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Stone Aerospace (SAS) specializes in the development of AI-controlled autonomous systems. Founded in 2001 by former national lab group leader Dr. Bill Stone, SAS has developed generations of agile unmanned underwater vehicles (UUVs) and robotic ice penetrators (cryobots) for outer planet NASA missions and for original terrestrial exploration, inspection, and intervention. These machines have been fielded to some of the world's most remote, unforgiving places for science, exploration, and national security.

Our DEPTHX vehicle explored the world's deepest freshwater hydrothermal spring. Our ENDURANCE vehicle was the first robotic system to enter a subglacial lake in Antarctica. Our ARTEMIS vehicle performed the first long range autonomous exploration missions beneath the Ross Ice Shelf. And our SUNFISH vehicle conducted original exploration and 3D mapping in the world's largest subterranean lake in Namibia.

Stone Aerospace, and its predecessor company, Cis-Lunar Development Laboratories, was responsible for the technical diving revolution in manned underwater access and has remained at the forefront of closed-cycle computer-controlled life support systems ever since, both for PLSS backpacks and for cabin life support.

Aside from our autonomous vehicles Stone Aerospace is a one-stop shop for custom-built intelligent systems design, whether a mobile vehicle or free-flyer in any environment or as a persistent static smart device or instrument that can communicate with a mothership by a variety of proprietary methods, including novel through-rock and through-ice transceivers in addition to traditional wireless uplink technologies. We have a long track record of developing, fabricating, and integrating custom-built instruments, sensors, actuators and propulsion systems into vehicles or as stand-alone devices. *If you can Imagine it Stone Aerospace can build it.*

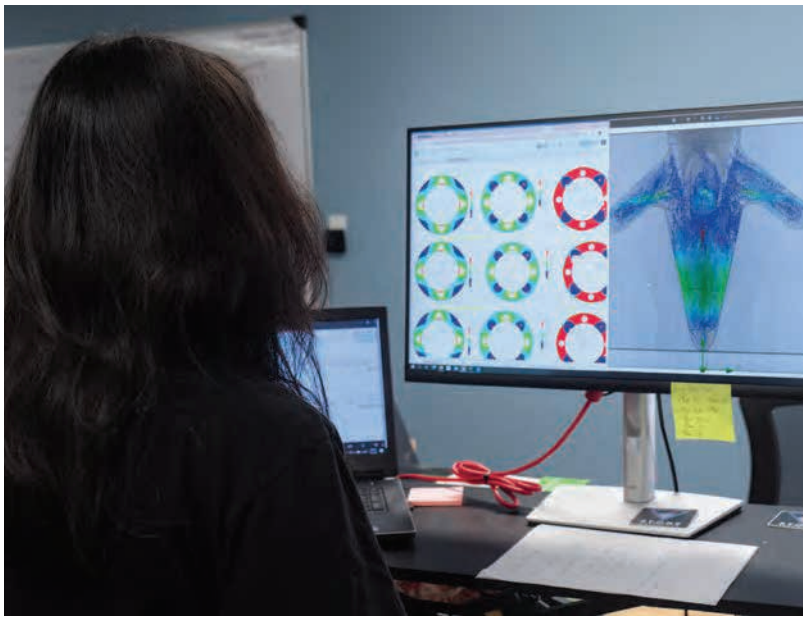
Engineering and Software Services:

In addition to complete end-to-end robotic systems design, fabrication, integration, and test our general engineering services include:

- Mechanical systems design (stress, dynamics, nonlinear, thermal, CFD)
- Structural mechanism design (including mechatronic interfaces)
- Custom PCB circuit board design and fabrication
- Embedded electronics design
- Custom embedded firmware development
- Wireless RF, fiber optic, and magnetic communications
- General robotics automation and autonomy programming
- Design of onboard power systems
- Design of remote optically-powered systems
- Design of closed-cycle life support systems (both PLSS and vehicular)

SAS has a track record of successful commercialization in the form of spin-off companies and IP licensing. Our SUNFISH AI behavior-based UUV represents the world's most sophisticated autonomous underwater system – the first to implement real-time 3D simultaneous localization and mapping as part of its navigation engine. SUNFISH has successfully conducted inspection, mapping, and exploration field operations in complex 3D overhead environments. Sunfish, Inc. was spun off from Stone Aerospace in 2019 to manufacture the device, provide field support, and offer robot-as-a-service data collection. For more information see: https://sunfishinc.com/. A portion of our closed-cycle PLSS IP has been licensed to Poseidon AB for the manufacture of technical diving systems, in the form of the Mk7 rebreather: https://www.poseidon.com/en-se/rebreathers/.

Stone Aerospace is a certified Texas small business. We welcome collaborations with aerospace and defense primes and are available for online or in-person briefings. Our IP is available for licensing or acquisition.



Test Services and In-House Fabrication:

Stone Aerospace maintains a number of unique testing capabilities. The *Europa Tower* facility is a vertical cryogenic vacuum chamber that can maintain a two cubic meter ice cylinder at conditions representative of the surfaces of the outer planet icy moons. The facility, newly upgraded in 2024, contains radiation sources for space-rating electronics. The current radiation sources include a 100 keV electron beam; a 160 keV xray source; a 1 kW deep ultraviolet (DUV) source; and a 5 kW Lyman alpha source. These features combine to create the only laboratory environment on Earth where space vehicles and subsurface life detection systems can be tested under relevant mission conditions in one place.

We also maintain a 150 cubic meter neutral buoyancy facility for testing of onboard code for autonomous underwater systems, including navigation, obstacle avoidance, autonomous docking, underwater data uplink and non-contact vehicle recharge.

We have an in-house IPG 5 kW industrial cutting laser that doubles as the power source for our photonic-powered vehicles and for testing of concepts for optical power transmission (over very long distances) and down-conversion of optical to electrical power for onboard persistent robotic vehicle presence.

Finally, we maintain in-house parts fabrication capability to speed prototyping of vehicular systems, including horizontal machining, vertical CNC milling, and 3D printing of large size polymeric parts.

Our IP:

Our intellectual property ranges from autonomous underwater vehicles, closed-cycle PLSS life support backpacks, reentry vehicles, novel launch systems, ice penetrators, and communications systems to optical power transmission and remote optical power conversion systems. We have more than a quarter million lines of proprietary autonomy code residing on industry standard robotic operating systems (ROS and Linux) and digital databases for electrical and mechanical vehicle system designs.

