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AN EXAMPLE OF SYSTEMS INTEGRATION FOR RCRA POLICY ANALYSIS

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ABSTRACT

This paper describes the synthesis of various computer technologies and software systems used on a project to estimate the costs of remediating Solid Waste Management Units (SWMUs) that fall under the corrective action provisions of the Resource Conservation and Recovery Act (RCRA). The project used two databases collected by Research Triangle Institute (RTI) that contain information on SWMUs and a PC-based software system called CORA that develops cost estimates for remediating SWMUs. The project team developed rules to categorize every SWMU in the databases by the kinds of technologies required to clean them up. These results were input into CORA, which estimated costs associated with the technologies.

Early on, several computing challenges presented themselves. First, the databases have several hundred thousand records each. Second, the categorization rules could not be written to cover all combinations of variables. Third, CORA is run interactively and the analysis plan called for running CORA tens of thousands of times. Fourth, large data transfers needed to take place between RTI and Oak Ridge National Laboratory.

Solutions to these problems required systems integration. SWMU categorization was streamlined by using INTERNET as was the data transfer. SAS was used to create files used by a program called SuperKey that was used to run CORA. Because the analysis plan required the generation of hundreds of thousands of cost estimates, memory management software was needed to allow the portable IBM P70 to do the job. During the course of the project, several other software packages were used, including: SAS System for Personal Computers (SAS/PC), DBase III, LOTUS 1-2-3, PIZAZZ PLUS, LOTUS Freelance Plus, and Word Perfect. Only the comprehensive use of all available hardware and software resources allowed this project to be completed within the time and budget constraints.

1. INTRODUCTION

Over the past several years, the computer industry has focused a great deal of attention on systems integration. This effort has given the users of computer technology the ability to network computers manufactured by different vendors and the ability to transport software from one machine to another. Standards for telecommunication protocols, programming languages etc. also have positively contributed to systems integratibility.

Social scientists have benefitted from these trends. Statistical software packages are now available for most computer platforms, requiring only the transport of standard code from one machine to the next. Network technology allows researchers and analysts to store large database on mainframes and to download data to their desktop PCs for analysis. New compilers and operating systems are now designed to be able to handle old code and file structures.

The future of systems integration is moving toward the complete integration of hardware and software. As one might expect, the business sector is leading this trend (Plouffe 1991; Bowman and Grupe 1990). The goals are to integrate disparate software systems, such as payroll, accounts receivable, inventory, and various decision support and database systems and the various hardware platforms, from personal computers to mainframes, into a seamless whole.

Does this trend have applications for social scientists? The answer is a most definite yes, but with a twist. In the business sector environment, a large number of the most important software systems in organizations are custom coded. Thus, the task is to integrate custom coded software while continuing the in-house development and maintenance of these systems.

Social scientists typically do not have the time or resources to custom code their own software. Thus, they do not have custom software to integrate. On the other hand, vendors market thousands of relatively inexpensive software products that could be of use to social scientists. Therefore, systems integration for social scientists should focus on synthesizing software packages into custom systems and on taking advantage of networking and other hardware capabilities as much as possible.

This paper presents a case study of systems integration on an Oak Ridge National Laboratory (ORNL) project related to estimating the cost of the corrective action regulations of the Resource Conservation and Recovery Act (RCRA). The investigators on this project had three basic constraints: computing was needed to process two very large databases; the project team was split between two states; and there was not enough time or money to custom code any software or to purchase new hardware. By the old axiom that "necessity is the mother of invention", the team integrated numerous computers and software packages and used local area and wide area networks to accomplish the project.

Section 2 provides a brief overview of the project and defines key terms. Section 3 describes the hardware and software resources used on the project. Section 4 discusses data flows between the computers and the cornucopia of software packages used for the data analysis. The paper concludes with a discussion of the benefits of systems integration.

2. RCRA CORRECTIVE ACTION COST ESTIMATION METHODOLOGY

The Resource Conservation and Recovery Act (RCRA), Subtitle C, is the federal law which regulates the treatment, storage, disposal, and recovery of hazardous wastes. The 1984 amendment to RCRA, known as the Hazardous and Solid Waste Amendment (HWSA), stipulates that facilities that treat, store or dispose of hazardous wastes -- the facilities are commonly referred to as TSDs -- must remediate situations where hazardous wastes have escaped into the environment from their solid waste management units (SWMUs). Landfills, waste piles, and surface impoundments are examples of SWMUs. There are over 2500 TSDs in the United States and over 70,000 SWMUs which potentially could require remediation. The U.S. Environmental Protection Agency (USEPA 1990), among others, believes that the costs of RCRA remediation or corrective action could rival or exceed the costs of the SUPERFUND program.

