The Elmer A. Sperry Award
2011

FOR ADVANCING THE ART OF TRANSPORTATION

The Elmer A. Sperry Award

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

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 2011

to

ZIGMUND BLUVBAND

and

HERBERT HECHT

in recognition for

Development and Implementation of Novel Methods and Tools for the Advancement of Dependability and Safety in Transportation

by

The Elmer A. Sperry Board of Award

under the sponsorship of the:

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

at the
SAE WORLD CONGRESS
http://www.sae.org/congress/techprogram/cfp.htm
Detroit, Michigan
April 24-26, 2012

Zigmund Bluvband

Dr. Zigmund Bluvband received his Ph.D. in 1974 from the Polytechnic University of Lvov, USSR, where he became part of the world renowned school founded and led by the Probabilistic Reliability Theory guru B.V. Gnedenko. Dr. Bluvband's dissertation was "Entropy Approach to the Reliability and Precision Analysis of the Primary Information Acquisition Systems". His earlier degrees include an M.A. degree in radio-electronics (1969) from the same university and an M.A. in mathematics (1974) from the Lvov State University.

In 1984, Dr. Bluvband founded ALD Group and has been serving as its president ever since. Under his leadership, ALD Group has become the world's biggest company in the areas of safety, reliability and quality for civil and military aviation, railway and energy. In this capacity, Dr. Bluvband has masterminded the suite of ALD software tools, widely used by the aerospace, railway and automotive industries worldwide. In 2000, Dr. Bluvband joined SoHaR Inc. in Culver City, California as the chairman of the board and research leader. At SoHaR he began working in close cooperation with Dr. Herbert Hecht. In prior employment, Dr. Bluvband acted as the reliability group leader of the Israel Aircraft Industry (IAI).

Throughout his career, Dr. Bluvband has accrued more than 35 years of experience in consulting and teaching in the fields of reliability, quality and safety. He is a known and welcomed speaker on dependability issues worldwide, conducting trainings & tutorials on reliability, availability, maintainability, and safety (RAMS), integrated logistics support (ILS), life cycle costing (LCC), certified reliability engineering (CRE), certified quality engineering (CQE) and Six Sigma for thousands of professionals in the USA, Europe, Israel and Far East countries.

Dr. Bluvband has focused his scientific and professional interest on the development of novel techniques for safety assessment and management of failure critical aviation systems. This interest has been reflected by the diverse spectrum of tools created under his guidance by ALD – aimed at empowering the design and reliability engineer with a capability to efficiently analyze modern highly integrated aerospace and transportation systems.

Dr. Bluvband has authored and co-authored 75 refereed scientific publications, eight patents of methods and applications in failure analysis & reliability and seven books, including Quality Greatest Hits: Classic Wisdom from the Leaders; 80/20; and Software Quality and Reliability.

In 2006, Dr. Bluvband was elected by the IEEE Reliability Society to receive the Lifetime Achievement Award "for major contributions as a leader and innovator in the field of reliability engineering". In 2009, he was elected as an academician by the International Academy for Quality (IAQ). Dr. Bluvband is a fellow of the ASQ and served as the chairman of the Israel Society of Quality from 1989 to 1994.

Zigmund Bluvband
Dependability and Safety Expert

Herbert Hecht

Dr. Herbert Hecht received his Ph.D. in engineering from the University of California, Los Angeles in 1967 with the dissertation "Economics of Reliability for Space Launch Vehicles," based on his work on Project Gemini. His earlier degrees include a bachelor of electrical engineering from the College of the City of New York (CCNY) and a master of electrical engineering from Brooklyn Polytechnic Institute (now Polytechnic Institute of New York University).

Dr. Hecht currently serves as the chief engineer of SoHaR Incorporated. In this capacity, he recently completed a study for the FAA of design assurance for flight critical systems that pointed out the importance of generation and review of requirements derived from design decisions (as opposed to functional requirements that are the basis for design). Earlier assignments include review of the development of air traffic control systems and of the voice switching and control system, the primary means of air-to-ground communication.

In several contracts with the U.S. Air Force Wright Laboratory, Dr. Hecht generated a handbook for design of flight critical systems and supervised the development of a highly simplified technique of sneak circuit analysis (SCA). Today's aircrafts, spacecrafts and missiles have a large number of operating modes, and SCA is required to ensure that no undesirable effects occur in switching from one mode to another. Previously, this analysis used to be performed by specialist teams using main-frame computers. The technique developed by SoHaR permits designers to conduct the analysis on a desktop computer and thus discover problems considerably earlier. The company has received a "Small Business of the Year" award for this work.

In prior employment, Dr. Hecht was director of Digital Technology at The Aerospace Corporation and Engineering Department Head for Helicopter and Light Aircraft Flight Controls at the Flight Systems Division of the Sperry Corporation, now Honeywell Flight Systems. While at The Aerospace Corporation, he was in charge of ascent guidance safety for Project Gemini, the two astronaut predecessors of the Apollo mission, and helped develop the guidance system for the Titan III missile. At Sperry he introduced redundant electronics to improve the reliability of helicopter flight controls. For this and other related work he was granted 11 patents.

