

# Solar-powered AUV: SAUVII

---

## Executive Summary

Autonomous underwater vehicles (AUV's) have been in use for the past decade for academic, commercial and military survey missions. Example missions include environmental and geologic mapping, MCM missions, harbor surveys and more. These successes notwithstanding, conventional AUV missions are time-limited by constraints of on-board vehicle power. Most missions are therefore short, of 4 to 12 hours duration. As a consequence, AUVs to date have not become the ISR (intelligence, surveillance and reconnaissance) counterparts of their UAV brethren. The Solar-powered AUV built by Falmouth Scientific, Inc., changes all this, offering a compact, man-portable AUV capable of offering long-term (weeks to months) monitoring, station-keeping and ISR mission support in all ocean conditions, with little or no intervention.

## Introduction

It has long been considered that AUV platforms, in-principle, could provide an effective solution for surveillance (security and anti-terrorist), environmental monitoring and data portal (to sub-sea instruments) requirements, but limitations in battery life have minimized AUV usefulness in such applications. The concept of a vehicle that would allow on-station recharging of batteries, using solar cells, has been presented as a means to significantly enhance the effectiveness of AUV platforms where long-term or ongoing deployment is required. The Solar Powered AUV (SAUV) is designed for continuous deployment (weeks to months) without requirement for recovery for service, maintenance or recharging.

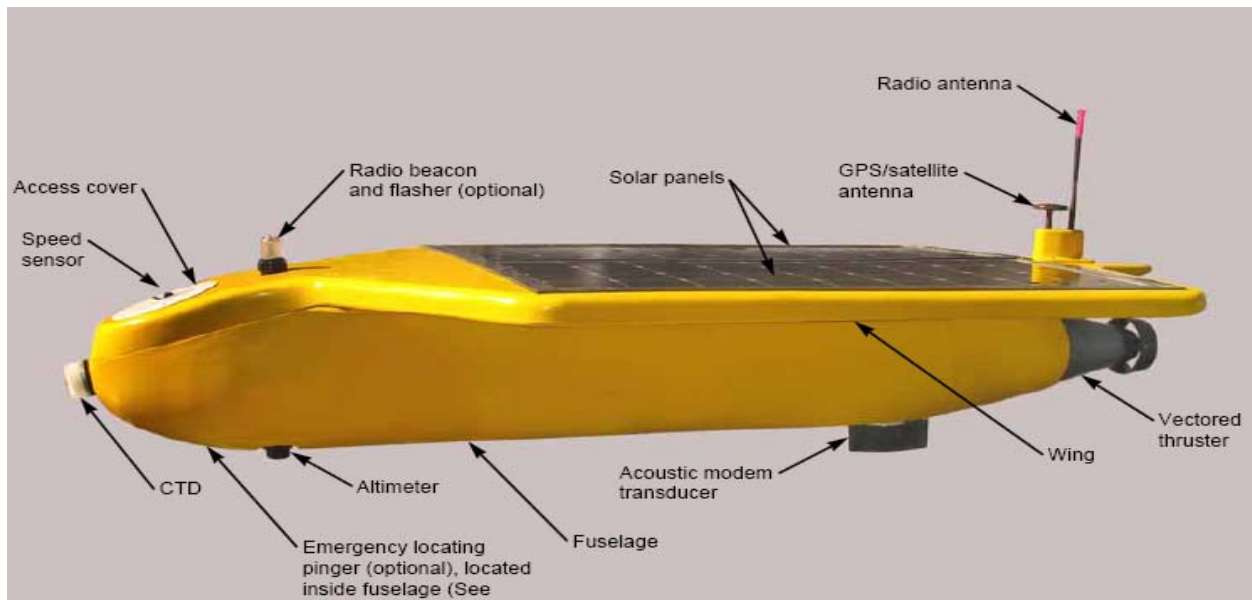
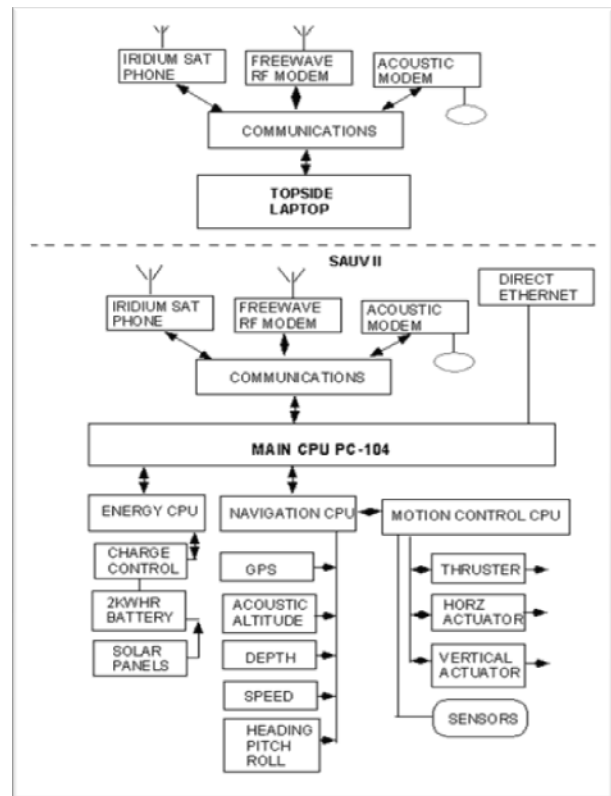


Figure 1. Solar-powered AUV, Version II, by Falmouth Scientific, Inc.

