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Installing and Commissioning a New Radioactive Waste Tracking System – Lessons Learned

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ABSTRACT

Ontario Power Generation (OPG) recognizes the importance of information management particularly with regards to its low and intermediate level waste program. Various computer based waste tracking systems have been used in OPG since the 1980s. These systems tracked the physical receipt, processing, storage, and inventory of the waste. As OPG moved towards long-term management (e.g. disposal), it was recognized that tracking of more detailed waste characterization information was important. This required either substantial modification of the existing system to include a waste characterization module or replacing it entirely with a new system. After a detailed review of available options, it was decided that the existing waste tracking application would be replaced with the Idaho National Laboratory's (INL) Integrated Waste Tracking System (IWTS).

Installing and commissioning a system which must receive historical operational waste management information (data) and provide new features, required much more attention than was originally considered. The operational readiness of IWTS required extensive vetting and preparation of historic data (which itself had been created from multiple databases in varied formats) to ensure a consistent format for import of some 30,000-container records, and merging and linking these container records to a waste stream based characterization database. This paper will discuss some of the strengths and weaknesses contributing to project success or hindrance so that others can understand and minimize the difficulties inherent in a project of this magnitude.

I. INTRODUCTION

With large quantities of information being generated during all phases of radioactive waste management, it is crucial that the database system employed is able to store as much pertinent data (from time of generation to disposal) as possible. After careful analysis, it was decided that OPG's existing operational waste tracking system did not meet their future needs.

With limited internal information technology (IT) resources available, it was also decided that a radiological waste tracking system specification would be written to meet their requirements. The requirements for the database would include, among others provisions for the incorporation of waste characterization data, scaling factor data (including future capabilities for gamma scanning spectroscopy), waste forecasting information, waste manifests, reports, and for multi-user interaction with secure login, and operational ease of use.

OPG Western Low and Intermediate Level Waste Storage Facility (WLILWSF)

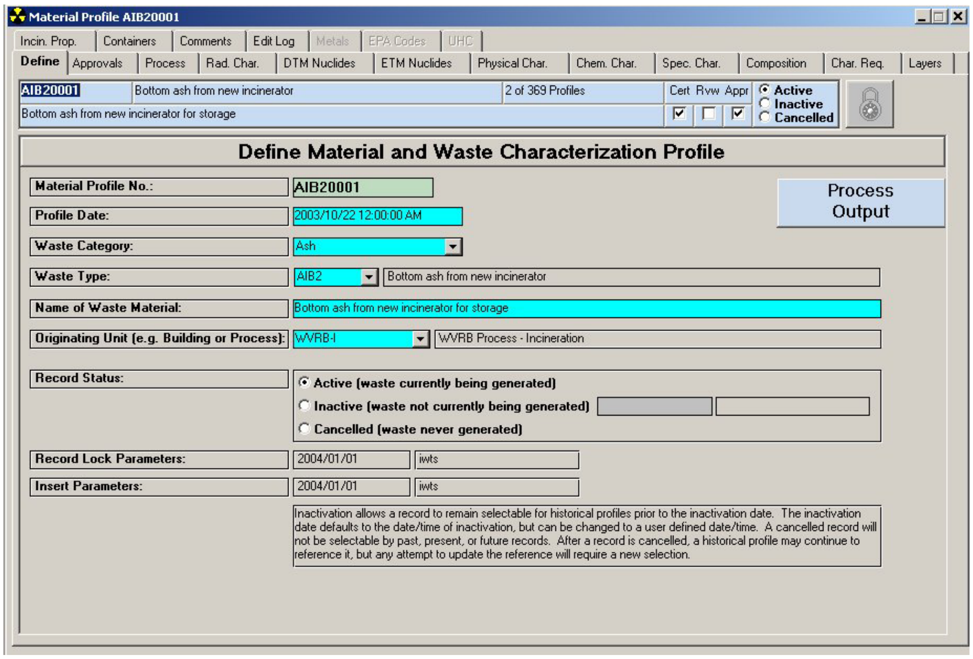
The cost estimate for developing a new waste tracking system was outside the funding available. Also, the time required to develop such a system was estimated to be years rather than months. Therefore, it was decided that it would be more cost effective to investigate other existing systems to determine if any met OPG's specifications. Several systems were investigated, but few had the features OPG required. A system was found at the Waste Management Symposia held in Tucson, AZ USA. The United States (U.S.) Department of Energy (DOE) INL had developed a waste tracking database system to manage their hazardous, radioactive and mixed containerized waste. This system met seventy-five percent of OPG's requirements and was fundamentally designed around OPG's core requirements. After preliminary communication with INL, OPG authorized a contract for a modified system that could suit OPG's requirements without altering the fundamental design of the application. The projected schedule for this project was to be no more than twelve months to deployment in the field.

