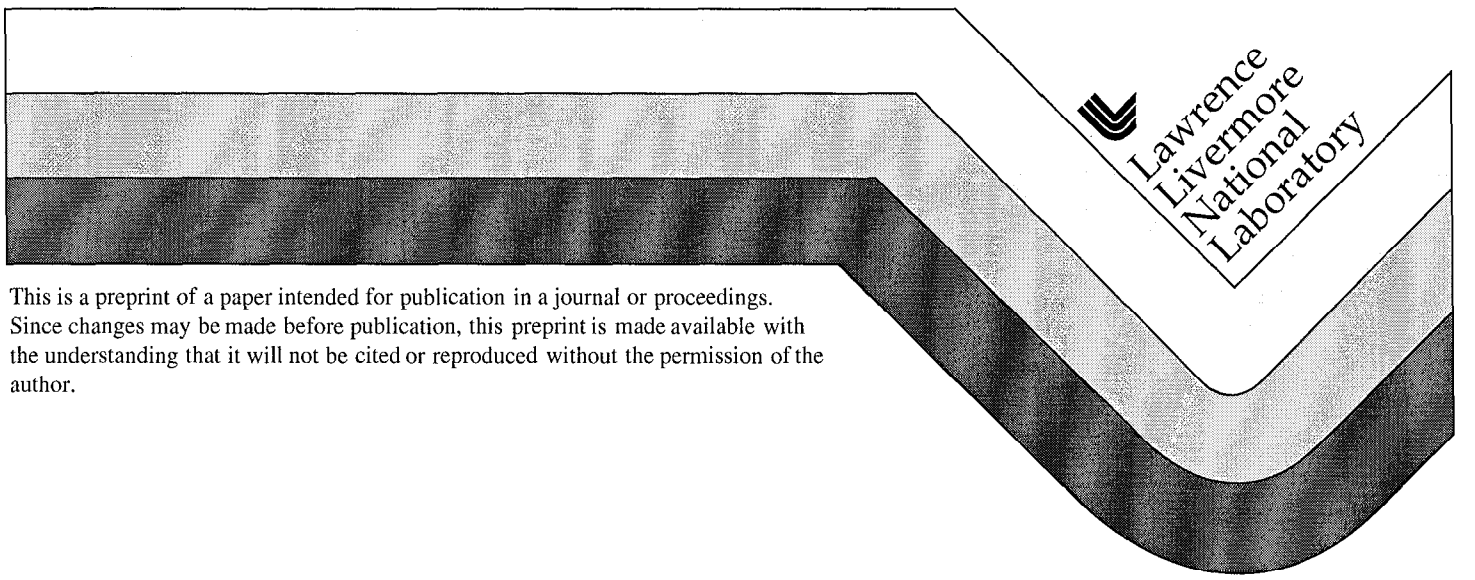
UCRL-JC-134874
PREPRINT

Future Vision of Nuclear Material Information Systems

C. Wimple
N. Suski

This paper was prepared for submittal to the
Institute of Nuclear Materials Management 40th Annual Meeting
Phoenix, Arizona
July 25 - 29, 1999

July 18, 1999



A Future Vision of Nuclear Material Information Systems*

ABSTRACT

To address the current and future needs for nuclear materials management and safeguards information, Lawrence Livermore National Laboratory envisions an integrated nuclear information system that will support several functions. The vision is to link distributed information systems via a common communications infrastructure designed to address the information interdependencies between two major elements: Domestic, with information about specific nuclear materials and their properties, and International, with information pertaining to foreign nuclear materials, facility design and operations. The communication infrastructure will enable data consistency, validation and reconciliation, as well as provide a common access point and user interface for a broad range of nuclear materials information. Information may be transmitted to, from, and within the system by a variety of linkage mechanisms, including the Internet. Strict access control will be employed as well as data encryption and user authentication to provide the necessary information assurance. The system can provide a mechanism not only for data storage and retrieval, but will eventually provide the analytical tools necessary to support the U.S. government's nuclear materials management needs and non-proliferation policy goals.

1 Background

In the last decade significant world events such as the end of the Cold War have reshaped the primary DOE mission from one of weapons production to weapons dismantlement and nuclear materials disposition. As a result of this evolution in the DOE mission, there are increasing interdependencies between domestic and international nuclear materials program (e.g., excess Pu disposition). The tracking and analysis of nuclear materials and information has become an increasingly important part of the DOE mission and has resulted in new demands for additional national database capabilities. In recent years several DOE initiatives and working groups have made recommendations for changes to the national database structure. These recommendations have ranged from adding or revising data elements to wholesale overhaul of the system.

