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MC&A Software Assistance to Ukraine

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ABSTRACT

The U.S. Department of Energy is assisting nuclear facilities in Ukraine to improve their ability to protect, control, and account for the nuclear material under their authority. Early in the assistance program the Ukrainian representatives requested assistance in automating the material accounting at their facilities. A PC-based application, AIMAS (Automated Inventory/Material Accounting System), was designed to provide a starting point for joint U.S./Ukraine system development. Computers with AIMAS prototypes have been installed at Kiev Institute of Nuclear Research (KINR), South Ukraine Nuclear Power Plant (SUNPP), Kharkiv Institute of Physics and Technology (KIPT), Sevastopol Institute of Nuclear Energy & Industry (SINEI), and the Ministry of Environmental Protection and Nuclear Safety (MEPNS). Microsoft Access 2.0, a windows-based relational database management system, is the application development environment. Since it is necessary to support a wide range of computing infrastructure needs and facility requirements, AIMAS has been designed to be highly flexible and user configurable. AIMAS functions include basic physical inventory tracking, transaction histories, reporting, and system administration functions (system configuration and security). Security measures include multilevel password access controls, all transactions logged with the user ID, and system administration controls. Interfaces to external modules are being designed to provide nuclear fuel burnup adjustment and bar code scanning capabilities for physical inventory taking.

1. INTRODUCTION

Since the dissolution of the USSR many of the successor states have requested assistance to improve their systems for control of nuclear materials. Ukraine has signed agreements with the U.S. concerning development of state systems of control, accounting and physical protection of nuclear materials. The U.S. Department of Energy (DOE) is providing assistance in nuclear material safeguards, including: MC&A systems, measurement techniques, and Physical Protection (PP) [1,2]. Training courses on MC&A and PP are also being provided to Ukrainian personnel. Site surveys have been performed at the WWR-M research reactor at the Kiev Institute for Nuclear Research, the Kharkiv Institute of Physics & Technology, Sevastopol Institute for Nuclear Energy & Industry and at the South Ukraine Nuclear Power Plant. Areas of the site MPC&A system not conforming with accepted international guidelines were noted and potential upgrades were recommended. Among the areas identified for assistance were the accounting systems for nuclear materials.

AIMAS (Automated Inventory/Material Accounting System) is a PC-based application for nuclear material control and accountability which runs under Microsoft Windows [3]. It is being developed as part of the U.S. Department of Energy Assistance Program to Ukraine in Material Protection, Control, and Accounting (MPC&A). This is a cooperative effort involving specialists from the U. S. and Ukraine. The first AIMAS software prototype was installed on computers delivered to Kiev Institute of Nuclear Research (KINR) and the South Ukraine Nuclear Power Plant (SUNPP) in June 1995. The prototype was designed to provide a starting point for joint U. S./Ukraine system

development. Subsequently, AIMAS prototypes have been installed at Kharkiv Institute of Physics and Technology (KIPT), Sevastopal Institute of Nuclear Energy & Industry (SINEI), and the Ministry of Environmental Protection and Nuclear Safety (MEPNS). The features of AIMAS include:

- basic physical inventory accounting (item level)
- transaction logging
- user defined fields (UDFs)
- basic reporting
- support for material balance areas (MBAs) and key measurement points (KMPs) distributed over multiple PCs
- on-line contextual help
- multilevel security
- multiple item (group) transfers within and between MBAs and KMPs
- import/export records to/from other systems
- enhanced query and reporting options
- extract information from a query and paste it into another application
- generate and process transfer diskettes to handle item transfers between MBA or KMP databases that reside on different computers

2. DESIGN APPROACH

2.1 Software environment

AIMAS is being developed using Microsoft Access 2.0, a relational database management system (RDBMS) and application development environment designed

specifically for MS Windows which supports standalone, networked, and client/server platforms. Access was selected for this project for several reasons:

- Microsoft is a large, stable company with international presence
- Access provides a complete windows-based RDBMS, support, and development environment
- Access offers an excellent data dictionary concept which promotes data integrity and eases data maintenance tasks
- Access provides a substantial library of built-in functions which substantially reduces development and maintenance effort over conventional programming approaches

Access has recently become the most widely-used PC Windows-based RDBMS, which should help insure a long product life for AIMAS. Although Access 95 has been released for the Windows 95/NT operating system, AIMAS has continued to be developed with Access 2.0 to provide operability within both Windows 3.1 and Windows 95. Access 95 is not compatible with Windows 3.1, which is still in widespread use in the U.S. and FSU.

