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TRU WASTE SYSTEM MODELS

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ABSTRACT

Transuranic waste is currently generated and/or stored at several sites throughout the Department of Energy complex. The goal of the DOE National Transuranic Waste Program is to effect a safe, integrated, and economical disposal system for these wastes. Several alternatives are being considered. The selection process will involve tradeoffs of cost, risk, dose, and system efficiency. Simulation models are being used to aid in the analysis of the various options. In addition to modeling the material flow, the simulation tracks many specialized operational parameters related to the material processed or the elapsed time. These parameters track the radiological and chemical exposure dose to workers; the radiological, chemical, and hazardous risk associated with processing and storing drums; and the capital and operating costs of the facilities. The system being modeled has a timeline of approximately 30 years to fund, design, construct, operate, and decommission the needed facilities. The intent is to model this timeline and to include facility costs not directly related to processing. The tracking of these parameters is piggybacked onto the main simulation engine. Flexible simulation models, controlled by the user at run time, were developed. Two such models are presented here. No analysis results are presented.

1 INTRODUCTION

Transuranic (TRU) waste is currently generated and/or stored at several sites throughout the Department of Energy (DOE) complex. The goal of the DOE National Transuranic Waste Program is to effect a safe, integrated, and economical disposal system for these wastes. Several possible alternatives are being considered. Each alternative is a large complex system with many subsystems and interactions. The selection of the preferred alternative will require the analysis of many different options and tradeoffs of cost, risk, dose, and system efficiency. Simulation models are being used to aid in the analysis of the various options. The simulation is used to model the handling of these wastes through waste retrieval, characterization, treatment, and final disposal. In addition to modeling the material flow, many operational parameters related to the material processed or elapsed time are also tracked. The tracking of these parameters is piggybacked onto the main simulation engine as described later. Two such models are presented here. No analysis results are presented; only the models and the methodology are discussed.

2 BACKGROUND

TRU waste has been generated by the DOE complex for some time. (TRU waste is defined in DOE Orders as waste containing alpha-emitting radionuclides with an atomic number greater than 92 and half-lives greater than 20 years, at a concentration greater than 100 nCi/g of waste. [DOE, 1993]) Past practice was to bury this waste in shallow land fills. This practice was stopped during the early 1970s. The wastes were then stored in such a manner that they could be retrieved and sent to a final disposal site when one was available. The Waste Isolation Pilot Plant (WIPP) was to be the first of possibly several disposal sites. The WIPP site was originally to open during the 1980s and receive the stored waste as well as newly generated waste. The WIPP is still not open and approximately 25 years' worth of waste has accumulated at the various DOE sites.

TRU waste is currently generated and/or stored at 16 DOE sites across the country. These sites are spread across essentially all of the contiguous 48 states as shown in Figure 1. The current volume of TRU waste is approximately 100,000 m^3. [DOE, 1992] Different amounts of waste exist at the 16 sites with the bulk (~98%) of the waste located at four sites and less than 0.01% of the total waste located on the seven smallest sites. The waste volume stored at each site is given in Table 1.