The Office of Non-proliferation and Arms Control, International Safeguards Division (NN-44), is charged to ensure that historical records of nuclear material transactions, material balances and inventories are maintained. In recognition of the changing mission of DOE and the demands of the user community, NN-44 initiated the Integrated Nuclear Information Program as part of its Strategic Plan in 1998.

1.1 DOE Nuclear Materials Databases

The Nuclear Materials Management & Safeguards System is the current national database which provides nuclear materials information relating to safeguards, nuclear materials management and production, inventory quantities and valuations and other information as requested or required by DOE or NRC. Over the past decade, several databases have been developed and deployed in the DOE, each of which has a unique and useful purpose that is not currently met by other means. Several of these databases are listed in Table 1; this is not intended to be an exhaustive list.

*Work performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

Database/System	Sponsor	Current Function
Nuclear Materials Management and Safeguards System (NMMSS)	NN-44	State System of Nuclear Materials Accounting and Control (MC&A Safeguards)
Local Area Network Materials Accounting System (LANMAS)	NN-51	Site-level nuclear materials accounting system
Nuclear Materials Inventory Assessment (NMIA) Database	DP-22	Supplemental Nuclear Materials Management information
Nuclear Materials Integration (NMI) Project Database	EM-66	Supports development of materials disposition pathways
Disposition Maps/Analysis and Visualization System (AVS)	EM (@INEEL)	Facilitates development of and stores materials disposition maps
Integrated Planning, Accounting, and Budgeting System - Information System (IPABS-IS)	EM	Supports EM business processes and information requirements
Integrated Data Base (IDB)	EM (@ORNL)	Through annual data reporting, compiles data on inventories of spent nuclear fuel and radioactive wastes
Integrated Spent Nuclear Fuel Database System	EM-67	Contains information on all fuel within the DOE-owned inventory, and SNF storage facilities
Characterization Analysis Database System (CADS)	MD (@Y-12)	Characterizes DOE surplus HEU material to facilitate disposition of the material. Supports monitoring/planning of HEU safeguards options.
Weapons Usable Plutonium Storage/Disposition Database	MD (@LLNL)	Supports planning for facility design, construction, and operation; for pit disassembly and conversion; for bilateral agreement with Russia on Pu disposition
Departmental Inventory Management System (DIMS)	CR-20	Used for collection, editing, and reporting of the values of nuclear materials inventories.

Table 1. Many DOE Nuclear Materials Databases

1.2 Stakeholders

The sponsors listed above represent only a portion of those entities that are affected in some way by the operation and usefulness of these many databases. Understandably, there are quite a few "stakeholders" that represent "users" or "sponsors." These include Departmental and other government elements that have national responsibilities for nuclear materials, as well as those with interest in nuclear materials outside the U. S.

The proposed integrated nuclear information system will provide a gateway to domestic and international nuclear materials information for DOE, other federal agencies, and foreign organizations. The primary users of the system output are DOE-HQ program offices: Defense

Programs, Office of Nuclear Weapons Management (DP-22); Environmental Management, Office of Nuclear Materials Stabilization (EM-60); Office of Fissile Materials Disposition (MD); Office of Nonproliferation and National Security, Office of Arms Control and Nonproliferation (NN-40) and Office of Safeguards and Security (NN-51), the Office of the Chief Financial Officer, Office of Financial Planning(CR-20), and the Nuclear Regulatory Commission. Defense Programs and Environmental Management are the primary "owners" of DOE nuclear material. The Office of Fissile Materials Disposition will take ownership of some materials (HEU and Pu) from Defense Programs and Environmental Management in accordance with approved "acceptance criteria" as the Materials Disposition Program moves into the implementation phase. The Office of Nonproliferation and National Security has responsibility for supporting the negotiation and implementation of international agreements and treaties. International organizations such as the International Atomic Energy Agency and Euratom will receive reports from the system.

