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# AN INFORMATION MANAGEMENT SYSTEM FOR A SPENT NUCLEAR FUEL INTERIM STORAGE FACILITY

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We describe the preliminary design of an integrated information management system for an independent spent fuel dry-storage installation (ISFSI) that can provide for (1) secure and authenticated data collection, (2) data analysis, (3) dissemination of information to appropriate stakeholders via a secure network, and (4) increased public confidence and support of the facility licensing and operation through increased transparency. A prototype of this information management system is being considered for potential installation at one or more ISFSIs in Taiwan.

## I. INTRODUCTION

As more countries consider increased use of nuclear energy, interim storage of spent nuclear fuel (SNF) will continue to increase around the world. As countries continue to postpone decisions about direct disposal or recycling of spent fuel, interim storage will be the *de facto* near-term solution to SNF management for decades to come. The International Atomic Energy Agency has projected worldwide inventories of SNF to increase steadily over the next few decades, with estimated total worldwide SNF reaching 450,000 tHM by 2020, of which about 100,000 tHM will be reprocessed and 350,000 tHM will be stored in either pools or interim dry-storage facilities. Security, safety, and safeguards concerns for such interim storage facilities will become increasingly important.

SNF storage facilities must collect a variety of information in order to monitor operations, site security, and compliance with safeguards requirements. Such information is relevant not only to a facility's operator, but to a variety of stakeholders, including regulators, nearby municipalities, emergency responders, and the general public. These information sets would be provided to various stakeholders, depending on stakeholder needs and sensitivity of information. We have developed a preliminary design for an Integrated Information Management System (IIMS) that will allow the operator of an Independent Spent Fuel Storage Installation (ISFSI) to consider options and available technologies to provide specific information pertaining to safe and secure operation and to securely share selected information with appropriate shareholders. This IMS is based on a prototype developed for a new ISFSI planned for the Chinshan Nuclear Power Plant site in northern Taiwan (Fig. 1) [1]. The Chinshan ISFSI will be the first dry-storage facility for BWR spent fuel in Taiwan, although additional similar facilities will be needed in the near future.

We describe the utility of an IIMS for an ISFSI, with special reference to the Chinshan ISFSI design criteria. The system will consolidate monitoring information from the ISFSI into a central data repository and provide downstream data to multiple information consumers (security, safety, operations, and safeguards). Authenticated information will be provided securely on a need-to-know basis to the various client subsystems. The system will not consolidate data external to the ISFSI; for example, it will not collect or manage information from the Nuclear Power Plant.

The ISFSI operator must be able to monitor for any "off-normal" events, such as potential cask overheating, tilting, or radiation leaks, as well as possible security breaches. In addition, the operator may be responsible for providing safeguards-relevant information to the IAEA. Benefits of incorporating an integrated approach into the design and operation of the ISFSI include the IIMS's ability to:

- provide increased security at reduced cost,
- make use of complementary aspects of safety systems for security systems,

- reduce impact on operations,
- address both “design-basis events” and events outside the design space,
- extend safety-based probabilistic risk assessment to security-based uncertainty risk analysis (to evaluate events outside the design space use risk measure),
- reduce personnel costs associated with security,
- render the security system robust to potential changes in the threat,
- incorporate intelligence gathering to improve security, and
- incorporate safety measures for mitigating consequences into security measures to help mitigate consequences.

The nuclear regulator must verify appropriate operations of the ISFSI through an integrated system of operational safety, security, and safeguards. The regulator can expect assurance that the IIMS offers channels of information transparency on licensing and operation of the ISFSI facility, as well as providing opportunities for increasing security without increasing operator burden and personnel costs. The regulator may also expect to provide managed information access, transmission monitoring, and sensor data to appropriate parties, and to allow stakeholders remote access to appropriate information.

Stakeholders will include the general public, regional authorities, emergency responders (e.g., police, fire, etc.), transportation authorities, environmental organizations, and others interested in the safe and secure operation of the ISFSI. Such organizations are likely to require a wide range of specific data (for example, emergency responders may need access to facility design drawings and locations of potential off-normal events).

