A computer database system for geotechnical data

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SUMMARY

Substantial amounts of money can be spent on borehole investigations for civil engineering projects, yet often the data once obtained is disregarded for future project considerations. It has long been argued that to tap into that wealth of data through computers would provide significant cost benefits for further investigations. Not only could such further work be more finely tuned against an improved prior indication of probable site conditions, but even more exciting is the immediacy of information produced. Although the facility would not replace the need for further site investigation, such work could be designed with greater efficiency, as it might merely have to substantiate a reliable preliminary assessment.

Argueably it has always been possible to carry out a similar preliminary assessment based on traditional archiving procedures. Yet in truth such usable archives rarely exist and where they do the staff commitment necessary to extract the data and correlate the findings for a new project usually makes the exercise impossible to contemplate. We are now on the threshold of a new concept in ground investigation for in the wake of the microcomputer revolution there is the opportunity to use the technology to provide not only the rapid retrieval of large quantities of stored data from previous site investigations, but also to allow it to be accessed by 'interactive interrogation'. This means that the information can be retrieved in a meaningful and useful form and not merely as endless screeds of tabulated numbers.

Just this approach has been adopted by the London Docklands Development Corporation where a database facility has been installed with a projected storage commitment of 10,000 borehole records and associated laboratory test results. This resides on microcomputers and allows simple and rapid storage and retrieval of borehole and other geotechnical data. A particular feature is that it will be capable of use by staff without specialised computer training or experience.

INTRODUCTION

The information that is collected for an investigation of the ground for a new civil engineering project principally takes the form of borehole records and associated laboratory data. This is usually supported by a report which describes the materials encountered below ground, together with an interpretation which assesses how the ground will behave in relation to the intended project and finally makes various recommendations to ensure that the response of the ground is acceptable for the serviceability of the project.

The interpretive reports, although of interest, tend to be specific in their consideration having usually been commissioned for particular projects. The detail contained in the interpretation therefore is usually not transferable to other projects even where these may be located on the same site. However, this is not so of the borehole and laboratory data. This is factual in character, forming merely a record of the vertical variation of the material types on the one hand and a quantified assessment of their behavioural characteristics using standardised laboratory techniques on the other.

As the ground at any one location will rarely change with time without some outside influence, the factual data can be used for successive development considerations. In addition, as the natural materials are not controlled by artificial site boundaries, with care, the data can be used to extrapolate to other areas.

METHODS OF DATA STORAGE

Traditionally site investigations for civil engineering purposes are carried out piecemeal, on a site by site basis by different interested parties. It is only when there is an organised study of a large area that it is possible to collect and collate the data in a way that could be used to a maximum advantage. From a practical point of view there are severe problems of basic storage for the large volumes of material that can be generated in any one area, let alone its cataloguing and re-use. To be of value the collected information must form a resource that is readily available to the interested parties. It is essential that any proposed system of data storage should have a number of attributes.

1. It must ensure ready access to contained information.
2. It should be capable of revision on a regular basis as more information is collected.
3. In order to ensure that it does not become redundant with time it should not be labour intensive in its structure or operation.

Storage and retrieval of the data can be undertaken in a number of ways (Table 1),

1. Traditional paper library
2. Microfilm/microfiche
3. Computer storage

STORAGE SYSTEM	ADVANTAGES	DISADVANTAGES
Paper archive	- Traditional reports can be stored in original format - Familiarity with the system	- Large storage commitment - Usually centralised - Needs efficient and reliable indexing - Trained staff required to adminster the system - Material may be on loan when required - Working copies need to be made for long term reference - Material can be lost or damaged - Material deteriorates with time
Microfilm/ microfiche	- Small storage commitment - Style of original format retained - Rapid perusal of large amounts of data possible by experienced user - May be held at many locations	- Needs efficient and reliable indexing - Trained staff required to administer system - Intermediate hard copies needed to allow comparative perusal of data
Computer	- Small storage commitment - May be held at many locations - Data can be processed by machine	- Data not necessarily in in original format

Table 1 A comparison of the main storage and retrieval systems for geotechnical data

Traditional forms of paper archive are often found not to be viable because of the long term storage commitment and the necesary provision of a librarian to control and index the material if it is to remain usable and intact from loss.