Dr. Hecht has served on the IEEE Computer Society Board of Governors and as chairman of the IEEE Computer Society Standards Committee. From 1985 to 1990, he was a visitor for Computer Engineering Programs for ABET (Accreditation Board for Engineering and Technology). From 1998 to 2000, he served on the National Research Council's Committee on the Engineering Challenges of Long-Term Operation of the International Space Station (a committee mandated by Congress). He has over 120 publications in refereed journals and is the author of *System Reliability and Failure Prevention,* (Artech House, 2004). He is also a chapter author in several other publications dealing with reliability of digital systems.

Herbert Hecht
Flight Critical Systems Expert

The Achievement

Dependability and safety are the most important system characteristics defining any transportation system availability and performance, as well as the total cost of transportation system ownership and engineering. The advancement of the art of transportation is inseparable from the development of dependability and safety, which are based on six main factors: reliability, maintainability, availability, durability, testability, and failure analysis.

Dr. Bluvband and Dr. Hecht have devoted their careers to innovation, conception, design, development, and implementation of visionary tools and methods for significantly improving ways of achieving dependability that are crucial for the highly integrated transportation systems of today.

Their early understanding of the need for industry to support high dependability goals is reflected in their most prominent work and patents. These include:

1. Development, deployment & implementation of integrated tools for reliability, maintainability, availability, and safety analysis - solving complex dependability problems in the transportation industry.
2. Implementation of the tools, unified techniques and practices for reliability growth and failure prevention in transportation systems.
3. Promotion and implementation of the failure reporting, analysis and corrective action systems, focused on the technological and organizational causes of failure, topics that rarely receive attention.
4. Setting-up of tools for system dependability requirements during the early stages of development, monitoring compliance with those requirements during all life-cycle phases, and focusing on the most important potential failures.

Under their initiative and supervision, the following solutions were developed and implemented in the transportation industry, introducing profound concepts that transformed into advanced methodologies:

- **BFA** – Bouncing Failure Analysis
- **SCA** – Automated Sneak Circuit Analysis
- **MMEL** – Automated MMEL from FTA (Fault Tree Analysis) and FMEA (Failure Modes and Effects Analysis)
- **DFT** – Dynamic Fault Tree for Rare Events
- **TA** – Testability & Troubleshooting Analysis

- **FA** – Failure Analysis
- **AG** – Availability Growth and Maturity Tracking
- **MCSV** – Mission Critical Software Verification
- **SAF** – Software Automated FMEA

All of these solutions have been integrated in the following Tools: RAM Commander, DLCC (Decision by Life Cycle Cost), FRACAS (Failure Reporting and Corrective Action System), MEADEP (Measurement - Based Dependability Analysis Tool + MOSET + MOFAT) and SCAT (Automated Sneak Circuit Analysis).

Dr. Bluvband and Dr. Hecht have worked closely with the leading transportation organizations worldwide, from railway to space. The success of these tools is reflected in the following comments from the corporate users.

LOCKHEED MARTIN: "... Zigmund's company was the only supplier of the needed application. The FavoWeb FRACAS application was integrated into the JSF (Joint Strike Fighter) ALIS (Automatic Logistics Information System). The JSF FRACAS application has been in use since 2004 collecting data and performing analyses.

The application of this distinguished FRACAS tool has been proven in actual service (during the last 6 years) which has actually advanced the art of transportation providing another exceptional contribution for the aircraft safety and dependability..."

SPERRY GYROSCOPE CO FLIGHT CONTROLS DIVISION (now Honeywell Flight System): " …a pioneering attempt at a "Universal autopilot". Other innovative work done included designs of flareout coupler that was a precursor of today's automatic landing systems. Development of the techniques for blending radar altitude and barometric attitude measurements for use in flareout control laws. Today's automatic landing control laws continue to blend radar altitude measurements with other measurements of vertical separation from the ground".

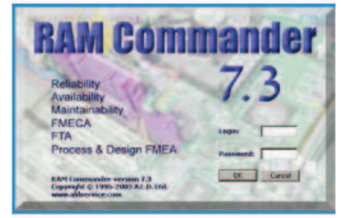
NASA: "Over the years their tools were deployed and successfully used in the analysis of human spaceflight systems and contributed to NASA identification of areas of risk that require mitigation to ensure safe and reliable missions. These tools were key in the trade studies evaluating architecture changes as weight needed to be reduced."

GULFSTREAM AEROSPACE LP: "... Dr. Bluvband company's toolkit was the only available supplier toolkit with applications which were integrated. The application of this distinguished toolkit was proven through actual utilization (over a number of years) which advanced the art of transportation systems providing an outstanding contribution for the aircraft system reliability and dependability.."

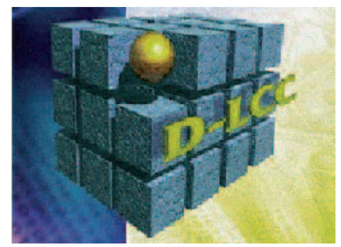
RELIASS – RELIABILITY AND SAFETY SOLUTIONS Limited (UK):
"As an integrator of Safety, Dependability, and Logistics Systems, RELIASS presented the outstanding contribution made by the Automated Analysis and Decision making Tools developed by Drs. Zigmund Bluvband and Herb Hecht to the Safety and Dependability progress in Transportation industry.

