

## Parasitic Power Pack (P3)

### Knowledge Based Systems, Inc.

1408 University Drive East,  
College Station, TX, 77840

Phone: (979) 260 5274

Fax: (979) 260-1965

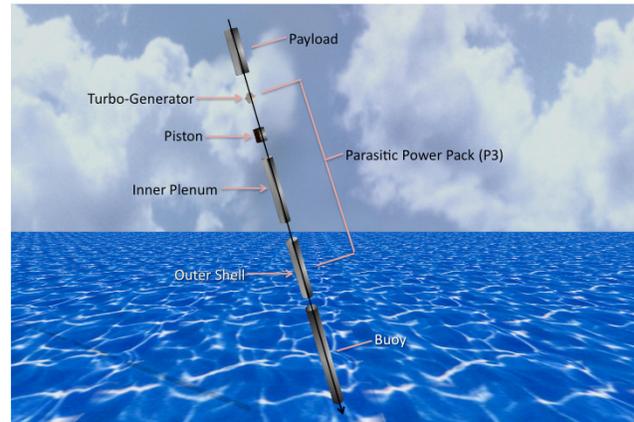
Website: [www.kbsi.com](http://www.kbsi.com)

### Dr. Paul Mario Koola

Email: [pkoola@kbsi.com](mailto:pkoola@kbsi.com)

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### PROBLEM STATEMENT

The Parasitic Power Pack (P3), developed by Knowledge Based Systems, Inc. (KBSI), is a robust, maintenance-free, power generator for free-floating ocean applications. The P3 power system is designed to be a modular insert into free-floating buoy systems that require small amounts of continuous, reliable electrical power.

The Parasitic Power Pack harvests energy from natural wave action in the open ocean. An inertial mass inside P3 captures wave energy from the buoyant up-and-down motion of the containing buoy induced by wave action. That captured energy is converted into electricity by a unique and innovative turbo-generator. An ultra-capacitor serves to store and distribute the electricity to the buoy's payload.

Wave energy harvesting is a promising approach to solving the sustainability limitations that arise with chemical battery power sources in buoy sensor networks. KBSI's unique design for P3 converts low-frequency, large-amplitude wave oscillations into useful power. The P3 is designed to be modularly integrated into buoys by simply replacing the current battery pack.

Applications such as Distributed Sensor Networks currently rely on chemical battery systems to provide the continuous power they need to operate sensors and communicate results. Maintenance of these chemical batteries in these systems is impractical. The P3 is an ideal replacement for the chemical battery packs usually employed for these applications.

Using batteries to power buoys at sea is an expensive proposition. Batteries become depleted and must be replaced. Locating the buoy in the ocean, hauling it onboard, and stopping the signal acquisition before battery replacement all add to the cost of maintenance. Vessel-operating costs and associated manpower costs add up quickly to make battery maintenance prohibitively expensive. In the lifecycle operation of these buoys, battery replacement could well be the highest cost driver.

P3 technology provides the following innovative features:

- Modularly replaces existing battery packs;
- Fits within prescribed buoy size and weight constraints;
- Ensures steady power output from the randomly fluctuating input wave power source using a built-in energy storage subsystem;
- Operates independent of wave direction;
- Supports “*free floating*” devices through its built-in inertial platform;
- Lifetime, “*maintenance free*,” robust design, effective in conditions exceeding sea state 5; and
- Low life cycle cost – No battery replacement costs at sea.

### **WHO CAN BENEFIT?**

P3 technology is designed to be a direct replacement for chemical battery packs used in free-floating buoy systems. Sensor and communication systems requiring continuous power in the sub-watt to one-watt range can directly benefit from this technology. Initially sponsored for military use, P3 technology is fully applicable to civilian applications such as near-shore communications relays and autonomous open-ocean data sampling. P3 technology would be an ideal solution for future buoys planned to operate in a distributed sensor network for weeks at a time. P3 provides this perpetual power required in such applications.

P3 technology is scalable. The initial P3 implementation fits a standard three-inch sensor buoy. Multiple modules can be linked together to provide greater power generation capability. Larger-diameter implementations of the P3 technology are feasible and can produce disproportionately higher power outputs.

Because P3 eliminates the requirement for battery replacement, life-cycle costs for free-floating buoy systems are significantly reduced. Perpetual power provided by P3 is the best value money can buy for free-floating, open-ocean buoy applications.

### **BASELINE TECHNOLOGY**

The current approach to powering sensor buoys is to use chemical batteries. There are many battery chemistries, such that buoy manufacturers can pick and choose from a wide range of products in the market. However, all chemical battery solutions have limited shelf life and limited operating life.