II. IWTS FUNCTIONALITY

The IWTS was designed around one primary goal: to integrate operational functions (in the field) into a database system that encourages data input. Too many software projects are performed in the office without any input from the users. This system was developed after significant consultation with Operations personnel, the main users for data input. Electronic approvals for waste disposition are provided to help the users expedite waste to final disposition. IWTS keeps a record of all the waste stream and container characterization data for easy retrieval. Other Operational functions performed by IWTS are the production of hardcopy shipping records, container labels, and physical inventory reports. The system was also required to be flexible and expandable.

The database system provides a tool to help manage radioactive, mixed, and hazardous containerized waste throughout the entire lifecycle, from waste declaration to disposal. This includes the tracking of waste during generation, characterization, treatment, storage, transportation, and disposal. The IWTS provides information necessary to help waste management personnel properly manage the waste and demonstrate compliance to regulatory agencies, facility-specific permits, and Safety Analysis Report (SAR) requirements. The IWTS technology includes a client/server architecture providing high reliability and a means for system expansion. A standard Windows[1] graphical user interface provides easy, intuitive, navigation.

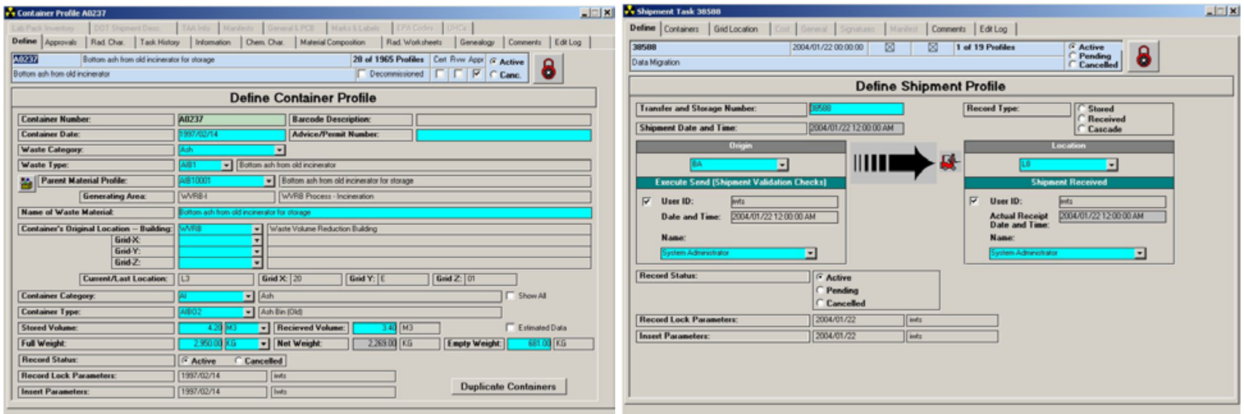
Hand-held tools can be used in conjunction with container bar codes to perform operational tasks such as recording inventories, shipment receipts, container information, and container movements.



