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# RadPoleCam Development

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**Abstract** – *The RadPoleCam was developed to provide Department Of Energy (DOE) first responders the capability to assess the radiological and visual condition of remote or inaccessible locations. Real time gamma isotopic identification is provided to the first responder in the form of audio feedback (i.e. spoken through head phones) from a gamma detector mounted on a collapsible pole that can extend from 1 to 9 meters (6 to 29 feet). Simultaneously, selectable direct and side looking visual images are provided from the 5cm (2in) diameter, waterproof probe tip. The lightweight, self contained, ruggedized, system will provide a rapidly deployable field system for visual and radiological search and assessment of confined spaces and extended reach locations.*

## I. INTRODUCTION

A first responder that needs visual access to tight, confined, or inaccessible spaces has limited technology options available to him, particularly if there is a potential radiological hazard involved as well. The subject of this paper is a system that provides the ability to access such environments as fast as possible under less than ideal conditions, and know, in a user friendly manner in real time, what radiological isotope has been encountered.

A search and detection device has been developed that gives simultaneous, remote, forward and side looking viewing and audio-based gamma spectrum collection and analysis in field environments. The waterproof, self contained, RadPoleCam (RPC) can be deployed from 1 to 9 meters (6 to 29 feet) upward and horizontally and 15 meters (50 feet) downward to give a first responder remote inspection capability. Providing the gamma radiation feedback by audio means permits the user to focus primary attention on the visual data from the cameras. Isotopic identification is performed automatically and the results are communicated by voice through waterproof headphones, obviating the need to divert visual attention away from the scene at hand.

## II. RadPoleCam DEVELOPMENT DETAILS.

RadPoleCam (RPC) has been developed under Department Of Energy, Office of Emergency Response, funding as a rugged, waterproof, man-portable field system that combines small space video probing with radioisotope location and identification. The main structure of the RPC includes a multiple section, collapsible pole that can be extended from 1 to 9 meters (6 to 29 feet), a self-retracting cable reel, and a composite cable which includes multiple coaxial and power cables. The interior of the reel area of the RPC contains a patented Sampled Data Spectroscopy (SDS) radiation measuring instrument, supporting electronics, and a spring loaded spool of cable capable of lowering the detector and camera assembly down 15 meters (50 feet) when decoupled from the pole.

The operator interface consists of a PDA, headphones, and video monitor or heads up display. Custom software name SLI™ (Search, Locate, & Identify) has been developed to handle the location and identification of isotopes.

When the RPC is used for remote isotopic detection an audio response is provided to the operator through waterproof headphones. As the pole's detector gets closer to a radioactive source, the frequency of the audio tone increases, and a synthesized voice directs the operator's actions. In normal operation, the gamma spectrum is divided into four energy bands, each having an alarm level established by the prevailing background radiation.

When at least one alarm level is reached, a distinctive alarm sound is played through the headphones indicating a source has been located, and additional instructions are provided to the operator. At this point the operator can choose to manually switch to the Isotope ID Mode, or the

RPC will automatically switch to the Isotope ID Mode if a second, higher level threshold is exceeded. SLI™ then collects a spectrum and compares it to a known library of isotopes. An isotope that matches with a 90% or better confidence level is displayed on the PDA screen and announced to the operator.

When deployed, the operator can selectively view multiple video angles by choosing the forward or side-looking/rotating view cameras to inspect the area or visually locate the gamma radiation source. High intensity LED's are included to provide near-field illumination at minimum power. The video is displayed on a small LCD panel or on the operator's heads-up display. All functions are powered from a common, belt worn, battery pack. Switches on the side of the reel assembly control power, camera selection, and side looking camera view rotation. All components are waterproof.

## III. COMPONENT DETAILS

The RPC integrates a group of common remote system components with new capabilities to provide all of the complimentary functions for remote viewing and radiological sensing that follow:

- A fully self-contained, deployable system for long duration field operations that is operator worn or carried and operates from a standard battery pack;
- The ability to reach long horizontal distances by pole extension and longer vertical distances by cable deployment;
- Combined multiple video (ahead and side viewing) sensors and operator viewing options;
- Gamma radiation sensing with isotopic identification;
- Integrated cable reel and electronics packaging to simultaneously accommodate high voltage supplies, sensitive low level signals, and serial communications;
- An operator control PDA for visual data display, as well as audio response through waterproof headphones;
- Computer programs, firmware, and algorithms.