2.2 Design goals

A primary objective of the AIMAS project has been to work cooperatively to achieve a MC&A capability that meets the needs of the facilities and the state-level IAEA reporting requirements. The approach taken to achieve this objective has been to:

- Field an initial software prototype early
- Take an evolutionary approach (build a little, test a little)

- Involve U. S. and Ukrainian MC&A experts and developers in the prototype iterations
- Leverage commercial off-the-shelf hardware and software to achieve a robust, supportable system

Simplicity, redundancy, and security have been major design goals. For example, a standalone PC can be assigned one or more KMPs, with inventory transfers between PCs synchronized with diskette data transfers. A transaction verification process is enforced by the software design to insure that items transferred to another PC are properly entered on the correct destination computer system. Any PC can assume the duties of a failed PC to maintain high system availability. Security measures include multilevel password access controls, all transactions logged with the user ID, and system administration controls.

2.3 Additional hardware features

The security and redundancy is further enhanced by the system hardware specification, which makes use of computers with all removable media, including high performance removable SCSI disk drives. The standard system hardware configuration calls for a single drive bay which accommodates a removable SCSI disk with a key lock to permit all MC&A activity to be isolated from general purpose computing. Two SCSI boot disks are used with each system, one for general purpose computing and one for MC&A application only. With management controls (limiting access to the MC&A disk to authorized personnel, and limiting use of this disk for MC&A application only), this limits the possibility of unauthorized access to the MC&A data and the possibility of

virus contamination from general purpose users of the system. In case of a computer system failure (not involving a disk failure), the removable MC&A drive may be used in any other MC&A computer configured for removable media. In the case of disk failure, the tables for the failed system can be moved to another MC&A computer from backup data.

3. AIMAS DESCRIPTION

AIMAS has been designed to be highly flexible and configurable, and to support a wide range of computing infrastructure needs to meet a variety of FSU nuclear facility requirements. AIMAS takes a Material Balance Area (MBA) concentric view of a facility, and permits Material Control and Accountability (MC&A) inventory databases to be distributed over one or more computer systems. AIMAS design functions include basic physical inventory tracking, transaction histories, reporting, and system administration functions (system configuration and security). External applications that interface with AIMAS provide burn-up adjustment capability and bar code data entry.

3.1 Setup and installation

Before running AIMAS for the first time, a set-up wizard is run to create an initialization disk used to configure the AIMAS computers. The set-up wizard is run by the system administrator to specify the MBAs which make up the material and accounting system, and to specify how the MBAs are distributed (if divided among more than one PC). In addition, the set-up allows the system administrator to specify the item locations within each MBA and the standard item descriptions common to all MBAs. This insures that the locations and descriptions, which are used in the drop down lists of the AIMAS data input form, are specified in a consistent manner on all AIMAS

computers. In addition, the system administrator can customize the database for their facility through the implementation of User Defined Fields (UDFs) and reports.

3.2 Major functions

AIMAS has four major functional areas: inventory browser and update forms, reports, material transfers, and system administration. Each of these functional areas may be selected from the AIMAS main switchboard panel. The AIMAS graphical user interface showing the main switchboard panel, browser form, and import/export form is shown in Figure 1.

3.2.1 Inventory forms

The main browser form displays the fields for a particular item. Navigation buttons permit moving through records (forward, back, first, last, find). A historical transactions subform may be opened to view all transactions for a particular item (listed with most recent transactions at the top). Currently there are 21 different transactions, including domestic receipt or shipment, accidental gain or loss, discrepancy between shipper and recipient, nuclear losses or production, etc. The records in the historical data subform are automatically generated and provide an audit trail of all transactions involving items in the inventory.

Data entry functions are also available from the main browser form for import, transfer, edit, and new item creation. A filter can be applied to change the order of records (sorted on a specified field) or to display a subset of the inventory (e.g., view only fuel assemblies of a certain type). The inventory can also be viewed in a data table (spreadsheet) view which allows scrolling, rearranging and/or hiding columns, and

creating ad hoc reports. The table view also permits records to be easily copied and pasted into other applications, such as a word processor or spreadsheet.

3.2.2 Reporting

Currently, AIMAS can generate the following reports: physical inventory, general ledger, inventory change document, material balance report, and any custom reports added by the facility. As noted, ad hoc reports can also be made in table view of the physical inventory. Microsoft Access provides many powerful reporting tools which permit a wide range of other reports to be made.

3.2.3 Material transfers

AIMAS has the capability to handle single or multiple item transfers within an MBA (intra-MBA transfer) or between MBAs (inter-MBA transfer). For a multiple item transfer, the user can either check off which items to transfer or use a select query to define the transfer set. If a transfer is made to a location corresponding to a database table on the same PC, the transfer is performed immediately and the physical inventory and historical data tables are updated. If the transfer is made to an MBA or KMP corresponding to a database on a different PC, then the item information must be transferred to the destination PC by creating an *MBA Transfer Disk.* AIMAS will prompt the user to insert a floppy diskette into the originating PC and generate the transfer file. The MBA transfer diskette must be inserted into the receiving PC to transfer the records. After the records have been transferred, the MBA transfer diskette must be returned to the originating PC to close out the transaction. Until the transaction is closed, the items are marked IN TRANSIT to indicate that the transfer transaction has not been verified.

