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ABSTRACT

Based mainly on interviews conducted at 14 federal agencies that had completed or were involved in software conversion projects, this publication provides guidelines for the entire process of software conversion. This is defined as the transformation, without functional change, of computer programs or data elements to permit their use on a replacement or changed data processing or teleprocessing system or service. It is noted that a conversion involving non-code-compatible machines is assumed since this situation produces the most problems. Following introductory information, six phases of the conversion life cycle are described: project initiation; the conversion requirements phase where studies and analyses are conducted to identify agency requirements and cost considerations; the conversion planning phase; the conversion preparation phase; the actual conversion phase; and the post-conversion phase. The objectives, activities, and management considerations involved in each phase are outlined. Appendices include a 51-item bibliography; a list of 23 conversion directives, standards, and other references produced by the federal government; an extensive methodology for software conversion costing; 11 case studies of software conversion projects at federal agencies; and a 27-item glossary. (ESR)

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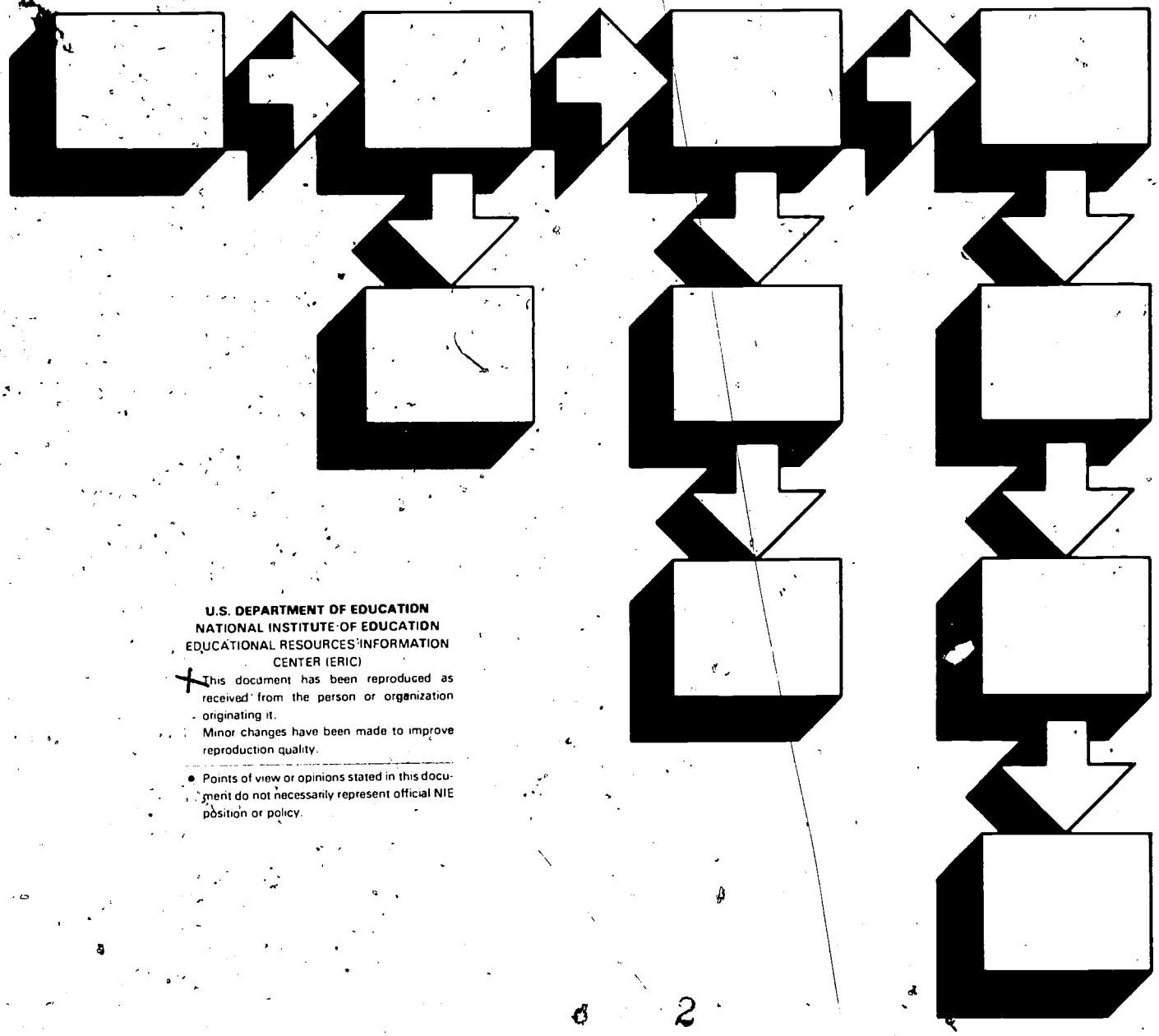
Guide to Software Conversion Management



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Guide to Software Conversion Management

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GUIDE TO

SOFTWARE CONVERSION MANAGEMENT

John J. Mayers
Neil Katz
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ABSTRACT

This guide was developed to help Federal ADP managers understand the entire process of software conversion and manage that process more effectively. Software conversions have life cycles with distinct phases. A better understanding of the conversion process and its associated costs, should help managers to plan and execute more software conversions more efficiently, effectively and with minimum operations disruption to Federal agencies. Although extensive references were consulted in preparing this guide, the most important sources were interviews conducted at fourteen Federal agencies that had completed or were involved in software conversion projects.

Keywords: Conversion costs; conversion planning; project management; conversion requirements; conversion preparation; conversion execution; documentation.

SECTION 1

INTRODUCTION

1.1 OVERVIEW

Previous studies of Federal conversions conducted by the General Accounting Office and the National Bureau of Standards revealed that there were management-related problems in the planning and execution of software conversion (23, 42, 43). In preparing for this guide interviews were conducted at fourteen Federal agencies. Managers were consulted who were involved in planning, preparing for, executing, or assisting in software conversions. These interviews revealed that the management problems addressed by GAO and NBS persist, because:

- o The total software conversion process is not well understood,
- o This lack of understanding leads to inadequate planning, preparation and a failure to apply practical management procedures at the right time to control the conversion process,
- o Software conversion costs and resources are not totally understood, considered or applied.

The goal of this guide is to provide information which can be used by Federal ADP system managers to resolve management problems and to accomplish all aspects of a software conversion in a more expeditious and cost-effective manner. Specifically, this guide is to provide assistance in the following areas:

- o Understanding software conversion,
- o Planning,
- o Project control,
- o Scheduling,
- o Staffing,
- o Application of resources.

There are many references which apply to software conversion. However, no reference treats the entire software conversion process from start to finish. In this regard, this guide is unique. It provides managers a perspective and description of software conversion, from project initiation through post conversion. It facilitates better understanding of the conversion process and thus, better management. It is not intended for this guide, however, to replace

other obligatory or useful directives and references. This guide serves as a supplement to other references and facilitates their application to specific agency conversions.

Software conversions in the Federal government range from very large projects taking upwards of five years to complete to very small projects lasting a matter of months. The conversions, which involve both code compatible machines and non-code compatible machines, vary in complexity. Further, Federal agencies differ considerably in size, organization and function and in their use of ADP. It is not feasible to develop a guide which covers every software conversion possibility. Consequently, this guide does not dictate a single method for accomplishing software conversion; rather it describes a broad range of procedures, techniques, considerations and activities, which if selectively implemented, will assist managers in minimizing the negative aspects of software conversion upon an agency's ADP organization, information systems and system users. It should provide managers the insight necessary to tailor conversion planning and execution to actual agency needs.

Additionally, the guide stresses many of the problems common to conversion efforts. These include not only short term problems specific to a conversion such as inadequacies in project management, but also longer term problems which have an impact on conversion and other software management considerations as well. An example of the latter is failure to use standardized languages. Use of non-standard languages, not only increases difficulty in conversion but also limits the ability to transport that software to another agency which might desire its use.

1.2 GUIDE QUALIFICATIONS

1.2.1 SOFTWARE CONVERSION-HARDWARE REPLACEMENT

Most software conversions result from the need to replace hardware systems because of processing saturation or equipment obsolescence. While there are other reasons for software conversion (e.g., transfer of a mission from one agency to another with a concomitant transfer of information systems), this guide is oriented towards conversion stemming from hardware replacement. Further, this guide assumes a non-code compatible conversion since this conversion condition produces the most problems and thus the most management lessons.

Users of this guide are cautioned that hardware replacement has only been addressed to support discussion of software conversion. From a total agency ADP standpoint there are many more hardware issues of interest to management. While this guide provides a limited discussion of some hardware replacement problems, a manager who is interested in both software conversion and hardware conversion must consider sources of information other than this guide.

1.2.2 SOFTWARE CONVERSION LEVEL OF EFFORT

This guide is oriented towards a medium- to large-scale effort converting non-data base management systems (DBMS), business applications. Since Federal system conversions range from very small to very large and include other types of software such as DBMS, scientific, modeling, and operating systems, managers may need to modify this guide to apply to specific agency requirements.

1.2.3 LEVELS OF MANAGEMENT

There are essentially four levels of management involved or interested in software conversion.

- o External Management - This management is at the appropriations or approval level, e.g., Office of Management and Budget.
- o Top Management - Internal management at the department level exercising broad approval and policy, and program roles.
- o Technical - Middle management involved with overall data processing, planning, and operations, e.g., manager of a data processing activity or ADP manager.
- o Technical Supervision/Staff - That management responsible for specific data processing operations, e.g., the supervisor of systems analysts and programmers.

This guide focuses on management activities at the technical management and technical supervision/staff levels. These are the levels where exceptional management skills must be applied to achieve successful conversions.

1.2.4 AGENCY STRUCTURE

This guide assumes a hypothetical agency structure (see Figure 1-1).

- o Top managers are those whose day-to-day interests concern overall agency functions and who exercise broad approval and policy and program roles. Nevertheless their support and understanding of software conversion issues are important to the success of any conversion (18).
- o Functional users are the users of agency information system (e.g., personnel, finance). They assist in software conversion, particularly in parallel testing.

- The ADP manager is the manager of all agency data processing activities - both hardware and software.

- The hardware and operations manager is responsible for day-to-day machine and communications operations.

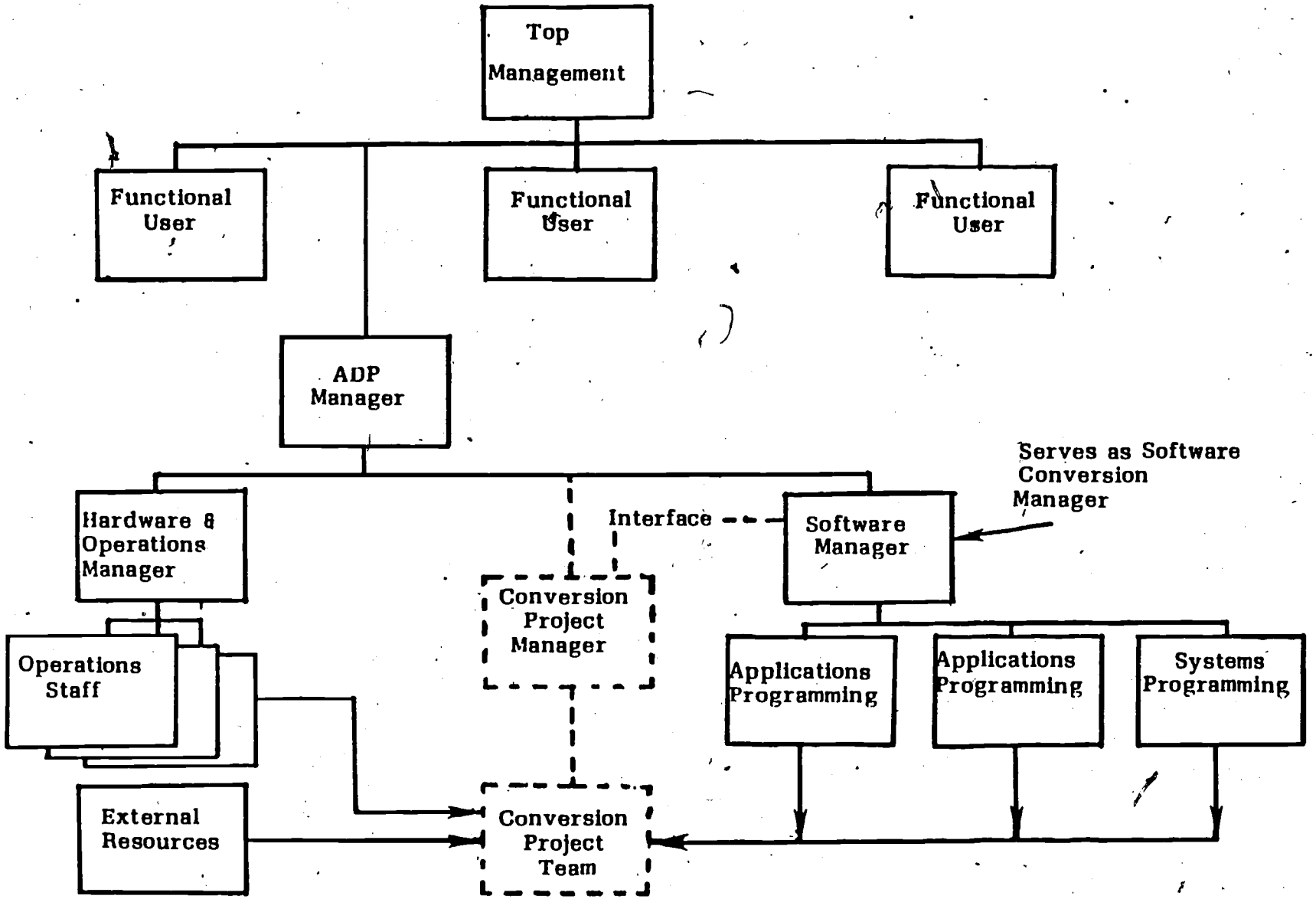
- The software manager is responsible for day-to-day applications, programs development and maintenance as well as systems programming. During software conversion this manager has an added, paramount interest in conversion activities. In the post-conversion phase this manager also ensures that post conversion plans and activities are accomplished. Thus, this manager has a strong coordination function with the conversion project manager.

- The conversion project manager is assigned full-time during the software conversion process. After conversion is completed the project manager returns to normal duties associated with day-to-day responsibilities. On a large conversion project there may be a full-time project management team.

Many conversion problems result because of lack of understanding of conversion management issues on the part of upper level management. It is to a software conversion manager's advantage to achieve as much software conversion project visibility as possible in order to effectively compete for management attention and resources. In this regard the software conversion project manager has been placed directly under the ADP manager in order to illustrate the need for high level visibility.

1.3 HISTORY OF SOFTWARE CONVERSION

Software conversion is generally viewed in the Federal ADP community as a traumatic and disruptive experience, to be avoided as long as possible, endured when necessary, and forgotten as quickly as possible. However, software conversions are common in the Federal government. Hardware systems are replaced on an average of every seven to eight years (23). The information systems processed on this hardware system commonly have a much longer life span, particularly major applications supporting such functions as finance and accounting, personnel, and payroll. This means that conversion is a historical step rather than an aberration in an information system's life cycle. If it is viewed as a recurring, historical event, management practices can be applied to improve conversion as they are applied to improve other software processes in the life cycle.



SOFTWARE CONVERSION ORGANIZATION

Figure 1-1

1.4 SOFTWARE CONVERSION IN THE INFORMATION SYSTEM LIFECYCLE

The traditional and well understood model of an information system's life cycle is depicted in FIPS PUB 38, Guidelines for Documentation of Computer Programs and Automated Data Systems and FIPS PUB 64, Guidelines for Documentation of Computer Programs and Automated Data Systems for the Initiation Phase (22, 25) (see Figure 1-2). If conversion is acknowledged as part of the information system's life cycle, it could be placed in the software life cycle's operations phase (see Figure 1-3).

Examination of the activities or processes which constitute software conversion reveals that there is a conversion life cycle imbedded in the overall information system's life cycle. This software conversion life cycle, itself, has distinct phases (see Figure 1-4).

- Project Initiation - The phase in which management acknowledges software conversion is a distinct possibilty in the near term. Managers determine if conversion must be accomplished or if feasible alternatives exist (e.g., improving the existing hardware system capacity, shifting workload to another computer, or improving the efficiency of existing software).

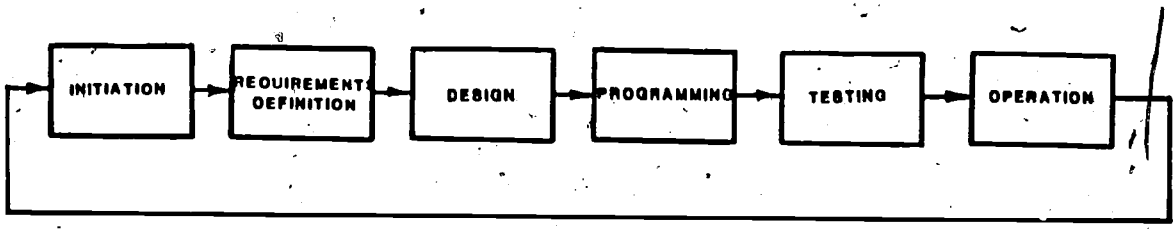
- Conversion Requirements - The phase in which, after determining that conversion must be accomplished, studies and analyses are conducted to identify all agency conversion requirements and cost estimates in detail.

- Conversion Planning - The phase in which conversion details are translated into detailed conversion plans.

- Conversion Preparation - During this phase all preparation activities leading to actual software conversion, itself, are conducted.

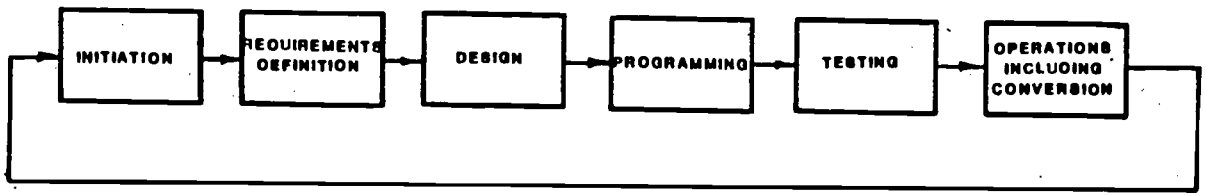
- Conversion Process - The phase during which software is actually converted.

- Post Conversion - During this phase the conversion project, per se, ends. Long-range planning is conducted for the next conversion. Management also has the opportunity to improve the next conversion by implementing practices and measures which are conducive to efficient conversion. The later stages of the post conversion phase eventually lead to the next project initiation phase.



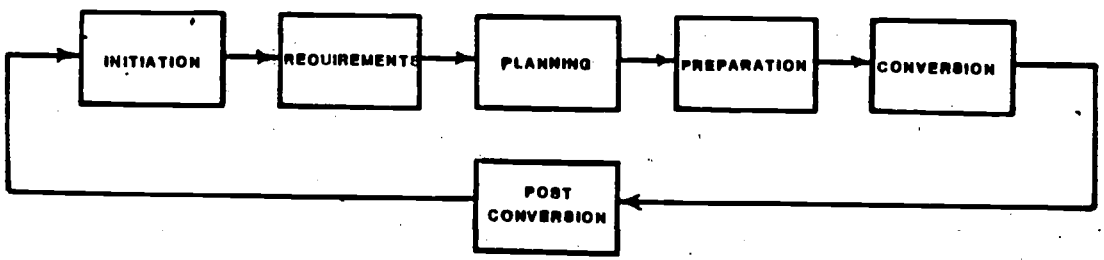
SOFTWARE LIFE CYCLE

FIGURE 1-2



SOFTWARE LIFE CYCLE

FIGURE 1-3



SOFTWARE CONVERSION LIFE CYCLE

FIGURE 1-4

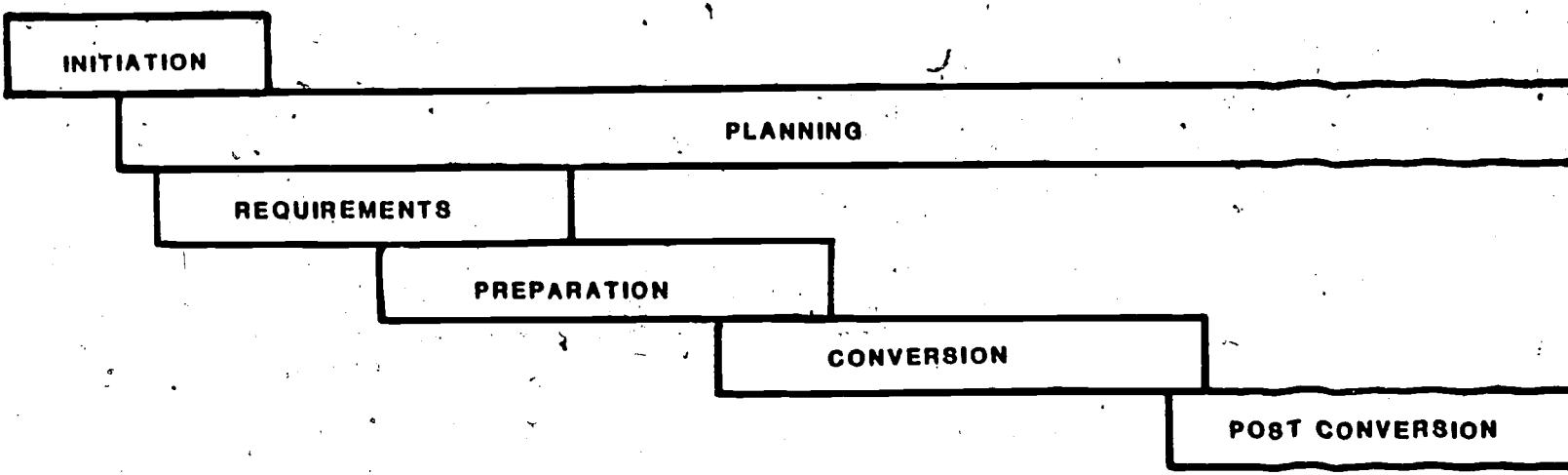
The phased approach of viewing software conversion provides the structure for this guide. However, in an actual conversion many of the activities associated with each phase proceed in parallel (see Figure 1-5). For example, this guide treats planning as a phase although planning is a continuous process. Likewise, while conversion requirements are being developed, preparation activities can be ongoing. Similarly, some software conversion may commence before preparations are finished. The reader or user of this document is asked to keep in mind that the sequential, or phased approach to this guide presentation must be tempered with the understanding that different activities also proceed in parallel.

1.5 PROJECT INITIATION PHASE

This is the phase in which management determines that software conversion is a distinct possibility in the near term. A conversion project manager is appointed and a small project team is assembled. A feasibility study is accomplished to determine if alternatives to conversion exist. If the most feasible alternative is procurement of new hardware, preliminary planning commences. In addition to the feasibility study other studies may be performed (e.g., to satisfy the requirements of Office of Management and Budget (OMB) Circular A-76, Policies for Acquiring Commercial or Industrial Products and Services for Government Use and OMB Circular A-109, Major Systems Acquisition).

There are two management pitfalls to avoid in this phase: failure to appoint a full time project manager with the authority and responsibility to complete the initial planning and manage the conversion effort from start to finish, and failure to start studies and planning early. Many conversion projects are delayed while inadequate plans are strengthened or experience slippages later in conversion due to planning oversights.

Key top management decisions are appointment of a project manager, approval of feasibility and other studies as required (e.g., OMB Circulars A-76 and A-109).



SOFTWARE CONVERSION PHASE RELATIONSHIPS

FIGURE 1-8

1.6 CONVERSION REQUIREMENTS PHASE

After approval of the feasibility study, the project manager and project team develop the details necessary to completely plan the conversion. Alternatives to many conversion activities (e.g., choosing specific automated conversion tools) are decided on a cost-effective basis.

The project manager also develops a software conversion study in this phase which is used to support an agency procurement request (APR) submitted to the General Services Administration (GSA) for hardware procurement. This study must be well constructed and carefully costed. It is particularly important to examine software conversion costs from a standpoint of converting to code compatible versus non-code compatible hardware. Generally, cost avoidances can be high in a code-compatible conversion, but this approach must be fully justified and supported.

In addition to the software conversion study, other studies initiated in accordance with OMB Circulars A-76 and A-109 may be ongoing and require input.

It is important to address security and privacy requirements in this phase. These tend to be overlooked from a systems standpoint but are extremely important. Incorporating security and privacy features into software during conversion is relatively straightforward if considered and planned well in advance.

The major management issue in this phase is maintaining continuity of the project manager and project team to allow them to develop the software conversion study and the details necessary for thorough planning.

The key management decision is approval of the software conversion study.

1.7 CONVERSION PLANNING PHASE

As the detailed requirements are developed, they are converted into conversion plans to support staffing, acquiring conversion contractor support, locating the conversion project team, acquiring necessary conversion facilities such as terminals, training, and accomplishing the actual conversion. Tracking mechanisms are also developed to keep management apprised of conversion progress. If a fully competitive hardware selection is in progress, planning must remain flexible until the target hardware is known. The conversion project manager maintains close coordination with agency personnel involved in hardware acquisition in order to gain early insight of planning impacts stemming from acquisition decisions.

The key management decision in the conversion planning phase is approval of all conversion plans necessary to complete the conversion.

1.8 CONVERSION PREPARATION PHASE

After conversion plans are developed, preparations are made for concentrated conversion of software. Preparations should be complete prior to conversion to preclude interruptions and wasted effort. Major preparation activities include assembling and training the conversion team, developing or obtaining conversion tools, installing equipment, obtaining conversion facilities, developing test data and contracting for conversion support. Tracking of conversion preparation plans ensures that schedules are met.

A major management concern in the conversion preparation phase is dealing with unforeseen problems such as unanticipated personnel losses and outside impacts such as budget cuts. Plans must remain flexible to accommodate these problems.

The key management decision in this phase is approval to proceed with the conversion.

1.9 CONVERSION PHASE

During this phase software is converted. Unit, system and parallel testing is conducted and operational systems are accepted by the information system users.

The critical management issues are dealing with unforeseen problems to keep the conversion on track, monitoring contractor performance for compliance with Statements of Work and ensuring that established agency software standards are met and documentation is produced.

The conversion phase ends when the last converted system is accepted by the functional user. A key management decision in this phase deals with accepting software which may not have completed parallel testing (e.g., it may not be practical to parallel test year-end reporting). Considerable risk is removed if the agency has developed and maintained good test data, and unit and systems tests have been successful.

1.10 POST CONVERSION PHASE

The first activities of the post-conversion phase involve disbanding the conversion project team and reorganizing the agency software operations into a normal, day-to-day environment. The project manager should conduct a post-conversion study and assess and record the entire conversion experience. Completion of activities to settle the staff in a normal software environment and the post-conversion analysis and assessment complete the conversion project. This post-conversion analysis and assessment has much utility in that it provides a historical reference of lessons learned, that may be applied in future conversions. It also facilitates planning for the next conversion. This planning should begin immediately and should continue until the next conversion.

In addition to planning, agency software standards should be enforced during the post conversion phase. Use of these standards will make the next conversion easier. Software security and privacy requirements, applied in a routine systematic fashion, will reduce the chance for oversight in a crisis conversion environment.

The critical management issues in post conversion are completing the post conversion analysis and assessment, developing and maintaining conversion planning, and ensuring that software is developed and maintained to high technical standards.

The key management decision in the post conversion phase is approving the post-conversion plan. This terminates the conversion project.

1.11 APPENDICES

The remainder of this guide follows the phases of the conversion life cycle presented above. Appendices to the guide include:

BIBLIOGRAPHY

Appendix A is the bibliography which was used in developing this guide.

CONVERSION DIRECTIVES STANDARDS AND REFERENCES

Appendix B contains a list of directives and references that are applicable to software conversion. They are recommended to be part of any software conversion manager's library.

SOFTWARE CONVERSION COSTING

Appendix C contains a costing methodology that managers can use to develop software conversion cost estimates. It can be used in the feasibility study during the project initiation phase, the software conversion study to support the agency procurement request, agency budgets, and to support any other cost requirements.

CASE STUDIES

Appendix D contains software case studies that were developed from actual agency experiences. They provide additional insight into software conversion's management issues.

GLOSSARY

Appendix E contains a glossary of terms used in this guide.

SECTION 2

PROJECT INITIATION PHASE

A point is reached in every information system's life cycle where conversion is considered in detail. The causes of conversion vary but are usually related to a real or perceived need to replace hardware. Eventually managers realize that software conversion is no longer an event to be faced at some undetermined time in the distant future, but a condition that is likely to occur and that requires initial but definitive consideration and planning.

Prior to any extensive commitment of resources to support a full scale software conversion, a feasibility study is required by General Services Administration 41 CFR Part 1-4 , to firmly establish the need for a conversion effort. There may be viable alternatives to a conversion, such as keeping the present computer system running for longer periods of time (e.g., 3rd shift, weekends), reducing the workload by identifying and cutting nonessential processing, or distributing some of the workload to other computers.

In addition to providing decisive information on whether or not a conversion is necessary, preliminary planning provides management early insight on the magnitude, direction, resource requirements, and cost of the software conversion project.

The time associated with project initiation activities, especially the planning, the estimating and statistical development, and conduct of the feasibility study should not be underestimated. Two to three person years of effort over six months could be required for a medium to large scale conversion.

A positive attitude toward conversion should be developed in the software staff. Rather than viewing conversion as a disruptive process, conversion can be approached as professionally challenging, an opportunity to broaden professional skills, and to exercise initiative in a dynamic environment. Conversion also offers an opportunity to upgrade the status of agency software to high technical standards. For example, old inefficient programs can be rewritten in standard languages using modern software engineering techniques. Documentation can be updated and made current. Unnecessary or outdated code can be eliminated.

2.1 REASONS FOR CONVERSION

There are many reasons for software conversion. Each reason has different effects on agency software conversion processes and management involvement.

