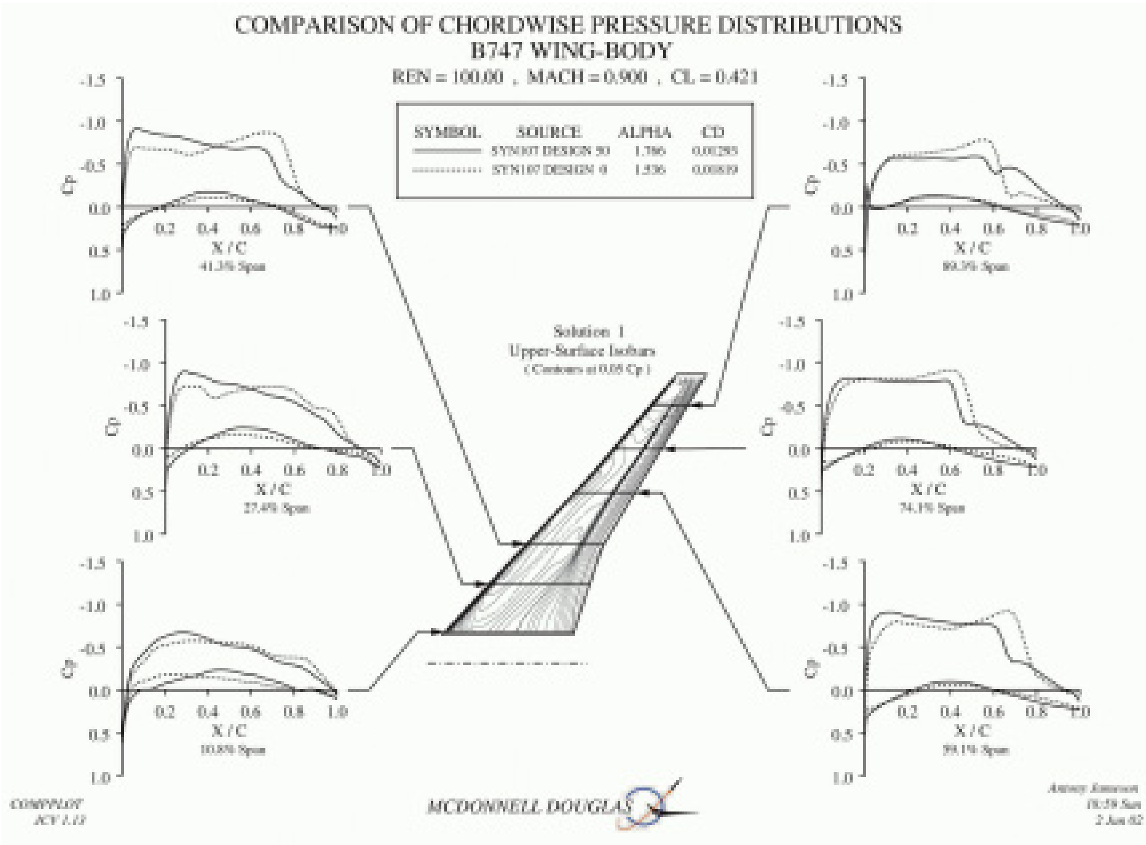


Figure 10. Comparison of chordwise pressure distributions on a 747 wing-body before and after redesign, Re=100 million, Mach =0.90, CL-0.42.

shows a comparison of the air density on the surface of the aircraft before (left) and after (right) optimization. The new design reduced the drag by 8.5%.

Working with the assistance of Kasidit Leoviriyakit and Sriram Shankaran, the method has also been extended to combine both aerodynamic and structural optimization for wing planform designs, which has the potential to yield substantially larger performance gains, of the order of 10 percent or more over aircraft currently in service. Recently SYN107 has been used to improve the aerodynamic design of new military aircraft projects for Boeing Phantom Works, and it has also been used to significantly extend the cruise Mach number and range of a new high end business jet.