In the case of Taiwan, one goal of the nuclear regulator (FCMA) is to build public support and confidence in the safe and secure operations of the ISFSI at Chinshan. FCMA will accomplish this by improving information transparency about licensing and facility operations, by increasing public involvement in and access to information about FCMA activities, and by fostering an open and productive relationship with stakeholder groups. FCMA expects an integrated information-management system for an ISFSI to be based on operational safety, security, and safeguards; to increase security at reduced operator burden and personnel costs; to provide managed access, transmitting, monitoring, and sensor data to appropriate parties; and to allow stakeholders remote access to appropriate information.

The IIMS provides a single centralized data repository for all information and data required by the operator of an ISFSI. If the operator needs to access disparate data sets, operators can go to the data repository and retrieve such data from a single location – and in a uniform data format. By contrast, the current design for the Chinshan ISFSI requires operators to search for data at various locations, and those data may be in different formats (such as electronic versus paper).

An IIMS could also reduce or eliminate manual safeguards inspections by the IAEA seal system for SNF interim dry storage.

The currently IAEA approved seal for a SNF interim dry storage cask is a metal wire E-cup, a passive system with no immediate event notification that requires manual inspection of the state of health during a given time interval (e.g., monthly). A remote monitoring seal system (such as Sandia’s Secure Sensor Platform) could provide an active seal system with immediate event notification, eliminating frequent manual inspection. Of course, if such a system were to be used, possibly redundant to the IAEA’s safeguards system, IAEA joint use policies and requirements would need to be followed.

*Figure 1*:  Artist's depiction of ISFSI Dry-Storage Facility planned for Chinshan [2]

## II.  GENERAL DESCRIPTION

The ISFSI at Chinshan is a new independent dry-storage facility to be situated in the southwest corner of the Chinshan nuclear power plant site.  A concrete foundation, security perimeter, and associated structures will be constructed by September 2011 (assuming a December 2010 start).  Twenty five NAC UMS-56 concrete casks, each containing 56 spent fuel assemblies, will provide storage capacity for 1,400 fuel assemblies.  The site is designed to store up to 30 casks, or 1680 assemblies.

Radiation dose rate, cask temperature, security cameras and safeguards at the facility will be under continuous monitoring.  The ISFSI currently has independent systems for tracking each of these data sets, as well as real-time video monitoring.  The integrated information-management system will collect, in a central data repository, all information pertaining to the safe and secure operation of the ISFSI.  Figure 2 illustrates the basic concept.  Each sensor (A, B, C) in Figure 2 represents a data-collecting device, such as a radiation detector, temperature monitor, a security video camera, and so forth.  The central data repository collects, aggregates, analyzes, partitions, and presents the information to various stakeholders according to each stakeholder's needs and authorized access permissions.

## III.  PRODUCT PERSPECTIVE

An IIMS for the ISFSI would operate within the bounds of the overall facility's internal information architecture. In the example of the ISFSI planned for the Chinshan power plant, the IIMS will integrate with the power plant's existing information architecture, interfacing with existing Chinshan servers and databases, and bounded by the power plant's firewall. (Fig. 3).

External interfaces to stakeholders such as an operator's offsite headquarters, the national regulatory authority, or the IAEA, would require exemptions to existing firewall restrictions and possible modifications to hardware and/or software.

The IIMS would tie together in-coming information from all ISFSI sensors, seals, ands cameras (Fig. 4).  As such, authorized users could have access to any combination of relevant information.  New sensor systems could be added without significant retooling of the information system.  Instead, new key-value pairs would be appended to the proper tables.

The system will require a dedicated server for the integration of data feeds.  Associated power supply, network switches, cabling, and other peripherals will be needed.  Some minor reworking of existing cables or fiber network may be necessary.  Information users will be able to make use of existing desktop computers, network infrastructure, browser software, and operating systems.

