Unmanned Aerial Systems – *The Good, the Bad and the Ugly*

Steven M. Presley, PhD
Professor and Director
Biological Threat Research Laboratory
Texas Tech University

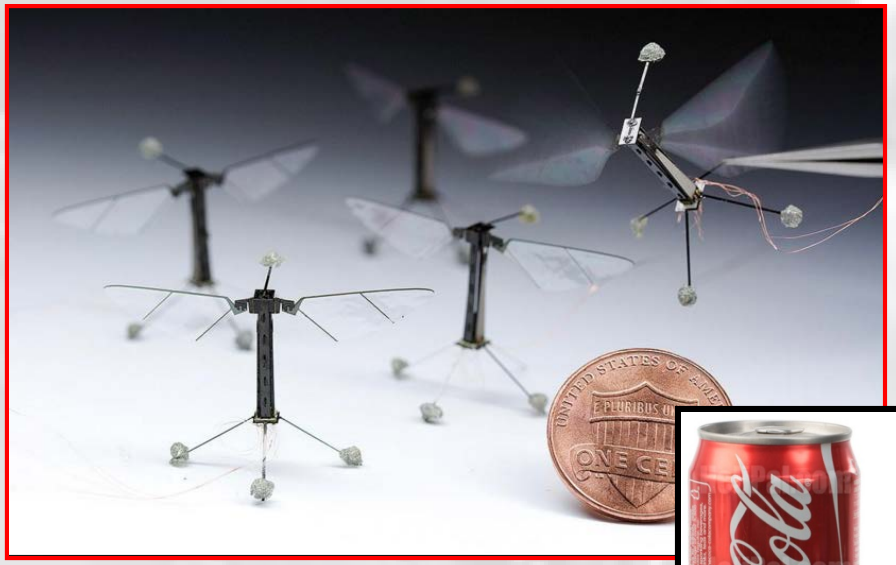
UAV/S Have Been Used For a Long Time

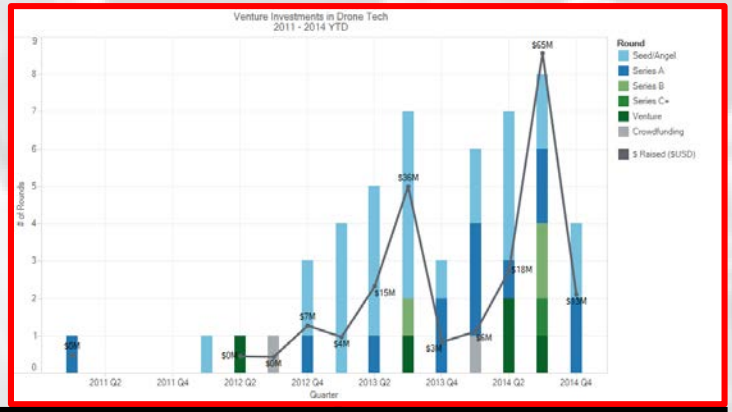
- Reconnaissance
- Physical Barrier

- Weather/Climate Monitoring
- Communication

WHAT ARE UAS'S?

- Emerging technologies/capabilities ($102M in 2014)
- "Wild, wild west" approach.
- Relevant to, and will influence every aspect of our lives





Fineco FX-1 Nano Drone
Fineco-Drone-FX1

~~USD $44.90~~ USD $32.90

VISA MasterCard

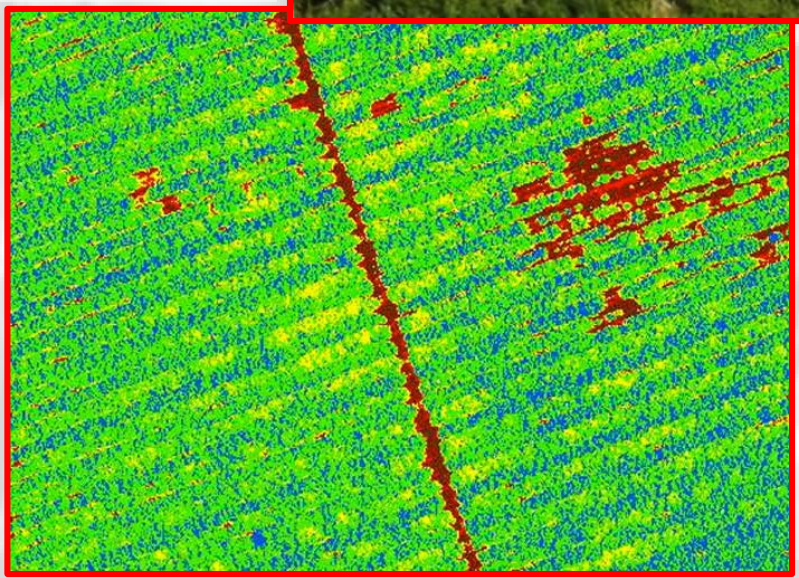
Currently Available "Off-the-Shelf" Capabilities

- Agricultural
- Environmental
- Fire & Rescue/HAZMAT
- Infrastructure
- Law Enforcement
- Transportation
- …

AGRICULTURAL

Applications include:

- Monitor crops for ripeness or stress.
- Inspect crops for diseases.
- Inspect crops for harmful insects.
- Inspect crops for nutritional deficiencies.
- Apply pesticides and herbicides.