1.3 Working Groups and Other Initiatives

There have been several working groups and other ad hoc initiatives that have put forth recommendations for improving the national database for nuclear information. These include the Fissile Materials Assurance Working Group, the Nuclear Materials Information System Working Group, the MC&A Quality Panel, the Nuclear Materials Integration Project, and, more recently, the Nuclear Materials Working Group chaired by the Office of Field Integration. In addition, in Fall 1998 the directors of the three nuclear weapons labs developed a white paper at the request of Under Secretary Moniz entitled "Integrated Approach for Nuclear Materials: The Case for a Roadmap."

Each of these initiatives have called for a more integrated and comprehensive approach to collecting and archiving nuclear materials information. Recommendations include, but are not limited to:

- Accounting for nuclear material in waste
- Revision to or addition of composition of ending inventory codes
- Item level tracking
- Item description codes
- Tracking foreign obligated material in the U. S.
- Limits of error on measurement data
- Consolidate several of the department's databases into a single system
- Maintain a distributed database system, but implement communication infrastructure
- Provide "on-line" access to nuclear information
- Increase the number of elements and isotopes currently tracked in NMMSS

Even more recently, it has been proposed that an Office of Plutonium, Uranium and Special Nuclear Materials Inventory be created as part of the recently announced Office of Security and Emergency Operations. The primary function of this Office will be to support broad nuclear material information needs of the government and public and assist in departmental decision making. This office would be responsible for maintaining real-time, reliable, and complete information on the most sensitive DOE fissile material.

2 Vision

In an effort to discharge its responsibilities over the State System of Accounting and Control in an efficient and cost effective manner, NN-44 envisions a fully integrated nuclear information system that will provide accurate and timely nuclear materials information in support of both domestic and international nuclear materials policy objectives. This vision goes beyond a nuclear materials control and accountability (MC&A safeguards) database, as currently implemented. It encompasses information that addresses the needs of *all* stakeholders identified in Section 1.2.

Some key benefits of this integrated approach are

- *Reduced time spent chasing down data from multiple sources*
  Government managers and officials will be able to go through a single focal point to get answers to many different questions related to nuclear materials
- *Improved efficiency by speeding access to needed information*
  Wherever practical and secure, direct electronic links will facilitate speedy development of answers and requested reports
- *Protect data through transparent but strong security mechanisms and access control*
  Strict access controls based on compartmentalization of information and need-to-know will be enforced to protect information and allow data owners to manage and selectively share data. For those who are granted access, simple and unobtrusive mechanisms will ensure secure access and data transmission.

In practical terms, this system would likely be manifested by establishing linkages among existing information systems and to a secure, controlled operations center. A key technology that will facilitate the integration and controlled sharing of nuclear materials information is a common infrastructure that enables communication among the system's various elements, and also provides a user interface for the system's users. Information may be transmitted to, from, and among system elements by a variety of communications links. Strict access control will be employed as well as data encryption and sender/receiver authentication to provide the necessary information assurance.

This integrated nuclear information system infrastructure can provide a mechanism not only for data storage and retrieval, but will eventually provide the analytical tools necessary to support the Department of Energy's nuclear materials management needs as well as the U.S. government's non-proliferation and nuclear energy policy goals.

2.1 System Scope

The scope of this effort can best be described in terms of two major elements: Domestic Nuclear Materials Tracking and International Nuclear Materials Tracking and Analysis.

Domestic Nuclear Materials Tracking will focus on information pertaining to specific nuclear materials and their properties. It may also contain information pertaining to nuclear facilities design or operation. U. S. owned nuclear materials will be tracked both domestically and abroad and foreign- owned or obligated nuclear materials will be tracked within the U. S. The domestic element will accommodate nuclear material information required for the State System of

Accounting and Control as well as other information required by Defense Programs, Materials Disposition, and Environmental Management for the purpose managing and processing DOE nuclear material. Wherever feasible, existing information systems will be accommodated and integrated via the INIP communications infrastructure.

The International Nuclear Materials Tracking and Analysis will provide international nuclear analysis, including estimates of weapons-usable nuclear materials inventories, information pertaining to foreign nuclear facility design and operations, and other information pertaining to the nuclear infrastructure outside the U. S. The international component may also provide a clearing house for all U. S. international reporting obligations, including the US/IAEA Agreement and additional protocols, bilateral agreements, and trilateral agreements.

