Overseas Applications of Microcomputers on a Transportation Planning and Engineering Design Project

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The application of microcomputers in various phases of a multidisciplinary project encompassing a comprehensive transportation planning study and preliminary engineering for a metro or rail rapid transit system and an underwater railroad tube tunnel for Istanbul, Turkey, is described. Microcomputers were used to process the results of a 9 person-year effort of travel data collection. Over 70 megabytes of processed data files were created using various specialized software programs. Calibration of a complex four-step transportation modeling system, as well as testing of numerous alternatives were successfully accomplished on microcomputers. A wide range of engineering applications, structural analyses, cost estimation, project control and scheduling, and cost control tasks also were accomplished for which the microcomputer was found to be an indispensable tool. Tabulations of data and results, computer-generated graphics, and the word processing capabilities of microcomputers permitted the efficient production of a large number of complex project reports (in two languages) on time and in a cost-effective manner. Staff training of personnel without previous computer experience was surprisingly easy and was accomplished within a very short period of time due to the user friendliness of modern software. The versatility of microcomputers and the effectiveness with which they were applied to this complex overseas project was surprising. Despite certain difficulties and problems, it is apparent that present day microcomputer technology can be successfully used in somewhat isolated overseas environments to develop a complex engineering/planning project.

The use of microcomputers on various phases of a multidisciplinary project in Istanbul, Turkey, is described. The project encompassed a comprehensive transportation planning study, as well as preliminary engineering for a metro or rail rapid transit system and an underwater railroad tube tunnel across the Bosphorus Strait. Advantages found in using microcomputers on the project are discussed along with problems encountered and lessons learned.

Computer technology has advanced rapidly with the recent introduction of fast and high-capacity microcomputers. This advancement, particularly with the PC-DOS family of microcomputers, coupled with the recent developments in transportation planning, engineering, and data-handling software designed for this family of machines, has led to very efficient, cost-effective, and user-friendly desk top computer power. Therefore, it was decided early in the planning of the Istanbul project that extensive use would be made of microcomputers.

IBM/XT and COMPAQ microcomputers were used to perform various tasks for the wide range of planning and engineering disciplines required for the Istanbul project. An IBM/AT was used to calibrate a four-step transportation modeling system, as well as to test the alternative transportation improvements being considered.

Over seven million pieces of information from a 9 person-year travel data collection effort were processed; the microcomputers were used to tabulate post-model run results and make graphics; to run and tabulate the results of cost estimation models; to perform economic and financial analyses of alternatives; and to carry out engineering analyses and data handling for extensive use as word processors for the heavy volume of report production in both Turkish and English. The microcomputers were also used for project cash flow and cost control and for various other project management tasks.

Seven microcomputers were used, including an IBM/AT; two IBM/XTs; two COMPAQ/plus (with 10-megabyte hard disk drive capacity) imported from the United States to Turkey; and two additional double floppy disk drive model COMPAQs obtained locally.

MICROCOMPUTER APPLICATIONS ON THE ISTANBUL PROJECT

Some of the applications of the microcomputer on the Istanbul project are described, particularly those relating to the transportation planning aspects of the project.

Travel Data Processing and Analysis

Sixteen different travel surveys and counting programs generated over 165,000 records with 209 types of data. An initial search of data collection and marketing research companies in the Istanbul region to carry out the surveys indicated that there were few qualified firms to choose from. All but one of the firms were either too small in size or were specialized in areas of market research that would not be applicable to the work needed for this study. The travel surveys were all conducted by this one firm under the supervision of the project staff. Data entry keypunching was also subcontracted to a local computer

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firm. All of the records in a data base were verified and checked thoroughly by the project staff. As each data base was corrected, it was converted to PC-File format (a general file-handling and data-base management program), and the diskettes were delivered to the planning and feasibility staff. The local firm for travel surveys and data entry completed their responsibilities satisfactorily and the subsequent work was accomplished in-house by the project staff.