RELIASS has been integrating and implementing their tools for more than 10 years now. These superior engineering and managerial instruments assist developers, manufacturers, and operators in a number of important international transportation projects in achievement of Dependability, Maintainability, and Safety goals..."

Integrated Solution Tools Developed & Deployed Under the Leadership of Dr. Bluvband and Dr. Hecht



RAM COMMANDER – World Leading Aviation RAMS Toolkit
Bouncing Failure Analysis (BFA)
Mission Critical Software Verification
Stress Analysis
Spare Part Optimization
Failure Mode and Effects Analysis (FMEA)
Fault Tree Analysis (FTA)
System Safety Assessment
MSG-3: System, Zonal, Structural
Master Minimum Equipment List (MMEL)
Software Automated FMEA



D-LCC – Life Cycle Cost, Total Ownership Cost
Cost Profile Analysis
Maturity Models
Sensitivity Analysis
Spares Calculation & Optimization
Cost Projection Analysis
Product Tree Cost Calculation (Spares)

FavoWeb
Web-based Dynamic FRACAS

WEB FRACAS – Dynamic Failure Analysis Tool
Failure and Maintenance Events Repository
Analysis for Trending, Pareto, Field Mean Time Between Failures (MTBF) etc.
Availability Growth and Maturity Tracking

MEADEP
SCAT

MEADEP – Measurement Based Dependability Analysis + MOSET + MOVAT Tools

SCAT – Automated Sneak Circuit Analysiss

Solutions Widely Used in Transportation

The transportation industry has welcomed the innovative methods and the useful tools developed by Drs. Bluvband and Hecht. Through joint R&D projects and the development of commercial tools, these methods have become widely disseminated. Current users include the following corporations:

- **Airbus**
- **ALSTOM Transportation**
- **BAE**
- **Deutsche Bahn**
- **Eaton**
- **Embraer**
- **FAA**
- **Gulfstream**
- **IAI**
- **Lockheed Martin**
- **NASA**
- **Northrop Grumman**
- **Raytheon**
- **SAAB**
- **Sperry - Honeywell**
- **Sukhoi / Alenia**
- **Siemens**
- **THALES**

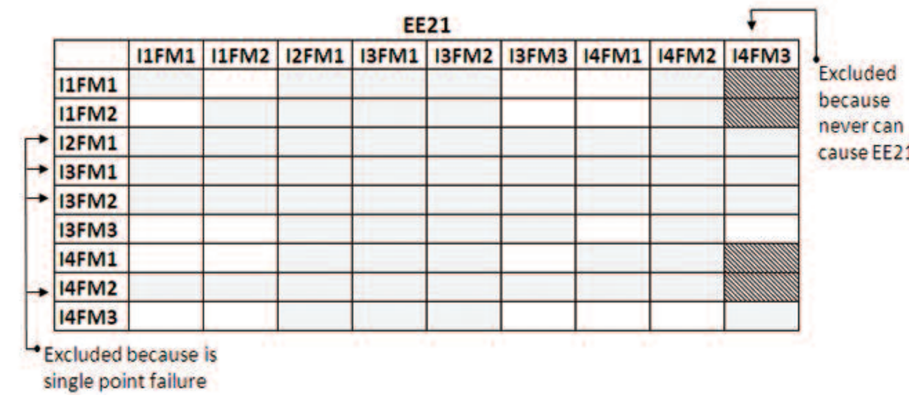
The substance of the methodology and tools that Drs. Bluvband and Hecht have developed can be summarized with several examples demonstrating the evolution from concept to methodology.

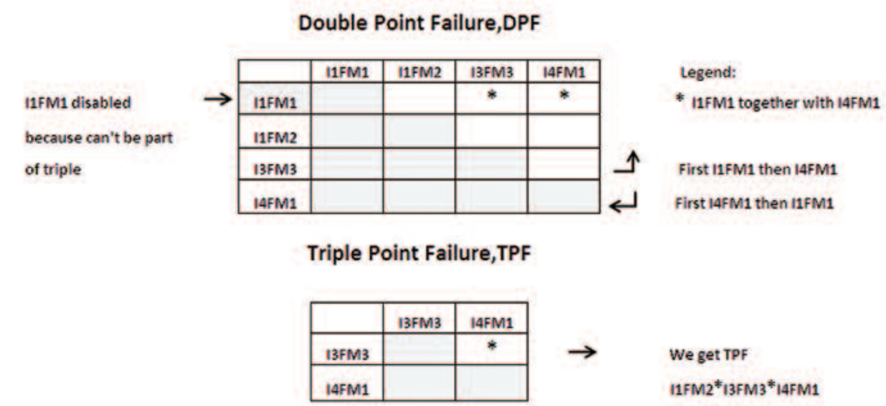
From Concept to Methodology (1)