ENVIRONMENTAL

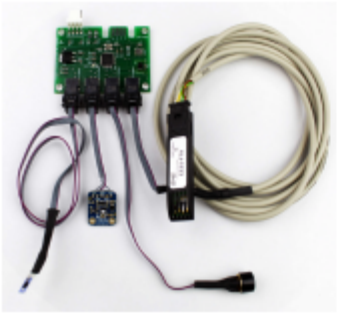
Applications include:

- Conservation activities (Geological and botanical analysis and management)
- Disease control
- Fisheries management
- Monitoring endangered species
- Anti-Poaching activities
- Monitor migration paths

ENVIRONMENTAL (CONT)

Applications include:

- Oil spill detection
- Oil spill damage assessment
- Oil/Gas pipeline surveillance incident mapping
- Coastline monitoring
- Sea ice monitoring
- Terrain mapping



iMet-XF

Atmospheric Sensor System for UAS Integration

Applications Include:

- Boundary layer research
- Atmospheric chemistry
- Pollution source monitoring
- Severe weather profiles

Can be used with fixed-wing UAS for precise, repeatable long-range patterns or rotary wing copters for stationary observations over longer time intervals

Suitable for any mission that requires accurate measurements with precise spatial coordinates

iMet-X main board serves as central host for pressure, temperature, relative humidity, surface temperature, and atmospheric chemistry sensors. Plug-in sensors can be optimally deployed on the airframe for maximum performance. Can be fully integrated with UAV data stream, GPS and power supply.

Programming Interface

- Measurement Specialties MS5607 Pressure
- GPS (UBlox)
- Ozone
- CO, CO2, CO4
- *All EPA Criteria Pollutants*

Size Relative to Radiosonde

InterMet is one of the world's leading suppliers of Atmospheric Sounding Systems for synoptic, military and research applications.

InterMet offers a complete line of sounding systems and sensors to meet customer requirements and budgets. We offer flexible, cost-effective solutions - and the highest level of customer service in the industry.

InterMet
International Met Systems
3854 Broadmoor Ave SE
Grand Rapids, MI 49512
Phone: (616) 285-7810
e-mail: info@intermsystems.com

Specifications Subject to Change without Notice
REV 150529

FIRE & RESCUE / HAZMAT

Applications include:

- Fire-monitoring support and coordination
- Search and rescue (SAR)
- Damage assessment
- Hot-spot detection
- Wildfire mapping
- Explosive detection
- Disaster & emergency response
- Hazardous material investigation

INFRASTRUCTURE

Applications include:

- Powerline monitoring
- Transmission tower inspection
- Power plant monitoring
- Remote infrastructure inspecting
- Water pipeline monitoring
- Facility security

LAW ENFORCEMENT

Applications include:

- Search for suspects and missing persons
- Standoff or hostage situation
- Accident or crime scene investigation/documentation
- Explosive and bomb disposal response
- Narcotics investigation
- Hazmat incidents
- Crowd/riot control
- Situational awareness
- Damage assessment

AeroVironment, Inc.

TRANSPORTATION

Applications include:

- **Package delivery**
- **Newspaper delivery**
- **Mail (USPS) delivery?**

LRN-B Applicable Emerging Capabilities?

Biosecurity

- On-demand space / area monitoring?
- Incident response support & training?

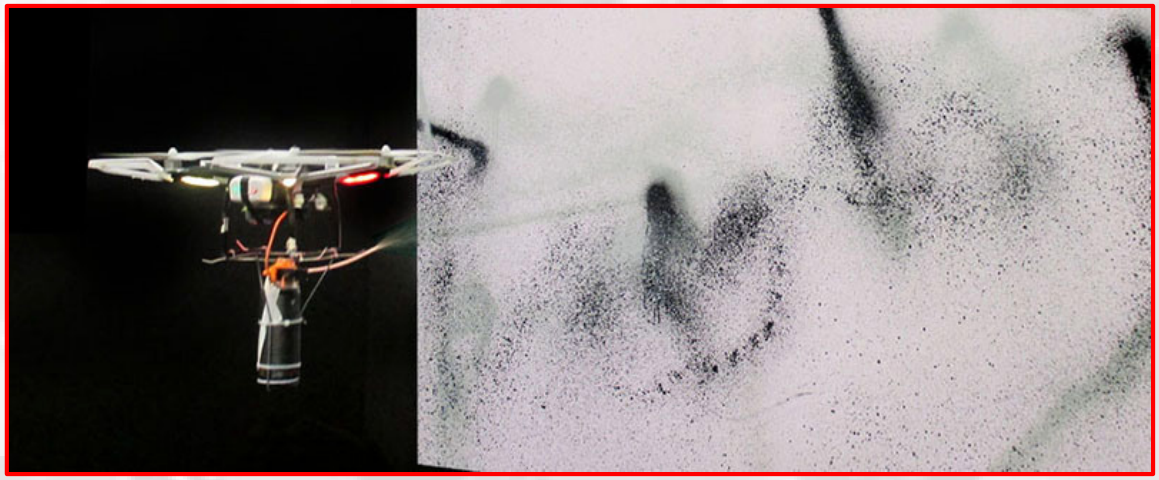
Biosafety

- Spill clean-up / decontamination?
- Area decontamination?