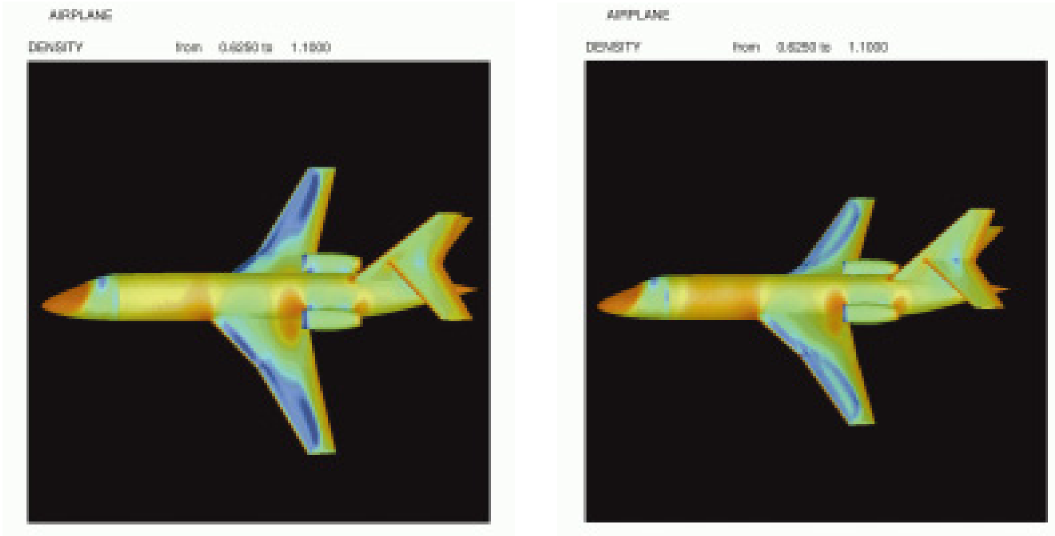


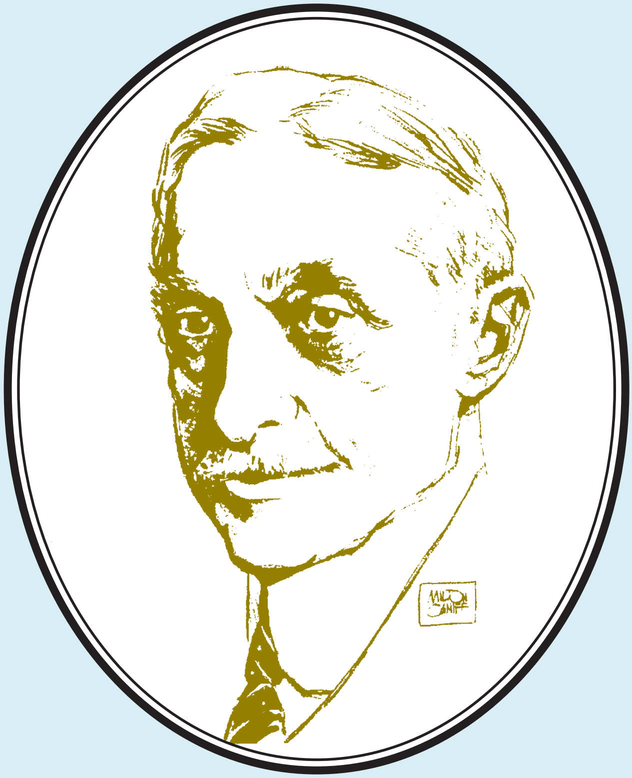
Figure 11. Comparison of density distributions on a Falcon before (left) and after (right) redesign.

OVERALL ACHIEVEMENT

The core elements of Antony Jameson's achievement are the following: First, based on his background in engineering, economics and mathematics, and his industrial experience in the jet engine and aircraft industries, he was able to identify key barriers which must be overcome to advance the practice of aerodynamic design. Second: he devised new and innovative mathematical and algorithmic solutions to previously intractable or infeasible problems that enabled the necessary advances. Third: he implemented these new algorithms in structured, modular and essentially error free software that was robust enough for sustained industrial use (30 years in the case of FLO22), and actually enabled significant improvements in the aerodynamic performance of many aircraft now flying.

CODES	
1970	FLO1, 2 SYN1
1971-1973	FLO 6
1975	FLO 22
1977	FLO 27
1979	FLO 36
1981	FLO 52, 57
1984	FLO 62, 67
1985	AIRPLANE
1985	FLO 82, 87
1988	FLO 97, 107
1989	SYN 36
1991	UFLO 82, 87
1993-1995	SYN 87, 88
1997	SYN 107
2001	FLO 82-SGS FLO 88-SGS
2003	SYNPLANE
2003-2006	FLO-3xx SYN-3xx