2.2 System Goals

Our basic goals for an integrated nuclear information system are as follows:

1. Actively involve stakeholders in all aspects of the system
2. Identify, adopt and/or develop, and adhere to *best practices for quality* throughout the entire life cycle of the system
3. Develop and share a comprehensive understanding of the flow of, use of, and objectives for nuclear materials in DOE's nuclear stewardship mission.
4. Assist in the development of DOE policies and procedures for the purpose of reporting data to and retrieving data from the system
5. Promote interchange of and access to nuclear materials information by authorized groups

Each of these goals is worthy of discussion in and of itself. This paper focuses on the more technical of these goals, number five.

2.3 Implementation Issues

Implementation of the working groups' recommendations and NN-44's vision requires careful consideration. In Summer 1998, a group sponsored by NN-44 set out to begin to understand the needs of the many nuclear materials information stakeholders listed in Section 0. Many different approaches were utilized to gather information, including one-on-one meetings, group exchanges, and distribution of a 50+ question questionnaire to hundreds of DOE nuclear materials managers and accountants. Through this exercise several important factors became apparent:

- To understand functional requirements for an integrated nuclear materials information system designed to address the needs of all qualified stakeholders requires a far more intense, broad, and comprehensive effort than what was undertaken.
- No existing nuclear materials information system begins to approach the complexity required for a comprehensive integrated nuclear materials information system; hence the proliferation of programmatic databases and information systems.
- The most detailed and comprehensive information resides at the sites where the material itself resides. This information is in information systems that are largely incompatible with each other and with headquarters programmatic and corporate information systems, and are unique to the needs of the site. In addition, these sites find it difficult to obtain necessary funding to upgrade systems to meet changing needs.

- Significant revisions to existing DOE orders governing the reporting of information to the national database will be required to implement most of the recommendations pertaining to new or revised data elements. Many of these recommendations could have significant impacts on the reporting sites both in terms of resources and budget.
- The current DOE organization and management structure makes it difficult (at best) to coordinate the efforts associated with development and enhancement of existing information systems.

In spite of these perceived difficulties, we feel strongly that coordinated, concerted action should be taken to stem the proliferation of incompatible information systems, and steps should be taken toward an integrated nuclear information system that would serve DOE's and the U.S.' government's nuclear information needs.

2.3.1 Infrastructure

In most cases, there are no linkages of any kind among the nuclear materials information systems listed in Table 1. At best, some engage in infrequent off-line indirect exchanges on compatible physical media, e.g. floppy or CD ROM.

As stated earlier, a key element of a successful integrated nuclear information system is the declaration, definition, and existence of a common infrastructure through which all integrated elements communicate. One potential approach to implementation would include a division of labor and responsibility between the central infrastructure management and operational organization, and the distributed elements that control information and utilize the communication infrastructure to pass data. The central organization would, in collaboration with the distributed elements, identify the standards by which nuclear materials information would be shared. These standards include data definition and format standards, interface standards, communication protocol standards, security standards, etc. that are common to a well defined, robust electronic communication infrastructure. An open, standards-based, documented interface definition for elements of an integrated system will, along with these other standards, accommodate changes to a given element, integration with future elements, and will make it easier to modify or enhance the infrastructure.

The central organization would also provide core services that become building blocks for tools needed by both central operations and the distributed elements. These services include a data dictionary for publishing and implementing the data definition and format standards, directory services for obtaining contact information on key personnel and organizations, common application program interface objects and modules for data sharing, security services for compatible implementation of access control and information assurance among all integrated elements, among others. It would also operate and maintain the necessary hardware and software to enable electronic linkages with the system's integrated elements, as well as develop and publish common mechanisms that enable electronic submittal and retrieval of data, a query capability, and report production and distribution services.

All services and standards would be clearly documented in infrastructure specification and policy documents. In addition, migration plans would be developed jointly with each currently existing

element that is to be integrated to assist in incorporating and/or developing necessary standards and services to enable appropriate communication.

2.3.1.1 Specific Technologies Envisioned

The infrastructure's flexible, standards-based architecture will enable module re-use as new (sub-) elements are added or existing ones are modified. Strict access control would be enabled through Kerberos/DCE. Data encryption and sender/receiver authentication could be implemented using public key infrastructure (PKI) constructs along with sophisticated, automated need-to-know (NTK) technology to provide the necessary information assurance. A Java-based data entry engine could accommodate both a graphical user interface (GUI) and hands-off data submission for time savings in system operations and for users in the field. A similar engine could also be employed for some report generation, report retrieval, and on-line analyses. The infrastructure would likely be based on TCP/IP, which is the underlying communication protocol for the Internet (unclassified) and SecureNet (classified), and would accommodate the development of interfaces to other non-TCP/IP-based protocols such as direct-dial. X.500 is a likely candidate for implementation of directory services, as it is now in common use around the DOE complex. An Internet Inter-ORB (Object Request Broker) Protocol (IIOP)-based architecture for communication among system elements could utilize Common ORB Architecture (CORBA) or Java RMI (Remote Method Invocation) constructs.