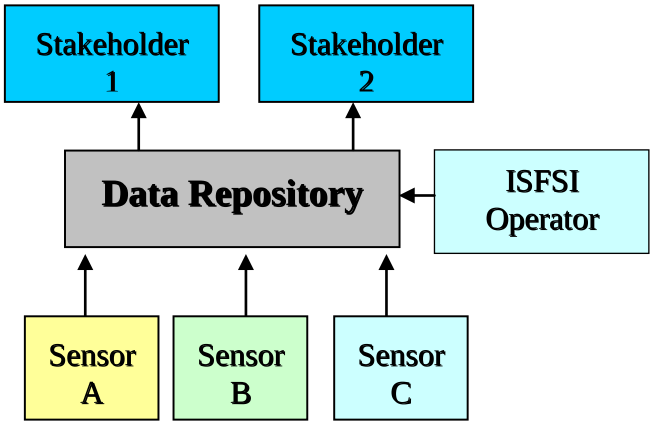


*Figure 2*: Concept of an Integrated Information Management System for an ISFSI

**PRODUCT FUNCTIONS**

Any information system involved with the ISFSI must accomplish a number of overlapping functions. The highest level functions are:

1) Public safety
2) Facility security
3) Nuclear nonproliferation
4) Chinshan plant operations
5) External domestic oversight (FMCA and AEC)
6) External international oversight (IAEA)

These functional relationships are summarized in Figure 5.

