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A National Laboratory / Private Industry Cooperative Research and Development Agreement (CRADA) *

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ABSTRACT

This paper provides an overview of the history and process of establishing a cooperative research and development agreement (CRADA) between Sandia National Laboratories and Magnavox Electronic Systems Company for the design, development, and testing of a 360-degree scanning, imaging, intrusion detection sensor.

The subject of the CRADA is the Advanced Exterior Sensor (AES). It is intended for exterior use at ranges from 50 to 1500 meters and uses a combination of three sensing technologies (infrared, visible, and radar) and a new data processing method to provide low false-alarm intrusion detection and tracking combined with immediate visual assessment.

The establishment of this CRADA represents a new paradigm in the cooperation between the Department of Defense, the Department of Energy, the National Laboratories and Private Industry. Although a formal document has now been executed, a CRADA is, nonetheless, primarily an agreement to work with each other to achieve goals that might otherwise be unattainable. For the DoD, a program contin-

ues in the face of uncertain funding. For the DOE, a CRADA is in place that meets congressionally mandated guidelines. For Sandia, sponsors are in agreement on requirements and synergistic funding. And for Magnavox, an opportunity is in hand to work with researchers in developing advanced security technology.

INTRODUCTION

Sandia National Laboratories

In the early 1970s, Sandia National Laboratories was tasked by the Department of Energy (DOE) to develop concepts, technologies, and solutions to address the concern of theft of nuclear materials in transit between DOE facilities. At the same time, the U. S. Air Force initiated a program at Sandia to conduct physical security R&D and implement systems to protect critical assets around the world.

In the mid-1970s, the DOE designated Sandia as the lead laboratory for development of physical security technology and funded Sandia to develop a technical capability in security modeling and systems analysis, security

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equipment and components, and security systems engineering, integration, and implementation. As a result of this investment the Security Systems and Technology Center was formed, with unique physical security systems capabilities that can be applied to deal effectively with any security threat.

Early expertise was drawn from existing Sandia programs in use control and sensor and communications technologies. To complement this technical expertise, a strong capability in systems analysis was also developed, dealing with threat, consequences and risk, facility characterization, and system performance.

A large effort was devoted to characterizing the components of security, consisting of detection (including assessment and communications), delay, and response elements. System engineering principles, such as protection in depth and balanced protection, were established and implemented at DOE and DoD sites.

Technology Transfer

Technology transfer at Sandia extends back three decades. Today, industry annually produces several billion dollars' worth of products made possible by Sandia-developed technology. Examples range from diamond drill bits to laminar-flow clean room technology.

This initiative was given impetus by the National Competitiveness Technology Transfer Act of 1989. This act made technology transfer an official mission of the DOE laboratories and allowed Sandia to utilize the Cooperative Research and Development Agreement (CRADA) with local governments, universities, private industry and other laboratories. In addition to CRADAs, the DOE's Work for Others (WFO) program, license agreements, and Employee on Loan are the most common ways to access the capabilities

of the Security Systems and Technology Center.

There are many methods of partnering with the national laboratories: The CRADA is just one way. Others are listed below.

Funds-In Technical Assistance - Use industry funds to provide short-term technical assistance not available from private industry.

Licenses - Negotiate equitable partnerships within broad guidelines.

MOUs/MOAs - Outline activities of joint interest; no associated funding.

Nondisclosure Agreements - Protect information that you want to provide, receive, or exchange.

Small Business CRADA - Work with small business using a streamlined version of the CRADA, for total project value of less than \$150K.

Small Business Technical Assistance - Use as much as \$5K in DOE funding toward personnel and other resources.

Work for Others - Work for a federal, academic, or private-sector customer on a no-compete, mission-relevant project for reimbursement.

Personnel Exchange - Work at your industry partner's facility for as many as 10 days.

Technology Partnerships Leave of Absence - Take as long as two years' leave to start a new business or expand an existing company.

User Facilities - Work with an industry partner using designated Sandia User Facilities.

