INTRODUCTION

The complex management strategies that operate in today's businesses offer significant challenges to those who design systems for the management of information. Managers today need information that is accurate, current and capable of being shared and consolidated across different business functions. A shift toward end-user computing has brought a growing need to replace aging application software with more effective and more highly integrated products.

Since the onset of the decade, numerous developments have made the job of designing such integrated systems more difficult. First, there have been the pendulum swings between centralized and decentralized data processing modes. Second, a slowly emerging awareness of the efficacy of relational DBMS and 4GL storage and retrieval methodologies has fundamentally altered the way systems developers think about data. Finally, although mainframe processing remains the choice for most large business applications, increased utilization of microcomputers has resulted from dramatic enhancements to PC technology, from an explosion in the availability of powerful microsoftware, and from new approaches to networking.

These developments of the eighties do not come without cost. MIS managers find themselves faced with a plethora of decisions on how to proceed without much guidance on a strategic level. This paper seeks to alleviate some of the confusion by offering a single long-range focus for systems development. The focus—building the system around SAS software—is now equally workable for mainframe and micro designs.

THE NEED TO EXPLOIT CURRENT TECHNOLOGY

Since corporate profitability and organizational effectiveness are tied closely to the ability to respond to changes in the operating environment, the manner in which management functions are computerized, becomes extraordinarily important. Doing business in the late 1980’s is tough. In these days when government agencies must compete for scarce funds, and businesses must be "lean and mean" to compete effectively in a marketplace of ever increasing complexity, management must have up-to-date information with which to make the right decisions to avoid damages or to capitalize on new opportunity.

The fourth generation of software (a category which includes all of the SAS Institute's products) represents a significant improvement over third generation software as a basis for developing computer applications to fulfill these needs. A combination of relational database management systems (DBMS’s), integrated dictionaries and easy-to-use analytical programming languages can drastically cut the time and the cost associated with development, operation and maintenance of software applications.

Nevertheless, many companies and government agencies have yet to make the shift to this new technology. In most cases with which I am familiar, this has been a function of management not fully understanding either what this technology is about or how to proceed in a manner that would minimize expenses and problems associated with the conversion from their current third generation system. Many organizations which have already purchased fourth generation products have yet all of the necessary components for a truly integrated system, nor know how to maximize their systems' potential.

I believe strongly in the idea that an organization must adopt a strategic perspective on information systems if it is to compete effectively in the future. Unfortunately, the very same business conditions that have given rise to the need for more immediate information also have promoted a "reactive" rather than "proactive" orientation toward developing integrated fourth generation systems. Information systems budgets are often the first to be cut in any attempt to increase short-term profitability. But, in the long run, such a reactive approach may have a devastating impact on corporate survivability.

This paper will review salient issues in the development of state-of-the-art integrated systems. I begin with a definition of "integrated system" that is somewhat different than that which is in conventional use. I then provide some reasons for developing such a system, and discuss, in general terms, the form such a system should take. This discussion is relevant to organizations of all sizes, irrespective of the hardware and software configurations currently in use. Next, I discuss the role(s) SAS software can play in such a system, review some common criticisms of SAS software and describe why I feel these criticisms are largely misplaced. Finally, I attempt to peer into the future, and point out how the SAS system can serve as the backbone of strategic solutions to information systems' needs. My recommendations are based on experience in building and customizing integrated systems of various sizes for both commercial and in-house human resource functions. Those systems span the full range of the hardware scale—from PC's to mainframes and were designed for organizations ranging in size from fewer than 200 employees to more than 40,000.

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WHAT IS AN INTEGRATED SYSTEM?

In conventional usage, an integrated system, quite simply, is any system that combines two or more functions (e.g., data-entry and analysis) under a single user interface. Under my definition, an integrated system is one that fulfills information processing and decision making needs at all levels of organizational activity. This includes everything from the processing of transactions to decision support, analysis and planning. Three things distinguish integrated systems from what I shall term "focused systems". First is the diversity in "units of analysis" which, in an integrated system, is great. Second, an integrated system will support a number of organizational functions. Finally, an integrated system will need to deal with a volatile environment in which the types of information requests made will constantly be changing in response to varying conditions.