Figure 1 shows the RPC in a collapsed form as deployed in the field. Figure 2 shows RPC in the pole extended configuration. The required wiring and interconnections are provided by a multi-coaxial and power wire composite cable that deploys through the center of the pole from the rotating reel on the operator end. The cable deployment method confines all excess cable to the reel.

Fig. 1. RPC Deployed In Collapsed Form

Fig. 2. RPC Deployed In Horizontal Extension Form

The multi-section fiberglass pole supports the sensing tip on the outboard end, the controls and electronics on the inboard end, and the interconnecting cable. The operator wears a 12 volt DC battery pack, a ruggedized PDA, and a video display. Headphones connected to the PDA provide the audio feedback.

Figure 3 shows the details of the components worn by the operator. A complete system is shown in the main view including battery pack etc. The insets show more details of the tip assembly (upper inset) and PDA with headphones (lower inset).

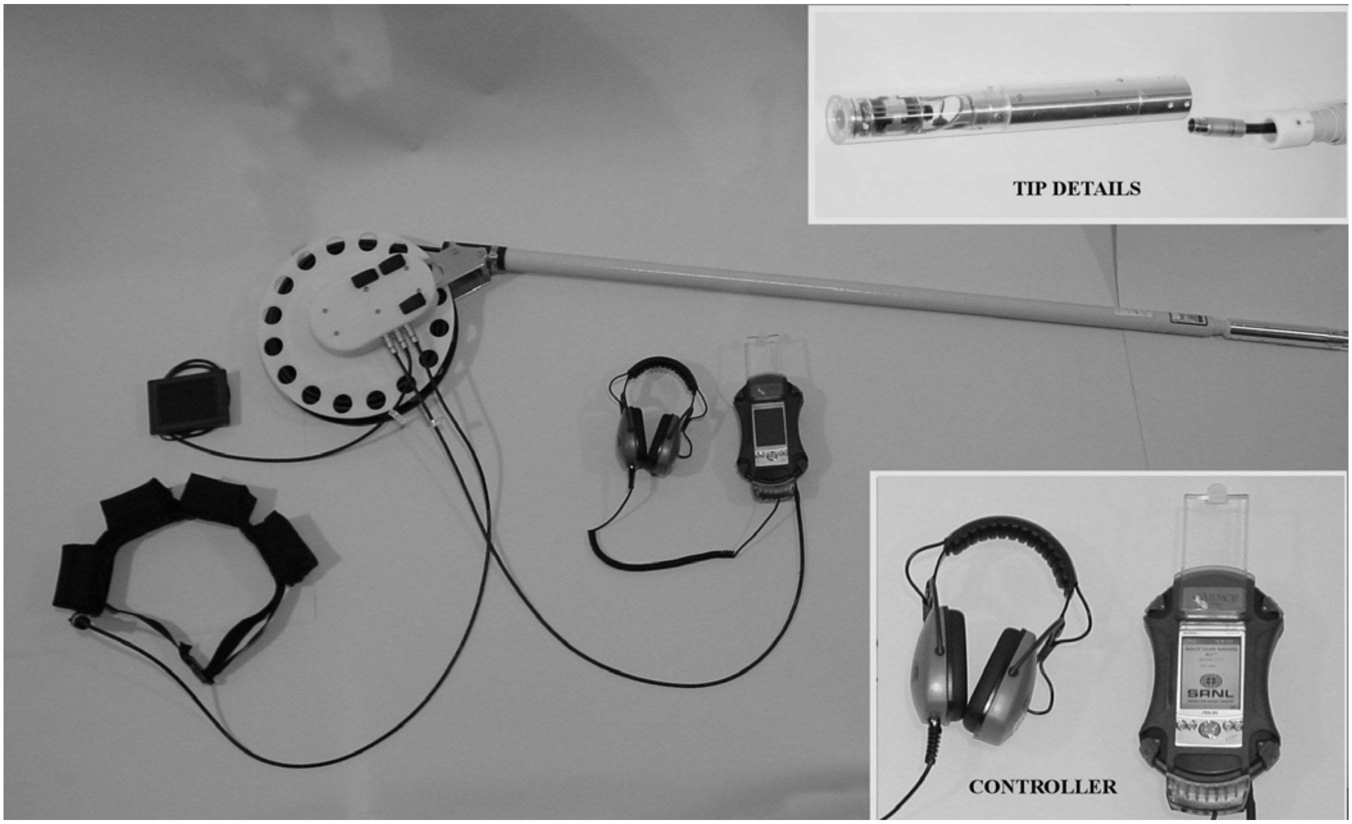


Fig. 3. Overview Of RPC Components

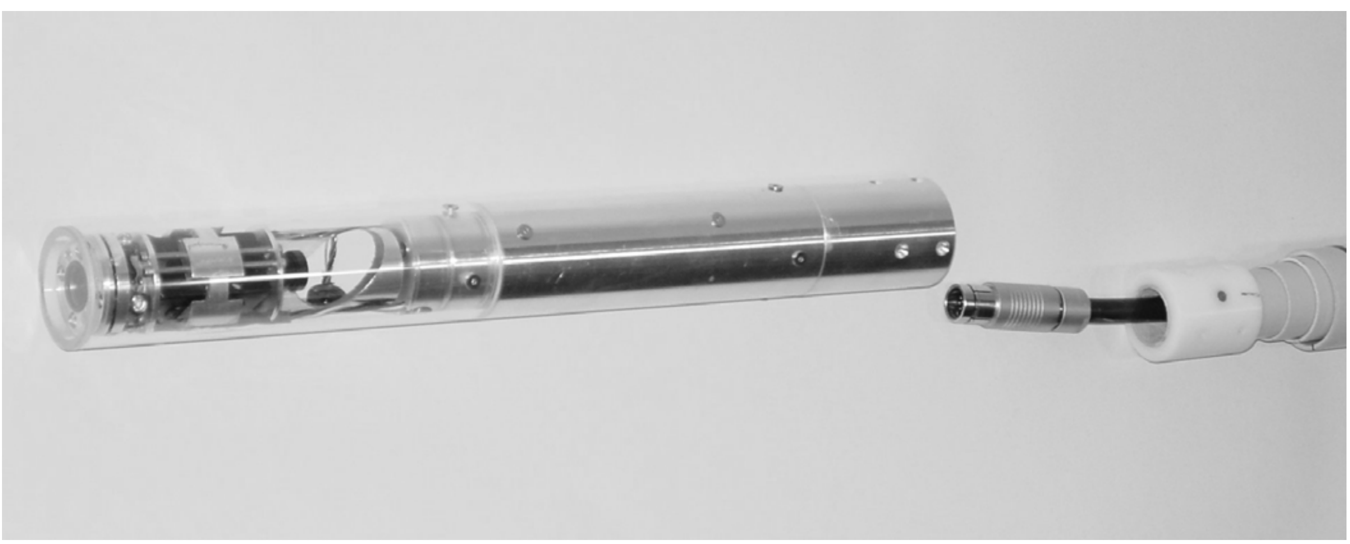

Fig. 4. RPC Video/Radiation Sensing Tip

Figure 4 shows a more detailed view of the RPC tip with the pole to the right, and Figure 5 shows an exploded view of the tip internal components. The tip is shown disconnected from the cable and pole as it would be for replacement or maintenance. The tip is separately waterproof when connected to the cable and can be deployed vertically by pulling the cable through the end of the pole and dropping the sensing tip supported only by the cable. This configuration allows for 15 meters (50 feet) or more of downward deployment, permitting top entry into any opening or chamber more than 50 mm (2 in) in diameter.