Microfilm and microfiche have the advantage that storage requirements are very small and that multiple copies are readily available so that material losses could be accommodated. Nonetheless for any storage system to be worthwhile it is essential that it should be used. Users of site investigation data continually refer to and cross reference the information contained on more than one page. This can not be carried out with microfilm or microfiche without the need to make intermediate paper copies. As they provide no more than a condensed form of traditional library, they would not eliminate the need for a librarian and an efficient index. Indeed, without the provision of a librarian and index the casual enquirer would very likely end up ignorant of the presence of the information contained in the system.

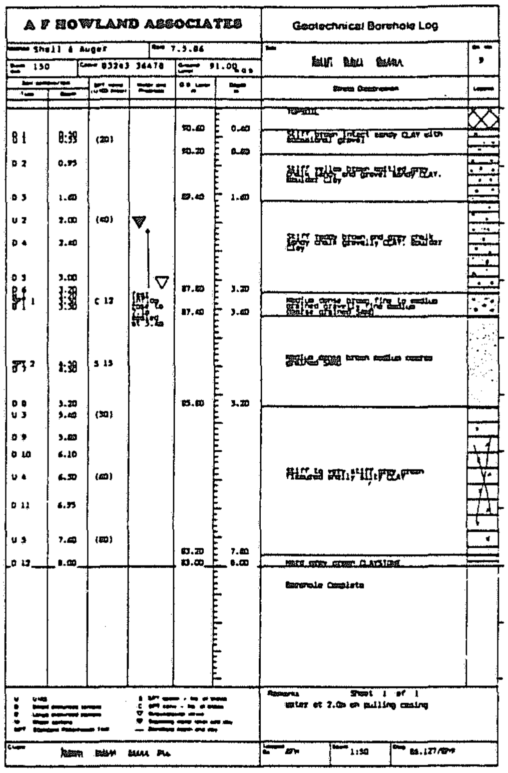
Developments in information technology and multiple data handling by computer systems lend themselves to the basic requirements of such a system. Small desk-top machines with large internal memories can now handle very complex and involved storage/retrieval systems which are highly suited to the character of the geotechnical data contained in site investigation reports.

THE SUITABILITY OF GEOTECHNICAL DATA TO COMPUTER STORAGE

The geotechnical data derived from the borehole record and laboratory test results provides the variation of a number of discrete parameters each referenced to depth. It is therefore of a form which is very suitable to simple tabulation (Figure 1). This is the basic format used by modern computer databases for the storage of information. Their use as the core of a storage and retrieval system would allow its datafiles to be interrogated and manipulated by any number of output programs. One particular advantage is that the output programs are separate from the database and can therefore be developed at a later time in line with the total development of the system. In this way the basic geotechnical data can be stored from very early on. The only requirement is that the input and storage should be structured to allow random access to the material through any subsequently chosen path.

The development of a usable system requires careful consideration of the mechanics of its intended use. From that and the conceptual requirement of the system as a whole the precise software and hardware can be determined.

The systematic storage and retrieval of borehole data has been attempted at various times using a variety of approaches (see for example Dearman and Strachan 1983, Harvey 1973, Lawson et al 1975, McMillan et al 1984, Wood et al 1982). In