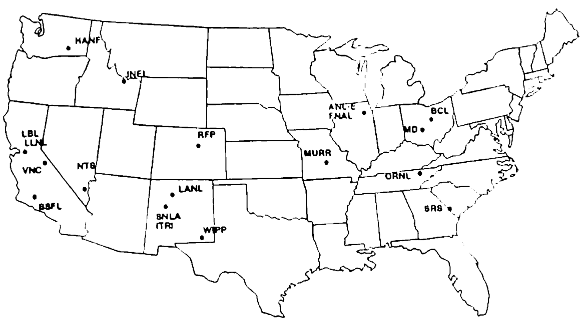

Figure 1: TRU Waste Storage Sites

Table 1: TRU Waste Storage Sites and Inventories

Site	Containerized Volume (m^3)
Idaho National Engineering Laboratory (INEL)	64761
Hanford (HANF)	15365
Savannah River Site (SRS)	9701
Los Alamos National Laboratory (LANL)	7957
Rocky Flats Plant (RFP)	934
Oak Ridge National Laboratory (ORNL)	685
Nevada Test Site (NTS)	597
Battelle Columbus Laboratories (BCL)	100
Argonne National Laboratory - East (ANL-E)	15
Inhalation Toxicology Research Institute (ITRI)	5.4
Santa Susana Field Laboratory (SSFL)	2.62
Sandia National Laboratories, Albuquerque (SNL-A)	1.4
Fermi (FNAL)	1.0
Lawrence Berkeley Laboratory (LBL)	0.94
University of Missouri Research Reactor (MURR)	0.1
Vallecitos (VNC)	0.02
Total	100126.48

All wastes considered here are contact-handled TRU (CH-TRU) waste. (CH-TRU waste is defined as packaged TRU waste with an external surface dose rate that does not exceed 200 mrem/hr. [DOE, 1993]) It should be noted that approximately one-third of the waste stored at the major sites is estimated to be low level waste (LLW) not TRU waste. LLW may be disposed of much more conveniently than TRU waste. Wastes are stored in 55-gallon drums, standard waste boxes, or special containers for oversized items. The two primary containers are the 55-gallon drum (0.2 m^3) and the standard waste box (nominally 4'x5'x7', 1.9 m^3). Approximately half of the 100,000 m^3 of waste is stored in 250,000 drums and the other half in 25,000 boxes. In total there are approximately 500,000 55-gal drum equivalents (DEs) of waste.

Waste containers are stored in two primary ways: (1) on open air pads or in warehouses where waste retrieval is relatively simple and (2) in buried storage arrangements (bermed storage) where retrieval is relatively difficult. These bermed storage arrangements predate the Resource Conservation and Recovery Act (RCRA) and are generally not in compliance with current RCRA storage requirements. Their early retrieval is often driven by RCRA compliance schedules not waste disposal schedules and thus complicates the timelines being developed. The exact waste composition of each container is not necessarily known. Due to changing regulations and practices over the more than 20-year period of waste generation, the exact waste composition permitted to be stored and the records of what was stored have changed and do not always meet current requirements.

The waste transportation network must be developed. The only known link is for waste shipments to WIPP. WIPP-destined CH-TRU waste will be shipped in TRUPACT-II containers. Each TRUPACT container can hold 14 standard 55-gallon drums or 2 standard waste boxes and each truck can hold 3 TRUPACT containers. Thus one TRUPACT truck can deliver 42 standard 55-gallon drums or 6 boxes. The WIPP capacity to receive and emplace waste is 250,000 f^3/yr (7079 m^3/yr). The work-off time is approximately 14 years for only the current volume of waste assuming all waste is TRU (no LLW) and assuming full capacity operation at WIPP. Additional waste generated and stored prior to the startup of this system plus waste generated and processed after startup will increase the work-off time.

3 TYPICAL ALTERNATIVES CONSIDERED

A typical proposed alternative must describe the process whereby the TRU waste are moved from their current locations to final disposal including all intermediate steps, all transportation links, and all timelines involved. Alternatives may differ in the time when events occur, in the extent of which activities and actions are performed on the waste, in where (at which site) the various activities are performed, or on what percent of the waste the various actions are performed. Typical activities are retrieving waste from the pads or berms; repackaging waste because the current container is damaged, oversized, or unacceptable for transportation or disposal; venting and aspirating drums to remove accumulated gases primarily hydrogen and volatile organic compounds (VOCs); characterizing waste to determine waste composition and the presence or absence of selected hazardous substances (lead, PCB, etc.); treating waste to make it more acceptable for transportation and/or disposal; and interim storage of the waste containers due to limited or nonexistent downstream capacity. Interim storage is often driven by RCRA compliance schedule needs.