AIRPLANES	
Canadair	Challenger (FLO 22) Regional Jet (FLO 22) Global Express (airplane)
Northrop	B2 (FLO 22) F23 (FLO 57)
Boeing	737-500 (FLO 27-28 incorporated in Boeing A488 software) 747-400 (FLO 27-28 incorporated in Boeing A488 software) 757 (FLO 27-28 incorporated in Boeing A488 software) 767 (FLO 27-28 incorporated in Boeing A488 software) 777 (FLO 27-28 incorporated in Boeing A488 software) 787 (FLO 27-28 incorporated in Boeing A488 software)
McDonnell-Douglas	C17 (FLO 22) MD11 (FLO 22, airplane) MD12 (FLO 67, airplane) MDXX (SYN 88) MDHSCT (FLO 67, airplane) MD90 (FLO 27 incorporated in dactran10) MD95: later Boeing 717 (FLO 22, FLO 67)
Airbus	310 (FLO 57 derivatives EJ30, EJ65) 320 (FLO 57 derivatives EJ30, EJ65) 330 (FLO 57 derivatives EJ30, EJ65) 340 (FLO57 derivatives EJ30, EJ65) 380 (SYN 88)
Beech	Premier (SYN 87 MB) Horizon (SYN 87 MB)
Embraer	190 (SYN 88)



Elmer A. Sperry, 1860-1930

After graduating from the Cortland, N.Y. Normal School in 1880, Sperry had an association with Professor Anthony at Cornell, where he helped wire its first generator. From that experience he conceived his initial invention, an improved electrical generator and arc light. He then opened an electric company in Chicago and continued on to invent major improvements in electric mining equipment, locomotives, streetcars and an electric automobile. He developed gyroscopic stabilizers for ships and aircraft, a successful marine gyro-compass and gyro-controlled steering and fire control systems used on Allied warships during World War I. Sperry also developed an aircraft searchlight and the world's first guided missile. His gyroscopic work resulted in the automatic pilot in 1930. The Elmer A. Sperry Award was established in 1955 to encourage progress in transportation engineering.

The Elmer A. Sperry Award

To commemorate the life and achievements of Elmer Ambrose Sperry, whose genius and perseverance contributed so much to so many types of transportation, the Elmer A. Sperry Award was established by his daughter, Helen (Mrs. Robert Brooke Lea), and his son, Elmer A. Sperry, Jr., in January 1955, the year marking the 25th anniversary of their father's death. Additional gifts from interested individuals and corporations also contribute to the work of the Board.

Elmer Sperry's inventions and his activities in many fields of engineering have benefited tremendously all forms of transportation. Land transportation has profited by his pioneer work with the storage battery, his development of one of the first electric automobiles (on which he introduced 4-wheel brakes and self-centering steering), his electric trolley car of improved design (features of its drive and electric braking system are still in use), and his rail flaw detector (which has added an important factor of safety to modern railroading). Sea transportation has been measurably advanced by his gyrocompass (which has freed man from the uncertainties of the magnetic compass) and by such navigational aids as the course recorder and automatic steering for ships. Air transportation is indebted to him for the airplane gyro-pilot and the other air navigational instruments he and his son, Lawrence, developed together.

The donors of the Elmer A. Sperry Award have stated that its purpose is to encourage progress in the engineering of transportation. Initially, the donors specified that the Award recipient should be chosen by a Board of Award representing the four engineering societies in which Elmer A. Sperry was most active:

American Society of Mechanical Engineers
(of which he was the 48th President)

American Institute of Electrical Engineers
(of which he was a founder member)

Society of Automotive Engineers

Society of Naval Architects and Marine Engineers

In 1960, the participating societies were augmented by the addition of the Institute of Aerospace Sciences. In 1962, upon merging with the Institute of Radio Engineers, the American Institute of Electrical Engineers became known as the Institute of Electrical and Electronics Engineers; and in 1963, the Institute of Aerospace Sciences, upon merger with the American Rocket Society, became the American Institute of Aeronautics and Astronautics. In 1990, the American Society of Civil Engineers became the sixth society to become a member of the Elmer A. Sperry Board of Award.

Important discoveries and engineering advances are often the work of a group, and the donors have further specified that the Elmer A. Sperry Award honor the distinguished contributions of groups as well as individuals.

Since they are confident that future contributions will pave the way for changes in the art of transportation equal at least to those already achieved, the donors have requested that the Board from time to time review past awards. This will enable the Board in the future to be cognizant of new areas of achievement and to invite participation, if it seems desirable, of additional engineering groups representative of new aspects or modes of transportation.

THE SPERRY SECRETARIAT

The donors have placed the Elmer A. Sperry Award fund in the custody of the American Society of Mechanical Engineers. This organization is empowered to administer the fund, which has been placed in an interest bearing account whose earnings are used to cover the expenses of the board. A secretariat is administered by the ASME, which has generously donated the time of its staff to assist the Sperry Board in its work.

