Description Biological Agent Warning Sensor (BAWS)

The BAWS sensor was designed to provide fully automatic and rapid detection (10's of seconds) of low concentration (25 ACPLA, 2-10um size) bio-agent clouds, with the additional requirements of low power, weight, size and the absence of any consumables, such as reagents. Several generations of the sensor have been successfully developed. The first, proof-of-concept sensor was developed in 1996, followed in 1997 by a second-generation Biological Agent Warning Sensor (BAWS II). In 1998, a prototype BAWS III sensor was built from a modified BAWS II sensor and tested successfully against bio-agent simulants at Dugway Proving Grounds. The first BAWS III unit, which incorporates the performance of this prototype in a lighter, smaller package, was completed in late February 1999. A total of fifteen BAWS III were evaluated in the JBPDS EMD phase in April-May 1999. Various field excursions, Joint Field Trials as well as live agent laboratory testing was also conducted from 1999 through 2001. The BAWS technology was successfully transitioned to Industry and twelve Low Rate Production BAWS have successfully passed Operational Assessment II held August –November 2001. In addition the twelve LRIP BAWS have been deployed in two excursions since December 2001 as part of a long-range reliability and performance growth evaluation.

The BAWS III sensor, is about 0.70 cubic feet, weighs 20 lbs., and consumes 35 W of power. In stand alone operation a single on/off switch on the front panel controls the sensor, and an LED light on this panel provides information on the status of the sensor during startup. This light turns green approximately two minutes after power up, at which point the sensor is fully on and acquiring background data. An additional ~6 minutes are needed for the sensor to learn the current fluorescent aerosol background, after which the alarm algorithm will detect threatening bio-agent clouds. All of the processing, from the initial particle detection through the alarm declaration, is performed within the sensor itself. The alarm signal can be transmitted via Ethernet, RS 232, to the JBPDS or a PC using IGOR Pro client (figure 3) . Finally, the acquired data are stored to an onboard flash memory card for later retrieval.

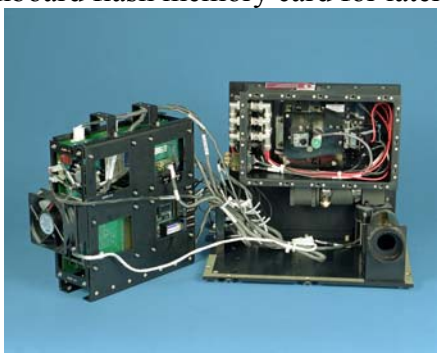

Figure 1: Photograph of the BAWS sensor with a weather proof cover and opened showing internal components

The basic operation of the sensor is straightforward. A fan draws particles through the top of the sensor into an optical interaction chamber, where particles in the air stream are illuminated with a pulsed ultraviolet microchip laser that was developed at MIT Lincoln Laboratory and has since been licensed out to industry. The geometry is such that at most one particle is illuminated by the laser in a single laser pulse. If the particle is biological, it will both elastically scatter the laser light and fluoresce at longer wavelengths. Three photomultiplier tubes (PMTs) measure the elastically scattered light, the UV fluorescence, and the visible fluorescence from the particle. The optics have been carefully designed to provide a clean laser beam in the interaction chamber and to minimize any fluorescence from surfaces that would interfere with the signal from the particle itself. Alignment of the optical path and the interaction chamber is currently done manually, after which the parts are epoxied in place. After leaving the chamber, the air stream passes over the electronics to provide cooling, and exits the sensor through the fan.

Directly after each laser pulse, the signals from the three PMTs are digitized by a 12-bit ADC with a 40 ns time gate and stored in a FIFO buffer on the signal processing board. After accumulating 8192 laser pulses, the FIFO is read out by an embedded PC. (Since the laser operates at about 8 kHz, this transfer occurs about once per second). The three coincident signals for each laser pulse are then analyzed for each laser pulse to determine if a fluorescent particle was present in the beam by comparing the signal levels to the background noise level. If a fluorescent particle was present in the beam, the processor calculates the normalized difference between the ultraviolet fluorescence and the elastic-scattering signal (to give a measure of the particle's fluorescence strength) and the normalized difference between the ultraviolet fluorescence and the visible fluorescence (to give a measure of the particle's fluorescence spectrum). Over the course of ~1 minute the spectral differences from all detected particles are accumulated in a two-dimensional histogram. Examples of the fluorescent spectral difference histograms for a background aerosol and a bio-agent simulant are shown in Figure 2. An alarm algorithm further processes these spectral difference histograms to determine if there is change in the fluorescent character of the background consistent with a bio-agent cloud. If there is such a change, an alarm declaration is made and sent out by the RS 232 port, audible horn or Ethernet port. In addition to the signal processing board and PC 104 stack, there are custom electronics to control the current to the diode laser pump, the temperature of the diode laser pump and microchip laser head, and the high voltage to the PMTs.

Figure 2: Example fluorescent signatures of the ambient background aerosol at Dugway Proving Grounds (on left) and of a bio-agent simulant aerosol (on right).

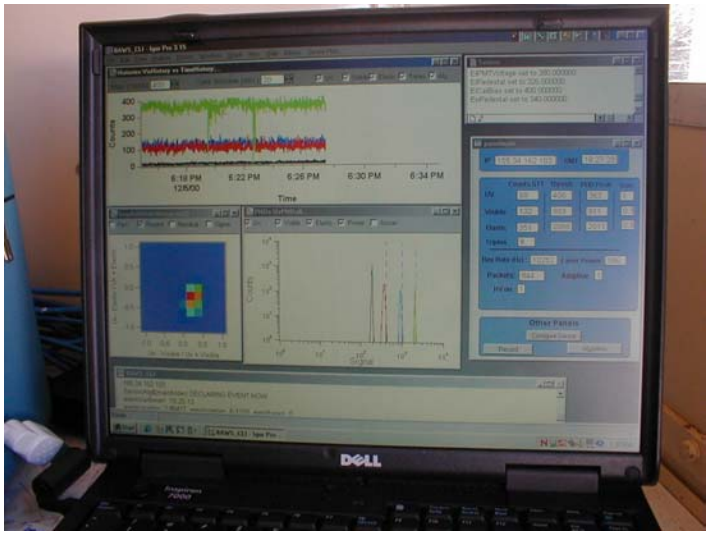

Figure3: Example of BAWS output using IGOR Pro on a lap top PC. A "Bio-Alarm" will automatically be displayed with an audible signal for ease of manual collection of data or is stored and can be downloaded at a later date.