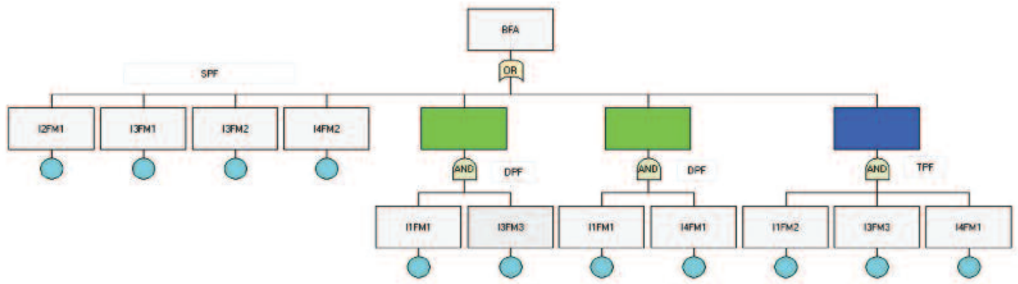
BFA

Bouncing Failure Analysis
Incorporated into RAM Commander Tool

- Integration of FTA (Fault Tree Analysis) with FMEA (Failure Mode Effect Analysis), i.e. Top-down with Bottom-up Failure Analysis.
- Automated FMEA incorporates failure combinations, not only single point failures, as a result of “bouncing” between two modes of analysis.







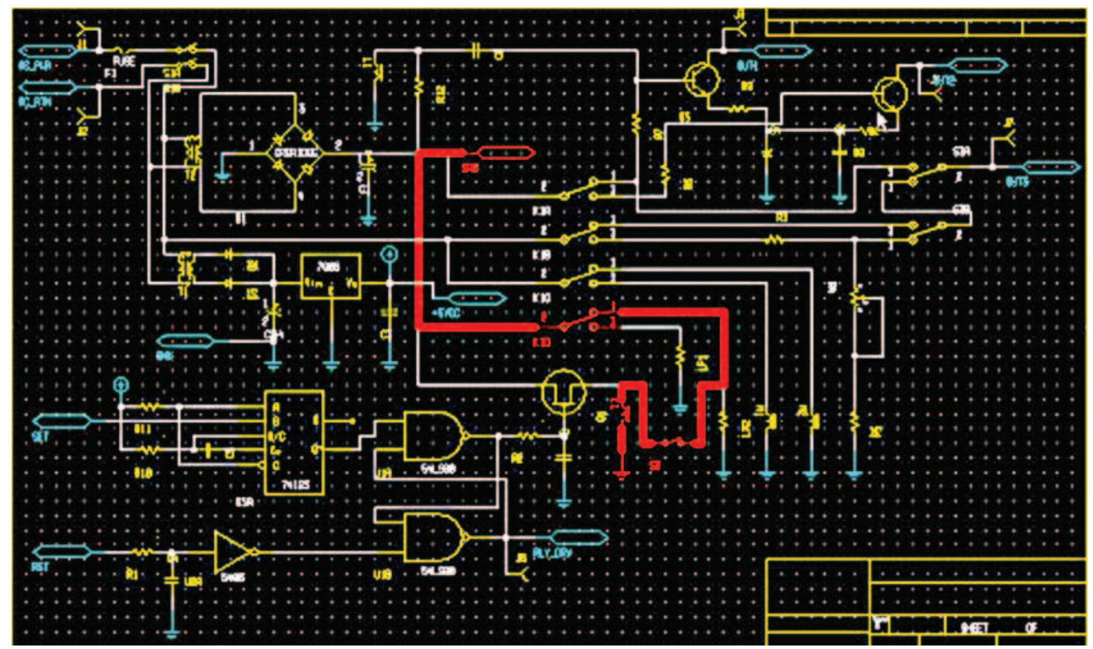
This invention is a method (system) of an inclusive ("360°") bouncing failure analysis, comprising a means to perform failure mode effects and causes risk analysis **(FMECRA)** in all possible directions – bottom-up, top-down, side-in, inside-out and side-to-side as a means to perform FMECRA for every element of object under analysis **(OUA)**; and, subsequently, for every pair of such elements; and then for every combination of three, then four, five, etc elements and their failure modes, causes, catalysts and triggers. The method can be implemented such that for each end effect (EE), it selects one-at-a-time specific end effect (EE) trajectory, searches all possible failure modes at the agreed bottom level of OUA, evaluates whether or not the selected specific EE can be caused by the specific failure mode, and, if failure is possible, it determines with which conditional probability. It then starts considering pairs (sets of two) from the above taken failure modes, but excluding the following combinations: **first** it excludes all single trajectory failure modes that were previously decided as causes of the selected EE, and **second** it excludes all failure modes that can never be a cause for the selected effect (which actually prevent or exclude the EE). If failure is possible from the remaining trajectories, it determines with which conditional probability. Then for every pair of failure modes not causing the selected EE and every additional failure mode not included in the considered pair, it excludes the following combinations: **first** it excludes all failure modes and pairs of failure modes that were previously decided as possible causes of the selected EE, and **second** it excludes all failure modes and pairs of failure modes which can never be a cause for the selected effect (which actually prevent or exclude the EE). If failure is possible, it determines with which conditional probability. It proceeds in a like manner for sets of three, four, etc until it has addressed combinations of all possible failure modes together and established conditional probabilities for all paths.

From Concept to Methodology (2)

Sneak Circuit Analysis

Incorporated into SCAT Tool

- Fully automated process: making use of a unique algorithm, applicable to both early and late stage design, this tool can offer over 10 fold time & cost savings
- Effective for any system that controls irreversible functions: from flight control systems, through fuses and latch control, to automotive speed control systems.



Circuit design with red path indicating a step in the sneak circuit analysis process.