For a given alternative some, all, or none of the steps many be involved. The extent to which each is performed is described. For example, characterization may include any or all of the following: 1) radioassay; 2) non-destructive examination/non-destructive assay (NDE/NDA); 3) x-ray analysis of drum contents; or 4) opening the container and visually inspecting the waste, sorting the waste, or taking grab samples for chemical analysis. Similarly, the other major activities have various ranges of simple to complex activities.

The sheer number of possible variations was staggering. A simple, quick, and efficient method to evaluate alternatives was needed. It was deemed impractical to construct a unique simulation model for each alternative. Some type of flexible model was needed.

4 FLEXIBLE SIMULATION MODEL

A flexible simulation model was desired rather than a rigid model of a given system configuration with specified routings. It was desired that the model could be controlled by user-supplied input read at run time. In addition, many parameters that are not typically found in simulation software packages needed to be tracked. The approach taken was to use the simulation software as the engine and to piggyback the special parameter accounting needs on the engine. This approach has worked very well.

The simulation engine is responsible for

- scheduling waste drum (entity) arrivals,
- scheduling waste drum processing,
- scheduling shift downtimes associated with facilities and trucks,
- scheduling construction downtimes associated with facilities and transportation systems coming on line,
- scheduling local truck transports used within a site,
- scheduling highway truck transports used between sites, and
- diverting drums to temporary storage when downstream processing is not available (blocked or not built).

The piggybacked accounting modules are responsible for tracking

- radiological and chemical exposure dose received by workers processing or transporting waste,
- radiological, chemical, and hazardous risks involved in processing a waste drum, holding a drum while it waits for a free processing location, or transporting waste,
- cost of processing drums or holding drums for processing,
- capital cost of facilities tied to a given construction schedule,
- total cost, and
- system throughput.

The user-supplied information controls

- processing times,
- routing of the waste drums,
- number of drums present at the site,
- basic factors used in calculating the dose, risk, and cost parameters,
- facility operational shifts,
- construction schedules,
- wait time function at the vent and aspirate facility,
- minimum hold time for drums diverted to interim storage, and
- cost escalation factors.

The system being modeled has a timeline of approximately 30 years to fund, design, construct, operate, and decommission the needed facilities. The intent is to model this entire timeline and to include facility costs not directly related to processing. This will allow all cost accounting to be performed by the model. User input cost escalation factors are included. The capital cost of the facilities is divided into five categories—research and development (R&D) cost, construction capital cost, construction operating cost, annual facility operating cost independent of production, and decontamination and decommissioning (D&D) cost at the end of the facility life. Each of these costs are accompanied by a schedule (call construction schedule). The annual accounting module tracks the facility at each stage of its life and feeds in the appropriate cost numbers. This allows the user to incorporate long lead-time facilities into the model while the construction schedule supplied is converted into construction downtimes understood by the simulation engine. Thus the (un)availability of long lead-time facilities can automatically impact waste drum processing and cause system backups and diversion of drums to interim storage facilities. Two general models were created—the single site model and the multi-site model.

4.1 Single Site Model

The single site model consists of nine interrelated facilities, which describe all waste movements and processing on a single site, plus one disposal facility. The model layout is shown in Figure 2. The 10 facilities correspond to the possible waste processing activities: pad waste retrieval (GNP), berm waste retrieval (GNB), vent and aspirate (VA), repackaging (RPK), waste characterization (CH), waste treatment (TP), highway truck loading facility (TL), interim storage (IS), low level waste disposal facility (LLW), and TRU waste disposal facility (DS). The first nine facilities are linked with local trucks while the TL and DS facilities are linked