This section presents the approach used to estimate the costs of RCRA corrective action. The first subsection presents the basic conceptual model. The next subsection documents the two databases that provide information on TSDs and SWMUs. The third subsection describes the PC-based model used to estimate costs of corrective action. Tonn et al. (1991) contains a complete description of the methodology.

2.1 CONCEPTUAL MODEL OF ESTIMATING COSTS

Figure 1 illustrates the conceptual model. Initially, databases are used to identify TSDs and their SWMUs. The databases also provide facility characteristics such as soil type and aquifer permeability and SWMU characteristics such as size, type, hazardous waste managed, and amount of hazardous waste managed.

Rules were developed to determine whether facilities in the databases fall under RCRA subtitle C. For those TSDs to be included in the analysis, each SWMU was categorized according to the kinds of technologies that would be used to remediate releases of hazardous wastes into the environment. For example, rules would determine whether a landfill would need to be soil capped or have its soil excavated and incinerated (it is more expensive to pursue the latter course). Expert environmental engineers provided the knowledge used to construct the categorization rules.

After determining how many SWMUs of what type fall into which technology categories, a PC-based cost estimation model, known as CORA, is used. Essentially, CORA produces cost estimates for each category of SWMU. Thus, CORA could produce a cost estimate to soil cap a landfill and could also produce a cost estimate for excavating a landfill's soil, incinerating the soil, and then placing the treated soil back into another landfill.

The CORA model requires numerous inputs, many of which cannot be discerned from the databases. For certain key variables, CORA is run with different estimates of the variables. Then the CORA results are adjusted to account for potential under or over estimation. Next, the results are adjusted to account for different estimates on the percentage of SWMUs that have had and will have releases into the environment, because only those SWMUs need corrective action. Finally, the results are adjusted to account for different estimates of the total number of SWMUs.

