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Contaminant Analysis Automation, An Overview

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Contaminant Analysis Automation, An Overview

The Team

To meet the environmental restoration and waste minimization goals of government and industry, several government laboratories, universities, and private companies have formed the Contaminant Analysis Automation (CAA) team. The goal of this consortium is to design and fabricate robotics systems that standardize and automate the hardware and software of the most common environmental chemical methods. In essence, the CAA team takes conventional, regulatory-approved (EPA Methods) chemical analysis processes and automates them. The automation consists of standard laboratory modules—SLMs™—that perform the work in a much more efficient, accurate, and cost-effective manner.

Led by SciBus Analytical, a small business operating out of Sunnyvale, California, CAA consists of the following organizations: Los Alamos National Laboratory (lead laboratory), Sandia National Laboratories, Oak Ridge National Laboratory, Idaho National Engineering Laboratory, Pacific Northwest Laboratory, University of Tennessee, University of Texas, University of Florida, Westinghouse Hanford Company, Hewlett Packard, Thru-Put Systems, and Varian.

The Technology

Every analytical method consists of three principal components: sample preparation, measurement, and data interpretation. The first component, sample preparation, remains a labor-intensive, time-consuming process that requires a skilled technician working in a potentially hazardous environment. This function contributes to the present average laboratory sample turnaround time of approximately 90–120 days.

Chemical measurement (or analysis) has received much attention from government and industry. Many companies have developed automated instrumentation to conduct analyses. Unfortunately, these developments have taken place independently, which prohibits machine compatibility or systems "plug and play".

The third component, data interpretation and documentation, consumes approximately 50% of the staff resources in environmental laboratories. In addition, the data interpretation tasks require the expertise of an experienced and costly analyst. According to research performed by Hewlett-Packard, the average burdened salary of a commercial laboratory employee is approximately $70,000 per year, with a burdened rate for a technician costing $50,000 per year and a chemist costing $95,000 per year.

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The key to reducing turnaround time, cutting expenses, and maximizing worker safety is automation. The CAA paradigm is similar to that of office automation, open systems architecture, where standard hardware interfaces and software drivers facilitate the rapid integration of computers, printers, modems, CD ROMSs, and other components. The end result of such automation is an efficient, safe, and cost-effective system that delivers defensible results.

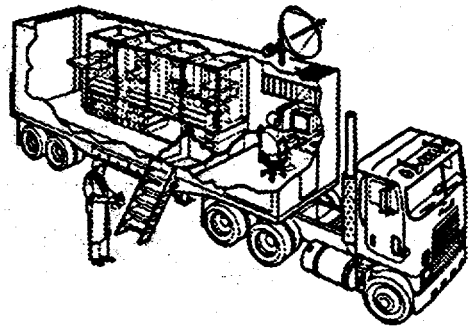
The basic component of the CAA system is known as a Standard Laboratory Module™ (SLM, or simply Module). Each Module performs a group of laboratory unit operations dictated by an analytical procedure. Such procedures can be internal to an organization, but most often the procedures used are approved by the EPA. In the CAA system, one Module is designed to prepare a sample, another to filter it, another to conduct the analysis, and another to interpret and synthesize the results.

This plug-and-play concept gives the CAA methodology great flexibility. For example, diverse matrices, such as soil and water, do not require separate automated systems. Instead, an end-user would replace the soil sonication Module with a liquid-liquid Module. The remaining systems can perform the same function. Moreover, the introduction of a procedure, such as florisil cleanup for polychlorinated byphenyls, can be accomplished by plugging the appropriate component into the automated system.

When combined into a complete system, the Modules form a Standard Analysis Method. These methods reflect conventional analytical methods that are approved by a regulating body, such as the EPA. Our system simply automates these methods, thereby increasing efficiency, enhancing worker safety, and reducing the cost of sample analysis and data interpretation.

A crucial component of CAA is the development of an automated data interpretation module. Presently, highly trained analytical chemists review large amounts of data because the Environmental Protection Agency has in place quality assurance requirements that stipulate an independent data review for each analysis. To eliminate this expensive and time-consuming process, CAA is developing an expert-system-driven data interpretation Module that will carry out the data assessment, data interpretation, and result-reporting tasks in a fully automated laboratory.

This Module can operate in two modes: the on-line mode, which automatically analyzes the data under the control of the laboratory automation, and an off-line mode that allows the chemist to build the tools required to construct automated data analysis methods, build calibration functions, and review the analysis processes.



Rather than collect and transport samples that may contain hazardous contaminants, the CAA team has developed each system so that it fits aboard an 18-wheeled truck. The truck contains all the necessary equipment, including the collecting, analyzing, and data interpretation modules.

The resultant raw data will be transferred to an object-oriented data base used for legally defesible, long-term storage. Basically, this data base will function as a repository for configuration, control, and audit trail information. All processed data will be in a standard format, enabling it to serve as a future reference.

Benefits

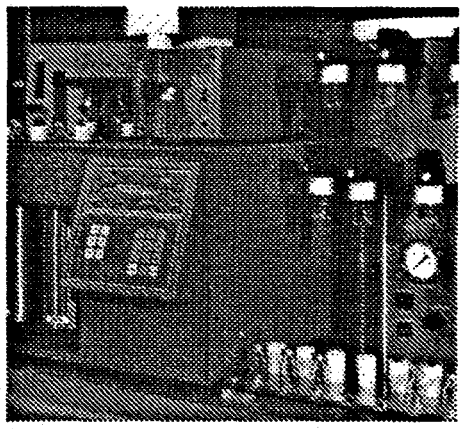
The CAA system benefits the end-user by enhanced flexibility in the following ways:

- It establishes a modular and expandable system that allows additional sample analysis to occur by maximizing the re-use of existing hardware and software.
- It creates an open system architecture and standards that define critical interface, thereby enabling multiple vendors to produce hardware and software products that fit into one cohesive system.
- It enables varied system configurations, which range from fixed sites (e.g., in existing buildings and laboratories) to transportable systems (e.g., Mini-SAMs that consist of two or more Modules) and fully mobile laboratories.

The advantages of the CAA system include tremendous financial and return-on-investment potential. According to a study conducted by Lockheed Environmental Corporation, automating sample preparation alone would result in an estimated 12.5% labor savings, with an increase in throughput/productivity of 23%. Adding automated information management systems (data interpretation Modules) would result in an additional 27% labor savings, with an added increase in throughput/productivity of 18%.

Given 7,860 total environmental laboratories in the United States, automated information management represents (at a minimum 50% labor savings) a $1.16 billion annual cumulative market savings. Using the same number of laboratories, automated sample preparations would yield an annual $544 million cumulative market savings and automated system analysis would yield $2.4 billion annually in cumulative markets savings.

High-speed automated laboratories located at potential cleanup sites will reduce sample turnaround from the traditional range of 90–120 days to a conservative 12–18 days, with many samples analyzed and data prepared in 1–5 days. Faster turnaround time will allow faster site cleanup and more efficient use of environmental engineering resources.



The Standard Laboratory Module is the fundamental building block of the CAA system. Users can use each module independently, combine Modules into Mini-SAMs that perform independent fucntions, or combine Modules into complete, EPA-approved Standard Analysis Methods.

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