- Hardware Processing Limits: Computer systems' saturation is the normal cause of software conversion. Hardware systems are commonly installed and continually upgraded to accommodate agency information systems as they are designed, implemented and enhanced. Eventually the point is reached where the hardware capacity for expansion no longer exists, information systems no longer are responsive to functional user needs, and little or no hardware resources are available for new application program development. In unusual cases, primarily due to poor planning, hardware systems upon installation, are expanded to capacity in a matter of months. Commonly, however, hardware systems last approximately eight years before capacity limitations cause replacement. In the normal case, software managers should be able to anticipate conversion well in advance through analysis of trends and have ample time to take all actions necessary to initiate conversion in an orderly fashion.

- Change in Missions and Functions: Federal agencies operate in a dynamic environment. Missions and functions can change as a result of new Federal laws and programs, and as a result of agency consolidations and reorganizations. As established agencies gain additional missions and functions, their information requirements increase. These increased information requirements result in new demands for information systems which ultimately lead to hardware saturation. However, in the case of hardware saturation caused by mission and function changes, conversion can be precipitated in a much more dramatic and shorter time frame than as a result of saturation due to normal systems growth. Thus, when mission and functions change, software managers usually have less time to initiate software conversion projects.

- Operational Requirements: Retaining existing application system software may no longer be operationally viable. For example, vendor software may no longer be supported by the vendor. The existing software, without vendor maintenance support, may not be useful for new systems development and existing system enhancements. Rather than retain obsolete, unsupported software for some systems and introduce new software for new systems, with attendent requirements for increased and different training and documentation, agencies may convert all software to a viable language. Another example of conversion caused by operational requirements has to do with old software

running in an emulation mode. Long-term emulation processing is generally inefficient for software that is frequently used. Managers may decide from a cost effective, as well as operational standpoint, to convert software running in an emulation mode.

- Technology: Some Federal computer systems do not become saturated and are useful for many years. Eventually, however, their age or lack of technological sophistication dictate their replacement. Vendors or manufacturers eventually discontinue maintenance and other support to old hardware. In other cases, even though support is still available, operating costs associated with operations' staff, power, and air conditioning may be unacceptable. Modern hardware and software may support the same functional applications at considerably reduced operational cost.

2.2 PROJECT INITIATION OBJECTIVE

The objective of the project initiation phase is to conduct the preliminary planning and studies to determine whether a conversion should be undertaken.

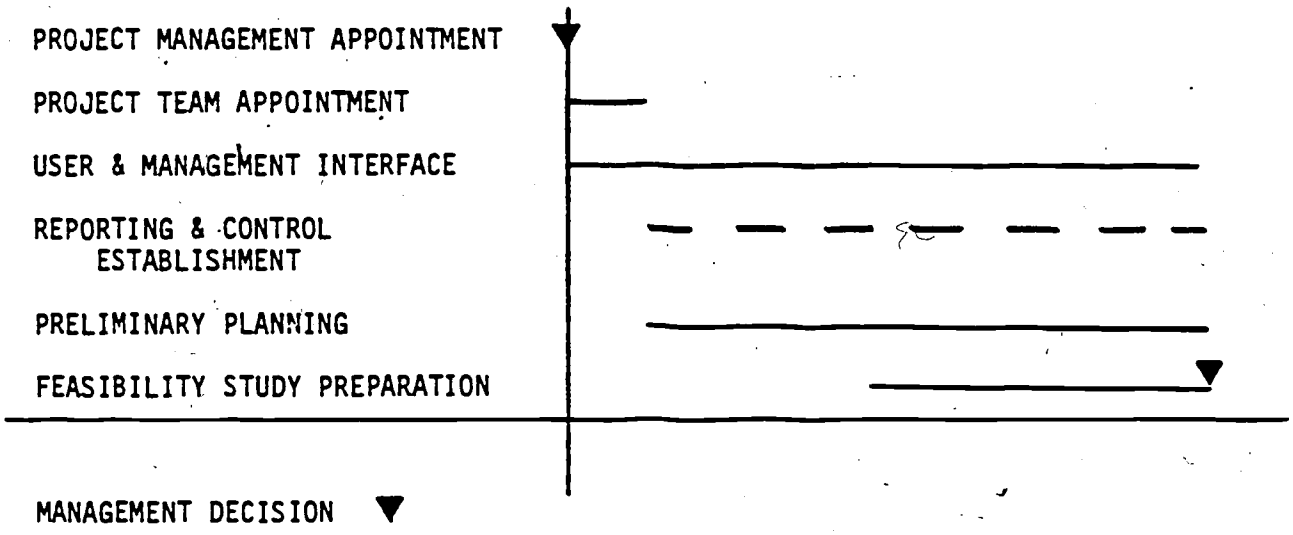
2.3 PROJECT INITIATION ACTIVITIES

The following activities occur during the project initiation phase (see Figure 2-1):

- Project manager appointment and project team establishment,
- Information system user and top management interface,
- Project reporting and control,
- Preliminary planning and estimating,
- Accomplishing a feasability study and cost analysis,
- Management decisions.

2.4 PROJECT MANAGEMENT APPOINTMENT AND PROJECT TEAM ESTABLISHMENT

Of prime importance to a successful conversion is the appointment of a project manager with the requisite technical/managerial background and the tenure and authority to manage the conversion project. Concurrently, a project team should be formed with the skills and experience necessary to accomplish the studies and analyses associated with the project initiation phase.



PROJECT INITIATION PHASE ACTIVITIES

Figure 2-1

The establishment of the project manager and project team should include provisions for adequate logistical and administrative support and a sufficient operational budget.

To be effective, there should be a separation between previous responsibilities and the conversion effort. The project team, as a unit, should work in a separate physical location. This location will serve as the focal point for the conversion. Distractions and interruptions will then be minimized, allowing the team to concentrate on the conversion activities.

The appointment of the project manager and project team usually signifies the beginning of software conversion cost expenditures. At this point direct costs can be identified to a particular project. Also, the assignment of a project manager is accompanied by accountability for project cost as part of the management responsibilities.

2.4.1 PROJECT MANAGER APPOINTMENTS

A full time project manager should be selected and appointed who will have experience and tenure to manage software conversion from project initiation to project completion. While this may appear self evident, a significant number of Federal conversion projects have experienced difficulties because:

- Conversion project management duties were assumed as additional responsibilities by fully committed software staff members.
- Project management was not exercised continuously through the different conversion phases. This lack of continuity disrupted and impeded conversion.

The qualifications to be considered in selecting a project manager should include:

- Planning ability,
- Ability to organize and manage resources,
- Project management and software conversion experience - Six to ten years of experience is recommended,
- Ability to deal effectively with people, particularly personnel in agency elements external to ADP, such as the functional users of information systems,
- Ability to react to problems and redirect efforts to resolve issues before they get out of hand.

While conversions should have only one project manager, it is conceivable that very large conversions might have a full-time project management team appointed for the duration of the project.

The project manager should be formally appointed and chartered in writing. The appointment should be approved by top agency officials. This provides project visibility and acknowledgement that the project manager has the authority to receive support and assistance from other organizational elements within the agency.

2.4.2 PROJECT TEAM ESTABLISHMENT

The composition of the project team for this phase will depend upon several variables, which include project complexity, timeframe, budgetary and personnel constraints.

Since project initiation activities are planning oriented, the project team should include one or more systems analyst(s), with three years minimum analytical and planning experience preferred. Team members must be familiar with the current ADP environment and applications, and be able to collect and evaluate workload statistics. Preference should go to selecting those personnel with previous conversion experience. Although the team during this phase may be very small, additional members can be added or reassigned as needs arise. Many managers use their most experienced personnel to assist in project initiation activities and continue to employ them in other subsequent, conversion activities.

2.5 INFORMATION SYSTEM USER AND TOP MANAGEMENT INTERFACE

Software conversion can be a lengthy and complex process dealing with an important agency asset -- its information base. Software conversion alters this data base. Problem-ridden conversions can result in considerable harm to an agency and its operations. Conversely, efficient conversions can improve the information processing posture of an agency. Therefore, it is extremely important that the functional users of automated information systems and top agency executives understand the issues of software conversion and support the conversion effort. Experience has shown, however, that full functional user and top management understanding and support are frequently not achieved.

To overcome this, at project initiation, the project manager can employ a variety of techniques to develop and maintain user's and management's interest and involvement in the conversion effort. These include:

- Briefings. Scheduled briefings are recommended to keep users and top agency executives apprised of project initiation activities. These briefings need not be formal. Short presentations as part of staff meeting agendas can be quite effective, especially since these meetings provide an opportunity to inform many managers and executives at one time of the conversion project status. Such briefings are of particular importance to top management. During the project initiation phase, agency executives will decide on conversion as a result of a feasibility study developed by the project manager and the project team. Regular briefings reduce the chance of surfacing surprises in the feasibility study, a point appreciated by management. Study issues can be raised well in advance for executive level attention. Once scheduled briefings are established, they should be continued throughout the conversion effort until the project is complete.

- Memoranda. Informal memoranda with general information of ongoing and planned activities might be employed.

- Management Staff Involvement. If it is difficult to directly inform top level managers of progress, it may be possible to inform or involve subordinate members of his/her staff who have immediate access and are charged with keeping top level managers informed of significant issues or potential problem areas.

- Articles in Agency Newsletters. Frequent but short articles can keep top managers and users informed of the software conversion project.

2.6 PROJECT REPORTING AND CONTROLS

Effective reporting and controls must be established and adhered to during a software conversion. Without some mechanism for accounting for work in progress, work completed, and work to be started, the project manager will have great difficulty in project tracking and monitoring.

2.6.1 REPORTING

At project initiation, reporting procedures can either be separate from, or merged with, other on-going, related actions (e.g., hardware replacement). These procedures should provide reports required by the project manager as well as higher levels of management. The initial framework for internal and external reporting should be formulated for the entire conversion effort.

2.6.2 PROJECT HISTORY

A project history should also be started during the project initiation phase. Thereafter it should be maintained by the project manager throughout the entire software conversion effort. The history should reflect significant project actions, events, costs, problems and means of problem resolution. It should also contain thoughts and observations of how subsequent project activities or future conversions can be improved. This history can be recorded in a journal or log or be contained in a project reference file. Ultimately the history log, if maintained, will be an invaluable reference in developing conversion plans and a post conversion analysis and assessment.

2.6.3 PLANNING AIDS

Project planning aids exist and include PERT, GANTT, and Work Breakdown Structures (WBS). Project planning aids selected for use are largely a matter of individual preference on the part of a project manager. However, at a minimum it is recommended that some visual, time dependent, planning aid such as bar charts be used. Although bar charts do not depict a critical path, they identify concurrent activities to alert the project manager of resource constraining areas that require special attention. They also visually portray starting and ending points of project activities and important milestones.

2.7 PRELIMINARY PLANNING

Adequate ADP project planning is one of the most critical factors of a successful software conversion. Federal procurement regulations require a feasibility study to be accomplished before any conversion to determine if other alternatives can resolve an agencies' information processing problems.

Additionally, other related studies are often required in the same approximate time frame as the feasibility study. Software conversion results in a change to agency operations. OMB Circular A-76, Policies for Acquiring Commercial or Industrial Products and Services for Government Use, requires examination of ADP operations at a time of significant change to determine if operations can be effectively turned over to a contractor. Also, an agency may consider hardware replacement and software conversion to fall under the provisions of OMB Circular A-109, Major Systems Acquisition. The project manager must have the planning and statistical base to accomplish the feasibility study or provide input into these other related conversion studies, as required.

Unfortunately, software conversion preliminary planning is frequently postponed to a point where it has an adverse effect on conversion schedules, or is conducted inadequately and without sufficient detail, ultimately leading to project slippage. To overcome this management issue and to provide a firm foundation for the feasibility study and other related studies for which input might be required, early

preliminary plans should be developed to provide managers insight into the probable magnitude of the conversion project, gross resource requirements and the probable length of time conversion will take. This can be accomplished by:

- o Current procurement and acquisition regulations and policy review,
- o Current ADP hardware and system software inventory,
- o Preliminary systems and applications program inventory,
- o Data file inventory,
- o Preliminary workload estimation,
- o Levels of effort and resource estimation,
- o Preconversion/conversion cost methodology development.

These activities accomplished by the project team during project initiation will provide a statistical and planning base for all subsequent conversion phases and activities.

2.7.1 CURRENT PROCUREMENT AND ACQUISITION REGULATIONS AND POLICY REVIEW

Along with agency policy regulations, there are many pertinent Federal procurement regulations and directives promulgated by GSA, OMB and Congress, as well as standards and guidelines promulgated by the National Bureau of Standards, that pertain to software conversion. The project manager and the project team should review this pertinent documentation. Of particular importance are the following three areas addressed by these documents:

- o Hardware/software planning and acquisition,
- o Software conversion,
- o Timesharing and remote computing services.

Appendix B to this guide contains the most important references that will assist in policy and regulation review.

2.7.2 CURRENT ADP HARDWARE AND SYSTEM SOFTWARE INVENTORY

The purpose of this activity is to document all currently existing ADP equipment and system software in order to establish the current environment, and identify any potential vendor's unique problems if converting the application programs to noncompatible, target hardware is necessary.

2.7.2.1 Hardware Inventory

A hardware inventory is necessary to understand the environment in which the software operates. Also, costs associated with hardware influence software feasibility studies. The project manager or the project team will be furnished the hardware inventory by the hardware staff. If not, the project team will have to establish it. The hardware inventory and equipment configuration should describe and display all ADPE components and peripherals, located either on-site or at remote locations. At a minimum, this inventory should identify each component by:

- Component name,
- Model number,
- Name of manufacturer,
- Location.

Although primarily focusing on computer center equipment, such as CPU, disk components, tape drives, printers, card reader/punch, and consoles, the inventory should also include such items as RJE stations, graphics equipment, data entry equipment, and other user-oriented hardware. Memory and storage capacity should also be identified. Additionally, an inventory of all commmunications equipment and network configurations should be acquired if data communications are employed.

2.7.2.2 System Software Inventory

The system's software inventory must encompass not only the operating system, languages, compilers, link editors, spooling and teleprocessing software, but also identify and describe utilities, software and hardware monitoring packages. The software inventory should include at a minimum:

- Name of software or language,
- Product number,
- Manufacturer,
- Version,
- Release/level number,
- Version/release date,
- Date installed,
- Local modifications,
- Documentation available, location, and condition,
- System software lease, purchase or cost information.

Care must be taken to document special conditions such as user exits and local modifications, where present.

The software inventory will be relatively straightforward if current system software documentation has been maintained. Where little or no documentation exists, the problem is magnified, but the inventory can and must be accomplished. To develop communications between the project team and the system programming staff, and to develop familiarity with systems software, it is recommended that one or two system programmmers temporarily augment the project team and provide systems software data.

2.7.3 PRELIMINARY SYSTEMS AND APPLICATION PROGRAMS INVENTORY

A preliminary inventory of application programs and systems currently in use serves a number of purposes:

- o This inventory is required to estimate the magnitude of the conversion.
- o It serves as a starting point in identifying those programs and applications that should be converted, if a conversion is approved. A more comprehensive and indepth inventory is undertaken once the conversion requirement phase starts.
- o Should a conversion not be justified as a result of a feasibility study, the inventory will serve as baseline documentation by the ADP staff during any future conversion studies.

The application program inventory is facilitated if one or more of the team members are familiar with the applications. Additional and supplemental information can be obtained from user groups.

The inventory should include at least the following information:

- o Name of system and brief description,
- o Numbers and programs within the system; lines of code per program and language; complexity of programming,
- o Interfaces with other systems,
- o Data bases accessed by the system.

While extreme levels of applications software detail are not required for project initiation activities, as much additional detail as possible should be developed, resources permitting. This will save time later, during the software conversion study conducted during the conversion requirements phase, when more extensive details are needed.

Cognizant functional users should review and verify the inventory and identify any applications that may have been missed.

2.7.4 DATA FILE INVENTORY

The project team should identify and document data files that are generated and processed by each program, and files that are shared by multiple programs and systems. This inventory contributes to the determination of the scale and complexity of the current software environment. The inventory is accomplished by one or more members of the project team through review of current program/system documentation, developed from workload statistical data and, where necessary, interviewing the appropriate users (39).

The inventory should include at least the following information:

- o File name,
- o Accessing system(s) name(s),
- o Medium (i.e. tape, disk, cards, etc.),
- o Data organization (e.g. sequential, random, indexed, etc.),
- o Code (e.g. BCD, EBCDIC, ASCII, etc.),
- o Estimated size.

2.7.5 PRELIMINARY WORKLOAD ESTIMATION

Summary statistics are then developed to reflect the basic total system workload (e.g., percent CPU busy, mean turnaround, number of jobs processed, etc.) and a profile established of future workload requirements. Since time is relatively limited during this phase, resource estimates should be based primarily on available or easily derived data. Most workload data is usually available from system operating statistics (e.g.: IBM System maintenance Facility, "SMF") and accounting, billing and history data. The accumulation and summarization of detailed, resource workloads from hardware/software monitors is usually too time consuming at this point in conversion planning. However, some consideration should begin regarding methods to develop a more extensive assessment and collection of workload data which is required in the conversion requirements phase.

2.7.6 LEVELS OF EFFORT AND RESOURCE ESTIMATION

Personnel requirements are identified for each conversion activity and levels of effort are estimated for the entire software conversion project. While there are many methods for estimating resources, a common software conversion management method is judgement based upon experience. The intent of this guide is not to

develop or recommend a particular estimating technique or methodology, but rather to identify various techniques or methodologies that will lead to reliable estimates. Appendix C describes and discusses in detail two popular estimation techniques, which include the Navy's PMCS model and the Federal Conversion Support Center's Hybrid Model (45). These should be assessed first before any other models are considered.

2.7.7 DEVELOPING PRECONVERSION/CONVERSION COST METHODOLOGY

A software conversion cost methodology is described in detail in Appendix C. A methodology should be adopted or developed during project initiation to provide a consistent basis for cost decisions throughout the project as well as for the feasibility study required during this phase. This cost methodology will be refined during the project as more detail is developed and more accurate cost estimates can be prepared. The cost methodology must be used to track project costs. In this manner, the software conversion cost methodology can assist project management by:

- Providing the ability to audit cost estimates,
- Identifying the major cost related efforts,
- Providing a consistent cost information base for recording and projecting software conversion costs.

2.8 ACCOMPLISHING THE FEASIBILITY STUDY AND COST ANALYSIS

The purpose of the preliminary feasibility study and cost analysis is to determine if there are alternatives to software conversion and provide top management with adequate decision-making information. The study will be developed by the project manager and project team. If study input is readily available, it should take approximately two months to complete. This study, to be effective, must address:

- The objectives, assumptions, constraints, and background of the current environment,
- The background and status of the current system(s),
- Projected or anticipated future requirements,
- Identification of alternative approaches,
- A summary of findings and recommendation(s) along with supporting costs/benefits/risks analysis.

Unless there are agency standards, it is suggested that FIPS PUB 64 be used as a guideline in completing the feasibility study and cost analysis (22). The following discussion is derived from that reference. Figure 2-2 shows the relationship of the various activities of the feasibility study which are:

- o Define Objectives, Scope, and Background

  This is the first step in a feasibility study and is to define the objectives and scope of effort.

- o Identify and Define the Current System

  The second step is to define the existing environment, organization, constraints, priorities, and technical and operational (workload) considerations on which this study is based.

- o Identify Alternatives

  This is the key stage where creative and intuitive thinking are employed. Viable alternatives and solutions are identified and described.

  Besides the status quo, possible alternatives might include increasing the hours of computer system operation, reducing non-essential or non-productive work, distributive processing, or conversion to larger hardware.

- o Assess Technical and Operational Feasibility

  The technical and operational feasibility (i.e., satisfying user requirements) of each alternative is assessed to determine if they are suitable technologically and operationally.

- o Estimate Costs of Alternatives

  All relevant costs (i.e., recurring, and non-recurring and present value) of each alternative must be estimated. Cost estimates developed using the software conversion costing methodology should be based on the full cost of each alternative, and defined in sufficient detail to allow cost comparisons of individual elements of cost among alternatives.

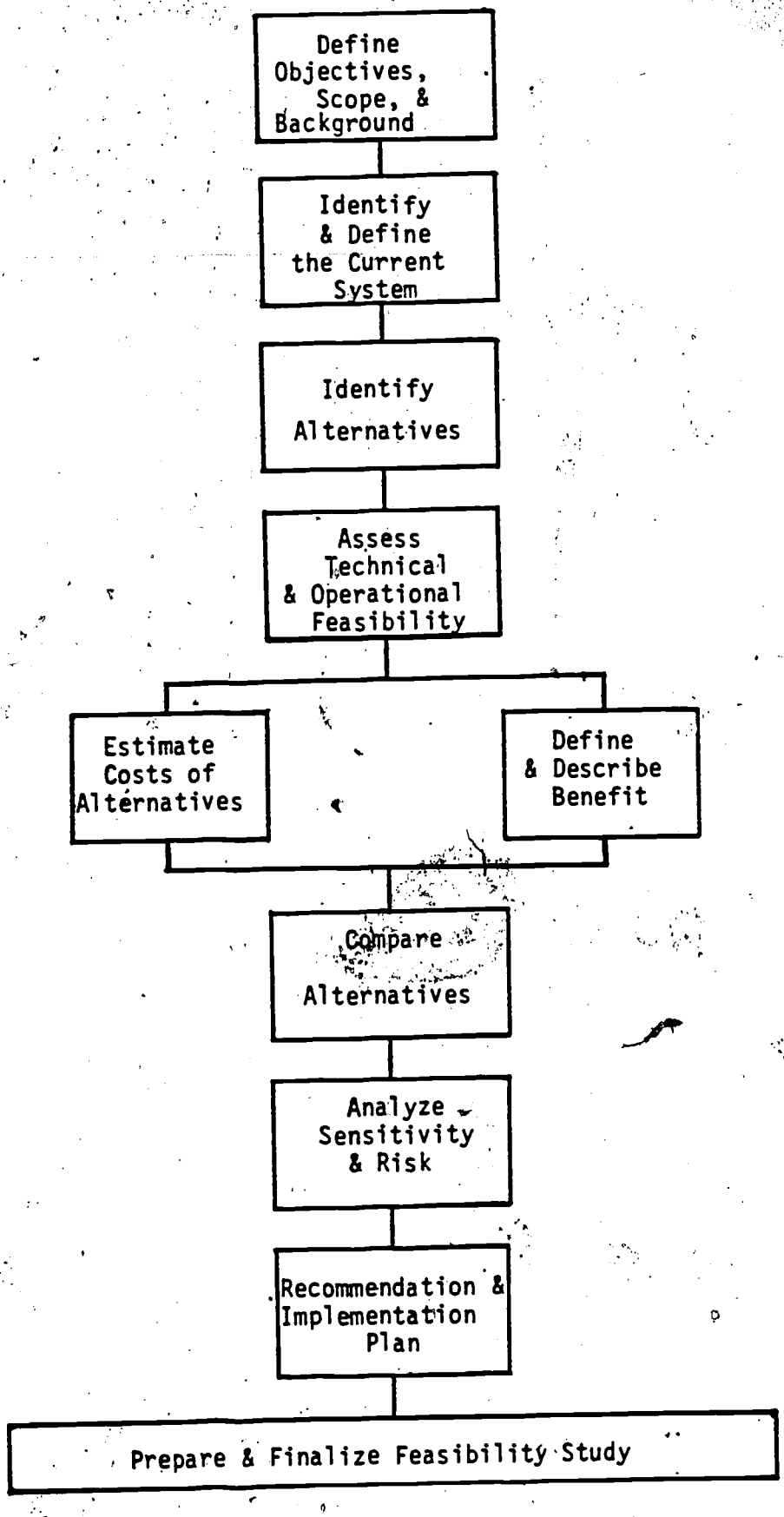

Define Objectives, Scope, & Background
Identify & Define the Current System
Identify Alternatives
Assess Technical & Operational Feasibility
Estimate Costs of Alternatives
Define & Describe Benefit
Compare Alternatives
Analyze Sensitivity & Risk
Recommendation & Implementation Plan
Prepare & Finalize Feasibility Study

Figure 2-2

- o Define and Describe Benefits

  Identify and define any quantifiable and non-quantifiable benefits or their estimated values for each alternative. Do not overlook the intangible benefits. While these may be more difficult to estimate or assign values, in many cases they may carry more weight in the final analysis and decision-making. These costs are reflected in each alternative, including the status quo alternative. Care must be taken to avoid double counting of costs or benefits.

- o Compare the Alternatives

  Compare the feasibility of each alternative in terms of desirability and advantages/disadvantages. The comparison is based upon the technical, cost and operational factors identified above.

- o Analyze Sensitivity and Risk

  A useful tool in feasibility studies, is sensitivity analysis which is a method for determining the impact of changes in assumptions on the total cost of the alternatives. Sensitivity analysis should address the range of values for assumptions such as workload, inflation factors, salaries, number of programs, complexity and conversion productivity. In this manner the least cost alternatives can be identified for any given range of assumption values and used with risk analysis to determine the preferred alternative.

- o Recommendation and Implementation Plan

  At this point, based upon the various cost/benefit and sensitivity analysis results, a recommendation or summary of findings is prepared, along with a proposed schedule for implementation.

- o Finalize Feasibility Study

  When prepared objectively and with adequate information, the feasibility study will provide management with the necessary data to make a decision as to the proposed recommendation.

2.9 PROJECT INITIATION MANAGEMENT DECISIONS

At the conclusion of the feasibility study and cost analysis, the ADP manager presents study results to top management for decisions. If there is no feasible alternative to resolve the agency data processing problem other than software conversion, management will likely be faced with another large issue: hardware replacement.

Once the software conversion decision is made, additional management decisions are required to support:

- o Software conversion resources,
- o An extended conversion schedule,
- o Authority to begin the conversion requirements phase,
- o Project funding.

It is recommended that the project manager present a decision briefing to top management and cover all decision requirements and recommendations as an entire package. This provides for efficient transition to subsequent software conversion phases.

If software conversion is not selected as a feasible alternative, project personnnel revert to normal operational roles. Care should be taken to preserve the results of all project initiation phase, statistical data and study results since this will prove useful in any future conversion planning.

2.10 ECONOMIC CONSIDERATIONS

During the project initiation phase, personnel will be the largest cost component. Included in this cost could be significant expenses required for establishing the project team including new hire or relocation expenses, initial project training courses, and office set-up expenses.

The software conversion cost methodology described in Appendix C should be initiated during this phase. A cost structure should be developed that represents the characteristics of the environment being costed and contain a level of detail that is sufficient to provide cost information for management use in the succeeding phases. The cost estimates developed during this phase will be based on summary levels of cost detail and may be provided through the use of software conversion cost estimation models, two of which are described in Appendix C.

2.11 PROJECT INITIATION MANAGEMENT CHECKLIST

- o Appointment of full time project manager
- o Charter approved by top management
- o Ongoing project costs tracked

- o Project team established
- o Top management and information system user interfaces established
- o Interface with hardware acquisition project members established
- o Project reporting and project controls established
  - Regular reporting in progress
  - History log established
  - Planning aids selected and used
- o Impact of Related Studies Determined
  - A-76
  - A-109
  - Other
- o Applicable acquisition and procurement, policy regulations and directives that affect software conversion identified and reviewed
- o Hardware inventory conducted
- o System software inventory conducted
- o Data files inventoried
- o Preliminary workloads estimated
- o Conversion resources (personnel) estimated
- o Cost methodology developed
- o Project costs tracked
- o Feasibility study and cost analysis conducted
- o Management decision to proceed/not proceed with conversion
  - Reorient efforts to proceed to next conversion phase
  - Plan for and pursue efforts to accomplish other alternative(s)

SECTION 3

CONVERSION REQUIREMENTS PHASE

The conversion requirements phase results in detailed identification and assessment of the scope, requirements, and complexities of the conversion effort. This phase is the transition between "what" is to be done (project initiation) and "how" it is to be accomplished (conversion planning).

Once the decision to convert has been made, the conversion project team must identify all of the details necessary to plan and execute the conversion. This requires an analysis of the current environment to include identifying feasible alternatives to various conversion processes and activities. Management decisions can then be made to choose the most cost effective method of accomplishing the conversion activities. In addition to the planning details, during the requirements phase a software conversion study is required to determine if the users needs are met at the lowest overall cost (13).

During the conversion requirements phase, the hardware procurement activities are interrelated and dependent on software conversion activities. For example, workload analysis is used to determine the magnitude of the software conversion project. Workload analysis also serves to help size the target hardware needs. Most importantly, the software conversion study, with its supporting cost analyses can identify procurement options which differ considerably in cost and time to implement. The software conversion study should address conversion to code-compatible as well as noncode-compatible hardware and the respective costs and operational impacts carefully developed. Code-compatible conversions are usually much less costly and disruptive to agency operations. While approval of code-compatible conversions cannot be guaranteed due to Federal competetive procurement policies, the likelihood is improved if code-compatible conversion hardware procurement requests are supported by reliable and thorough cost analyses.

3.1 REQUIREMENTS PHASE OBJECTIVES

The primary objective of this phase is to provide the information necessary to accomplish detailed conversion planning. An additional objective of this phase is accomplishment of a software conversion study which, in turn, supports preparation and submission of an Agency Procurement Request (APR) to the General Services Administration.