The raw data had to be sorted by station/location, day of survey, and direction using the PC-File program. The classified PC-Files were then converted into ASCII files to be processed using SYSTAT, a general purpose statistical program. The SYSTAT package was used to tabulate trip volumes by station, day, direction, time of day, and type of vehicle. Vehicle volumes were tabulated and the average vehicle occupancies derived from the survey were applied to yield person trips by mode of transportation. A stratified small sample home interview survey was also analyzed using the SYSTAT program.

Transportation Modeling System Calibration and Application

A four-step transportation modeling system (trip generation, trip distribution, mode choice, and trip assignment) was calibrated running the model on IBM/XT and IBM/AT microcomputers. TRANPLAN was used for the trip distribution and trip assignment steps in the model, while separate programs were developed for the trip generation and mode choice models. Findings from the model calibration efforts showed that the modeling system performed remarkably well because the estimated number of total person trips compared closely to their respective observed values at different screenline locations. In addition, the estimated number of automobile and transit trips were also comparable to their respective observed values. In carrying out this work, the data plotting capabilities of the microcomputers was of great help when comparing estimated values with observed values and presenting results to the client.

The modeling system has been used to test and evaluate several transportation alternatives including a metro system, light-rail transit, commuter railroad improvements, express bus routes on exclusive busways, conventional local bus service improvement and shared taxi operations, ferry boat system improvements, and a railroad tunnel beneath the Bosphorus connecting the Asian and European sides of Istanbul.

Testing of the alternatives was carried out entirely on the IBM/AT in the project office. A complete overall modeling system run, including network building, trip distribution, mode choice, and trip assignments of automobile and transit person trips, took less than 2.5 hr. The model results, capital/operating cost estimates, and economic evaluation of alternatives were tabulated or analyzed using SYMPHONY.

Highway link and transit link/line data files were created using the IBM editor program. Various TRANPLAN programs were run on both IBM/XT and IBM/AT microcomputers and the run time comparisons for a 107-zone system (with 1,835 highway and 1,544 transit links) are given as follows. The advantage of the newer, faster technology of the IBM/AT computer over the earlier PC/XT series is clearly shown.

Program Name	*Run Time* (min.) *IBM/XT*	*IBM/AT*
Build highway network	5.5	1.5
Build highway skim table	10.0	4.0
Gravity model	25.0	8.0
Create origin-destination (O-D) trip table	3.0	1.5
Load person trips to highway network	12.0	2.0
Overall TRANPLAN-related steps of model system (107 zones with 1,835 highway and 1,544 transit links)	57.5	19.0

Engineering-Related and General Purpose

The engineering design group used microcomputers to perform a wide range of different tasks related to the project. The structural group carried out a finite-element analysis, an analysis of wall and pile designs using special purposes structural software written in FORTRAN, and various drawing/plotting programs such as AUTOCAD and PLOTTRACK. The civil and alignment group used COGO and similar programs for the geometric design/analysis of guideways and roadways. The cost estimating groups primarily used SYMPHONY for cost spreadsheets.

The project included an intensive study of the hydraulic characteristic of the Bosphorus waterway. The group doing this work collected meteorological, tidal, current, salinity, density, conductivity, and temperature data. SYMPHONY, GRAPHS, AUTOCAD PENPAD (for digitizing), and specialized programs written in BASIC were used to process, analyze and plot data. The geological and geotechnical group used SYMPHONY to tabulate and analyze data for an extensive subsurface investigation program.

Finally, the project involved the production of an extraordinary volume of reports, contract documents for subcontractors, handouts for presentations to various government agencies and many other documents, in both English and Turkish. This was a major undertaking almost exclusively accomplished on the microcomputers throughout the office using VOLKSWRITER DELUXE. It was decided early on not to invest in dedicated word processors but to utilize the compatibility of the various PC DOS computers so that any of the office units could be used. Two microcomputers were assigned to a word processing department, but virtually everyone in the office mastered word processing quickly so that the work could be done on any available machine.