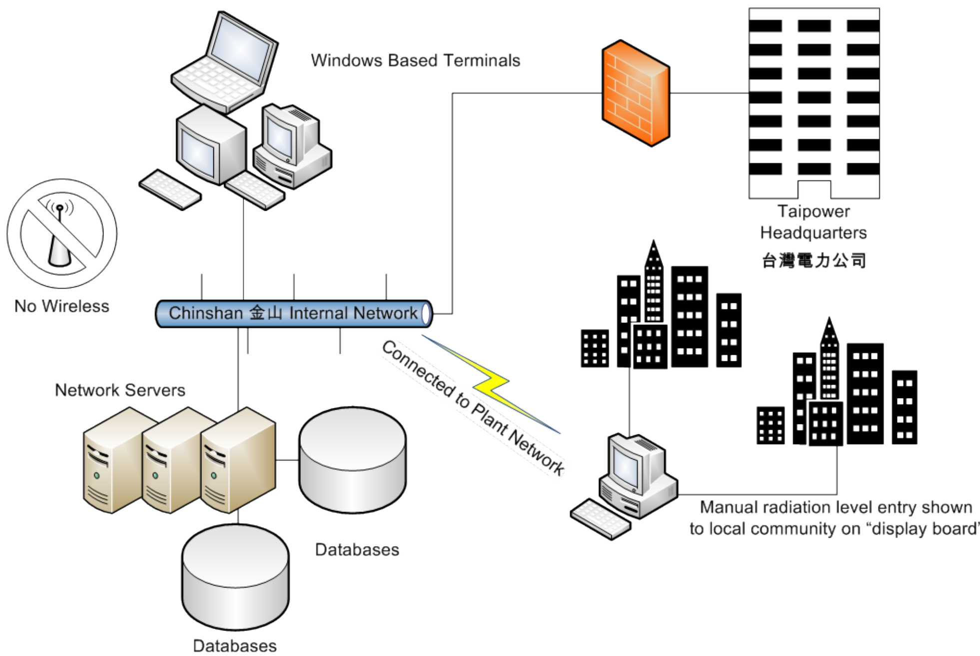


*Figure 3*: Current Chinshan internal network architecture

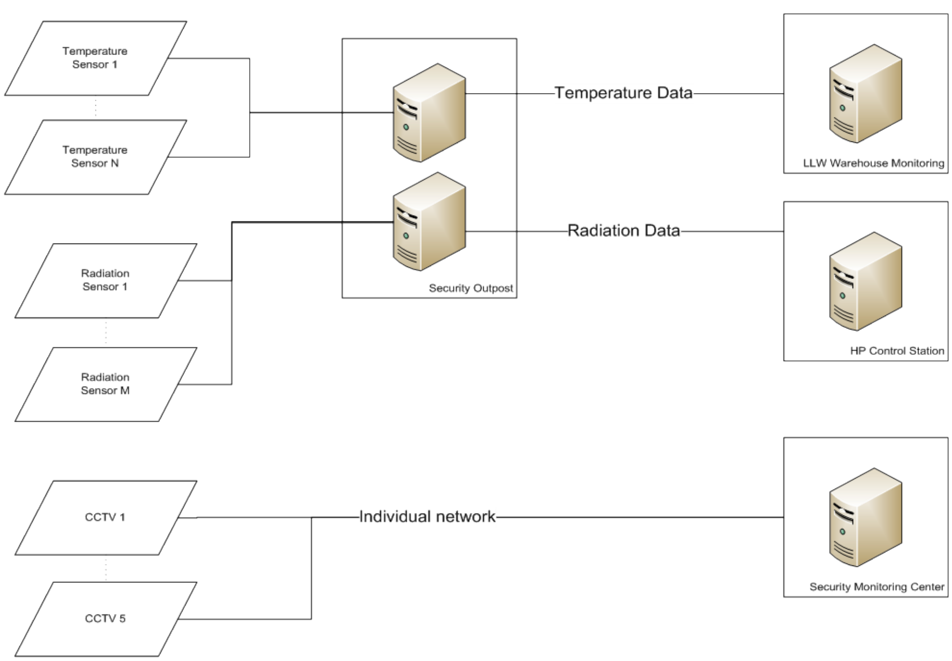


*Figure 4*: Current design of data flows for the Chinshan Independent Spent Nuclear Fuel Storage Installation

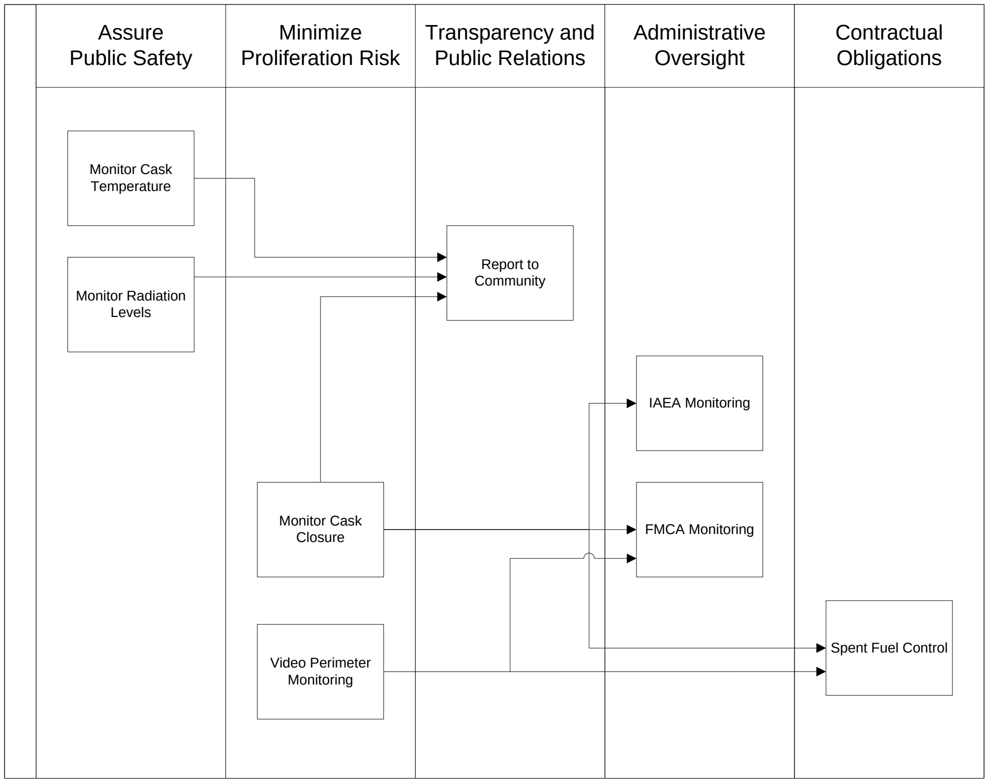


*Figure 5*: Functional relationships among processes for the Chinshan Independent Spent Nuclear Fuel Dry-Storage Installation.

