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Oak Ridge Y-12 Plant

Presented At:

The 21st Annual ESARDA Symposium on
Safeguards and Nuclear Material Management

Sevilla, Spain

May 4 - 6, 1999

Prepared by the Oak Ridge Y-12 Plant
managed by
LOCKHEED MARTIN ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
under contract DE-AC05-84OR21400

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ABSTRACT

Oak Ridge has developed an intelligent facility and information management system to provide near real time, verifiable status of safeguarded materials in a nuclear storage facility. The Graphical Facility Information System (GraFIC™) is a versatile software package designed to operate in a distributed computing environment. GraFIC™ is integrated with a suite of rugged, low-cost sensors that remotely monitor the physical and/or assigned attributes associated with stored nuclear materials and reports item and facility activity to an unlimited number of authorized clients. The software also contains facility management tools to assist with space planning, record management, item location, and a variety of other facilities needs.

INTRODUCTION

The Graphical Facility Information Center (GraFIC™) is an information system that provides an inexpensive and flexible method of remotely verifying complete “up-to-the-minute” inventory status of stored items and facility assets. In addition, GraFIC™ provides features needed for day to day management of storage and other facilities. GraFIC™ combines an easy to use graphical user interface with extensive online help so users need little training. GraFIC™ can be configured to work with most sensor systems used to monitor facility assets.

Some of the features of GraFIC™ are:

- Inventories on demand
- Real-time alarm notification
- Hierarchical view of facility status and assets (overview to detail)

- Long-term storage and retrieval of inventory data
- Linking of procedures, drawings, and assets to associated facility areas
- Space planning and management
- Easy update of configuration information
- Many built-in reports that can be viewed on-screen or printed
- Ability to integrate with other sensor systems

Although GraFIC™ was originally developed to manage storage facilities for Special Nuclear Material (SNM) at the Oak Ridge Y-12 Plant, it has many potential applications. GraFIC™ would be useful for any facility that houses valuable assets or dangerous items. Some examples are law enforcement agency evidence lockers, military weapons storage facilities, and art museums.

BACKGROUND

Since the end of the Cold War, one of the Oak Ridge Y-12 Plant's major missions has been the storage of SNM. Department of Energy (DOE) orders require that the status of the SNM inventories be confirmed periodically. This inventory confirmation provides assurance that the SNM is secure and has not changed. Confirmation of inventory status involves the measurement of physical characteristics of the stored material, in this case weight and radiation level. These measurements, which are currently done manually, are very expensive, both in terms of time and in number of people required. In addition, there are security and safety concerns when the stored items are measured manually.

The Continuous Automated Vault Inventory System (CAVIS) was developed to provide a way

of remotely performing the inventory confirmation. CAVIS is a hardware and software sensor system that is capable of obtaining weight and gamma ray signature measurements from stored SNM. However, the CAVIS system by itself provides no user interface and is limited to very short-term storage of sensor readings. The GraFIC™ system was conceived to provide those elements missing from CAVIS - an easy-to-use user interface and long-term storage of sensor readings and other data. In addition, GraFIC™ has been designed to provide intelligent facility management features for the storage areas. Early in the development cycle, the GraFIC™ team recognized that the features of GraFIC™ could have broader application, and so the system was designed to permit easy adaptation to other facility environments.

COMPONENTS

The GraFIC™ system is designed on a client-server model. The server and all client software can be run on a single system, but a more typical arrangement would include at least the following three processing units: a database server, one or more sensor sub-systems, and one or more client workstations. A typical GraFIC™ installation is depicted in Figure 1.

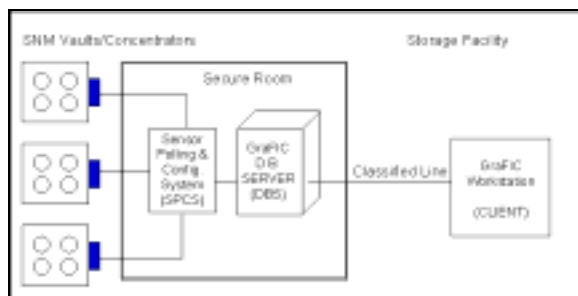


Figure 1 Typical Installation

Database Server

The main purpose of the Database Server (DBS) is to control client access to the relational database. The database is logically partitioned into three subsets:

- 1) One group of data holds the current facility configuration and the current facility status. These tables are normalized as is typical of a relational database.
- 2) The second group of tables holds configuration and status history. Each of

these tables is not normalized so it can serve as a stand-alone log. These data are kept for thirty days and is provided for use in problem resolution.

