

NED C. FORRESTER
Senior Engineer
Woods Hole Oceanographic Institution

Education:

B.S.E.E., Massachusetts Institute of Technology, 1976
M.S.E.E., Massachusetts Institute of Technology, 1976

Experience:

Student, 1973-1976; Engineer, 1976-1978; Senior Engineer, 1978-1979; Principal Engineer, 1980-1982;
Consulting Engineer, 1982-1985; Digital Equipment Corporation
Research Engineer, 1985 to 1995, Senior Engineer 1995-present, WHOI

Equipment and Techniques Developed (• = major projects):

- Induction motor servo for printer carriage drive, 6/75-2/76
- Video character display chips and μ -processor control for VT-100 video terminal, 6/76-6/78
- Custom graphics display chips for workstations and video terminals, 1/80-7/85
- Electric propulsion system for Alvin, 7/85-8/86
- Electrical distribution system for Alvin, 8/85-5/86
- High efficiency, 6 Watt power supply for tomography receiver, 6/86-9/86
Line frequency monitor and shutdown for Alvin battery chargers, 12/86-6/87
- Short and long baseline acoustic navigation system for Alvin, with digitally tuned filters, 8/86-1/90
- Transformer/inductor design optimization programs, 2/87-7/87
- 12 KVA power distribution and control system for the Argo/Jason tethered vehicles, 2/87-4/88
Data reduction programs for Alvin data disks, 1/88-3/88
Software to read Alvin serial data stream on PC, 3/88-5/88
Digitally tunable 100 kHz analog front-end for acoustic modem, 3/88-9/88
Alvin battery charging software, 7/89-9/89
- Overhaul of Alvin instrument panels and wiring, 12/88-8/89
- Electrical distribution system for Alvin with 120 Volt to 26 Volt DC/DC converters, 10/88-8/89
- 120 V to 28 V, 50 Amp power converter for Alvin hydraulic pump motor, 4/89-7/89
- UNIX/C programs for collection, logging and distribution of Alvin data, 11/88-9/89
- Digitally Programmable, 200 kHz acoustic receiver board, 4/89-10/89
200 W power amp for Alvin's acoustic navigation transceiver, 2/89
Installation on Alvin of prototype pressure-tolerant motor controllers, 12/89
EIA-232 isolation modules, 11/89-8/90
Improvements to Alvin Data Collector, including: renovation of real-time clock hardware and firmware, addition of event counters, and PC program to test camera data output, 2/90-9/90
- C software interfaces to Alvin data system for: Mesotech sonar, magnetometer, U.W. entrainment array, geo-compass, heatflow probe, and other instruments, 12/89-8/90
Alvin 286 computer and plasma display, 5/90-9/90
5 ch. heatflow probe with heater, finished hardware and firmware, simulated thermal response of heater, 4/90-7/90
- 2000 V, 20 kW DC power system architecture for TROV/FOSS I vehicles, 1/90-10/90
Power, control and status interfaces, and convection cooling for Alvin pressure-tolerant motor controllers, 10/90-5/91
Thermal analysis of TROV tether, 11/90
- 20 kW, 400 HZ power transmission system for TROV vehicle, including protective devices and voltage control, 11/90-10/91
Designed toroidal, low weight, oil cooled, pressure tolerant transformers for TROV power system, 12/90-7/91