IWTS Material Profile describing waste characterization data

Information contained in IWTS includes characterization, transaction, regulatory compliance, and reporting data. The characterization data describes the waste stream characteristics from a radiological, chemical, and physical perspective. Individual containers are also characterized by their radiological, chemical, and physical properties, based on the associated waste stream characteristics. Once the container and contents (waste) are characterized, it is possible to perform transactions or tasks against a container. Tasks can represent physical movements (receipts, storage, or disposal), administrative functions such as performing inventories, and operational processing (incineration, compaction, and repackaging). Transportation manifests can be produced from the system using the data already in place. This makes shipping changes easy to accommodate. Checks are made each time a task is performed to verify correct authorizations and ensure facility limit compliance issues have been satisfied. For process tasks, IWTS performs radionuclide partitioning, if desired, across the process. Process tasks also generate a container genealogy from any stage in the life cycle of the waste. With this genealogy information, any waste can be tracked completely through the entire transformation process (e.g., from generation of incinerable waste to the final ash bin sitting in a disposal facility).

[1] Microsoft Corporation



IWTS Container Profile describing container characterization and a Shipment Profile describing a transaction

Several standard operational and management reports are contained within IWTS. Typical operational and management reports can include:

- Generation forecasting
- Generation quantities
- Received waste volumes
- Stored waste volumes and inventories
- Number of days a container is stored
- Processed quantities
- Radionuclide inventories
- Current and decayed radionuclide source terms.

Ad hoc queries can also be generated at any time using standard data query software, such as MS Access.

What makes IWTS versatile is the fact that all stakeholders including generators, and waste management, transportation, Operations personnel, and regulatory agencies, can access one system for all their information. The information load is spread over multiple organizations to allow each one to perform the job that they know best. This also cuts down on the proliferation of multiple databases and spreadsheets that are required when there is no single source of data. Access rights and visibility of data screens can be customized for each user or group of users, so that they can only input, view or edit data relevant to their job function.

III. DEVELOPMENT ISSUES

It became apparent early in the contract negotiations, that the original IWTS database platform (Sybase) was not supported by OPG (OPG only supports Oracle and SQL Server 2000). This presented some development issues because methodologies in one database are not always portable to another platform. Some re-design was required since some features, such as character strings, were not ported in the same original format. For example, SQL Server did not strip padded spaces and therefore many screens had overflow text conditions. This required a change from fixed character lengths to variable character lengths. Stored functions were very restrictive in SQL Server, forcing re-writes into stored procedures.

Other development activities centered around reporting platforms. It was very difficult to develop new reports using an older reporting package. This was, especially difficult because the customer wanted reports to look a certain way. OPG and INL spent many hours working through the reporting issues which included discussions about who the users were going to be and how they were going to access the reports. Working with the older reporting package yielded less than desired results, and so the decision to use a standard office software package was made. This allowed the INL to provide the queries for the reports, leaving the report layouts and input screens to the customer.

IV. TESTING

Testing cannot be understated. Paramount to creating a quality product is the philosophy of utilizing independent testers (independent from the developers). This keeps developer paradigms to a minimum while creating test cases typical of a system user. Designs can be tweaked as a byproduct of the testing independence.

Testing delays can extend a project schedule if it is not watched carefully. Developers cannot continue to the next stage of development until they have a reasonable assurance that the work they have done thus far is working reasonably well. INL had the luxury of being able to provide very short turnaround testing cycles for the developers by dedicating an independent person to that task. This kept errors and bugs from escalating into excessive re-work and thus kept costs at a minimum.

V. REQUIREMENTS / DESIGN

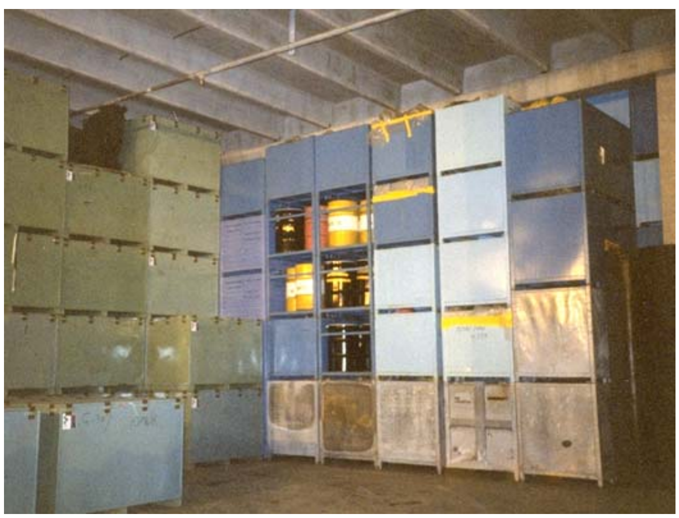
The customer's visit to the contractor's site early in the project's life cycle to define the exact scope of work required to modify the system to meet all technical and functional requirement (T&FR) specifications proved to be invaluable. The visit resulted in the development of a document identifying the gaps between the existing product and the customer's specification. This document did not come without consuming a significant amount of resources. Three OPG personnel and five INL personnel worked for a week to define the T&FRs necessary to modify the existing system. Another two weeks were spent by INL to write the document and acquire appropriate approvals. The T&FR specification not only defined the software modifications, but was the basis for the final negotiated cost and schedule contract. With the gaps clearly identified in the approved T&FR specification, a detailed cost estimate could be produced, leaving little room for mis-interpretation. This was the working document for any and all customer change requests during the development phase and was also the tool that helped minimize scope creep.