- 3) The third group is made up of a single table, the DAILY_ARCHIVE table. This table, which is also designed as a stand-alone log, contains inventory data (one row per sensor per day). This information is kept online for a year and then is archived to offline storage.

When sensor readings are stored in the database, the DBS converts each reading to engineering units. The historical logs are automatically updated when the current storage configuration or status is updated.

Sensor Sub-System

A GraFIC™ installation may include one or more front-end processors that comprise a sensor sub-system. The sensor sub-system is responsible for obtaining periodic sensor readings and reporting alarm conditions to the DBS for instant alarm notification. A generic sensor system interface is provided through tables residing on the DBS. A more tightly coupled interface is provided to the CAVIS sensor system and is called the Sensor Polling and Configuration System (SPCS).

The initial implementation of GraFIC™ at the Oak Ridge Y-12 Plant utilizes the CAVIS sensor system to monitor SNM that is stored in Modular Storage Vaults (MSVs). An MSV (see Figure 2) is a concrete slab that contains twenty cells, each of which holds a canister of SNM. Each cell has a weight sensor and a radiation sensor.

An embedded controller (Sensor Concentrator) is attached to the side of the vault and monitors the sensors. These vaults are placed in stacks, ranging from one to five vaults in height, and a concrete lid is placed on top of each stack.



Figure 2 MSV Stack

The SPCS commands the concentrators to scan all sensors at periodic intervals. The readings from these scans are saved in medium-term storage (for a few days) and sent to the DBS for long-term storage. In addition, the SPCS

continually monitors the sensors via the concentrators and reports out-of-limits readings to the DBS for instant alarm notification. The SPCS accepts commands from the DBS to do such things as alter its scan rate, download alarm limits, etc.

Workstation

A GraFIC™ installation may have one or more workstations to provide access to the user interface. These workstations may be placed in locations that are convenient to the workers who need to use them. The user interface portion of the product is given a more thorough treatment in later sections.

CONCEPTS

Hierarchical Storage

Central to the design and use of the GraFIC™ system is the idea that all storage may be hierarchically represented - that any particular storage container is housed by a parent container and so on until the root storage level is reached. The storage hierarchy one chooses to implement is left totally to the end users discretion. Storage level types, parent-child relationships, and storage level instances are all user-definable.

For example, one might have a site that has buildings located on it. Each building may have one or more floors that are further subdivided into rooms. Each room in turn may have cabinets, racks, vaults, etc. These may in turn be further subdivided almost without end.

Hierarchically this can be represented as follows:

- Site
 - Building
 - Floor
 - Room
 - Cabinet
 - Shelf
 - Location on shelf
 - Rack
 - Shelf
 - Location on shelf
 - Vault
 - Cell
 - Can

Linkage To/From Storage Levels

Each storage level may have properties unique to the application assigned to it. For example, a storage level of type building may have a manager or custodian assigned to it, or perhaps a storage level of type container may have a lid assigned to it.

In addition to the user-definable properties mentioned above, each storage level may have one or more of the following assigned to it:

- *CAD drawings* - to-scale drawings that may be attached to the storage level. Examples include a drawing of the site or building, a floor plan of the building, and a drawing of a particular container.
- *Entry Requirements* - the training or security levels that one needs to have access to this storage level.
- *Seals* - the tamper indicating devices that may be assigned to a storage level for security purposes.
- *Lots/Assets* - items that reside in a storage level and are tracked for inventory purposes.
- *Sensors* - to monitor the state of a storage level. When an inventory is performed, those assets that have alarmed sensors in their storage ancestry are flagged as potential concerns.
- *Documents* - such as procedures. These may be attached to a particular storage level or to all storage levels of a particular type. The documents may reside locally or be a pointer to a WEB site.
- *Material Balance Area (MBA)* - to categorize storage levels for accounting purposes.

Not only can various attributes/objects be linked to storage levels, but storage levels can also be linked to graphical entities (polygons, lines, and icons) on a drawing/map. This allows those entities to reflect the state of the storage level and to provide the user with access to the storage level data from a drawing/map. This provides the user with a geographically based view of the storage hierarchy. Consider the following examples:

- A room can be shaded red when a alarm condition exists for the room. Similarly, a vault can be displayed as an alarm icon when a problem exists.

