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REGIME-INDEPENDENT CHARACTERISTICS OF ATTRIBUTE MEASUREMENT SYSTEMS

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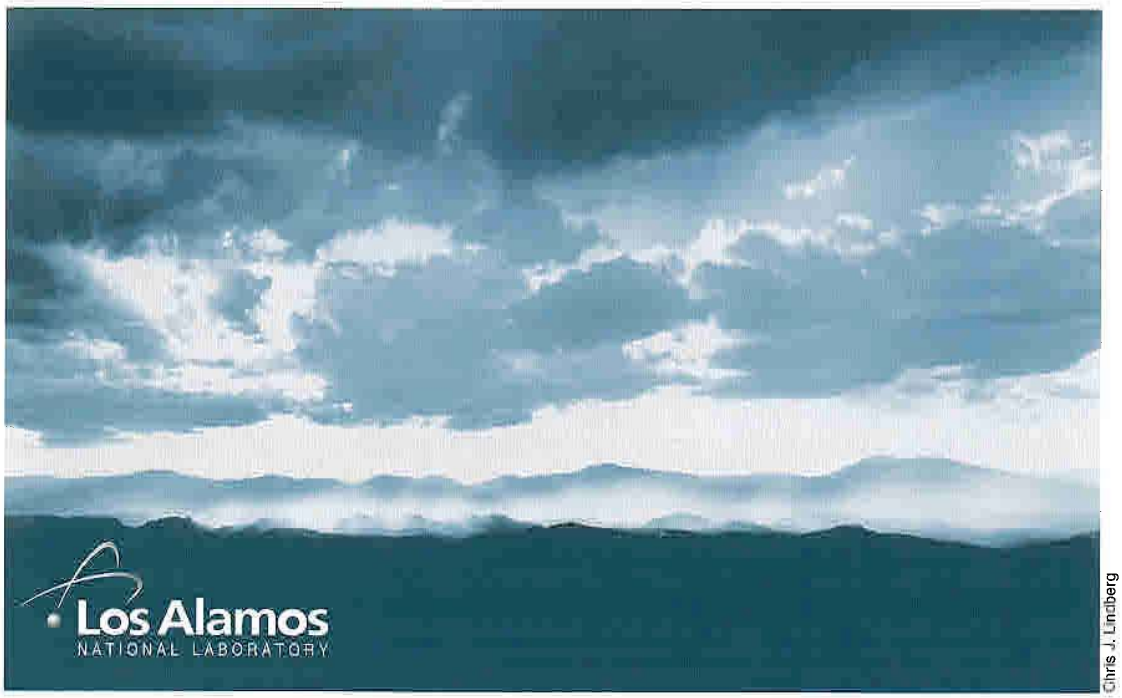

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ABSTRACT

Many monitoring and inspecting efforts that are intended to address storage of classified nuclear materials utilize attribute measurement systems. Although such measurement systems have been extensively described, these descriptions have often been dependent on a specific monitoring regime or set of attributes. There are a number of desirable features of attribute measurement systems that are independent of the specifics of the intended use. In particular, many details of the information barrier as well as details of system authentication are common to various regimes of use. These common features can be exploited during the design of each individual measurement system. In particular, the utility of unclassified reference material measurements as an aid to authentication depends on separation of security and data analysis functions. If there is communication between these functions, then the usefulness of both reference material measurements and the open mode for authentication will be severely degraded.

INTRODUCTION

Any potential verification system must meet two criteria:

1. classified information cannot be released to an inspecting party (information protection), and
2. the inspecting party must be able to reach credible and independent conclusions (authentication).

The first requirement has traditionally been satisfied by allowing only Host country personnel to be present during measurement of a classified item. The second requirement has traditionally been satisfied by allowing the inspecting party to have detailed knowledge of data, spectra, pulse streams, and so on. However, neither of these traditional methods can satisfy both requirements simultaneously. These measurement constraints have been discussed previously in the context of other measurement systems. [1]

Attribute measurements [2] utilize standard nondestructive assay (NDA) measurement methods using both neutrons and gammas. However, since any useful radiation measurement performed on a classified object will yield a classified result, unclassified attributes are generated from the classified measurements. These attributes can be thought of as unclassified characteristics of the material being measured that indicate that the material is consistent with declaration. Possible attributes include but are not limited to presence of plutonium, plutonium mass exceeding an agreed (unclassified) value, time since separation of plutonium, and plutonium isotopic composition below an agreed (also unclassified) value.