Our extensive suite of behavior-based autonomy and navigation code operates on full 6-degree-of-freedom platforms (whether UUVs, UGVs, UAVs, drones or spacecraft). We have also developed a broad patent portfolio, implemented in field tested hardware, in the area of ultra high-power laser energy transmission to remote, non-line-of-sight locations for ISR, remote autonomous power generation and vehicle operation, and hypervelocity projectile launch capacity.

Our life support tech includes control of synthetic breathing gases, real-time multi-gas decompression management, head-up and wrist displays, AI-based fault detection and advisory systems, and real-time oxygen control.

Stone Aerospace Patents:

RE46054	10,705,296
8,770,195	10,705,297
8,800,344	10,739,522
8,820,135	10,739,523
9,873,495	10,739,524
9,090,315	10,739,525
9,383,520	10,780,961
9,850,711	10,782,482
9,869,819	10,852,485
9,963,939	11,493,233
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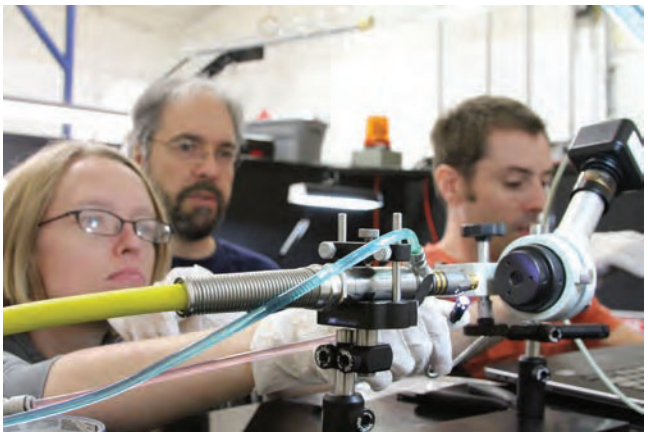

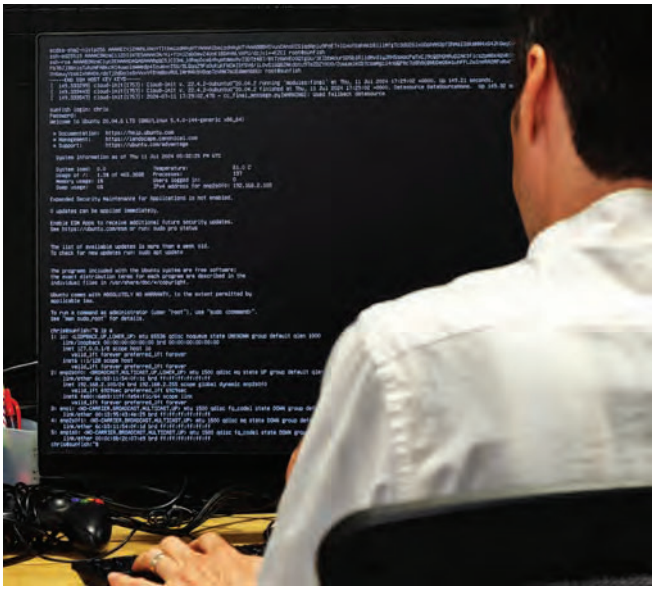

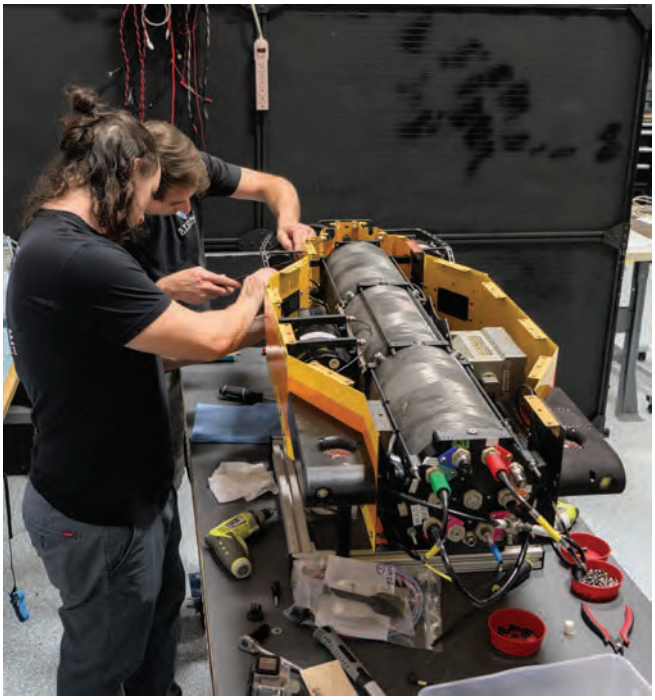

Stone Aerospace

Technology

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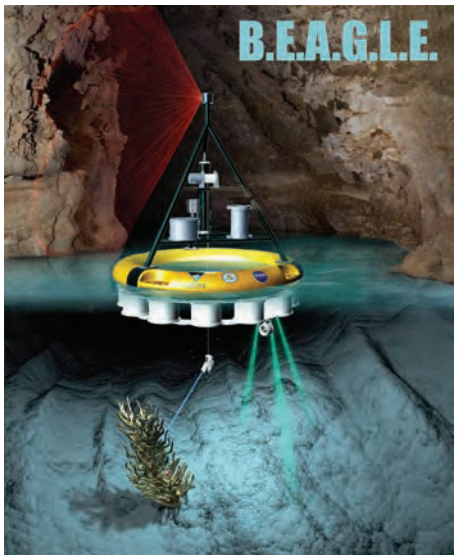


Current Projects

LUX: Lunar Underground eXplorer:
The First Extraterrestrial Cave Exploration Mission

Stone Aerospace is developing **LUX,** a revolutionary sub-selenian space exploration vehicle. It is a hovering robotic vehicle designed to breach inaccessible lunar lava tubes, such as the Mare Tranquillitatis Pit. Acting as the lunar equivalent of an aerial drone, LUX explores subsurface voids unreachable by traditional wheeled rovers or ballistic hoppers. The project leverages Stone Aerospace's deep heritage in deploying autonomous underwater vehicles in Earth's most extreme truly unexplored environments.