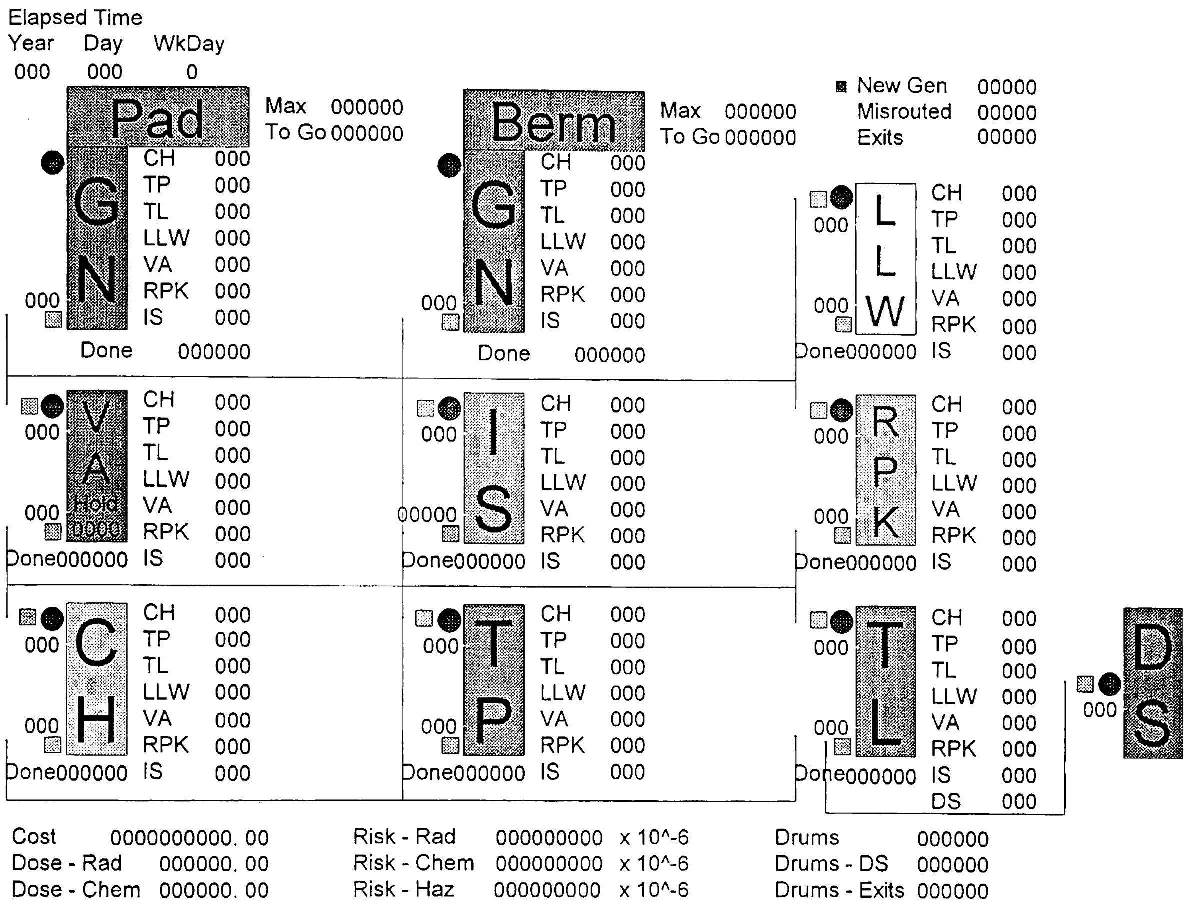

Figure 2: Single Site Model

with highway trucks. Under the flexible model concept, any of the first nine (all facilities except DS) facilities may process waste and then route the waste to any of the nine facilities including itself. Infinite loops are possible because a facility may route a drum to itself. It is the user's responsibility to avoid such loops. The routing logic is read at run time from a file.

Each facility consists of a receiving dock, a processing location, and a shipping dock. The size of the receiving and shipping docks are model variables. The time spent on the dock is tracked because certain regulations limit the amount of time a drum may be in "temporary storage." It is anticipated that the entire system will pool large quantities of drums on the receiving and shipping docks to smooth the process flow. It should be remembered that the transportation links are essentially manual operations somewhat weather dependent and that large variations in entity arrivals and pickups should be expected. Also there is no economic incentive to move a drum quickly through the system to keep the work in process inventory small, because the drum is disposed of and not sold to generate revenue as in a typical manufacturing operation.