As can be seen from the foregoing discussion, microcomputers were used to produce reports, graphics, plots, and displays for both analytical and presentation purposes in all the disciplines. In addition, microcomputers enabled staff to be trained in the uses of both general purpose and task-specific software. The training of young Turkish engineers in state-of-the-art computer usage was a significant benefit to the host country as well.

MICROCOMPUTER HARDWARE AND SOFTWARE

Hardware

Various models of compatible microcomputers were used, based on the DOS operating system. Printers, plotters, and back-up units have been used also (Table 1).

Software

The software purchased for this project is listed as follows:

Software Purchased	*Function*
PC-FILE and dBASE III	For coding of survey results and initial sorting of raw data
SYSTAT	A general purpose statistical analysis program for travel/home interview surveys and counts, statistical analysis, and estimation of mode choice model parameters
SYMPHONY	Spreadsheet program for data tabulations, summaries, graphing, and word processing
TRANPLAN	The transportation modeling system used for network building, trip distribution, application of the mode choice model, and automobile/transit trips assignment
AUTOCAD, PENPAD, and PLOTTRACK	Used for digitizing and plotting graphs
VOLKSWRITER DELUXE	Word processing
COGO and SIMILAR	Programs used for geometric design/analysis and alignment studies for railroads and roads
MICROSOFT FORTRAN compiler	Used for FORTRAN programming
IBM professional editor	Used for data entry and editing

Programming languages include:

- FORTRAN—Used in finite element analysis of structural members and to estimate modal shares outside TRANPLAN using a binary logic model framework. Programs were also written by planning and engineering staff to complement available software programs for specific tasks.
- BASIC—General purpose programming language.

ADVANTAGES OF MICROCOMPUTERS

The following paragraphs address the various advantages revealed when using microcomputers for the Istanbul project.

Speed, Capacity, and Ease of Implementation

It was found that the direct hands-on access to the microcomputer, the ease of learning the microcomputer systems, and the availability of existing software permitted a much larger portion of the available professional time to be spent in creative discussion and analysis. The elimination of the need for Job Control Language (JCL), which is frequently needed when using a mainframe computer, simplified both the programming and the running of the programs.

For example, it took approximately 3 months to process and tabulate the transportation-related raw survey data. The data processed for the statistical analysis and tabulation graphics generated over 70 megabytes of microcomputer-related files. The calibration of a four-step transportation modeling system was successfully accomplished in approximately 3 months. The data processing efforts were achieved by using only IBM/XTs and COMPAQs, and the files were backed up onto a magnetic tape unit (TALLGRASS Model 4060).

Microcomputer capability in computational and reporting tasks is unique because the planner or engineer has instant access to a desktop unit providing direct control of the work. Programs written for microcomputers are usually designed to be user friendly, and personnel can be trained in their use in a short period of time. The ease of access and control of the microcomputer makes it possible for the professional to spend time more efficiently and productively. By proper scheduling of time and machine use, the microcomputer can be loaded for tasks such as data sorting or model runs, while the user is working on other tasks, or even during the lunch break.

Use of microcomputers has resulted in a change in required staff qualifications. Previously, much of the data processing was done by technicians. For example, on the planning study for the Caracas Metro, which one of the authors of this paper directed from 1966 to 1969, it was necessary to send a small team of analysts back to the United States where computer facilities and staff were available to operate the transit ridership forecasting models. The hands-on interactive nature of the