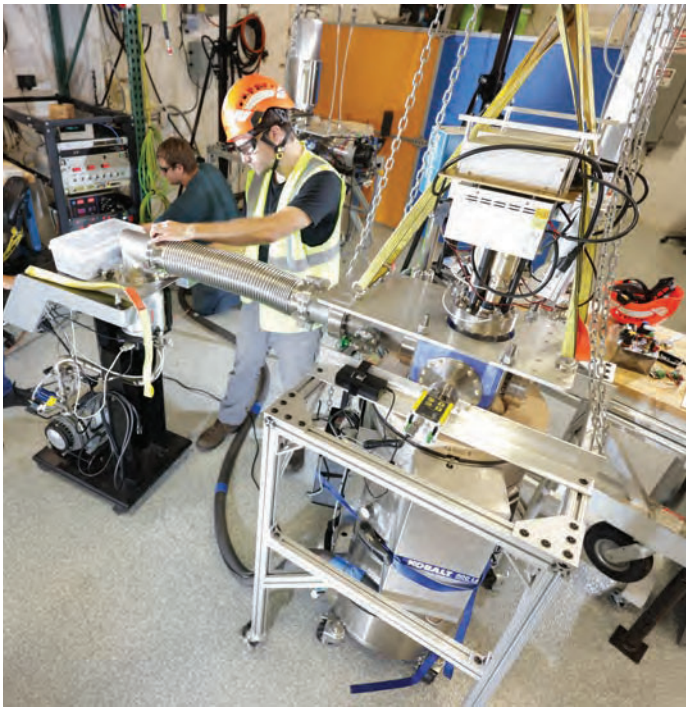
Key technological highlights include:

- **Fully Autonomous Navigation**: Features six-degree-of-freedom controlled flight guided by field-proven 3D-SLAM algorithms, high speed LIDAR, radar and Stone Aerospace's proprietary subterranean exploration behavior code. The vehicle makes its own decisions on what and how to explore into completely unknown overhead terrain without human intervention.
- **Fiber-Optic Waveguide**: LUX self-deploys a multi-kilometer ultra-thin waveguide for high-bandwidth, non-line-of-sight communications. Mission success is guaranteed as all data is already transferred back to a relay lander prior to any mission-terminating event.
- **Laser Power-over-Fiber (PoF)**: Multi-kilowatt laser power is beamed down the fiber tether from a surface lander to recharge onboard batteries. This also enables a NASA NIAC Phase I-awarded, non-polluting propulsion system.

By enabling **kilometer-plus cave penetrations**, LUX establishes a robust technical roadmap for sustained robotic and human presence on the Moon and Martian caves.

ICAR-Above&Below:
Radiation Survival of Microbes and Biomarkers in Deep Planetary Ices

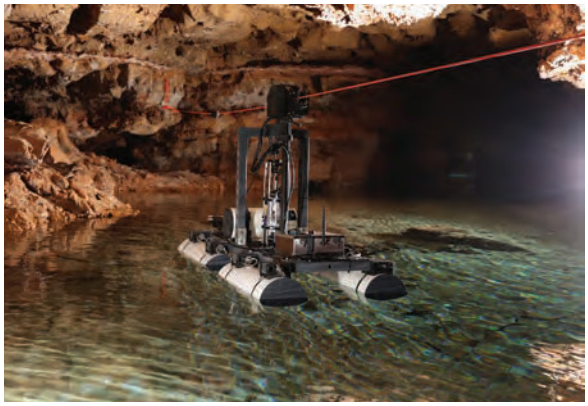
Stone Aerospace designed, developed, and operates the **ALIENS** (Advanced Laboratory for Instrumentation and Extraterrestrial Near-surface Simulation) space radiation facility in Austin, Texas. ALIENS facilitates simulation of planetary surfaces and subsurfaces, including both composite ices and regoliths, under cryogenic temperatures (down to 77 K), hard vacuum (to 10^{-8} Torr), and a variety of radiation sources. These conditions are relevant to the Moon, Martian polar caps, and Ocean World moons such as Europa and Enceladus. ALIENS currently enables investigation of radiation effects to test specimen depths of 60 centimeters, which allows detailed investigation of secondary radiation (bremsstrahlung) effects on deep embedded materials (which can include microbes, biomarkers, endogenous and exogenous planetary sourced impurities as well as custom-fabricated regolith specimens). Specialized cold-room specimen fabrication methods have been developed in parallel that permit the assembly of homogeneously doped test articles with depth dependent dosimetry. The facility includes both walk-in -30 C specimen fabrication space and industrial medical grade -80 C long term specimen storage.



The experimental methodology utilizes retrofitted liquid nitrogen dewars and stainless steel vacuum chambers. To simulate planetary radiation, the chambers accommodate four distinct sources within the spatial constraints of the dewars: a 100 KeV flood electron beam linear accelerator; a 100 KeV X-ray tube; a 100 W Hydrogen Lyman alpha source; and a 180 W Deep Ultraviolet (DUV) source. Stone Aerospace maintains a team of licensed radiation technicians and certified industrial radiation shielding vaults for the ionizing sources.

BEAGLE:
Autonomous detection of nanobacteria in subterranean lakes

Stone Aerospace designed and fielded BEAGLE (Biomass Enumerator And Geochemical/ Limnological Explorer) – a human-portable, unattended, and persistent floating science platform designed to gather geochemical and biological data from extreme astrobiology target sites. Currently deployed at a depth of 200 m below the surface at Wind Cave Lake, SD – an ultra-low biomass subsurface ocean analog – BEAGLE investigates the limits and adaptations of microbial life under nutrient-limited conditions and explores manganese oxide as a potential biosignature. To operate within the cave, BEAGLE's lightweight, corrosion-resistant compact modular chassis is hand-carried through tight passages and assembled lakeside. It achieves precise lateral positioning across the lake's deepest sections using a friction drive following an anchored low-stretch transit line. Engineered for persistent, remote science, the platform minimizes power consumption through custom single-board computers with smart sleep-wake functionality, allowing up to 6 months of unattended operation. BEAGLE deploys a sensor sonde package as it moves, creating programmable automated 2D chemistry scans. It includes an Aqua TROLL 500 probe, a Doppler Velocity Log (DVL) for bathymetry and collision avoidance, mSURFS – a custom protein fluorescence spectrometer, and a pumped ultrafiltration water-sampling system. BEAGLE also tests novel methods for extreme remoteness low bandwidth mission control. The floating autonomous platform transmits data wirelessly via LoRa radio hardware to a shore-side relay. There the highly compressed data packet is modulated onto a 3.75 kHz magnetic field oscillator. It is this field that penetrates the 200 m of limestone to be received via a 10 m diameter loop antenna on the surface, demodulated and encoded to a boosted cell phone data link to the project's principal investigator. The PI then signals a decision-to-collect in the face of nanobacteria detection, which is then transmitted through rock to the vehicle which carries out the order.

