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AVNG Authentication Features

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Abstract

Any verification measurement performed on potentially classified nuclear material must satisfy two seemingly contradictory constraints. First and foremost, no classified information can be released. At the same time, the monitoring party must have confidence in the veracity of the measurement (called authentication). An information barrier (IB) is included in the measurement system to protect the potentially classified information. To achieve both goals, the IB allows only very limited, previously agreed-on information to be displayed to the monitoring party. In addition to this limited information from the potentially classified measurement, other measurements are performed and procedures are put in place for the monitoring party to gain confidence that the material being measured is consistent with the host's declarations concerning that material.

In this presentation, we will discuss the techniques used in the AVNG attribute measuring system to facilitate authentication of the verification measurements by the monitors. These techniques include measuring unclassified items while allowing more information to be displayed; having the monitor understand the system function, design, and implementation; and randomly selecting the order of measurements.

Introduction

The AVNG attribute measurement system [1-5] was designed and built at VNIIEF in Russia to make measurements of potentially classified plutonium items and display previously agreed-on characteristics of the item in an unclassified form. Detailed measurements of the item were made behind an information barrier (IB) and unclassified "attributes" based on these measurements were displayed outside the IB. The attributes were derived by comparing the measurement results to

thresholds and only reporting whether the result was above or below the threshold (e.g. mass of plutonium > 2kg.)
A measurement system such as the AVNG could be used to verify a declaration made concerning a treaty-limited plutonium item. A monitoring party could use displayed attributes as well as any procedures before, during, or after the measurement to gain confidence that the item's properties were consistent with the declared properties. A primary design criterion of an AVNG-like system is that classified information cannot be released. This criterion is often in conflict with the monitoring party's desire to obtain as much information as possible for authenticating the system and the measurements.

The AVNG was built, and certified, not to release classified information, but it also had many features and procedures to aid with the authentication process. The AVNG was demonstrated at VNIIEF in June 2009 [6] with US observers in attendance.

Availability of information about the AVNG system

The US observers had a great deal of information about the AVNG before arriving at the demonstration. Although the AVNG was a designed and built at VNIIEF, the concept, design, procurement of parts, and testing had been discussed, presented, and reviewed at numerous joint US/Russian meetings over the multiyear span of the project.

Both the hardware and the software implementation in the AVNG were derived from design and operational specifications that were jointly developed. The US observers were informed about, and to some extent involved in, the process of moving from a conceptual design, to a construction plan, and to the finished system. Information about the development and final implementation of the concept of operations of the AVNG was also shared and discussed with the US team.

In all, the US team knew the plans for the AVNG, the process of its development, and the final implementation. The results of testing of the system were also shared.
At the demonstration the US team recognized and were familiar with all the components of the AVNG, knew its measurement capabilities, and knew how it was to be operated. This familiarity made it much easier to understand the demonstration, and to have confidence that the measurements being shown were made by the AVNG as it had been planned. Through this cooperative design process, the observers also had confidence that the system was capable of making the measurements shown.

Having knowledge of the design and access to the drawings would greatly aid the process of understanding and validating such a system.

Design features of the AVNG

One of the main features of the AVNG, intended to assist with the authentication process, was that the measurement system had two modes of operation: "classified" and "unclassified". In the classified mode the only information available outside the IB were the attribute results (displayed as red and green lights). The unclassified mode, however, incorporated a data display on an external monitor of the details of the measurements that had produced the attributes. When a known unclassified item was being measured, the gamma spectrum, the neutron multiplicity results, and the calculated values were all accessible. This information increased confidence that the AVNG would perform properly when it went back to the classified mode.

The measurements and calculations performed in the two modes should be identical and not depend on the nature of the material being assayed. Without this condition there would be no assurance that the results observed in the unclassified mode would have relevance to results presented in the classified mode. This condition was enforced by the design of the system. There are two computers in the AVNG: the measurement computer and the control computer. The control computer has inputs that indicate what type of item is being measured and whether the system is allowed to operate in the unclassified mode. The measurement computer is unaware of this information and performs the same operations for any item. Care was taken to control the information that could be passed between the two computers – in particular no information can go from the control to the measurement computer (see Figure 1).