A good human resource information system (HRIS) provides an example of what is meant by an integrated system under the broader definition:

- It collects information relevant to a diverse set of potential units of analysis (e.g., applicants, employees, dependents, positions, openings, training courses, wage scales, benefit plans, etc.)
- It transcends functional boundaries within a major organizational activity (e.g., payroll, benefits, pension administration, employee recruitment, training and development, performance appraisal, compensation, EEO, human resource planning, etc.)
- It deals with highly volatile information. Human resource information needs are difficult to anticipate and often are affected by factors outside the organization's control.

THIRD GENERATION VERSUS FOURTH GENERATION INTEGRATED SYSTEMS

In one sense, the old-style, third generation management information systems (MIS's) were integrated. All requests for information were passed to a centralized processing department (programming staff). But, being the "only game in town" is about the only reason managers would rely on such a system for decision support today. To be effective, managers need access to all of the information bearing on a particular problem at hand. The information must be current and immediately accessible. Managers must also have direct or indirect access to analytical tools that can quickly be applied to assess the importance and relevance of the information. The third generation management information system is not up to this task.

In response to the need for more current information (and more of it), the Information Center concept was introduced. Made possible partly by the introduction of fourth generation technology and largely by the explosion in popularity of desktop PC's, the purpose of the information center is to allow managers and others who must use information to directly extract and manipulate data from the central database without the assistance of programming staff (Toor and Beekman, 1983). Such systems, of course, must be user-friendly (i.e., designed for use by those not familiar with computer concepts). Consequently, information center systems most often operate on the "menu-driven" principle, though the better ones utilize both menu-driven and command driven modes of application initiation and execution. The idea is that managers and other users should be able to concentrate on getting results, and not waste time bogged down in programming logic or waiting for centralized programming support.

WHY DOES YOUR ORGANIZATION NEED AN INTEGRATED SYSTEM?

In most cases, justification for development of an integrated decision-support system will derive purely from an evaluation of business need and return on investment (Slater et al, 1985). In today's environment, users' requirements are constantly changing. Even in organizations with a strong proactive orientation, managers must react to and make decisions based upon unanticipated events, many of which may be outside the company's control (e.g., fluctuations in interest rates or currency exchange rates, acquisition of new contracts, labor shortages, etc...). This implies a strong need for ad hoc analytical capability, one of the most costly and time consuming functions in the traditional data processing environment.

As more and more organizations realize that SAS software, DBMS's and related fourth generation products can be combined to produce remarkable increases in programmer and end-user productivity, we can expect an even increasing shift toward these systems. In comparison with third generation systems they have used, most companies report significant increases in both volume and quality of throughput with the fourth generation integrated systems. And, along with increased productivity has come reduced applications maintenance and development costs.
In some cases, the initial justification for developing and implementing an integrated system will not be based on cost analyses, but rather in an evaluation of new activities it can support (Torgler, 1983). Thus, the transition from a third generation payroll-personnel package which satisfies only basic functional and reporting needs to one with the analytical capability to evaluate employee-positon, analyze compensation patterns across different classes of employees, and simulate labor force changes can be justified without direct reference to cost. Nevertheless, the ability to exploit these new tools for decision making is itself a competitive advantage that can be translated into a "bottom dollar" evaluation.

WHAT FORM SHOULD YOUR INTEGRATED SYSTEM TAKE

For most organizations, a full software toolkit is necessary for successful applications development and usage. Since no vendor has yet provided the complete range of products needed, MIS managers must seek to integrate various products themselves. SAS software, being one of the most complete and heavily used of the current generation of software tools makes it a logical starting place for centralization of the decision support process. SAS software has been proven in the marketplace as a tremendous improvement over third generation languages such as FORTRAN, COBOL and PL/I. In combination with other products, SAS software can serve as the cornerstone of a system to solve the problems of almost any organization (i.e., regardless of size or available resources).

An integrated information system should, at a minimum consist of the following parts:

1) A full-screen data entry facility with built-in mechanisms for error checking;
2) An appropriate access method for transaction processing;
3) A query/extract language with which to select subsets of the database;
4) A system dictionary to drive subsystem interfaces;
5) A text processing capability with advanced features such as variable substitution and graphics insertion;
6) A generalized report formatter for presentation of quality reports and graphics;
7) A spreadsheet facility;
8) A package containing a wide range of analytical procedures and that can be applied to most routine analytical requirements;
9) An applications development facility that promotes productivity;
10) A code generator to translate panel-captured user requests for reports and analyses;
11) A front end capability to link system components and support and control the user environment.