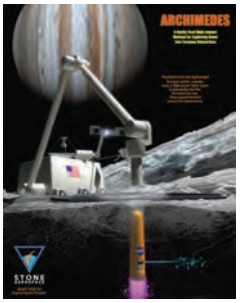


SpaceBrake: Low Ballistic Coefficient On-Demand Downmass Reentry Vehicles

Stone Aerospace has designed and patented the SpaceBrake suite of ultra-light deployable reentry vehicles that can be stored in low Earth orbit and used for on-demand return of made-in-space products, emergency evacuation of personnel, direct landing of military tactical material, and removal of orbital debris. SpaceBrake's low ballistic coefficient significantly reduces reentry heating loads. It eliminates ionization, enabling contact with the vehicle at all times and allowing the vehicle to access GPS positioning information during the entire reentry trajectory. A system for bringing down a 10 kg industry payload will have a gross weight of less than 50 kg. A system for bringing down 3 space tourists will have a mass of less than 300 kg. SpaceBrake is a deployable system. It launches in a compact, space-efficient volume. A system for bringing back 10 kg of payload will occupy less than 0.5 cubic meters of stowed volume. The impact of the above capabilities means that we can send large numbers of these devices up on supply missions with excess volume that are not mass constrained. Almost no launch vehicle operates at 100% packing efficiency. SpaceBrake can fill in the gaps and go as "excess baggage," thus not impacting the prime mission. The low heating loads allow us completely re-use of the vehicle. The vehicle terminal velocity is low enough (equivalent to jumping down 2 meters) that no parachutes, air bags, nor retro rockets are needed for landing. SpaceBrake uses patented dynamic morphing. This characteristic of the deployable aeroshell means that the vehicle will have significant "cross range," thereby significantly reducing the landing area "footprint."

Stone Aerospace

Technology



Notable Previous Projects and Vehicles

Autonomous Vehicles Designed and Built by Stone Aerospace:

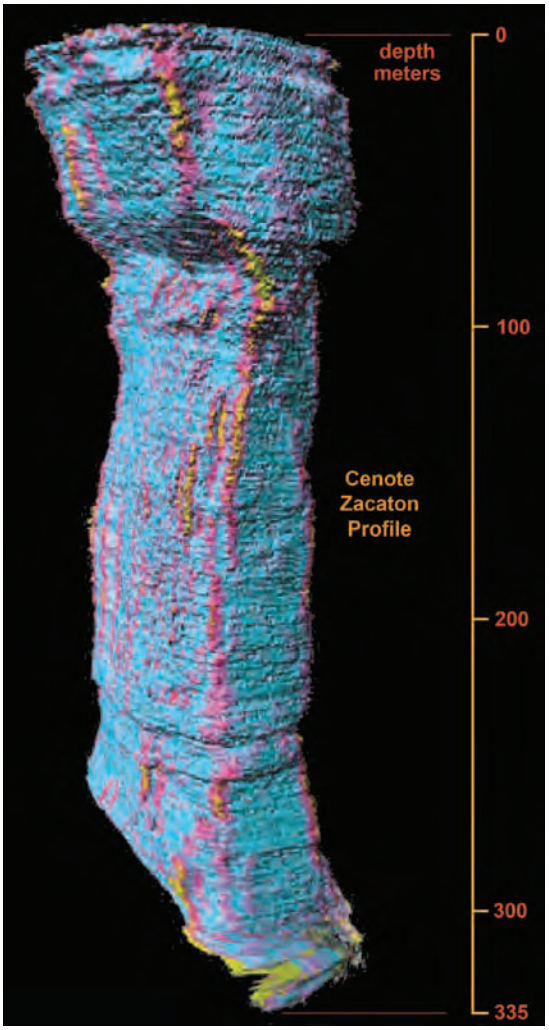
DEPTHX: (Deep Phreatic Thermal Explorer)

Stats:
Diameter: 210 cm; Height: 146 cm
Weight: 1,000 kg
Onboard Power: 5 kWH
Range: 10 hours
Avg Speed: 0.3 m/s
Positive Control: 4DOF (x,y,x,yaw)
Maximum Depth: 1,000 m
Instruments: IMU, RLG, DVL, Depth, CTD, pH, CDOM, DO, SO4, core sampler, water sampler, 64 tight beam sonar transducers

Mission: Concept tests for prototype of Europa lander 3rd stage hydrobot; test 3D-SLAM exploration and mapping navigation system; test hierarchy for autonomous microbe discovery and collection.

Highlights:

On February 10, 2007, DEPTHX became the first robotic system to enter completely untethered into an unexplored subterranean hydrothermal vent. It built 3D maps as it explored and returned home on its own maps to within 15 cm of its homing position. DEPTHX also implemented real-time science autonomy in which the vehicle followed chemoclines and thermoclines to wall surfaces where it used machine vision searches for changes in background coloration that might suggest the presence of microbial communities of interest. On May 16, 2007, using autonomous SLAM navigation, DEPTHX explored Cenote Zacaton to a depth of 335m and produced a 3D map in the process. On May 26, 2007, DEPTHX explored into Cenote Zacaton where it discovered a chemocline (H_2S) at a depth of 114m. It autonomously made a decision to follow the chemocline to a nearby wall, collected a core sample, and returned home. The rock samples autonomously collected by DEPTHX at Zacatón (to depths of 280 meters) subsequently resulted in the discovery of 4 new phyla of bacteria (at a time when less than 100 were known on Earth).