Sample collection

- Air?
- Liquids?
- Soil?
- Vegetation?

"Tyrone Drone", for unmanned aerial graffiti (with spray paint and flame thrower)



NOTHING NEW ...

George P. Anderson,[1] Keeley D. King,[2] David S. Cuttino,[3] James P. Whelan,[4] Frances S. Ligler,[1] Joseph F. MacKrell,[1] Christopher S. Bovais,[1] David K. Indyke,[1] and Richard J. Foch[1]

[1]*Naval Research Laboratory, Washington, DC 20375*

[2]*Geo-Centers, Inc., Rockville, Maryland 20852*

[3]*Science Applications International Corporation, Rockville, Maryland 20850*

[4]*Alexeter Technologies, Chicago, Illinois 60630*

Abstract: The ability to identify aerosolized bacteria remotely with the use of a small unpiloted, all-electric aircraft was demonstrated. Swallow, an aircraft custom-built for the purpose of air-particle collection, was catapult-launched, flown by line of sight for 20-min missions, and recovered by landing on a short runway. Once airborne, the sensor payload, which included a particle collector, fluidics control unit, and biosensor, was activated. The sensor utilized was the *Analyte 2000* fiber optic biosensor, which performs four simultaneous fluorescent sandwich immunoassays on the surface of tapered optical probes. Five-minute test cycles were conducted continuously and monitored at the ground station until the plane returned. Then Swallow and its sensor payload could be ready for additional flights within 30 min of landing. During the trial, Swallow successfully collected and identified an aerosolized bacterial sample. © 1999 John Wiley & Sons, Inc.* Field Analyt Chem Technol 3: 307–314, 1999

Keywords: UAV; biosensor; remote sensing

use of simple respirators; however, timely warning is critical to allow for protective actions to be taken.[1] Currently, remote identification of aerosolized bacteria requires that the cloud pass ground-based sensor systems. Although fixed, ground-based sensors are appropriate for providing early warning for base protection, it is unlikely that a limited number of truck-mounted sensor systems can be deployed with sufficient density or close enough to mobile front-line personnel to provide adequate coverage.

In order to provide near-real-time remote detection capability, we have tested the feasibility of mounting a biosensor system on an unmanned air vehicle (UAV). Such an aircraft would be able to provide early warning detection capability along a line several kilometers long. It could also survey hostile areas or terrain not accessible to the large truck-mounted sensor systems.

We have previously reported on the successful field test-

AVAILABLE "OFF-THE-SHELF" TODAY

UAV-BASED AEROSOL COLLECTORS AND DETECTORS

Research International, Inc. is partnering with the Russian company ENICS to offer the world community unmanned aerial vehicles (UAVs) with integrated CBRN capability. These systems offer the user new levels of capability and flexibility. Sensors on a UAV platform can perform monitoring and surveillance tasks virtually independent of ground conditions; search patterns can be varied in response to immediate weather conditions; and sensors can be deployed to other venues with little advance notice. One sensor-equipped UAV can perform the same level of surveillance as 12 to 24 fixed location sensors and with greatly increased flexibility.

SASS 2300 Air Sampler

The SASS 2300 Air Sampler extracts and transfers airborne pathogens, particulates, bacteria and spores from sampled air to small water volume for analysis. It employs a patented wetted-wall aerosol collection method that has received U.S. Department of Homeland Security Certification under the U.S. Safety Act of 2002.

SASS 2300 highly effective for collecting Newcastle virus in California chicken facilities.

TACBIO BIOLOGICAL AEROSOL DETECTOR

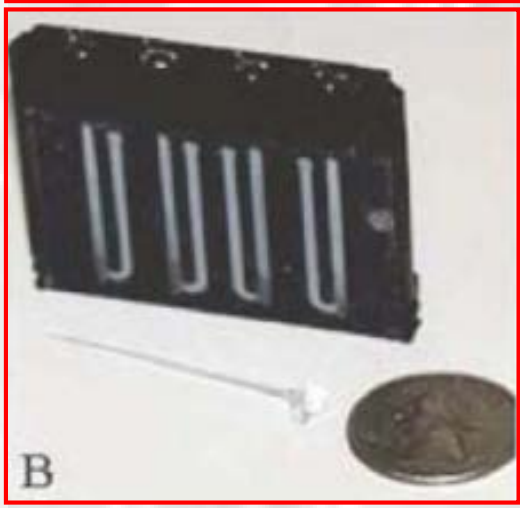
TacBio developed for military, homeland security, and public health applications. Compact and rugged portable biological particle detector that uses both diffractive scattering and natural biological fluorescence to monitor and classify aerosol particulates as either biological or non-biological origin - an aerosol 'trigger'.