CONCEPTUAL APPROACH REPEATED FOR EACH SWMU TYPE FOR EACH MAJOR SCENARIO

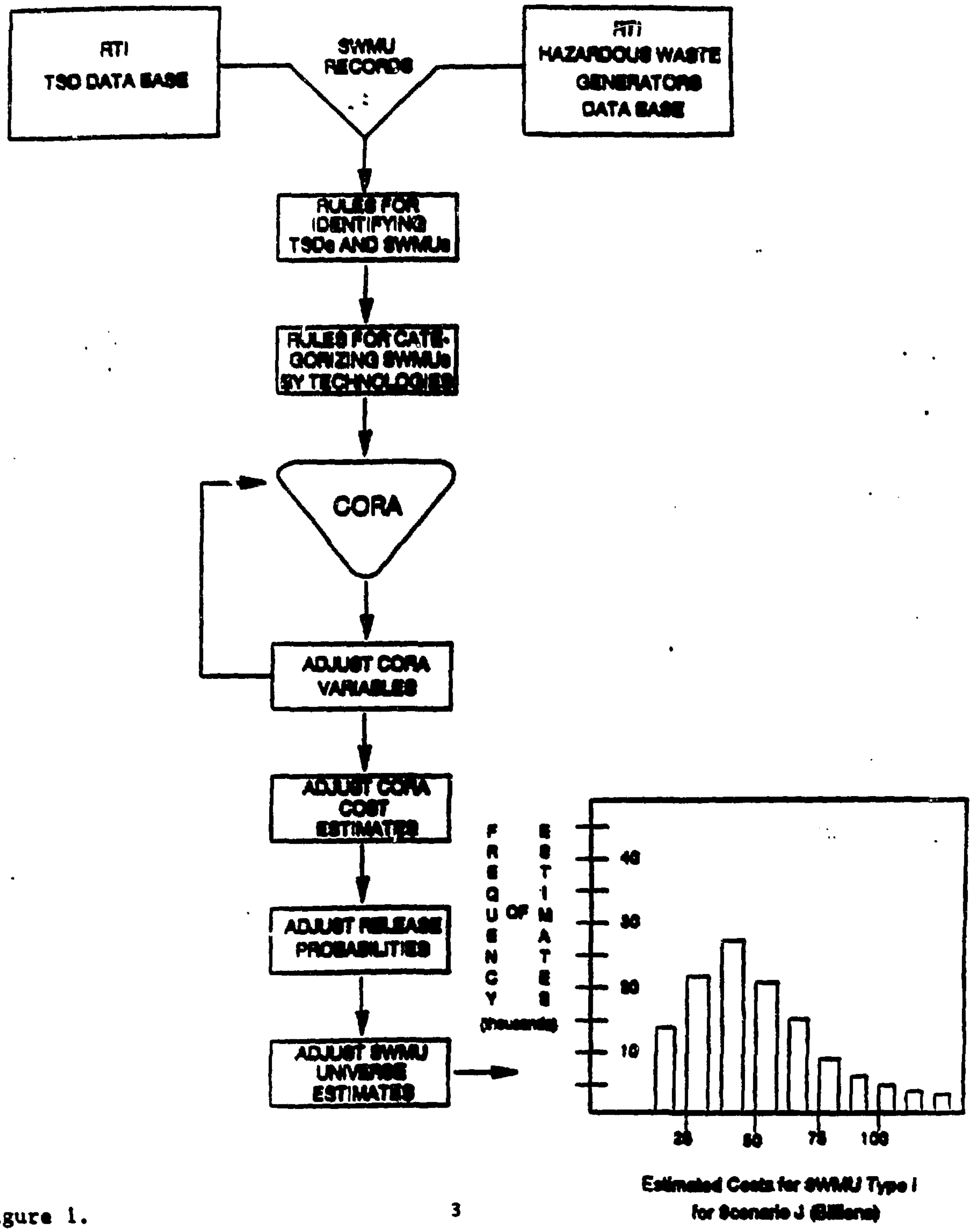

Figure 1.

The resulting outputs are charted to present estimated costs on the y-axis and the number of analysis scenarios which indicated those costs on the x-axis. For example, for landfills, there may be 100 different combinations of CORA variable assumptions, CORA cost estimate adjustments, SWMU release percentages, and SWMU universe assumptions that produce a cost estimate of $700,000,000. There may be only 20 combinations where the cost is $20 million. This presentation format allows one to assess how all the key assumptions effect the results, where the preponderance of the evidence rests, and what the worst case costs might be.

This is a unique approach to cost analysis. The typical approach is to make a set of assumptions and then perform sensitivity analysis over the key variables. The typical approach may also require judgments about most likely values for the variables in order to produce probability distributions. This approach appeared impractical in this study because of the shear number of variables and their potential permutations. Also, in virtually every case, it seemed more reasonable to give equal weight to the potential values of the variables rather than to insist some values were more probable than others. Instead, this study simultaneously incorporates ranges of equally weighted assumptions for numerous variables and maps out "cross products" of the assumptions in terms of a population density of cost estimates.

2.2 DATABASE DESCRIPTIONS

The U.S. Environmental Protection Agency funded the creation of the two databases used in this project. Research Triangle Institute (RTI) managed the data collection process. The databases contain information on all the nation's TSDs and on a sample of the nation's hazardous waste generators.

2.2.1 National Survey of Hazardous Waste Treatment, Storage, Disposal, and Recycling Facilities (TSDR)

From January through November 1986, RTI conducted the 1986 National Screening Survey to identify and collect summary information from all hazardous waste treatment, storage, disposal, and recycling facilities in the United States. The primary objective of this census of more than 5,600 facilities was to gather enough of the same type of information from each TSD to enable EPA to determine the best approach for a more detailed survey.

From January through February 1987, RTI conducted a computer-assisted telephone interview follow-up of the 3,000 active TSDs identified in the 1986 Screening Survey. These facilities were asked to verify and update the data they had provided previously.
With this information, RTI developed an understanding of the types of technologies used to manage hazardous wastes at the TSDs. This information served as the basis for distributing detailed questionnaires for the subsequent 1987 TSDR Survey.

All active TSDs identified by the telephone follow-up as having treatment, disposal, or recycling technologies were censused for the 1987 National Survey of Hazardous Waste Treatment, Storage, Disposal, and Recycling Facilities (TSDR). If a facility only conducted storage operations, they were sampled rather than censused. In total, 2,600 facilities received a detailed package consisting of an instruction booklet and some combination of 15 different questionnaires, depending on the technologies the facility had on-site.

These questionnaires, totalling 328 pages and 801 questions plus multiple answer options, were developed over an 18-month period in small group meetings with government officials and industry trade associations. The questionnaires were tested in a pretest conducted from January 1987 through March 1987. Fifty-five facilities received the appropriate questionnaires and 10 of those were visited. The questionnaires were revised using the results of the pretest.

Approximately 11,000 individual booklets were sent to the 2,600 TSDs between July 1987 and December 1987. Each facility received only those questionnaires appropriate for the processes that they operate, based on the earlier follow-up. Each questionnaire asked for details on the particular types of processes used at the TSD.

The initial TSDR survey was mailed in August 1987 with follow-ups for the next six months. As of May 1, 1989, approximately 99 percent of the questionnaires had been returned. The resulting database contains over 240,000 records that are organized into over 60 distinct files.