3.2 CONVERSION REQUIREMENTS ACTIVITIES

The following conversion requests phase activities (shown in Figure 3-1) must be conducted:

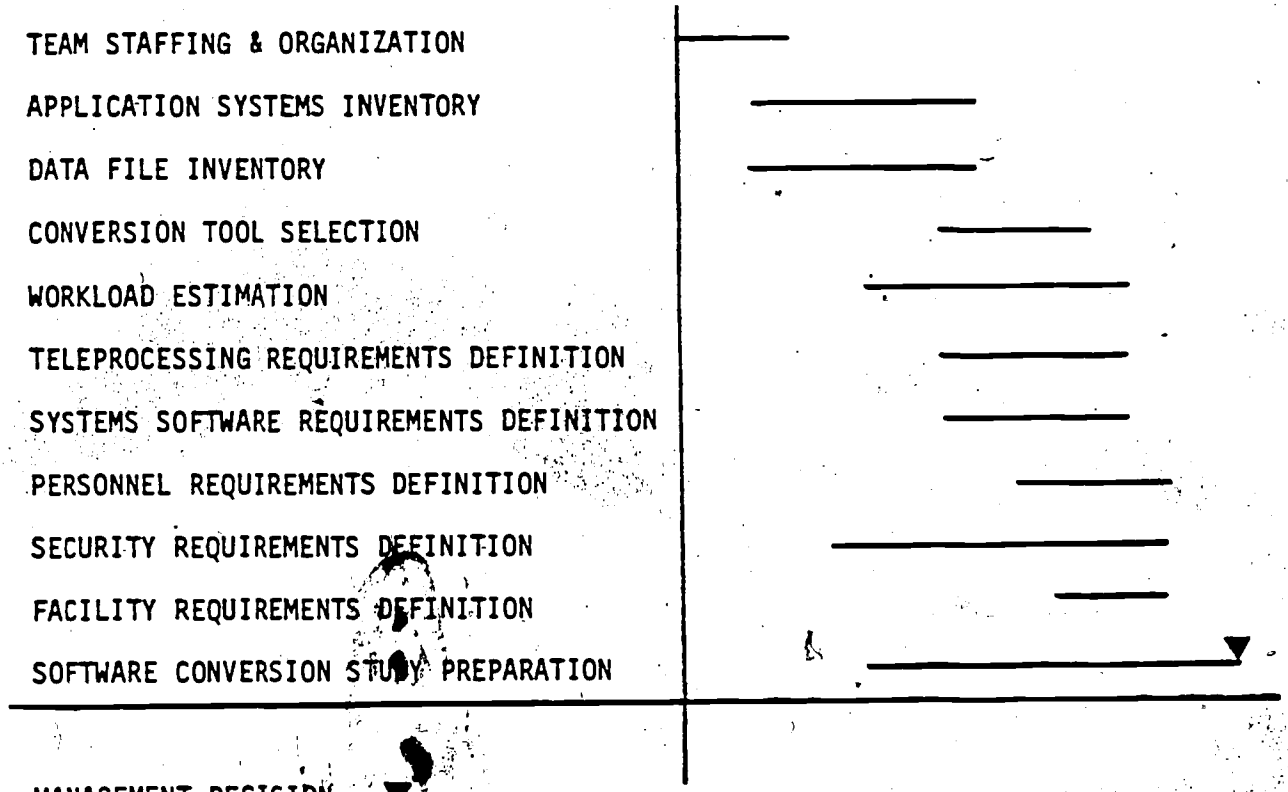
- o Project team staffing and organization,
- o Application systems and programs inventory extension and assessment,
- o Data file inventory extension and assessment,
- o Conversion tool identification and selection,
- o Workload estimation and refinement,
- o Distributed and teleprocessing requirements definition,
- o Systems software requirements definition,
- o Personnel requirements definition,
- o Security requirements definition,
- o Conversion facilities requirements definition,
- o Software conversion study preparation.

3.3 PROJECT TEAM STAFFING AND ORGANIZATION

3.3.1 PROJECT TEAM STAFFING

The full-time project manager appointed during project initiation will continue to manage the conversion project during the requirements phase. The project team requires systems analysis skills and planning experience to develop requirements; the same skill base needed for project initiation. Since requirements definition and development of the software conversion study are analogous to activities in project initiation, the same team members should be adequate except for very large conversions. As a guideline however the following table is offered to aid in team staffing:

Lines of Code To be Converted	Team Size
Less than 100K	1-2
100K to 500K	2-3
over 500K	4-5



CONVERSION REQUIREMENTS PHASE ACTIVITIES

Figure 3-1

These figures are derived, in part, from an Army estimate (39) and from case studies described in Appendix D.

During the requirements phase the project team might be augmented by consultants, by guidance provided by the Institute for Computer Sciences and Technology (ICST), or by support from the Federal Conversion Support Center* to assist in developing special requirements such as security and teleprocessing or to accomplish the software conversion study.

3.3.2 TURNOVER CONSIDERATIONS

A key issue that management should anticipate, and plan for, is personnel turnover. The longer the project, the higher the turnover rate. According to Tripp and Wahi (34), multi-year projects should plan for up to 25% turnover in staff per year. The implications of this apply to lengthy requirements phases as well as entire conversion projects. Managers must be prepared to replace project team personnel and possibly project managers.

Problems in turnover may be reduced by team organization and assignment of duties. Primary responsibilities for conversion requirements can be assigned to individual team members. Other team members should be assigned secondary or back-up responsibilities. If one member leaves unexpectedly, the corporate project memory is not lost.

Regularly conducted project discussions and reviews to keep all team members apprised of project status also contribute significantly to reducing the effect of project team personnel losses.

3.4 APPLICATION SYSTEMS AND PROGRAMS INVENTORY EXTENSION

The purpose of this activity is to extend the application system and project inventory conducted during the project initiation phase. The details of the systems and programs in terms of complexity and construction are added to the inventory.

This inventory will also identify specific systems and programs to be converted or dropped. The inventory will permit the project team to group and assess the agency application software inventory from various perspectives. For example, the inventory can be considered from a standpoint of complexity, applicable conversion technique (e.g., automated tool, line-for-line coding, etc.), or language. Estimating of

*

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levels of effort and identification of the best techniques to accomplish conversion are considerably aided by this inventory. Additionally, the project team will develop insight into many potential conversion problems and means to accomplish problem resolution.

Catalog worksheets printed on large paper will assist the project team in inventorying and assessing application software. For very large conversions it is recommended that this worksheet be automated. Automation will assist the project team in easily analyzing the software inventory from various aggregate perspectives (e.g. language, lines of code, environment, or complexity). The following information corresponds to a suggested worksheet (Figure 3-2) developed from Federal sources (39, 47). It should be modified according to specific agency needs.

- o PROGRAM ID: Specify a unique identifier for each program.
- o SOURCE LANGUAGE & VERSION: Specify the programming language and version in which the current program is written.
- o LINES OF CODE: Enter the number of lines of code in the program. Indicate number of vendor extensions, if known.
- o MODULES AND EXTERNAL CALLS: Specify the number of segments, calls to external subroutines, and macros which are copied.
- o COMMUNICATION INTERFACES: If the program interfaces with communication drivers or special telecommunication interfaces, indicate interface name and function, e.g., 3270 protocol/screen format.
- o SOURCE PROCESSING ENVIRONMENT: Specify the mode of processing such as batch, remote job entry (RJE), interactive, or real-time for the source program.
- o FILES: Specify the name and number of input, output and input/output files processed by this program. Temporary files should not be included.
- o DOCUMENTATION: Indicate the level of documentation available for this program using the following codes: 0 = None available; 1 = Insufficient for conversion; 2 = Satisfactory.
- o COMPLEXITY: Specify the code that best reflects the level of program complexity. Refer to Figure -3.
- o TARGET LANGUAGE AND VERSION: Specify expected language and version if target hardware is known.

PROGRAM INVENTORY CATALOG WORKSHEET

Application System: Administration — Prepared by: Terld

Source Hardware: IBM 360/50 — Date: July 12

Program ID	SOURCE												TARGET (if known)		COMMENTS
	Language & Version	Loc.	MOD, EXT, CALLS			Comm. Interface	Environment	FILES			DOC.	COMPLEX	Status	Language & Version	Environ.	
			Seg	Rtn	Macros			I	O	I/O						
A4101	COBOL/68	609	2				Batch	3	1		2	2	C			
A4114	COBOL/68	430					Batch	2	2		2	2	C			
A5010	Assembler	1492	7	4	2		Batch	4	4		1	4	R			

SAMPLE PROGRAM WORKSHEET

Figure 3-2

Complexity Factors	A	B	C	D
Language	ANSI FORT., ANSI PL1, ANSI BASIC	COBOL BASIC, other high level	High Level w/some Assembler	Assembly
Structured Design	Extensive	Moderate	Some	None
Lines of Code	Less than 500	500-999	999-2K	Over 2K
Number of External Calls Used	Less than 4	4-8	9-15	Over 15
Number of Segmentation Overlap Routines	Less than 5	5-9	10-20	Over 20
Operating Environment	Batch	Batch with RJE	On-Line	Real-time
Embedded Documentation	Extensive	Moderate	Some	None
Access Method	Sequential	Index Seq.	Direct Access	Other
Number of Data Files	Less than 5	5-7	8-11	Over 11
No. of Control Stream Language Statements	Less than 5	5-10	11-25	Over 25
Number of Utilities to be Converted	Less than 3	3-5	6-10	Over 10
	# X 1 = A = _____	X X 2 = B = _____	# X 3 = C = _____	# X 4 = D = _____
Complexity Code A+B+C+D	LEGEND: up to 14 = Simple (1); 15 to 24 = Average (2); 25 to 30 = Complex (3); 31 to 40 = Very Complex (4)			

COMPLEXITY TABLE

Figure 3-3

- TARGET PROCESSING ENVIRONMENT: Indicate whether the target program processing environment will be batch, remote job entry (RJE), interactive, or real-time.

- COMMENTS: Enter any comments or information such as justification, primary user contact, regulatory authorization, etc. If one or more automated tool(s) is applicable, enter name of package, if known.

- CONVERSION STATUS: Indicate the action to be taken for this program. C = Convert; P = Purge; R = Redevelop.

Other statistics which should be summarized for the entire conversion effort include:

- Total number of programs by application system,

- The total number of lines of job stream language by application system,

- The number of job streams by application system,

- Major systems applications by complexity, e.g., payroll, financial, personnel.

3.5 DATA FILES INVENTORY EXTENSION AND ASSESSMENT

Although this activity should have been completed in project initiation, it is of sufficient importance to conduct a review (and refinement where necessary) prior to use in the software conversion study.

In particular this activity should concentrate on a reexamination and assessment of the data files in terms of determining if they can be converted as is, converted with minor changes, or require a major conversion due to architectural incompatibilities. One of the major technical management considerations in assessing file conversion requirement is knowing and understanding the differences in data conventions (e g., XS3, ASCII, EBCDIC, BCD). Other items which must be addressed as file requirements definitions include the collating sequences of the different character sets and the internal character representation such as packed decimal, hexadecimal, or octal. The implications with respect to sorting, file maintenance, and their effect on report listings are well known.

File inventory information may also be used to determine the priority or order of programs to be converted within a system and, to a greater or lesser extent, the order of systems depending upon file interrelationships and interdependencies between programs and application systems.

Using the sample file worksheet (39, 47) (shown in Figure 3-4), the following information should be included in the inventory:

- FILE ID: Specify a unique identifier for each file.
- FILE MEDIUM: Indicate the storage medium, e.g., 9-track tape, removable disk, high speed drum.
- CODE TYPE: Select the appropriate code to indicate the code data is currently stored in:

1 = ASCII	5 = Binary
2 = EBCDIC	6 = Packed decimal
3 = BCD	7 = Floating point
4 = XS3	8 = Bit level
	9 = Other

- NUMBER OF VOLUMES: Indicate if more than one tape reel or disk pack is required for this file.
- ACCESS METHOD: Identify the appropriate file either sequential, direct access, or index sequential, organization which applies. If none of these file organization techniques are applicable, specify the type of organization used.
- RECORD FORMAT: Specify whether the record format is "FIXED," "VARIABLE," or "OTHER." If "OTHER," describe under COMMENTS.
- RECORD SIZE: Specify the size (in characters) for each file (use one line for each record type). Enter the number of records for each record format in the file.
- BLOCK SIZE: Specify the size (in characters) for length of the record block size. If file is unblocked, enter record size.
- SECURITY/PRIVACY: Indicate whether special procedures will be necessary to protect the contents of the file or to limit read/write access to the file or parts of the file. Indicate whether "R" - Read or "W" - Write restrictions apply to the file.
- COMMENTS: (optional). Enter any comments or additional information about the file. Use this column to further describe RECORD FORMAT (if necessary) or applicable automated tools, if known.
- CONVERSION STATUS: Indicate the action to be taken for this file. C = Convert; P = Purge, R = Redevelop.

PROGRAM FILE CATALOG WORKSHEET

Application System: Supplies
Program: Commercial Purchases
Source Hardware: IBM 360/50

Prepared by: Jones
Date: 04 25 M

FILE ID	FILE MEDIUM	CODE TYPE	No. VOLUM	ACCESS METHOD				FILE SIZE			SEC/ PRIvacy	COMMENTS	STATUS
				SEQ	DIR ACC	IND. SEQ.	OTHER	RCD F-MAT	RCD SIZE	BLK SIZE			
AYX400	9TR TAPE	2	1	X				FIXED	380	3200			C
AYX408	DISK	2	1		X			FIXED	4650	4650			

SAMPLE FILE WORKSHEET

Figure 3-4

The file inventory data should then be summarized by access method with the following information provided for each method:

- o File medium, e.g., disk, tape or card,
- o Total number of files,
- o Total number of characters,
- o Percentage of the total number of files which have data stored by code type,
- o Percentage of the total number of files which have fixed and variable length records,
- o Percentage of the total number of files which require privacy or security protection.

As with the applications and programs inventory, automation of the file inventory for very large conversions will help summarizing and analyzing file conversion parameters as they affect conversion requirements.

3.6 CONVERSION TOOLS IDENTIFICATION AND SELECTION

Once the application systems program and file inventories have been completed and associated with an appropriate conversion technique, review of suitable and available automated tools should begin. Most agencies have some resident conversion tools. However, the screening should be expanded beyond this base. A reference of particular usefulness is the Federal Conversion Support Center Conversion Products/Aids Survey (46).

3.6.1 TYPES OF TOOLS

For the purpose of this guide, three basic types of automated tools are addressed:

- o Translators

  Translation is the process of automatically converting computer programs from one language to another or from one hardware configuration to another. It is rare that 100% translation is achieved, and inevitably manual final adjustment is required.

- o Emulators

  It may not be practical to convert a program if a total redesign was planned immediately following a conversion or conversely, convert a program that will be terminated in the not too distant future. Operating the old programs using an emulator feature or package to represent the source machine on the target machine may offer a feasible alternative. However, other factors such as possibly degraded performance need to be taken into consideration before a decision is made to emulate.

- o Conversion Aids

  This category encompasses all other types of automated tools. These include file converters, test data generators, source program directories, optimization routines, standardization auditors, operating system converters, operation control stream language conversion, flow charting aids and benchmark generators.

3.6.2 SELECTION AND OPTIMIZATION

Feasibility study techniques should be used to select tools. For example, manipulation of program and file inventories will reveal areas where tools may be feasibly used. Alternative tools can be compared with manual methods and costed to determine the most effective approach.

Each tool has its inherent advantages and disadvantages depending upon the circumstances and environment involved. Moreover, it should be recognized that selection and implementation of any of these tools is but a part of the conversion effort. Use of these tools can enhance the actual program and file conversion effort, but they will not produce completely automated conversion. Some form of additional manual effort is required for efficient program and file operation on the source system. The need for this manual effort, and related costs, have to be considered when analyzing use of automated tools. Unless other estimates are known, estimate 20% manual effort — 80% automated tool.

Case study research associated with this guide uncovered one automated conversion where the target system consumed 20 hours of run time compared to three hours execution time on the source system. This is an extreme example but it illustrates that subjective human judgement of conversion results and manual refinement of application programs converted with automated tools are necessary to optimize and fine-tune converted software.

3.6.3 CONVERSION TOOL EVALUATION FACTORS

Candidate conversion tools should be weighed against the following considerations:

- o Availability

  Establish whether the tool is a well established "off-the-shelf" package or a new but untested one; determine whether it should be leased or purchased; determine how soon it can be delivered.

- o Documentation

  Determine if the package is fully documented; if documentation includes updates and revisions.

- o Support

  Ascertain if the vendor will stand behind the product; determine the history of the vendor and the package; judge whether the in-house staff can handle the package.

- o Operating Efficiencies and Costs

  Compare the tool to other similar tools in terms of purchase or lease cost, maintenance fees and support availability, hardware resources required, operator training required, and the availability and cost of such training. In terms of performance determine how the converted program(s) compare to the source program. Identify past users to verify this performance, and determine if the vendor would adhere to such performance claims in a contract.

- o Agency Needs

  Any particular considerations that apply to an agency. For example, will agency hardware handle the tools being considered.

The Federal Conversion Support Center or contractors can assist in selection of automated tool(s) should resources, time, or experience preclude an in-house effort.

3.7 WORKLOAD ESTIMATION REFINEMENT

The aggregate workload analysis conducted during project initiation should be further refined. This will require an in-depth analysis of not only production workloads but expected systems' enhancements and new systems' developments that will place a demand on the target hardware.

The associated hardware capabilities, operating systems, and communication requirements complete this analysis. Factoring in historical workload and projected user's requirements, future workload requirements can be extrapolated and summarized. This workload profile can then be analyzed as a complete, integrated entity. The profile picture will depict the operational environment that must be accommodated by the target system.

3.7.1 WORKLOAD PARAMETERS

The most common information (40) used to determine workload are itemized below. Utilizing hardware/software monitors (e.g., PLAN/4, TSOMON, etc.) facilitates obtaining the raw workload data.

- JOBS PROCESSED - Number of batch jobs started.
- TRANSACTIONS PROCESSED - Number of on-line transactions processed.
- CPU TIME - Number of hours of total program CPU time (both batch and on-line).
- DISK EXCP - I/O executions for all direct access devices, in thousands.
- TAPE EXCP - I/O executions for all magnetic tape devices, in thousands.
- LOCAL PRINT - Number of lines spooled for local print, in thousands.
- REMOTE PRINT - Number of lines spooled for remote print, in thousands.
- CONNECT TIME - Connect hours for terminals and RJE.
- TAPE MOUNTS - Number of tape mounts, in thousands.

After investigating the make-up of the jobs, transactions and connect times (if any), an analysis can be made of the effect of this workload on the system. Equipment resource utilization is a measure of work units needed to process the current workload on the source system. The main descriptive data elements for measuring resources used are CPU time, jobs processed, disk EXCEPS top EXCPS, and print volume. An additional element describing percent CPU busy time should also be included since it is a key indicator of maximum resource utilization.

3.7.2 WORKLOAD ESTIMATION

While numbers of jobs, EXCPs and print volumes are useful data in the workload analysis, they provide no yardstick to determine the total workload. The mere fact that 401,053 batch jobs have been run in the past 12 months does not provide much insight into workload levels. Further, to state that this represents a monthly average of 50,088 or an approximate 1,670 jobs per day or 70 jobs per hour, does not measure the demands on the system. The same logic holds true for EXCPS and print volume. What is important are processing demands per hour in the day and hours for each shift. These demands are further influenced by systems down time and systems and application programming hours that must run in unbroken sequences. Resources should be examined closely with the view in mind of ascertaining where and when saturation occurs.

3.8 DISTRIBUTION AND TELEPROCESSING REQUIREMENTS DEFINITION

Because of evolving technology the hardware environment will likely change during conversion. While from an information system user's standpoint automated support remains the same, changes may be planned in the hardware configuration. The agency may be considering centralization of multiple site processing or distributing currently centralized processing. These potential changes in the hardware environment and the related teleprocessing requirements have to be assessed.

The systems and applications and data file inventories identify distributed and teleprocessing requirements for the source system. The workload analysis identifies gross processing requirements. An analysis should be made of the processing requirements for hardware configuration alternatives being considered by the agency. If the staff involved in hardware procurement do not accomplish this analysis, it must be done by the software conversion staff.

Each conceptual hardware configuration should be analyzed with respect to software processing requirements. This accomplishes a number of purposes:

- It assists in verifying that considered hardware configurations are feasible,
- It improves the specificity of the hardware RFP,
- It identifies distributed, multiple site, and teleprocessing software requirements.

3.9 SYSTEM'S SOFTWARE REQUIREMENTS DEFINITION

Requirements have to be developed for systems software which support applications software and data files. Included are compilers, spooling, utilities and hardware monitoring packages. Requirements should be developed as mandatory or desirable by the

project team. This serves two purposes: It assists developing the hardware procurement RFP and in software conversion planning. Early in the planning phase the hardware configuration will be unknown. Planners must be cognizant of systems software that they can be assured of and that which may or may not be supplied by the hardware vendor.

3.10 PERSONNEL REQUIREMENTS DEFINITION

Application system and program, file, conversion tool and teleprocessing requirements will be used by the project manager to identify the conversion resource requirements.

In assessing resources the project manager must weigh internal resources available against the total workload to determine the adequacy of the in-house staff. Once the initial level of effort is estimated and outside resources (i.e. contractor assistance) is deemed necessary, cost effective determinations will have to be made regarding where to apply external assistance (i.e. planning preparation, conversion, etc.)

Finally, if preliminary requirements indicate need for outside assistance, requirements should be developed for the RFP for software conversion assistance (e.g. type of procurement, deliverables, milestones, duration, etc.) which will be prepared in the conversion preparation phase.

3.11 SECURITY REQUIREMENTS DEFINITION

Security and privacy are often overlooked during software conversion. A project team review of all agency information systems for agency and Federal security and privacy requirements will assist in engineering security features into sensitive software data files and software processing during conversion and avoid costly modification later.

The basic Federal security requirements are contained in the Office of Management and Budget (OMB) Circular A-71, Transmittal Memorandum No 1, Security of Federal Automated Information Systems (July 1978). In general this regulation requires design and approval of agency software of security specifications, security design reviews and security testing to comply with A-71 or other applicable Federal policies (e.g., DOD security regulations). These policies are pertinent to software conversion. If software support is to be acquired commercially, either as general purpose packages or converted by a contractor, security specifications have to be developed. Additionally, a risk analysis is required whenever an agency undergoes a significant software change. Agency software security requirements have to be compared with this risk analysis. The project manager should enlist the support of the information system users and the agency information system's security officer in developing security conversion requirements. If an agency has extensive sensitive information systems, assistance from an outside information system's consultant as an advisor to the project team is recommended.

3.12 CONVERSION FACILITIES REQUIREMENTS DEFINITION

3.12.1 CONVERSION PROCESSING FACILITIES

The requirements of accomplishing software conversion on systems running production applications have to be developed. This applies to conversion associated with hardware replacement as well as conversions that are not associated with hardware replacement.

The key requirements are to provide conversion processing time and convenient and nondisruptive hardware systems access, regardless of whether it is source or target, and nondisruptive production support to information system's users. Note: If sensitive processing is accomplished on agency computers, security must be carefully considered for all alternatives considered.

Any use of excess capacity on a source target computer for conversion will likely be cost effective. Additional advantages include convenient location and conversion team familiarity with the source system Disadvantages could include inconvenient access time. Final determination of conversion processing facilities will depend upon a requirements analysis to determine if additional operators have to be hired and if production schedules can be adjusted to provide time convenient to the conversion project team. Otherwise, alternative choices such as commercial time sharing, use of leased, off site, production facilities, or use of surplus capacity at another government agency should be investigated.

If software conversion activities must be accomplished on the same system used for production and there are no feasible, cost effective alternatives for avoiding contention between production and conversion activities, negative impacts must be minimized The project manager should consider:

- Reexamination of application systems to determine if some unnecessary systems have been overlooked and can be eliminated to provide for additional processing time,
- Soliciting the cooperation of information system users and agency executives to determine if some information systems degradation can be accepted,
- Examining information systems to determine if modifications can produce required information with less processing.

The key management issues here are achieving cooperation and support by users and top managers and having sufficient time to explore alternatives to any possible hardware contention problems. If contention is not resolved, the project manager can expect slippage in the conversion and inefficient use of project team resources.

3.12.2 CONVERSION TEAM FACILITIES

Conversion resource assessments will result in estimates of the conversion team size, the extent of contractual effort, and whether contractors should be located at the agency or their own facilities. Conversion team facility requirements can then be developed.

3.13 SOFTWARE CONVERSON STUDY PREPARATION

The culmination of this phase is the preparation of a software conversion study. This study, mandated by FPMR Regulation F-492, and amended by F-496, provides the justification for the conversion and development of the Agency Procurement Request (ADP) for submission to GSA for hardware acquisition. There is no specific format presented in the software conversion study. However, it is recommended that the project manager acquire a conversion study checklist from the Federal Conversion Support Center. This guide is useful in structuring a study to meet agency requirements and to insure completeness. In general, the study should include:

- o Problems

  Describe the agency ADP problems which result in the need for hardware replacement/software conversion.

- o Current ADP Environment

  Describe the existing systems to provide a basis for determining the economic and technical advantages of the proposed new system or change. This description should include the following information:

  - Equipment - Itemize all equipment used by the existing system.
  - Software - Itemize all system and applications software including all data files.
  - Other Systems Software - Identify all other software to include operating systems, utilities general purpose software.
  - Personnel - Identify skill categories and number of personnel required to operate/maintain the existing system.

- Workload Analysis An analysis of the existing system workload should provide a baseline for determining trade offs and advantages of the target system. Processing and system requirements should also be described.

- System requirements (i.e., the proposed ADPE Environment)

  Describe the requirements and objectives of the proposed target system.

- Procurement Alternatives

  Describe each alternative system in detail. State reasons for consideration. Alternatives should include fully competitive (noncode-compatible), Limited competitive (code-compatible), and sole source. Include projected procurement schedules.

- Cost/Benefit Analysis

  The purpose of the cost/benefit analysis is to provide management with adequate cost and benefit information to analyze and evaluate the alternative (target) systems. Describe the cost of procurement, training, site preparation, benchmark, contractor assistance and conversion for each alternative. State benefits in quantifiable terms. Non-quantifiable benefits should address organizational objectives, user's satifaction and improved missions and goals. Describe the risks in terms of cost for each alternative considered.

- Recommendations and Implementation Schedule

  State the reasoning and justification to support the recommendation of the selected procurement alternative over the other alternatives with an indepth discussion of cost to benefits. Identify consequences of not taking action. Include a schedule and milestones for each major phase of the recommended system and conversion.

3.14 REQUIREMENTS PHASE MANAGEMENT DECISIONS

At the conclusion of the conversion requirements phase the ADP manager submits the software conversion study for agency executive approval. This study will normally accompany and be approved with other hardware/procurement related actions, primarily the Agency Procurement Request.

Other agency executive decisions that will be required during the conversion requirements phase will be approval and funding support from:

- o Federal Conversion Support Center,
- o Outside resources which might be required to assist in security requirements or the software conversion study.

3.15 COST AND ECONOMIC CONSIDERATIONS

In the conversion requirements phase, project personnel costs will comprise a significant portion of operational costs incurred. Additional areas of cost which may be incurred include consultant fees such as security assistance or in preparing the software conversion study. If operating personnel are used to assist in the software inventory or workload analysis, their costs should be assigned to the conversion project.

The software conversion project cost estimates developed during project initiation will be refined using the workload, data file and program data that is developed. Personnel cost estimates can be improved by using the actual salaries of personnel currently assigned to the project, and those proposed in the future. At this stage in the cost estimation process, cost may still be estimated at a summary level of detail, however, as specific cost areas can be identified, (e.g., project personnel salaries) this detail should be incorporated into the costing information.

In determining the conversion requirements, a major area of cost input will be in the assessment of in-house personnel resources, and the feasibility of using conversion tools. The assessment of the current staff's ability to perform the conversion must address factors such as the availability and cost of current staff, potential new hires, and contractor personnnel. The assessment of staff adequacy should be based upon the full cost of the project. In this manner the use of higher cost, contractor personnel may be justified if the project duration can be shortened. Similarly, the feasibility of conversion tools should address the full cost impact on the entire project, and not just the cost of completing one task in the project.

Cost input will also be required in the completion of the software conversion study where the project budget is detailed by cost element, phase, function and year, and a cost-effectiveness analysis of the proposed course of action is provided. This study will require a close coordination between the cost included in the hardware acquisition estimates and the conversion project estimates to assure that all costs are reflected, and none are counted twice.

3.16 REQUIREMENTS MANAGEMENT CHECKLIST

- o Full-time project manager continues
- o Project team staffed with skills for requirements definition
- o Project briefings to top management continued
- o Special assistance/skills identified
  - Security
  - Telecommunications
  - Software Conversion Study
- o Project team augmentation provided
  - FCSC
  - Consultant
- o Application system and program inventory extended.
- o Data files inventory extended
- o Potential conversion tools selected, information requested
- o Workloads estimated and refined; future workloads fully projected
- o Requirements analyzed from distributed processing perspective
- o Requirements analyzed from teleprocessing perspective
- o Systems software requirements developed
- o Conversion personnel requirements developed
  - In-House staff
  - Contractors
- o Security requirements defined
  - Compared with new risk analysis
  - Information system user input
  - Agency information system office input
  - Processing requirements doublechecked
- o Conversion hardware facilities requirements defined

- o Conversion team facilities requests defined
- o Software conversion study completed
  - Code compatible alternative carefully costed
  - Non-code compatible conversion alternative carefully costed
- o Executive approval of software conversion study

SECTION 4

CONVERSION PLANNING PHASE

During the conversion planning phase, the project team will develop the organization and the schedules to be followed in preparation for and during the conversion.

Economic considerations associated with these activities must be addressed. The cost information previously developed for budget estimates, cost-benefit analyses and feasibility studies and the software conversion study will become more refined as conversion activities are planned in more detail. This information can support the preparation of future budgets and conversion plans.

The importance of planning cannot be overstated. It is, in fact, the most important phase. Proper planning, early in the software conversion process, will prevent many problems from occurring, and will prepare management for handling the unforeseen contingencies that may occur (23, 39).

The case studies presented in Appendix D reiterate the importance of proper planning. Managers who experienced fairly smooth conversion efforts had prepared detailed plans, schedules and milestones, and tracked performance. On the other hand, for those conversions that had experienced difficulties, the major problems could usually be traced directly to inadequate planning. Managers, when queried as to how they could improve future conversions, emphasized the need to plan early and in detail.

This section describes the activities related to compiling a conversion plan. Associated planning costs can be developed in accordance with the methodology in Appendix C. The impacts of this cost information on management decisions are discussed as they occur.

4.1 PLANNING OBJECTIVES

The objective of this phase is to prepare a conversion plan which encompasses all subordinate plans and schedules to prepare for and complete the conversion. Conversion plan development requires a thorough examination of all activities that must occur prior to, during, and after the conversion efforts.

To meet this objective, the following results must be achieved:

- Planning must be detailed, and flexible,
- Personnel must be assigned,
- Facilities must be planned,
- Schedules must be developed,
- A reporting hierarchy must be developed,
- A project tracking mechanism must be developed.

4.2 DECISIONS IMPACTING PLANNING

During the planning phase there are three major decision areas which have the most affect on conversion and that will be made by top agency executives or external organizations:

- o Budget decisions by top management, or external organizations (e.g., Office of Management and Budget),
- o Procurement decisions by external organizations (e.g., GSA),
- o Schedule decisions by agency executives.