The information barrier (IB) that surrounds the detector systems ensures that only the unclassified attributes are displayed and that the displayed unclassified attributes have a causal relationship to the object being measured. Details of attribute measurement system design as well as a complete measurement system are discussed in Refs. [4] and [5].

INFORMATION PROTECTION

The concept of an IB in the closed mode is illustrated in Fig. 1 and described in more detail in Ref. [3]. All potentially classified information is contained within a barrier behind which the inspector has no access.

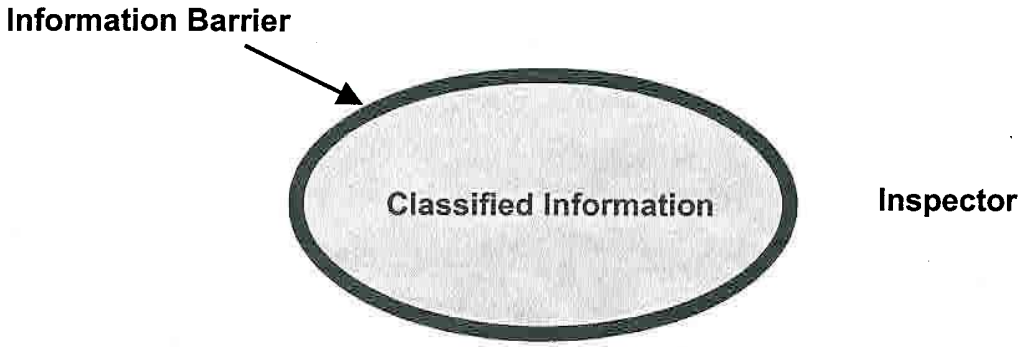

Fig. 1. Conceptual illustration of an information barrier in the closed mode. All potentially classified information is separated physically, electrically, and procedurally from the inspector by the barrier or series of barriers.

Although the concept illustrated in Fig. 1 is simple, practical implementations are generally more complex. No penetrations of the IB are shown in this conceptual illustration, but in reality, a number of penetrations both electrical and procedural are required for implementation of a functioning measurement system. Every electrical penetration through the IB (e.g., power connections and attribute outputs) must be carefully considered to ensure that no unanticipated information can be transferred. In addition, any physical or procedural penetration (e.g., cryogenic detector support) also allows for a potential path for information loss from within the barrier.

CLASSIFIED DATA VS CLASSIFIED SYSTEMS

An important point in the design of these measurement systems is that while the measurement *data* itself may be classified, the measurement *system* should not be. This design feature will allow inspection of the system by all interested parties as well as open discussions about the design itself. This inspection and discussion constitute an important contribution to the acceptance of the veracity of the attribute outputs by the inspector.

In addition to the system itself, the measurement results and raw data obtained from unclassified reference materials are also unclassified. Thus, these results and data can be examined in detail by the inspector to increase confidence that the measurement system is designed and operating as specified.

MODULAR CONSTRUCTION

Design of measurement systems as a series of simple, well-defined modules allows for

- individual testing and optimization of each module,
- isolation of failing modules,
- individual replacement of failed elements,
- each module to be as simple as possible,
- each module to perform a single function,
- each module to be replaced individually, and
- easy accommodation of changes in attributes.

These features aid in both the information protection and authentication requirements on the measurement system as well as aiding in the production of an easily maintained system. Simplicity of maintenance is especially important, because a system incorporating an IB may cause difficulty if extensive troubleshooting is required.

OPEN MODE

By its very design, a measurement system containing the IB illustrated in Fig. 1 will be difficult to authenticate. Information protection concerns mandate protecting the detailed classified information within an IB. However, if an impenetrable barrier surrounds all of the raw data, then this raw data cannot be used to assist in verifying the correct operation of the system. One way of approaching this apparent contradiction is to use a measurement system with two modes of operation. If a classified item is being measured, the IB is intact and only simple yes/no binary outputs are allowed, as illustrated previously in Fig. 1. If no classified material is present, the IB can be opened allowing access to all of the raw data to assist in authentication of the measurement system. This mode of operation is illustrated in Fig. 2. An example of a measurement system incorporating two modes is given in Ref. [6].