2.2.2 National Survey of Hazardous Waste Generators (GENSUR)

The information collected in the TSDR Survey is used in conjunction with the results from the 1987 National Survey of Hazardous Waste Generators (GENSUR). A survey population of approximately 41,000 hazardous waste generators was established based on information from the 1985 Biennial Reports, and a sample of 10,400 facilities was chosen for the GENSUR. The approximately 2,600 TSDs in the TSDR were selected with certainty, as were the nation's 1,000 largest hazardous waste generators. Stratified random sampling was employed to select the balance of the sample with the strata defined by state and the quantify of hazardous waste generated by a facility in 1985. Each selected generator received a survey package consisting of an instruction booklet and 9 different questionnaires.

These questionnaires, including 234 pages and 527 questions with multiple answer options, were developed over an 8-month period in consultation with government officials and industry trade associations. Each facility received all the questionnaires, except for the TSDs, that received only booklets on General Facility Information and Hazardous Waste Characterization.

The detailed questionnaires were tested in a field pretest of 9 facilities conducted in mid-1987. The surveys were mailed in December 1987. As of May 1, 1989, approximately 88 percent had been accounted for. The resulting database has over 490,000 records on 10,400 facilities.

2.3 THE COST OF REMEDIAL ACTION (CORA) MODEL

The CORA Model was developed for EPA by CH2M Hill (CH2M Hill 1989). It is designed for the development of cost estimates, in 1987 dollars, for remedial actions at SUPERFUND sites. Cost estimates are driven by what technologies will be used to remediate sites. CORA is appropriate for studying RCRA corrective action costs because technologies used to remediate RCRA sites are exactly those used to remediate SUPERFUND sites.

CORA is comprised of two distinct subsystems: an expert system and the cost system. The expert system is designed to assist the user determine what kinds of technologies should be used to remediate a site. The expert system module was not used in this project.

The cost system contains cost modules for each technology and activity that would be needed to remediate a SWMU. Over forty technologies are represented in the cost system. Examples of technologies are soil capping, groundwater pumping, incineration, and groundwater monitoring. The cost modules were developed to minimize the amount of information required to develop cost estimates and to allow users the ability to provide as much information as is available in order to improve cost estimates.

Costs are broken into capital and first-year operations and maintenance costs. The CORA manual describes how the modules were created and what data were used as the basis for the cost estimates. In this study, the operations and maintenance costs were projected and therefore calculated for various periods into the future.

CORA is PC-based and interactive. It is designed to consider one SWMU at a time. In contrast, this project's methodology calls for running CORA numerous times: for each technology category (16) of each type of SWMU (8) for every combination of different values of CORA variables (# depends on the technologies involved in each of the 16 SWMU categories) for each cost scenario (3).

3. HARDWARE AND SOFTWARE RESOURCES

Analogous to mathematics papers which devote a section to defining terms and symbols, this section lays the foundation for the rest of the paper by discussing the computer hardware and software used in this project.

3.1 HARDWARE RESOURCES

Table 1 lists the computer hardware used on the project, which falls into three categories: VAXes, PCs, and networks. RTI utilized two VAX systems. One is their Confidential Business Information (CBI) VAX. Both of the databases discussed in Section 2 reside on this computer. In order to protect the data, the CBI VAX is not accessible via network or modem. Its links to the outside world are through gateway machines, such as the generic PC listed in Table 1. This PC has a physical switch which either links it with the CBI computer or to the rest of the RTI network. For this project, files transferred to the generic PC from the CBI VAX were then transferred to a VAXCluster at RTI for transmission over INTERNET to ORNL.

The majority of the data processing at ORNL was done on an IBM P70, portable. The use of the machine is described in great detail in Section 4. In addition to this computer, ORNL used a VAXStation 2000, 2 PCs, and made use of a local Ethernet, a reservation wide broadband network, and the INTERNET. The networking infrastructure at both RTI and ORNL probably cut the time needed to complete the project by 40%.

TABLE 1. HARDWARE RESOURCES

Research Triangle Institute	-2 Mini Vaxes Generic 80286 PC, 40-MB HD -Local Area Network Wide Area Network
Oak Ridge National Laboratory	-IBM P70 (portable) 80386, 20-MHz, 8-MB, 60-MB HD -DEC VAXstation -Generic 286 PCs -Ethernet -Wide Area Network
Other	Internet

3.2 SOFTWARE RESOURCES

More so than computer hardware, this project used a large number of software packages, as listed in Table 2. RTI's software needs were relatively sparse, SAS for data analysis on the CBI VAX, and software to enable file transfers between (RTI) computers and onto the INTERNET.

Most of the software packages listed under ORNL were loaded and run on the IBM P70. The three main packages are CORA, SuperKey, and PC SAS. Given the size of these packages and the volume of data produced, several memory management packages were employed (QEMM, VDISK, and Norton Utilities). The ORNL VAXStation is a designated INTERNET node which uses the TELNET software. Local to ORNL, files were transferred to the PCs from the VAXStation using Kermit. Several auxiliary software packages assisted in document preparation and analysis. The PIZZAZ Plus package was useful to take images of CORA screens and place them in ASCII files for later inclusion in the technical report. It would not have been possible to complete this project within budget had the project team not had these software packages available.