- The user may point, click, and choose a storage level from the map for inventory, editing, or viewing purposes; thus an entire site, building, room, or cabinet can be inventoried with a click while viewing the item in its actual physical location.

Security/Administration

Because GraFIC™ is designed to run on a Windows NT system (or systems), the well-known security features of Windows NT are available. The GraFIC™ application is built on a multi-tiered security model. GraFIC™ users fall into several categories, and the user interface features available depend on the user's category. Since the security model is implemented using Oracle™ roles, this protection is enforced even when other products, such as browsers or ad-hoc query tools, are used to access the database. The GraFIC™ application enforces a two-person rule for configuration updates and alarm acknowledgement. Under this rule, two privileged users must log onto GraFIC™ before updates or alarm acknowledgements can be made.

USER-INTERFACE

The user interface is the most visible aspect of the GraFIC™ system, and so deserves a deeper look.

The user interface provides three main services: update of configuration information, built-in reports, and views of the hierarchical storage and its status.

Configuration/Modification

The user interface allows the user to enter and update information about the system, storage hierarchy configuration, and assets stored/tracked by the system, as well as the sensor system used to monitor the assets. The input windows have been designed to be as intuitive as possible and context-sensitive help is provided to answer the user's questions.

Reporting

Several built-in reports are supplied with the GraFIC™ system:

- *Inventory Report* - contains the status of the stored inventory for the selected date
- *Alarm Report* - contains the historical or current alarms for the selected area
- *Alarm Criteria Report*- contains the current or historical alarm limits for the selected area
- *Seal Report* - contains the history of tamper indicating devices in use in the selected area

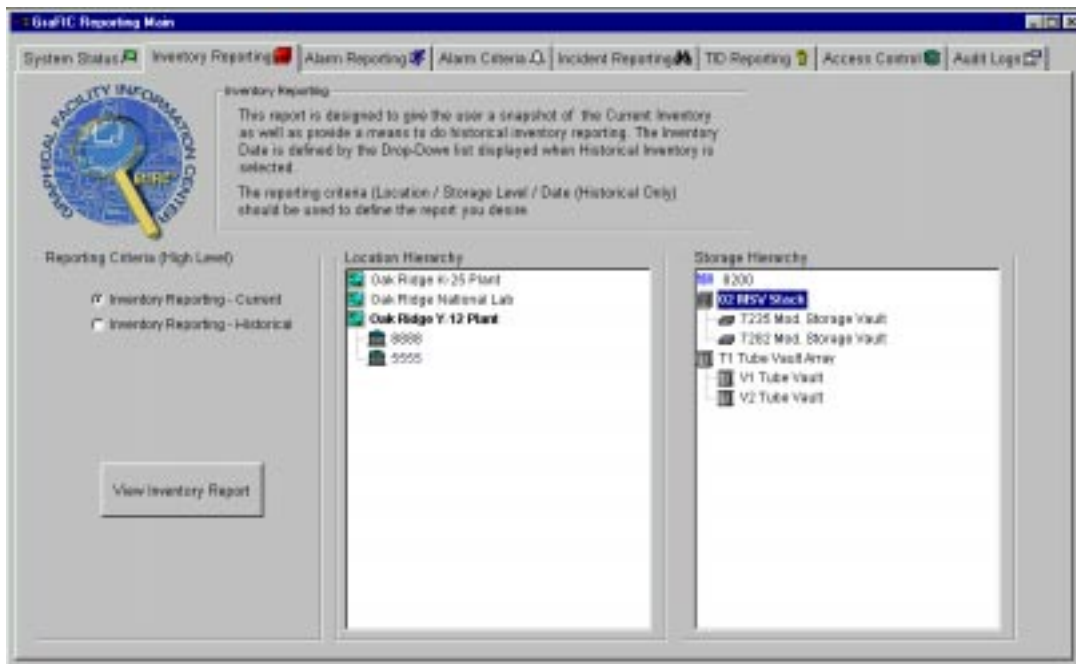


Figure 3 Sample Report Selection

- *Incident Report* - contains a list of sensor readings which were taken just prior to the occurrence of an alarm, all sensor readings which were taken while the alarm condition was in progress, and sensor readings which were taken from the sensor just after the alarm condition ended for the selected alarm
- *Access Control List Report* - contains a list of all GraFIC™ users and their privileges
- *Audit Report* - contains all changes that have been made to a storage level, lots/assets, and sensors.