The Elmer A. Sperry Board of Award welcomes suggestions from the transportation industry and the engineering profession for candidates for consideration for this Award.

PREVIOUS ELMER A. SPERRY AWARDS

1955 To *William Francis Gibbs* and his Associates for design of the S.S. United States.

1956 To *Donald W. Douglas* and his Associates for the DC series of air transport planes.

1957 To *Harold L. Hamilton, Richard M. Dilworth* and *Eugene W. Kettering* and Citation to their Associates for developing the diesel-electric locomotive.

1958 To *Ferdinand Porsche* (in memoriam) and *Heinz Nordhoff* and Citation to their Associates for development of the Volkswagen automobile.

1959 To *Sir Geoffrey de Havilland, Major Frank B. Halford* (in memoriam) and *Charles C. Walker* and Citation to their Associates for the first jet-powered passenger aircraft and engines.

1960 To *Frederick Darcy Braddon* and Citation to the Engineering Department of the Marine Division of the *Sperry Gyroscope Company*, for the three-axis gyroscopic navigational reference.

1961 To *Robert Gilmore LeTourneau* and Citation to the Research and Development Division, *Firestone Tire and Rubber Company*, for high speed, large capacity, earth moving equipment and giant size tires.

1962 To *Lloyd J. Hibbard* for applying the ignitron rectifier to railroad motive power.

1963 To *Earl A. Thompson* and Citations to *Ralph F. Beck, William L. Carnegie, Walter B. Herndon, Oliver K. Kelley and Maurice S. Rosenberger* for design and development of the first notably successful automatic automobile transmission.

1964 To *Igor Sikorsky* and *Michael E. Gluhareff* and Citation to the Engineering Department of the Sikorsky Aircraft Division, *United Aircraft Corporation*, for the invention and development of the high-lift helicopter leading to the Skycrane.

1965 To *Maynard L. Pennell, Richard L. Rouzie, John E. Steiner, William H. Cook* and *Richard L. Loesch, Jr.* and Citation to the Commercial Airplane Division, *The Boeing Company,* for the concept, design, development, production and practical application of the family of jet transports exemplified by the 707, 720 and 727.

1966 To *Hideo Shima, Matsutaro Fuji* and *Shigenari Oishi* and Citation to the *Japanese National Railways* for the design, development and construction of the New Tokaido Line with its many important advances in railroad transportation.

1967 To *Edward R. Dye* (in memoriam), *Hugh DeHaven*, and *Robert A. Wolf* for their contribution to automotive occupant safety and Citation to the research engineers of *Cornell Aeronautical Laboratory* and the staff of the Crash Injury Research projects of the *Cornell University Medical College*.

1968 To *Christopher S. Cockerell* and *Richard Stanton-Jones* and Citation to the men and women of the *British Hovercraft Corporation* for the design, construction and application of a family of commercially useful Hovercraft.

1969 To *Douglas C. MacMillan, M. Nielsen* and *Edward L. Teale, Jr.* and Citations to *Wilbert C. Gumprich* and the organizations of *George G. Sharp, Inc.*, *Babcock and Wilcox Company*, and the *New York Shipbuilding Corporation* for the design and construction of the N.S. Savannah, the first nuclear ship with reactor, to be operated for commercial purposes.

1970 To *Charles Stark Draper* and Citations to the personnel of the *MIT Instrumentation Laboratories,* Delco Electronics Division, *General Motors Corporation*, and Aero Products Division, *Litton Systems*, for the successful application of inertial guidance systems to commercial air navigation.

1971 To *Sedgwick N. Wight* (in memoriam) and *George W. Baughman* and Citations to *William D. Hailes, Lloyd V. Lewis, Clarence S. Snavely, Herbert A. Wallace*, and the employees of *General Railway Signal Company*, and the Signal & Communications Division, *Westinghouse Air Brake Company*, for development of Centralized Traffic Control on railways.

1972 To *Leonard S. Hobbs* and *Perry W. Pratt* and the dedicated engineers of the Pratt & Whitney Aircraft Division of *United Aircraft Corporation* for the design and development of the JT-3 turbo jet engine.

1975 To *Jerome L. Goldman, Frank A. Nemec* and *James J. Henry* and Citations to the naval architects and marine engineers of *Friede and Goldman, Inc.* and *Alfred W. Schwendtner* for revolutionizing marine cargo transport through the design and development of barge carrying cargo vessels.