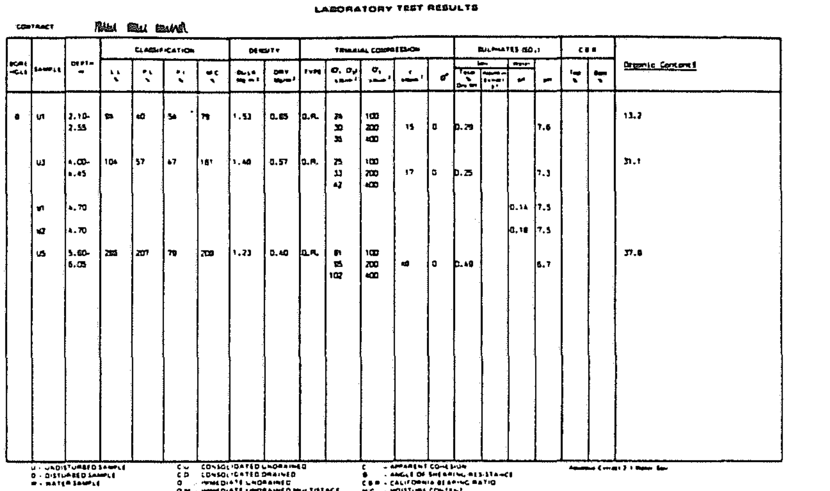


Figure 1. The typical style and format of geotechnical borehole and laboratory data showing the strong emphasis of the data to be referenced to depth.

the early 1970's the Construction Industry Research and Information Association (CIRIA) undertook a feasibility study of the formation of a National Registry of Ground Investigation Reports (Tuckwell and Sadgrove 1977). Its intention was to consider the development of a data store of the wealth of borehole data which exists for civil engineering purposes and to make it more readily available to other interested parties. This concluded that microfilming would be a better and more appropriate method for storage than the use of computers. The actual storage and retrieval of the microfilmed information would then be carried out by manual filing. It was concerned that the extraction of data from the source reports for computer storage would 'require judgment, introduce scope for errors and be too costly'.

The advances in computer technology since those conclusions now makes the misgivings unnecessary. The use of microcomputers to produce conventional borehole records has been demonstrated by the authors to be both practical and to have significant advantages in time and efficiency (Howland 1986, Howland and Podolski 1985). The general approach has been amended to allow direct input to a computer database so eliminating any possible concern over the need for judgment or for the errors that could otherwise arise during subsequent transcription of the data.

THE DESIGN OF A SUITABLE DATABASE SYSTEM

1. Software

A GEotechnical DAtabase SYstem (GEODASY) has been developed by G D Systems Limited initially for the london Docklands Development Corporation (LDDC). REVELATION was chosen as the development software which allowed a versatile, high performance dictionary-driven relational database to be developed which met the exact operating requirements of the LDDC (Figure 2). GEODASY has a number of in-built features which make it ideally suitable for the handling of geotechnical data:-

1. There is no limit to the number of individual records that can be stored. The only practical limitation is caused by the total storage capacity on the computer. Hence although the System has been developed to cope with an estimated 10,000 records, in practice this can be added to indefinitely.

2. The geotechnical data to be stored consists of twenty possible data fields at any given depth. However very few of these fields will actually contain data. With more conventional database structures this would cause a large amount of redundant storage commitment since the empty fields would also have disk space allocated to them. With GEODASY only those fields which contain data are stored. This makes the System particularly efficient for the storage of such data.

3. At any stage in its life new fields can be added to GEODASY without re-structuring the database or affecting the existing entries within it. So if for example it becomes necessary to incorporate a new test on every borehole record added after the database has been used for a period it can be done without affecting the integrity of the previously stored data.

4. GEODASY runs under PC-DOS or MS-DOS and is also compatible with the PICK operating system which is used by a wide range of mainframe and mini computers. This ensures that GEODASY remains flexible and will fit in with a wide range of established end-user computing requirements.

