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Information Barriers—A Historical Perspective

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ABSTRACT

The concept "transparency" was introduced into the safeguards lexicon in the early 1990s, and the term "information barrier" was introduced into the safeguards lexicon in the late 1990s. Although the terms might have been new, the concepts were not. Both concepts have been used by the International Atomic Energy Agency (IAEA) and its inspectors since the early 1980s, but the terms "transparency" and "information barrier" were not used for those concepts then. The definitions of these concepts have evolved in recent years, and these concepts have been applied to a broader category of special nuclear material measurement problems. The origin and features of the information barrier concept will be traced from an early implementation by the IAEA to the current state-of-the-art information barrier technology used in nonproliferation, arms control, and dismantlement.

INTRODUCTION

The concepts of transparency and of an information barrier were introduced in the early 1980s [Ref. 1], but the explicit terms "transparency" and "information barrier" were not used until about ten years later.

The Hexapartite Safeguards Project [Ref. 1] was formed in 1980 by the six technology holders of gas centrifuge facilities,[*] and the inspectorates of the International Atomic Energy Agency (IAEA) and Euratom. The Hexapartite Safeguards Project was formed to wrestle "…with the problem of how to get effective and credible safeguards at uranium enrichment plants [specifically, gas centrifuge facilities] while protecting sensitive information and minimizing the operator's burden." At that time, the transparency and information barrier approaches were incorporated into a protocol called limited-frequency unannounced access. Today, the connotations expressed in "protecting sensitive information and minimizing the operator's burden" are used in the definitions of information barrier and transparency.

Transparency has been applied to monitoring regimes in the nonproliferation, arms control, and dismantlement environments. Transparency is designed to give the

[*] The United Kingdom, Australia, Germany, the Netherlands, Japan, and the United States.

inspecting party assurance and confidence that the inspected party is living up to the conditions of an agreement. One definition of transparency is *measures that a country takes to build international confidence that it is abiding by treaties, agreements, or unilateral declarations while minimizing operational impact on facilities and loss of information that could negatively impact national security or result in proliferation of weapons-design information.* Safeguards are generally considered to consist of intrusive measures whereas transparency measures are generally not as intrusive. Safeguards are designed to establish and maintain a material inventory. This requires precise and accurate measurements. Transparency measures generally cannot maintain or confirm material inventory and are generally not as precise and accurate.

An information barrier [Refs. 2–4] is designed to prevent the release of classified or proprietary information while allowing meaningful measurements and independent conclusions. The information barrier must provide the inspecting party with the confidence that the unclassified output accurately represents the classified input. The inspected party must be convinced that classified, or proprietary, information cannot be released to the inspecting party. An unclassified interface must be used to display, and possibly record, measurement results. The results of the classified, or proprietary, measurement can be reported as a simple yes or no that signifies whether the measurement result meets or fails to meet predetermined criteria. This can be accomplished by a combination of hardware, software, and administrative controls.

Recently, new information barrier concepts have been applied to support the Trilateral Initiative [†] [Ref. 5], the Fissile Material Transparency Technology Demonstration (FMTTD) [‡] [Ref. 6], and the Plutonium Production Reactor Agreement (PPRA).[§] These measurement systems incorporating information barriers are tasked with preventing the release of classified information while, at the same time, allowing useful confirmatory measurements.

[†] In 1996, representatives from the United States, the Russian Federation, and the IAEA began working together under the Trilateral Initiative to examine technical, legal, and financial issues regarding IAEA verification of excess weapons-origin fissile material. Development of an inspection regime under the Trilateral Initiative is in accord with the obligations of the Russian Federation and the United States to Articles I and VI of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT).

[‡] The Fissile Material Transparency Technology Demonstration (FMTTD) was a demonstration by the United States to delegates of the Russian Federation that weapon components in a storage facility could be verified without revealing classified information. For the demonstration, measurement attributes used to verify this material in the United States weapon component were provisionally agreed upon by the two parties.

[§] The Plutonium Production Reactor Agreement (PPRA) between the United States and the Russian Federation is to confirm that Russian plutonium oxide from spent fuel in storage was reprocessed before 1 January 1997. Measurement attributes of the plutonium oxide agreed by the two parties will be used to verify the material under this agreement.

