

Gensor

Making Technology *Work*

The *Ameba* Bio-Chem Sensor: A \$10 Solution for the Maritime and Cargo Industry

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The *Ameba* Bio-Chem Sensor: A \$10 Solution for the Maritime and Cargo Industry

The AMEBA sensor from Gensor is a scalable unit designed to sample the air and water in designated locations, automatically detect dangerous biological, chemical and radiation agents, and instantly communicate its findings to on-site personnel as well as monitors at central facilities.

As specialized for the shipping industry, which must deal with over 9000 containers per day entering the US, the Ameba sensor is adapted to the standard shipping container at a cost of about \$10 per container, with the electronic and biochemical apparatus connected only briefly at the ports of embarkation (preferably) and disembarkation (necessarily).

In addition to sensing biological and chemical contaminants, the Ameba system will detect major changes in contents enroute, and the presence of live humans or animals in a shipping container **without disturbing the hatch or seal.**

Each sensor, as a stand-alone device or as part of a network, is designed to work in real time, that is, to detect, analyze and communicate its findings in seconds so immediate action can be taken to stop the spread of these dangerous agents.

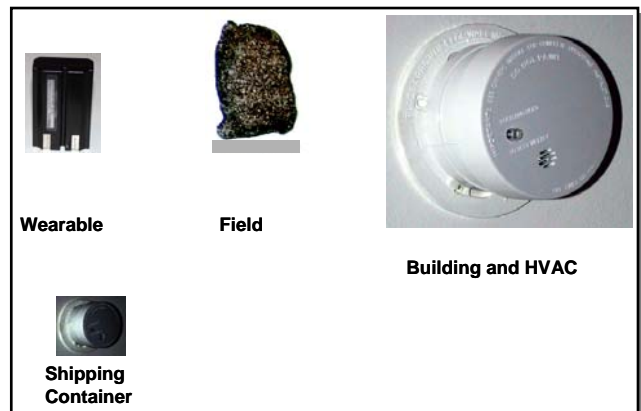
The sensor is composed of five modules:

- The Bio-chemistry package
- The Physics package
- The Decision package
- The Electronics package
- The Special Communications package

The *Ameba* Product Line

Five types of sensor are under development:

- Low cost long term adapters for shipping containers
- Standard self-contained remote site sensors
- Wearable full function sensors for military personnel
- Wearable low cost specific function sensors for first responders
- Read-out monitors for shipping container sensors

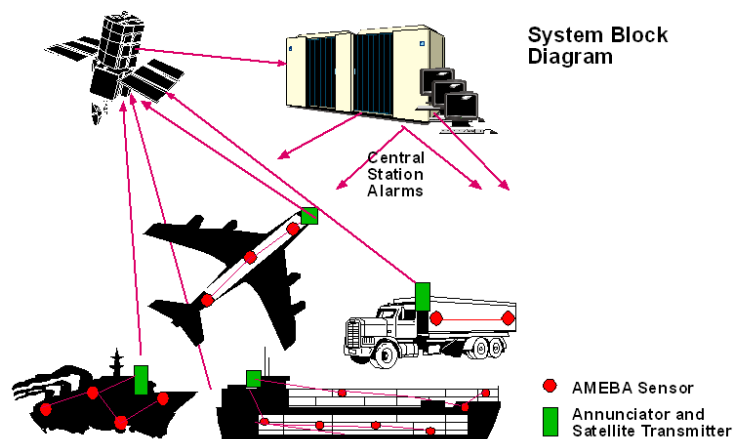


The *Ameba* Sensor's Competitive Advantages

We believe that the *Ameba* sensor will have the following competitive advantages over other biological, chemical and radiation sensors now in use or under development:

- Self contained
- Small and lightweight (standard site model will be the same size and weight as current home smoke alarms)
- Easily scalable
- Easily transportable
- Internal diagnostics (does not require laboratory analysis)
- Customized in field to detect specific pathogens, chemical agents and radioactive particles
- Cartridge inserts each have multiple sensitivities and can be easily reprogrammed and updated
- Rapid response times
- Individual or multi-unit systems
- Continuous monitoring
- Automatic reporting even from remote locations
- Reports on site and/or to a central monitoring facility
- Uses existing satellite communications technology
- Encrypted burst transmission
- Can also report by standard phone line or wireless cell phone
- No technician maintenance required
- Low cost to purchase and maintain (approximately \$1,250 per unit to purchase the standard site model and \$250 for annual monitoring and maintenance)

Scientific and Technological Overview of the *Ameba* Sensor



Gensor's *Ameba* sensor, now under development, is a deployable, reusable autonomous detection and recovery system which is designed to be employed in a surveillance role where the threat of biological and/or chemical agents exists in a specified geographic location. The system is designed for covert deployment and recovery from a non-fixed remote site. The system mimics natural biologics and is afforded a significant stealth advantage over other detection devices. The system is designed to patrol a programmed course, provide 3-dimensional, high volume atmospheric sampling, detection and capture of suspect molecules and recovery to a remote site.

The system is not susceptible to random detection efforts ('bug sweeping') and can be employed to map detection zones in a quantifiable manner allowing the deduction of production schedules, agent transport and positioning variables critical to monitoring manufacturing scale-up activities.

The *Ameba* sensor consist of five subsystems:

1. **The Bio Package**, which provides the detection and recovery technology based on high affinity 'capture' molecules using van der Waals reactions to specific cell quorums, partial DNA/RNA sequences or biochemical radicals, and producing via electrochemical amplification 40-200 photons per single molecule detection.
2. **The Physics Package**, which samples large volumes of atmospheric air, recognizes and binds the suspect molecule providing either an immediate detection signal or report, which is stored and/or up linked for remote observers.
3. **The Decision Package**, which provides the signal collection, processing and a sophisticated decision software subsystem that makes the diagnosis and sensor "health" checks.
4. **The Electronics Package**, which provides either remote or onboard computer support, communications and housekeeping functions of the system.
5. **The Special Communications Packages**, which consist of an on-board *minimum-neg entropy* LPI communications package and a relay transceiver with the capability to service up to 100 sensors of all types—although only about 1-5 would be required for the present application.

The Bio Package

The sensor system integrates existing micro-robotic technology, programmable GPS/conventional navigation microprocessor technology and bio-imprint or aptomeric chemistry technology into a self-contained, miniaturized, programmable and deployable vehicle for remote atmospheric sampling. These are all proven, fundamental technologies which lend themselves to applied engineering of a device platform which is economical, adaptable, scalable and upgradeable. The system can be rapidly custom engineered for specific mission parameters and is intrinsically stable in the presence of conventional surveillance defeating systems.

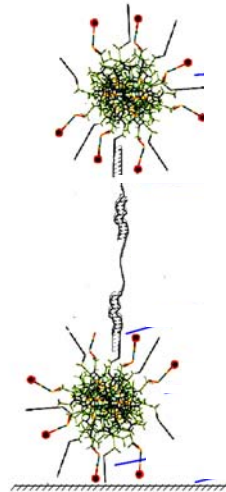


Deployment schemes which obviate repetitive patterns and provide both temporal and spatial flexibility minimize the probability of discovery.

The Scientific Basis of the Biological Sensor Process

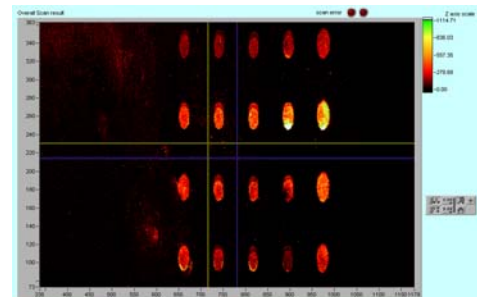
The *Ameba* sensor includes a series of hybrid molecules each possessing a single monoclonal anti-body-receptor which varies in binding affinity and specificity. Varying the affinity of binding allows detection of a peptide which has undergone deliberate point mutation designed to alter its binding characteristics (and evade detection). Combining antibody specificities which recognize families or genera (of microorganisms) with those that recognize species again allows one to detect a broad range of organisms in which species-specific peptides have been genetically altered, or which include previously uncharacterized species.