## IV. USER CHARACTERISTICS

Users of information provided by this system may be grouped into four categories: Chinshan local staff (operations, security, safety, IT), Taipower staff (Taipei), AEC staff (FMCA), and the general public.

Chinshan staff are responsible for the day-to-day operation of the facility. ISFSI operations will be minimal except during arrival of new casks or IAEA inspections. Security personnel will need continuous real-time information, including perimeter integrity and video. Safety staff will use continuous real-time data on cask temperature and radiation levels. IT staff will maintain the system. All levels of Chinshan users may considered to be trained in the use of the integrated information system. IT staff will be experts with a high level of understanding of all hardware and software components.

Taipower staff at company headquarters in Taipei will be highly computer literate, have excellent high-speed Internet connections, and have a very high level of understanding of the system. They will very likely receive specialized training about the ISFSI system.

FMCA staff at the AEC may be considered to be highly computer literate, have excellent high-speed Internet connections, and have a high level of understanding of the system. If warranted, they may receive specialized training about the ISFSI system.

The general public will view only a subset of Chinshan information. Their access will be entirely via public websites. Public fluency with computer systems in general and knowledge of spent fuel storage specifically will vary widely.

## V. GENERAL CONSTRAINTS

Below are described items that may limit the developers' options for designing the system.

***Regulatory Policies***. Any information system must abide by applicable local, national, and international regulations and laws. These include local environmental ordinances, directives from national nuclear regulatory agencies, and international treaty or contract obligations. The system should minimize (and if possible, completely avoid) any impact on previously approved and licensed designs.

***Hardware Limitations***. The system should, in so far as is possible, make use of hardware that is similar in nature to existing systems at Chinshan. This will reduce the maintenance burden for hardware support and reduce costs over the lifetime of the system.

***Interfaces to other Applications***. In so far as is possible, the system should deliver data and information to existing and legacy systems at Chinshan so that they continue to function normally. In most cases this will be a simple pass-through of signals to the health physics, security, environmental monitoring, and extant operational systems.

***Audit Functions***. Any system must be accessible to facility auditors to test and verify the behavior of the software and hardware. The system may also need to be authenticated by appropriate regulatory agencies, especially FMCA and IAEA.

***Control Functions***. No control functions are envisioned in this system since the storage casks are passive containers. Security alarm features will be needed, but in and of themselves, they will not control any plant operation or function.

***Higher-Order Language Requirements***. Wherever possible, systems should be developed by using software languages, database management systems, and information frameworks that are similar to existing systems at Chinshan. This will reduce training and maintenance costs, as well as increased buy-in by IT personnel at the plant.

***Criticality of the Application***. The system will need to be operational 24x7 with appropriate backup and fail-safe measures installed. However, short-term system failures will not result in catastrophic consequences on the magnitude of a systematic failure of reactor control systems. Even so, a short-term failure would be not only embarrassing, but would bring a high level of national and international scrutiny to the site. A thorough risk assessment should be conducted for the system.

***Safety and Security Considerations***. The system installation must conform to all relevant safety codes and regulations, especially but not limited to electrical and fire safety. Adequate physical security must be provided to protect the information at the level of the most sensitive data. Additional security may be necessary to conform to IAEA joint-use policies. Safety and security need to be addressed in parallel so that constraints in one area do not compromise the other.

## VI. DATA PROCESSING

Data processing activities may be subject to a number of requirements. Real-time temperature measurements should be available via pass-through to any requesting application. Temperature data may be stored at pre-defined intervals in the system database. Excursions beyond a pre-defined maximum will result in an alarm flag being set. Data stream failures or system outages will result in a statement of health (SOH) failure flag being set.

Real-time radiation measurements will be available via pass-through to any requesting application. Radiation data will be stored as a time-stamped event when a change in value is detected above a given threshold. Excursions beyond a pre-defined minimum or maximum will result in an alarm flag being set. Data stream failures or system outages will result in a statement of health (SOH) failure flag being set.