CASCADE HEADER ENRICHMENT MONITOR

A requirement from the Hexapartite Safeguards Project for the uranium enrichment measurement at centrifuge plants is that the nondestructive assay (NDA) measurement must only confirm the declarations of the facility operator. The measurement must be quick and result in only a go/no-go or yes/no answer that confirms only that the enrichment level is low-enriched uranium and consistent with the facility declaration. The measurement does not have high precision or accuracy, consistent with only a go/no-go measurement result. Also, the characteristics of an operating centrifuge facility make a high-accuracy, high-precision, on-line measurement extremely difficult. The measurement algorithm uses the Sequential Probability Ratio Test [Ref. 7], a statistical test that is designed to make a decision in the minimum amount of time. This instrument is used on the header pipes outside the centrifuge cascade area, thus reducing the impact on the host facility and protecting the proprietary information associated with the centrifuges. This measurement has the characteristics consistent with a transparency regime.

An IAEA-approved instrument for use during a limited-frequency unannounced access inspection is the Cascade Header Enrichment Monitor (CHEM). The CHEM [Refs. 8–12] is an active/passive gamma-ray spectroscopy instrument developed in the early 1980s that verifies, on line and in real time, the enrichment of the gaseous uranium hexafluoride (UF_6) in the header pipes of an operating gas centrifuge facility. This instrument uses off-the-shelf electronic components (Davidson portable multichannel analyzer [PMCA] and a laptop computer) that are used daily by the IAEA inspectors.

The result of the enrichment measurement, which could reveal proprietary information, is reported as a simple go/no-go statement. This is accomplished by a combination of hardware, software, and administrative controls as shown conceptually in Fig. 1. This figure shows the measurement instrument(s) and data analysis, or threshold comparison, inside a barrier. The data analysis result is passed through a data barrier so only qualitative results are presented on the unclassified display outside the barrier. This schematically represents an information barrier. The CHEM algorithm determines how much data are needed to make a decision based on the measurement criteria, and it makes and presents the decision. The only conclusion from the CHEM presented to the inspecting party and the inspected party is "low-enriched uranium confirmed" or "low-enriched uranium not confirmed." If the header pipe happens to be under vacuum at the time of the measurement, the result at the conclusion of the measurement is "XRF indicates gas is consistent with vacuum." The instrument is a go/no-go instrument, or a yes/no instrument. There is no hard-copy output. At the conclusion of a measurement session, all data in the memory of the Davidson are erased, and nothing is stored in the memory of the computer. The CHEM prevents the release of proprietary information while allowing meaningful measurements and independent conclusions. The CHEM algorithm follows the concept of an information barrier presented in Fig. 1.

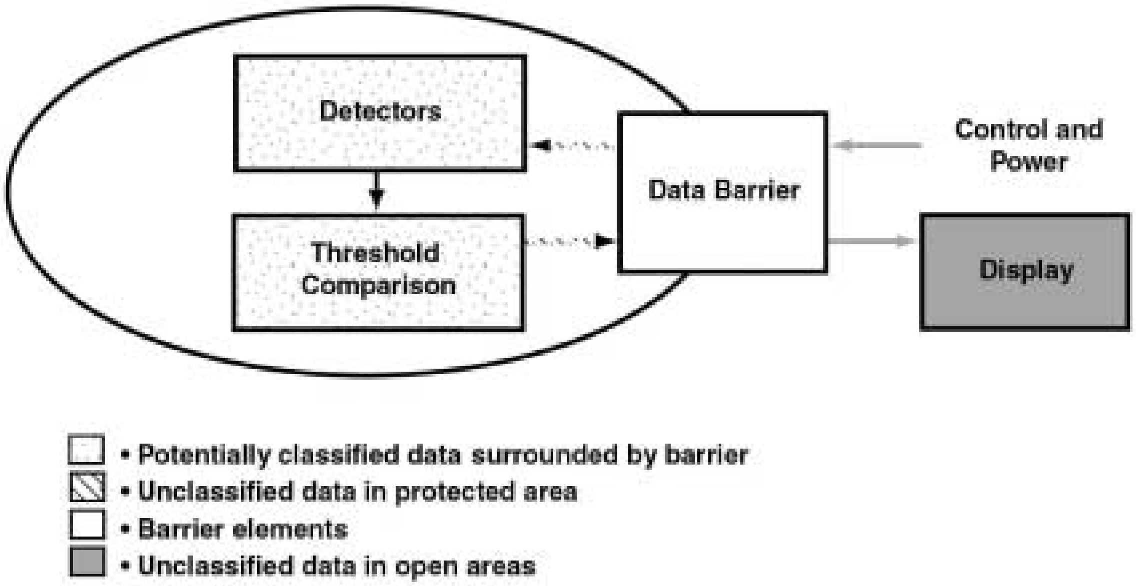

Fig. 1. Conceptual diagram of the first-generation information barrier. The work of the detectors and the computational analysis are performed inside the barrier. After the data barrier is applied, the unclassified results of the measurement are presented on the display.