Figure 3 shows an example report selection. When the user requests a report, it is displayed on-screen and may also be printed.

Commercially available tools may be used to provide ad-hoc query and reporting support, if such support is needed.

Viewing Storage and Status

Access to and viewing of the storage arrangement is provided primarily through the *Storage Explorer* (see Figure 4). The hierarchical storage tree is displayed on the left while information regarding the selected storage level is provided in a list on the right. An alarm indicator is placed beside any

branch that contains an alarm condition. Information appearing on the right may include sensors and their current state, any storage level specific alarms, child storage levels, assets contained in the storage level, seals for the storage level, drawings or documents attached to the storage level, and entry requirements for the level. After selecting an item in the list, the user may view, edit, add, or delete depending upon his/her assigned privilege. In addition, when a sensor is selected, the user can view a plot of sensor readings over time.

If the selected item is an alarm or a sensor in alarm, and two users with sufficient privilege are logged in, then the user can acknowledge the alarm. Acknowledgement of an alarm indicates that someone has noted the alarm condition. An alarm condition will not end until the condition has returned to normal and the alarm has been acknowledged. An "Incident Report" for the selected alarm may also be obtained from the *Storage Explorer*.

GraFIC™ provides a second major method of viewing storage and asset information through its map and drawing functionality. Each drawing/map is a to-scale representation of a storage level. The drawing could be a site map, a building floor plan, or a sketch of a container. Graphical entities on

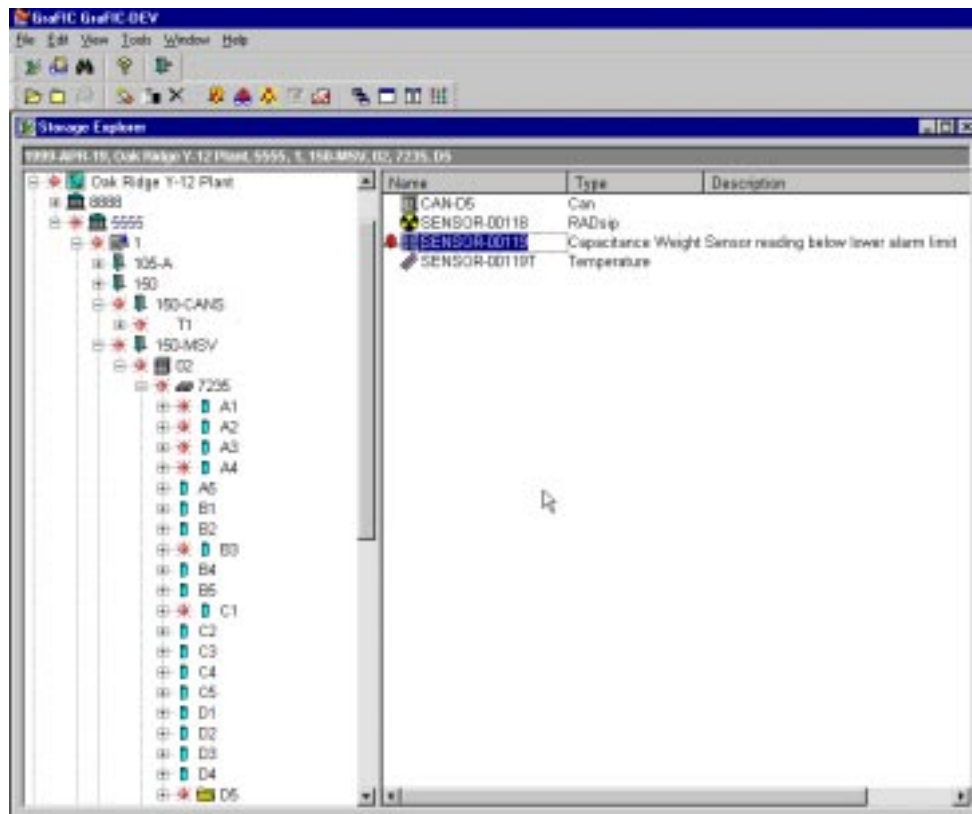


Figure 4 Storage Explorer

the drawing can be attached to other storage levels and thus reflect the storage level's state and provide a means to access the storage level's data. Storage levels may be represented on the map as either a shaded polygon or as a point icon. Icons are re-locatable to reflect their actual geographical location. The state of a storage level icon/polygon represents its current alarm status.

given area can hold while meeting the defined constraints.