One of the more difficult issues when modifying an existing system is the paradigm shift that must be made. The customer must take the complete knowledge of their current system and try to understand how those concepts are transposed to the new system. In some cases, this process was difficult. In one instance, difficulty arose when the old system did not contain some of the information required by the new system. The new system also did not readily accept information from the old. For example, the old system had a clearly identified field for container status. The new system did not have this field but the information could be inferred from data in other parts of the system.

VI. DATA MIGRATION

When migrating data from one system to another, it cannot be overstated how important a thorough data migration plan must be in order to minimize the complexities of this transformation. Both the customer and the contractor should develop a thorough data migration plan which describes their plans and rules for making decisions on how the data will be migrated. Usually, data is migrated from a simple system to a more complex one. This provides ample opportunity for "data exposure." Data exposure occurs when existing data is given the detailed scrutiny that the new system requires, sometimes for the first time in many years. This can be a daunting task, as experts must scrub the data in order for it to withstand the unforgiving rules of the new system. This process can take months of sorting, sometimes record-by-record to ensure "clean" data. Once the task of importing the data has been accomplished, the task of verifying the data in the new system can take on a whole new level of effort. In fact, one of the most important phases of commissioning any new system is data integrity. Data is the product. Without correct data, there are no reports or forecasts. There can be no meaningful output if the data is corrupt, bad, or incomplete.

One of the most underestimated parts of this project was the need for data clean up. The amount of effort to provide a "clean" database to the contractor was nearly an order of magnitude larger than had been originally estimated. Even though each customer is unique, any database system that has been used for many years without robust ways to perform routine data integrity checks can expect a large investment of time to correct the deficiencies. The customer must understand that scrubbing the data is their responsibility and is paramount to the success of the migration effort.



OPG WLILWSF Low Level Storage Building

Some of the data difficulties were as simple as inconsistent numbering schemes. Some container numbers had leading zeros and others did not, some had replaced the numeral "0" with the letter "o" or the numeral "1" with the letter "l" or "I". Other problems arose due to inconsistent facility grid locations, multiple records for the same container listing different waste types or even different container types, and some out-of-range volumes. Over 154,000 records were examined, but only 28,000 records were actually imported (Note that much of this was due to a conscious decision not to import the older raw waste receipt records, just the current inventory of waste stored). All of these issues had to be examined and cleaned up prior to data migration into the new system. A number of trial iterations and "trial imports" were done. Each time, import errors were logged and examined to determine the cause, resulting in subsequent revisions to the scripting rules.

While it is important to estimate the man-hours required to scrub the data, it is equally important to obtain management commitment and approval for the time necessary to spend on this task. Without management commitment and approval, schedules are very difficult to maintain. The contractor relies on clean data to run import scripts without error. Any delay in receiving a "clean" database from the customer has an immediate one-for-one delay in the schedule.