2.3.1.2 Data Definitions

As each of the nuclear materials information systems in Table 1 have been developed largely independently, there is little consistency among them in terms of how the data are represented for each system. This means that the data dictionaries for these systems, which defines the usage, intent, and format for each data element, are largely incompatible. There are some notable exceptions, such as the use of a common set of codes to represent the composition of ending inventory, which is used by NMMSS, LANMAS, and the NMIA database, and the existence of a cross walk between NMMSS financial modules and financial balance sheet codes in use by the Office of Financial Policy. Unfortunately, as in the case of the financial cross walk, it can be difficult to maintain and utilize a current translation. A consequence of this incompatibility is that comparison, validation, or reconciliation of the data among these many systems is difficult to accomplish manually, and virtually impossible to do in any sort of automated fashion.

The ultimate success and usability of an integrated system of nuclear information databases will rest on the development of a set of commonly used data definitions, and perhaps an agreed upon translation mapping among related but dissimilar data element definitions to achieve a level of compatibility required for effective sharing and understanding of collections of data from multiple data sources. Establishment of a cross-program working group(s) should be considered for the development of effective and usable data content and format definitions. The development and use of a set of commonly used data definitions will provide consistent data across all elements and sub-elements, and a common access point for a broad range of nuclear materials information.

3 Conclusion

The time is ripe for a fresh look at satisfying DOE's and the U.S. government's needs for access to accurate, timely nuclear materials information. Changing missions and needs over the past decade have resulted in the proliferation of many disjoint and largely uncoordinated information systems to

satisfy specific needs. There are a wide variety of nuclear materials information stakeholders throughout the government, each of which are served by these information systems in different ways. Several working groups and initiatives have emerged to attempt to address the disjointedness of these systems, and have produced a long list of recommendations. So far, little action, in terms of policy and budget, has taken place to address these recommendations.

We have presented a vision, developed under NN-44's guidance, of an integrated nuclear information system that would address the working groups' recommendations and provide flexible, adaptable and secure service for the future. Such an integrated system, based on open, standards-based, current technology, would have both Domestic and International elements and responsibilities, and would strive to maintain the investment already made in information systems that support these activities. While there are obvious involvement, quality, mission, and policy goals for such a comprehensive system, we have purposefully focused on the system's technological aspects in this paper. We have presented implementation issues and proposed solutions for the infrastructure that would enable integration of existing information systems, and discussed development of a common data dictionary, both integral to the system's success. The approach presented here would stem the tide of disjoint system development, and meet DOE's and the U.S. government's current and future needs for accurate, timely, and verifiable nuclear materials information.

Carolyn Wimple (cwimple@llnl.gov) is a Project Leader at the Lawrence Livermore National Laboratory. She received her BS in Computer Science from California State University, Sacramento, in 1984. Since then, Carolyn has contributed to a variety of projects at LLNL, specializing in computer graphics, and electronic data formats for technical and business information. For the past seven years, Carolyn has held various leadership positions within LLNL's Technology Information Systems Program, leading efforts focused on DoD CALS and EDI (Department of Defense Continuous Acquisition and Lifecycle Support and Electronic Data Interchange), secure data sharing over the Internet, and Internet security consulting. She is currently engaged in researching the information and information technology needs of the U. S. Department of Energy's nuclear materials management, safeguards, and domestic and international policy efforts.

Nancy Suski (suski2@llnl.gov) is currently the International Nuclear Analysis Program Manager in the Nonproliferation, Arms Control, and International Security Directorate at the Lawrence Livermore National Laboratory. Previous to this position, she established and managed the Washington D.C. Operations Office for Fission Energy & Systems Safety Program and managed $10 M/yr Uranium Enrichment Technical Support Project. She has extensive experience in nuclear fuel cycle technologies including uranium enrichment, fission, fusion and waste management. Nancy has her MS in Mechanical Engineering from UC Davis and her BS in Engineering Science from Trinity University in San Antonio, TX.