GraFIC™ also provides a *Find* feature that allows the user to search for assets, alarms, drawings, documents, sensors, or any storage level that contains all or part of a user provided search string. After selecting an item from the found results, the actions that one may take are identical



Figure 5 Mapping Example

Linked storage levels that have drawings attached to them may be directly accessed from the parent drawing. Figure 5 depicts a world map that has point icons linked to a site storage level, which has a site map attached to it. Storage level polygons on the site map represent buildings that in turn have a floor plan attached to them. The floor plan in turn has point icons that represent vaults contained in the various rooms of the building's floor. At any point along this chain, the user may point, click, and choose a storage level from the map for inventory, editing, or viewing purposes; thus an entire site, building, room, or cabinet can be inventoried with a click while viewing the item in its actual physical location.

The maps also provide a storage feature to assist users in planning for future storage needs. Using this feature, a user enters required storage constraints, and GraFIC™ will determine the number and location of storage containers that a

to those found in the *Storage Explorer*. For example, a user can acknowledge alarms, open drawing, or get detailed information regarding the storage level. Figure 6 shows the *Find* feature being used to search for lots/assets that exist in a particular branch of the storage hierarchy. Date and time constraints may also be used as search criteria. This allows the user to answer such questions as, "Where has container XYZ been over the past month?"

Summary

The GraFIC™ system is being developed initially to provide fast and inexpensive SNM inventory status confirmation, real-time alarm notification and other storage facility management features for the Oak Ridge Y-12 Plant. The system also has many other potential applications. The GraFIC™ project team has designed the system so that it can be easily adapted to fit any facility or

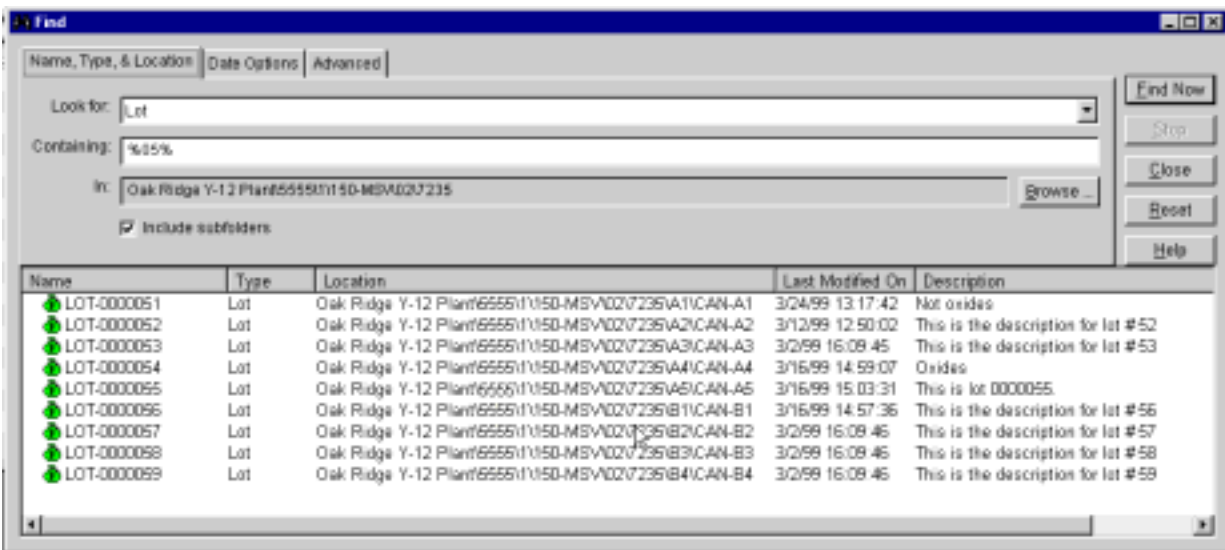


Figure 6 Find Example

inventory situation. Display details are easily adjusted to reflect any storage environment. GraFIC™ can also be configured to interface with existing databases to provide access to already collected facility and personnel information without the need for duplication.

* Managed by Lockheed Martin Energy Systems, Inc. for the U. S. Department of Energy under contract DE-AC05-84OR21400.

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