The contractor must be aware of the customers business rules that were used in order to create scripting rules, which can be applied to bring the data into the new system. Without a thorough understanding of the original data structure, the data being imported can be lost, placed in the wrong fields, or changed without knowledge. Decisions are required to be made for those new fields where no information exists in the old system. Duplicating old transactions or simply bringing in the current inventory is another decision that may be required. Each decision path has drastically different levels of effort. It was decided with OPG, that trying to recreate past transactions with a data set that was not kept consistent was not a viable option. Bringing in current inventory reduced the complexities to a manageable task. The commissioning process was successful in verifying correct data migration.

VII. PROJECT MANAGEMENT

The failure to recognize that an integrated cradle-to-grave waste management system is worthy of a full project team is a fundamental trap that should be avoided. Both the customer and the contractor need full project teams. Project teams should include personnel from all organizations who have a stake in the development of the system (e.g. management, Operations, IT, projects, safety, transportation, security, etc.). This project originally included only a small team of people from the customers Operations, IT, and waste management group. Due to a lack of understanding of the complexities associated with a system like this, no formal project management was established. Hence, the project was primarily run by two employees, trying to manage and foresee all aspects of this task. This strategy worked for the first few months because of the relatively small set of requirements that were provided. However, the lack of participation by other organizations combined with scope creep, led to additional costs and schedule slips. In fact, what was originally thought by OPG to take about a year (prior to establishing the contract with INL), ended up taking approximately two years. The two years were required to complete the conversion of the data platform, perform the requirements gap analysis, establish phased contractor contracts, customization of the program, scrubbing of the data, importing data and commissioning of the system. The need for this expanded schedule was recognized and accepted by all parties fairly early in the project, once the complexity of the task was better understood.

Participating organizations have areas of expertise, which need to be incorporated in order for the whole system to be successful. Early representation from these organizations can greatly increase the probability of success. In the case of this project, Operations support was requested for about six man weeks over the course of the project. What was not understood was the need for support to not only provide input into the design of the new system, but also to help clean the data, participate in design reviews, commission the new system, and train other Operations personnel. Operations support totaled approximately eight man months by the time this system was put into a production environment. This time was primarily spent assisting with the data migration effort where existing data required extensive vetting and cleanup. The Operations contact was the only person who fully understood the content of the old system and his involvement was crucial to the success of the data migration.

The IT organization required that the project personnel meet all company standard software and hardware platforms. What was not discussed, were the details of security logins, audit software, operational maintenance support, and commissioning support that included development, acceptance testing, and production phases. Other areas of IT concern that surfaced later in the project were reporting standards, user ID management, email integration, and use of database queries within the corporate IT infrastructure.

Contractors must assert the same rigor as the customer in their project management, as applicable. INL had initial problems bringing in a complete project team since most resources familiar with this product were either busy with other work, or did not possess the knowledge base required for a project of this magnitude. After discussions with senior management, INL was able to negotiate for internal resources with the idea that new developers would be trained by personnel already knowledgeable in the IWTS system. INL eventually found personnel who could perform functions such as project management, technical support/interface, subject matter expertise, design, development, testing, configuration management, and other related software project responsibilities.

VIII. IT SUPPORT

Inherent to any software project is the need for full IT support. Without their involvement, any new system installation fights a battle that cannot be won. Although IT personnel were invited to the initial meeting with the contractor, they were not involved again until very late in the project cycle. Many application organizations (including the waste management group) believe they can run an information systems project independently.

What overwhelms any application organization quickly, are the requirements they must meet in order for the new system to comply with company IT policies. This can prove to be very costly in hindsight if it is not dealt with up front. Case in point, OPG's waste management group knew they wanted the best product on the market, a product that would meet their needs. After investigating the options, a product was chosen. The waste management group was subsequently advised that the platform on which the new product was developed was not compatible with those supported by the company. In addition, security schemes required approval from the company cyber security organization.

Another consideration when estimating an IT project is a life-cycle approach to risk identification and mitigation. Pre- and post-production commissioning procedures, quality level determinations, disaster recovery and backup plans, and modification/bug fix support procedures should be developed or identified. Many of these IT issues are never considered early in the cost-estimating phase of an information management project.