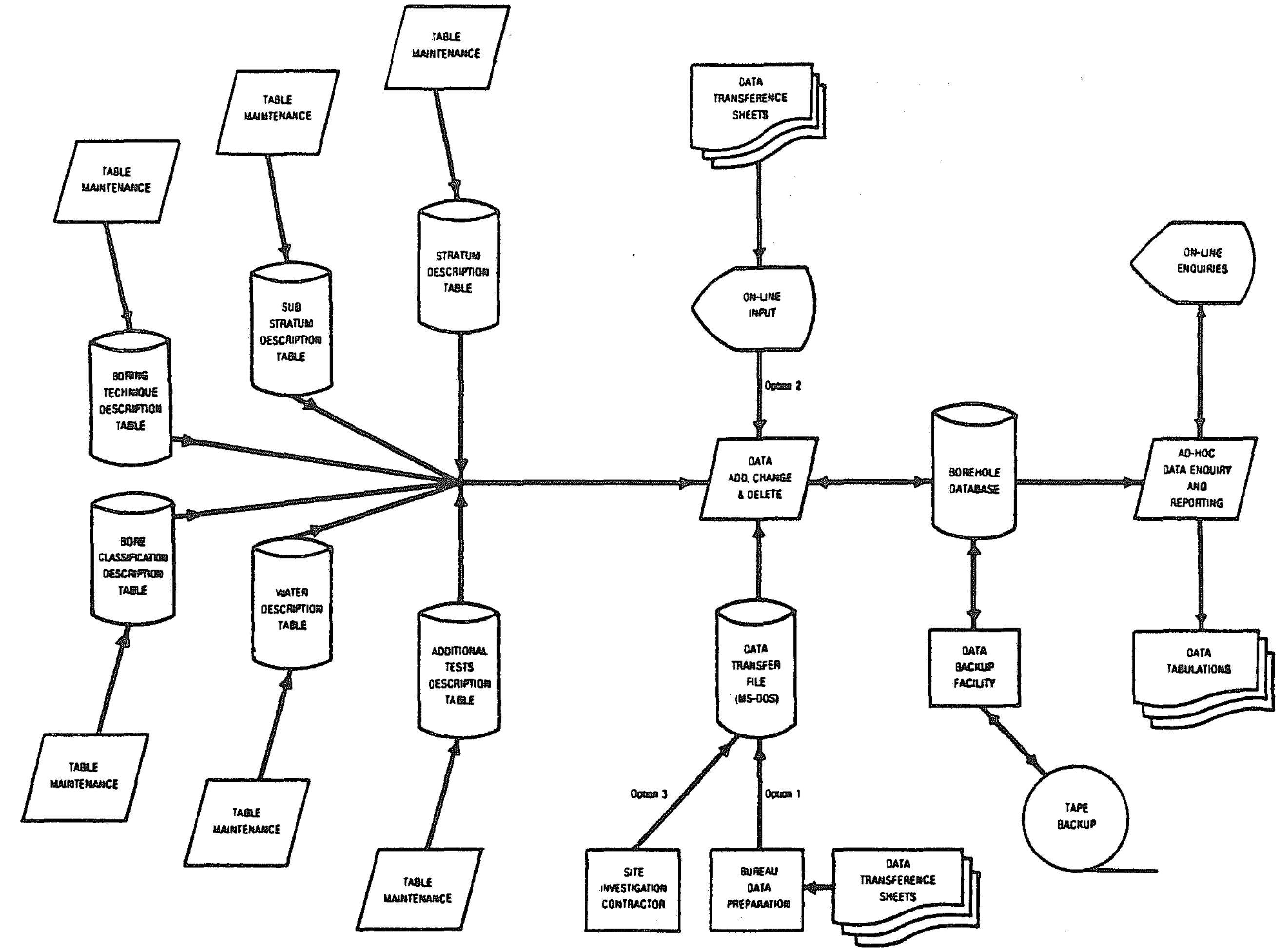


Figure 2. An overview of the GEODASY database system showing the main components in schematic form.

2. Hardware

A computer-based geotechnical data system could be developed equally well on a mainframe, a mini-computer or a micro-computer. For the London Docklands Development Corporation it was decided that certain operating advantages would exist if it was developed to run on an industry standard microcomputer. For example this would provide a degree of autonomy from a centralised system. This has a benefit for a number of reasons. It isolates the large storage commitment for the data and therefore any likely interference with other demands on space from other users. It allows a number of specific peripherals to be supported by the machine which are required for the output of the data in the manner proposed. Perhaps most importantly the envisaged procedure for the use of the system lends itself most readily to the microcomputer.