- Expanded transformer design software to include three-phase transformers and calculation of temperature rise in a convection-cooled environment for rectangular and toroidal geometries, 4/91-7/91
- 400 Amp crowbar over-voltage protector for Jason/TROV/FOSS I, 6/91
- Ground-Fault-Interrupter for 1200 V, 35 KVA, 400 Hz system, 9/91-10/91
- Water-jet thruster manifold and valves for TROV, 10/91-2/92
- Software to combine attitude and angular rate data using LP/HP filter, 11/91
- Six DOF computer model of TROV vehicle system, 10/91-4/92
- Five axis PID control software for TROV vehicle, 1/92-4/92
- 12 kW, 60/400 Hz power transmission and distribution system for FOSS I vehicle, including custom transformers, 5/92-9/92
- Current-limited, short-circuit protected, 400 Volt, 3 Amp, solid-state power switch, 9/87-9/92
- Power, wiring and instrument interface design for FOSS I vehicle, 5/92-7/93
- Documentation system for FOSS I, including automated drawing and parts list compilation, 7/92-7/95
- 8 channel, current-limited, 0.5 Amp, 50 Volt, isolated signal switch, 10/92
- Motor phase filter, 10 Amp, 3-phase, >70 db attenuation at 100 kHz, 5/93-6/93
- LC type, 900 Volt, TI arc-lamp ignitor circuit, and lamp current monitor, 3/93-4/93
- 3 Watt, low noise, low impedance split-rail power supply system for arctic acoustics, 7/93
- Relative Acoustic Tracking System accuracy analysis, for acoustic and inertial navigation errors, 10/93
- Heave compensating crane performance analysis and simulation, 11/93-4/94
- Common to Ground voltage monitor and clamp, 100 V, 3 A, 1/94
- PC software to operate FOSS video camera interface, 2/94
- Optical analysis of FOSS video camera dome port and first-order correction, 3/94
- FOSS Klein 595 Side-scan sonar interference reduction, 4/94
- Dynamic analysis of new TROV roll control system, 5/94
- REMUS AUV chassis wiring and system board design: power, analog and digital I/O for PC104 system and various instruments, 9/94
- Measurement and analysis of TOSS vehicle vertical drag coefficient, 11/94
- Software to capture digital scope waveforms from IEEE-488 bus, 11/94
- TROV bow thruster performance measurement and analysis, 11/94-1/95
- Closed loop control software for TROV vehicle with new bow thrusters, 12/94
- Failure analysis of Klein 595 sonar transducers, spice modeling and actual measurement of arc induced transients, 1/95-2/95
- Software for computer-assisted generation of purchase orders from parts lists, 4/95-9/95
- Design and construction of LEO-15 node and surface power and control systems, 5/95-8/96
- Joystick amplifier for driving servo valve coils, current limited, 8/95
- Design of TOSS II vehicle power and instrument wiring and construction of vehicle electronics, 3/95-10/95
- Design of signal and power wiring for TOSS II Mission Control Van, 8/95-10/95
- System integration of Klein 2000 side-scan sonar with TOSS II, including over 30 db internal interference reduction, addition of notch filters for suppression of CTFM interference, 9/95-7/96
- Intercom audible alert for TOSS system, 6/96
- Determination of GPS antenna requirements for reliable surface reception by REMUS AUV, 8/96-10/96
- Conversion of FOSS I tow vehicle to TOSS I (TOSS II equivalent), wiring of new Control Van, 5/97-10/97
- REMUS battery charging and data transfer through single contact and seawater return, 1/97-7/98
- Documentation and wiring of TOSS NAVCOM van, 2/98-4/98
- Remote control system for TOSS hydrographic and deep-tow winches, 5/98-6/98
- LEO Guest Port simulator for testing guest instruments, 5/98-3/00
- Experimental investigation of REMUS LA battery gassing and methods of hydrogen control, 5/98-8/98
- Electrical integration of micro-turbulence shear probes and related instruments on REMUS, 8/98
- Development of electrical parts database and maintenance tools for use with Orcad Capture CIS, 1/99-
- SAHRV motherboard, chassis wiring and support equipment, 3/99-10/99
- Method to multiplex power and 10Base2 Ethernet on two wire connection, 3/99-7/99
- Integration of Li-Ion smart batteries to REMUS SMBus, 4/00-10/01
- Li-Ion smart battery charge/discharge cycle tester and data logging and control software, 3/01-10/01
- GPS receiver/antenna installation for REMUS, 1/01-3/01