TABLE 2. SOFTWARE RESOURCES	
Research Triangle Institute	SAS - Statistical Software VMS DCL - Operating System PROCOMM - Telecommunications Software Kermit - Telecommunications Software
Oak Ridge National Laboratory	Cost of Remedial Action Model (CORA) SuperKey - Runs interactive PC programs in batch mode PC SAS - Set up SuperKey files and statistical analysis QEMM - PC Memory Manager VDISK - RAM disk drive emulator Norton Utilities - Disk cache for SAS operations EMACS - Editor TELNET - Communications software Kermit - Telecommunications software Wordperfect - PC and VAX Version LOTUS Freelance Plus - PC graphics PIZAZZ PLUS - Screen dump to ASCII files DBase III - Early data analysis LOTUS 1-2-3 Early data analysis MS DOS batch files FASTBACK PLUS

4.0 THE SYSTEMS INTEGRATION SOLUTION

The proposed methodology posed several difficult computing challenges which were compounded by a tight budget and short-term milestones. The methodology calls for: processing several hundreds of thousands of records; finding every record for every solid waste management unit that falls under RCRA Subtitle C which could potentially require corrective action; classifying every SWMU into one of 16 categories that define how each SWMU would be remediated; running the CORA model numerous times for each of eight SWMU types and for each of the 16 categories that each SWMU could fall into, adjusting each CORA output in over 100 ways, and aggregating the results by SWMU category by SWMU type to a SWMU type level and then into total costs. Complicating this already complicated approach is the fact that ORNL and RTI are hundreds of miles apart.

Thus, the system integration goals were to: minimize the amount of data processing at RTI; maximize the efficiency of data transmission between RTI and ORNL; minimize the need for staff to hand set up and run any software system; and maximize the usefulness of software and hardware already available to ORNL and RTI.

The systems solution formed into two parts: the solution of RTI/ORNL communication; and the solution of ORNL's data processing problem. Each is discussed below.

4.1 DATA FLOWS BETWEEN RTI AND ORNL

Figure 2 illustrates the final data flow system that developed between RTI and ORNL. The first step in the process was to transfer to RTI the rules ORNL developed to classify the SWMUS. Table 3 presents the rules used to classify waste piles, land treatment units, and surface impoundments in the larger study's base case. Over all, there were 12 of these tables.

The tables of rules were developed on the ORNL VAXStation and then transmitted via INTERNET to RTI. RTI staff transferred these rules by hand to the SAS code residing on the CBI VAX. A problem with the rules, as RTI found, is that they do not cover all possible permutations of the variables in the rules. Therefore, numerous SWMUs were uncategorized. Lists of these SWMUs were at first transmitted by RTI to ORNL via overnight mail or FAX. This proved cumbersome and time consuming. RTI staff worked to transfer the files from the CBI VAX to the switched PC to the RTI VAXCluster and then to ORNL via INTERNET.

The ORNL analyst was able to display the list on the VAXstation, make edits to show which categories the uncategorized SWMUs should be placed, save the files, and transmit the files back to RTI via INTERNET. At the height of the project, these files were being received back at RTI within the hour of their original transmission.

Once all the SWMUs were categorized, RTI needed to transmit 24 final statistical analyses, one for each of the eight SWMU types for each of three analysis scenarios. These outputs exceeded 50 pages each. Again express mail was used initially. However, RTI was able to transfer these outputs through their computer system and on to the INTERNET. The outputs were received on the ORNL VAXStation and problems with overloading e-mail buffers never materialized. These files were then copied to another ORNL VAX for printing.

Unfortunately, time ran out before the project team could devise a way for RTI to send SAS files that could be directly injected into the PC SAS code on the IBM P70. Future phases of the project will entail much more data and this capability will become a necessity.