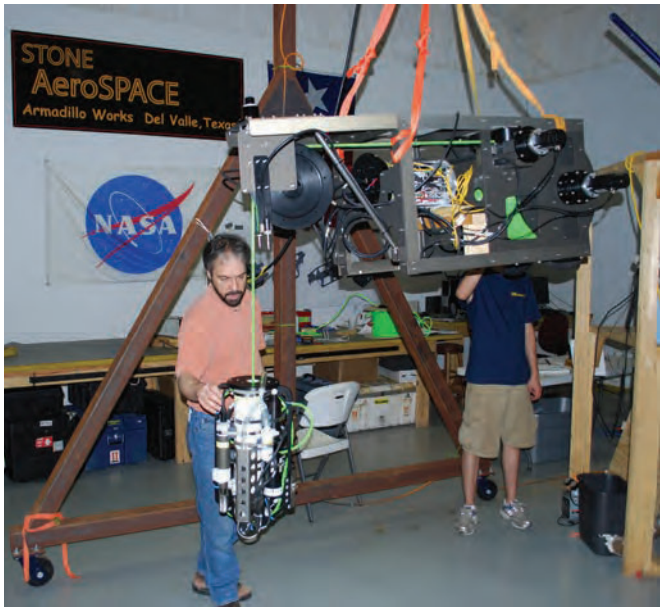


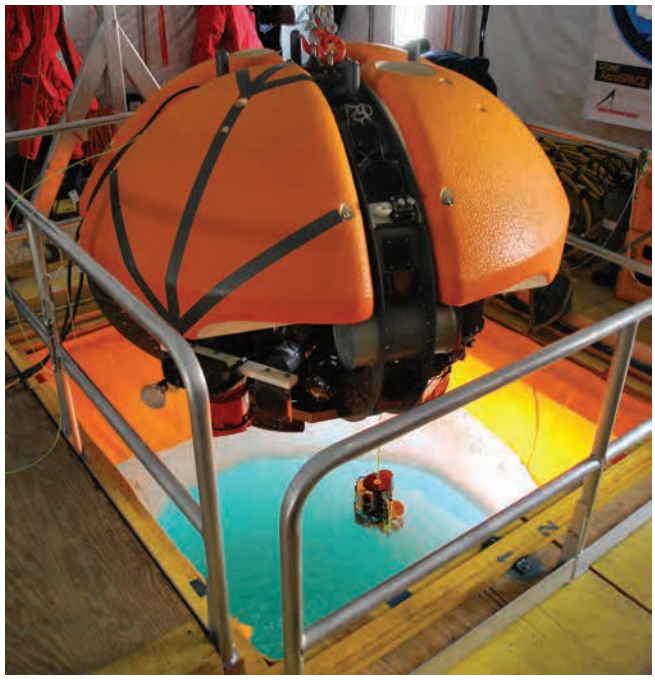
ENDURANCE (Environmentally Non-Disturbing Under-ice Robotic ANtarctiC Explorer)

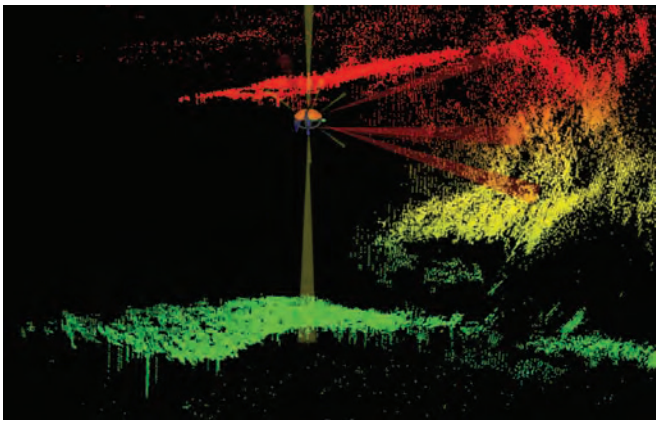
Stats: ENDURANCE used the DEPTHX frame and propulsion but completely replaced the science payload.

Science Payload Instruments: CTD, pH, CDOM, PAR, turbidity, redox, chlorophyll fluorescence, imager and lighting in a compact deployable auto-sonde.

Mission: Explore subglacial Lake Bonney, Antarctica; construct a 3D topographic map of Lake Bonney; build a 3D chemistry map of Lake Bonney; explore and map the underwater head of Taylor Glacier.







Highlights:

Designed for sub-ice autonomous navigation, exploration, and in-situ science, ENDURANCE was successfully fielded to Antarctica (3 months each during the Austral summers of 2008-9 and 2009-10). It produced complete 3D maps of permanently ice-covered, unexplored West Lake Bonney, 3D maps of the underwater junction of Lake Bonney with Taylor Glacier, and complete 3D aqueous chemistry characterization of the lake, traversing 76 kilometers under the ice cap. Individual missions of more than 4 kilometers were launched from a single melt hole (and the only exit point) in the 5 meter thick ice cap of West Lake Bonney. The vehicle used a 3-stage navigation and docking engine to return to and rise up through the melt hole on its own. Of historical note, ENDURANCE autonomously explored Scott Pass in the Bonney Riegel narrows between East and West Lake Bonney, where Capt. Robert Scott's party took measurements on foot in 1903. One hundred seven years later ENDURANCE hovered where Scott stood, and created a 3D map which revealed a water level rise of 16 meters during that time period.

ARTEMIS: (Autonomous Rover-airborne Radar Transects of the Environment beneath the McMurdo Ice Shelf)

Stats: Length: 442 cm; Width: 120 cm
Height: 72 cm
Weight: 1,200 kg
Onboard Power: 12 kWH
Range: 20 kilometers
Avg Speed: 1.5 m/s
Positive Control: 6DOF (x,y,z,yaw,pitch,roll)
Maximum Depth: 1,000 m

Instruments: IMU, RLG, DVL, iUSBL, 2 X Multibeam, 2 x machine vision, 5 cameras, Depth, CTD, DO (optical), DO (membrane), ORP, PAR, pH, CDOM, DO, 30 x water sampler, Laser altimeter, protein fluorescence spectrometer, chlorophyll, turbidity, thru-ice custom tracking system, 15 km vehicle-deployed fiber data link and 2 X 1 km range tight beam bathymetry sonar.

Mission: Acquire ground-truth up- and down-look bathymetry beneath the Ross Ice Shelf for the purpose of calibrating the Europa Clipper ice penetrating radar instrument.