IX. CUSTOMER/CONTRACTOR COMMUNICATION

A key to any project is communication. Frequent dialogue between stakeholders, especially dialogue between customer and contractor, is essential for project success. After the initial request for the INL's system had been issued, INL requested a visit to OPG's site to evaluate their waste management and existing waste tracking system. This interface very early in the project provided a two-way communication path for both parties to evaluate the effectiveness of using INL's system to meet OPG's needs. It was soon determined that INL's existing tracking system would meet OPG's fundamental requirements and, with some modifications, could incorporate most of the requirements of OPG's original specification. This preliminary visit provided clear communication between the two parties. Expectations were discussed and a path forward was established.

Another interface was established between OPG, INL, and Austech Development Inc. (ADI). ADI originally designed OPG's existing waste tracking system. One of the most critical phases of commissioning a system of this magnitude is making sure the data is migrated into the new system without error. ADI was invited to the design reviews so that they could help guide OPG and INL with issues regarding data structure or design philosophies originally created that needed to be incorporated into the new system. The relationships between the three parties were excellent, which made data migration issues easy to resolve.

With minimal initial support from the IT group, OPG arranged for a dedicated IT point of contact. This helped bridge the communication gap between the parties involved in the development of the software product and those involved in activities necessary to deploy the product. The IT representative had to be kept abreast of development activities in order to facilitate acceptance testing and final production use.

There is one important lesson to be learned: the more frequent the communication, the less likely big problems will arise. Frequent communication minimizes misinterpretation, rework, duplicate efforts, delays, and many other problems that, if left unchecked, can escalate into project catastrophes.

X. SYSTEM ACCEPTANCE

The process of accepting a new system involves customer testing, training, deployment, commissioning, and final production turnover. A strategy that seemed to work well was incremental customer testing and training. There were four distinct installments of the system during development to allow the customer to test the software and receive training in order to gradually familiarize themselves with the new system. This approach allowed the customer to ease into the changes over time as well as provide a mechanism for stimulating design feedback for incorporation into the product. Commissioning was performed by OPG Operations with the final software. Based on final actual use with real operational data, it was easy for operations personnel to find a few last minute bugs and/or design changes necessary for production use.

An area that is difficult to define or measure is user system acceptance. One of the most difficult estimates a project manager can make is operator "mis-one-ism" and the time required to acclimate its users to the new system. It is difficult to know ahead of time if the environment these users will be placed in will result in a positive or negative experience. Power users, those who deal with the system daily, need to be included in the project from the start. They must have input in defining requirements, design reviews, testing, training, and verification and validation prior to production use. Involving them from the beginning will lessen the risk of an ultimately negative experience, and improve the likelihood that the product will be used.

Nuclear Waste Operations

XI. RESULTS

The time invested by OPG, INL, and ADI ultimately resulted in project success. The IWTS system was installed, commissioned, and placed into production status in December 2004. After two months of system use, the responses have been mostly favorable. As with any new system, start-up issues were anticipated, however, both customer and contractor worked very hard to address each issue in a timely manner as they arose.

Operations staff was involved from the beginning and their requirements were incorporated into the design of the system. Reports that were not possible with the old system are now available to many groups, including those responsible for waste characterization and waste forecasting. Other organizations, including the generators, will be worked into the system as the new year progresses.

At OPG, the results of commissioning a new radiological waste tracking system were successful primarily because of the willingness by all organizations, including the contractors, to identify problems, communicate regularly, provide solutions, and produce the necessary products as budget and time allowed. Without this kind of teamwork, OPG's waste management organization may not have only lost money and time, but also credibility.

XII. CONCLUSION

As described above, an information management project embellishes many aspects that must be considered in order to be effective. The strengths that contributed to the success of this project were:

- A well defined technical and functional specification document
- Thorough product testing
- Good customer/contractor communication
- Customer involvement through all phases of the project
- Personnel dedicated to making the project a success.

The weaknesses which should be mitigated are:

- Limited project management
- Few resources dedicated to data clean-up

- Late involvement of IT expertise.

It is typical in most companies for high-level management to struggle with cost estimates that seem beyond reasonable comprehension. However, after thorough examination, it is found that in order to accomplish the requirements set forth for an integrated system with multi-organizational users, the costs do not outweigh the rewards of a fully functional system where all users come to rely on it for their success.