These eleven components can be divided into three major categories. Items 1-4 are components of data storage and retrieval. Items 5 and 6 are in the realm of reporting and analysis and items 7-9 can be classified as tools for systems development and integration. In the next section, I will evaluate SAS software with respect to its ability to handle system needs under each of these categories.

AN EVALUATION OF SAS SOFTWARE

Data Storage and Retrieval

The most important factor affecting the choice of software to handle data storage and retrieval is the size of the database. When the number of records to be processed is small (e.g., fewer than 1000) and the majority of information queries can be directed at a limited number of variables contained within a single file, then SAS software is a good choice. With virtually unrivaled file handling capabilities, storage of data in SAS datasets can provide small systems all the power and flexibility they need to get the job done well. SAS/FSP® is an adequate tool for development of data entry applications, and it provides all of the necessary mechanisms for formatted full-screen entry and error-checking. It does however fall considerably short of other software in its ability to query the database and quickly locate records for updating. In addition to using locate commands that are somewhat cumbersome for the end user, SAS/FSP®'s reliance on primitive sequential access techniques to retrieve observations is an important negative (see Ingram and Rothrock, 1984).
In a DBMS, data are maintained in an integrated database comprised of many files or relations. The DBMS enables multiple users to have rapid "write-capable" online access to case data. Whereas SAS (except under certain conditions to be described later) processes data sequentially, DBMS's utilize indexed write access to a SAS dataset at any given concurrent write access by multiple users. Operate as efficiently as it eventually might. May, eventually eliminate this as a cause of concern. At present, it does not appear to operate as efficiently as it eventually might. One probably can expect some type of "queuing facility" in future versions that will eliminate the need for waiting among users attempting to update a single record at the same time.

As time passes, the other objections to SAS software become less salient. Many fears of certain options on the INFILE and SET statements currently permit indexed access that meets the needs of certain limited applications. And, if true database capabilities are required, it must be recognized that SAS interfaces to many mainframe DBMS's are available. On the one hand, there are the interfaces supported by the SAS Institute (for IMS, SQL, DB2 and SYSTEM 2000®). And, articles in recent issues of the proceedings report users' successful experiences with interfaces to other mainframe products such as MODEL 204, INQUIRE, RAPID and TOTAL (e.g., see Merline, 1986; Smith, 1986). Finally, according to several of my consulting associates, promising products are commercially available for ADABAS and RMIS.

Although DBMS interfaces to SAS are for the most part restricted to mainframe systems, progress has been made toward solving the problem on PC's as well. Landon (1986) describes a SAS-DBASE3 interface that appears to perform admirably. And, I predict that within the next year, numerous other such PC based interfaces will be developed and made available.

At present, all of the DBMS interfaces to SAS require users to execute two-steps before processing data within the SAS system. First, data must be extracted from the database. Then, it must be read into a SAS dataset. However, within a year or so, SAS users should be able to produce reports and conduct analyses using SAS procedures directly from the DBMS databases. Look for this capability to be supported first for System 2000, IMS, SQL and DB2. But, very soon thereafter, this next generation of interfaces to SAS should become a generic feature.

In some cases, the database problem can be solved very inexpensively with other approaches. Parrow (1984, 1985) describes an approach which uses ISPF tables and data passing routines based on formatted ASCII output that is very effective for routine applications. Info Tech's DS/DB product provides a means of maintaining indexed access and query language functionality while storing data in SAS datasets. Of particular interest with respect to these latter solutions, is that they are presently applicable to both mainframe and PC systems.

**Reporting and Analysis**

In assigning grades to SAS under this heading, one has to give A's for flexibility, power, and support and perhaps, a B+ for ease of use. Various SAS procedures (particularly PROC PRINT and PROC TABULATE) provide a powerful, generalized report formatting capability, especially when used in combination with sorts, and formatting options. SAS/GRAPH®, although not as easy to use as some other commercially available graphics packages that have been designed for simplicity, is still the most powerful and most popular of the mainframe graphics tools. Moreover, like other SAS products, it is constantly being improved to satisfy the increasing diversity of and demand for executive level decision support.