TacBio is extremely useful for tracking background levels of airborne non-biological and biological materials and providing an alarm and/or digital activation command to other equipment if there is a rapid increase in the aerosol background. Monitored remotely using Windows-based software provided with the unit, and operating characteristics adjustable using BioLink™ Bluetooth transmitters and receivers.

RAPTOR: Portable, Multianalyte Bioassay Detection System

Completely self-contained, portable, 4-channel, rapid, automatic fluorometric assay system for monitoring toxins, viruses, bacteria, spores, fungi and other diverse targets. Reliable third-generation product introduced in 2000, will operate for two years or more with no breakdowns or leaks, and will tolerate debris-laden samples such as are produced in mailrooms and food processing facilities.

Integrates optics, fluidics, electronics, and software into one compact system for laboratory and field assays. It performs user-defined, multi-step, assay protocols for monitoring fluorescently-labeled chemical reactions occurring on the surface of each of the system's four disposable optical waveguide sensors. Toxins and bacteria such as ricin and *B. anthracis* have been detected at levels below <1.0 ng/ml and 100 CFU/ml, respectively. Typical assay times of 10-15 minutes. Coupons may be reused if test results continue to be negative.



BioHawk 8-Channel Collector/Bioidentifier

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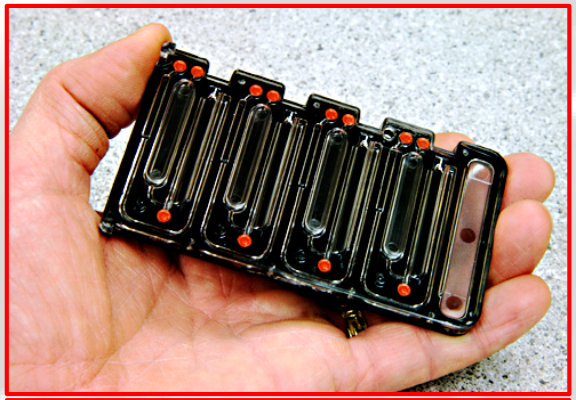
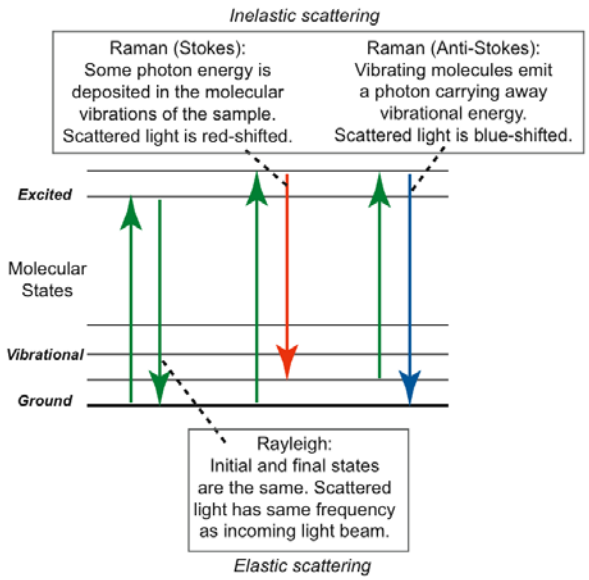
Bioassays are performed within a small disposable credit card-sized plastic assay coupon which can be used for up to 10 assays. Single assay coupon can handle up to eight different analytes simultaneously, up to 80 individual assays can be performed per coupon. Results transmitted a through the touch panel LCD display, an audible alarm, a pulsating light, or by Bluetooth wireless or RS-232. System operations remotely controlled in real time.

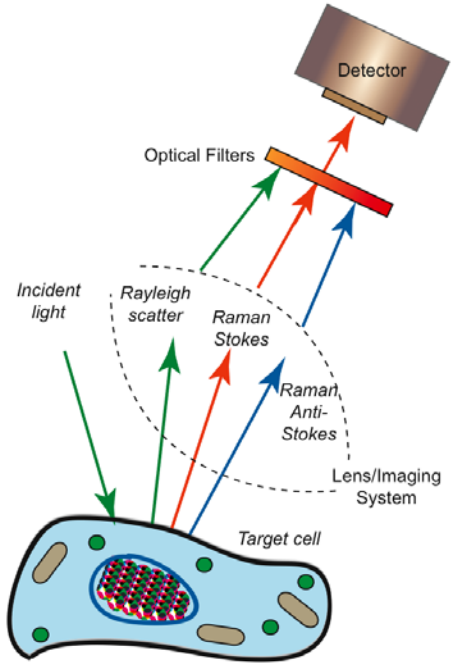
Measures: 14”W x 14.5”H x 6.75”D, less than 30 pounds. Sensitivity: analyte dependent, 1 to 10 ppb typical for toxins, 100 to 100,000 CFU/ml for bacteria.