4.2.1 BUDGET

Conversion cost estimates made during the project initiation phase feasibility study and the requirements phase software conversion study will have been entered into agency's budgets and submitted to OMB and to Congress for approval and appropriations. Cost estimates developed during the conversion requirements phase will have also been submitted to GSA for review and approval (14, 15). The project manager should continually review the status of conversion fiscal decisions to determine if the conversion is approved and any fiscal constraints applicable to planning.

4.2.2 PROCUREMENT

The conversion planning will also be impacted by the selection of the target machine. Cost evaluations, Federal regulations and statutes (e.g., the Brooks Act) may require a competitive procurement (14, 15). This could result in selection of non-code compatible hardware, creating a more difficult conversion hardware environment.

At the initial stages of the conversion planning phase the target hardware will be unknown. The project manager must initially formulate plans to cover conversion on both code compatible and non-code compatible target hardware. There is no way to avoid planning for both contingencies. However, the software conversion study completed in the requirements phase should provide insight into a probable procurement alternative that will be chosen. If there are significant cost savings or avoidances in a code compatible conversion, initial planning emphasis can be focused in that direction. If cost savings are ambiguous, the most difficult conversion, non-code compatible, can be assumed.

Sometimes in the mid to late stages of the conversion planning phase the target hardware procurement alternative will be known. If code compatible hardware will be acquired (even though competitive selection has yet to take place) detailed plans can be formulated. If a fully competitive acquisition is pursued, much planning will have to wait until

the procurement process is completed and the target hardware is identified. This condition often places pressures to complete detailed plans in a short timeframe, prior to target hardware installation. The project manager has to anticipate this contingency. It is extremely important for the project manager to maintain continuing interface with the hardware selection staff to gain knowledge of hardware selection decisions as early as possible.

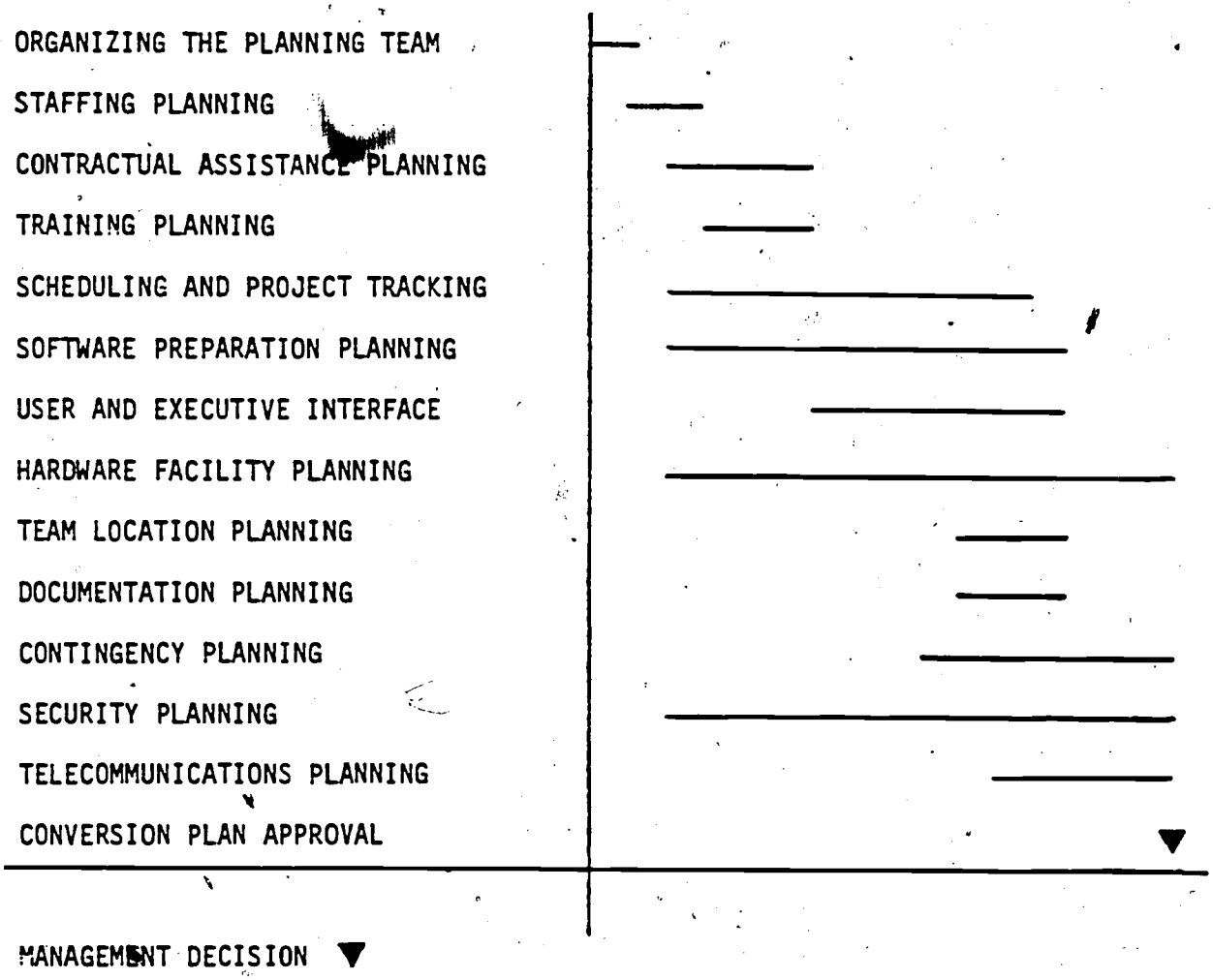
4.2.3 SCHEDULE RESTRICTIONS

The time frame for the conversion effort may be affected by management decisions. Contractual arrangements or budget decisions may dictate seemingly arbitrary installation times of the target equipment or removal of the source equipment. To meet overall agency needs, management may require the conversion to be completed by a certain date. The software conversion plans are thus additionally constrained. Application of additional agency resources may have to be planned to meet the completion schedule, or outside contractors with appropriate expertise may have to be used. These actions may affect operations and/or the cost of the conversion effort.

4.3 CONVERSION PLANNING ACTIVITIES

Figure 4-1 illustrates the activities that occur during the software conversion planning phase. During this phase the project manager must organize the project team for developing detailed plans for the software conversion. Thereafter, the project manager and project planning team will:

- Develop a staffing plan to accomplish the software conversion,
- Develop a training plan,
- Plan a conversion schedule and mechanisms to track conversion plan execution,
- Plan for software program preparation,
- Involve functional users and top management in conversion plans,
- Plan for use of conversion hardware facilities,
- Provide for location of the conversion team,
- Plan for documentation of converted software,
- Plan for contingencies.



CONVERSION PLANNING PHASE ACTIVITIES

Figure 4-1

4.4 ORGANIZATION OF THE PROJECT TEAM FOR PLANNING

Before detailed planning can begin, personnel who will participate in the planning must be assigned (47). Project team staff members who participated in the project initiation and requirements phases will normally continue in planning roles since planning requires in-depth understanding of the requirements.

Additionally the project team skills should be extended by augmenting the team with:

- o Systems Programmers to provide planning details or systems processing impacts,
- o Application Programmers who have insight in the construction of agency information systems,
- o User's Representatives who will assist in the conversion (e.g., during parallel testing),
- o Operational Personnel who will also assist in the conversion (e.g., assisting in system testing planning schedules),
- o Communications Staff to provide assistance in teleprocessing planning,
- o Security Personnel to assist in security and privacy planning details.

These personnel may participate at different times, and at different levels, but their planning input is needed. Where in-house specialist skills are lacking, external assistance (e.g., Federal Conversion Support Center; consultants, etc.) can be effectively used to shorten planning schedules and to develop more detailed, comprehensive plans.

4.5 CONVERSION STAFFING PLAN

One of the initial steps is the development of a plan for organizing and structuring the conversion project team, (i.e., determining personnel to participate in the conversion, identifying responsibilities and developing a management hierarchy).

4.5.1 TEAM COMPOSITION DURING ACTUAL CONVERSION

Members of the project team during the conversion phase should include (33):

- o Task Leaders - Senior-level personnel with senior level analyst and programming skills at the leadership level, preferably with some conversion experience.

- o Senior Systems Analysts/Programmers - Personnel with senior level programming skills, preferably with some conversion experience. These personnel should be able to assist programmers with conversion programming problems.

- o Senior Programmers - These report directly to their Task Leaders and perform the actual program conversions.

- o Operational Personnel - Staff members responsible for operation of source and target equipment.

- o Vendor/Contractor Support Personnel - Personnel who will train and assist agency personnel during the conversion effort.

The size of the conversion project team is dependent on the software conversion workload estimated during the conversion requirements phase.

Selection of personnel is dependent on a number of considerations, including:

- o Conversion Experience - prior conversion experience is important. Even if conversion experience has been in a different hardware/software environment, conversion insight is valuable.

- o Skills - Extensive selection of entry or low-skill level people will lead to delays, conversion slippage and increased costs. For this reason, many agencies assign their most experienced personnel to conversion duties. It is preferable to assign personnel who know both source and target hardware and languages. If this is not possible, personnel with knowledge of target hardware and languages should get priority.

- o Availability

  Experience indicates that personnel assigned to conversion efforts should remain on the project until their part is completed. Plans should provide that each staff member be dedicated to the conversion effort during the time assigned.

A matrix management approach can be applied to resource planning. Matrix management can assist by identifying conversion personnel skills and applying them to conversion tasks with maximum effectiveness. Figure 4-2 illustrates how this can be accomplished. This also assists in defining conversion responsibilities.

NAME	APPLICATION	SKILLS	AVAILABILITY
Smith	Payroll	COBOL,CSL	4 months
Jones	Personnel	COBOL,CSL	6 months
Butler	Modeling	FORTRAN,CSL	2 months
Brown	Personnel	COBOL	6 months
Green	Personnel	COBOL,FORTRAN	3 months
Larkins	Modeling	FORTRAN	3 months
Donnley	Payroll	COBOL,CSL	4 months

APPLICATION	PERSON MONTHS EFFORT	ASSIGNMENT	COMMENT
Payroll	8	Smith 4, Donnley 4	
Personnel	18	Jones6, Brown6, Green3, Smith2,	short 1
Models	4	Larkins2, Butler2	Larkins over 1

SAMPLE MATRIX MANAGEMENT
PLANNING

Figure 4-2

4.5.2 ASSIGNMENT OF RESPONSIBILITIES

Plans should be developed for assignment of responsibilities to all members of the conversion team. This will increase understanding of conversion duties and reduce the possibility of duplication of effort or omission of important conversion tasks at critical times.

4.5.3 MANAGEMENT HIERARCHY

A management hierarchy (see Figure 4-3) should be included into the conversion plan for control and project reporting.

4.6 PLANNING FOR CONTRACTUAL ASSISTANCE/AUTOMATED CONVERSION TOOLS

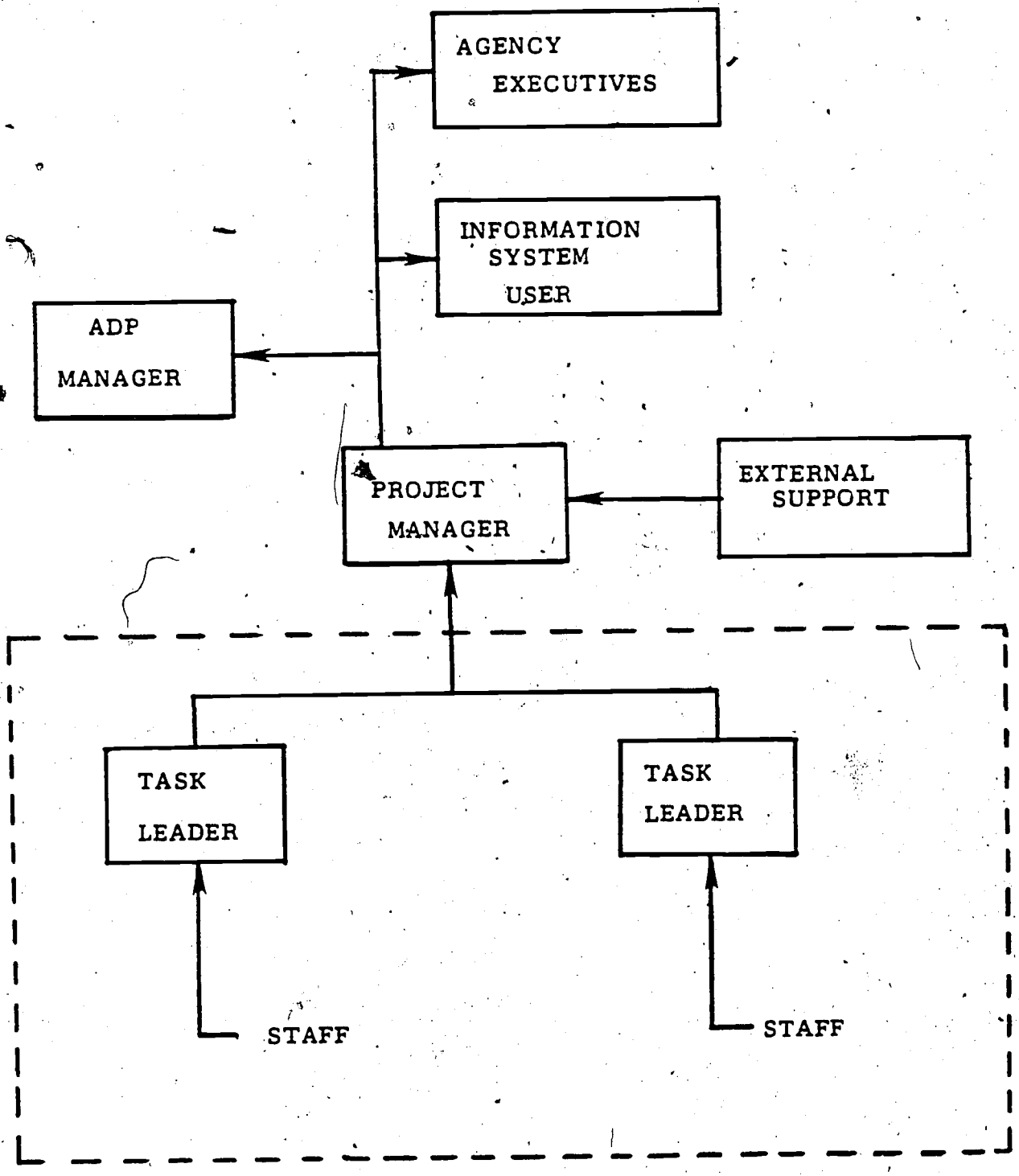
An assessment of automated tools and the need for contractual assistance was made during the requirements phase. Decisions to use automated tools or to obtain contractual conversion assistance were based on a number of factors, including:

- o In-house expertise,
- o Cost effectiveness,
- o Internal resource availability,
- o Conversion time frame.

During the planning phase it is important to plan for the use of contractors or automated tools. Planning details should specify:

- o When to employ them,
- o Who will use them,
- o How they can be acquired,
- o Where to acquire them,
- o Training needs.

The requirements for and identification of conversion tools will have already been made during the requirements phase using guidelines such as those provided by the Federal Conversion Support Center (40). The emphasis will be on planning the use rather than selection. Final selection will only be determined when the target hardware is identified. Likewise, planning details for employment of conversion contractors can only be made after target hardware identification and full assessment of the cost benefits of use of in-house resources vis-a-vis contractor support can be assessed.



SAMPLE REPORTING HIERARCHY

Figure 4-3

4.6.1 PLANNING FOR A SOFTWARE REQUEST FOR PROPOSAL (RFP)

If a decision was made to obtain the services of a contractor to assist during the conversion, plans have to address (47):

- What goes in the RFP,
- When it is to be issued,
- How it is to be released (i.e., competitive, sole source),
- Type of contract (i.e., fixed price, cost plus, fixed fee).

The experiences of Federal agencies interviewed indicated that the following should be included in a software conversion RFP plan:

- Number of lines of code to be converted,
- Number of programs, files, applications to be converted,
- Conversion schedule,
- Average effectiveness level and efficiency of code,
- Documentation,
- Provision for test data,
- Vendor evaluation criteria.

Programs, files and lines of code are known from data developed during the requirements phase. Cost is generally based on fee per line of code converted. Most agencies contacted in developing this guide, that used an outside contractor, based their fee schedule on this scheme.

It is important to plan a conversion schedule for inclusion in the contract. Planning the schedule is described in Section 4.8. An agency should consider including incentives and/or penalty fees in the contract. Any penalty fees should reflect the total cost impact to the agency of the increased costs of continuing current operations beyond the scheduled software acceptance date. A warranty clause may also be included. This clause would require the contractor to provide personnel after conversion completion for troubleshooting purposes.

Agencies commonly specify that a contractor must deliver programs that execute a certain percentage of code using test data (e.g., 70%). This alone does not assure production of efficient or effective code. The agency should consider stating in the RFP an average operating efficiency level expected for each program converted. A number of Federal agencies did not include this in their contracts, and they experienced many programs running much longer on target machines than source machines, despite the fact that the target machines had faster processing times.

The RFP plan should also state what documentation the contractor must provide. These should be in accordance with agency standards or FIPS PUB 38 or 64.

Provision of test data should be defined in the planning. Most agencies choose to develop and provide the data to test contractually converted code since agencies have the best insight regarding information system processing requirements. If an agency chooses to let a contractor develop test data, plans should be developed for agency verification prior to test data use and acceptance of converted software.

Planning should allow all statement of work and evaluation criteria to be continually refined up to the point of issuances of the RFP. Evaluation criteria should be summarized but developed in detail so that contractors will know the exact terms expected for acceptable performance. In this regard it is useful if RFP plans are developed in looseleaf notebook form in a format corresponding to a statement of work and evaluation criteria. This will facilitate translation of plans into contract formats.

It is advantageous for the project team planning the use of contractors to have contractual experience. If this experience is not resident, it must be gained somehow. One agency, inexperienced in managing a software conversion contract; gained experience by releasing a preliminary, short-term software conversion RFP. The RFP required that the selected contractor convert one application system from the source to the target system. This small contract effort served a number of purposes. It surfaced a number of conversion problems in converting to the target system, provided the management team experience in conducting a conversion, and also provided the experience in managing a software contract. Additionally, this approach produced insight into additional performance criteria and schedules that were translated into planning the major software RFP.

4.6.2. CONTRACT MONITORING

During the planning phase, a mechanism should be developed for monitoring the contract. If the contract is large enough, the project manager should be assigned as, or have assigned on the project management team, a full-time Contracting Officer's Technical Representative (COTR).

4.7 PLANNING FOR TRAINING

A training schedule for the project team as well as the entire software staff should be developed. Training itself should begin and end prior to the conversion. However, if carefully planned, training can extend into the conversion phase. Proper training of personnel and adequate training schedules are of major importance in keeping the conversion process on track (33). The impact of training conducted too late is apparent if staff is being trained when they should be converting software. What is not well understood is that training can be conducted prematurely. The time lapse between training and conversion degrades effectiveness.

Following is a checklist of conversion training plan requirements. Based on this checklist, the project planning team should develop a detailed training outline, the content of each subject area and a training schedule. Training should include all conversion and operational personnel, and functional users. The project manager should coordinate training plan schedules with all concerned to ensure that the content and schedule meet agency requirements.

Training Requirements

- o Conversion aids/automated tools
- o Target system software
  - Compiler differences
  - Disk file management
  - New peripherals
  - Utilities
- o Target hardware
  - Operation
  - I/O procedures
  - Data format
- o Program changes (programming conventions, code and I/O differences)
- o Data
  - Collating sequence
  - Logical compare differences
- o Program job control language
- o Instructors
- o Training facilities

Training planning will require coordination with contractors. The hardware vendor should be made responsible for training personnel on use of the new equipment (operations, procedures, software) and describing differences between source and target equipment. Instruction on use of automated tools may require training by the supplying vendor or, if developed internally, by in-house personnel.

4.8 PLANNING THE SOFTWARE CONVERSION SCHEDULE AND DEVELOPING PLANNING TRACKING MECHANISMS

A schedule of system and program conversions must be established. An inventory of all applications and programs was made during the project initiation and conversion requirements phases. This established the number of programs, files, and number of lines of code by language and the level of conversion effort (in terms of man-hours) each program or system will require. Using this inventory, the project planning team should establish the schedule for converting these programs, whether done in-house or by an outside contractor.

4.8.1 SOFTWARE CONVERSION PRIORITY

The first step in scheduling is to determine the order of the files and programs to be converted and results expected in a chronological list.

Top management or functional users may require some systems to be converted earlier than others because of future agency plans. Users may also request that their systems be transported to target hardware as soon as possible to take advantage of its capabilities. Based on these parameters, plans must be developed around resource availability.

4.8.2 RESOURCE PLANNING AND RESPONSIBILITIES

Plans must permit conversion to coincide with the availability of resources, including personnel, equipment, funding, and processing time. This precludes inefficient situations from developing which contribute to slippage and cost overruns, such as:

- o Hardware available but files and programs not being converted,
- o Files and programs in a state of conversion but no or insufficient processing resources.

This will prevent potential future problems in terms of overlapping responsibilities and provide accountability for the various systems, programs and files earmarked for conversion.

4.8.3 SCHEDULE PLANNING

A detailed schedule of applications, programs, and files to be converted should be established regardless of whether conversion is performed in-house or by an outside contractor. A number of methods can be used to do this, but they all have common features.

- o Identify personnel responsible for application program file conversion.
- o Establish time frame for conversion.
- o Establish deliverables or results (e.g., code translation, unit, system and parallel tests).
- o Establish a progress reporting mechanism and tracking system.

Four types of schedules should be maintained, and tracked. These schedules serve as cross-references to each other (33). They are:

- o Application system conversion schedule,
- o Application program conversion schedule,
- o File conversion schedule,
- o Personnel schedule.

Figures 4-4 through 4-7 are sample forms that may be used for scheduling activities.

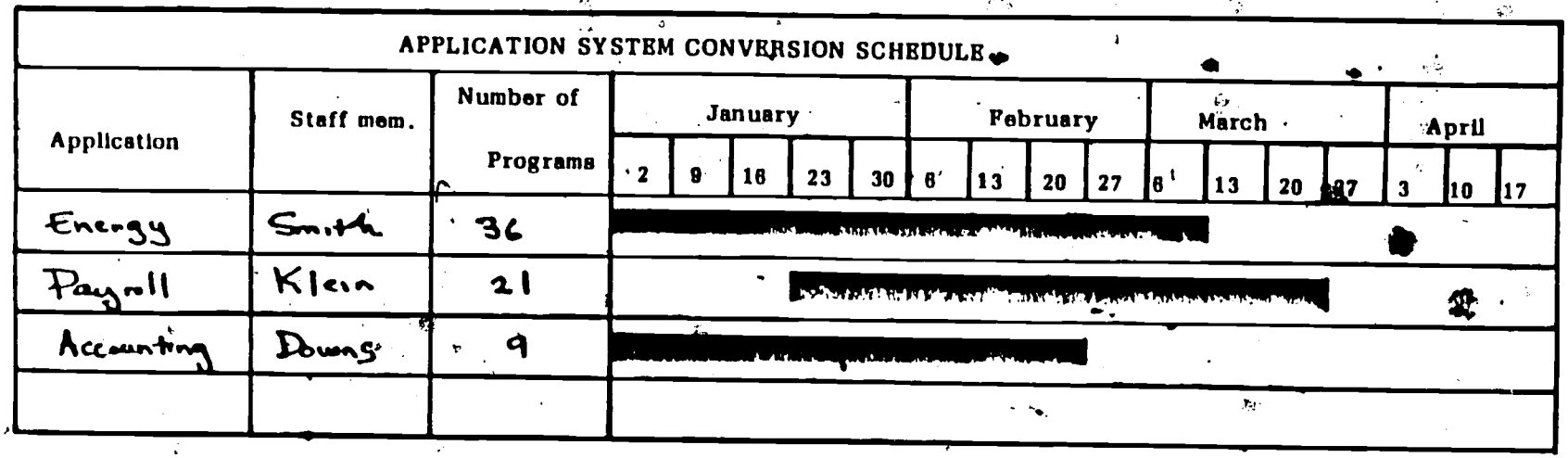
4.8.4 REPORTING MECHANISMS - TRACKING AND MONITORING

To maintain control and awareness of project status the project manager will want to establish a mechanism by which project status is tracked and reported laterally and upward. At the project team level reporting is most detailed and should contain:

- o Program/application file name,
- o Individual's name responsible for conversion,
- o Start date/completion date,
- o Current status,
- o Expected completion date,
- o Problems.

The detailed information at the project team level will be supplied by the task leaders for each activity for which they are responsible. For higher level reporting, the project manager will summarize project status information and disseminate to top management in regular reports.

As shown in Figure 4-8 a number of tracking mechanisms are available, both automated and manual. Selection of a method should be based on requirements and policies of the particular organization, and by the project manager's management style. The important point here is to establish this mechanism and integrate it into software conversion planning.



SAMPLE APPLICATION SYSTEM SCHEDULE

Figure 4-4

Source: U.S. Army Guide
for Software Conversion

APPLICATION PROGRAM CONVERSION SCHEDULE

Application	Program	File	Staff Member	January					February				March				April		
				2	9	16	23	30	6	13	20	27	6	13	20	27	3	10	17
Energy	Trans 1	Energy Master	Smith	■	■														
Energy	Building 1	Energy Master	Smith			■	■												
Payroll	Federal	Payroll Master	Klein				■	■											
Payroll	State	Payroll Master	Klein						■										
Accounting	Recievables	Accounting Master	Downs	■															
Accounting	Payables	Accounting Master	Downs		■														

SAMPLE APPLICATION PROGRAM SCHEDULE

Figure4-5

Source: U.S. Army Guide for Software Conversion

Note: All programs for each application not shown.

FILE CONVERSION SCHEDULING																	
FILE	STAFF MEMBER	January					February							April			
		2	9	16			6	13	20				27	3	10	17	
Energy Master	Smith																
Payroll Master	Klein																
Accounting Master	Downs																

SAMPLE FILE CONVERSION SCHEDULE

Figure 4-6

Source: U.S. Army Guide for Software Conversion

PERSONNEL ASSIGNMENT SCHEDULE

Staff Member	Application	January					Februrary				March				April		
		2	9	16	23	30	6	13	20	27	6	13	20	27	3	10	17
Smith	Energy																
Klein	Payroll																
Downs	Accounting																

SAMPLE PERSONNEL ASSIGNMENT SCHEDULE

Figure 4-7

Source: U.S. Army Guide
for Software Conversion

	TRACKING/PERFORMANCE MEASUREMENT	MODIFICATION OF PLANS	TREND ANALYSIS
Nichols PMS (N5500)	X	X	
ASA-PMS	X		
MSCS		X	
Project Manager	X	X	X
OPTIMA 1100		X	
Projacs		X	
IBM 5110 PCS	X	X	X
MCS		X	
COPES	X		X
Navy Conversion PMS	X	X	X

PROJECT MANAGEMENT TRACKING PACKAGES

Figure 4-8

The tracking mechanism should also provide cost performance information for each activity such as estimated budget, actual expenses to-date, and variance between estimated and actual costs. Variance criteria could be established that would flag potential cost overrun conditions for early, management attention.

Figures 4-9 and 4-10 illustrate sample tracking charts that may be used by project managers. Figure 4-9 is a periodic (weekly, biweekly, etc.) report indicating the status for each program (application, file). The chart is completed at regular intervals by the project manager for a summary overview of the entire conversion. Figure 4-10 is an application tracking chart that can be used by task leaders and the project manager to keep track of each program within the application.

4.8.5 MULTIPLE SITE CONVERSION SCHEDULES

Management of conversions at multiple sites (e.g., in a distributed processing environment) presents additional problems. If centralized control cannot be exerted, tracking and monitoring progress for a multiple site conversion will be difficult. In multiple-site conversion planning it is essential that top executives assign responsibility for maintaining schedules and reporting conversion progress.

4.9 SOFTWARE PREPARATION PLANNING

The condition of software and data files, prior to conversion, might be such that they cannot be efficiently or effectively converted. Preparation activities have to be planned (27, 39) including procedures to:

- Update documentation,
- Remove obsolete programs and code,
- Develop test data,
- Modify programs, as required, prior to conversion.

During the conversion requirements phase, documentation was reviewed for completeness and accuracy. Since poor documentation directly affects conversion effectiveness, corrective action must be planned and tracking mechanisms should be developed to ensure documentation requirements are met.

Plans to allow for the removal of obsolete programs and code should include notification of users that their asistance is required and solicited in a positive, participatory role and obtaining support from top management.

Test data development planning is extremely important. It affects the accuracy and effectiveness of the converted programs and considerable developmental lead time is often required. This is discussed in more detail during the conversion preparation phase.