Approximately 500,000 entities (drums or DE) will be introduced into the model over the 30-year simulation period. These entities are created over the simulation time as required to meet processing demands and to avoid the large computing processing penalty that would be paid if they were all created at run initialization. Approximately 5,000 to 10,000 entities are active in the model at any one time. The automatic creation of entities is controlled by the simulation engine logic where entities are ordered to the PAD or BERM storage areas on an as-needed basis. The objectives of the model are to determine the processing interactions of the nine facilities, to help size the interim storage area, and to determine the needed throughput capacity of each facility.

4.2 Multi-Site Model

The multi-site model consists of multiple single site models linked with a common highway truck network to a common disposal site (DS). A typical model layout is shown in Figure 3. In this case each site consists of only nine facilities plus the common DS facility. The nine facilities may route drums to any of the nine facilities on that site but cannot route across sites. Only the TL facilities may route drums, via highway trucks, to the disposal site (DS). The objective of this model is to determine the processing interactions of the multiple sites as they vie for the common highway trucks and for the finite DS facility throughput. Additional accounting modules are used to track the standard parameters and to identify them with individual sites as well as the overall system.

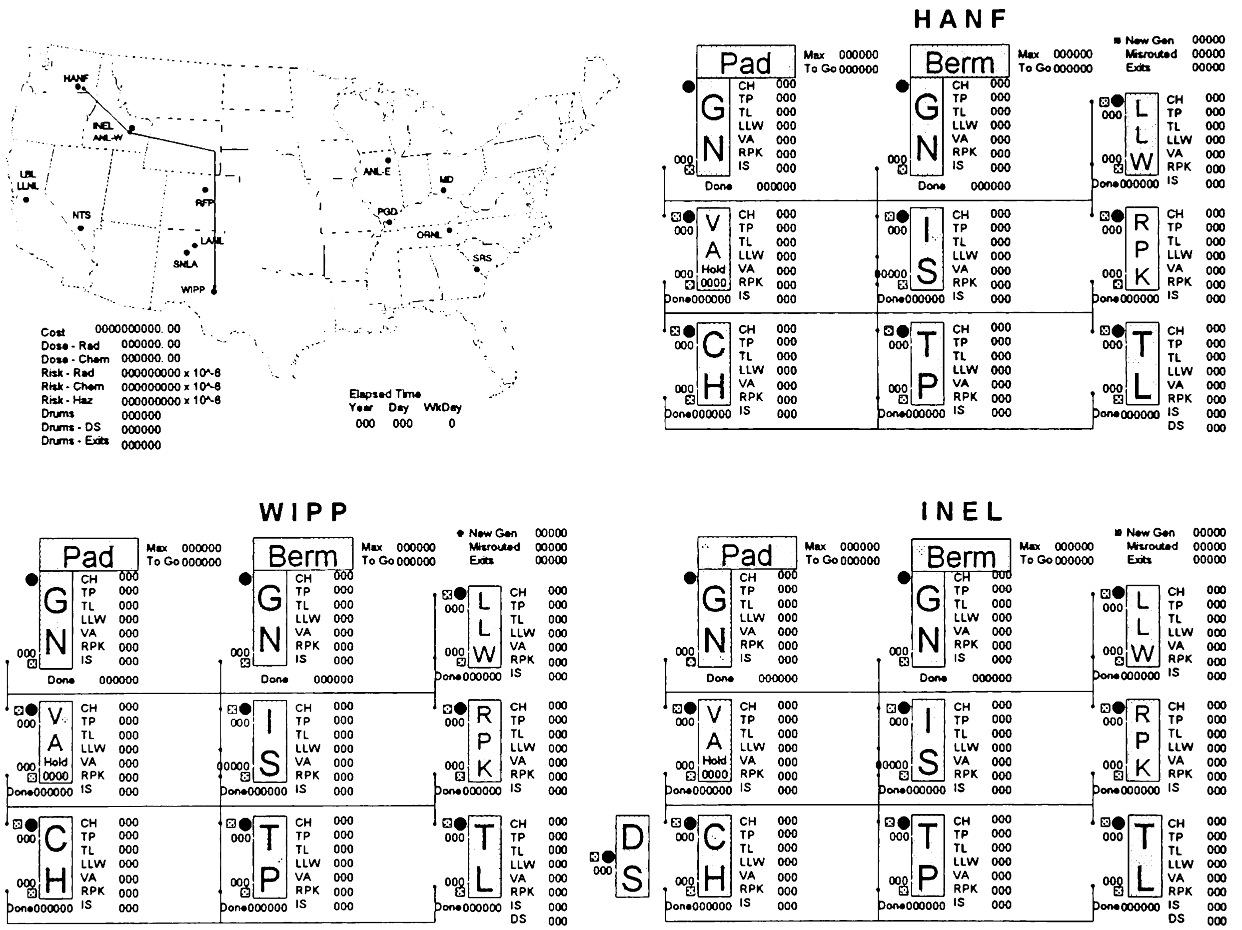

Figure 3: Multi-Site Model with Three Sites

5 TYPICAL RESULTS