Naturally, not all reports will lend themselves to generalized solutions. To accommodate this, the SAS system provides unlimited flexibility with the FILE and PUT statements of the DATA step. Although programming with these tools requires more sophisticated programming skills than most end users are willing to develop, it is really not that much more difficult to produce user formatted reports in SAS than it is to request them via other fourth generation languages. And, the important thing to remember is that such reports can be produced quickly by those with a modicum of SAS experience, and if needed routinely, can be hard coded and associated with a menu option for future end user requirements.

With respect to analysis, you just don't find anything better than SAS. Base SAS alone answers the need for the great majority of the analysis requirements of major corporations. Coupled with SAS/STAT®, SAS/ETS®, SAS/OR®, SAS/QC® and an extensive Supplemental Library of user written PROCs, there are very few analytical strategies germane to corporate decision making which cannot be implemented directly without top-level programmer involvement. In those cases where an analytical need is not addressed by the powerful facilities of SAS/IML® often can come to the rescue. Finally, if all else fails and the analysis must be programmed in a third generation language, your programmers can write these routines in C and later recast them in
the form of SAS PROCS so that end users can
later answer all of their analysis needs with a
fully integrated system utilizing a standard
language and syntax.

In sum, SAS provides the ability to read
data stored in virtually any format, manipulate
it using the relational processing capabilities
inherent in the SAS data step (MERGE, SET
and UPDATE) and analyze it using the largest single
compilation of statistics and graphics
available within any single software system.

Systems Development and Integration

Prior to the introduction of the
production version of SAS/AF, the SAS MACRO
facility was the sole means for SAS users to
develop end-user systems written entirely in
the SAS language. By providing the capability
to pass arguments across job steps (and even
across jobs) the MACRO facility first made it
possible to write menu-driven systems that
would conditionally execute SAS statements.
Although these systems were relatively
difficult to write, they provided
unsophisticated users access to powerful
capabilities in the SAS data step without
having to learn SAS language and syntax. The
MACRO facility still stands as an excellent
method for optimizing usage of SAS in a
production environment, and its value has
actually increased with the presence of SAS/AF.

The development of SAS/AF marks
significant progress in the quest for a SAS
based application development tool that could
doubly serve to structure a user's dialogue
with the application environment. Yet although
this facility represents an important step
forward, it falls short of the capabilities of
the leader of the pack (ISPF). SAS recognizes
this of course and has responded by improving
its own compatibility with ISPF (via SAS/DM1®).
But I think you can also expect to see
improvements in SAS/AF itself.

One thing that SAS/AF and SAS/FSP do
extremely well is provide a convenient and
powerful means for prototyping applications.
Although cumbersome to an experienced
programmer, they are much more easily used by
sophisticated end users in quickly prototyping
applications that will be reviewed and
potentially modified prior to implementation.
The inability of SAS/AF based systems to
directly call on non SAS software is a
disadvantage, but probably a temporary one.

COMMON CRITICISMS OF SAS SOFTWARE

Over the years, numerous complaints have
been lodged against SAS software. These
complaints really seem to be confined to three
major categories: lack of efficiency and poor
documentation. To some extent, these
claims are valid, but they also reveal a lack
of understanding of the full capabilities of

the SAS system as well as a general laziness
with respect to learning what is necessary to
do the job best.

As has already been discussed, SAS is
relatively inefficient in its default mode for
data storage and retrieval. But, methods for
improving this efficiency are available and
well documented (e.g., see Roberts et al, 1985;
Howard and Rabb, 1986). With regard to program
execution, SAS is also inefficient compared to third generation languages. But
such inefficiencies are largely irrelevant
except in cases of routine heavily computer-
intensive applications run on a frequent basis.
For ad hoc requests, the simplified programming
structure of the SAS language means
considerable savings in programmer time, which
after all, is more costly than computer time.

For routine reports run regularly, SAS
still affords significant savings if those
reports or analyses often require changed
parameters. And, even when reports or analyses
are fixed, differences between SAS and more
efficiently executed programs often are
negligible when the analytical requests are not
terribly complex. Does the difference between
45 seconds and a minute really matter to those
that need the information?