CRADA GUIDELINES

Under a CRADA, Sandia and the sponsor agree to work together to perform certain research and development activities. Sandia's efforts may be funded entirely by the private partner in a collaborative arrangement or with

some mix of government resources, if they are available. The funding amount, if any, provided by the partner, does not include a profit for Sandia. The work is performed on a best-efforts basis up to and not exceeding the funding amount. The CRADA process does not require unique capabilities on Sandia's part, but fairness of opportunity is required. Sandia assures this requirement has been met before entering into any agreement. Information generated by the parties under a CRADA that would be considered proprietary if generated independently as a private entity may be exempted by statute from the provisions of the Freedom of Information Act. Provisions do exist for the protection of the sponsor's proprietary information. Most importantly, the parties may negotiate a broad range of intellectual property agreements appropriate to the needs for commercialization.

DESCRIPTION OF ADVANCED EXTERIOR SENSOR (AES) CONCEPTUAL DESIGN

The Advanced Exterior Sensor (AES) project was begun in 1992 as a conceptual study and requirements analysis for a next-generation exterior intrusion detection sensor. The study concluded that many recent advances in technology, such as uncooled infrared detectors and high-performance image processing computers, could be capitalized on to provide enhanced detection performance under a variety of environmental conditions. The operator would also be given an image of the scene for immediate visual assessment.

To overcome limitations of some sensors in adverse environmental conditions, three sensing technologies were combined in the conceptual design. Advanced image processing hardware and algorithms based on artificial neural systems and fuzzy logic would be used to intelligently process data derived from

detectors and arrays operating in radio frequency, infrared and visible wavebands. An AES block diagram is shown in Figure 1. An overview of the conceptual design is presented below. Additional details can be found in [Pritchard-94].

Figure 1. AES Block Diagram

Panoramic Sensing and Imaging Module

Remote Sensor Platform

The Remote Sensor Module (RSM) is an environmentally hardened rotating platform that holds the three sensors. It rotates at one revolution per second; the sensors mounted on the RSM provide a complete, 360-degree panoramic image in that time.

Infrared detector array

A thermo-electrically cooled lead-selenide (PbSe) linear detector array is the primary sensing device in the AES infrared sensor module. This array provides economical infrared imaging capabilities without the need for cryogenic detector cooling mechanisms.

Visible Sensor

A visible-waveband linear detector array was added to reinforce the infrared detector during periods of low thermal contrast in warm background, daytime operation [Pritchard-93]. The detector selected uses time-delay-and-

integration to enhance signal strength at high scan rates.

Radar Sensor

Electromagnetic waves at radio frequencies (RF) have the ability to detect humans and vehicles and provide substantially improved atmospheric penetration over the visible and infrared wavebands. For this reason, an RF subsystem has been included in the *AES*.

Data Processor Module

Proposed Configuration

The sensor data processing module (DPM) is based mainly on commercially available parts and is remotely located from the RSM. The DPM can reside in an environmentally controlled area and use 110/220 Vac power. The main components are:

1. Industry-standard VMEbus backplane and industrial quality enclosure.
2. General-purpose processor for system resource management and overall control.
3. Custom data input interface board with Fibre Channel interface, FIFO buffers, and ImageBus interface to the digital signal processors.
4. High-speed digital signal processor boards using the Texas Instruments TMS320C80 Multimedia Video Processor (MVP).

A video motion detection algorithm has been developed for the *AES*. It includes a change detector based on the principle of optical flow. The algorithm has proven to be a good indicator of motion in a scene that is otherwise affected by camera shake or sway. This new algorithm is a good candidate to satisfy the detection and false alarm requirements for the *AES*.

Processing Requirements

To process the 18 Mbytes per second of data expected from the *AES* remote sensor module, motion detection algorithms which meet the *AES* performance requirements will require 10 GFLOPS (billion floating point operations per second) or more of processing power. This performance is available in the 'C80 MVP processor boards.