The SAUV is designed as a multi-mission platform to allow payload configuration by the end-user to optimize the SAUV for coastal/harbor monitoring, data portal (to moored sub-surface instruments) applications, or any other application where long-term deployment is required. The SAUV is designed to reside on the surface while recharging batteries and then to execute its programmed mission. While on the surface the SAUV is designed to communicate via Iridium® satellite or RF communications link to upload collected data and to allow reprogramming of mission profiles. A bi-directional acoustic link provides for data acquisition from sub-sea instrumentation.

The vehicle can be pre-programmed to submerge to depths down to 500 meters, to transit to designated waypoints, or to operate on the surface during conditions suitable for battery charging via solar energy input.

A block diagram of the system architecture is shown below in Figure 2.



The SAUV II system functional capabilities include:

- Operate autonomously at sea for extended periods of time from weeks to months. Typical missions require operation at night and solar energy charging of batteries during daytime.
- Communicate with a remote operator on a daily basis via Satellite phone, RF radio, or acoustic telemetry.
- Recharge batteries daily using solar panels to convert solar energy to electrical energy.
- Operate at depths to 500 meters.
- Operate at speeds up to about 3 knots.
- Battery system provides a total capacity of about 2.4 KWhrs.
- Acoustic altimeter capable of 100 meter altitude tracking and depth sensor to 500 meters.
- Capability to acquire GPS updates when on the ocean surface. Capability to compute SAUV position at all times using GPS when on surface and dead reckoning when submerged.
- Capability to maintain fixed depth and fixed altitude and to smoothly vary depth or altitude profile.
- Capability of navigating between waypoints (latitude and longitude).
- Capability to log and upload all sensor data correlated in time and SAUV geodetic position.
- Provide sufficient volume, power, interfaces, and software hooks for end user payload sensors.
- Allow user to program missions easily using a Laptop PC. Allow user to checkout basic operation of SAUV system in the lab or aboard ship using the Laptop PC.
- Provide for graphical display of mission and payload sensor data on Laptop PC.

## Competitive Analysis

Traditional AUVs offer mission durations ranging from hours to days. They are largely limited by on-board battery power, and hotel load. As an example, a REMUS 100 can operate for 22 hours at 3 knots, or 8 hours at up to five knots. While significant long-distance records have been set by very large vehicles such as the Urashima (10m long, 2.5m diameter, 300 km range), no true station-keeping AUVs capable of multi-month ISR missions have emerged.

Gliders offer an alternative platform, with effectively infinite mission duration, but limited directivity. As an example the SLOCUM glider by Webb Research (now Teledyne-Webb Research) advertises effectively limitless mission duration, utilizing a buoyancy-controlled saw-toothed vertical profile to induce propulsion. While buoyancy-driven motion offers long-duration missions, sensor duration is still limited to hotel power, and maneuverability is limited – the vehicle can get down, but it can't stay down.

An interesting alternative to the buoyancy-driven approach is provided by Liquid Robotics's Wave Glider. The Wave Glider used a two-body configuration to produce thrust. The buoyant surface unit is lifted up and down by wave motion, and linked to submerged "thrust surfaces" to induce forward motion. The Wave Glider boasts 86 watts of power from solar panels, and 600 Watt-hours of on-board battery storage to provide up to 5 watts continuous hotel power for instruments. The vehicle can remain at the surface indefinitely, but it cannot dive, and is hostage to wave conditions and direction.

Based on the literature available on the Liquid Robotics website, the SAUV II can outperform the Wave Glider in power, endurance, and mission-configurability.

With its square meter of solar panels, the SAUV II can collect from 300 to 900 Watt-hours per day and carries 2.4KWhr on-board batteries. At full charge, the system would provide approximately 1900 WHrs of energy available (assumes 20% reserve), versus 600 WHr on-board batteries on the Wave Glider. A possible mission scenario might involve traveling 3 miles @ 2 knots, consuming 41 W continuous. Assuming a hotel load of 10W, the resulting energy use would be 51W continuous over 1.5 hours, for a total consumption of 76.5 Whrs, leaving plenty of energy for both station keeping and data transmission once at the surface.

The SAUV II can dive under its own power to depths of up to 500 meters, then remain there and execute a mission, such as mapping, imaging or chemical sampling. The SAUV II can also remain on the surface, either station-keeping independent of sea-state conditions, or navigating to access objectives or avoid exposure. The SAUV II is self-propelled, controlled by a single vectored thruster and responsive to changing mission instructions, via an existing embedded Iridium satellite modem, RF modem, or Acoustic modem along with mission controller software.

## Summary

The combination of energy availability, flexible user payload capacity, and the ability to dive or remain on the surface makes the SAUV II an extremely flexible platform for a wide range of missions.