Emerging Applications for Existing Technologies

Coherent Anti-Stokes Raman Spectroscopy **(CARS) – stand-off field identification of specific agent. <u>Claimed to be able to detect and identify *B. anthracis* endospores in the environment at up to 1 Km (0.62 miles) distance.</u>**





In Raman scattering, target cell organelles produce different degrees of red-shift, forming the basis for molecular spectroscopy.

EMERGENCY RESPONDER TRAINING

Situation Update Four

05 Oct (1735) – During halftime activities at the TTU vs TA&MU game, a maroon UAV appeared in the stadium and flew back and forth above (20-25') the crowd three times appearing to leave a very faint vapor trail.[*Temps= 63°F/87°F; avg %RH=48%; wind=SSW@6-12mph w/ light gusts; partly cloudy*]

Image captured on TTU fans I-phone. Believed to be an AG-V8A by HSE Inc.. Capacity: 10 kg, Endurance: 10-20 min, Max Spraying Efficiency 32~35 acres / trip

Preventing the Nefarious Use of UAS

FAA is trying to get a grip on them [31DEC15]

- **Title 14: Aeronautics and Space**
  - **PART 1—DEFINITIONS AND ABBREVIATIONS**
  - **PART 21—CERTIFICATION PROCEDURES FOR PRODUCTS AND PARTS**

City, county and state jurisdictions are wrestling with the issue (privacy, physical damage, etc.).

Really only a few viable options for rapidly and effectively stopping a UAV/UAS being employed for nefarious purposes,


Just catch ‘em,

or “jam” them with EMP or other signal disruption technologies (but some are “jam” proof)!


Thank You

EXTRA PICS

iMet-XF UAV Sensor

PTU and Atmospheric Chemistry Sensors for UAV Integration

iMet-X main board serves as central host for PTU and atmospheric chemistry sensors
Plug-in sensors can be optimally deployed on the airframe for maximum performance
Can be fully integrated with UAV data stream, GPS and power supply
A growing family of compatible sensors for measuring pressure, temperature, relative humidity, surface temperature and gasses
iMet-XF Data Sheet

Available Sensors:

PT-100 Temperature
EE03 Temperature / RH
IST RH
InterMet Bead Thermistor
IR Surface Temperature
CH4 (Methane)
CO (Carbon Monoxide)
UBlox CAM M-8 GPS
iMet-XF Programming Kit

Biological Agent Detection with the Use of an Airborne Biosensor

George P. Anderson,[1] Keeley D. King,[2] David S. Cuttino,[3] James P. Whelan,[4] Frances S. Ligler,[1] Joseph F. MacKrell,[1] Christopher S. Bovais,[1] David K. Indyke,[1] and Richard J. Foch[1]
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Keywords: UAV; biosensor; remote sensing

Introduction

To be effective, biological agents require dissemination as aerosol particles 0.5–5 μm in diameter.[1] The aerosol could be delivered by simple technology, such as industrial sprayers or as a line source from an airplane. The threat of biological weapons is best exemplified by the estimates that only 50 kg of aerosolized *B. anthracis* spores released as a line source would cover an area greater than 20 km downwind and incapacitate up to 25% of the personnel in the area.[1] Fortunately, biological weapons are easily defeated by use of simple respirators; however, timely warning is critical to allow for protective actions to be taken.[1] Currently, remote identification of aerosolized bacteria requires that the cloud pass ground-based sensor systems. Although fixed, ground-based sensors are appropriate for providing early warning for base protection, it is unlikely that a limited number of truck-mounted sensor systems can be deployed with sufficient density or close enough to mobile front-line personnel to provide adequate coverage.

In order to provide near-real-time remote detection capability, we have tested the feasibility of mounting a biosensor system on an unmanned air vehicle (UAV). Such an aircraft would be able to provide early warning detection capability along a line several kilometers long. It could also survey hostile areas or terrain not accessible to the large truck-mounted sensor systems.

We have previously reported on the successful field testing of a particle sampler and sensor payload carried on a customized remotely piloted aircraft powered with a standard combustion engine.[2] The objective of the project described here was to integrate an automated fiber-optic biosensor with a cyclone air sampler on a custom-built, all-electric, remotely piloted airplane and demonstrate that the vehicle could fly through a biological aerosol cloud, collect a sample, identify the target analyte, and transmit that information to a ground station. Another objective of the program was to demonstrate catapult-launching of the aircraft. In combination with electric propulsion, catapult-launching permits rapid deployment of the aircraft to the target area without the need for runway facilities.