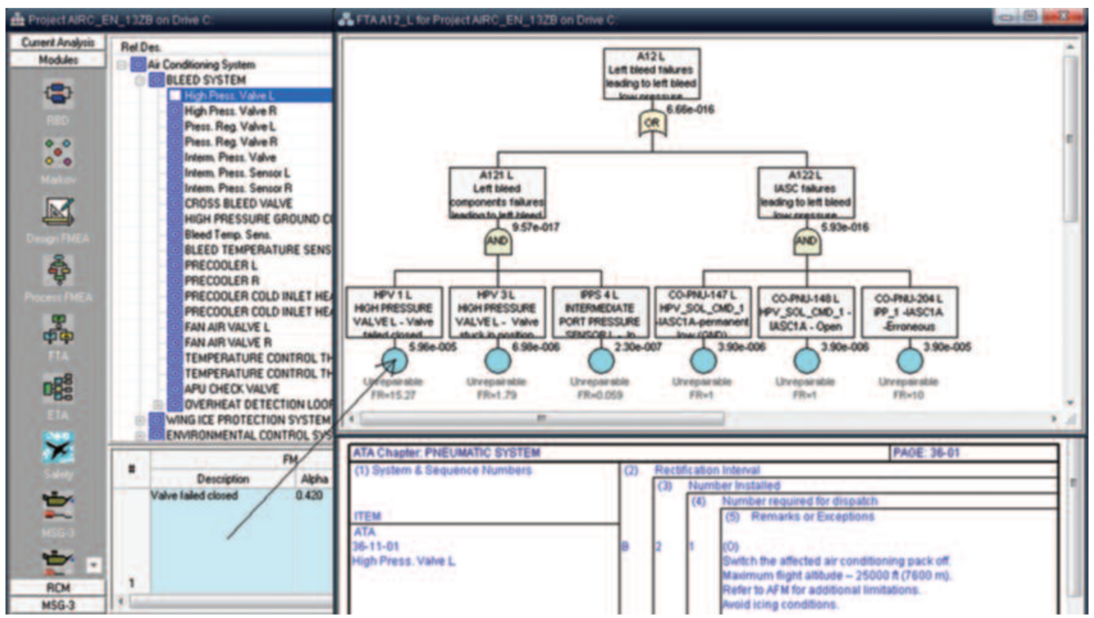
From Concept to Methodology (3)

Automated MMEL from FTA and FMECA
Incorporated into RAM Commander Tool

- **Automated Process of generating MMEL** (Master Minimum Equipment List)

  The tool automatically searches for a Basic event in the Fault tree which corresponds to the specified FMECA event, simulates the failure condition, calculates the in-flight worst case scenario (given the failed item) and then, if appropriate, enters the suitable item as a candidate to the Master Minimum Equipment List (MMEL) for an aircraft.

  – This revolutionary approach saves hundreds of engineering hours devoted to critical systems where FTA and MMEL are required.



From Concept to Methodology (4)

Dynamic Fault Trees (Dynamic Gates)
Incorporated into RAM Commander Tool

- **Improved (Fast) DFT, based on Grude Monte-Carlo**
- **Rare-event** estimation of DFT, based on **Monte Carlo** simulation with combination of importance sampling (**Patent Pending**).
- DFT has an **imperative usage** for aircraft reliability and safety estimation, because of very high requirements for TOP event probability – "**rare-event**" probability ($<10^{-9}$).

Direct Monte-Carlo method-requires practically impossible very large number of simulation cycles- $10^{10}\ldots10^{13}$).

The invented and implemented methodology for rare-event probability estimation (aircraft loss) uses a dynamic fault tree with a plurality of aircraft items' failure conditions and may include both static gates and dynamic gates (AND, OR, "K out of N", PAND, SEQ, SPARE, etc.), based on non-repairable in-flight items with failure times distributed exponentially, Weibull, normal, log-normal, etc.

In the case of a rare-event estimation the importance sampling method is used. The most essential problem in this method is how to select an appropriate reference probability distribution. Unfortunately, well-known approaches for reference distribution selection (scaling, translation) are not applicable for dynamic fault trees analysis.

The mixed continuous-discrete pdfs method was proposed (both for initial and reference probability distribution) instead of the usually used pure continuous pdfs.
For each of the aircraft item number i the following equations calculate values of the primary control reference parameters

$$1-G_i(t) = \frac{1-F_i(t)}{D}$$

where D is some common (for all aircraft items) secondary control reference parameter. For the use of the importance sampling scaling transformation the following expressions are proved:

$$v_i = 1 \Big/ \left(\frac{1}{u_i} + \frac{\log(D)}{T} \right)$$ - for Exponential PDF of fi(t)

$$v_i = \frac{T}{\left(\left(\frac{T}{u_i} \right)^{b_i} + \log(D) \right)^{\left(\frac{1}{b_i} \right)}}$$ - for Weibull PDF of fi(t)

Several secondary control reference parameters D1,…, Ds. also may be used, as well as values of primary control reference parameters v 1,…, v i,…, v N.

From Concept to Methodology (5)

Automated Troubleshooting Procedures

Incorporated into RAM Commander and FavoWeb Tools

- Developed as complementary analysis process to FMECA, assigning tests to failure modes and performing full scale testability study.
- Enables engineers to check coverage on the fly and generate skeletal maintenance troubleshooting procedures automatically.