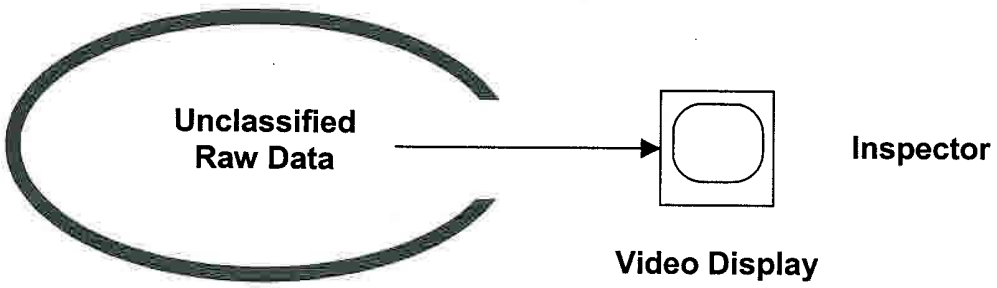

Fig. 2. An IB in the open mode. In this mode, all of the unclassified raw data can be displayed on video monitors to aid in authentication of the measurement system. In this mode, an open door in the IB allows the inspector access to the unclassified raw data.

SEPARATION OF FUNCTIONS

Another feature that can be very important in raising an inspector's level of confidence in a measurement system is the complete and verifiable separation of security and data analysis functions. One of the mechanisms used to increase inspector confidence is the measurement of unclassified reference materials in the open mode. Since these measurements are unclassified, the inspector can observe the raw data at every stage of the analysis process. Given sufficient experience with the detector signals and the data acquisition system, the inspector can gain a reasonable level of confidence that the measurement system is operating correctly *in the open mode.*

However, inspector confidence is also required *in the closed mode.* When the system is closed, the only display available to the inspector is the binary red/green display. In order to satisfy the information protection criterion, this binary display cannot display enough information about a measurement to generate inspector confidence. Thus, the confidence generated in the open mode must be transferred into the closed mode. This transfer of confidence is greatly enhanced if the data acquisition system operates in exactly the same manner in the open and closed modes. If there is no difference in the acquisition system between the two modes, and that fact can be verified, then the data processing can be assumed to be the same in the closed mode (when the data cannot be inspected) as it was in the open mode (when the data could be inspected).

Thus, if reference material measurements in an open mode are intended to raise the inspector's level of confidence in closed mode operation, then the data acquisition system must function in the same manner in either case. The most convincing way to prove this is to design a measurement system with no data-passing connections between the security and data acquisition functional elements. In particular, the security and data acquisition functions cannot be collocated in a single physical component, computer or otherwise. If the functions are effectively separated, the data processing elements will process the raw data identically for both classified and unclassified measurements and the security components will enable appropriate display of the data depending on its classification.

SUMMARY

Complete implementations of the attribute measurement system (or other system intended to measure classified items) can usefully include these regime-independent design features:

- integral information barrier,
- unclassified system architecture,
- modular design,
- open mode to enhance authentication, and
- separation of functions.

Inclusion of these features will help to enable the attribute measurement system to effectively protect classified information while simultaneously allowing for authentication.

Rigorous implementation of the IB structure shown in Fig. 1 can address the information protection issue mentioned as criterion 1 in the introduction. Many of the other features mentioned in this paper (e.g., the unclassified system, open mode, and separation of functions) may be included in a measurement system to increase the inspector's confidence in the operation of the system in the closed mode (criterion 2).

The separation of security and data analysis functions is critical to the use of unclassified reference material measurements as aids to authentication. Any measurement in the open mode, and the open mode itself, is only useful if the confidence generated can be transferred to the closed mode. If there is communication between the two functions, then the usefulness of both reference material measurements and the open mode for authentication will be severely degraded.

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