3. Data Acquisition

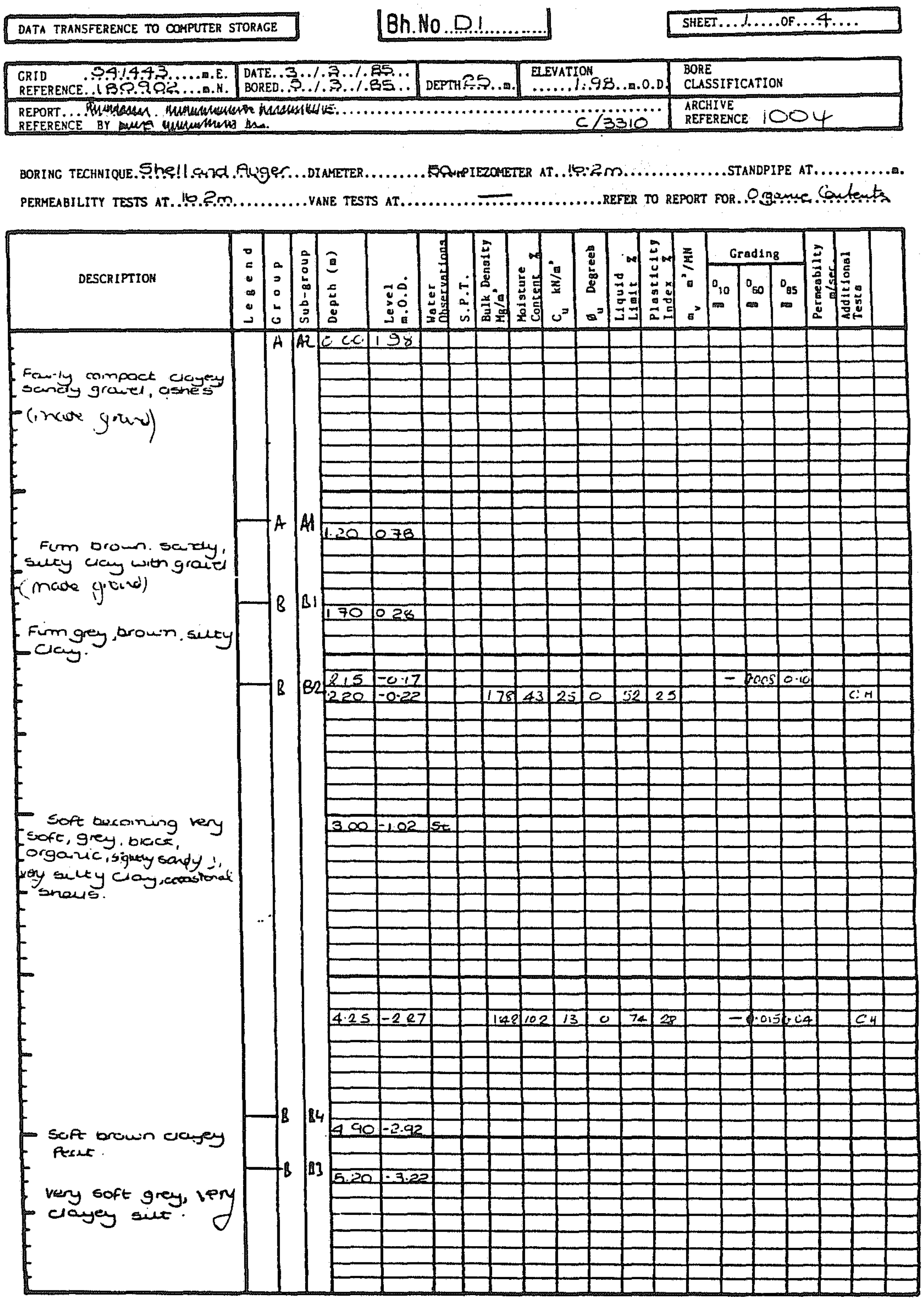
Having developed GEODASY it was necessary to capture the backlog of data that was at the time only in paper archives. The usefulness of the System relies upon the presence of sufficient data in a readily accessible form. The most functional system in the world is of little use without data.