The other major negative attributed to SAS
products involves the quality of its
documentation. The fact is, if you've ever
read a copy of the SAS72 manual, you probably
think that the present documentation reads like
a paperback novel. Nevertheless, there is some
validity to the argument. The explosive growth
of SAS Institute Inc. and its software product
lines has led to documentation which has grown
in bulk but not necessarily in clarity.
Incremental enhancements in the SAS base
and statistics products have led to manuals which
do not clearly communicate the underlying
simplicity of the system. As Blank (1984) has
noted, SAS Users Guides offer little guidance
to enable new users to distinguish between
fundamental concepts and those of highly
specialized interest.

Nevertheless, when evaluating SAS system
documentation, one cannot forget that the end-
user documentation used most frequently is that
which is in the form of online help facilities.
The latter, available with the Display Manager
and other SAS products, compare favorably with
others I have seen in packages of all types.
Moreover, we must recognize that training will
reduce the need for documentation that is not
of the "reference manual" type. SAS Institute
offers excellent training courses and effective
video-based training.

The final criticism to be addressed
involves user-friendliness. Back when SAS
first began to penetrate the broad corporate
market for information systems, end-users did
in fact have problems using SAS software. In
comparison with such 4GL's as FOCUS, SAS was a
"bear" to learn. Few companies had adopted

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menu-driven, executive-proof systems and few users cared to take the time and give the effort to become proficient in generating their own reports via the data and PROC steps of batch jobs. With the widespread use of menu-driven systems today, an entire base of objections has been eliminated. Whether via macros, ISPF, SAS/AF, or other facilities, the incorporation of code generator technology into end-user computing makes this a dead argument. While someone must still write the complex programs that satisfy end user requests, these individuals (often third generation language programmers) have never objected to SAS software on this basis. In fact, the reason SAS became popular in the first place was due to how much it simplified programming tasks as compared to the traditional programming languages.

A LOOK TOWARD THE 1990'S AND BEYOND

Looking ahead, we might ask --- what does the future hold for integrated systems development and operation? Although a definitive answer is hard to give, three major developments appear to be virtually sure bets.

First, in an evolutionary mode, we can expect continued rapid declines in the cost for computer hardware and software. And, unlike other combination goods and services in the marketplace, the lower cost will be accompanied by higher quality and greater utility. The cost of memory and of disk storage should continue to drop while hardware processing speed and capability increases at an increasing rate.

The other two changes are more revolutionary than evolutionary. These include adoption of strategies for truly distributed DBMS and for expert systems (commonly discussed under the heading "Artificial Intelligence"). Distributed DBMS products (such as Oracle's SQL*) are at the forefront of an effort to maximize systems' "connectivity". The promise eventually is to make it possible for users on one machine to access data stored on any other machine (regardless of type, manufacturer or operating system) and to be totally unconcerned with where the data resides or in what type of DBMS it is stored. To position yourself for advantage in this new market means developing software that is highly portable. That SAS Institute Inc. sees portability as a strategic issue is simply illustrated by its recent acquisition of Lattice Incorporated. Lattice, a supplier of an excellent C language compiler, allows SAS complete compatibility with mainstream, minicomputer and PC systems. Expect SAS Institute to be among the leaders in incorporating distributed DBMS technology into its product lines.

The third area of change in the future, as noted above, is in the realm of expert systems. Programming expert systems requires exceptional skill and considerable computer resources. Consequently, those that develop these systems wish to achieve maximum utility in the most efficient possible manner. Those who write expert systems' needs simple commands to accomplish basic tasks so that they can concentrate on the expert portions of the system. This makes SAS software a logical choice as the language of expert systems prototyping and possibly even final development.

THE STRATEGIC VALUE OF SAS SOFTWARE

This paper began with a discussion of the need to take a strategic view of future information systems needs. Such a strategic view implies taking action today based upon long range goals and our best bets on what kinds of software can help the organization to achieve those goals. After reviewing current software offerings in the area of data storage and retrieval, data reporting and analysis and applications development/systems integration, we have seen that SAS software is an excellent choice for today's needs. The SAS system, being one of the most complete and highly used of fourth generation software is a logical candidate for providing the skeletal structure of a fully integrated system.

Those areas in which SAS software can be legitimately criticized (storage and processing efficiency) are rapidly becoming less important as hardware technology improves. Conversely, those areas in which SAS software excels (e.g., flexibility, power, portability, integratability and user support) are precisely the areas which will determine software acceptability in tomorrow's environment. SAS software should be the vehicle of choice to carry business and government computer systems into the future.

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REFERENCES

REFERENCES (CONTINUED)