From Concept to Methodology (6)

FRACAS – Failure Reporting and Corrective Action System

Incorporated into FavoWeb Tool

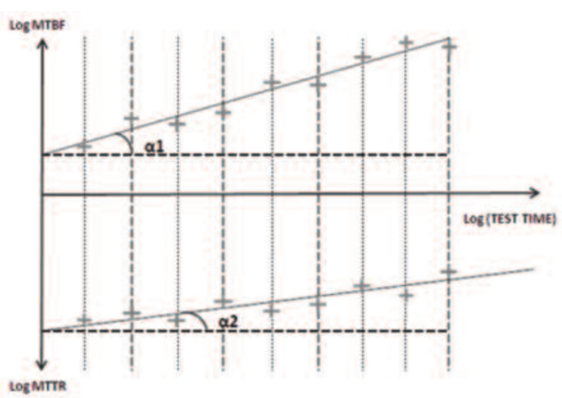
- Revolutionary automated speech-to-text failure and incident data collection, management and analysis – *Overcoming the main problem of failure analysis: poor delayed reporting causing loss of significant information.*
- Patented technology for automatic on-line free text failure records categorization oriented on a personalized specific search and iteratively converging search outcome. The invented and implemented semi-automated approach makes feasible to find most of the field anomalies automatically, by text categorization algorithm mixed with reasonable and cost-effective amount of human expertise.
- Solution: real-time failure data collection ensuring adequate failure reporting by vocal / visual technologies.
- Provisions of training for the original supervised learning algorithm making possible an efficient study of safety and reliability problems reported from the field as a free text by pilots, operators, inspectors etc.

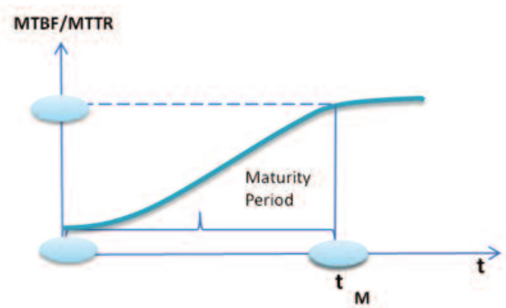
From Concept to Methodology (7)

Maturity Models of Reliability & Availability
Incorporated into FavoWeb, Ram Commander and DLCC Tools

AG

- Developed **new Holistic** approach based on advanced mathematical concepts to collect, track and measure **Availability Growth (AG)** and Maturity of a Transportation System.
- Since the standard NHPP does not take into account parameters of repairs, the expanded procedure as the basis for the availability growth tracking was developed and implemented. For this task the parameters of "mixed" flows – failures and repairs – were defined and estimated instead of single ("continuous") flow for the standard NHPP task.





Reliability / Availability Maturity Curve

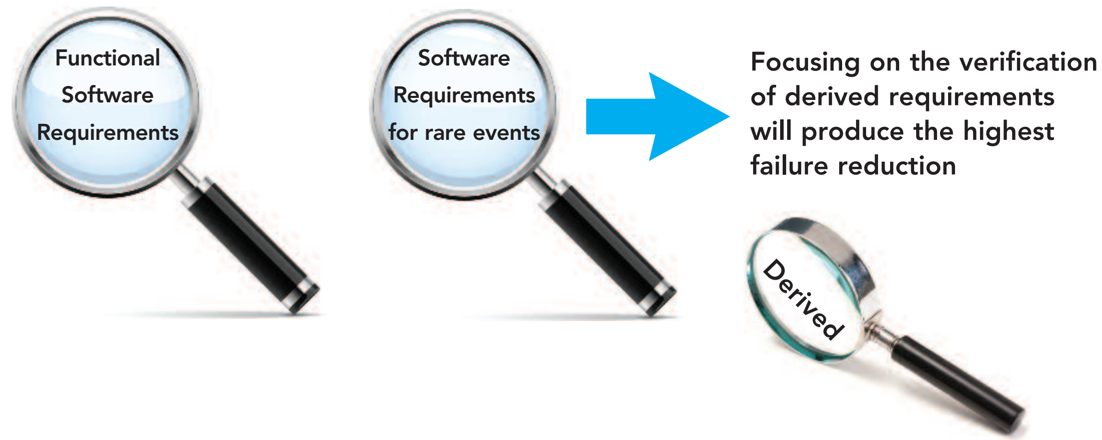
From Concept to Methodology (8)

Focused Mission Critical Software Verification
Incorporated into MOCET and MOVAT Tools

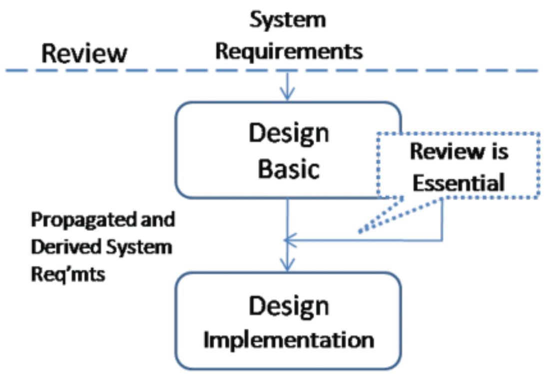
MCSV

Innovative approach to identify the derived requirements which pose the highest risk:

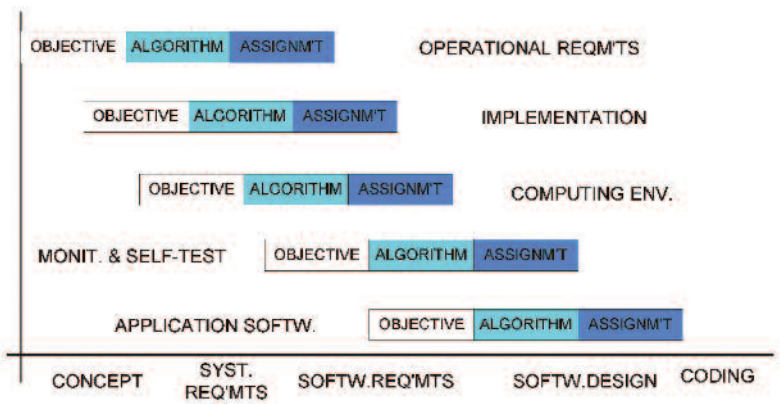
- they occur later in the development cycle – they are derived from design decisions
- there is less experience with formulating and verifying them.



The conventional waterfall model assumes that the requirements established at the start of design will be propagated by the design and will be imbedded in the implemented in the end product. Therefore requirements are reviewed prior to design and subsequent reviews concentrate on correct implementation. In complex systems this assumption is no longer valid. SAE ARP 4754 "Certification Considerations for Highly-Integrated or Complex Aircraft Systems" recognizes that decisions made as part of design generate additional (derived from the design or for short "derived") requirements that affect the implementation. As an example, the decision to employ a fan to cool an essential electronic component makes the fan a safety critical item and leads to a requirement for monitoring its operation.



In a typical system there will be many derived requirements and a systematic review of them is essential. Because it occurs in the midst of a very busy stage of development, economy of personnel is important. Bluvband and Hecht have created a structured review model, shown here for a typical aircraft system but adaptable to many other environments.



The horizontal bars represent review teams for specialty areas, thus avoiding involvement of excess personnel. They are shown in the order in which the derived requirements are expected to be generated. Operational requirements are close to the conventional system requirements, e. g., electric power and communication but will include additional detail such as back-up requirements for critical loads. The implementation category may include calibration and special interface requirements. Each of the horizontal bars has three subdivisions that represent typical requirements development: the objectives are stated in natural language, and they are later translated into an algorithmic form that may permit verification by simulation and finally they are assigned to a specific hardware or software element with a specified accuracy and iteration rate. Reviews are conducted at each stage but are focused on the contributions (and error potential) of each segment.

From Concept to Methodology (9)

SAF

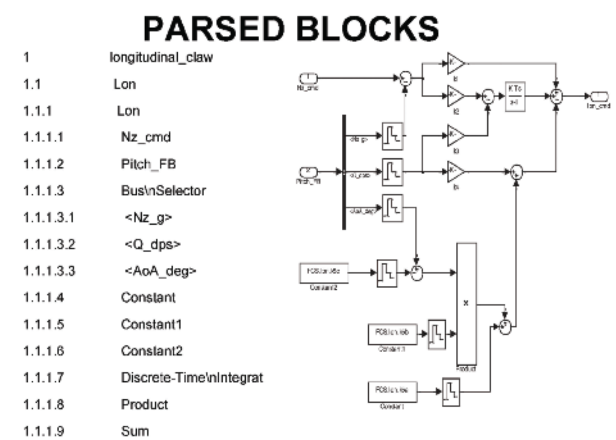
Automated Failure Mode and Effects Analysis (FMEA) for Software

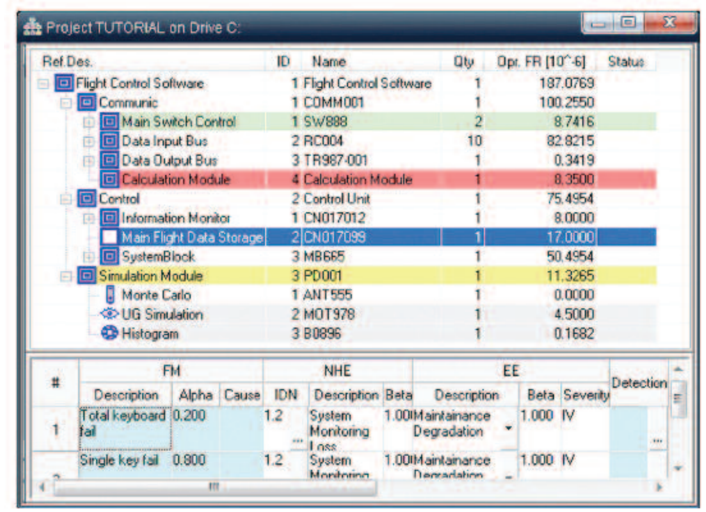
Incorporated into FavoWeb, MOCET and MOVAT Tools

Revolutionary approach to Certify Software Design.

- Within the FMEA, software objects are equivalent to hardware components thus ensuring coverage and completeness.

- Automated parsing of Simulink symbols into hierarchical FMEA elements.