Additionally, the CHEM [Ref. 13] has two basic operating modes, show and hide. The show mode is password protected. The show mode is used to verify the enrichment calibration of the CHEM using a calibrated secondary pipe standard. The show mode is used during all the enrichment calibration activities, conducted outside and completely independent of the centrifuge facility. This is the ideal mode of operation for laboratory training of IAEA inspectors. During these activities, there are no classified or proprietary aspects of the measurements and calibration. While in the show mode, all intermediate and final results (all count rates and enrichment) are displayed on the screen of the computer.

The hide mode is used during an actual inspection activity by IAEA inspectors and the measurements on the cascade header pipes. No uranium enrichment value is displayed. No count rates are displayed. However, intermediate qualitative results are displayed on the screen of the computer. The final conclusion of the measurement ("low-enriched uranium confirmed," or "low-enriched uranium not confirmed," or "XRF indicates gas is consistent with vacuum") is presented to the inspector.

Before the IAEA inspector makes the decision between show and hide, there is a "calib," or calibrate, mode. This mode is used to perform an energy calibration of the Davidson PMCA. The calib mode allows complete access to all the features of the Davidson PMCA.

During all measurements, whether in the show mode or the hide mode, the CRT display on the Davidson PMCA can be turned on. The controls on the Davidson PMCA that manipulate the CRT display are also active. All other control buttons on the Davidson PMCA are deactivated.

INFORMATION BARRIERS AND ATTRIBUTE MEASURING SYSTEMS

Attribute measurement systems incorporating information barriers are under development for measuring attributes such as mass, isotopic composition, age, or shape of classified plutonium objects. These measured values are compared with unclassified thresholds. The only output of the attribute measurement system is a series of red or green lights indicating whether or not the object failed or passed the appropriate threshold.

These systems incorporate recommendations of the Joint DOE-DoD Information Barrier Working Group (IBWG) [Ref. 14]. In particular, the IBWG recommends simple measurement systems that can be inspected by both the inspecting party and the inspected party with a minimum of extraneous capabilities and a minimum number of inputs and outputs. In addition to the inspected party certification, the inspecting party must be able to authenticate these measurement systems. Stored classified data are to be minimized or eliminated.

The first-generation attribute measurement system (Inspection System with Information Barrier or ISIB) designed for the Trilateral Initiative is discussed in Ref. 5. The second-generation system jointly developed by Russian Federation, IAEA, and United States technical experts (Attribute Verification Systems with Information Barriers for Plutonium with Classified Characteristics Utilizing Neutron Multiplicity Counting and Gamma Spectroscopy or AVNG) is discussed in Ref. 15. A similar system, measuring additional attributes (Attribute Measurement System with Information Barrier or AMS/IB) was designed for the FMTTD and is described in great detail in Ref. 6.

As the information barrier concept has evolved during the last several years, it has become more sophisticated. A block diagram of a more recent information barrier is shown in Fig. 2. Conceptually, data protection features are separated from the detector system(s) and computational block. Redundant layers of defense (defense-in-depth) protect the data from accidental release to the inspecting party, even in the event of a failure of any individual element of the information barrier.