TASK LEADER: Smart				WEEKLY PROGRAM STATUS				WEEK OF: Jan 16
Week of	Application	Program	Staff mem.	Start Date	Sch Date Complete	Complete Date	Status	Costs
Jan 2	Energy	Trans 1	Smith	Jan 2	Jan 15	Jan 16	Completed 1 day late	11 days $36.00 Correct Time
Jan 2	Accounting	Recievables	Downs	Jan 2	Jan 8	Jan 8	Completed on time	5 days $13.00 Correct Time
Jan 9	Accounting	Payables	Downs	Jan 9	Jan 15	Jan 11	Completed ahead of Schedule	9 days $12.00 correct time
Jan 16	Energy	Building 1	Smith	Jan 16	Jan 22		In process	

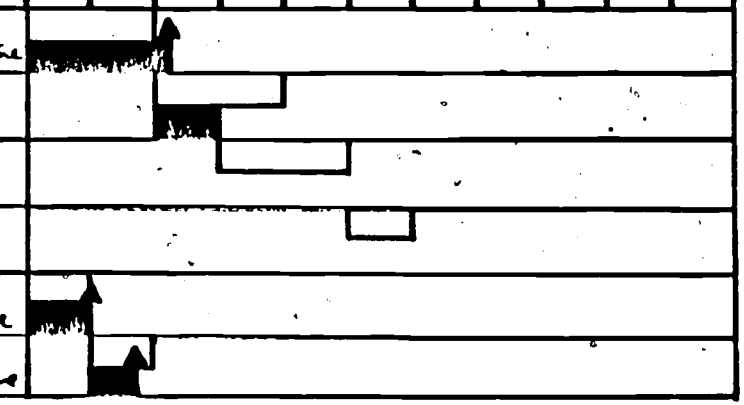
SAMPLE WEEKLY PROGRAM STATUS REPORT

Figure 4-8

WEEKLY PROGRAM STATUS TIMELINE

Completed ▲

Program	Staff Member	Start Date Sch/Act	Completion Date Sch/Act	Costs
Trans 1	Smith	Jan 2 / Jan 2	Jan 15 / Jan 16	11 man days $36.00 Connect Time
Building 1	Smith	Jan 16 / Jan 16	Jan 22	
Payroll Fed	Klein	Jan 23	Jan 29	
Payroll State	Klein	Feb 6	Feb 12	
Receivables	Downs	Jan 2 / Jan 2	Jan 8 / Jan 8	5 man days $13.00 Connect Time
Payables	Downs	Jan 9 / Jan 9	Jan 15 / Jan 11	4 man days $12.00 Connect Time



SAMPLE WEEKLY STATUS TIMELINE

Figure 4-10

Program modification activities should be included in the conversion plan. These activities are listed below.

- o Language Translation

  The experience of some Federal agencies indicated that language translation should occur prior to conversion, if possible. (e.g., Assembly languages to COBOL for a COBOL to COBOL conversion)

- o Enhancements

  If new user enhancements and functional redesigns are required, they should preferably be scheduled prior to or after conversion, and not during the actual conversion.

- o Removing Vendor Extensions.

  All programs should have been examined for vendor specific extensions during the requirements phase. These should have been identified and documented. Conversion planning should allow time for the removal of vendor specific extensions and coding, if possible. However, vendor extensions may provide capabilities that standard languages do not. It may not be possible to remove these extensions and still provide the same output. Redesign activities may be required.

- o Optimization

  Programs should be examined for efficiency. If optimization is warranted, plans should be developed to streamline code prior to conversion. This reduces actual conversion time and ensures production of efficient software.

4.10 FUNCTIONAL USER AND EXECUTIVE INVOLVEMENT

Functional users should be involved throughout this phase, since their cooperation is essential for a smooth conversion effort. Users should be included in planning for scheduling and testing (47). The cost of user committee or work group should be included in the total cost of conversion, and the size and involvement of this group should be determined partially on cost considerations.

It is unlikely that agency executives will wish to be involved in the conversion planning details. However, the project manager should

ensure that agency executives are continually apprised of planning progress. This level of management can lend significant support and assistance in resolving many planning conflicts that will occur outside the authority of the project manager or ADP manager.

4.11 HARDWARE ACTIVITIES

The project team must stay abreast of all activities relating to the hardware procurement, since these activities will affect the conversion plans.

The hardware procurement decisions will impact planning and conversion costs according to the selection of the target environment equipment, and the availability of the target equipment for installation, testing, and operations.

It is recommended that agency staff involved in hardware acquisition regularly participate in software conversion planning conferences.

The project manager must plan for production and conversion processing. A number of options are available for conversion and should have been identified on an operational and cost-effectiveness standpoint during the requirements phase:

- On target hardware colocated with source hardware,
- On target hardware located in another facility,
- Through time sharing on hardware provided by the target vendor,
- A combination of the above alternatives.

If the target hardware is not installed prior to the start of the conversion, time sharing arrangements on a compatible machine will be required. The hardware RFP may require the vendor to provide these services, or a commercial timesharing service may have to be used.

The target hardware may have to be initially installed in another location if source hardware is still required for production and the current computer facility is too small. This will require providing another facility and all appropriate services, e.g, air conditioning, power, raised floors.

The selection of production and/or conversion facilities is dependent on a number of variables, including cost, availability, and time frame. Preparing another computer room is expensive, requiring detailed planning and contract work. If the target computer is placed in another facility, the conversion team may have to relocate.

Use of a time [redacted] service may result in two additional costs:

- o Equipment [redacted], modems) required to interface with the servi[redacted]
- o Computer time.

4.12 PLANNING FOR LOCATING THE CONVERSION TEAM

Plans must be prepared for providing facilities to house the conversion team. Sufficient space may be available to house the planning team as a group, but not be large enough to accommodate the conversion team. If members of the team are located in a number of different places, it will be advantageous to move them to one location during the conversion effort to increase management control. If converted programs are to be run on hardware located external to current facilities, it may be advantageous to temporarily relocate the conversion team to or near that facility.

4.13 PLANNING FOR DOCUMENTATION OF CONVERTED PROGRAMS

Plans should specifically require the conversion team to produce documentation in accordance with FIPS standards or guidelines. Additionally, plans should provide sufficient resources and time for documentation production. If contractors are to be used for software conversion, RFP planning should be reviewed to ensure documentation requirements are addressed. Documentation improves software maintenance on a day-to-day basis and significantly aids programmers and analysts in software conversion.

4.14 CONTINGENCY PLANNING

To reduce the likelihood of problems occuring during conversion, continuous review of plans for potential problems can assist in early identification and resolution of many otherwise disruptive influences before they occur. No conversion will be problem-free, however. The project manager should expect problems and develop a plan to handle those contingencies as they occur.

During conversion most unanticipated problems occur due to:

- o Failure to Maintain Conversion Schedules Schedule slippage can be significantly reduced if plans provide adequate resources in terms of personnel and time to accomplish conversion activities. Problems are further reduced if specific staff capabilities and limitations are considered in developing schedules and assignments. However, the project manager must anticipate that some personnel will fall behind schedule.

- o Personnel Changes Unexpected losses of personnel will occur due to sickness, extended vacations, transfers and termination.

- o Scheduling Deficiencies Because requirements can never be perfectly defined, some schedules will be developed that are too rigid or unrealistic.

- o Contractor-Related Problems Contractors frequently fall behind schedule or converted programs may require more optimization than anticipated.

- o Hardware Delivery and Installation Delays Hardware installation may be delayed due to contractual difficulties, transportation delays due to strikes, manufacturing difficulties or problems in site preparation.

Plans should provide a "reserve" of personnel resources and time to permit the project manager the flexibility to adjust schedules and levels of effort to meet contingencies on a case-by-case basis and still accomplish conversion by the established end date. Task order contracts can also be negotiated prior to conversion to apply contractors on a quick reaction basis in resolving conversion problems.

The use of a detailed costing structure as described in Appendix C can assist the project manager in contingency planning and execution. Potential and actual problems can be analyzed and alternatives selected at the lowest overall cost to the agency.

If contractors are going to be used to convert software the potential for problems can be reduced by detailed planning of the RFP in terms of expected deliverables, documentation, and software performance. Penalties or awards in the contract are recommended to provide incentive for the contractor to stay on schedule and perform effectively.

4.15 SECURITY/PLANNING

Security plans should be developed to meet requirements developed during the requirements phase. Specific areas which require planning attention include:

- o Identification of security software features which meet the needs of the risk analysis and assignment of conversion team responsibilities for inserting security features into software and procedures during conversion,

- o Access control to sensitive software, databases, system libraries and documentation,
- o Isolating software testing and the use of non-sensitive data from the operational environment,
- o Software security assurance and certification,
- o Conversion team security training,
- o Personnel clearances to include contractors and consultants,
- o Operational procedures during testing and cut over,
- o Facility requirements for sensitive software conversion products (e.g., locked cabinets, safes for sensitive listings, etc.),
- o Security specifications in the RFP that must be addressed by the contractor,
- o Teleprocessing, multi-site and distributed processing security.

NBS FIPS PUBS 31, 41, 48, 65, and 73 address security and risk management considerations which may be helpful in dealing with security needs during the planning stage. These FIPS PUBS are described in Appendix B.

4.16 TELECOMMUNICATIONS PLANNING

Plans and schedules must be developed to assure that the converted software and data files can interface with or be supported by teleprocessing hardware and software environment.

4.17 FORMAL CONVERSION PLAN

All the activities described in this section should be incorporated into a formal conversion plan which will serve as the guide during the conversion process. Figure 4-11 is a candidate outline of a conversion plan that can be used as a guide by project managers.

The conversion plan should answer the questions of:

- o Who shall participate and conduct the conversion?
- o When will the conversion take place?
- o Where will the conversion take place?
- o How much will the conversion effort cost?

It is recommended that the plan be developed in draft form and coordinated with the hardware acquisition staff and information system users prior to presentation to agency executives for approval.

Section	Description
1	Background
2	Summary of Workload Analysis
3	Budget Summary
4	Personnel Resources - Management Team - S/W Conversion Team - Availability
5	Conversion Schedule - Responsibilities - Schedule
6	Project Reporting and Tracking
7	Conversion Aides
8	Software Contract
9	Training Plan - Security Plan - Telecommunication Plan
10	Facilities Plan - Production - Conversion - Team Location - Equipment Resources
11	Contingency Plans
Appendices	Budget Schedule

SAMPLE OUTLINE OF CONVERSION PLAN

Figure 4-11

4.18 PLANNING DECISIONS

At the conclusion of the planning phase the conversion plan will be presented to agency executives for approval to proceed with preparation and conversion activities. It is recommended that the plans be presented as part of a formal briefing where the entire plan can be explained and an appreciation gained by top management for planning ramifications and impacts on overall agency operations.

Once plan approvals are gained other management decisions will involve approving conversion preparation and conversion budgets and implementation procedures associated with conversion preparation, the next phase.

4.19 ECONOMIC CONSIDERATIONS

During the conversion planning phase, personnel costs should continue to be the major element of cost. Outside consultant services may also contribute to the cost of this phase if these services are used to assist in the planning effort in areas such as developing the conversion plan, reviewing the conversion plan or actually preparing the formal conversion plan for submission to upper management. Expenses may also be incurred in the acquisition of automated project planning, tracking and reporting aids.

In this phase, the cost estimates developed for the software conversion cost structure will be refined as conversion activities are defined in more detail. Cost information should be developed at the most detailed level that is anticipated to be required. The accuracy of individual cost estimates at this level may not be great; however, the overall accuracy of the total cost of conversion should improve due to the use of more detail and the ability to estimate future project costs using the actual costs incurred during the previous phases.

Conversion cost information will be used during this phase to assist project management in developing the conversion schedule and resource assignments. Scheduling decisions should be based on total cost considerations that include the entire procurement action, not just the software conversion effort. The detailed costing methodology given in Appendix C can assist in the assignment of resources to the conversion effort by allowing a cost-benefit analysis regarding the use of outside personnel resources for conversion functions. Also, the conversion cost information will assist the preparation of the formal conversion plan by providing detailed cost information for budget planning by developing budget schedules by function, phase or year; developing alternative cost justifications for the use of outside contractors and conversion aids; providing continued justification for the conversion effort; and ensuring the cost-effectiveness of contingency plans.

4.20 PLANNING MANAGEMENT CHECKLIST

- o Planning team assembled
- o On-going costs being tracked
- o Team augmentees identified
  - System programmers
  - Security
  - FCSC
  - Consultants
  - Telecommunications
  - Others
- o Coordination and interface on-going with hardware acquisition staff
- o Budget available to support planning
- o Project planning constraints identified
  - Budget constraints affecting conversion
  - Hardware procurement
  - Time and schedule limitations
  - Others
- o Conversion staffing plan developed
  - In-house staff
  - External conversion resources
- o Training plan developed
- o Plan for use of contractual assistance and conversion tools during conversion completed
  - RFP planning
  - Tool acquisition, training and use planning
  - Contract monitoring
- o Software conversion schedule planned
  - Priorities considered
  - Conversion responsibilities assigned
  - Schedule developed
  - Information system user input
  - Multiple site schedules considered
- o Conversion plan tracking mechanism developed

- o Software preparation plan developed
  - Documentation updates
  - Removal of obsolete programs and codes
  - Test data
  - Preconversion program preparation
  - Optimization
- o Continuous interface with agency executives and information users
- o Conversion facilities planned
- o Locating conversion team planned
- o Documentation production planned
- o Contingency planning accomplished
- o Security plans developed
- o Telecommunications and distributed processing plans accomplished
- o Conversion plan drafts
  - Internal agency coordinationor
  - Agency executive approval

SECTION 5

CONVERSION PREPARATION PHASE

This phase is a direct continuation of conversion planning in that many of the plans made during that phase are acted upon. At the end of this phase, the project manager will have accomplished all activities that are required to begin actual conversion (23).

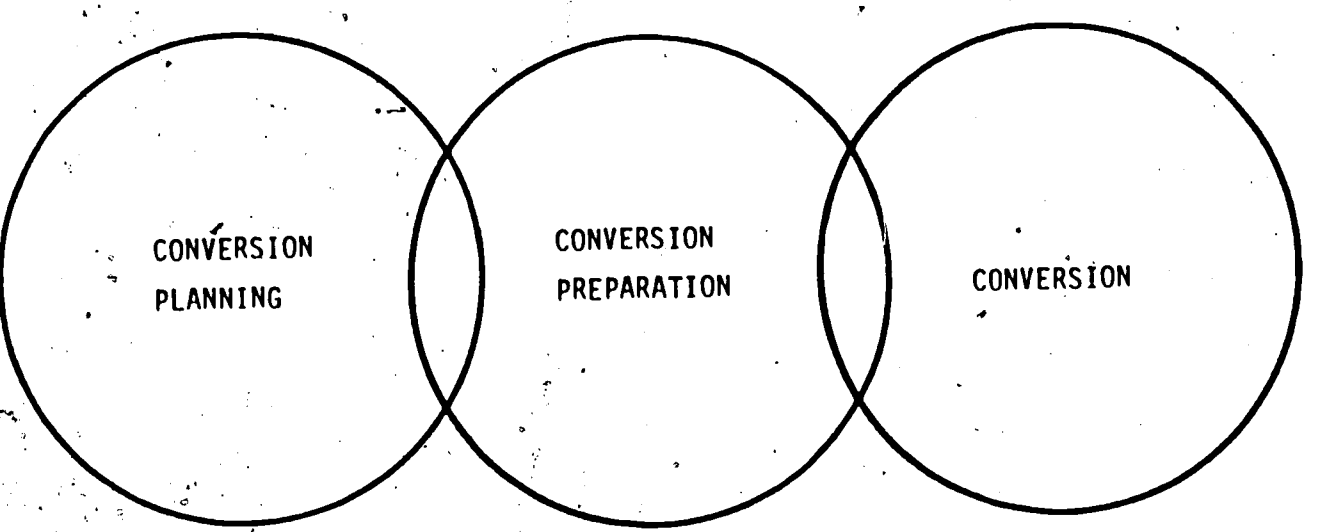
On a timeline of conversion activities, the preparation phase may be significantly overlapped by conversion planning on one side, and the conversion phase on the other. This is illustrated in Figure 5-1. However, the activities or functions that occur during preparation are distinct from planning or actual conversion activities. Thus, preparation is discussed as a separate phase.

While preparing for the conversion, the project manager must continue to monitor project cost performance relative to the initial budget established during project initiation. The preparation activities may require significant expenditures over a short time period as the conversion staff is acquired, facilities and equipment obtained and conversion tools developed. Due to the change in magnitude of conversion related expenditures, the project manager may find it necessary to track project costs closely and report regularly (e.g., monthly) to top executives to assure them that cost controls are being used. By comparing software conversion preparation costs estimates against actual costs incurred, the project manager will be able to refine cost estimation data and procedures. This will permit more accurate projection of conversion costs in future phases and future conversions.

During this phase the project manager will begin to see areas in the conversion plan that need improvement or revision. The conversion plan, however, should have the flexibility to allow for changes, and modifications by the project manager when needed.

5.1 OBJECTIVE

The objective of this phase is to complete all activities necessary for the project team to commence conversion. This objective is accomplished by following the conversion plan and conducting all activities that, if not accomplished, would interfere with or impede the conversion effort. These include assembling the staff, training, obtaining software tools, obtaining contractual assistance, and obtaining facilities and necessary equipment.



PHASE INTERACTION

Figure 5-1

5.2 DECISIONS IMPACTING SOFTWARE CONVERSION

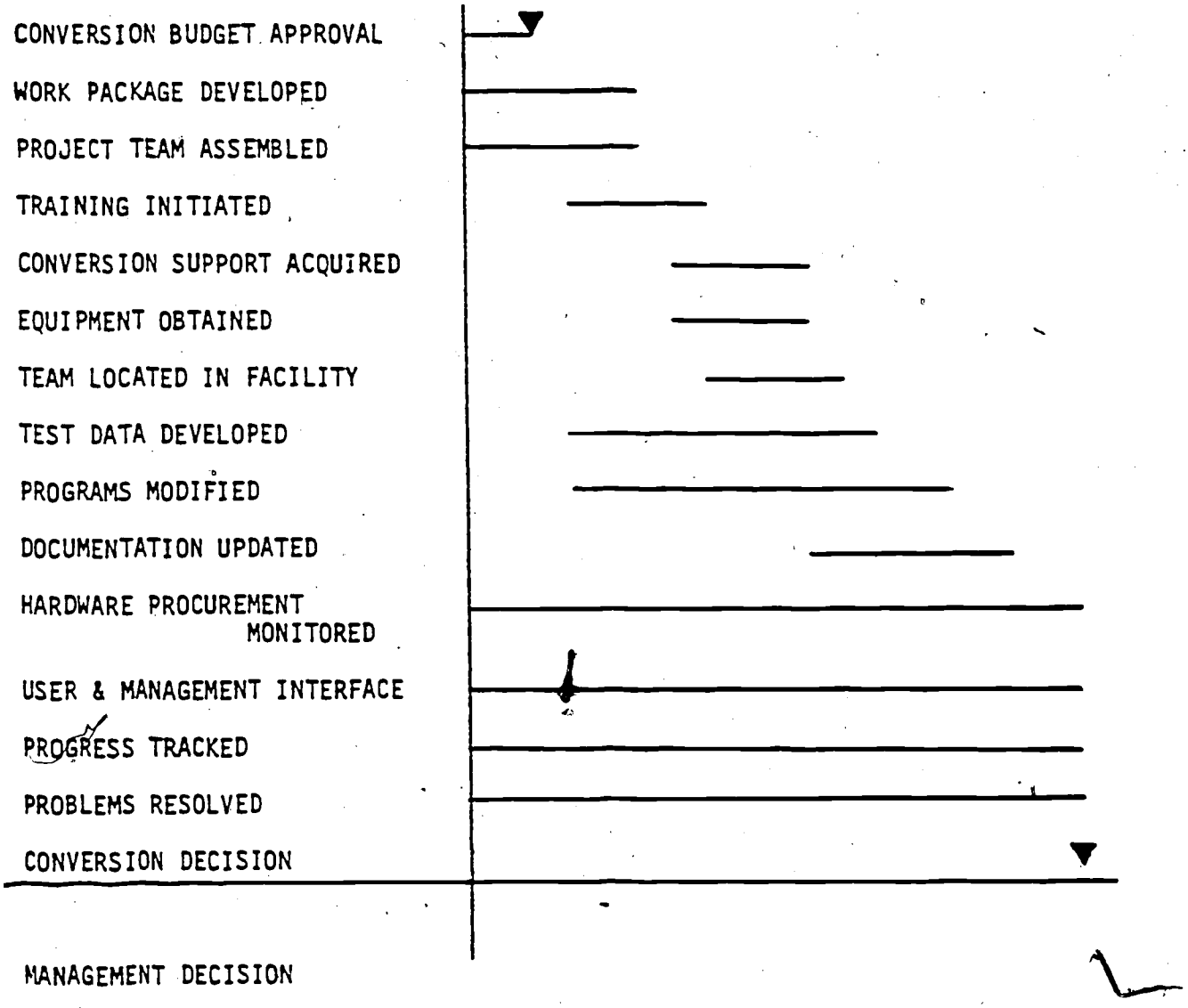
The project manager must be aware of, and prepared for, decisions made by top management and external organizations. New decisions may be made that affect the conversion effort. The conversion plan and schedule will have to be modified based on these new decisions. For example, the budget may be changed, forcing the project manager to change conversion schedules. The target machine may be changed, forcing a change in scheduling, staffing, and training.

By continually addressing the full cost of the conversion effort, the project manager will be in a position to correctly relate the conversion cost impact of these external decisions to agency executives and involve this level of management in the total conversion effort.

5.3 CONVERSION PREPARATION ACTIVITIES

Figure 5-2 illustrates the major activities that occur during the preparation phase. They provide the framework for the subsequent portions of this section, and include the following:

- The conversion budget must be approved,
- Work packages must be developed,
- The project team must be assembled and assignments disseminated,
- The training staff must be assembled and training must start,
- Contractual support, if needed, must be obtained,
- Software tools must be obtained or developed, and team members trained in their use,
- Equipment must be obtained and located with appropriate users (e.g., terminals),
- The project team should be located in the facilities to be used during conversion effort,
- Test data and files must be developed,
- Program modifications should be started,
- Documentation should be updated,
- Hardware procurement should be monitored,



CONVERSION PREPARATION ACTIVITIES

Figure 5-2

- Users' and agency executive's conversion responsibilities must be coordinated,
- Progress must be tracked throughout the phase,
- Problems as they arise must be addressed and the conversion plan modified as needed.

5.4 BUDGET APPROVAL

It is imperative that prior to beginning costly preparation activities, project management obtain final approval for the budget. This final approval should reflect any recent budgetary changes and financial reporting requirements desired by management. In previous conversion phases, costs were primarily related to personnel. Costs will climb during the preparation phase as the larger conversion team is being assembled, contracts are awarded, and equipment and facilities obtained.

5.5 DEVELOPMENT OF WORK PACKAGES

The project manager and team leaders will develop and assemble comprehensive conversion work packages to facilitate conversion (45).

Work package preparation includes the effort to physically assemble all work packages and to establish an inventory and control system for the work packages. Each work package should contain enough information to enable the converter to adequately define what is to be converted (programs, files, control stream language, etc.), to ascertain the system/subsystem functions, to identify all system/program documentation needing to be redocumented, and to execute and test the converted system/subsystem to guarantee conversion was successful. A work package should be large enough to encompass a functional area (a system or subsystem) and should be made up of information describing the overall package (system/subsystem) and its individual components (programs, files, etc.). The content and makeup of individual work packages should be determined for each conversion, but will typically consist of such items as:

- Work package transmittal sheets,
- System/subsystem descriptions,
- System/subsystem test data and descriptions,
- System/subsystem control stream language job streams,
- System/subsystem run documentation,
- Program inventory forms,
- File inventory forms,
- Program descriptions,
- Source and compile listings,
- File descriptions,
- Program test data,
- Program documentation,
- File documentation.

5.6 ASSEMBLE CONVERSION TEAM

Conversion team members who will work on the conversion must be assembled or notified during this phase (47). Each person must be informed of:

- When their conversion work will begin,
- To whom they will report,
- Other members of the project team,
- Reporting mechanisms to be followed,
- Areas of responsibility,
- Schedule for completion of tasks,
- Priority ranking of assignments,
- Training schedule,
- New work locations, if applicable,
- Equipment available.

Project managers may find it helpful to notify the conversion staff members and inform them of their responsibilities using a form or written format. This will improve understanding and ensure all pertinent information is conveyed to team members. An initial group meeting is recommended to discuss the overall goals and objectives of the conversion effort. Thereafter task leaders can then meet with their respective staffs and disseminate detailed information to each individual. Project team members should be made aware of the fact that they will be dedicated to the conversion until their particular duties are completed.

Task leaders should hold regular meetings with their staff to discuss progress and review any problems which may arise.

Project team members will be furnished work packages as part of tasking. Project team members should review their particular tasks, and notify their task leaders if they foresee any problems (e.g., not enough time scheduled for a particular program conversion). The problems that surface may require modification of the conversion plan.

5.7 TRAINING

The project team members should be scheduled for any training that is required. If on-the-job training is to be used in lieu of formal training courses, some initial productivity loss can be expected as the learning curve is gained. If on-the-job training was not considered during the requirements phase, the conversion plan and schedules will require adjustment. In addition to the conversion staff, training will be provided operational personnel, functional system users, and other members of the ADP staff, not involved in conversion, but who will ultimately perform software-related work on the target system.

The project manager must acquire and provide the instructors to train the conversion staff and ensure that training plan objectives have been met (33). Except for very large conversions, one to two

instructors should be sufficient. Multiple-site conversions may require more trainers if software conversion is decentralized or if a constricted conversion schedule requires concurrent training at two or more locations.

System programmers should make special training presentations, as required, to inform the conversion team of systems programming impacts on application software. Also, any security-related training should be accomplished.

5.8 OBTAINING CONTRACTUAL ASSISTANCE AND AUTOMATED CONVERSION TOOLS

5.8.1 PREPARATIONS FOR OBTAINING CONTRACTUAL ASSISTANCE

Any planned outside assistance must be obtained during this phase. The project manager will have to provide assistance in or accomplish:

- o Preparing the software conversion RFP,
- o Releasing the RFP,
- o Evaluating proposals,
- o Selecting a contractor.

Plans for these activities were made during the conversion planning phase including planning the specific content of the RFP. However, contractual procedures in obtaining software conversion support can take from four to six months from time of issuance of the RFP. The contract must be solicited, evaluated and responded to by vendors, negotiated and awarded. The potential for time delays is great. It is essential that contractual assistance be obtained on schedule because slippage in this area may force slippage of the whole conversion effort.

The selection of a contractor to assist in the conversion process is critical since the contractor's ability will affect the outcome of the entire conversion effort. Contractual evaluation factors applied in this phase include, but are not limited to:

- o History of Company

  Specifically how long has the vendor been in business; financial standing; soundness of corporate management practices; background of corporate management.

- o Experience

  Types of conversions the vendor has been involved in; success; problem resolution methods; familiarity with the agency target hardware environment.

- Personnel

  The skill and experience level of the employees; turn over rate.

- Cost, Deliverables and Responsibilities

  The proposed deliverables and schedule; responsibilities assumed by the contractor; contract cost.

- Testing

  Ability of the contractor to meet test objectives; proposed alternatives; acceptability of alternatives.

After selecting a software contractor, meetings should be held with their representative. It is important that lines of communication be kept open and that misunderstandings be quickly detected and resolved. Since a contract statement of work can never completely address all contingencies that occur during the conversion, it is important to develop and maintain a professional, cooperative working relationship with the contractor.

The contractor should thoroughly understand how progress is going to be monitored, and how performance penalties or awards will be determined. This includes identifying to the contractor which staff members responsible for specific areas of the conversion are contractual points of contact.

5.8.2 AUTOMATED TOOLS

Automated tools, if used, must be obtained or developed during this phase. If they are to be obtained from a commercial source, another RFP may have to be released. (Note that the decision to develop the tools in-house or obtain them from an outside source was made in earlier phases.) Potential contractors should be required to perform a live test demonstration on a sample program prepared by the project team. Results should be evaluated for accuracy and efficiency and based upon the full cost impact of each proposal on the total software conversion cost. The cost of the automated tools should be compared to original estimates and, if significantly greater than the estimates, their cost-effectiveness should be reevaluated.

If the tool is to be developed in-house, a staff must be assigned to develop the tool as well as tool verification data. Data processing resources must be made available to the developers. After tools have been acquired or developed, the conversion team members must be trained in their use.

5.9 LOCATING CONVERSION TEAM/OBTAINING EQUIPMENT

Project team members should be located in their team facilities. New offices should be equipped with adequate furniture -desks, chairs, lights, telephones. The project manager should ensure that adequate resources are available to those team members who require moving assistance (e.g., boxes, transportation etc.) (4).

Relevant data processing equipment that project team members may require (e.g., card files, terminals, modems, and telephones) must also be obtained. These should be in place and tested prior to starting the actual conversion process.

5.10 CONVERSION FACILITIES

Management must obtain conversion facilities, and develop procedures for use. Information distributed to the project team prior to the conversion should include:

- Location of facilities,
- Operational procedures,
- Hours available,
- Points of contact,
- Access and security issues,
- ADP communications, telephone numbers,
- Logon procedures,
- Protocols and passwords required to log on hardware,
- Troubleshooting procedures.

5.11 DEVELOPMENT OF TEST FILES AND DATA

Good test data should be developed prior to code conversion. If the conversion is to be done totally in-house, project team members will have to develop the test data. A management question arises, however, when a software contractor is used. Who should develop the test data, the contractor or the organization? All of the organizations interviewed in preparation of this guide developed their own test data. However, it may be feasible for the contractor to develop the test data for agency review and validation. Deciding who should develop test data will have been accomplished during the requirements phase. Whether test data is developed by an agency or contractor, it is important that information systems users have the opportunity for input and review.

Test data preparation and generation includes all creation, preparation, and generation of test data sets to validate the converted programs, files, and systems (45). It should ensure that unit test data

sets are small enough in volume to minimize testing costs, but thorough enough to exercise at least 70% of the logical paths of the program. Several studies have independently shown that typically a system will spend 50% of the run time in 4% of the object code; and 10% of the code typically will account for 90% of the run time. The implication is that 90% of the testing may only be exercising 10% of the code. Thus, ensuring that about 70% of the logic paths are executed may still be inadequate. The 70% tested must include the code that is typically the most frequently used. Preparation of test data for execution of the programs following clean compilation should stress the use of data that will execute a maximum amount of the program logic with a minimum amount of input data. Because test data are usually prepared and generated on the source computer, their preparation and generation should include the conversion or transfer of the test data files to the target computer so file comparisons can be performed.

5.12 PROGRAM MODIFICATION AND INCORPORATION OF USER ENHANCEMENTS INTO SOFTWARE

Any additional modification of programs should occur during this phase. Project team members should:

- Remove any obsolete programs and code. This will require team members to interact with users.
- Program desired user enhancements into the system in advance of conversion. It would be preferable to do this after the conversion. However, if time allows or enhancements are mandatory, changes should be accomplished during this phase.
- Remove vendor extensions from the code. However, this may not be possible because the extensions may meet a requirement that cannot be provided by standard languages, or by target vendor extensions. Project team members should familiarize themselves with these extensions, reprogram where possible, and develop alternative plans for extensions that cannot be removed.
- Optimize software to shorten conversion time and ensure efficient code is converted.