High affinity bio-imprint molecules enable the biochemical engineering of specific receptor-ligand pairs which can be designed to provide irreversible binding of desired molecules or molecular domains for the purpose of isolation, immobilization and recovery. The economical and efficient production and screening of these molecules affords a high level of adaptability to the changing roster of suspect biochemical agents.



Sensitivity

The level of sensitivity is on the order of biologic sensitivity. Conventionally, this is in parts per million in liquid phase and parts in many millions in vapor phase or gas phase. Single minimal antibody receptor affinities have a variety of binding affinities, binding kinetics and binding specificities. This allows one to detect single agents and establish a dose response for detection which will quantify the amount of exposure.



Recent test run using BT, showing positive and negative controls.

If you vary the affinity of binding, it will allow the detection of small molecules that have even undergone some degree of molecular alteration—such as biologically active polypeptides. Peptide agents, particularly those biologic agents which have historically be known to mutate over time can sometimes evade detection in purely chemical-reagent-based systems (including antigen-antibody reactions). The ability to have a receptor which relies upon the conformational chemistry of the agent means that relatively small molecular changes do not negate the affinity or the response from the sensor system.



Nanomolecular Substrate



Both the RNA and CDNA coding for each of these sequences associated with the receptor can be isolated—and for many agents of interest has already been catalogued. The specific coding for an agent detected and captured by the system can even be incorporated into automated synthesis apparatus for mass production.

The use of an optical signal transducer suggests longer in-field life. The selection of a luminescent mechanism rather than a more conventional fluorescent mechanism is a response to the fact that in the field the precise time of exposure is not known, and repeated illumination of the biological components of the sensor to ultraviolet radiation will limit sensitivity and life.

To summarize, the fundamental technology is based upon many years of experience in molecular cell biology. It is considered to be relatively straightforward and a very feasible component of this project. The bio-engineering work will focus on development of the matrix to retain these receptor molecules and to be able to deliver them to various fields of deployment.

The objectives of the program do not present any significant bio-technological hurdles since the techniques that will be employed here are well established and essentially they are staples in the biologic engineering and bio-technical world.

Rather the challenges exist in the development of systems to house the sensor and enable opportunistic deployment and appropriate logistic characteristics including life in the field.

The Physics Package

The Physics Package of the *Ameba* sensor has the responsibility of

- (1) extracting desired aerosol and solid particles from the air
- (2) eliminating particles of inappropriate size (dust on the right, and smoke on the left)
- (3) sorting these particles while preserving viability of carried organisms
- (4) concentrating and impinging the desired particles on the sensitive surface of the Bio Package.

This section describes the design of the physics package at the present stage of development, and provides some data in the form of empirical and simulation analyses to support that design.

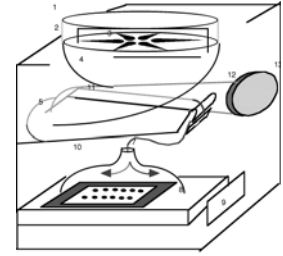
The Physics Package is divided into four phases, not precisely corresponding to the above functions. It is optimized for acquisition of particles (aerosol or solid) forming particular mammalian threats, i.e. nominally 1-5 μ in mean diameter.



Overview of the Physics Package Components.