1977 To *Clifford L. Eastburg* and *Harley J. Urbach* and Citations to the Railroad Engineering Department of *The Timken Company* for the development, subsequent improvement, manufacture and application of tapered roller bearings for railroad and industrial uses.

1978 To *Robert Puiseux* and Citations to the employees of the *Manufacture Française des Pneumatiques Michelin* for the development of the radial tire.

1979 To *Leslie J. Clark* for his contributions to the conceptualization and initial development of the sea transport of liquefied natural gas.

1980 To *William M. Allen, Malcolm T. Stamper, Joseph F. Sutter* and *Everette L. Webb* and Citations to the employees of *Boeing Commercial Airplane Company* for their leadership in the development, successful introduction and acceptance of wide-body jet aircraft for commercial service.

1981 To *Edward J. Wasp* for his contributions toward the development and application of long distance pipeline slurry transport of coal and other finely divided solid materials.

1982 To *Jörg Brenneisen, Ehrhard Futterlieb, Joachim Körber, Edmund Müller, G. Reiner Nill, Manfred Schulz, Herbert Stemmler* and *Werner Teich* for their contributions to the development and application of solid state adjustable frequency induction motor transmission to diesel and electric motor locomotives in heavy freight and passenger service.

1983 To *Sir George Edwards*, *OM, CBE, FRS; General Henri Ziegler, CBE, CVO, LM, CG; Sir Stanley Hooker, CBE, FRS* (in memoriam); *Sir Archibald Russell, CBE, FRS;* and *M. André Turcat, L d'H, CG*; commemorating their outstanding international contributions to the successful introduction and subsequent safe service of commercial supersonic aircraft exemplified by the Concorde.

1984 To *Frederick Aronowitz, Joseph E. Killpatrick, Warren M. Macek* and *Theodore J. Podgorski* for the conception of the principles and development of a ring laser gyroscopic system incorporated in a new series of commercial jet liners and other vehicles.

1985 To *Richard K. Quinn, Carlton E. Tripp*, and *George H. Plude* for the inclusion of numerous innovative design concepts and an unusual method of construction of the first 1,000-foot self-unloading Great Lakes vessel, the M/V Stewart J. Cort.

1986 To *George W. Jeffs, Dr. William R. Lucas, Dr. George E. Mueller, George F. Page, Robert F. Thompson* and *John F. Yardley* for significant personal and technical contributions to the concept and achievement of a reusable Space Transportation System.

1987 To *Harry R. Wetenkamp* for his contributions toward the development and application of curved plate railroad wheel designs.

1988 To *J. A. Pierce* for his pioneering work and technical achievements that led to the establishment of the OMEGA Navigation System, the world's first ground-based global navigation system.

1989 To *Harold E. Froehlich, Charles B. Momsen, Jr.*, and *Allyn C. Vine* for the invention, development and deployment of the deep-diving submarine, Alvin.

1990 To *Claud M. Davis, Richard B. Hanrahan, John F. Keeley*, and *James H. Mollenauer* for the conception, design, development and delivery of the Federal Aviation Administration enroute air traffic control system.

1991 To *Malcom Purcell McLean* for his pioneering work in revolutionizing cargo transportation through the introduction of intermodal containerization.

1992 To *Daniel K. Ludwig* (in memoriam) for the design, development and construction of the modern supertanker.

1993 To *Heinz Leiber, Wolf-Dieter Jonner* and *Hans Jürgen Gerstenmeier* and Citations to their colleagues in *Robert Bosch GmbH* for their conception, design and development of the Anti-lock Braking System for application in motor vehicles.

1994 To *Russell G. Altherr* for the conception, design and development of a slackfree connector for articulated railroad freight cars.

1996 To *Thomas G. Butler* (in memoriam) and *Richard H. MacNeal* for the development and mechanization of NASA Structural Analysis (NASTRAN) for widespread utilization as a working tool for finite element computation.

1998 To *Bradford W. Parkinson* for leading the concept development and early implementation of the Global Positioning System (GPS) as a breakthrough technology for the precise navigation and position determination of transportation vehicles.

2000 To those individuals who, working at the French National Railroad (SNCF) and ALSTOM between 1965 and 1981, played leading roles in conceiving and creating the initial TGV High Speed Rail System, which opened a new era in passenger rail transportation in France and beyond.

2002 To *Raymond Pearlson* for the invention, development and worldwide implementation of a new system for lifting ships out of the water for repair and for launching new ship construction. The simplicity of this concept has allowed both large and small nations to benefit by increasing the efficiency and reducing the cost of shipyard operations.

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