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July 27, 2005

INMM 46th Annual Meeting  
Phoenix, CA, United States  
July 10, 2005 through July 14, 2005

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This work was performed under the auspices of the U.S. Department of Energy by University of California, Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

# **AVNG SYSTEM SOFTWARE – ATTRIBUTE VERIFICATION SYSTEM WITH INFORMATION BARRIERS FOR MASS AND ISOTOPICS MEASUREMENTS**

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## **ABSTRACT**

This report describes the software development for the plutonium attribute verification system – AVNG. A brief synopsis of the technical solution for the measurement system is presented. The main tasks for the software development that is underway are formulated. The development tasks are shown in software structural flowcharts, measurement system state diagram and a description of the software. The current status of the AVNG software development is elucidated.

## **INTRODUCTION**

The development, manufacture, testing and demonstration of the plutonium attribute verification measurement system is being carried out within the framework of the Agreement № 37713-000-02-35 made between the University of California, Los Alamos National Laboratory (LANL), USA and the Russian Federal Nuclear Center-VNIIEF, Russia. The parties are developing a measurement system with Information Barriers for the verification of plutonium attributes for samples inside sealed AT-400R containers.

The following attributes are verified during the measurement of the sealed container:

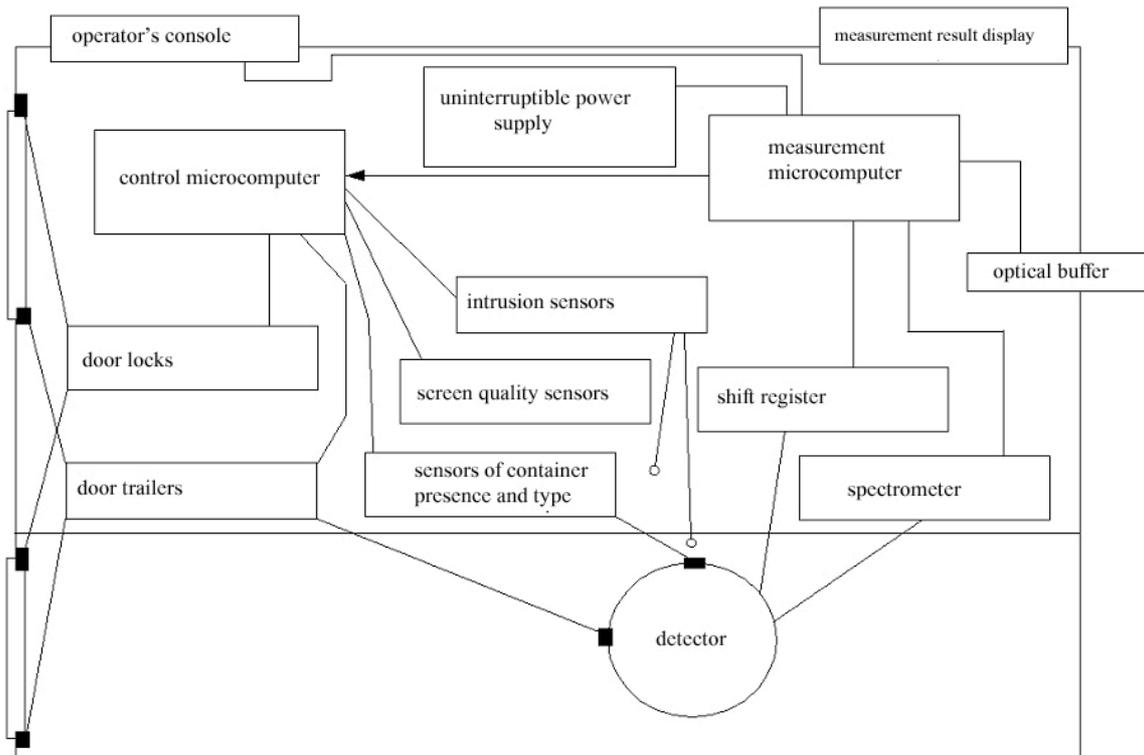
- The presence of plutonium in the container;
- that the  $^{240}\text{Pu}/^{239}\text{Pu}$  isotope ratio exceeds an established threshold value;
- and, that plutonium mass exceeds an agreed threshold value.

The goal of the work presented in this paper is the explanation of the software development for AVNG measurement system. The measurement system has dual-computer architecture, therefore the software includes programs for the both computers and the interaction protocol between the computers.

The software being developed was required to meet the following requirements:

- it (the software) could not allow data the isotopic and the mass information about the material in the sealed container to be released if the system encountered a hardware failure;
- the source code for the programs and the operating system must be open for expert analysis.

## BRIEF DESCRIPTION OF THE TECHNICAL SOLUTION



*Fig. 1 Structural layout of AVNG hardware.*

A flowchart of the AVNG system hardware is shown in figure 1. The measurement and the control computers are industrial IBM-PC microcomputers. PCL-818 multifunction boards manufactured by Advantech are employed along with the proper set of daughter boards from the same vendor to connect peripherals to the computers. The intrusion sensors used in the system are infrared sensors built by Ademco, the container presence sensors are Omron optical sensors. The container type is determined by presence or absence of grooves on the container to find which a “belt” is used collected of Omron optical sensors.

### AVNG SOFTWARE

The operating environment chosen for the AVNG software is the eCOS (Version 2.0 final version) operating system (embedded configurable OS). When it was being selected, this environment was actively supported by Red Hat, at present it is supported by ecosCentral group. The eCOS operating system is a multithread operating system with basic task interaction devices: semaphores, queues. The source code for this operating system is available, which meets the requirements to the operating system for AVNG.