Buoy manufacturers and operators can profit from this new perpetual power source because P3 produces electricity from ocean wave actions alone, eliminating the need for storage and periodic replacement of batteries. The initial price of this technology is comparable to that of battery packs; the life-cycle cost of the technology is substantially less than existing technology because there is no need to replace the power source at sea.

## TECHNOLOGY DESCRIPTION

P3 technology is a direct replacement for and a significant improvement on chemical battery technology for powering open-ocean buoys. P3 is designed to be directly compatible with power specifications of the existing battery packs it replaces. P3 technology matches the free space and weight restrictions prescribed by the buoy platform. Maintenance-free and robust, P3 technology presents a fraction of the life-cycle cost associated with existing battery power sources.

<i>Feature</i>	<i>Advantage</i>	<i>Benefit</i>
<i>Perpetual power</i>	<i>No battery replacement</i>	<i>No battery replacement costs</i>
<i>Long Shelf Life</i>	<i>No chemicals to degrade</i>	<i>GREEN Technology</i>
<i>Size and weight fits buoy</i>	<i>Can be easily integrated into buoy replacing battery</i>	<i>No platform redesign</i>
<i>Manpower savings</i>	<i>Elimination of inefficient battery replacement labor</i>	<i>Manpower deployed to more productive activities</i>
<i>Lower Lifetime cost</i>	<i>Sustainable power with reduced manpower</i>	<i>Cost savings in the range of \$5000* per buoy per year. * Assuming \$50,000 vessel charges per day replacing batteries for 10 distributed floating sensors once a year.</i>
<i>Perpetual Persistent Ocean Surveillance</i>	<i>New distributed sensor applications</i>	<i>Force multiplier supporting perpetual floating ocean sensors</i>

## CURRENT STATE OF DEVELOPMENT

In the Phase I effort of our research, we developed “Wave to Wire” analytic models and built a physical prototype that far exceeded the power requirements specified by the research sponsor. In the Phase II effort, KBSI is increasing the fidelity of the analytic models and extending our initial results to produce a device with power outputs on the order of 600-900 mW at 6-9 volts and housed inside a three-inch buoy.

We will begin testing a prototype system in 2011. A custom-developed test rig provides millions of cycles of oscillation, simulating operation over extended periods of time in realistic ocean waves.

## REFERENCES

TPOC SAPWAR

## WHEN THE TECHNOLOGY WILL BE READY FOR USE

The technology will be ready for deployment in July 2012. The target power rating of current development efforts is 900 mW. P3 will be validated in a realistic laboratory-based sea simulator in January 2012. Sea trials are expected to be complete by June 2012.

<b>Milestone</b>	<b>TRL</b>	<b>Measure of Success</b>	<b>TRL Date</b>
<i>Proof of Concept</i>	3	<i>Meet target power 4mW (Achieved 5.8mW)</i>	<i>May 2008</i>
<i>Component validation in a laboratory environment</i>	4	<i>Meet target power 4mW (Achieved 25mW)</i>	<i>March 2009</i>
<i>Component validation in a laboratory realistic simulated sea environment</i>	5	<i>Meet target power 900mW</i>	<i>January 2012</i>
<i>Sea trials</i>	6	<i>Survives Sea trials</i>	<i>July 2012</i>

### **ABOUT THE COMPANY**

**Knowledge Based Systems, Inc. (KBSI)** is a dynamic engineering and systems analysis, consulting, and systems/software development company. Our history reflects our capability and determination to complete projects on schedule, within budget, and with high quality results.

Since its founding in 1988, KBSI has established a reputation for excellence in turning research results into innovative commercial technologies. KBSI has been awarded a multitude of major research and development contracts.

KBSI transitions innovative research and technology into cutting edge solutions and software for government and commercial clients worldwide. Over the past two decades, we have used our experience in systems analysis, design, and development methods and technologies, including discrete event simulation, process modeling and analysis, data mining, and artificial intelligence, to develop solutions for a host of government and commercial projects.

Our customer-centered approach ensures that we work to understand the challenges faced by our clients, and that, as partners, we work together to design and implement the right solutions to meet their needs and develop their capabilities for the future.

KBSI is an experienced Navy contractor with approximately 75 employees. KBSI has extensive experience in the SBIR arena, with approximately 142 DoD SBIR awards, 56 of which are Phase II awards. The company has also had a number of Phase III awards from DoD agencies. On this SBIR effort, KBSI is developing the “Parasitic Power Pack (P3)” power generation device for use in buoy platforms.