AIMAS also has import and export capabilities to transfer records between other (non-AIMAS) computer systems. These capabilities are described in the section *External Interface Support* below.

3.2.4 System Administration Utilities

AIMAS provides the system administrator with several features for system configuration management and security. AIMAS has support for users that require different levels of access. The system administrator is a special user that has privileges to create other user accounts and configure the AIMAS systems. Below the system administrator are two classes of users: read/write user (has the ability to view, enter, modify, report, and transfer data), and the read/only user (can only view data and generate reports). The system administrator can also configure the drop-down lists that appear in AIMAS, as well as perform functions previously described during the initial setup.

4. EXTERNAL INTERFACE SUPPORT

AIMAS provides a generalized import/export feature to provide an external interface to other applications. The import feature permits users to read data and effect transactions from a file. Imports can be made from character delimited or fixed field-width ASCII files. Exports can be additionally made to a DBF (dBase) file. AIMAS permits the user to create and store templates describing the format of the import/export file. Items that are imported are held in a temporary table and examined by AIMAS for format errors (for example, does a date field contain a valid date?) and may be previewed in a data sheet before committing to the AIMAS database.

Templates can be reused later to simplify the process of performing periodic data imports or exports. For example, this feature could be used to make periodic burnup

adjustments which are calculated by another computer program. Another common use of the import is to transfer records to AIMAS from another MC&A system due to the receipt of a shipment of items from another facility.

4.1 Bar code entry

An example of an external application used with AIMAS is a bar code reader. Bar code entry is a fast alternative to keyboard entry and is not susceptible to transcription errors. Modern bar code readers are actually microcomputers, so they can be programmed to prompt users and record data for use with AIMAS.

A typical bar code application for MC&A will use a set of bar-code labels to identify inventory materials and another set of bar code labels to identify storage locations. Tamper-indicating seals can have integral bar-code information as well, providing an optional third set of identifiers.

The bar code reader is programmed to display a menu on its liquid crystal display (LCD). The user selects an option from the menu and the bar code reader prompts the next action until the transaction is complete. In a typical transaction, the user will select a transaction type (new material, internal or external transfer). The item, location, and seal identifiers will be scanned to complete the transaction record. Data entry can be done as single transactions, or an entire room can be inventoried at once. Data is stored in an ASCII format and imported into the AIMAS database.

For the Kharkov Institute of Physics and Technology, two hand-held bar code readers, one wedge reader, three scanners, and a bar code printer have been provided as part of the U.S. MPC&A cooperative program with Ukraine.

4.2 Burn-up adjustments

A nuclear reactor operating under IAEA Safeguards is required to report the isotopic content of its fuel. Periodic burnup calculations provide the means to obtain predicted partially-burned and spent fuel isotopics. First, neutron cross sections must be generated in few-group form, accounting for basic fuel design parameters and prior exposure history. The AIMAS database provides necessary information for this step. Second, those cross sections are used in a multidimensional reactor neutronics solution for instantaneous flux and power distributions. Third, a burnup calculation is made to account for neutron-induced reactions such as fission and capture, which lead to buildup and decay of fission products and transuranics.

The PSU-LEOPARD code has been selected for 4-group cross sections and modified to produce a standard output binary library usable by the neutronics/burnup code VENTURE-PC. VENTURE-PC has been upgraded by eliminating problem size restrictions, benchmarked for validity, and modified to create output data files for interfacing to AIMAS, which in turn provides the end-of-step fuel isotopic composition and energy production information to AIMAS. Since cross section generation takes such little computation time, the above sequence of calculations are performed at nominally monthly intervals throughout the life of a reactor core loading, thereby obtaining burnup-dependent cross sections.

A graphical user interface has been designed in Visual Basic 4.0 for controlling the information flow between the user, the burnup/neutronics module, and the AIMAS database. At the start of a calculation sequence, the interface permits the user to make selections for the number of fuel assemblies for which neutron cross sections are needed

(fixed for a given reactor model), the step time, and the average power over the step. Then, the user can initiate the calculation sequence through LEOPARD and VENTURE-PC, with final recovered data being returned to files usable by AIMAS. Fuel shuffling and discharge are planned to be part of the User Interface, but have not yet been implemented.