Due to remarkable foresight and in expectation of an eventual storage system the LDDC had been collecting information in a form suitable for easy entry into a database system (Figure 3) for some years before the technology to develop the system was available. This meant that approximately 2,000 borehole records and their associated laboratory test results were able to be loaded onto the database using the services of a commercial computer punching bureau with greater ease and speed than via direct on-line entry methods.

The LDDC is continuing to gather data for its database but has recently changed the means by which this is achieved. Under the terms by which it organises its site investigation contracts the contractor is required to supply the borehole and laboratory test data not only in traditional paper form but also on microcomputer floppy diskette. This is able to be loaded automatically onto the database via a series of controlled validation checks with no additional keying by the LDDC staff. The on-going maintenance of the database is therby ensured at minimal effort by the LDDC.

4. The use of the system for enquiries

An overriding requirement of the system is the


DATA TRANSFERENCE TO COMPUTER STORAGE

Bh.No. D1

SHEET 1 OF 4

GRID REFERENCE 541443 m.E. 180902 m.N. | DATE BORED 3/3/85 – 5/3/85 | DEPTH 25 m | ELEVATION 1.98 m.O.D. | BORE CLASSIFICATION

REPORT REFERENCE BY [illegible] C/3310 | ARCHIVE REFERENCE 1004

BORING TECHNIQUE Shell and Auger DIAMETER 150 PIEZOMETER AT 16.2m STANDPIPE AT ... m.

PERMEABILITY TESTS AT 16.2m VANE TESTS AT — REFER TO REPORT FOR Organic Contents

DESCRIPTION	Legend	Group	Sub-group	Depth (m)	Level m.O.D.	Water Observations	S.P.T.	Bulk Density Mg/m³	Moisture Content %	C_u kN/m²	ϕ_u Degrees	Liquid Limit %	Plasticity Index %	m_v m²/MN	Grading D_{10} mm	Grading D_{60} mm	Grading D_{85} mm	Permeability m/sec	Additional Tests
Fairly compact clayey sandy gravel, ashes (made ground)		A	A2	0.00	1.98														
Firm brown, sandy, silty clay with gravel (made ground)		A	A1	1.20	0.78														
Firm grey, brown, silty clay.		B	B1	1.70	0.28														
		B	B2	2.15	-0.17										–	0.005	0.10		
				2.20	-0.22			1.78	43	25	0	52	25						CH
Soft becoming very soft, grey, black, organic, slightly sandy (?), very silty clay, occasional shells.				3.00	-1.02	St													
				4.25	-2.27			1.48	102	13	0	74	28		–	0.015	0.04		CH
Soft brown clayey peat.		B	B4	4.90	-2.92														
Very soft grey, very clayey silt.		B	B3	5.20	-3.22														

Figure 3. A typical transference sheet used for rapid keyboard entry of the geotechnical data by a commercial punching bureau.

simplicity of its operation by the user. In order to be useful to as wide a range as possible it was necessary to build a system that could be used by even the casual enquirer with minimal instruction. Therefore, GEODASY incorporates a number of standard enquiry and print options that can be used by the user.

Probably the most important attribute of the borehole data is its grid reference which uniquely identifies its geographical position. Most enquirers will want to access the data geographically to establish , for example, what previous investigations have been carried out in their area of interest. The information extracted from the database can be tabulated although of more benefit and impact is the ability to display it graphically. A grahics tablet has therefore been used to digitise base plans of the LDDC area. Data extracted by the enquirer can then be presented on a recalled plan. Data displayed in this form can be manipulated and added to by the use of the keyboard, the graphics tablet or a keyboard mouse.

With the standard options built into GEODASY most casual enquiries can be satisfied quickly. However the System also incorporates a powerful dictionary driven report generator and data retrieval command language. By defining simple English commands the user is able to list data and information in any format required. With this option the usefulness of the system is only limited by the imagination of the user.

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MS-DOS is a registered trademark of Microsoft Corporation. PC-DOS was developed by International Business Machines Corporation. REVELATION is a registered trademark of Cosmos Incorporated. PICK operating system is a registered trademark of Pick Systems.

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