At some point immediately prior to a system conversion, software development should be frozen. This will help ensure that outputs on source and target systems are the same during parallel testing. However, the experience of many conversion managers indicates that this is more difficult in practice than in theory. Functional users often require modifications at some point during the conversion, and some systems cannot be frozen. Established and enforced systems change

procedures can reduce problems of simultaneously converting software that is under development. Change control procedures permit identification of a software version configuration and a continuing record of all changes as they are applied to specific versions. A version can be selected for conversion and the recorded changes added later. If an agency does not have good change control procedures in effect, the project manager should enlist the support of the ADP manager to establish and implement change procedures prior to actual conversion.

5.13 DOCUMENTATION

The project manager will have to ensure that documentation is updated. Documentation should be brought to a current state for all software that is not going to be completely redeveloped (33). For software documentation that is in a poor state of maintenance or is non-existent, the project team will have to do considerable research and writing. Some training may be necessary, particularly for newly assigned personnel or contractors, in agency documentation standards or FIPS PUB 38 and 64. Managers will have to arrange for administrative support in documentation production and perform quality reviews as documentation is produced. It is advisable to produce documentation on automated equipment (e g , word processing) to facilitate revision and maintenance.

If user documentation revision or update is required (i.e , users manuals) managers will have to coordinate with functional users and achieve their cooperation in the documentation effort.

5.14 HARDWARE PROCUREMENT

The project manager must keep informed of all activities relating to the hardware procurement. The project manager of one agency interviewed did not stay abreast of hardware procurement activities, and was surprised when target hardware was switched midway through the conversion effort. This forced abrupt, disruptive changes in planning and conversion preparation.

5.15 USER AND TOP MANAGEMENT INVOLVEMENT

As in all other phases, functional users should be involved throughout conversion preparation. Users have to keep the project team informed of any new functional requirements that impact on software to be converted, particularly those that occur from outside the agency. User's cooperation is also needed in modifying programs, freezing the software, and in obtaining documentation.

5.16 TRACKING PROGRESS

The tracking mechanism, developed during the conversion planning phase is implemented during this phase. After assignments are disseminated, management must track the progress made by the project team as it prepares for conversion.

At the project management level all preparation activities will be tracked in detail. The project manager must have immediate access to information on a daily basis concerning progress in:

- Program modification,
- Program preparation,
- Documentation,
- Test data development,
- Facilities - staff and conversion,
- Equipment installation,
- Software conversion contract,
- Automated tools development.

The project manager cannot develop the project details alone. The project team leaders will assist in compiling and reporting on assigned project responsibilities (e.g., specific program modifications, documentation, etc.). Project status should be displayed on visual tracking aids selected for use. Bar charts are commonly used since they can display the status of all project activities and whether objective end-dates have been reached. Regularly-scheduled project team meetings (at least to the team leader level) are recommended, no less than on a weekly basis, to allow team members to surface potential problems and to keep the entire team apprised of progress.

At levels above the project manager, project status information should be summarized and regularly reported no less than on a monthly basis. Graphics (e.g., bar charts) displaying status of major preparation activities are equally useful in reporting project status to agency executives as the more detailed charts are to the project manager. Scheduled project status briefings maintained since the project initiation phase will continue and assist in keeping top management informed. Exception reports of significant problems, beyond the capability of the project manager to resolve, should be immediately provided.

5.17 DEALING WITH UNFORESEEN PROBLEMS

Unanticipated problems begin to surface during this phase. As problems are identified, they must be addressed. This is a key management issue. Postponement of problem-solving, no matter how minor the problems appear, may result in having to cope with larger, compounded problems during actual conversion.

Common problems that may arise during conversion preparation can be associated with the following list. Comments are offered on how the occasion of these issues may be reduced or avoided.

- o Unexpected management decisions
  - Budget modifications
  - Change in target machine
  - Schedule change forced on project management

  Comment: Continuing coordination with agency staff members and regular executive level project status briefings may provide advance information to plan and execute schedule changes.

- o Project team
  - Personnel losses
  - Poor personnel morale
  - Skills don't meet expectations
  - Personnel cannot be dedicated to project

  Comment: Regular team briefings can improve morale. Quick reaction task order contracts can be executed to acquire additional staff and skills needed.

- o Training
  - Inadequate training
  - Poor attendance
  - Conversion environment changes (target hardware or software is changed)

  Comment: Training plans should have provisions for remedial training and additional classes. Each absence should be challenged. Training schedules published well in advance reduce conflicts with leaves, etc.

- o Contractual assistance
  - Delays in preparing RFP package
  - No vendor bids
  - Vendors cannot meet requirements of RFP
  - Poor customer/contractor communications

  Comment: Accumulate RFP input in looseleaf form as it is developed in the requirements phase. This eases RFP preparation. Advertise well in advance an intent to issue an RFP and what the scope of work will be. On large projects insist on a full-time contractor project manager and have the COTR on the project management team.

o Automated tools

- No commercial tool available to meet agency requirements
- No vendor bids
- Delays in development in-house
- Tools inefficient and/or inaccurate

Comment: Assessment of automated tool requirements early in the requirements phase should preclude this issue

o Project team facilities

- Delays in obtaining equipment, e.g., office furniture, telephones, modems, terminals, etc.
- Facilities are unavailable
- Delays in moving personnel

Comment: Identify requirements early; obtain budget.

o Conversion facilities

- Low priority given to project team personnel
- Facilities are inadequate or inconvenient
- Data communication problems
- Unreliable hardware

Comment: Maintain ongoing coordination with hardware staff. Anticipate problems early and explain ramifications at executive level project reviews. Identify backup hardware and communications in contingency planning.

o Test data

- Developed test data is inadequate
- Delays in developing test data

Comment: Solicit early user input in developing test data. Stress continuous agency maintenance of test data packages.

o Program modification

- Users continue to enhance their programs, or request enhancements
- Modification more difficult than anticipated

omment: Established change control procedures, good documentation, and use of standard languages, and restricted use of vendor unique utilities during normal software operations should ease problems in this area.

o Documentation

- Additional documentation not available
- Users do not cooperate
- Development or modification of documentation more difficult than anticipated

Comment: Establish and enforce documentation standards at all times.

o Hardware procurement

- Target hardware changes
- Delays in obtaining target hardware

Comment: Continued and close coordination with hardware acquisition staff is a must.

o User involvement

- Users do not cooperate: additional enhancements, modifications requested
- Users fail to provide documentation
- Users react negatively to freezing of software

Comment: Maintain regular reporting to top agency officials to gain their support and cooperation. Continue user interface. Involve users in project planning.

o Tracking progress

- Project team members fail to maintain records
- Project team members fail to use reporting hierarchy
- Tracking mechanism does not adequately track progress
- Project management fails to use tracking mechanism adequately
- Costs not tracked

Comment: Assign reporting responsibilities; review plans and tracking for flexibility and ease of use. Plans should be "looseleaf" in nature. Rely on visual tracking aids.

5.18 CONVERSION PREPARATION MANAGEMENT DECISIONS

At the conclusion of the preparation phase, agency executive approval will be given to proceed with conversion activities. In an actual conversion environment conversion will commence before all preparation activities are completed. The actual conversion decision will be based on a determination that conversion can commence with minimum disruption due to uncompleted preparations

5.19 ECONOMIC CONSIDERATIONS

Preparation for conversion may require large, one-time expenditures to activate the software conversion plans. As a result, cost elements other than personnel may become significant. These include one-time expenses for the purchase of conversion tools, ADP equipment, and office furniture and fixtures to accommodate additional conversion team resources (e.g., contractors). Renting these items may reduce the magnitude of these costs; however, certain nonrecurring expenses for freight, installation and site preparation may still occur. Personnel costs and related occupancy costs will increase during this phase as the project team is assembled. Items such as moving expenses, new hire expenses, and office space renovation expenses should not be overlooked.

The software conversion life cycle cost information should continue to be defined at the same level of detail used during the previous phase. The cost information should be updated as actual expenses are incurred. Cost estimates prepared for the conversion phase should be to reflect the actual expenses of the conversion team assembled during this phase, and refined to incorporate any changes in project scope or schedules.

The primary use of the software conversion cost information during this phase is the comparison of actual expenses to cost estimates. Significant cost variations identified should be reported to top management for early resolution of potential budgetary problems. Equipment, facilities and conversion tool acquisitions should be evaluated using the total project cost of the conversion effort to determine the lowest cost alternative. During this phase minor adjustments in the decision plans may be made. These adjustments should also be evaluated on the full cost impact of each alternative to assure the cost-effectiveness of any changes.

Communication with management and users during this phase should include cost considerations, such as expenses to-date, projected budgets, and evaluation of the continued cost-effectiveness of the proposed conversion effort.

5.20 CONVERSION PREPARATION MANAGEMENT CHECKLIST

- o Conversion preparation budget adequate and approved
- o Costs being tracked
- o External impacts affecting preparation and conversion assessed
  - Conversion project budget changes
  - Target hardware changes
  - Other
- o Project team reorganized for conversion preparation
- o Staffing schedules prepared
- o Training plans in effect
- o Software conversion RFP
  - Prepared
  - Issued
  - Negotiated
  - Contractor selected
  - Contractor/project management coordination
- o Automated tools acquired
  - Contractor developed
  - In-house developed
- o Staff trained in tool use
- o Conversion project team
  - Notified
  - Briefed
  - Responsibilities assigned
  - Assembled and located
  - Trained
- o Conversion facilities obtained
  - Computer support
  - Terminals
  - Team informed of procedures

- o Test data and files available and tested
  - Information system user input
- o Software development frozen (if possible)
- o Change control procedures in effect
- o Programs modified as required prior to conversion
- o Documentation completed
- o Continuous and ongoing coordination and reporting with
  - Top management
  - Information system users
  - Hardware staff
- o Plan tracking in effect
- o Contingency plans reviewed for effectiveness, remedial action taken
- o Costs being tracked
  - Cost estimates refined for future use
  - Extraordinary costs reported to agency executives
- o Conversion budget and preparations reviewed
- o Agency decision to convert

SECTION 6

THE CONVERSION PHASE

During the conversion phase the adequacy of planning, organization, and project management is revealed. The conversion phase also provides the opportunity to develop a software posture which will directly affect the success of any future conversions.

6.1 OBJECTIVE

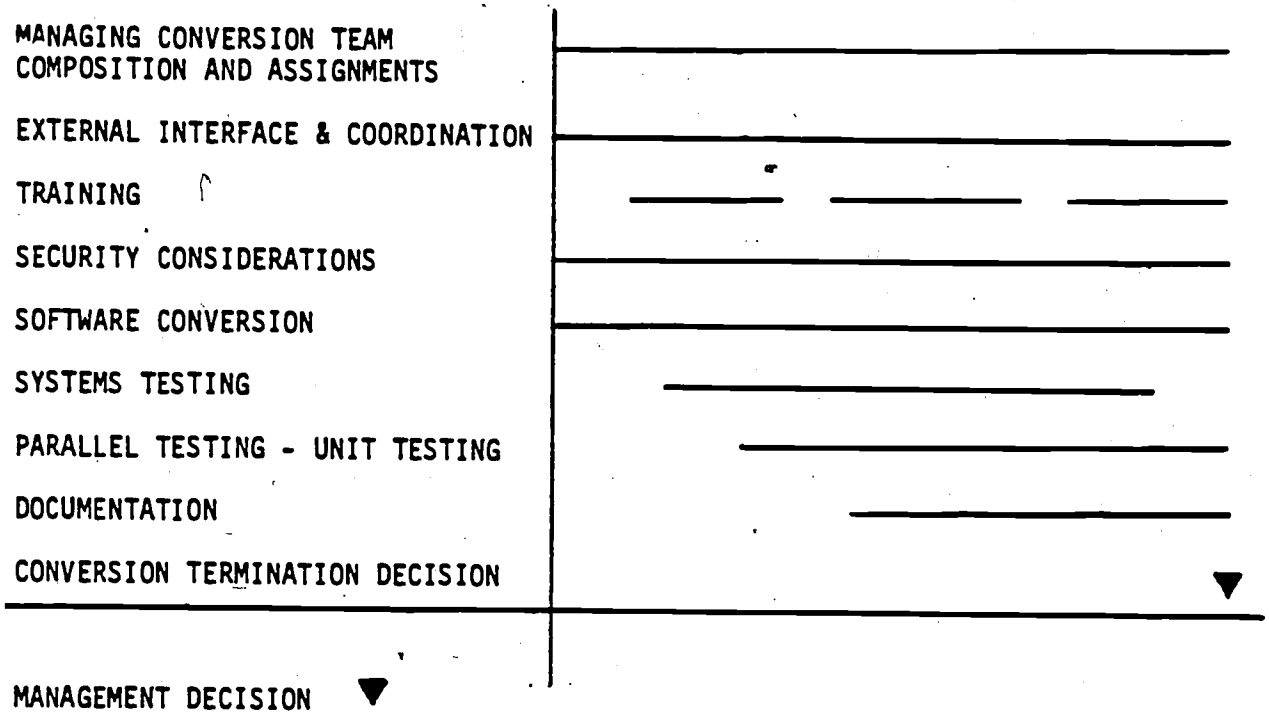
The objective of the conversion phase is to complete the conversion as effectively as possible in the time provided, and within authorized budget limitations. While the objective is simply stated, the decisions, organization, and activities that relate to attaining this objective are complex and will require continuing and involved project management attention throughout the effort.

6.2 CONVERSION PHASE ACTIVITIES

Figure 6-1 illustrates the major activities that occur during conversion. These are:

- Team management, organization and staffing,
- External interface and coordination,
- Training,
- Security considerations,
- Software conversion,
- Unit and systems testing,
- Parallel testing and crossover,
- Documentation.

These activities will be discussed in subsequent portions of this section. The purpose of the discussion is not to provide managers minute, technical details associated with the various functions, e.g., software testing. Many technical references exist to provide this information if the experience is lacking in the project management or project team staffs. Rather, the intention is to provide managers an understanding of the functional relationships and the management considerations that apply to preclude or reduce problems during conversion and achieve the goal of an efficient and effective software conversion.



CONVERSION PHASE ACTIVITIES

Figure 6-1

SYSTEMS TESTING - UNIT TESTING

6.3 MANAGEMENT, ORGANIZATION AND STAFFING

Managing the skill mix and composition of the project team will be the biggest management challenge during the conversion phase. There are multidimensional variables of skills, numbers of personnel, and time requirements. See Figure 6-2.

6.3.1 TEAM COMPOSITION

During the software conversion phase the project team will be composed of analysts and programmers augmented or assisted by systems programmers, training personnel, system operators, security personnel and information systems users. The skill mix is usually made up of in-house personnel as well as consultants and contractors in levels of effort established during the requirements phase and applied according to conversion plans and schedules.

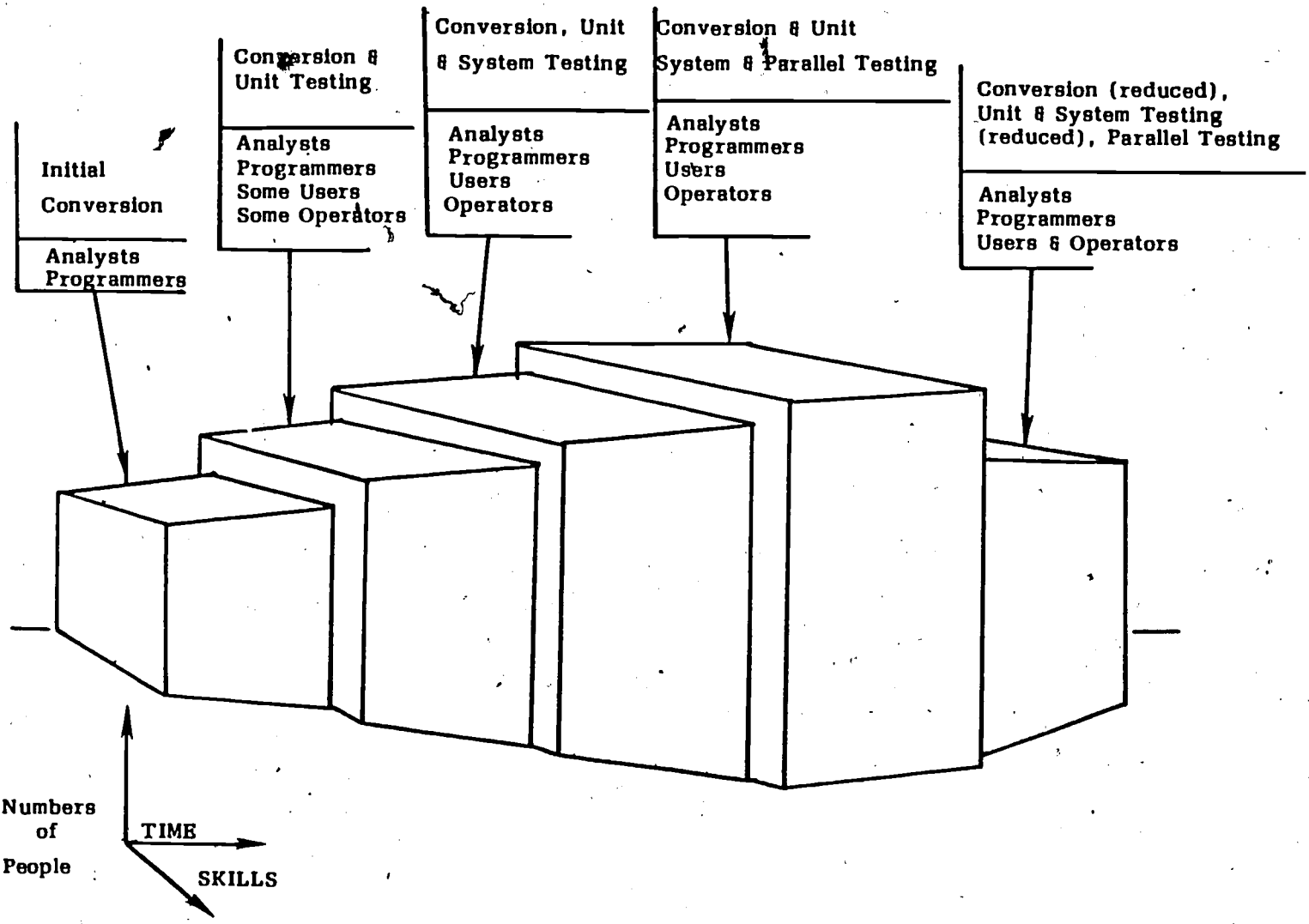
Initially the project team consists primarily of analysts and programmers. As unit testing is implemented, systems operators and programmers will assist.

Midway through the conversion, information systems users will be assisting in system and initial parallel testing. Security personnel and information systems users will be assisting in software verification and validating achievement of security and privacy software requirements. Input from data entry personnel, tape and disk libraries and input/output staff members will permit the project manager to develop efficient procedures during parallel testing and refine user and operator manuals.

In the later stages of the conversion, as applications on the new system complete parallel testing and are accepted by users, the need for analysts and programmers converting code diminishes. Project team activities are primarily associated with parallel testing, software security certification, user acceptance and documentation. As people are no longer required in conversion activities, they revert back to normal duties.

6.3.2 PROJECT TEAM ASSIGNMENTS

Assignments and schedules for the conversion project team will have been issued during conversion preparations. However, new staff members, including contractors, will most likely be required to replace personnel losses or applied to resolve unexpected problems as a result of contingency planning. Providing these new additions written instructions on their project duties, responsibilities and reporting procedures will facilitate their integration into the project effort.



SOFTWARE CONVERSION TEAM SKILLS AND NUMBERS OVER TIME

Figure 6-2

6.3.3 PROJECT TEAM INTERNAL INTERFACE

During conversion, project meetings are particularly important to keep the entire team appraised of status. On large conversions the total staff involvement at any one time can be 30-40 personnel. Team meetings of this size are impractical on a day-to-day basis. Periodically (e.g., on a weekly basis) the team should be apprised of progress or status. The project manager should hold more frequent meetings, probably daily, with task leaders to coordinate conversion activities.

The press of conversion activities will create tendencies to cancel or postpone meetings with the team or task leaders. This should be avoided. Besides keeping the project staff informed of status, meetings assist in developing a team spirit and sense of belonging to an organization in an otherwise ad hoc assembled group of personnel. Most importantly, since management commonly assigns high quality talent to conversion team duties, meetings can focus considerable talent and experience on means to resolve problems that may arise.

Conversion team leaders and designated specialists working on specific conversion tasks should be inputting status to tracking mechanisms established for project control. There will be a tendency for members to delay this input due to the press of business. Project managers will have recurring needs for status information quickly in order to respond to top management requests or to respond to inquiries originating outside the agency (e.g., GSA). Project managers should therefore monitor the degree of currency of project status information and discipline or revise the tracking procedures if information currency slips.

Graphics, such as bar charts, should be used at the team level since they visually aid the project manager and the team in determining status. Conversion task leaders and other specialists (e.g., security) also will be inputting status and historical information into a history log. This log should be in looseleaf form but organized in some fashion which will support the post conversion analyses. The format described in Section 7 for the analysis report is suggested. In addition to its historical significance, this log will be useful to newly-assigned team members in gaining an overview and understanding of project objectives and status.

6.4 EXTERNAL INTERFACE AND COORDINATION

During conversion regular and continuous interface is required with agency executives, functional information systems users, hardware operations personnel and any contractors employed for software conversion.

6.4.1 AGENCY EXECUTIVES

Regular project briefings and other status reporting mechanisms, established and ongoing from project initiation, are critical during the conversion phase. Although contingency and other planning should have precluded many problems arising during the conversion phase, no conversion will be 100% devoid of problems. Significant, unforeseen problems should be expected due to influences outside the control of the agency, ADP or project manager. Prime examples which have affected Federal conversions include budget cuts and hiring freezes. If contingency planning has not provided the project manager the flexibility to deal with these problems, support of top management will be required.

6.4.2 INFORMATION SYSTEMS USERS

Close and continuous interface will be required with functional information system users during conversion. Their support to conversion efforts is critical during this phase.

Information systems users will assist the project team in system and parallel testing. Additionally, if security or privacy features have been engineered into software, users will have to assist in security verification and software accreditation procedures. Project managers can expect that busy users will experience some inconvenience as a result of conversion activities. Their continuing support will be directly related to rapport established prior to actual conversion.

User interface is most important in freezing new software developments during conversion. Frozen software reduces many problems for the project manager. User and top managment support in freezing development will have been achieved during prior conversion phases. However, since the time of actual conversion can be quite lengthy, extending over a year in large conversions, project managers can expect impatience and some support to wane for postponing new enhancements. Attention to developing conversion priorities and schedules, approved by users during the planning phase and adherence to these schedules during conversion will build confidence among users that their inconvenience in obtaining new enhancements will be minimal. If new enhancements cannot be avoided, change control procedures can reduce the trauma of converting dynamic systems and programs.

6.4.3 HARDWARE AND OPERATIONS STAFF INTERFACE

Considerable support will be required from the operations staff particularly during testing. Although testing can be planned and scheduled, actual testing will require many schedule modifications as software systems are debugged. These schedule changes will inconvenience the operations staff. Project managers should encourage participation of operations staff members at project meetings to promote operations staff cooperation and encourage their input on day to day scheduling adjustments.

6.4.4 CONTRACTOR INTERFACE

Planning for conversion with large contractor software conversion efforts should have provided a COTR on the project managers staff and a contractor project officer. If this has been accomplished, the day to day interface necessary to keep contractual efforts on track with in-house conversion actions will be facilitated.

6.5 TRAINING

Most of the training for conversion was accomplished in the previous phase, conversion preparation. Nevertheless some training will be required in the conversion phase.

If newly assigned personnel are applied to the conversion team to replace unexpected losses, they will have to be trained in their duties. Additionally, there will be ongoing, ad hoc training requirements to operators, data librarians and data entry personnel as operating procedures are refined during testing. This training is normally accomplished by members of the project team. Project managers should ensure that the necessary procedures and documentation (e.g., operations manuals) are developed and used in conjunction with this training.

Information systems users normally do not require extensive training unless new functional changes are included in the converted software. Some user training may be required when users assist in systems testing. During parallel testing users will have to be trained to the extent that they can differentiate between and compare the source and target hardware production runs.

6.6 SECURITY CONSIDERATIONS

The project manager, working in conjunction with the agency information system security official and the information systems users will ensure that the design reviews are conducted during systems testing and that sensitive systems are carefully monitored for security during parallel testing. In accordance with OMB Circular A-71, the sensitive information systems will require certification at the completion of systems testing by the information systems security officer or agency official designated to certify that the systems meet the documented and approved system security specifications, meet all applicable Federal policies, regulations and standards, and that test results demonstrate that the security provisions are adequate.

6.7 THE SOFTWARE CONVERSION

Software will be converted in-house, by contractor, or a combination of the two, using schedules and work packages developed during planning and preparation activities.

6.7.1 IN-HOUSE CONVERSION

The first source programs to be converted should be the most complex or those that have been frequently modified. Complex programs force project team members to become thoroughly familiar with the new software If there are going to be software problems which could result in serious slippage, management is provided an early awareness of this condition and can apply remedial actions. Frequently-modified programs are the most complex as a result of the modifications. They are also normally associated with information systems of high user interest. Giving these priority, converting them first, and placing them in an operational mode avoids user pressures to incorporate new enhancements during conversion.

If new enhancements cannot be avoided, one method of minimizing the effect of modification during the conversion is to implement change control procedures which carefully record all changes. Duplicate work packages, go the the project team and the other to the maintenance programmer(s). The maintenance programmers continue to make changes as the frozen programs are converted. Changes to the converted program are added later (23).

6.7.2 APPROACHES

The conversion approaches taken by the project team are team conversion, individual conversion or a combination. The project team members will employ the previously-decided techniques of manually converting code on a line-for-line basis, reprogramming, redesign, the use of automated tools, or a combination of the four methods. Selection of the approach will be an agency management decision based upon available personnel resources, skills and experience, time available, and desired performance of the converted programs.

6.7.2.1 Team Conversion

With team conversion, each member of the team is assigned either Control Stream Language (CSL), data files, or source programs. One person or group of people is in charge of converting all CSL, another handles all data files, and a third converts all source programs. The teams differ in size as dictated by the conversion workload. Also, the skills required of the team members would differ. The CSL and data file teams need not be trained in application program languages, e.g, COBOL, Assembly Language, FORTRAN, etc. The advantage of this approach is the facility in developing conversion staff skills. Each team has only to become experienced in specific rather than broad software skill areas. The expertise in each area will be more quickly acquired and applied. Each team can develop expertise in the other areas later, as time permits.

6.7.2.2 Individual Approach

With the individual approach, each person converts all aspects of the system in his/her realm of responsibility: CSL, data files, and source programs. For shared data files, conversion responsibility should be assigned to one person. The advantage of this approach is that individuals become familiar with the total requirements of the individual systems. The responsible person can often anticipate and resolve some problems which might arise based on this insight. The disadvantage of this approach is that it takes longer to develop all the skills associated with system conversion rather than one particular area of expertise, e.g., CSL.

6.7.2.3 Modified Approach

The modified approach is a combination of the two. An example would be team conversions of CSL and data files. Application programs would be converted by a functionally-knowledgeable project team member. This approach permits tailoring existing resources and skills to agency conversion needs.

6.7.3 CONTRACTOR CONVERSION

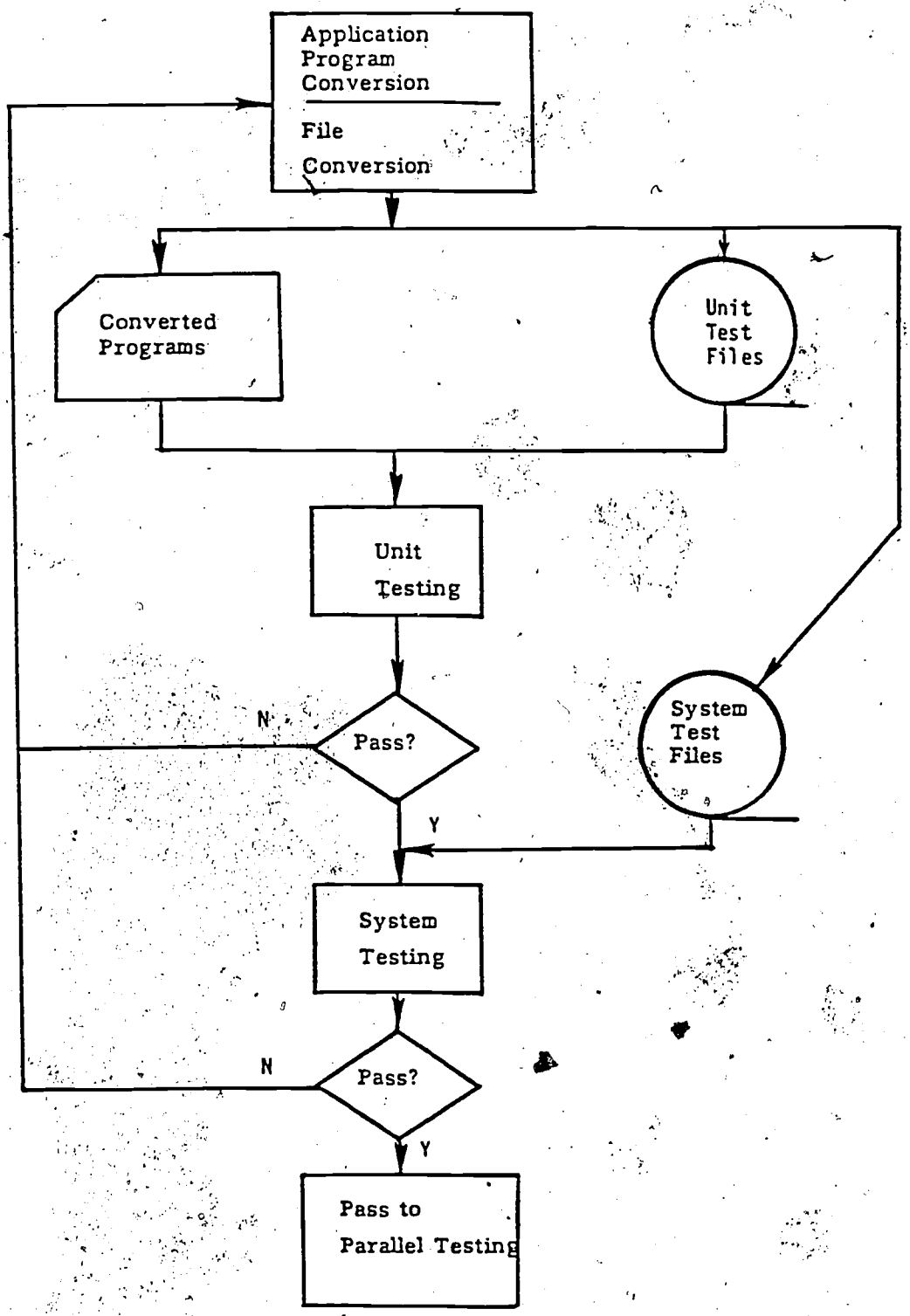
With contractor conversion of the source code, the project manager is less concerned with the approach. The management concerns, instead, are contract management and issues associated with timely delivery, quality and documentation of software.