Real-time video will be available via pass-through to any requesting application. Video data will be stored as a time-stamped still frame whenever a scene change is detected. Data stream failures or system outages will result in a statement of health (SOH) failure flag being set. Five CCTV monitors (plus an unknown number of backup monitors) will be installed to provide site and perimeter security. IAEA-compliant DCM-14 devices will probably be used, although the system should be able to be upgraded to IAEA XCams in the future. Assume DCM-14 systems with scene-change detection. Surveillance systems will be placed as indicated in ISFSI maps provided by Taipower [1].

Two sealing devices will be applied to each cask. Data will be in the form of time-stamped events whenever the seal state changes (that is, the cable signals open) or as time-stamped statement of health (SOH) SOH messages. Real-time seal status will be available via pass-through to any requesting application. Seal data will be stored as a time-stamped event when a change in value is detected. An open seal will result in an alarm flag being set. Data stream failures or system outages will result in a SOH failure flag being set.

## VII. DATA OUTPUT

Data outputs may also be subject to a number of requirements. Real-time temperature data may be requested by any connected service if authorized. Queries against the system data tables may provide historical temperature statistics for any interval. Alarm and SOH logs may be viewed by approved users and systems.

Real-time radiation data may be requested by any connected service if authorized. Queries against the system data tables can provide historical radiation statistics for any interval. Alarm and SOH logs can be viewed by approved users and systems.

The video feed may be requested by any connected service if authorized. Queries against the system data tables can provide historical sequences of images for any interval. Alarm and SOH logs can be viewed by approved users and systems.

Seal status may be requested by any authorized connected service. Queries against the system data tables can provide historical seal status statistics for any interval. Alarm and state-of-health (SOH) logs can be viewed by approved users and systems.

## VIII. EXTENDABILITY

The system must be capable of being extended to new, different, and/or more numerous sensors. It is highly likely over the course of the facility lifetime that the DCM-14 digital video cameras will be upgraded to the new IAEA X-Cams. In addition, it is plausible that other seals and sensors will be replaced by next-generation technologies. Numbers of sensors may change as well. Also, entirely new monitoring technologies may be applied, such as, detectors for fission gases (Xenon), which could indicated cladding breakdown. The ISFSI should be able to accommodate any combination of changes to the safety, security, and safeguards hardware. Of course, it is impossible to foresee what input formats will be used by future hardware. However, any such system should use industry standard protocols and transmit its data in an understandable format.

Incoming data will be available via pass-through to any requesting application. Data will be stored as a time-stamped record whenever a value is changed. Data stream failures or system outages will result in a statement of health (SOH) failure flag being set. New data feeds may be requested by any connected service if authorized. Queries against the system data tables can provide historical sequences of data for any interval. Alarm and SOH logs can be viewed by approved users and systems.

## IX. INTEGRATED DATA WAREHOUSE

All data streams originating in the ISFSI will be consolidated into a single database. As shown in Figure 2, a single data repository will collect and store sensor, seal, and video-monitoring data. Stakeholders such as Taipower Headquarters, AEC, FCMA, and the IAEA will have access to information based on need-to-know and predetermined permissions. Three alternative integration locations are possible in the logical dataflow: (1) early integration occuring within the security outpost just outside the ISFSI perimeter; (2) intermediate integration implementing the integrated storage system downstream from the security outpost but still at the power-plant site; (3) late integration of the data streams occurring downstream of the ISFSI local users (security, health physics, and environmental monitoring), and could have the system installed at the Chinshan power plant or as far afield as Taipower headquarters in Taipei.

The integrated data warehouse will store all incoming data streams in a Relational Database Management System (RDBMS). The RDBMS will write data to the appropriate tables via SQL queries. Data will be stored as key-value pairs to ensure that the architecture is extensible. Any data may be requested by any connected service if authorized. Alarm and SOH logs can be viewed by approved users and systems.

## X. USER INTERFACE REQUIREMENTS

Existing display interfaces will be used for facility users in Health Physics, Security, and Operations. Browser-based interfaces may be created as needed and will be specified by Taipower or other stakeholders (FMCA, IAEA).

## ACKNOWLEDGEMENTS

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