Function 1: Acquisition and Large-particle Sorting

The challenge is that of capturing valid air samples despite wind direction and velocity. For this task we plan an omni-directional variant of the NACA flush intake design used in low-speed aircraft, which has the advantage of providing a positive Bernoulli-derived pressure to assure that sampling takes place. This has the further advantage of minimizing rain effects, which could have an undesired effect on the Bio Package.



One such flush intake is diagrammed below. One such duct is of course unidirectional.

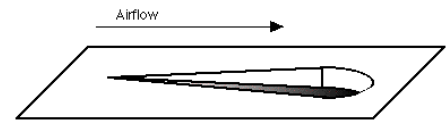
Consider 5 or more such intakes disposed around a circle, and covered by a hat. These intakes have a common (large-diameter) central opening, with a smooth transition to a common intake.

The main motive power for sampling is provided by a small DC-operated axial fan moving 15 L/m of air at very low pressure (pressure to be determined experimentally).

Function 2: Isokinetic Filtering

The entrance-ways to these ducts are covered by a mechanical dust filter of high porosity. This filter will be prepared using laser forming techniques and a hydrophobic base. The design of the filter will be to exclude particles of minimum diameter $>10\mu\text{m}$.

The mechanical filtering components generally act on the mechanical minimum diameter of a particle. In the region of interest here, the Reynolds Number $Re < 1$ and the orientation of an elongated particle is random. However, the primary filtering method to eliminate e.g., dust and smoke, must therefore act on the aerodynamic (actually Stokes) diameter of the particle, and therefore mechanical filtering is insufficient. See Function 3 below.



Function 3: Aerodynamic Isokinetic Filtering

Selection of particles having the desired aerodynamic diameters (as opposed to minimum diameters) is aerodynamic in nature. The proposed configuration uses particle sorting originally due to evolution, i.e. the behavior of the turbinate bone in the nose (patent pending).

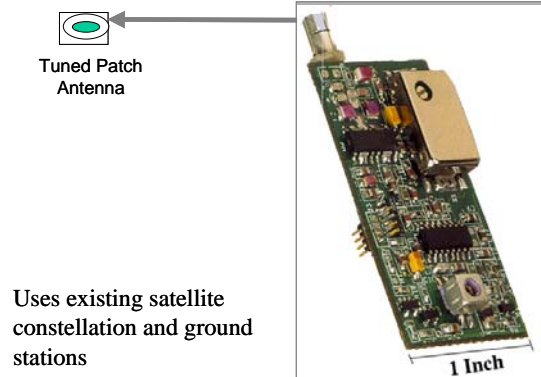
The design is somewhat counterintuitive, but is borne out by the data. In the regime of interest aerosol particles having approximately the same density can be sorted by mean aerodynamic diameter quite efficiently. For the regions of interest the diagram on the right is illustrative, and preliminary calculations have established the notional angle of attack of the aerodynamic filter.

Basically, as shown in the simulation below, the dam sets up a local vortex which sorts the particles isokinetically, by density and aerodynamic diameter. The underlying theory is also discussed below



Function 4: Impingement

Isokinetic impingement is the primary method of forcing the particles on to the substrate. Conventional aerodynamic impaction methodologies exhibited in commercial off-the-shelf viable-particle impactors are satisfactory and probably optimal for the application. We therefore plan to utilize the impaction chamber of an existing device (see photograph) for Function 4.



The Annunciation Package

Annunciation may at user option take one or more of several forms. Since diagnosis is done onboard, technician intervention is not required, except (optionally) at post-event forensic analysis.

1. Local alerting
2. Wireline communications
3. VHF or cellphone annunciation
4. Direct sensor-to-satellite signaling for remote locations

Sensors are typically used in groups to maximize coverage and minimize false alarms (e.g. due to deliberate spoofing by an attacker). The annunciation is therefore normally routed to a central computer site for response.

The communications network utilizes a proprietary self-organizing principle so that partial disabling or breakdown of individual sensors (deliberate or statistical) does not prevent network operation. This is similar to the TCP/IP protocol.