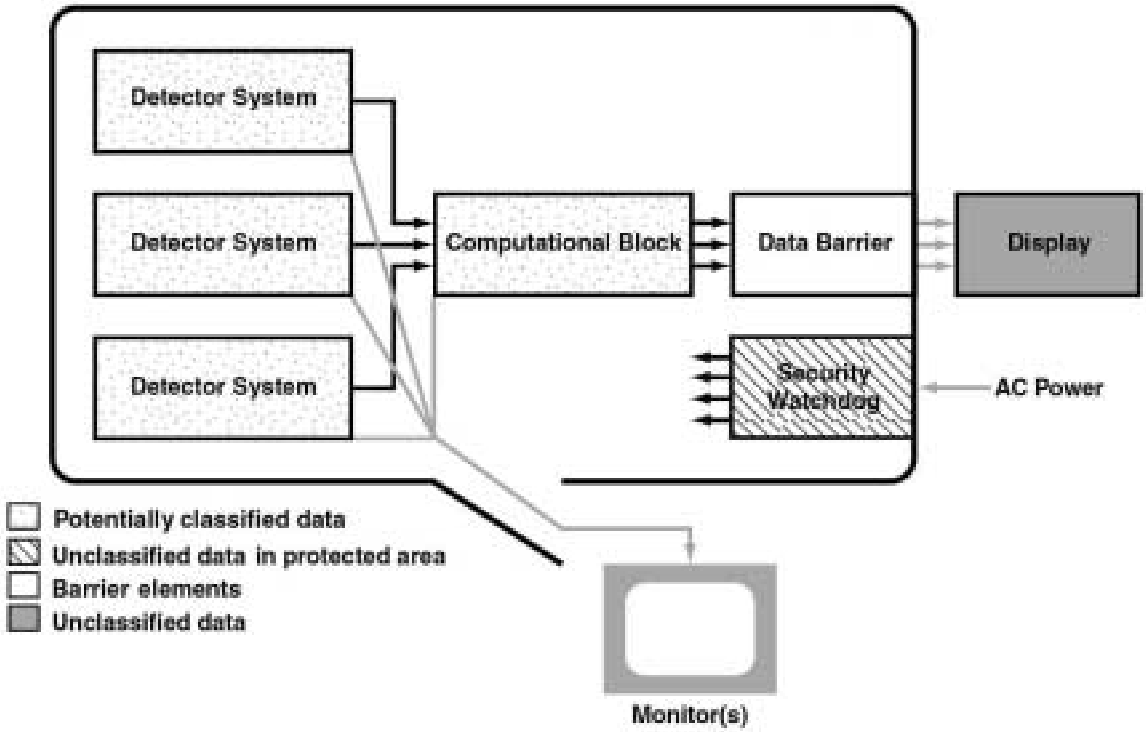

Fig. 2. Conceptual diagram of the second-generation information barrier. The detectors and computational analysis are performed inside the barrier. The security watchdog supplies AC power to all other elements of the measurement system and checks for access or breaches of the information barrier. This information barrier is shown in the open mode, with monitors connected to the system. In the secure mode, the monitors are disconnected from the system, and the physical barrier is closed. There are classified data in the protected area when a classified object is measured. The data barrier is applied, and the unclassified results of the measurement are presented on the display.

The actual measurement techniques used are standard NDA safeguards techniques, for example high-resolution gamma-ray spectroscopy and neutron multiplicity counting. To avoid false results, the most accurate NDA measurements possible are made and then the resulting data are protected by an information barrier against possible disclosure. This approach is preferable to making less precise and less accurate measurements that might have a lower probability of revealing sensitive information but which could increase the possibility of false conclusions. The normal data collection and data analysis algorithms are applied to the data and results are determined. Then a barrier is applied to the data so that only qualitative results or unclassified results are presented on the display. At the completion of a measurement, all raw data, intermediate analysis results, and any quantitative final results are erased from the volatile computer memory. There is no hard-copy output or long-term storage of classified information.

These measurement systems incorporating an information barrier have an open mode and a secure mode. In the open mode, background data, calibration data, and other unclassified data can be taken and analyzed, and the quantitative results (both intermediate and final) can be studied. Such unclassified measurements increase the confidence of both the inspecting party and the inspected party that the measurement system is operating as desired. The information barrier operating in the open mode in which quantitative results can be studied is shown conceptually in Fig. 2. In the secure mode, the monitors are disconnected from the system, and the physical barrier is closed.

In the secure mode, only qualitative answers, yes or no, are presented to the inspecting party and the inspected party. All of the unclassified measurements can be repeated in the secure mode. In addition, in the secure mode, classified data may be acquired and analyzed, but only unclassified yes/no results are displayed. No intermediate display or detailed outputs are available in the secure mode.

All equipment and instrumentation used in the measurement system are contained in electromagnetically shielded cabinets. A key feature of the information barrier is the security watchdog [Ref. 16]. This module supplies AC power to all other elements of the measurement system and monitors for access or breaches of the information barrier, either intentional or inadvertent, and controls physical access to all the equipment. Any breach of the system results in the security watchdog removing power from the system and thus removing all measurement data from the volatile memory that the system uses.

CONCLUSIONS

While the terms "transparency" and "information barrier" are relatively new to the safeguards lexicon, coined and applied mainly for the arms control, nonproliferation, and weapons dismantlement environments, they are not new concepts. These concepts have been used within the safeguards community, including the IAEA, for approximately two decades. The CHEM is an early example of a transparency measurement that includes an information barrier consistent with the concept presented in Fig. 1. It also has many of the same features of more recent and more sophisticated information barriers (Fig. 2), but uses different terminology than is used today in a discussion of information barriers. The information barrier in the CHEM uses show and hide for the two operating modes. The most recent information barrier uses the terminology open and secure. The displayed conclusion from the CHEM is referred to as a go/no-go or yes/no result, while the latest information barrier uses the terminology yes/no or pass/fail.

The CHEM does not store any information and produces no hard-copy output. The information barrier of the 1980s was designed to protect facility proprietary information and met all of the requirements of the time. The CHEM does not have all the features of current information barriers, such as the security watchdog, is not as robust, and does not have any electromagnetic shielding. The latest information barrier described here evolved to protect classified weapons design information. The two information barriers described have many similar features, though developed approximately twenty years apart in time.

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