The tip has two color video cameras positioned for forward or side looking viewing as selected by the operator. The side looking camera has 360 degree continuous rotation capability for viewing to all sides. This is accomplished by a motorized mirror that can rotate in either direction as selected by the operator.

High intensity LED lighting is provided by two independent sets of one watt LED's. Four illuminate in the forward direction and four illuminate sideways. The cameras view through the front and side of a polycarbonate tube that protects and seals the waterproof tip.

The aluminum body protects and seals the radiation sensing portion of the tip without significant gamma shielding effects and interfaces to the quick disconnect, waterproof connector. This configuration allows the tip and cable to be detached from the pole and lowered separately into an area or cavity of interest.

The present design allows the lowered configuration to be deployed 15 meters (50 feet) from the operator. This distance is only limited by the amount of cable on the RPC spool and can be increased by adding a separately transported extension cable.

Also shown in Figure 5 is the gamma sensing NaI(Tl) crystal and photomultiplier tube housed behind the cameras in the RPC tip. This is coupled by two miniature coaxial cables through the cable assembly to the electronics package in the reel assembly.

The composite cable that supplies all of the tip's needs is a specially built "Elocab" cable that combines coaxial cables for gamma sensing, coaxial cables for two video cameras, and power wires in a ruggedized polyurethane jacket.

Figure 6 shows the cable reel end of the RPC with the access side removed so that the internal components can be seen. The electronics package for the gamma detector is mounted in the center of the reel along with camera and supporting LED power supplies.