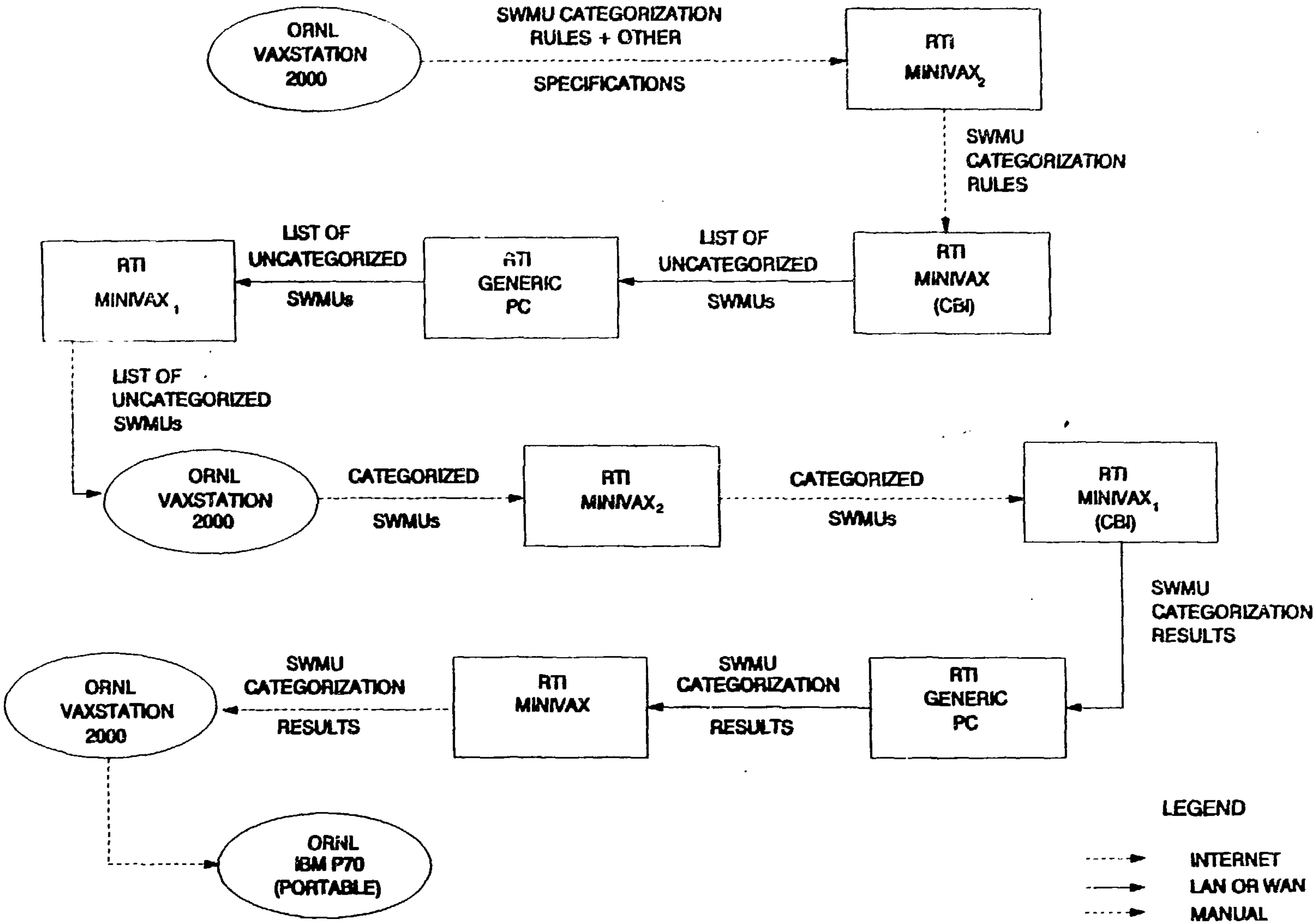

FIGURE 2. STAGE 1 – DATA FLOW

TABLE 3. CATEGORIZATION RULES FOR
WASTE PILES, LAND TREATMENT UNITS, AND SURFACE IMPOUNDMENTS
BASE CASE

		VARIABLES			
SWMU CATEGORY NUMBER	SIZE (ACRES)	PERM-EABILITY (1)	RISK TO POP (2)	LEVEL OF WASTE (3)	TYPE OF WASTE (4)
1A SOIL CAP	GE 3	1	1	1,2	1,2,3
2A + P&T*	GE 3	2,3	1	1,2	1
2B + P&T	GE 3	2,3	1	1,2	2
2C +P&T	GE 3	2,3	1	1,2	3
3A RCRA CAP	GE 3	1	2,3	1,2,3	1,2,3
4A + P&T	GE 3	2,3	2,3	1,2,3	1
4B + P&T	GE 3	2,3	2,3	1,2,3	2
4C + P&T	GE 3	2,3	2,3	1,2,3	3
5A INCINERATION	LT 3	1	1,2,3	1,2,3	2
6A + P&T	LT 3	2	1,2,3	1,2,3	1
6B + P&T	LT 3	2	1,2,3	1,2,3	2
7A SOLIDIFICATION	LT 3	1	1	1,2,3	3
8A + P&T	LT 3	2,3	1,2,3	1,2,3	3
9A SOIL VAPORIZATION	LT 3	1	1	1,2	1
10A + P&T	LT 3	2,3	1,2,3	1,2,3	1
11A SOIL FLUSHING	LT 3	3	1,2,3	1,2,3	2

1 - permeability of acquifer- 1=low, 2=med, 3=high
2 - risk to population of HW releases - 1=low, 2=med, 3=high
3 - level of waste - 1=low, 2=med, 3=high
4 - type of waste - 1=volitiles,2=organics,3=metals

* pump & treat

4.2 COST ESTIMATION PROCESS

Early on in the project, it was realized that the methodology required running the CORA model thousands of times. At one point, it was calculated that it would take several man-years of effort to manually run CORA. This was unacceptable.