TABLE 1 LIST OF MICROCOMPUTER HARDWARE USED IN ISTANBUL METRO RAIL/TUNNEL PROJECT

Computer Type	Printer Type	Plotter Type	Back-Up Unit Type
COMPAQ/Portable	OKIDATA-92	–	–
COMPAQ/Portable	OKIDATA-92	–	–
COMPAQ/Plus	FX-100	HP-7475	TALLGRASS-4060
COMPAQ/Plus	OKIDATA-82	–	–
IBM/XT	OKIDATA-93	PENPAD	–
IBM/XT	OKIDATA-93	MOUSE SYSTEMS	–
IBM/AT	OKIDATA-2410	–	TALLGRASS-4060

microcomputer permits direct involvement of project staff, which is very cost effective. By avoiding the time lost when waiting for data to be processed on a mainframe in another office, and having answers in minutes rather than days, costly professional time (particularly in the case of U.S. personnel being maintained overseas) was saved almost daily for the Istanbul project.

The use of the microcomputer for word processing on a project where two (or more) languages are involved provides a substantial saving in professional time used for editing and correction. On this project, the PC-DOS computers could be patched with a simple keystroke to convert to the Turkish alphabet.

The wide-ranging library of engineering software now available to the engineer equipped with the PC-DOS microcomputers is well known. Even for the preliminary sections of the engineering designs undertaken on this project, substantial use was made of the microcomputer for structural and tunneling analyses. The wide-ranging versatility of the microcomputer included other important uses for cost control scheduling, cash flow analyses, and personnel and office management tasks. On the latter applications, it can be said that the microcomputer paid for itself.

Comparison of Microcomputer and Mainframe Utility

A mainframe computer is clearly capable of performing most of the functions for which the microcomputers were used in this project. The advantages of the microcomputer include:

- Fast turn-around time,
- Ease of learning,
- Direct access,
- Cost effectiveness,
- Multipurpose uses such as word processing, and data handling/analysis, and
- Direct control of work by the professionals on a real-time basis.

Although the memory capacity of the microcomputer may currently limit its application for very large and complex systems, the rapid advancement of the state of the art in microcomputer technology with the introduction of faster and more powerful systems and software is resulting in the use of microcomputers for larger and larger undertakings. The benefits of microcomputer use in planning and engineering projects were revealed by their use in the Istanbul project.

PROBLEMS ENCOUNTERED AND LESSONS LEARNED

Problems with the installation and operation of computer facilities in a developing country posed some interesting challenges. For the benefit of others interested in similar applications, some of these are described in the following section.

Hardware Import and Installation and Supplies

Initial investigations regarding procurement of microcomputers indicated that the local firms could not deliver all the necessary equipment in less than 90 days. In addition, the initial cost savings, resulting from differences in microcomputer costs, convinced the project management that most of the equipment should be purchased in the United States. The hardware items listed previously were imported in early May 1985, and the import duties were waived conditionally on reexportation of all the equipment at the end of the project. The shipment of IBM/AT was delayed until June 1985 pending issuance of an export certificate by the U.S. Commerce Department. The IBM/AT had not yet been introduced on the local market.

The release of hardware items from customs (except the IBM/AT) took over 1 month because of the lack of advance knowledge on the part of project management of the various government regulations. The release of the IBM/AT was delayed much longer, until mid-September 1985, for similar reasons and extra requirements related to the IBM/AT. The unit was the first microcomputer of its kind to be exported to Turkey, and, at the time the U.S. government expressed concerns relating to the exportation of high-technology computers. Procurement of necessary supplies and parts and maintenance services for the microcomputers was not free of problems either. COMPAQ had no representation in Istanbul and all of the local IBM representatives were found to be European-based affiliates. Because of this they did not wish to provide maintenance services other than to clients who had purchased computers locally. This situation was rather burdensome at times in terms of maintaining the equipment. Eventually, some maintenance services were secured from a local firm.