6.7.4 QUALITY

Converted software should be closely reviewed for quality. The pressures on personnel during conversion to meet the conversion schedule, may cause project team members to retain unnecessary or unoptimized code (48). The conversion phase provides the opportunity to develop well engineered source programs based on modern techniques of software engineering (39, 42, 43). It is also an opportunity to design out old routines which require operator intervention but, due to technical evolution of hardware, are not applicable on the new system. It is particularly important for contractually-converted software to be examined for quality and performance to ensure converted systems execute in acceptable run times. The project manager should regularly schedule and conduct structured walk-throughs of all conversion projects and similarly examine contractually-converted software.

6.8 UNIT AND SYSTEMS TESTING

Initial testing is normally accomplished in two steps: individual application program and file (unit) testing, and system testing (see Figure 6-3). Managers will have to schedule or arrange supplies and paper stock, machine time, operators, test data, system



TESTING SCHEDULE

Figure 6-3

programmers, and possibly, during systems testing, user involvement. Test criteria should be established beforehand. The test criteria should include performance factors that relate to the desired level of quality, be used to evaluate individual or contractor performance, and ensure that cost-effective results are being obtained.

6.8.1 UNIT TESTING

Individual data files should be tested to ensure that they have been 100 percent converted. Individual application programs require testing to ensure that the code is executed. The adequacy of this testing depends upon the quality of test data. The ultimate objective is 100 percent testing of code execution. While this objective is realistically unattainable, the project manager is encouraged to continually refine test data towards achieving that objective.

6.8.2 SYSTEMS TESTING

After unit testing of programs and files are completed they are subjected to systems testing. The purpose of this testing is to ensure that the systems operate adequately on the target hardware. Systems test data consist of representative production runs with appropriate performance consideration taken into account. All systems documentation should be written in an acceptable draft state by the end of systems testing. Systems testing will involve information systems user participation to verify the acceptability of new input and output procedures.

6.8.3 TESTING PROBLEMS

6.8.3.1 Assembly Language and Utilities

Project managers should be prepared to handle serious problems during systems testing if the agency converts from Assembly Language on a saturated machine or has made extensive use of vendor unique utilities. Unacceptable run times can occur which require redesign or extensive reprogramming.

6.8.3.2 Testing Shortcuts

Quality test data is extremely important and difficult to develop and maintain (48). Managers should resist test data shortcuts as an expedient for avoiding the need to develop different test packages, however.

Unit test data should not be used for systems testing. Unit test data is designed to exercise the converted code. The systems test data is derived from, and represents typical production runs. The test data construction is different. The project manager should also resist accepting code for systems integration testing that has not completely

fulfilled unit code execution tests. The manager should likewise not put code into a parallel testing mode that has not been fully tested and debugged during systems testing. Shortcuts in testing due to pressures of conversion only defer problems to the later stages of software conversion. Testing problems need to be resolved as early as possible to preclude an unmanageable situation in which cumulative testing problems have to be addressed and solved late in the conversion phase. Unit and systems testing reduce to a minimum software problems that will come to the attention of the functional user during parallel testing. A low incidence of errors in production runs inspires user confidence and support.

6.8.3.3 Production Interference

Because it is difficult to forecast exactly the machine time and other resources required for actual testing, management will have to maintain close coordination with operations personnel and users to gain their support and cooperation to alleviate unexpected testing problems that place an unplanned burden on normal operations.

PARALLEL TESTING AND CROSSOVER

During parallel testing the project manager is going to be concerned with running the old and new systems in a parallel production mode to ensure that conversion has been accomplished.

A management problem exists for those applications that are infrequently processed (e.g, fiscal year end summaries). It may be impractical to continue parallel testing long enough to compare all long term applications. The objective will be to achieve user's confidence, crossover to the new system, and remove the old hardware in order to reduce costs associated with parallel testing or back-up processing. When all systems have been or are undergoing parallel testing, a firm completion date must be established to force an end to the conversion project.

As systems complete parallel testing it is important that users formally acknowledge acceptance. This provides a basis of understanding between the users and the project manager that conversion of the systems has been successful.

6.10 DOCUMENTATION

The project manager should demand software documentation in accordance with agency or FIPS standards. Managers should be especially cautious regarding documentation associated with that software converted by a contractor (42). The normal form for delivery of contractually-converted software is in an undocumented state. Managers should anticipate that even if contracts require documentation, the contractor may be unfamiliar with documentation standards, may have underestimated resources and may try to avoid or modify contractual documentation requirements.

6.11 CONVERSION MANAGEMENT DECISIONS

The conversion phase is over when the last system completes parallel testing and documentation is completed. Upon assurance that users have accepted the converted information systems, agency executives will approve project management recommendations to implement post-conversion activities to restructure the software conversion project team to a normal operational mode, close out software conversion contracts, vacate or release any conversion facilities and equipment no longer required, and to conduct a post-conversion analysis of the conversion project.

It is recommended that these decisions be based on recommendations presented as part of a formal briefing to top agency managers and information system users. This will lend assurance that conversion has been successfully executed and keep management informed of the conversion activities that are required during the post-conversion phase.

6.12 ECONOMIC CONSIDERATIONS

During the conversion phase the major elements of cost will be personnel-related. Hardware and telecommunications expenses may become significant during this phase for file and program conversion and testing. These expenses may be reflected by direct hardware rental costs of indirect time-sharing charges. If the software conversion effort uses existing ADP resources, the costs of these resources should be identified and allocated to the conversion effort on a full cost-basis. The cost of using contractors should be estimated and recorded according to the detailed cost structure approach presented in Appendix C. In this manner, contractor costs should be detailed by cost element; i.e., personnel, facilities, hardware, overhead, profit, etc. for each conversion activity or function, and not given as a lump sum contract service expense. With this cost breakdown, the technical evaluation of contractor's performance will be possible.

Actual cost performance should be collected and recorded in the cost structure for use in post-conversion audits.

The use of the software conversion cost information is mainly in the tracking of project costs and the comparison of actual cost to cost estimates to identify significant cost variations. Communications with users and top management should include cost information such as expenses to-date, budget projections, and an evaluation of the cost-effectiveness of the project. Minor changes in project schedules and the allocation of in-house or contractor resources to specific tasks should be performed with consideration of cost impacts. This project refinement activity should include an assessment of each alternative on the full cost of conversion in order to address the lowest total overall cost.

6.13 CONVERSION PHASE MANAGEMENT CHECKLIST

- o Conversion team
  - Located in facilities
  - Requisite skills and experience available
  - Team members aware of schedules, duties and responsibilities
- o Interface continuing with
  - Agency executives
  - Information systems users
  - Hardware operations staff
  - Contractor project officer
- o Project status being tracked
- o Project status current
- o Project reports current
  - At project level
  - At agency executive level
- o Training being accomplished
  - New hires on project team
  - Ad hoc to users, operators, etc.
- o Security
  - Features implemented in software; verified
  - Monitored by information system security officer; users
  - Software certified by information system security officer, IAW OMB Circular A-71
  - Most complex software being converted first
  - Change control procedures established for conversion of software with new enhancements
  - Conversion team members following established security procedures
- o Contract being monitored; quality of software and documentation assured
- o Unit and systems test data separate
- o Files 100% converted

- o Software converted to level of acceptable code execution
- o Users participating in systems and parallel testing
- o Close interface with hardware operations staff during testing
- o Users formally accepting systems at completion of parallel testing
- o Firm parallel testing end date established to force project end
- o Agency executives and users approve end of the conversion phase
- o Agency executives approve post conversion phase activities
  - Settling staff into normal software operations
  - Close-out contract
  - Post conversion analyses and assessment

SECTION 7

THE POST-CONVERSION PHASE

Post-conversion is the phase of a software conversion life cycle between actual conversions. It extends for an indeterminate but considerable period of time, generally 2 to 5 years, depending upon the frequency of hardware replacement. This phase provides the best opportunities to learn from fresh conversion experiences and to initiate actions which will improve the utility and effectiveness of an agency's software and concomitantly facilitate future software conversions.

Additionally the true costs of conversion are most apparent in this phase if costs have been tracked. Differences between estimated and actual costs can be identified and evaluated. These evaluations can then lead to better cost estimating in future conversions.

7.1 OBJECTIVES

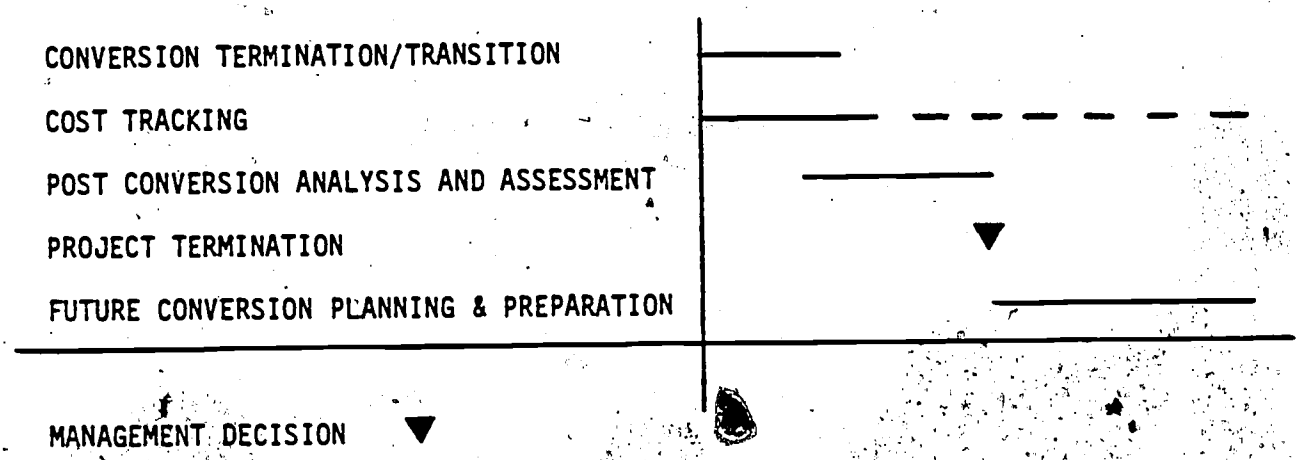
There are two objectives in the post-conversion phase:

- Reestablish the agency software organization in a normal operating environment. The associated activities are to complete any functions from the software conversion phase which remain undone (e.g., documentation, completion of parallel testing); settle the software staff in a normal organizational structure; and begin normal software maintenance and development actions.

- Develop a better agency posture for future software conversions. The agency should conduct a post-conversion assessment of the conversion experience; begin planning for the next conversion; and initiate actions which will cause the next conversion to be more effective and efficient.

7.2 POST-CONVERSION ACTIVITIES

Figure 7-1 illustrates the major activities that occur during the post-conversion phase. Many of these activities are closely related and have much overlap, particularly those that pertain to the post-conversion analysis and assessment, planning, and conversion improvement techniques. These activities provide the framework for subsequent discussions in this section which provide an understanding of the post-conversion management issues. This general understanding will assist



POST CONVERSION ACTIVITIES

Figure 7-1

managers in identifying other post-conversion functions that pertain to their particular agency software conversion environment and form a base on which to build or implement actual post-conversion plans and actions to improve future conversions.

Post-conversion activities can be generally grouped into three categories:

- o Conversion Termination/Transition Activities

  These are transition activities between a conversion environment and a normal software maintenance and development environment. Typical activities include finishing parallel testing, completing documentation, closing out software conversion contracts, disbanding the project team, and settling the agency software staff into a normal software organization (e.g., systems programming, maintenance programming, developmental programming).

- o Post-Conversion Analysis and Assessment Activities

  These activities involve conduct of a thorough review and analysis of the entire conversion experience and preparation of a formal after-action report. This document will provide managers a historical perspective of the conversion, and assist in understanding future conversions and ways to avoid repetitious mistakes. It also provides a reference on which to base the closely-related activities of future conversion planning and implementing actions to improve future conversions.

- o Future Conversion Planning and Conversion Enhancement Techniques

  Early initiation of future conversion planning reinforces the recent conversion lessons learned and significantly improves management's ability to comprehend all the issues of future conversion. Management can also implement and enforce many techniques and procedures which will improve the quality of the agency software and, at the same time increase software portability. These methods include use of modern software engineering techniques of structured design and programming, maintaining current documentation, avoiding the use of non-standard programming languages and vendor unique utilities, maintaining high quality test data and files, and maintaining disciplined program files and data bases.

7.3 CONVERSION TERMINATION/TRANSITION ACTIVITIES

In a theoretical conversion, activities associated with the conversion phase would have been completed before the post-conversion phase began. In a real situation activities of one phase extend into another. The most significant on going functions of the conversion phase that are likely to extend into the post-conversion phase are parallel testing and documentation. Activities such as closing out contracts and disbanding the conversion team will be more transitionary. Still other activities such as commencing new user enhancements postponed until after conversion approach true post conversion activities.

7.3.1 COMPLETION OF PARALLEL TESTING

Software is converted on a prioritized, scheduled basis according to conversion plans. Thus, in the initial stages of the post-conversion phase all of the software will have been converted. However, for those software applications converted last, some residual testing, particularly parallel testing, will likely still be on going.

The management issue here is to strike a balance between continuing parallel testing to ensure that the converted software meets functional user requirements, while at the same time, avoiding protracted or unduly long parallel testing and operations. Parallel testing is costly in terms of dollars and staff resources. As long as parallel testing and operations persist, transition to a normal software environment cannot be accomplished. Therefore managers should closely examine parallel testing with a continual involvement to determine if the seemingly endless details of parallel testing outweigh the benefits of maintaining two hardware operating environments. Project managers may have lost the perspective to make this judgement. Upper management must be prepared to exercise "brute force" decisions to terminate parallel testing.

7.3.2 DOCUMENTATION

Software documentation should be written concurrently while converting software. However, during the later stages of the software conversion phase, documentation efforts may fall behind and extend into the post-conversion phase. Also, some documentation modifications will be required due to changes or modifications to converted software as a result of final parallel testing.

Although documentation may extend into the post-conversion phase, it is critical that management ensure completion before total transition of software operations to a normal state. Software that is not documented tends to remain undocumented and this creates a continuing source of problems (23).

7.3.3 CLOSING OUT CONTRACTS

If contract services have been used to convert software or to augment the conversion team staff, the project manager will be involved in contract close-out activities. If extensive contractual support was used, contract close-out will be significantly aided if the software conversion project management team has a full-time COTR to assist in contract functions (48).

Contract monitoring should have been an ongoing function throughout the conversion process. During the post-conversion phase, the Statement Of Work (SOW) should be reviewed and compared with the deliverables to ensure that contractual obligations have been met. Actual cost performance should be compared against original estimates to determine contractual awards or penalties. Software deliverables should also be examined for quality and fully supported by documentation that is well written, usable and conforms to agency standards or FIPS PUB 38 and 64.

Contractual issues and disputes should be resolved informally whenever possible, or if necessary, formally through the contracting office. A full assessment of contractual costs and obligations should be conducted to assure that the agency received full benefit of services and to surface and resolve outstanding cost issues, thus avoiding any prolonged contractual disputes which would detract from normal operations. When all contractual issues have been resolved, the contracting office should be notified, in accordance with agency procedures, to close-out the contract.

The key management concerns are to ensure that contractual obligations have been fulfilled, and potential or actual problems or issues identified and resolved as expeditiously as possible in order to accomplish a speedy transition to normal software operations.

7.3.4 DISBANDING THE PROJECT TEAM

As parallel testing and documentation is completed, remaining members of the project team should be released. Those team members who are normally part of the agency software staff will revert to normal duties. Since large scale conversions frequently last in excess of one year the "normal" duties might be quite new. For example, personnel turnover might have resulted in newly-hired personnel being assigned directly to the conversion team. For these people, there will have been no previous experience in agency day-to-day operations. They must be assisted in adapting to the normal environment.

Requirements for reorganization of the agency software staff may also impact disbanding the project team. Agency growth or functional changes may have altered the authorized staffing level or skill mix of the software staff. Differences in the source and target computer systems may also have generated a need to restructure the software staff.

Management problems in settling the agency software staff into a normal operational mode can be reduced by informing all conversion team personnel of the normal agency software organization, and providing current duty descriptions, and internal operating instructions. Training can also be of assistance particularly if the project members worked only on specialized conversion tasks (e.g., only converted job stream language).

7.3.5 NEW USER ENHANCEMENTS

User information system enhancements, deferred until after conversion, will commence. Because of the length of some software conversions, some application software may have multiple change requirements. Information system software changes and enhancements should be carefully analyzed. It may be cost-effective to redesign systems, and to incorporate all changes at once, rather than patching them into the old system structures. Also, if there are many enhancements required, priorities will have to be established. Priority assignments will require functional user involvement and top management decisions and support.

The management issues include identifying and establishing priorities for developing new user enhancements and determining the most cost-effective approach for accomplishment. Managers should also ensure that all software changes are accompanied by appropriate changes in system documentation.

7.4 COST-TRACKING

During the post-conversion phase, tracking conversion related costs as they are incurred on a day-to-day basis is important to reflect total conversion costs in the post-conversion analysis and assessment.

Operational cost items associated with the post-conversion phase include, but are not limited to:

- Staffing - Staff resources devoted to conversion-related actions as opposed to normal operations (e.g., costs associated with disbanding the project team and resettling the normal software staff; training).
- Contractual - Costs associated with closing out contractor support.
- Computer and Facility - Costs associated with residual conversion functions such as completion of parallel testing and residual use of facilities by the project team.

- o Administrative - Costs associated with clerical and administrative support to the project management and project teams; particularly the administrative support associated with the post-conversion analysis and assessment and future plan development. Documentation production will also incur administrative costs.

7.5 POST-CONVERSION ANALYSIS AND ASSESSMENT

One of the most important post-conversion functions is an analysis of the entire software conversion experience. The time and resources required to conduct the analysis and assessment depend upon the magnitude of the software conversion project. A medium to large conversion project assessment might involve 2-3 people for 2-3 months. The analysis should be conducted by the project manager and the project management team with input solicited from parties that had an important interest or role in the software conversion (e.g., the contractor, project team, hardware acquisition staff, involved functional users). The most important sources should be conversion history logs maintained on an ongoing basis during the software conversion and the knowledge and experience of the project management team that remained intact during the entire conversion experience.

It is important that the post-conversion be conducted in a positive manner. It should not simply be a list of problems or shortcomings encountered during conversion. The assessment should describe the entire process and identify those procedures that were satisfactory and effective as well as those that were less than satisfactory. It should offer future software conversion managers suggestions and recommendations to improve their conversion efforts. The assessment should identify how the agency can plan, now, for future conversions; ongoing software practices and procedures to improve future conversions; and other actions (e.g., policy change recommendations) which may be required.

7.5.1 POST ANALYSIS REPORT

A post-conversion analysis report should be produced as a formal document. It serves four important agency purposes.

- o Historical Reference

  The report provides a historical reference for agency personnel to use in future software conversions. The identification of problem areas and solutions should provide future software conversion managers insight and enable them to better manage and execute a software conversion.

- Conversion Costs

  The report displays actual conversion costs. If the software conversion cost structure, detailed in Appendix C, has been used throughout the project, the report will reflect all costs including those frequently overlooked or disregarded by managers. For example, the costs of assigned staff personnel, particularly those involved in conversion part-time, are frequently overlooked; conversion costs related to parallel testing, particularly with government-owned machines are not fully considered; the full extent of training costs (e.g., training time) tends to be underestimated.

- Basis for Software Conversion Planning

  Planning for software conversion should be an ongoing activity and not solely relegated to a planning phase immediately preceding an actual conversion. Continued planning for the eventual software conversion can shorten the planning time span when a conversion decision is made, provide more detailed and comprehensive plans, and improve the overall conversion process. The report provides insight on how to structure the planning.

- Identify Ongoing Actions or Procedures to Improve Conversion

  There are many actions and procedures managers can implement and enforce which will improve the posture of an agency to conduct a cost-effective conversion. The report, by identifying these actions and their importance, assists agency personnel in understanding the need for these procedures and encourages implementation.

7.5.2 ANALYSIS CONSIDERATIONS

Elements to be considered in the post-conversion assessment will depend upon the software environment of the particular agency. However, the following are generally applicable.

- Planning

  - Adequacy of feasibility study
  - Adequacy of software conversion study
  - Impact of other studies (e.g., A-76, A-109)
  - Adequacy of planning time
  - Sufficiency of detail

- Adequacy of tracking and management follow-through
- Adequacy of cost estimates
- Planning problems, their resolution and means of avoidance
- Future planning requirements

o Staffing and Organization

- Adequacy of project management team
- Adequacy of project team
- Skill mix
- Proper location of conversion staff
- Adequacy of conversion assignments and control
- Staffing and organization problems, their resolution, and means of avoidance
- Future planning requirements

o Use of Contractors

- Requirements for contractors
- Their optimum employment
- Adequacy of the Request for Proposal
- Adequacy of contract monitoring
- Adequacy of deliverables and services
- Contractor problems, their resolution and means of avoidance
- Future planning requirements

o Software Conversion

- Selection, use and adequacy of automated tools and techniques
- Conversion of languages
- Conversion of utilities and procedures
- Conversion problems, their resolution and means of avoidance
- Future planning needs

o Hardware Staff Interface

- Adequacy of hardware acquisition staff interface
- Adequacy of conversion support
- Conversion problems, their resolution and means of avoidance
- Future planning requirements

o Facilities

- Adequacy of facilities
- Success in single site/dual site conversion
- Facility requirements and use

- o Documentation
  - Adequacy of pre- and post-conversion documentation
  - The use of documentation
  - Adequacy of agency documentation standards
  - Documentation problems, their resolution and means of avoidance
  - Future planning requirements
- o Test Data and Files
  - Employment of test data and files
  - Adequacy of test data and files
  - Optimization of test data and files
  - Development responsibility for test data and files
  - Test data and file problems, their resolution, and means of avoidance
  - Future planning requirements
- o Training
  - Adequacy of training
  - Timeliness of training
  - How training was conducted
  - Training problems, their resolution and means of avoidance
  - Future planning requirements
- o Security
  - Agency specific security and privacy requirements
  - Adequacy of security and privacy software conversion activities
  - Extent of unresolved security or privacy software issues
  - Security and privacy problems, their resolution, and means of avoidance
  - Future planning requirements
- o Distributed and Remote Sites
  - Adequacy of planning
  - Interface
  - Adequacy of software conversion
  - Specific problems, their resolution and means of avoidance
  - Future planning requirements

- o Telecommunications
  - Adequacy of telecommunications planning
  - Adequacy of telecommunications staff support
  - Conversion-related problems, resolution, means of avoidance
  - Future planning considerations
- o Top Management and Functional Users
  - Their support of conversion
  - Freezing development of new user enhancements
  - Their roles and involvement in conversion
  - High level management and user conversion-related problems, their resolutions and means of avoidance
  - Future planning requirements
- o Directives and Policy
  - Adequacy of directives and policy
  - Conflicts in directives and policy
  - Responsibility for directives and policy conflict resolution
  - Future planning considerations
- o Unforeseen Problems
  - Unforeseen problems, their resolution, and means of avoidance
  - Future planning considerations
- o Software Conversion Management

  If not otherwise addressed, cover shortcomings or support from software conversion management that affected other related projects or operations.

  - Telecommunications
  - Hardware acquisition
  - Hardware operations
  - Information system users
  - Agency executives
  - Budgets and plans
- o Costs
  - Actual conversion costs by phase, function and cost element
  - Total conversion costs

- Adequacy and source of funding
- Adequacy of budgeting
- Comparison of cost estimates to actuals
- Adequacy of cost analyses
- Cost overrun detail and reasons
- Conversion cost related problems, their resolution and means of avoidance
- Future planning considerations

7.6 PLANNING AND INITIATING ACTIONS TO IMPROVE FUTURE CONVERSIONS

Future software conversions can be made more efficient and effective through employment of a combination of planning and procedures that encourage easily maintainable software and its conversion. Some activities can be specifically identified as pure planning — i.e., conversion planning input into agency ADP budget submissions required by OMB Circular A-11. This is long-range planning. At the agency software operations level, some software conversion improvement actions will be planned and implemented. This is technical planning and it will differ among agencies. Practices conducive to efficient software conversion such as disciplined documentation may be firmly established and on-going at one agency and require no planning, only continued implementation. At another agency, however, a documentation standards policy may have to be planned and implemented. If managers pursue both long-range and technical conversion planning, future conversions will be much simplified.

7.6.1 LONG-RANGE CONVERSION PLANNING

Long-range planning is based on costs. The cost estimating, analysis and tracking experience gained in the recent conversion, if continually refined during the post conversion phase, can assist managers in estimating correct levels of conversion resources. If the project manager has been following a total cost estimating methodology as recommended in Appendix C, the structure can be transferred to agency personnel who are routinely involved in long-range planning.

Planning full costing methodology permits an agency to analyze costs from different dimensions. For example, costs can be developed for personnel, by phase, year, or for a total conversion project. Alternatively, all costs of conversion (e.g., personnel, equipment, etc.) can be developed by phase or by year. This methodology will produce consistent cost estimates from whatever perspective they are examined (e.g., full costs of programmers will result in the same total if they are developed by year or by phase). This consistency results in significant advantages for an agency by precluding conflicting cost estimates and providing credibility to agency plans, studies and budgets.

7.6.1.1 Agency Long-Range Plans

Office of Management and Budget Circular A-11 requires agencies to prepare and submit annual agency-wide ADP plans which support budget estimate submissions covering at least five years. Since federal hardware is replaced every 7-8 years and conversion time of 1-3 years are incorporated in that span, software conversion planning will be required in the majority of agency plans.

7.6.1.2 Input To GSA

General Services Administration CFR Part 101-35 also requires GSA be furnished a copy of the agency long-range plan developed to support budget submissions with supplementary information addressing:

- o Trends in data processing workloads that will or may saturate existing ADP systems capabilities prior to expiration of the anticipated systems life,
- o Opportunities to take advantage of cost-effective enhancements brought about as a result of hardware technology and software improvements,
- o System redesign or conversion activities planned or in process to improve efficiency.

This supplementary annual input to GSA illustrates the need to maintain continued software conversion planning based on costs. All plans and input will have to be addressed in terms of cost impacts.

7.6.1.3 A-76 Studies

ADP is considered a commercial and industrial type activity. OMB Circular A-76 requires specific evaluation of these activities annually as well as at the time of major change to determine if government ADP services and functions could be cost-effectively assumed by a contractor. Major agency conversions or hardware acquisitions are usually preceded by an A-76 study. Software conversion planning input based on full costing is required.

7.6.1.4 A-109 Studies

An agency may consider a hardware replacement a major systems acquisition falling under the provisions of OMB Circular A-109. Software conversion planning input will be required to develop the mission need for the system, analysis of alternatives, and selection of a final system.

7.6.1.5 The Next Conversion

Ongoing, long-term planning for conversion will provide the details and methodology already in place to support future conversion feasibility studies, software conversion studies and conversion planning. An agency will thereby be in a position to complete a future conversion project in a much shorter time span than required for current projects.

7.6.2 CONVERSION TECHNICAL PLANNING AND ACTIONS TO IMPROVE FUTURE CONVERSIONS

During the post-conversion phase many actions and procedures can be planned or implemented by management to improve future conversions. These procedures should be either established agency practices or implementation of ongoing conversion plans. Most of these procedures are synonymous with disciplined software management and should be implemented and enforced regardless of their role in future conversions.

The following technical planning considerations that can be applied or enforced during the post-conversion phase were developed from analysis of software conversion case histories. They all support portability and efficient conversion.

- Software Libraries and File Maintenance. Conversion planning and execution is often complicated by extraneous and outdated programs, files, and data bases (e.g., outdated systems, old test files). Software libraries and data bases require disciplined control and purging to ease actual conversion planning and execution. Such purging makes maximum effective use of hardware facilities on a routine basis.

- User's Support. Rapport and understanding must be maintained between the data processing staff and the functional users. This reduces user's pressures for introduction of new enhancements during conversion.

- Top Management Support. Executive-level support is required during conversion to provide authority to software conversion managers and assist in providing resources to complete conversion and resolve unforeseen problems. The ADP managers should seek some continuing means to give software management visibility during the post conversion phase. Periodic briefings, perhaps at six months intervals, are recommended.

- Training. Continuous training of the data processing staff in good software engineering and documentation techniques promotes routine production of software of high technical standards as well as portability.

- Security. Sensitive systems require security features to be carefully considered and engineered into software. The time of actual conversion does not provide the optimum environment to develop security specifications due to conversion pressures. Security is best addressed systematicallly during the post conversion phase. Then, security features are already engineered into software at the time of conversion.

- Documentation. Adequate, current documentation, in accordance with agency standards or FIPS PUB 38 or 64 provides, at the time of actual conversion planning, detailed systems information needed to prioritize and develop schedules. It improves understanding of system requirements by outside personnel who assist in planning (e.g., contractors). Documentation facilitates the efforts of those actually involved in conversion duties.

- Standard Languages. Use of standard languages, by definition, facilitates portability or conversion of software. Vendors offer hardware and operating systems that accommodate standard languages. Conversion tools and techniques are available to convert standard languages. Programmers, analysts and consultants are generally familiar with standard languages.

- Vendor Unique Utilities. Reliance on vendor unique utilities degrades portability and conversion. Software staffs should be discouraged from large-scale use of such utilities.