The main stages in the software development were as follows:

- The maximization of multisequencing to simplify software writing, debugging and support.
- The development of unified software flowcharts to provide for the maximum use of the code fragments in the both (control and measurement) microcomputer code.
- The active use of alarm functions to service inputs-outputs according to fixed time schedule.

## **CONTROL MICROCOMPUTER SOFTWARE**

The control microcomputer software consists of five threads and seven alarm functions. The four functional threads have equal priority and the control thread has higher priority. The control thread is not only responsible for the set of alarm functions activation and thread switching speed computation, but also includes an additional element for reliability control of the program operation. There is fixed estimation for the switching speed for each thread. If the system goes beyond the preset limits, the microcomputer is considered to have an unrecoverable failure that initiates system shutdown procedure. Alarm functions of daughter boards the presence control, Watchdog Timer (WDT), timely cleaning control, and control over the time allocated for the operation are the main elements that affect the operation reliability of the control microcomputer.

The software development progress to the present is as follows:

- The control microcomputer software is completely written and now is being debugged. The debugging has been rather time consuming, since maximum possible number of variants of the system behavior and external impacts have to be “gamed” with the use of diverse imitators.
- In the situations “gamed” to this day, the control microcomputer software has operated stably the errors and drawbacks are being corrected, and there are no grounds to deem that some fundamental errors are inherent to the developed software flowchart.

Figure 2 presents a state diagram of the system and is common for the both microcomputers.

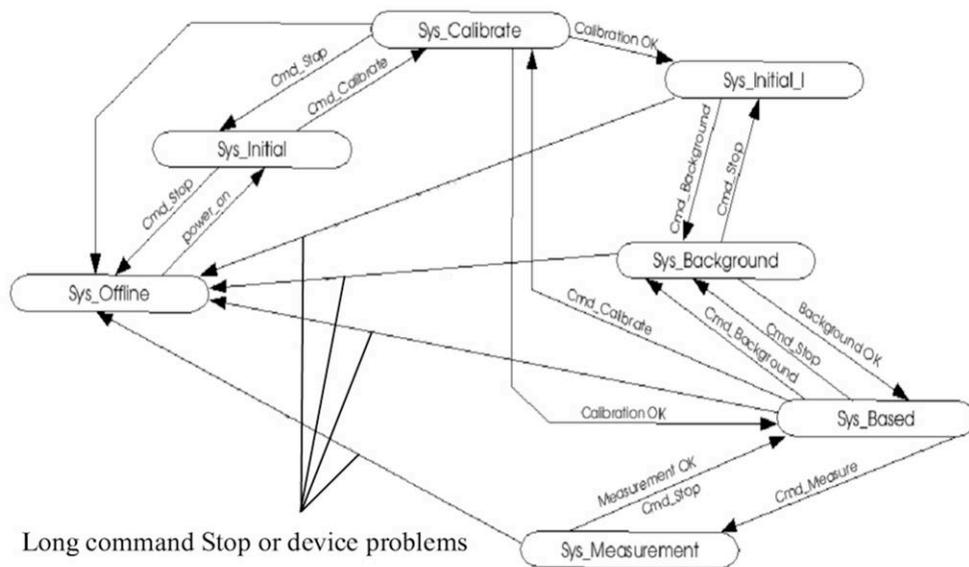


Fig. 2 State diagram of the measurement and control microcomputers

## MEASUREMENT MICROCOMPUTER SOFTWARE

The measurement microcomputer software consists of nine threads and seven alarm functions. Eight functional threads have equal priority and the control thread has higher priority. The control thread is not only responsible for the set of alarm functions activation and thread switching speed computation, but includes also an additional element for the program operation reliability control. This is the permanent estimation of the switching speed for each thread. If it goes beyond the preset limits, then the measurement microcomputer is considered to have unrecoverable failure, and the system shutdown procedure is initiated. Alarm functions of daughter boards presence control, Watchdog Timer (WDT), timely cleaning control, and control over the time allocated for the operation are the main elements of control over the measurement microcomputer operation reliability. The flowchart shows that the system software is built to make the maximum use of the code fragments in programs for both microcomputers.

The operation of the peripherals is arranged through the processes (threads) spectrometerThread, shiftThread, upsThread. The interaction of the streams is implemented through command and data queues. Since all the devices are connected with the measurement microcomputer via a RS232C interface, all the device threads employ specialized classes to work with the devices, which are daughter ones of the common class serialPort. The device threads execute high-level commands (carry out calibration, report the result) and uninterruptedly communicate with “their” devices. Presence of a device in the communication line and its activity is determined by response to a command like “report the device type or the software version”, that is given in preset time intervals.

StateMachineThread thread is responsible for the developed state diagram implementation. The thread tracks the measurement microcomputer's switches according to the state diagram. Among the auxiliary functions of the state machine there may be particularly noted the final decision making on the container passing or not passing the test for material mass and isotope ratio, and control over the measured results displaying and data transmission to the verification printer/terminal.

Messages to the control thread, to a separate thread, in fact, which services messages to the system from working threads (of equal priority) come to controlMail queue and are processed by controlMailThread thread. A message coming to controlMail queue includes type, code and arrival time. The message type defines procedure of its processing, and the code defines measured results displaying and/or the status word to be transmitted to the control microcomputer.

Progress of the software development:

- All the alarm functions have been written (functions from the control microcomputer program are used with minimal changes introduced).
- The processes for the discrete signals shaping, scanners of discrete and analog inputs have been completed.
- A code for the power supply support thread has been written.
- The state machine model is practically ready (This is being developed and tested with the use of data flow emulators).

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