The Swallow UAV was specifically designed for the task of airborne sample collection. Swallow's all-electric design with tail-mounted propeller simplified placement of the particle collector in the nose of the plane, where it could collect

Correspondence to: G. P. Anderson

Field Detection of Bacillus Spore Aerosols with Stand-Alone Pyrolysis–Gas Chromatography–Ion Mobility Spectrometry

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[1]*U.S. Army Edgewood Chemical Biological Center, Aberdeen Proving Ground, Maryland 21010*
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[3]*Center for Micro Analysis and Reaction Chemistry, University of Utah, Salt Lake City, Utah 84112*

Received 19 May 1999; revised 23 June 1999; accepted 14 July 1999

Abstract: A commercially available, hand-held chemical vapor detector was modified to detect gram-positive *Bacillus subtilis* var. *globigii* spores (BG) in outdoor field scenarios. An airborne vapor monitor (AVM) ion mobility spectrometry (IMS) vapor detector was interfaced to a biological sample processing and transfer introduction system. The biological sample processing was accomplished by quartz tube pyrolysis (Py), and the resultant vapor was transferred by gas chromatography (GC) to the IMS detector. The Py-GC/IMS system can be described as a hyphenated device where two analytical dimensions, in series, allow the separation and isolation of individual components from the pyrolytic decomposition of biological analytes. Gram-positive spores such as BG contain 5–15% by weight of dipicolinic acid (DPA), and picolinic acid is a pyrolysis product of DPA. Picolinic acid has a high proton affinity, and it is detected in a sensitive fashion by the atmospheric pressure-based IMS device. Picolinic acid occupies a unique region in the GC/IMS data domain with respect to other bacterial pyrolysis products. A 1000 to 1, air-to-air aerosol concentrator was interfaced to the Py-GC/IMS instrument, and the system was placed in an open-air, western United States desert environment. The system was tested with BG spore aerosol releases, and the instrument was remotely operated during a trial. A Met-One aerosol particle counter was placed next to the Py-GC/IMS so as to obtain a real-time record of the ambient and bacterial aerosol challenges. The presence/absence of an aerosol event, determined by an aerosol particle counter and a slit-sampler–agar-plate system, was compared to the presence/absence of a picolinic acid response in a GC/IMS data window at selected times in a trial with respect to a BG challenge. In the 21 BG trials, the Py-GC/IMS instrument experienced two true negatives and no false positives, and developed a software failure in one trial. The remaining 18 trials were true positive determinations for the presence of BG aerosol, and a limit of detection for the Py-GC/IMS instrument was estimated at approximately 3300 BG spore-containing particles. © John Wiley & Sons, Inc.* Field Analyt Chem Technol 3: 315–326, 1999

Keywords: pyrolysis; gas chromatography; ion mobility spectrometry; *Bacillus subtilis* spores (BG); field biodetection; outdoor biodetection; biodetection biological aerosols; aerosol concentrator

Introduction

Recent and current events around the world have highlighted the possibilities for deliberate outdoor dissemination of harmful biological substances,[1–6] and at least 12 countries are known to have some degree of biological warfare program capabilities.[7,8] Alleged biological terrorism attacks in Japan[9,10] and threats on U.S. domestic commercial establishments have increased significantly in the past five years.[11–14] Reports of alleged localized aerosol releases and hoax domestic biological terrorism in the form of postal mail packages, allegedly with spores of the pathogenic *Bacillus anthracis* and *Yersinia pestis* (bubonic plague) organisms, serve to exacerbate the problem.[15–19]

Desirable goals in effectively countering the biological warfare and terrorism applications of harmful biological agents include their ready detection and possible identification in a relatively short period of time. The detection of biological aerosols, particularly that of bacterial cells and spores, is an important component of U.S. military biologi-

Correspondence to: A. P. Snyder

TACBIO BIOLOGICAL AEROSOL DETECTOR

TacBio was developed by the U.S. government for military, homeland security, and public health applications. It is a compact and rugged portable biological particle detector that uses both diffractive scattering and natural biological fluorescence to monitor aerosol particulates and classify them as being of either biological or non-biological origin.

TacBio is extremely useful for tracking background levels of airborne non-biological and biological materials and providing an alarm and/or digital activation command to other equipment if there is a rapid increase in the aerosol background. It cannot identify the type of biological material detected, and for that reason it is correctly characterized as an aerosol 'trigger.'

Operation may be monitored remotely using Windows-based software provided with the unit, and changes made to its operating characteristics as needed or desired. Signals may be transmitted wirelessly between the TacBio and a monitoring PC or other equipment using BioLink™ Bluetooth transmitters and receivers, or via RS-232 cables.