- Li-Ion 250 Wh battery for REMUS, including controller board with data communication, protection and charger, board test fixture, test and embedded battery software, 11/01-11/02
- 8 kWh Li-Ion battery system for SAMS: smart battery data system, 1.5 kW chargers with computer control and software, 10/01-4/03
 - SAMS weight release controller board and software, 3/02-4/03
 - SAMS radio system and antennas: GPS, ARGOS, Freewave modem, 10/01-7/03
- 7 kWh Li-Ion battery system for Tunnel AUV with 450 Wh battery packs and controllers, 7/02-12/02
- GPS, Iridium and 2.5 GHz WIFI ceramic patch antennas for deep ocean application, tuned for polyurethane encapsulation; passive, active, and L1/L2 GPS designs, 9/03-9/04
- Develop software for SMS messaging on Iridium, 10/03-7/04
- Guest instrument isolation switch, 20 A maximum, programmable current limit, signal isolation, 11/03-7/04.
- 5 kWh Li-Ion battery system for REMUS-600 and dock, using 500 Wh, 63 cell packs and REMUS control electronics, 5/03-9/04
- 5.2 kWh Li-Ion battery system for SAMS II, 650 Wh, 84 cell pack design, control and protection electronics, 5/03-9/04
 - SAMS II battery chargers, upgrade to programmable voltage and current, 5/04-7/04
 - SAMS II weight release board: added software to relay GPS by Iridium SMS during power emergency, 7/04.
- Review of U.S. DOT Hazardous Material Regulations (49CFR171-178), International Air Transport Association Dangerous Goods Regulations, and International Maritime Dangerous Goods Code for impact on Li-Ion battery transportation. 5/03-9/05
 - Performance evaluation of REMUS-100 batteries over extended temperature range, 5/06-6/06
 - LSG magnetic sensor integration in REMUS-600, test program support, 1/06-4/06
- Multi-channel towed acoustic array, per-channel digitizing electronics and network data telemetry, field re-programmable, 1/06-8/09
- High-speed driver for high-intensity light emitting diode array, 20 MHz, 1 and 3 channels, 9/07-5/10
- Acoustic data analysis software for acoustic array data, 6/08-8/09
 - Submersible load cell for array drag measurement, 11/08-9/09
 - Study Low-power, long endurance REMUS AUV: main electronic, sensors and thruster, 11/08-9/09
 - 3-Axis magnetic sensor for towed array, 6/09-9/10
- 72-channel towed acoustic line array with per-channel, 3-axis gravity and magnetic sensors, 6/09-9/10
 - Power control for REMUS-600 variable ballast system, 5/11-6/11
 - Controller/interface for chip-scale atomic clock, 6/11-7/13
- Matlab simulation of solar/wind power generation for Ocean Observatories Initiative buoys, 9/11-11/11
- Pseudo-sinusoidal drive motor controller, major redesign and firmware upgrade, closed-loop commutation phase control, torque measurement from phase current, 12/11-8/13
 - Perl code automation of Magtrol dynamometer in constant velocity and torque modes, 1/12-6/12
- Vehicle core redesign for reduced power consumption and wiring complexity, 9/12-5 Amp charge capability for REMUS battery controller, 12/13-3/14

Courses Taught:

13.465, Ocean Instrument Field Laboratory, taught vehicle systems part of course, 95, 98
 6.002, "Circuits and Electronics", two-session tutorial, 4/04

Research Interests: Power, analog and digital electronics, signal processing, control systems, programming, simulation, electromagnetic compatibility, electric batteries, electric power transmission, and electrophysical devices.

Publications: Author or co-author of 22 technical publications (see attached bibliography).

Patents:

#4,769,637 "Video Display Control Circuit Arrangement"
 #4,799,173 "Transformation Circuit to Effect Raster Operations"

Unpublished Results:

- “Alvin Emergency and Service Batteries”, 8/86
 - “Main Battery Charging Procedures”, Alvin, 1/87
 - “Line Transient Protector for GNB Battery Chargers”, 1/87
- “Data Extraction Programs for Alvin Data Files” 1/89
 - “Fault Current Calculations for the Alvin Electrical System”, 6/89
 - “Alvin Release Circuit Resistance and Current Calculations”, 6/89
 - “Telemetry Receiver Tunable Analog Acquisition Board”, 10/89
 - Contributions to “Alvin User Manual”, 9/90
- “Specification for High Input Voltage DC/DC Converter”, 10/90
- “Alvin Electrical Schematic, A000202”, 12/90
 - “Test Plan for Hydraulic Pump/Motor”, for Alvin, 1/91
 - “Alvin battery purchase, space, weight, power trade-offs”, 3/91
 - “Specification for 195 Amp-Hour Lead Acid Cells”, 4/91
 - “Jason 120 Volt System Over-voltage Protection Crowbar”, 6/91
 - “Toroidal Power Transformer Specification”, 6/91
- “FOSS Vehicle Power Transformer Specification”, 7/92
- Electrical schematic and parts documentation for TOSS I and II vehicles, 7/92-6/98
 - “Factors Affecting Absolute Position Accuracy of Vehicle Mounted Relative Acoustic Tracking System (RATS)”, 10/93
- Electrical schematic and parts documentation for REMUS autonomous vehicles, 9/94-10/01
- “Transducer Failure Mechanism Search”, 3/95
- Electrical schematic and parts documentation for LEO-15 Observatory, 5/95-9/98
- “LEO-15 Instrument Interface Specification”, http://adcp.who.edu/LEO15/HARDWARE_DOC, 9/97-3/00
- “Safety Review of South Florida Ocean Measurement Center”, 4/99 and 6/99 (consulting work for FAU)
- “Towed Optical Survey System: Technical Documentation”, 7/00-9/02
 - “SAMS Battery Setup and Calibration Procedure”, 4/02
 - “REMUS Smart Battery Tester”, 6/02
 - “REMUS Battery Controller Board Setup and Calibration Procedure”, 8/02-9/02
- “REMUS Battery Description”, 9/02
- “SAMS Battery Manual”, 4/03
 - “SAMS Battery Configuration Options”, 5/03
 - “12.75 inch and Docking Battery Configuration Options”, 5/03
- “REMUS-600 Vehicle and REMUS-100 Dock Lithium Battery Data Package”, 12/04
- “REMUS-6000 Battery Information” (description of battery, housings, and support and test equipment), 2/04-2/05
- “Approval Request for Shipping ‘REMUS-600’ Lithium ion Batteries”, DOT, 5/05
- “REMUS-6000 Battery Manual”, (use, maintenance and emergency information), 10/05-11/05
 - “Request for Amendments to Competent Authority Approval 2005050020”, DOT, 2/06, 5/07
 - Internal Memo: “1 MHz Transducer Tuning”, 12/07
 - “REMUS-600/3000 and REMUS Dock Battery Manual”, 4/09
 - “REMUS100/600/3000/6000 Guest Port Electrical Specification”, Forrester, N., Goldsborough, R., 10/08
 - REMUS-600 alternate battery trade-off study, 5/09: battery_alternates.xls
- Internal memo: “Transducer tuning: 160, 200, 500, 1000 and 1400 KHz”, 12/11
- Networked Expandable Digital Sonar Array, 75 pp., (hardware description complete) 11/12-
- 105766 Sinusoidal Thruster Motor Controller, 20 pp., (hardware description complete) 8/13-
- Core Electronics Upgrade: Guest Port Internal Connection Options, 18 pp., 4/13-5/13
- Results of Fast Charge Test of REMUS 600 Battery, 12 pp., 10/13-11/13
- 102379 Battery Controller Functional Description, 45 pp., (hardware desc. complete), 1/14-2/14
- REMUS 600 5 Amp Battery Charger Design Study, 24 pp., 12/13-5/14

Cruise Participation:

5/1/86-5/10/86: Alvin sea trials, 1986, Atlantis II.
1/9/87-1/21/87: Work on Alvin's charging and electrical systems, one Alvin dive, Atlantis II.
5/31/88-6/14/88: Sea trials of Alvin's new long and short base line navigation system., Atlantis II.
8/10/89-8/22/89: Alvin sea trials, 1989, Atlantis II.
2/27/93-3/9/93: FOSS I sea trials, USNS Wilkes.
6/24/93-6/30/93: FOSS I sea trails, USNS Wilkes.
4/12/94-4/18/94, 4/30/94-5/1/94: FOSS I sea trails, OCP Seacon.
11/8/94-11/14/94, FOSS I cruise support, USNS Wilkes.
10/24/95-11/6/95, TOSS II sea trials, USNS Silas Bent.
6/30/96-7/5/96, TOSS II sea trials, USNS Pathfinder.
8/8/96-8/11/96, TOSS II cruise support, USNS Pathfinder, Naples IT.
5/16/97-5/19/97, TOSS II sea trials, support of ASCP Installation, R.V. Ewing.
10/17/97-10/26/97, TOSS I sea trials, acceptance tests of upgraded TOSS I vehicle, USNS Bowditch.
7/16/98-7/30/98, REMUS field exercise in support of coastal modeling, docking trials.
9/14/98-9/18/98, REMUS field exercise in support of Navy Special Warfare VSW-MCM.
11/2/98-11/12/98, REMUS and docking support at AUV Fest '98, R/V Gyre.
10/11/99-10/23/99, REMUS field exercise three in support of Navy Special Warfare VSW-MCM.
6/11/00-6/15/00, REMUS field exercise FBE-H rehearsal in support of Navy Special Warfare VSW-MCM.
4/17/02-5/2/02, SAMS sea trials, USNS Heezen.
2/14/03-3/6/03, SAMS sea trials, USNS Pathfinder.
6/2/03-6/7/03, Inspection of NYC Rondout to West Branch aqueduct.
8/10/03-8/15/03, REMUS trials at AUV Fest '03, Keyport, WA.
7/10/04-7/21/04, SAMS II sea trials, Charleston-Nassau, USNS Pathfinder.
10/24/05-11/5/05, SAMS II re-build sea trials, Naha, Okinawa, Japan, USNS Bowditch.
5/28/08-6/6/08, NEST '08, Acoustic array experiments, off NJ USA, R/V Hugh Sharp.
7/25/08-8/12/08, PLUS/INP '08, Acoustic array experiments, off Kauai, HI, USA, R/V Melville.
10/24/08, SPACE '08, Acoustic communications experiments, REMUS towed array, MVCO, R/V Tioga.
7/25/09-8/10/09, PLUS/INP '09, Acoustic array experiments, off Kauai, HI, USA, R/V Knorr.
9/21/10-10/6/10, PLUS/INP '10, Acoustic array experiments, off San Diego, CA, USA, R/V Moana Wave.
11/1/13-11/15/13, CONKEX, PLUS sea trials, Key West, FL, NAWC-38.
7/30/14-9/4/13, Schnoor-14, U.S. Navy exercise, Guam, R/V Revelle.

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Bibliography:

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- Blake, W., English, P., Forrester, N., Furlong, T., Rose, R., Watson, R. Jr., "A VLSI Chip Set for an Integrated Text and Graphics Video Subsystem", Solid-State Circuits Conference, Digest of Technical Papers, IEEE International, vol 29, pp. 126-127, 1986
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- Forrester, N.C., Stokey, R.P., von Alt, C.J., Allen, B.G., Goldsborough, R.G., Purcell, M.J., Austin, T.C., "The LEO-15 Long-term Ecosystem Observatory: Design and Installation", IEEE, Proceedings of Oceans '97, vol. 2, pp. 1082-1088, 1997.
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- Stokey, R., Austin, T., von Alt, C., Purcell, M., Forrester, N., Goldsborough, R., Allen, B., "AUV Bloopers or Why Murphy Must have been an Optimist: A Practical Look at Achieving Mission Level Reliability in an Autonomous Underwater Vehicle", *Proceedings of the Eleventh International Symposium on Unmanned Untethered Submersible Technology*, pp 32-40, August 23-25, 1999.

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- Reif, R., Liffers, M., Forrester, N., Peal, K., "Lithium Battery Safety Program at Woods Hole Oceanographic Institution", American Society of Safety Engineers, *Professional Safety*, Feb. 2010.