ARTEMIS was the first long range autonomous vehicle to travel under the Ross Ice Shelf in Antarctica. It tested new stand-off bio-sensing technology based on deep ultraviolet laser induced fluorescence of microbes. A four month deployment to Antarctica was successfully fielded in Fall of 2015. The vehicle was deployed vertically down a 16 m drilled shaft, afterwhich it righted itself and conducted 20 missions to distances of 5 km from the access shaft. Critically, ARTEMIS used a 3-stage patented autonomous rendezvous and docking system that allowed the vehicle to find the hole from maximum range, lock onto an optical target, achieve hard dock capture, and re-orient for vertical travel up the drilled shaft without human intervention. The vehicle maintained a real-time Gbps fiber data link with mission control throughout each exploration run.

SUNFISH:

Stats:

Length: 161 cm; Width: 47 cm
Height: 20 cm
Weight: 37 kg
Onboard Power: 3 kWH
Range: 25 kilometers
Avg Speed: 1.5 m/s
Positive Control: 6DOF (x,y,x,yaw,pitch,roll)
Maximum Depth: 200 m

Instruments: IMU, DVL, Multi-beam, 2 x machine vision side-look inspection cameras, bow camera, CTD, nitrate sensor, sterile water sampling, sterile filter sampling, LED lighting, strobe lighting, cine 6K camera, (optional) up to 8 km onboard data fiber spooler.

Mission: Originally the under-ice rescue vehicle for the research AUV ARTEMIS. Currently SUNFISH is seeing expanded use as a cost-effective aqueduct inspection and intervention tool for city water supplies.

Highlights:

SUNFISH is a person-portable full 6DOF robotic vehicle that can fly and maneuver at any attitude and perform full 360° roll, pitch, and yaw maneuvers simultaneously. It uses this unique capabiltiy to perform 4π steradian sensor scans to provide full spherical situational awareness in any unknown environment, in full 3D. Using this capability, SUNFISH successfully explored and mapped the world's largest, deepest subterranean lake. Its exploration AI engine allows it to enter completely unknown 3D environments and return with detailed maps with texture mapped imagery.

Cryobots and Space Environmental Facilities:

VALKYRIE: (Very-deep Autonomous Laser-powered Kilowatt-class Robotic Ice Explorer)

Stats:

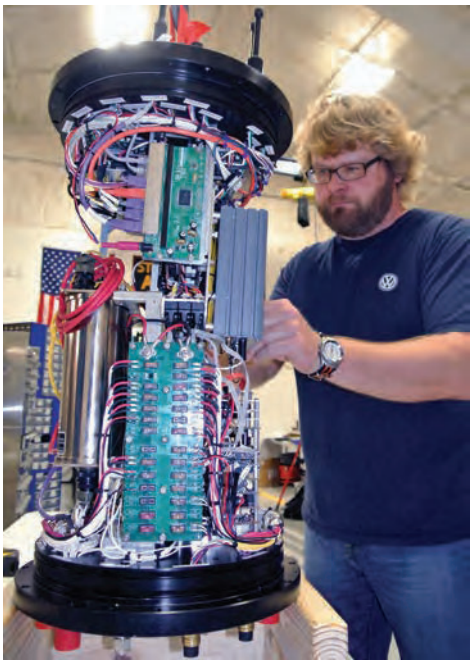
Length: 250 cm; Diameter: 25 cm
Weight: 150 kg
Onboard Power: 5 kW laser conversion
Avg Speed: 10 m/hour in temperate ice
Maximum Depth: 4 km

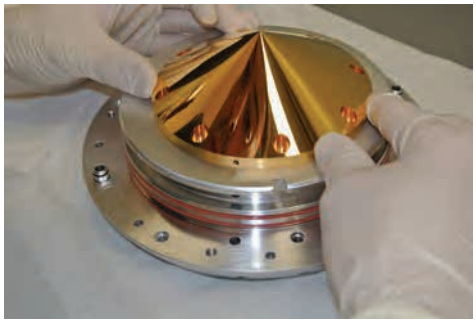
Instruments: IMU, depth sensor, DUV fluorescence spectrometer, sterile water sampling, sterile filter sampling, forward-look SAR (synthetic aperture radar), fiber data link.

Mission: Design, build, and field test a prototype of a Europa mission cryobot (self-contained ice penetrating robot) using a high energy laser as a surrogate for nuclear power and onboard closed-cycle hot water jets for descent and turning.

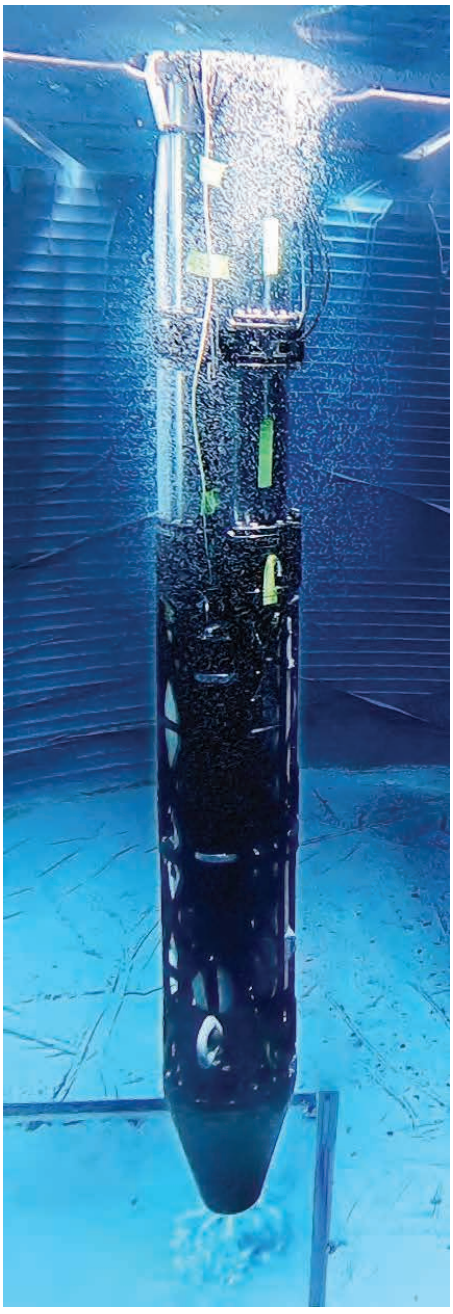
Highlights:

VALKYRIE is a flight-scale ice-penetrating cryobot that was the first to demonstrate steerable cross-range maneuvering in an ice penetrating robot. It was also the first cryobot to utilize closed-cycle hot water drilling (CCHWD). This range of cryobot size (25 cm diameter operating with an onboard heat source in the range of 5 to 8 kW_{th}) is commensurate with Pu238 RTG thermal sources modeled at Jet Propulsion Laboratories for a potential Europa lander mission. The truly novel aspect of VALKYRIE is its power source. RTG material is not available for general terrestrial field use so a surrogate surface power supply had to be developed that could be sent to the vehicle through a vehicle-deployed tether. Physicists at Stone Aerospace suggested the use of photons for this remote power source. Following two years of laboratory experiments, VALKYRIE was linked to a surface 5 kilowatt industrial laser via a high power fiber optic tether. The beam was internally diffused into an optical dump surrounded by a heat exchanger which in turn heated incoming icewater to power the CCHWD jetting system. The vehicle was successfully tested on the Matanuska glacier in Alaska.





THOR: (Thermal High-voltage Ocean-penetrator Research platform)



Stats:

Length: 230 cm; Diameter: 35 cm
Weight: 150 kg
Onboard Power: 50 kW_e / 45 kW_{th}
Avg Speed: 10 m/hour in temperate ice
Maximum Depth: 4 km

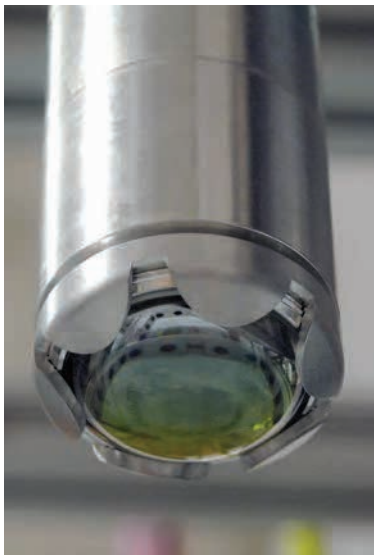
Instruments: thermistor, voltage, and current sensor arrays, pressure and flow rate sensors.

Mission: Demonstrate a flight-scale cryobot "power unit" designed around the NASA GRC Kilopower reactor and operated sustainably at reactor peak thermal output levels.

Highlights:

THOR is a flight scale Ocean Worlds cryobot system designed to use closed-cycle hot water drilling technology powered by a micro fission reactor. For terrestrial testing a nuclear surrogate power system, consisting of a 10 kV AC surface supply and a vehicle-spooled tether was developed at Stone Aerospace / Austin. THOR is currently designed to penetrate up to 500 m of ice and be able to transition to an actively spooled sonde behavior upon break-through into a subsurface ocean. THOR was tested in a 0°C test tank for 72 hours operating at 45 kW_{th} thermal load, making it the highest power operational cryobot currently in existence. This operating duration would have been sufficient to penetrate any location on the Ross Ice Shelf in Antarctica. High voltage AC electricity was converted on the vehicle using a novel liquid resistor and closed-loop heat exchanger that emulated the Kilopower reactor. Planned future enhancements include a sampling subsystem as well as spatial, environmental, and life-detection sensors to characterize the ice and water it transits through. This platform and sensor suite will then be used to develop and test strategies and behaviors for autonomous exploration and sampling as the vehicle descends through an ice column and into and through a subglacial water body below. THOR will integrate a VMCS (vertical motion control system) module, also developed at Stone Aerospace, to permit persistent presence in a subglacial lake or ocean followed by autonomous controlled retrieval to the surface to return physical samples for laboratory analysis.

ARCHIMEDES: (A Really Cool High Impact Method for Exploring Down into Europan Subsurface)



Stats:

Length: 20 cm; Diameter: 7 cm
Weight: 1 kg
Onboard Power: 5 kW coherent laser
Avg Speed: 26 m/hour in temperate ice
Maximum Depth: 4 km

Instruments: side-look fluorescence spectrometer, dust logger, pressure/ depth, lateral imager and lighting.

Mission: Demonstrate an ultra compact direct laser penetrator (DLP) for use by Martian polar cap landers and outer planet moon landers for mid-range subsurface life detection.

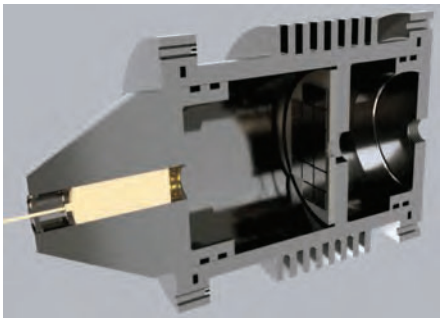
Highlights:

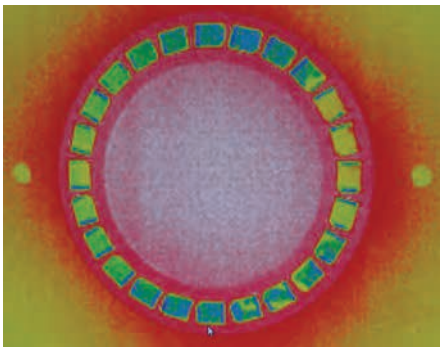
Stone Aerospace has developed a radical new concept for compact, high speed ice penetrators based on focusing coherent laser light at a particular wavelength into the ice column ahead of the nose cone of a descending cryobot. The concept was first demonstrated in 2016 and achieved the still-standing descent speed record for cryobots of 26 m/hour operating at 5 kW optical power transmission. Light is transmitted to the vehicle via a specially built fiber optic transmission tether. This tether is small enough in diameter (less than a millimeter) that a small diameter vehicle in the 5 to 10 cm diameter range can carry up to 4 kilometers of transmission fiber, which is deployed by the vehicle as it descends. Descent (or ascent) speed is driven directly by the input power and inversely proportional to the square of the vehicle diameter. Laboratory experiments conducted by Stone Aerospace have shown that 20 kW of coherent laser light can be sent over very long fibers. Proprietary experimental data predict that significant levels of power (in the kilowatt range) can be transmitted up to 40 kilometers and, furthermore, that input power levels as high as 100 kW coherent light can be utilized. We have developed, and proven via lab tests, remote down-conversion systems for generation of electrical power in remote autonomous systems that deploy their own fiber. The DLP cryobots have also been laboratory proven in cryogenic vacuum-ice tests to work under outer planet moon surface conditions. Stone Aerospace maintains an extensive patent portfolio in high energy optical power transmission and down-conversion.