In the process of installing the IBM/AT microcomputer, running the diagnostic tests, and trying to install the software programs, the following problems were detected by the local service personnel:

1. The math coprocessor, which had been purchased for the IBM/AT, had neither been installed in the AT nor shipped with it for installation. This was vital for the efficient running of TRANPLAN programs.
2. The AT was equipped with a 20-megabyte hard disk drive and one high-capacity floppy disk drive. A 360K double-sided floppy disk drive compatible to the AT should also have been installed in the machine in order to easily transfer data between the AT and the XTs and the COMPAQs in the office. The second disk drive had been specified during the process of ordering the IBM/AT from the United States, but the message was missed somewhere. This second drive had to be imported and added later.
3. The high-density floppy disk drive was not functioning properly. It inconsistently read floppy disks placed in the drive. The local firm suggested the need for Adjustable Diagnostic Test diskettes to readjust the high-density disk drive. Such software was not locally available and had to be brought to the project by a traveler.
4. Initially, the TALLGRASS units were inoperable with the AT. Both units functioned properly with both XTs. This prob-

lem was critical because files that were supposed to be created on the AT could not be backed up and the 70 megabytes of processed data could not be retrieved for use on the AT. It was realized later that an updated version of TALLGRASS software was needed to interface with the AT instead of the existing software. A search was conducted for 2 weeks in the United States until a member of the project staff was informed by a friend from California that a local IBM representative in the Istanbul area could provide the software.

Hard Disk Failure

The hard disk installed in the IBM/AT failed in mid-November 1985 during a critical period of calibrating the transportation modeling system. The local service representative determined after 2 days of examining the hardware and operating system that the hard disk needed replacement. The hard disk was not available in the local market. The AT was still within the warranty period, but the original AT seller in the United States could not supply the replacement in a reasonable time. Consequently, an AT machine in the consultants' New York office had to be taken apart to obtain a hard disk unit that could be shipped to Istanbul. The entire process took approximately 3 weeks before the AT became operational again. In the meantime the model calibration efforts were continued using the XT, but with much slower operation.

Power Incompatibility

Because Istanbul uses 220-V 50-cycle alternating current (AC), power outlets needed to be made compatible with the 110-V 60-cycle AC imported microcomputers. Transformers were installed in the office before machines arrived. Unfortunately, the transformers had to be replaced because they were found to be inadequate in handling the total requirements of the computers, together with their accessories such as the units and the larger-sized printers. The project management had decided to import an uninterruptable power supply (UPS) back-up unit in case the electrical power was disrupted during a critical model run. Local electrical firms could not supply such a unit and it had to be imported. The order went out in June 1985. When it finally arrived in October, the prevailing local import/export formalities had to be accomplished again for its release from customs. This resulted in several more weeks of delays. When the UPS finally arrived in the project office, it was discovered that its electrical requirements were incompatible, in almost all respects, to the local current. Fortunately, the local power reliability turned out to be satisfactory and the power disruptions were limited to occasional electrical transients. External surge protectors were installed for all the microcomputers in the office, and two had to be replaced due to accidental use of wrong voltage outlets (220 V instead of 110 V).

Accessibility to Software Developers

The project's planning and feasibility study staff faced software problems on several occasions during the data processing and model calibration efforts: questions had to be communicated at long distance to the firms in the United States that had developed the software programs.

The lack of direct access to the developer of the software because of distance (inaccessibility to user hotlines) for immediate resolution of problems is an important factor when considering the use of sophisticated software overseas. Work schedules and contingency plans should be made accordingly. It was found that software on diskettes must be shipped in special X-ray resistant bags for protection against the X-ray devices at airports. In one case, before the introduction of the protective bag, several diskettes were damaged in transit, possibly by X-rays.

Data Storage Limitations and File Handling/Back-Up Procedures

Because of the storage limitations of individual microcomputers, proper use of the machines for general purpose and specific tasks should be taken into consideration.

Files were backed up on a regular basis, initially onto diskettes and later onto a TALLGRASS technology tape cassette (with over 55 megabytes capacity per cassette). The purpose of this was to clear both hard disk memory space and floppy diskettes (if necessary) for efficiency of operation and creation of new files.