Unfortunately, CORA was designed to run interactively and to collect data for one SUPERFUND site at a time. It was never designed for batch use. The project team was also unable to obtain the source code for CORA because it is a proprietary product. Thus, it was not possible to alter CORA to run in batch mode.

The SuperKey program, developed by Borland, is able to record files of key strokes used to run other PC programs. It was reasoned that by capturing the strokes needed to run CORA, editing the files for other runs, and then using SuperKey to handle the other CORA runs, a great deal of time could be saved. As it happened, not enough time was saved because too much time was needed to generate the SuperKey files.

The solution was to use PC SAS to generate CORA macro files on a large scale. These files were designed to be used by SuperKey, which actually managed all the CORA runs. This was convenient because the results from CORA were then fed back into PC SAS.

The PC SAS solution was not the end of the story, as Figure 3 attests. To meet the processing and memory requirements of the analysis plan, efforts were made to optimize the system design. The result was a design that required three separate configurations of the P70.

In the first step, the data received from RTI were entered into an ASCII file for use by PC SAS. SAS code was written to generate CORA macro files for use by SuperKey and a SAS data set to be used to organize the CORA results . At this point, the IBM P70 needed to be reconfigured to manage the next portion of the data analysis process.

Thus, in the second step, the VDISK software was loaded to create a virtual D-drive. A copy of CORA was transferred from the C-to the D-drive, where CORA would run much faster. SuperKey was switched on to run CORA the many hundreds of times. The CORA outputs were indexed and collected in a file. After the process was finished, the CORA outputs were transferred to a file on the C-drive before the P70 was rebooted a second time.

The third stage of the analysis required that the CORA outputs be adjusted and aggregated. The rebooting allowed SAS to operate to accomplish these tasks. Because of a great deal repetition on the analysis, MS DOS batch files were created to run SAS for each of eight SWMU types and each of three cost scenarios, to aggregate costs first at the SWMU level and then for total costs.

Several times for a particular category for a particular SWMU (e.g., landfills needing soil caps or waste piles requiring incineration), the methodology resulted in over a hundred thousand different cost estimates. The aggregation routines required sampling from these hundreds of thousands of cases several thousand cases. Use of the MS-DOS batch files allowed the ORNL analyst to lug home the P70, fire it up before bed, and let it run through the night.

4.3 MISCELLANEOUS

Several other software packages assisted this project. Document preparation packages, such as WordPerfect and LOTUS Freelance Plus are becoming essential items these days. A package called PIZZAZ Plus was useful in downloading screen images into ASCII files. For documentation purposes, it was important to

include as much information about CORA as was possible. To explicitly show what data were input into CORA, it was decided to include the actual CORA screens as an appendix in the technical report. Using PIZZAZ Plus, all of the important screens were put into ASCII files and then drawn into WordPerfect for inclusion in the technical report.

The size of project files exceeded the capacity of the P70's hard disk. Therefore, processing was organized into three groups and FASTBACK PLUS was used to backup and restore the data by group. Finally, DBase III and LOTUS 1-2-3 were used in the early stages of the project to manipulate CORA outputs. These packages were not needed after a decision was made to use PC SAS.