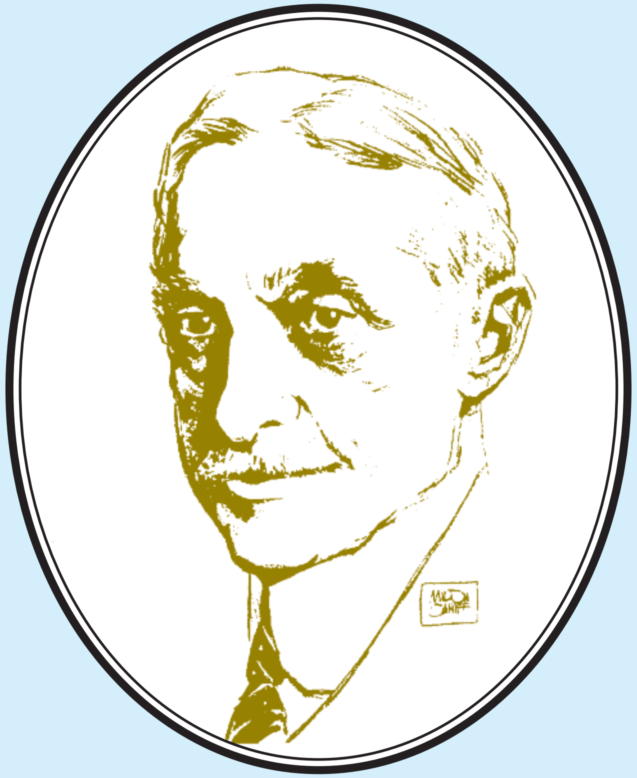




Dr. Zigmund Bluvband & Dr. Herbert Hecht

Published and Pending Patents

TITLE	ISSUE DATE	REF.
System and Method for Failure Reporting and Collection (by vocal / visual technologies)	8/25/99	Il Pat. 112513
System and Method for Failure Reporting and Collection (by vocal / visual technologies)	5/14/02	U.S. Pat. 6,389,561
System and Method for Failure Reporting and Collection (by vocal / visual technologies)	8/13/08	Europ. Pat. 0725373 (DE / FR / GB/IT/SE)
System and Method for Bouncing Failure Analysis	Pat. Pending, 2007	U.S. Pat. App. No.: US 11/795,562 Publication 4/23/2009 no.: US 2009/0106593
System and Method for Bouncing Failure Analysis	Europ. Pat. Pending, 2007	Europ. Pat. App. No EP 06700964.7
On-Line Iterative Multistage Search Engine with Text Categorization and Supervised Learning	1/9/12	Allowed U.S. Pat. App. No. US 12/007305 Pub. No. US 2008/0168056
Multi-stage Iterative Image Search with Feedback and On-line Supervised Learning	Pat. Pending, 2009	U.S. Pat. App. No.: US 61/273,652
Radio-Controlled Craft Guidance System	7/30/57	U.S. Pat. 2801059
Servo System with Magnetic Rate Taking	12/30/53	U.S. Pat. 2812487
Redundant Fail-Proof Amplifier and Alarm	2/18/58	U.S. Pat. 2824296
Flare-out Control	4/8/58	U.S. Pat. 2830291
Radio Controlled Craft Guidance System	4/14/58	U.S. Pat. 2881992
Fail-Safe Servo-Mechanism system	7/14/59	U.S. Pat. 2894491
Modulator Circuit	8/30/60	U.S. Pat. 2951213
Flight Control Equipment	10/16/62	U.S. Pat. 3058700
Aircraft Altitude Control System	12/25/62	U.S. Pat. 3070333
Electromagnetic Signal Generator	3/19/63	U.S. Pat. 3082388
Servo Mechanism Apparatus	8/18/64	U.S. Pat. 3145330



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 war-ships 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 gyropilot 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. In 2006, the Society of Automotive Engineers changed its name to SAE International.

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 & 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 & 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.

2004 To *Josef Becker* for the invention, development, and worldwide implementation of the Rudderpropeller, a combined propulsion and steering system, which converts engine power into optimum thrust. As the underwater components can be steered through 360 degrees, the full propulsive power can also be used for maneuvering and dynamic positioning of the ship.

2005 To *Victor Wouk* for his visionary approach to developing gasoline engine-electric motor hybrid-drive systems for automobiles and his distinguished engineering achievements in the related technologies of small, lightweight, and highly efficient electric power supplies and batteries.

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.

2007 To *Robert Cook, Pam Phillips, James White,* and *Peter Mahal* for their seminal work and continuing contributions to aviation through the development of the Engineered Material Arresting System (EMAS) and its installation at many airports.

2008 To *Thomas P. Stafford, Glynn S. Lunney, Aleksei A. Leonov,* and *Konstantin D. Bushuyev* as leaders of the Apollo-Soyuz mission and as representatives of the Apollo-Soyuz docking interface design team: in recognition of seminal work on spacecraft docking technology and international docking interface methodology.

2010 To *Takuma Yamaguchi* for his invention of the ARTICOUPLE, a versatile scheme to connect tugs and barges to form an articulated tug and barge, AT/B, waterborne transportation system operational in rough seas. His initial design has led to the development of many different types of couplers that have resulted in the worldwide use of connected tug and barges for inland waterways, coastal waters and open ocean operation.

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