The process of obtaining new burnup information after the reactor runs for a month is:

1. Define the burn step duration and reactor conditions (i.e. the loading).
2. Create the input data files to LEOPARD and to VENTURE-PC using most recent step output files from VENTURE-PC and any updates to the reactor caused by fuel replacement or shuffling.
3. Run LEOPARD; obtain burnup-dependent cross section binary library for all fuel elements in the reactor model, for conditions approximating the mid-point of the next burn step.
4. Run VENTURE-PC; obtain neutron flux and power distribution at beginning of step; burn to end of step; recompute neutron flux and power at end of step (the step may be subdivided if necessary for greater accuracy).
5. Post-process VENTURE-PC output files of fuel composition to extract IAEA reporting information.
6. Import results into AIMAS as a burn-up adjustment transaction.

5. FUTURE DIRECTIONS

The goal of the DOE MPC&A Assistance Program to Ukraine is to identify areas of the MPC&A system that were not conforming with accepted international guidelines and to work with Ukrainian specialists to implement potential upgrades. To this end

DOE has provided assistance in various areas of nuclear material safeguards, including: MC&A systems, measurement techniques, and Physical Protection. The U.S. has supplied nondestructive assay instrumentation and procedures to assist in material verification. Assistance in repackaging and inventorying material is also being contributed. AIMAS is being developed in response to the Ukrainian request for assistance in automating the materials accounting at their facilities.

It was recognized early during the MPC&A Assistance Program that Ukrainian participation in the development efforts was needed to assure success. AIMAS was designed to provide a starting point for joint U. S. / Ukraine system development. The initial prototypes were delivered to sites in Ukraine to elicit comments and help direct subsequent effort. As the work continues the Ukrainian MC&A specialists are becoming more involved in customizing AIMAS to the needs of their facilities.

Additional training in automated data processing was an area identified by the MPC&A Assistance Program as valuable to Ukraine. The degree of computer literacy of the Ukrainian MC&A specialists who will be operating the nuclear material accounting systems varies widely. In order to prepare the MC&A specialists to work with a computerized accounting system, DOE is offering courses in automated data processing in Ukraine. These courses range from basic MS Windows operation to programming in MS Access. This training, together with that provided by LANL in MC&A systems and Measurement Statistics, will help prepare Ukrainian specialists for the automated MC&A systems used in the international community.

Ukrainian specialists are working to adapt AIMAS for the Ukrainian environment. Documentation and screens have been translated from English to Russian. The product is

then reviewed by U.S. and Ukrainian specialists to insure that the translations are correct and can be understood by MC&A specialists. Ukrainian specialists are also testing and evaluating AIMAS against the needs of the facilities to track nuclear material and to provide reports for the state regulatory agency. This functional analysis will produce a report describing how the facilities are using the present version of AIMAS and make recommendations for modifications to improve the utility of the software. Ukrainian and U.S. specialists will work together to produce a production version of the code which can be used by the facilities in routine operation.

6.0 REFERENCES

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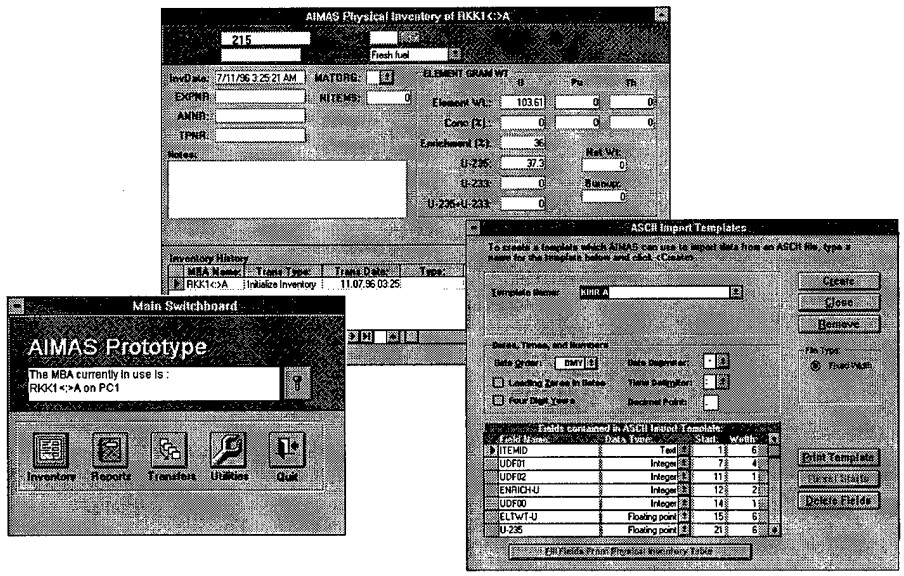
AIMAS Physical Inventory of RKK1 <:>A
Main Switchboard
AIMAS Prototype
The MBA currently in use is :
RKK1 <:>A on PC1
Inventory
Reports
Transfers
Utilities
Quit
ASCII Import Templates
Create
Close
Remove
Print Template
Delete Fields

Figure 1 caption: AIMAS user interface: main switchboard panel (lower left), inventory browser (top), and import/export panel (lower right).

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