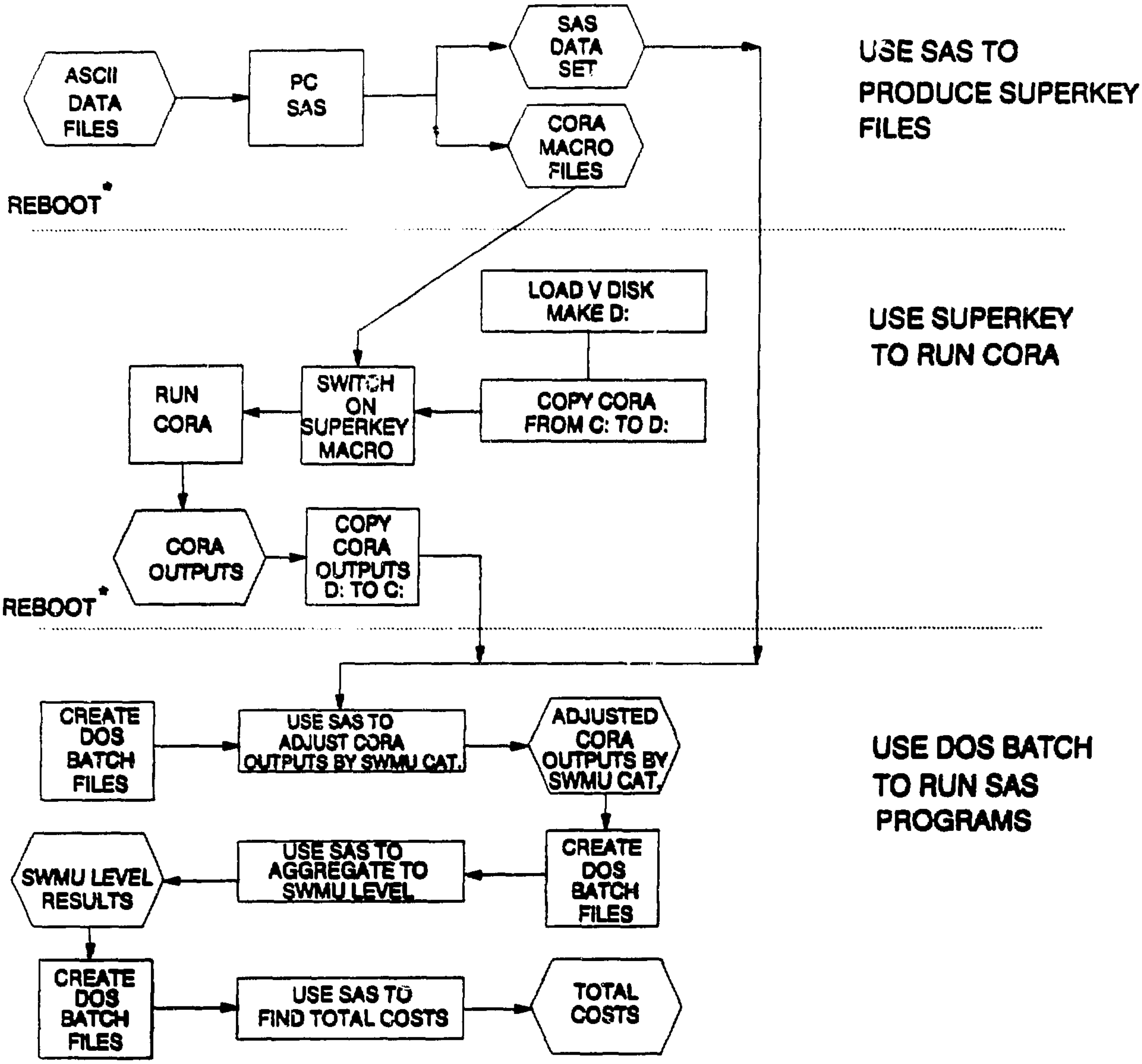

Figure 3. Stage 2: Cost Estimation*

*ALL DONE ON IBM P70 (PORTABLE)

5. DISCUSSION

The experiences with system integration on this project have several implications for future social science research. One, knowledge of programming languages may become of secondary importance to having knowledge about one's computing resources and the requirements of software packages that need to use the resources. In this project, knowledge of PC memory management techniques, not C or Fortran, was the key to successfully conducting the data analysis on the IBM P70. Issues and topics with respect to microcomputing, such as those discussed by Hake (1990), are very important.

Two, the network infrastructure, both at ORNL and RTI and between these institutions proved invaluable. Electronic transferring of the rules files and output files saved an enormous about of time and money. Use of e-mail also improved project coordination and made communication more efficient. The two project managers did not end up playing phone tag and the two systems analysts conducted all their communications over e-mail. In fact, the systems analysts did not communicate by phone at all during this project.

Three, it is clear that social science researchers can benefit from the availability of software resources. Because ORNL is a large institution and the ORNL project team works in a division populated by experienced computer users, numerous software packages were available for use, and if not, peers readily knew the names and developers of other software packages. SuperKey and PIZZAZ Plus are two good examples of programs that were brought to the attention of the project team by others at ORNL. Thus it is recommended that computer service centers at institutions where social scientists conduct research provide assess to a wide array of PC-based software packages.

The last point is that this project could not have been completed three or four years ago. The processing power was not available at the PC level and if CORA had been built to run on a mainframe, the charges for using a mainframe would have been prohibitive. Even being able to bring home a rather heavy portable PC helped immensely in managing the overall data analysis. The future will be even better. PCs will have even more processing power and memory. The use of networks and remote login, etc. will increase as will the capability of networks. For rather small amounts of money and with some creativity and knowledge of computers, social scientists will be able to tackle very large and complex data analysis problems.

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