- See more at: http://www.resrchintl.com/TacBio.html#sthash.MW3HQBC4.dpuf

CHARACTERISTIC	DESCRIPTION
Operating principle:	Aerosol particle counter with UV fluorescence signature detection.
Particle size range:	Respirable particle range.
Threat identification:	Aerosolized bacteria, spores, viruses, toxins.
Interferents:	Interferent resistant to diesel smoke, pollen, silica dust..
Detection limit:	Dependent on target aerosol. 100 to 300 ACPLA typical.
Start-up time:	1 minute.
Time to alarm:	Less than 1 minute. A 30 minute historical baseline is used for alarm protocols.
Sampling volume:	1 liter per min of ambient air nominal.
Communication:	RS-232 or wireless BioLink Bluetooth. Also compatible with RS232-USB and RS232-RS422/485 adapters.
Data storage:	Collected data is stored on a removable SD-type data card. A 1.0 GB card will store more than 5 years of aerosol data.
Alarms:	Electronic digital alarm; Red LED and >100dB piezoacoustic alarm on unit (piezo alarm may be optionally de-activated by user) .
Power:	6.5 watts at 13.7 VDC. Can be used with BA-5590 primary battery; BA-5390 extended life battery; or UBI 2590 rechargeable battery. Operable on AC mains power or vehicle power with proper converter.
Continuous operating time:	Essentially unlimited if powered externally, or 30 hours on BA-5590 primary battery.
Pump life:	30,000 - 40,000 operating hours.
Operating temperature range:	-20° C to 60° C.
Humidity:	0 to 97% non-condensing
Consumables:	None
Size:	14.5 x 17 x 30.5 cm without inlet air stack; 14.5 x 17 x 39.4 cm with inlet stack attached.
Weight:	8.8 lbs (4 kg) with battery.
Package:	EMI-resistant aluminum shell.

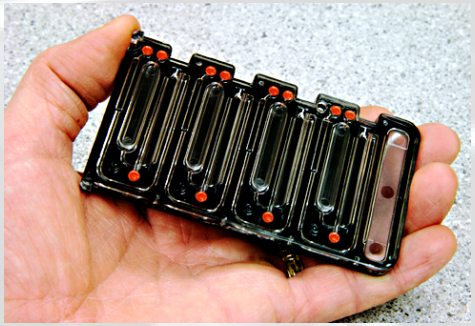
Oligonucleotide targeting[edit]

Surface enhanced Raman spectroscopy (SERS) can be used to target specific DNA and RNA sequences using a combination of gold and silver nanoparticles and Raman-active dyes, such asCy3. Specific single nucleotide polymorphisms (SNP) can be identified using this technique. The gold nanoparticles facilitate the formation of a silver coating on the dye-labeled regions of DNA or RNA, allowing SERS to be performed. This has several potential applications: For example, Cao et al. report that gene sequences for HIV, Ebola, Hepatitis, and Bacillus Anthracis can be uniquely identified using this technique. Each spectrum was specific, which is advantageous over fluorescence detection; some fluorescent markers overlap and interfere with other gene markers. The advantage of this technique to identify gene sequences is that several Raman dyes are commercially available, which could lead to the development of non-overlapping probes for gene detection.[47]

Cao YC, Jin R, Mirkin CA. 2002. Nanoparticles with Raman Spectroscopic Fingerprints for DNA and RNA Detection. *Science* 297(5586): 1536-1540.

Coherent Anti-Stokes Raman Spectroscopy (CARS) – stand-off field identification of specific agent.

BIOHAWK® 8-CHANNEL COLLECTOR/BIOIDENTIFIER (Research International, Inc., 17161 Beaton Road SE, Monroe, Washington 98272-1034 USA - See more at: http://www.resrchintl.com/Biohawk_Bioidentification_System.html#sthash.y5Hq6Q6a.dpuf)



BioHawk 8-Channel Collector/Bioidentifier

BioHawk® is a portable 8-channel bioassay system integrated with an aerosol collector. It is suitable for the high-sensitivity monitoring of biological agents, toxins, explosives, and chemical contaminants. Assay results are typically available in 10 to 20 minutes. BioHawk can be programmed to monitor surrounding air for aerosol threats with the built-in air sampler, and to periodically transfer a wet concentrate from the air sampler to the bioidentifier portion.

Bioassays are performed within a small disposable credit card-sized plastic assay coupon which can be used for up to10 assay procedures before being discarded. Since a single assay coupon can handle up to eight different analytes simultaneously, up to 80 individual assays can be performed before discarding or removing the coupon. Assay results are transmitted a through the touch panel LCD display, an audible alarm, a pulsating light, or by Bluetooth wireless or RS-232 link to personnel at a remote location. System operation may also be remotely controlled in real time.

Functions such as air sampling and bioidentification are performed using multi-step recipes developed by Research International and stored in the system's computer memory. Users need only the most fundamental level of training since the internal processes and steps are preset through the built-in computerized recipes. For more advanced users, Windows-based software allows the user to develop their own customized sample collection and detection protocols.