AVNG HARDWARE STRUCTURE FLOWCHART

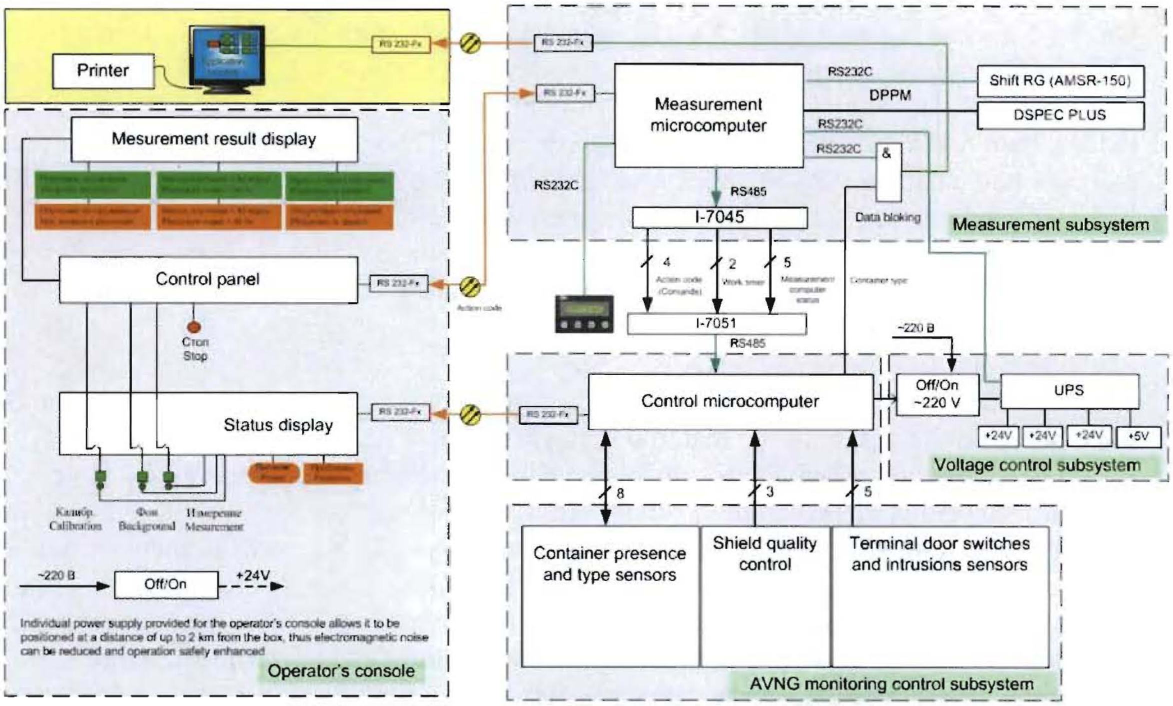

Figure 1 Block diagram of the AVNG hardware system. Note that only the Control computer has access to the container-type (classified vs. unclassified) and door-switch sensors. The communication between the two computers is strictly one-way – no information is allowed to pass from the Control to the Measurement computer.

The AVNG hardware and software are constructed in a simple to understand, well documented, modular fashion. This design would allow an inspector to more easily confirm that the system was built to match design specifications as intended. Two examples of modularity are: the software, where the routines each have clear, single functions; and the custom electronics. The custom electronics are assembled out of I-7000 series modules (see Figure 2). There are a wide variety of these modules to chose from, each with a well-defined function as well as interface characteristics. The use of these modules makes it easy to ascertain the intended function of a system. In addition, the use of a modular design could facilitate possible random selection for authentication of electronic components. (The random selection process and some of the issues associated with it are discussed in reference 7.)

Figure 2 The custom electronics were made using easy-to-understand I-7000 series modules.

The AVNG concept of operations has a clearly defined procedure – enforced by the control computer – for the system startup. This sequence involves making measurements of the radiological environmental backgrounds and performing a calibration measurement with known radioactive sources to assure that the measurement system is functioning properly. Only if the backgrounds are low enough so they don't interfere with the assay measurements and the system responds correctly to the calibration sources can an assay measurement be performed. This procedure gives confidence that the AVNG will be able to perform an assay with the required accuracy. Knowing in advance what is expected to happen at each stage of the operation makes it easier for the observer to understand what they are being shown and increases confidence in the whole process.

Use of plutonium reference materials to test the system

During the demonstration, the AVNG operation was tested with certified plutonium reference materials [8] that had been explicitly manufactured to have masses and isotopic compositions appropriate for this purpose. When one of these reference materials (RM) was measured with the AVNG the reported results could be compared with the expected, certified values of the reference materials. These checks gave added confidence that the AVNG not only was capable of making the required measurements, but that results from unknown plutonium items would be correctly reported.

The RM had been produced at the Mayak facility in Russian and subsequently measured and certified as Russian State Reference Materials. Acceptance test measurements of the RM were made at IPPE using gamma spectrometry, neutron multiplicity counting, and calorimetry. The data from these acceptance test measurements were sent to the US where it was confirmed that the analysis of the data showed that the relevant RM properties agreed with those listed in their certificates. At IPPE the RM were placed in AT400R containers and had a seal applied to them. The AT400Rs were shipped to VNIIEF for use in the demonstration and the seal identity and integrity was verified during the demonstration (see Figure 3). These procedures increased the confidence that the RM being measured were those with the expected properties.

Figure 3 Left: seal being applied to the AT400R containing the one of the RM after the acceptance tests at IPPE. Right: Seal being checked during the demonstration at VNIIEF.