Typical results are presented in tabular and graphical form. Higher level information is normally presently in graphs showing trends over time. Composite graphs are used to display multiple function trends over time. Figure 4 is typical of one such graph where the breakout of the different types of money are shown. The standard simulation usage parameters are used to help evaluate the systems performance and to indicate where changing facility throughput would improve the overall system performance. Most of the information presented is directed toward understanding how this proposed alternative performed and how this proposed alternative performed compared to other alternatives. It should be noted that many of the evaluation criteria, against which each proposed alternative is evaluated, are subjective criteria and difficult to quantify. Thus the need is to understand or develop a feel for how well a proposed alternative performed.

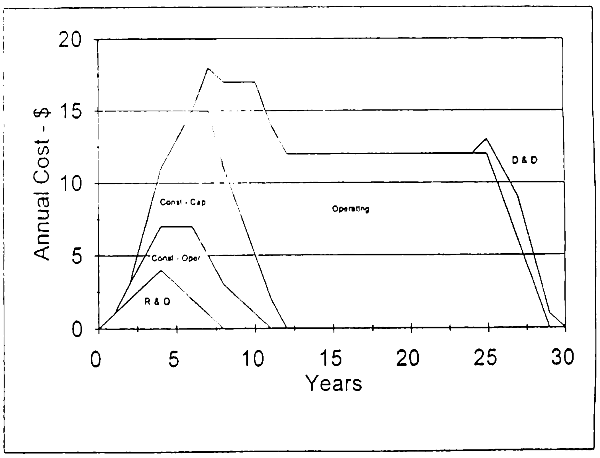

Figure 4: Typical Results Showing the Breakout of the Different Types of Money

6 CONCLUSION

The flexible model approach with piggybacked modules has worked very well. Piggybacking the specialized parameter tracking modules to the simulation engine was relatively straight forward and convenient. The ability to piggyback to commercially available software eliminated the need for developing specialized software to solve the current problem. This in itself is considered to be a major benefit. However, some frustration was felt when trying to incorporate the special modules and to create flexible run time models because current software limitations restrict the use of typical programming constructs. It must also be realized that the current application pushed the limits of the simulation software and used it in a way that the software developers had not foreseen.

7 SOFTWARE AND COMPUTER USED

The commercial software package used is ProModel for Windows, version 1.10. The application was developed and is run on a 486DX2-66 personal computer with 16-MB RAM and a 340-MB hard drive. No machine-dependent limits were encountered during either development or running of the models.

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