- Man portable. Measures:35.6 cm W x 36.5 cm H x 17.1 cm D. Weighs less than 30 pounds.
- Air sampler uses multi-stage, wetted-wall cyclone principle for enhanced particulate collection.
- Air collection at 325 LPM, nominal.
- Uses disposable wet assay coupon. Reusable up to 10 times. Eight simultaneous assays.
- Fast assays: 10 - 15 minutes typical.
- Auto-flush protocols for decontamination.
- Analyte range: toxins, bacteria, spores, fungi, multi-cellular pathogens.
- Sensitivity: analyte dependent, 1 to 10 ppb typical for toxins, 100 to 100,000 CFU/ml for bacteria.
- Operator interface: Day / night touch screen LCD.
- Designed to MILSPEC 810F.
- Flash memory retains raw / processed data for over 6,000 assays

The instrument's biodetector section consists of a disposable 8-channel fluorometric assay coupon (see Figure 3) suitable for the high-sensitivity detection of biological agents, toxins, explosives, and chemical contaminants. All target-specific reagents needed to perform an assay are contained within the coupon. The only fluid not carried in the coupon is a saline buffer used to wash the system between assays. It is stored within a refillable reservoir in the instrument and a waste water reservoir is also provided. This ensures that no fluids are discharged from the instrument during either air sampling or the bioassay step.

BioHawk General Specifications

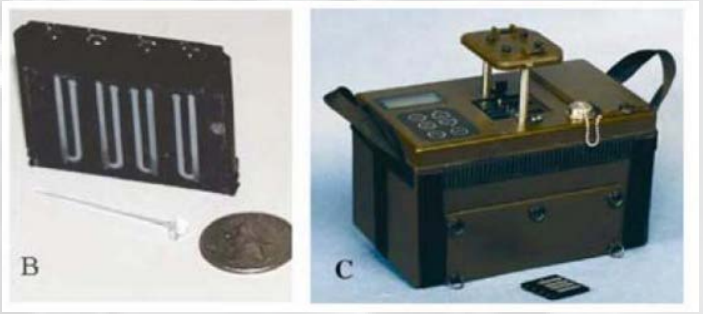
CHARACTERISTIC	DESCRIPTION
Use Profile:	Indoor/outdoor sample collection, transfer, and assay; storage of 255 assay recipes; user in full MOPP gear either walking or in moving vehicle.
Collection principle:	Multi-stage wetted-wall cyclone with enhanced particulate collection.
Assay method:	Disposable wet assay coupon-reuseable up to 10 times. Eight simultaneous software-based assays. Antibody or nucleic acid. Coupon reseals on removal for archival storage.
Fluid Handling:	Fluids manipulated under microprocessor control using peristaltic and syringe pumps; sample may be oscillated to lower assay time; reagent is recovered for reuse.
Fluids storage:	Snap on 3-section fluid pack. Clean water: 1 liter; Buffer: 250 ml; Waste: 500ml
Human interface:	Day/night Touchscreen LCD display, usable in MOPP gear.
Digital communication:	RS-232 bi-directional serial link
Physical size:	35.6 cm W x 36.5 cm H x 17.1 cm D
Weight:	20.9 lbs. dry; 25.9 lbs. with battery and fluids (9.5/11.8 kg).
Operating/storage:	1 to 66°C and -29 to 66°C. Reagent deterioration can reduce upper limit significantly.
Humidity:	10% and above. May be operated in rain.
Survivability:	MILSPEC 810F; MTBF of about 30,000 hours is determined by air sampler fan.
Data storage:	Flash memory retains raw/processed data for over 6000 assays.
Power Consumption:	5.6 W at idle; 17.5W with fan operating and one assay performed each 30 minutes.
Power source:	Primary battery BA-5390A/U, 1.05 kg (2.3 lb); lifetime 14 to 45 hours. Rechargeable battery UBI-2590; lifetime is approximately 56% of the BA5390A/U primary battery. Universal lump-in-cord power supply, 82-265 Volt (47-63 Hz).
Alarm:	Visual LED and 103 dB @0.6m waterproof horn; adjustable. RS-232 data link.
Decontamination:	Auto-flush protocols using onboard water, or manual flush with detergent and/or disinfectant. High-performance pull-through fan easily removed if contaminated.
Sound level:	60 dB (A).
Ancillary equipment:	Heavy-duty hard-shell transport case with wheels.

11.4.3 Evanescent Fiber Optic Biosensors

The first use of an optical fiber as a biosensor, and one of the first optical biosensors was described by Hirschfeld and Block [21, 22] in the mid 1980s. This type of sensor was also the first biosensor to be fully automated and used remotely. In 1996–1998, Ligler, Anderson, and colleagues developed a biosensor payload for a small, unmanned plane and tested it at Dugway Proving Ground, Utah. The payload included a biosensor with four fiber probes, a RAM-air driven cyclone for collecting aerosolized bacteria, an automated fluidics system, batteries, and a radiotransmitter. They demonstrated that the airborne biosensor could collect a biothreat stimulant, identify it, and radio the data to an operator on the ground in 6–10 min [23, 24].

The best known of the commercially available fiber optic biosensors is the RAPTOR-Plus, made by Research International (http://www.resrchintl.com)

(Fig. 11.6). This system is proving to be very reliable in terms of long term operation (¿3 years to date, George Anderson, personal communication). In both the 4-probe Raptor and the more recently developed 8-fiber BioHawk, a disposable coupon contains the fiber probes, providing protection during long-term storage and fluidic channels for automated sample processing.



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md4-200

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