High Energy Optical Power Transmission and Conversion

Subsurface exploration vehicles, such as the cryobot and autonomous underwater, under ice vehicle prototypes developed by Stone Aerospace for future NASA outer planet missions, all suffer from a common problem: high bandwidth wireless data transmission, common to all other spacecraft, is not possible due to dielectric attenuation of radio frequency signals in ice and water, especially salt water such as might be encountered in a subsurface icy moon ocean. To resolve this problem and to allow real-time science analysis by subject matter experts during an analog test mission, we have developed and integrated increasingly sophisticated fiber optic communications links - deployed by the vehicles. The Stone Aerospace ARTEMIS AUV, for example, carried, and deployed, 15 kilometers of fiber for missions under the Ross Ice Shelf in Antarctica. The Stone Aerospace-developed SUNFISH vehicle currently carries an 8 kilometer axial fiber spooler to allow for both data monitoring and supervised autonomy during the vehicle execution of onboard AI code. A secondary mission-limiting characteristic of non-nuclear powered robotic vehicles is the inherent range constraint imposed by battery power sources.

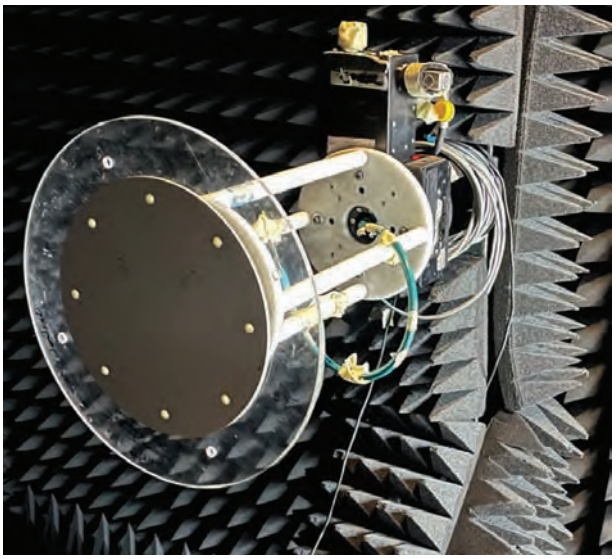
Beginning in 2008 we investigated the ability to send significant optical power to our vehicles through the use of industrial lasers and optical waveguides. Initial experiments were conducted with custom-doped fiber with power levels of 20 kW. The concept was initially used to send thermal power to the VALKYRIE cryobot. More advanced techniques were used for the ARCHIMEDES DLP cryobot, which utilized collimated photons being directly injected into the ice column ahead of the vehicle. We went on from there to develop a direct optical-to-electrical power system for persistent operation of a remote AUV, ultimately succeeding in directly driving thrusters on an AUV without the use of pulse modulation accumulator batteries. We are experts in this arena and maintain an extensive patent portfolio. Our research has indicated the techniques we have developed are applicable to ranges of up to 40 kilometers from the laser source with injection powers of up to 100 kW.



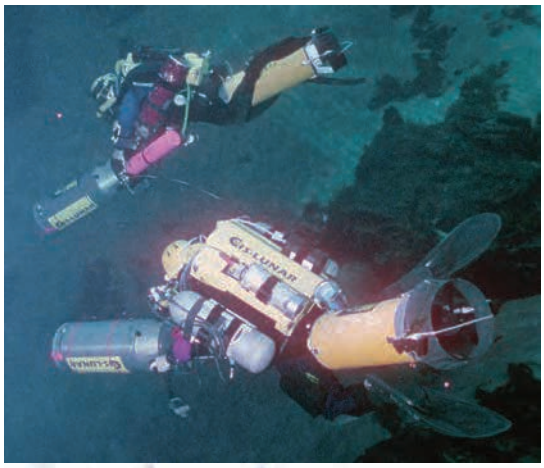


Novel Data Communications Systems

Our autonomous vehicles are designed to go to places under both ice and rock. Frequently it is desirable to know the absolute position of the vehicle (free of onboard navigational drift) or to be able to communicate with the vehicle absent a fiber optic data link. The latter topic is central to a cryobot mission where the possibility exists of cryo ice seismicity leading to a failed fiber. Stone Aerospace has developed modular, deployable, nuclear-battery powered “puck” geometry transceivers that will operate in both ductile and conductive cryo ices using frequencies in the UHF, MF, and HF bands. These systems have been tested in ice and will achieve up to 3 km range. Tracking through rock and ice is a different regime. We have developed, and extensively used in polar regions and subterranean environments, a series of 1 to 30 watt ultra low frequency magnetic field generators that have allowed us, e.g., to track the ARTEMIS vehicle to an accuracy of 10 cm while the vehicle was 100 m deep under the Ross Ice Shelf. We have similarly modulated these beacons to transmit 1 kbps of data through up to 1,200 m of solid rock.



Closed-Cycle Life Support



Stone Aerospace is the world leader in the design of fully closed-cycle, computer-controlled portable life support systems (PLSS) for use in underwater environments. We were responsible for the technical diving revolution of the late 1980s and early 1990s and developed the first commercially available fully redundant closed-cycle diving systems. The ground-breaking Cis-Lunar Mk1 rebreather was used for a continuous 24 hour underwater mission in 1987. The dual Cis-Lunar Mk5 had a range of 18 hours underwater, independent of depth, and an operational depth rating of 200 meters. It was used for the first saturation cave diving missions in 1999 on dives lasting 22 hours to 100 m depths. All of our systems incorporate real-time decompression, heads-up, and wrist-mounted displays and in-mission programmable control systems. Stone Aerospace is also the prime designer for the Poseidon line of diving rebreathers, including the Mk6 – a computer controlled 15 kg device with a depth rating of 60 m and a range of 3 hours, about the size of a briefcase; and the Mk7 (Se7eN), a technical diving unit with a 6 hour range and 200 meter depth rating. More than 4,000 units have been sold to date. The design principles, sensing, and control code in these systems are equally applicable to spacesuit PLSS systems.