Procedures during the demonstration

The demonstration was performed over 3 days, at VNIIEF, according to a plan and procedure that had been previously agreed to by the US and Russian participants. The AVNG system and the RM were in a secure area at VNIIEF. The US observers were in a conference room in an open area. A telephone connection provided real-time communication between the two areas allowing the US observers to stay apprised of the progress of the demonstration and provide input to the proceedings. Measurements and tests were performed in the mornings and complete video recordings were made of the entire proceedings. The video camera ran continuously and included commentary by the Russian operators on what was happening and why. In the afternoon, the US observers watched the video with Russian experts present to answer questions. Copies of the video were sent to the US after the appropriate reviews had been completed.

To assure the observers that the video they watched actually corresponded to the activities in the secure area, several procedures were implemented. The telephone calls between the two locations were recorded on the video; notes, with time stamps, taken by the observers could later be correlated with the video. Telephoned requests at specific times, such as "smile and wave at the camera", could later be seen on the video (see Figure 4). At the beginning of each day the US observers presented the Russians with some 'markers' that could not have been predicted beforehand (e.g. an airline baggage tag). The marker was then seen in that day's video. For measurements that were made in the open mode, information about the measurements was displayed on an external monitor. This display was printed out and brought to the US observers to examine and compare to the video.

The observers were allowed to make several choices concerning the tests being performed. At one point they selected which RM would be measured next, and at another time they requested that a calibration measurement be made using the (empty) background container instead of the calibration container, which contained sources. The video of the resulting activities and the AVNG displays shown in the video were consistent with these choices.

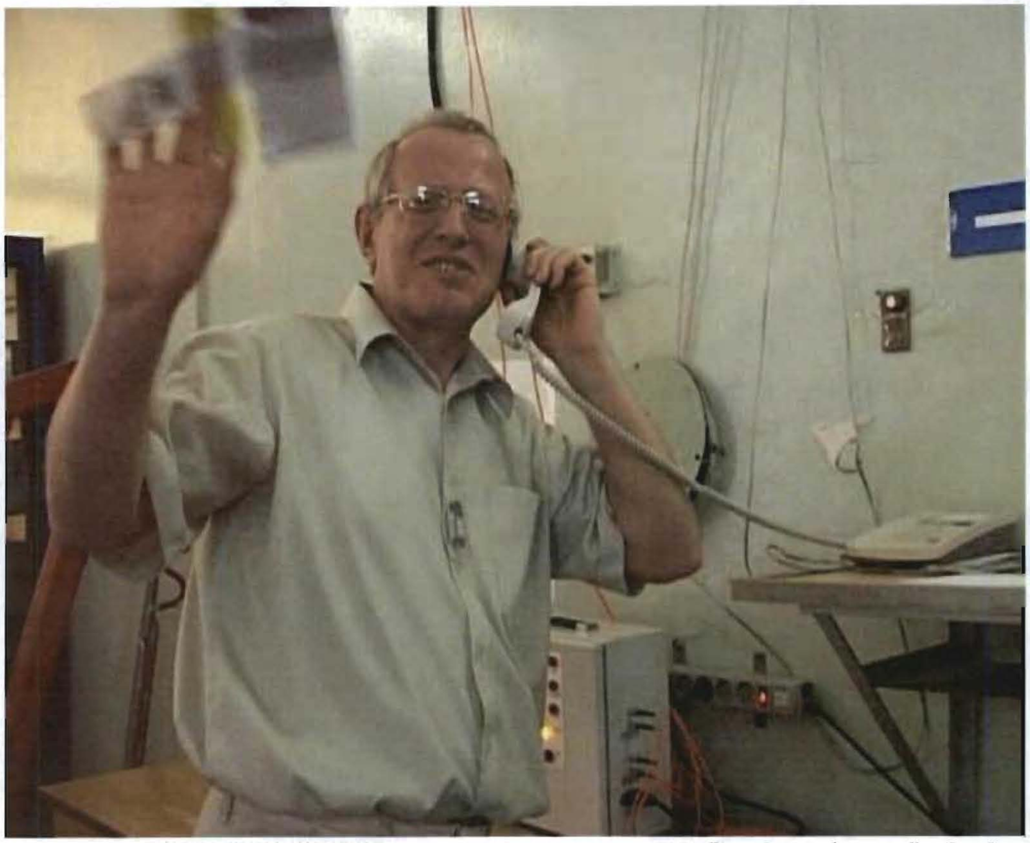

Figure 4 Frame grab from the video showing the response to a "smile and wave" telephone request from the US observers.

Conclusions

Attribute measurement systems, such as the AVNG, must first satisfy the host that no classified information will be released during their operation. Authenticating such a system will generally not produce an absolute level of confidence, but will be a matter of providing many layers of confidence-enhancing measures, both features designed into the system and procedures followed during its operation. Given the constraints within which it operated, the AVNG and its demonstration incorporated many authentication elements including:

- Cooperative design,
- Documentation,
- Dual-mode design,
- Modular design,

- Use of tags and seals,
- Random choice of measurement items, and
- Video-stream authentication.

These elements increased the confidence of the US observers that the measurements shown to them were made by the AVNG system as designed and that these results corresponded to the characteristics of the items being measured.

Acknowledgement

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