It was decided that two copies of each file should always be available. A working copy of each file was kept in a safe located in the office, and a second copy (stored either on tapes or diskettes) was kept in a safe deposit box in a bank nearby.

The importance of a back-up device, such as the TALLGRASS unit, was not fully realized until the staff completed the overall data processing activities, which generated over 70 megabytes of processed data files. The files were copied onto tapes on a daily basis as the work progressed. The staff was forced to do this because of the memory space limitation of the XT and the AT. Had the tape unit not been available, the number of diskettes required for clearing the hard disk space and providing the back-up files would have resulted in a very costly and inefficient operation.

Staff Training and Management of Microcomputer Time

The need for staff training was realized long before the arrival of the microcomputers in the office. In the weeks following the arrival of the equipment, introductory seminars were held in the office on microcomputer operation. The seminars had enthusiastic participation of the staff at all levels. Thereafter, the management of time on the microcomputers became very important as the demand for their use by staff increased. Staff members were encouraged to stay late in the afternoons or occasionally spend the weekends to get familiarized with microcomputer operation. The staff quickly learned this by using the general purpose software programs such as SYMPHONY or VOLKSWRITER. Different departments developed skills in using more specific software programs such as TRANPLAN and finite element analysis. Training for the use of these programs was provided by the responsible techni-

cal staff in each department. Software user manuals were prepared by the senior staff directly involved in each technical task. The importance of documentation detailing the file archiving/retrieval and system operations should not be underestimated.

After the various expatriate specialists and senior staff completed their assignments and returned to the United States, the local staff had to be able to fully use the computerized systems developed during the course of the project. Consequently, the need for the training of the local personnel, as well as the preparation of adequate documentation, were of great importance. It was learned that the most efficient way of satisfying these needs was through active participation of the local staff at all levels in the uses of various software programs and their involvement in the corresponding documentation on a daily basis.

CONCLUSIONS

The use of microcomputers on this project in Turkey can be considered a success. In spite of the problems involved in importing, obtaining, and maintaining these facilities, the project goals were accomplished efficiently through use of microcomputers. An added side benefit was provided to the host country in the training of local engineers in a variety of microcomputer applications.

In undertaking a program of microcomputer utilization in a third world country with limited local resources, stringent importation restrictions and untrained local personnel, a number of considerations should be kept in mind:

1. Knowledgeable personnel in the United States must specify well in advance the amounts and types of hardware and software needed for the anticipated tasks.
2. Personnel should be provided in the overseas office who are well acquainted with the importation documentation and paperwork necessary to enter the required equipment into the country in a timely and cost-effective manner.
3. With overseas government clients for whose projects customs duties can usually be waived or sidestepped, it is usually cost effective to buy the equipment and software in the United States because the locally available equivalents usually carry heavy import duties already included in the price.
4. Time must be allowed and training provided for updating the local staff on procedures.
5. Local electrical parameters, such as voltage, frequency, voltage regulation, outages, and so on, must be planned for during selection of equipment.
6. Access to software originators, particularly for uncommon packages, must be available to avoid delays to the work.
7. Consideration must be given to file back up methods as in any endeavor of this kind, particularly when relatively untrained personnel must process costly software and data files.
8. When a great deal of report text must be developed (in this case, in two languages), it is a major benefit if word processing, together with several copies of the same program, can be made available to all personnel using compatible computers (not dedicated word processors). On this project, VOLKSWRITER DELUXE was chosen because of its simplicity and the fact that everyone could learn its use very quickly.
9. An interesting effect was noted: No matter how many computers became available during the early days of the project, they were always found to be fully occupied. Computer time management was quickly found to be a vital consideration.
10. Ample spare parts, extra diskettes, must be purchased from the start.

Finally, the versatility of microcomputers and the ease and effectiveness with which they were applied to this complex project overseas was most satisfying. The rapid advancement of the state of the art in microcomputer technology is enabling planners and engineers to manage ever more efficient, timely and cost-effective operations both at home and in overseas environments.

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