The entire portion of the reel shown rotates as the cable is deployed for either pole or cable deployment of the tip. The electronics connect to the outside world through a slip ring assembly in the center of the reel that exits through the back. The cover plate to the right bolts on top of the reel as shown to seal the entire unit.

Locating the electronics in the rotating center of the reel is vital to a successful system. It allows uninterrupted coaxial connections for the high voltage and very sensitive signals going to and from the tip-mounted gamma sensor, avoiding any signal integrity issues with slip rings and additional connectors in these important connections.

Fig. 5. RPC Tip Internal Components

Figure 7 shows a close-up view of the electronics board that performs the gamma detector support and spectrum analysis. This board requires +/- 12 VDC and generates the required high voltage for the detector and the low voltage analog and digital supplies. It receives the detector input for direct digitization, and creates the gamma spectrum that is used to identify the isotope present.

Figure 8 shows a ruggedized PDA that interfaces to the electronics board. It provides the visual and audio outputs that comprise the operator interface and evaluates the spectrum against a library of known spectra to perform the isotopic identification. The PDA connects to a pair of waterproof headphones that provide the operator with gross gamma data, specific instructions and isotopic identification results.

When a low level gamma source is encountered, the operator is instructed, through audio commands, how to proceed. This could include instructions to wait for a period of time to allow more counts to accumulate, or options to begin the isotope identification process, such as "press button to evaluate spectrum". A high level gamma source will immediately trigger an automatic spectrum collection and evaluation. In such cases the operator is instructed to remain stationary until the spectrum collection is complete.

If a specific, gamma emitting isotope is encountered, the RPC will announce to the operator what isotope has been found and the confidence level of the evaluation. All of this information is provided simultaneously as spoken words in the headphones and visually on the PDA screen.

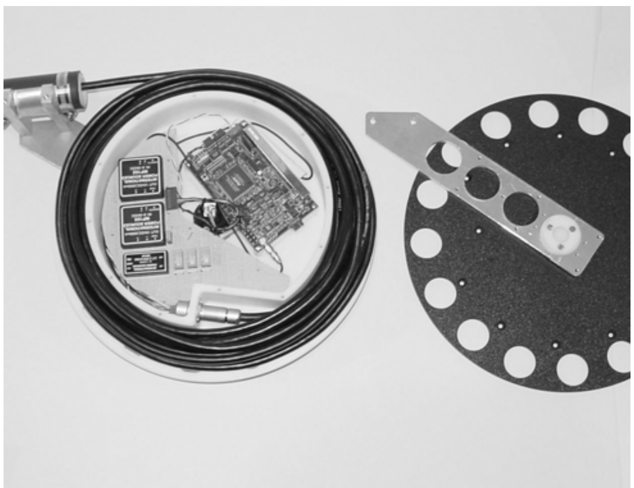

Fig. 6. Cable Reel Showing Internal Components

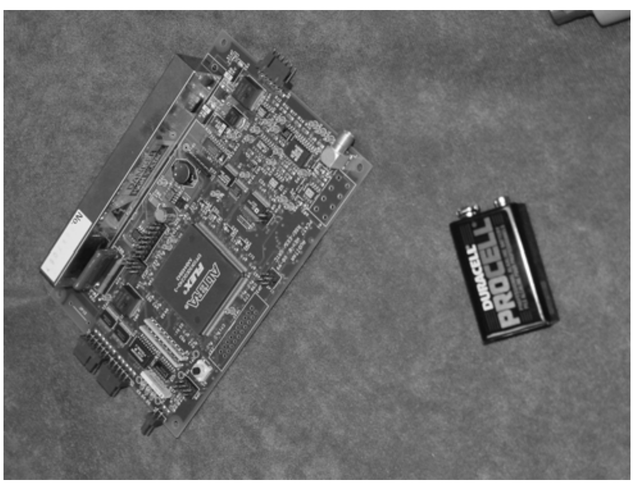


Fig. 7. One Board Spectrum Analyzer

Fig. 8. PDA In Ruggedized Housing

## IV. CONCLUSIONS

The RPC provides a first responder with a rugged, waterproof, self contained device for the detection of radiological sources, while making visual inspections of otherwise inaccessible locations. A gamma radiation spectrum is immediately evaluated by the on-board electronics and an audible isotopic identification of the material encountered is provided. The RPC can be deployed through small openings over considerable distances to provide the simultaneous visual and radiological evaluations of search areas in support of numerous emergency response missions.

## ACKNOWLEDGMENTS

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