A necessary criterion for the new motion detection algorithms is that the processing can be efficiently pipelined or divided between multiple processors without incurring a heavy overhead penalty. The detection technique considered for the *AES* meets this criterion. Another requirement imposed on the algorithms is that operations be computable in integer format without adversely affecting desired results. This requirement is common for high-speed signal processing systems and is not expected to degrade system performance. The 'C80 MVP is designed for 8-bit pixel operations in integer format.

Display and Control Module

Flat-panel displays are continuously improving because of changes set in motion by the laptop computer industry. Although not yet specifically designed, the *AES* display and control module software can run on any Windows NTTM machine. For semi-rugged applications, a display platform can be purchased as an entirely off-the-shelf product from a manufacturer of related products, industrial controls, or rugged computer displays. The display and control module will have the capability to connect to and control multiple RSMs while also displaying imagery from the sensors. RSM control will be implemented using an ethernet connection and TCP/IP protocol.

THE AES CRADA PROCESS

The CRADA with Magnavox is the result of months of diligence on the part of both Sandia National Laboratories and Magnavox. A paper was presented on the design and modeling of the AES at the 1994 IRIS Specialty Group Meeting on Passive Sensors [Pritchard-94]. A representative of Magnavox approached the presenter and suggested the matter be discussed in more detail. The potential was recognized for entering into a CRADA not only to commercialize the technology but to relieve some of the cost burden from the program sponsor (DNA).

On May 29, 1994 a *Commerce Business Daily* ad was published. As a result of the CBD ad, approximately 45 companies requested more information. A follow-up letter was prepared for these responders and mailed on September 15, 1994. A variety of companies were interested in more information. The letter described the intent to cost share during Phase 3 of the project, and that cost sharing may total as much as 50 percent of a \$2-3 million project. As a result of the follow-up letter, only one company, Magnavox Electronic Systems Company, had continuing interest. CRADA negotiations began with them late in 1994. To this date, there has not been any other interest.

It took approximately 12 months to complete the CRADA. This period of time is much longer than usual (six months) for beginning a CRADA with a national laboratory. Some of the extra time was a result of this being the first *Work for Others (WFO)* CRADA within the Department of Energy (i.e., funding for execution of the CRADA came from an agency outside the DOE). Since it was the first such CRADA and did not involve DOE funding, many issues and unknowns had to be resolved before DOE and the sponsoring agency (DNA) would agree to acceptance of the CRADA. In January 1996, the CRADA was finally approved by all parties.

SUMMARY

To further the Advanced Exterior Sensor (AES) project, Sandia has established a Cooperative Research and Development Agreement (CRADA) with Magnavox Electronic Systems Company, Mahwah, NJ. The CRADA with Magnavox is for the development, integration, and testing of an advanced, infrared detector set for the AES. Sandia is developing the remainder of the remote sensor module and the data processing module, including a visible waveband detector set, a radar detector set, the rotating platform, and data processing hardware. The goal of the CRADA is to expedite commercialization of exterior video motion detection hardware and software.

REFERENCES

Pritchard-90 "An Infrared Imaging Area Sensor for Tactical and Physical Security Applications," D. A. Pritchard, *IRIS Specialty Group on Passive Sensors*, ERIM, Ann Arbor MI, March 1990.

Pritchard-92 "Status of the Video Imaging System for Detection, Tracking and Assessment (VISDTA) Scanning Surveillance Sensor Program," D. A. Pritchard, *IEEE International Carnahan Conference on Security Technology*, 1992.

Pritchard-93 "Evaluation of Automatic Detection of Humans and Vehicles," D. A. Pritchard, R. F. Davis, and J. E. Simpson, *IRIS Specialty Group on Targets, Backgrounds, and Discrimination*, ERIM, Ann Arbor, MI, January 1993.

Pritchard-94 "Panoramic Imaging Perimeter Sensor Design and Modeling," 1994 *IRIS Specialty Group on Targets, Backgrounds, and Discrimination*, ERIM, Ann Arbor, MI, held at Sandia National Laboratories, Albuquerque, NM, March 14-16, 1994.

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