- Software Engineering. Modern techniques of structured software design and development, and modular programming facilitate conversion and ease of software maintenance.

- File Design. Files should be designed for ease of access by standard languages. DBMS should be employed so that they can be supported on a variety of common vendor computer systems.

- Test Files and Data. Test files and data require design and maintenance to ensure that quality software is developed and implemented. This quality assurance is required during software maintenance as well as during conversion.

- Optimization. Software under continuous modification should be periodically examined for efficiency and optimized as required.

7.7 POST-CONVERSION MANAGEMENT DECISIONS

There are two major management decisions.

First, any parallel testing which continues into the post-conversion phase must be terminated. This will halt costly conversion activities and lead to restructuring the conversion staff into an environment conducive to routine operations.

Second, the post-conversion analysis and assessment report should be approved. This is the last official act of the project manager and concludes the conversion project. Activities continue, however, in planning and preparing for the next conversion.

7.8 ECONOMIC CONSIDERATIONS

It is important to distinguish between the identification of software conversion costs and the use of this cost information as it applies to this phase. In order to provide a standard, finite definition of software conversion for cost estimation purposes, the cost structure defined in Appendix C ends with appproval of the post-conversion analysis and assessment report. Costs will include significant expenditures associated with settling the conversion team into routine software operations (e.g., relocation expenses moving from temporary real estate, shipping terminals used only for conversion). Other software conversion costs which are not project-related (e.g., long term planning) incurred during this phase will not be estimated in the software conversion cost structure.

During this phase, personnel expenses will constitute the majority of the total cost as manpower is expanded to perform the post-conversion analysis and assessment. Additional cost areas that may be significant during this phase include relocation expenses for the conversion staff and freight and transportation expenses for the office furnishings. If equipment acquired for the conversion effort is released, a reasonable residual value for the equipment should be credited to the total software conversion cost.

The use of the software conversion cost information during the post-conversion phase will require a review of both estimated and actual costs accumulated over the life of the project. Analysis of cost results should address areas such as the amount and degree of deviation between estimated and actual costs, specific areas of cost deviation identified through the use of a detailed cost structure, and the validation of cost estimation techniques and models. The actual cost information recorded can provide a basis for evaluating the effectiveness of conversion tools and may be used to prepare recommendations for improved procedures that can increase the cost-effectiveness of software conversion.

7.9 POST CONVERSION MANAGEMENT CHECKLIST

- o Parallel testing terminated
- o Documentation completed
- o Conversion staff reverted to normal duties
  - Informed of organization
  - Informed of duties
  - Trained as necessary
- o Contracts closed out
  - SOW reviewed
  - Obligations met
  - Cost issues (if any) resolved
- o Unneeded conversion facilities released
- o New user enhancements pending changes analyzed for redesign
- o Ongoing costs being tracked
- o Post-conversion analysis completed
  - Report complete
  - Support planning and future conversion
  - Coordinated with staff
  - Approved
- o Project manager released
- o Ongoing long-term planning based on full cost methodology; adequate to support
  - A-76 Studies
  - A-109 Studies
  - A-11 Planning
  - Budget
  - Future conversion
- o Conversion technical planning ongoing
- o Conversion technical plans implemented to promote efficient, portable software
  - Software library maintenance and purging
  - File maintenance and purging
  - Continuous user interface

- Continuous top executive interface and reporting
- Training supporting good software practices
- Security requirements regularly addressed
- Documentation procedures
- Standard language used
- Vendor unique utilities discouraged
- Software engineering practices
- Files designed for standard language access
- Test files and data maintained and used
- Regular optimization of software

APPENDIX A

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BIBLIOGRAPHY

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APPENDIX B

CONVERSION DIRECTIVES, STANDARDS AND REFERENCES

The following references should be part of any software conversion manager's library.

FEDERAL DIRECTIVES:

FPR 1-4.11 Procurement and Contracting Government-Wide for Automatic Data Processing Equipment, Software, Maintenance Services and Supplies. This regulation defines procurement and contracting policies relating to the acquisition of hardware, software, maintenance and supplies for ADP.

FPMR 101-35 ADP and Telecommunications Management Policy. This regulation establishes the general policies and procedures relative to the acquisition, management and utilization of ADP equipment, software, maintenance and supplies.

FPMR 101-36 ADP Management. This regulation defines the requirements, policies and procedures governing the use, utilization and management of government ADP facilities.

FPMR 101-37 Telecommunciations Management. This part prescribes policies and procedures governing the utilization of telecommunication services by Federal agencies.

FPMR Temp. Reg. F-496 Federal Conversion Support Center. This temporary regulation advises agencies of the reimbursable services provided by the Federal Conversion Suport Center (FCSC) for ADPE and teleprocessing services, software conversion support assistance, guidance, and support. This regulation replace FPMR Temporary Regulation F-492, October 18, 1979, in that it removes the F-492 requirement for FCSC evaluation reports on conversion studies.

Public Law 89-306 Federal Property and Administrative Services Act of 1949 (as amended by the Brooks Act, October 30, 1965). This Act establishes the authority to provide for improved and efficient procurement, maintenance, operation and utilization of ADP equipment. It also establishes an ADP fund for use by Federal agencies.

Public Law 96-511 Paperwork Reduction Act of 1980. December 11, 1980. The purpose of this Act is to reduce paperwork and enhance the effieiency of the Government. Specifically it calls for the improvement and increased efficiency in the use of ADP and telecommunication services.

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National Bureau of Standards. FIPS PUB 65. Guidelines for Automatic Data Processing Risk Analysis. August 1979. Presents a technique for conducting a risk analysis of an ADP facility and related assets.

National Bureau of Standards. FIPS PUB 73. Guideline for Security of Computer Applications. June 1980. These guidelines describe methods and techniques that can reduce the hazards associated with computer applications.

Executive Office of the President, Office of Management and Budget, Circular No. A 76, Policies for Acquiring Commercial or Industrial Products and Services for Government Use. This policy document prescribes evaluation of government run operations, at time of major change (such as software conversion), to determine if operations can cost-effectively be transferred to contractor support.

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National Bureau of Standards. Conversion of Federal ADP Systems: A Tutorial. Special Publication 500-62. August 1980. This document presents in tutorial fashion an analysis of several recent conversion projects with observations and salient problem areas identified. Several case studies are included.

U.S. Army. Army Automation Planning Guide for Software Conversion. Technical Bulletin 18-122. October 1977. This report presents a detailed outline of the conversion preparation process including both pre-award and post-award activities.

APPENDIX C

SOFTWARE CONVERSION COSTING

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SOFTWARE CONVERSION COSTING

The information contained in this appendix has been developed to provide guidance for the practical application of the concept of full costing to the management of software conversion projects The purpose of this appendix is to define the approach, or methodology, that should be followed in developing software conversion costs. The approach presented is intended to be a generalized methodology and attempts to discuss cost considerations in general terms This total system approach can then be modified, as appropriate, to fulfill the specific costing requirements of each software conversion project.

It is important to understand the steps for developing a total conversion costing methodology. The methodology consists of two parts. The first is the definition of full conversion costs which requires:

- o Identification of project characteristics,
- o Development of the full cost structure,
- o Estimation of the cost data,
- o Analysis of the cost data.

The second part is the application of the cost data to support management decisions. The remainder of this appendix describes these steps in more detail. It is important, however, to continue to view costing in terms of a total methodology, to assure that the maximum return is obtained from the costing development effort.

C.1 INTRODUCTION

Software conversion project managers are required to prepare budgets, monitor the progress of programs and projects, estimate the cost of new capabilities, and make a variety of other system-related decisions on a frequent basis It is the objective of this appendix to provide a consistent cost methodology that can assist the project manager by ensuring that the required conversion cost data is both available and reliable. Also, by providing a consistent costing methodology, historical costs can be uniformly accumulated and updated to increase the accuracy of future estimates.

C.1.1 SCOPE OF THIS METHODOLOGY

The identification of software conversion costs addressed in this appendix includes all major cost factors directly attributable to a

software conversion effort. The software conversion project may be conducted as part of a total hardware installation effort, with planning, analysis and implementation tasks being conducted concurrently. The scope of this appendix, however, will be limited to the software conversion effort which is just one major factor in that hardware transition effort Other hardware-related costs such as site preparation, installation, and ongoing operations will not be included. Identification of software conversion costs will include both direct and indirect costs that can be identified with the conversion effort, and may span organizational boundaries and include the user community costs.

If the software conversion is accompanying hardware replacement, the costing of the software conversion effort should form an important input into the life cycle cost (LCC) of the total acquisition effort. The total LCC should include the total cost of acquiring, installing and operating the ADP system from the inception of the acquisition process until the system becomes obsolete. The development of accurate and detailed software conversion cost estimates will not only aid the conversion project decisions but will also aid in the selection of the total system acquisition alternatives. The software conversion project manager should assure that a single cost estimation effort is conducted where software conversion cost estimates are supplied to the total acquisition LCC, and where acquisition decisions are communicated to the conversion project to be reflected in the software conversion cost estimates. This sharing of cost information can prevent situations where ambiguous and conflicting costs are reported to upper management.

C.1.2 CONVERSION COST DEFINITION

The first step in the understanding of the conversion costing methodology is the definition of conversion costs. This can be accomplished by identifying the full cost structure that represents the software conversion effort, and by defining the length of the software conversion cycle.

C.1.2.1 Full Costing

Full costs of a software conversion include the obvious direct costs of ADP employees and software conversion tools Indirect overhead costs such as space rental, ADP management and support costs can also be identified or reasonably allocated to a particular conversion effort, especially if the costs are incurred within a particular agency. The biggest problem of defining the full costs of a system occurs in the user community, or in organizations beyond the control of the ADP facility management or even the agency management.

C.1.2.2 Conversion Cycle Length

The length of the software conversion cycle depends upon the beginning point, when costs begin to accumulate, until the project has

been completed. The following factors should be considered in determining the project cycle length:

- o Beginning Point - For the purpose of this appendix, the beginning event for the estimation of costs is assumed to occur with the appointment of a conversion project manager. This point does not necessarily coincide with the beginning of the software conversion effort since software conversion has a continuous life cycle. Each life cycle has a distinct project, however, and development of project costs is the important issue. With the appointment of a project manager:
  - Costs can be clearly identified with a particular project, and,
  - Accountability for costs has been clearly established.

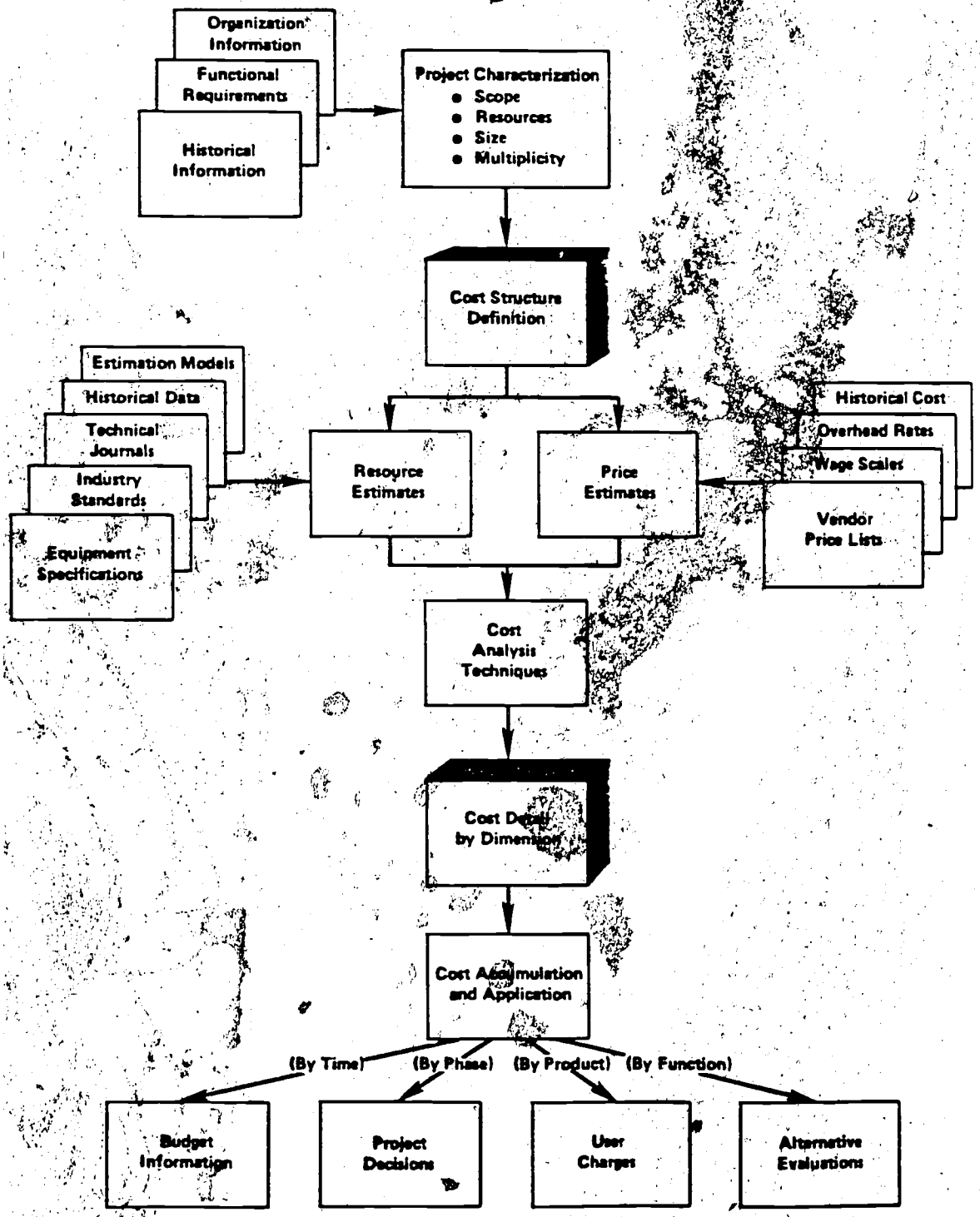
  If, for some reason, significant project-related costs have been incurred prior to the appointment of a project manager, these costs should be retained in the historical cost records.
- o Ending Point - For cost estimation purposes, the software conversion project ends when conversion has been completed, conversion resources have been reassigned, and the post-conversion audit and analysis have been completed.

The subject of costing — its definition, estimation and use by project management — has no single, cookbook approach that can be applied for all projects. Instead, what is needed is a methodology that addresses the costing requirements of management in general, and the guidance that can mold the methodology to the individual needs of each project. This is the approach taken by this appendix.

C.2 CONVERSION COSTING METHODOLOGY

The process to be followed in identifying the full cost of the conversion effort is illustrated in Figure C-1. The major steps in this process include:

- o Characterization of the Conversion Effort - This includes a general understanding of the project goals and objectives, source environment, potential target environments, current software inventory and inventory status.



COST DEVELOPMENT PROCESS

Figure C-1

- Definition of a Cost Structure - The cost structure should reflect the requirement for more detailed cost information as the project progresses and should include major categories of cost.

- Estimation of Costs - Defined by the cost structure using resource and price estimates developed from historical data, models, price lists, industry sources, etc.

- Analysis of the Cost Data - Specific analysis objectives are based on the requirements for the use of cost data by project management.

- Application of the Cost Data - To provide specific cost input for costing decisions and activities.

Each of these steps is described in more detail in the sections that follow.

C.3 CONVERSION PROJECT CHARACTERIZATION

The characterization of the conversion effort is an important preliminary step in the execution of the conversion costing methodology. Through a thorough evaluation of the major characteristics of the conversion project, a cost structure can be developed that reflects the material costs expected to be incurred and allows for the application of costs, with sufficient detail, to fulfill expected management requirements.

A conversion project may be characterized using several factors including:

- Software environment, e.g., current languages used, whether they are in standard ANSI language, degree of documentation,

- Multiplicity, e.g., whether the conversion involves multiple sites, systems, or user organizations,

- Financial impact, e.g., whether the expected dollar size of project will require increased reporting efforts,

- Mission supported, e.g., whether workload cycles will restrict the project schedule.

This characterization step should result in an informal, written understanding of the relevant project characteristics stated in terms of the project's goals and objectives. This understanding should be approved by the project manager during project initiation in the development of a conversion cost structure. This understanding should also be reviewed periodically throughout the project and revised as needed.

C.4 COST STRUCTURE DEFINITION

The primary component of the methodology is the design of a comprehensive cost structure that addresses the full cost of the conversion, aids in the estimation of conversion resource requirements and price factors, and allows the application of a single cost information base to several project costing needs. The cost structure defined in this appendix meets these requirements through the use of cost dimensions.

A cost dimension is a classification scheme that identifies a particular characteristic of an entire project. For example, project costs may be recorded as follows: personnel $75,000, equipment $10,000, facilities $10,000, miscellaneous $5,000 The cost of the project may also be defined along functional terms, such as, conversion $80,000, training $12,000 and administration $8,000 In a similar fashion the total project cost could be divided into cost per phase, cost per year and so forth. In each case, a summation of costs along any dimension would yield the same result, or in this example, $100,000.

The purpose of the dimensional cost structure is to minimize cost ambiguities in addition to providing the following:

- o Assistance in defining the full cost of a project,
- o A work breakdown for ease of cost estimation, and
- o Detailed cost information for use by project management.

The full cost of a project can be defined using single dimensions and, similarly, a summation of costs along each dimension would yield the same full cost figure. The benefit of a dimensional approach is the ability to identify categories of cost (such as software conversion personnel costs) that span several dimensions. The following dimensions should be included in the software conversion cost structure:

C.4.1 COST ELEMENT DIMENSION

Cost elements correspond to the basic accounting units that represent personnel, material and facilities The cost element dimension has been developed for this cost structure using ADP terminology and providing a level of detail that is consistent with the amount of funds normally expended for each category. It is the responsibility of each project manager, working with the cost analyst, to identify the cost element level of detail that reflects the characteristics of the project and supports the application of the conversion costing methodology to the project's needs.

The cost element detail that follows is illustrated in Figure C-, and should be viewed as general guidance. Important cost areas may be expanded if they are material to the decisions supported by the costing methodology. Elimination or consolidation of the cost element

PERSONNEL

- COMPENSATION
- GENERAL BENEFITS
- TRAINING EXPENSES
- TRAVEL AND TRANSPORTATION EXPENSES
- HIRING/SEPARATION EXPENSES
- MOVING EXPENSES

OCCUPANCY

- FACILITIES
- UTILITY SERVICE
- OFFICE EQUIPMENT
- HOUSEKEEPING EXPENSES
- SECURITY EXPENSES
- ENVIRONMENTAL CONTROLS
- OTHER OCCUPANCY

ADP HARDWARE

- OPERATING UNIT
- DATA ENTRY DEVICES
- PRINTERS
- TIMESHARING SERVICE
- EQUIPMENT MAINTENANCE
- OTHER ADPE

ADPE SUPPLIES

MISCELLANEOUS EXPENSES

- OFFICE SUPPLIES
- TELEPHONE SERVICE
- PRINTING/DUPLICATING EXPENSES
- SMALL CONTRACT SERVICES
- OVERHEAD
- GENERAL AND ADMINISTRATIVE

ADP SOFTWARE

- OPERATING SYSTEMS
- CONVERSION SUPPORT SOFTWARE
- GENERAL PURPOSE SOFTWARE
- SOFTWARE DOCUMENTATION
- SOFTWARE MAINTENANCE
- OTHER SOFTWARE

TELECOMMUNICATIONS

- LINE CHARGES
- TERMINAL EQUIPMENT

SOFTWARE CONVERSION COST ELEMENT DETAIL

Figure C-2

dimensional detail should be done only with careful consideration as to the impact on the cost estimation techniques and the ultimate application potential of the resulting structure.

The following is a definition of each significant cost element:

- o Personnel - The personnel cost element will normally be common to each software conversion project and account for a significant portion of the costs. Personnel costs are also the most likely to be underestimated either through an incomplete definition of the work to be performed, quantity of personnel required, level and cost of skills required, or amount of ancillary personnel costs. The personnel cost element consists of the following sub-elements:
  - Compensation - includes base wages, cash awards, overtime pay and premium pay in the form of shift differentials, incentive pay, merit pay, and other allowances for all regular, part-time, permanent and temporary employees.
  - General Benefits - includes employer-paid medical, dental, life and disability insurance, and contribution to non-social security retirement plans, federal and locally-imposed payroll taxes such as FICA (social security), FUTA (unemployment), and workman's compensation taxes; and other benefits such as professional dues and memberships, subscriptions, awards, uniform cost and cleaning, and any other personnel expenses that are not otherwise described.
  - Training Expenses - includes expenditures for tuition, fees, educational books, materials and training aids.
  - Travel and Transportation Expenses - includes the transportation of employees for business, training or relocation purposes. It includes actual transportation expenses for auto, airlines, bus, and train travel, as well as meals, lodging, tolls, tips and other travel expenses.
  - Hiring/Separation Expenses - includes advertising costs, credit/background investigations fees, employment agency fees, testing service fees, and outplacement fees.

- Moving Expenses - includes the cost of transporting personal property such as the shipment of household goods, property storage, closing costs and mortgage interest adjustments.

In addition to the personnel cost categories listed above, it may be beneficial to be able to identify personnel salaries based upon individual skill categories. This process will assist in the estimation of salary expense by providing common job titles, and will aid in the application of the costing methodology for alternative evaluation purposes. A personnel skills category definition would be applied to the salary cost element and, in the federal government, would contain costs by job title, GS level and GS step.

o ADP Hardware - ADP hardware expenses may be incurred during the software conversion effort in terms of CPU hours purchased from a service bureau or provided by the equipment vendor, or target equipment obtained on a short-term basis to provide the test environment and on-line conversion capabilities required during the project. Subelements of this category include:

  - Operating Unit - includes the mainframe, operator consoles, storage and memory devices acquired for the project,
  - Data Entry Devices - includes the terminals and other input equipment,
  - Timesharing Service - includes the cost of timesharing services used during the project,
  - Equipment Maintenance - includes the cost of normal hardware maintenance service contracts,
  - Other ADPE - includes ADP equipment not included above, such as tape cleaners, hardware monitors, test equipment, and spare parts.

o ADP Software - ADP software includes an ever-increasing proportion of ADP costs as data processing installations use more canned programs, and less in-house software is developed This cost element includes only purchased or leased software. ADP software includes the subelements of:

  - Operating Systems - includes the mainframe operating software including spooling software,

- Conversion Support Software - includes the system support software such as compilers, utilities, translators, and tools,

- General Purpose Software - includes multi-use software such as SAS, SPSS, RPG, etc.,

- Software Documentation - includes the manuals, guides, and software handbooks obtained for use with the ADP software,

- Software Maintenance Service - includes the cost of normal software maintenance service contracts,

- Other software - includes other software-related costs.

o Telecommunications - The telecommunications cost element includes the hardware and service required to provide data communications between ADPE components to support software conversion This element includes the following subelements:

- Line Charges - include the cost of leased lines, trunks or network service,

- Equipment - includes the cost of modems, concentrators, front-end processors, terminals equipment maintenance service.

o Occupancy - The occupancy, or space cost element is used to identify the costs required to house the project team. It is a cost element that has been occasionally overlooked, since occupancy costs are frequently borne by a service agency (e.g. GSA). The occupancy cost element consists of the following subelements:

- Facilities - include the building, land, common areas, leasehold improvements, and other physical structures,

- Utility Services - include electric power, gas, oil, coal, water, sewage and garbage service,

- Office Equipment - includes the general office furniture and fixtures, typewriters, copiers, plants, pictures, decorating fees, etc.,

- Housekeeping Expenses - include janitorial supplies and equipment,

Security Expenses - include the access cards, cameras, locks, monitors and alarms required to control access to the building or the computer installation,

Environmental Controls - include the normal heating and air conditioning equipment expenses as well as an uninterrupted power source, humidifiers, dehumidifiers, water chillers,

Other Occupancy Expenses - include all other occupancy-related costs not included above.

- ADP Supplies - In a typical ADP operation, ADP supplies can account for a small, but significant percentage of costs. For this reason, a separate cost element is assigned to distinguish the ADP-related supplies from all other supplies.

- Miscellaneous Expenses - Miscellaneous expense is a cost element that incorporates costs not specifically detailed by the prior cost elements. It should include general categories of expenses that are not ADP related. The characteristics of each project will determine the materiality of the subelements defined for this cost element. The list of subelements that follows should be used as a guide that can be expanded as needed to provide a consistent level of cost detail.

  Office Supplies - include general administrative office supplies that are not directly ADP-related. These would include pens, pencils, copier paper, pads, folders and the like.

  Telephone Services - include the charges for local service, long-distance and special voice communication lines.

  Printing Duplicating Expenses - include the cost of using off-site printing and duplicating services.

  Small Contract Services - include the relatively small contract services that cannot be defined in terms of other cost elements, or are too small to be of material significance. Major software conversion contracts should be identified by the specific resources (amount and price) being provided to allow a detailed identification of costs.

- Overhead - includes indirect costs associated with the performance of a project that cannot be defined in terms of other cost elements, or are too small to be of material significance. The use of this overhead category should be kept to a minimum since the objective of the cost structure is the identification of the full cost detail.

- General and Administrative (G&A) - similar to the overhead category, G&A is common in the federal government as a means of allocating indirect costs to an operating unit. As with overhead, the use of the G&A element should be summarized and applied only when a cost detail is not available or the amount of the cost is relatively insignificant.

The cost element dimension detail provided in this section should be used as a foundation for the construction of a conversion cost structure that is representative of the software conversion effort and reflects the full cost of the project. The function dimension discussed in the following section serves as an additional means of assuring that the full costs of the software conversion are addressed.

C.4.2 FUNCTION DIMENSION

Functions are general categories that may include one or more activities that are performed during the software conversion project. It is important to distinguish between functions and activities. From a project management standpoint, activities are important for establishing project control. Conversion activities may not require a substantial amount of resources, for example, the appointment of a project manager. From a cost estimation standpoint, however, conversion functions better represent the conversion effort. The function dimension is included in the cost structure since it aids in the identification of the full cost of a software conversion project by identifying all significant functions. Also, the function dimension helps in the cost estimation process by providing cost categories that correspond to existing software conversion cost estimation models, and are sufficiently detailed to provide a work breakdown structure with which to develop costs. A consistent set of software conversion functions can also aid in the use of historical costs to estimate future software conversion costs. The following functions illustrated in Figure C-3, correspond to the conversion tasks identified by the Federal Conversion Support Center and include:

- o Conversion Management and Administration - includes the resources involved in managing and administering the conversion effort, such as user and upper management liaison, contract administration, and personnel activities involving the project team.

CONVERSION MANAGEMENT AND ADMINISTRATION

CONVERSION PLANNING ANALYSIS AND PREPARATION

- PROJECT PLANNING
- STUDY PREPARATION AND SOFTWARE INVENTORY IDENTIFICATION
- POLICY REVIEW
- SOFTWARE WORK PACKAGE PREPARATION
- TEST DATA GENERATION

APPLICATION PROGRAM AND SYSTEM SOFTWARE CONVERSION

DATA FILE AND DATA BASE CONVERSION

- TRANSFERS ONLY
- SIMPLE TRANSLATIONS
- AVERAGE COMPLEXITY TRANSLATIONS
- COMPLEX TRANSLATIONS
- VERY COMPLEX TRANSLATIONS

OPERATION CONTROL LANGUAGE OPERATING PROCEDURE CONVERSION

REDOCUMENTATION

SYSTEM AND PARALLEL TESTING

TRAINING

- CONVERSION TOOLS
- TARGET SYSTEM AND TARGET SOFTWARE

SOFTWARE UPGRADE

- CONFORMITY TO ANSI STANDARDS
- COMPLETE CURRENT SYSTEM DOCUMENTATION
- PURGE OBSOLETE SOFTWARE
- FUNCTIONAL SOFTWARE REDESIGN

GENERAL

- FACILITIES MAINTENANCE, SECURITY ETC.

SOFTWARE CONVERSION FUNCTION DETAIL

Figure C-3

- Conversion Planning, Analysis, and Preparation -includes the preliminary conversion activities such as:
  - Project planning and analysis at the project, system and task levels, and identification of the conversion work package,
  - Study preparation and software inventory identification including quantity, language, age, documentation, etc.,
  - Review and implementation of conversion policy, procedures and documentation standards,
  - Preparation of the software work package,
  - Test data generation and validation.
- Application Program and System Software Conversion - includes the resources required for reprogramming, program logic modification, simple translation or other methods of software conversion, including the use of conversion translators and aids.
- Data File Conversion - includes the following types of conversions:
  - Transfer only - where the source and target systems and environments are fully compatible,
  - Simple translation - where the conversion is basically character-to-character, from source to target character set, on a one-to-one basis,
  - Average complexity translation - which involves character-to-character, character-to-word, or word-to-word conversions with the conversion parameters embedded in the files,
  - Complex translation - where the conversion parameters are external to the files These conversions usually require development or modification of several pieces of conversion software and generally call for multiple steps,
  - Very complex translation - usually includes DBMS files and may require major development of special software,

- Operation Control Language Operating Procedure Conversion - includes the resources required to convert the operating procedures from one environment to another, including rewriting, reprogramming, and the use of operation control language translators and generators,

- Redocumentation - includes the resources used in reviewing and analyzing existing documentation, rewriting, and clerical editing, proofing, and typing of the new software documentation,

- System and Parallel Testing - includes the resources used in the system test and parallel test of the system to demonstrate interoperability between system components (programs, files, and job streams) and overall correct execution. When the system functions as expected, software acceptance testing would commence to achieve acceptable comparison of outputs against the current or source system results,

- Training - includes the resources used in training course preparation, delivery and participation for the following activities:

  - Training which trains the project team in new conversion techniques or the use of software conversion tools,

  - Training which trains functional users, DP staff, project team and other personnel in the target system environment, and target system software.

- Software Upgrade - used to identify software costs incurred during a conversion not directly associated with new hardware. These costs must be budgeted and tracked, but may or may not be included for hardware evaluation purposes, depending upon the regulations currently in force Software upgrade occurs whenever current applications are changed to conform with government ANSI standard language, documentation is developed to provide a complete description of the current systems, obsolete programs are purged, or a functional redesign of a program is performed,

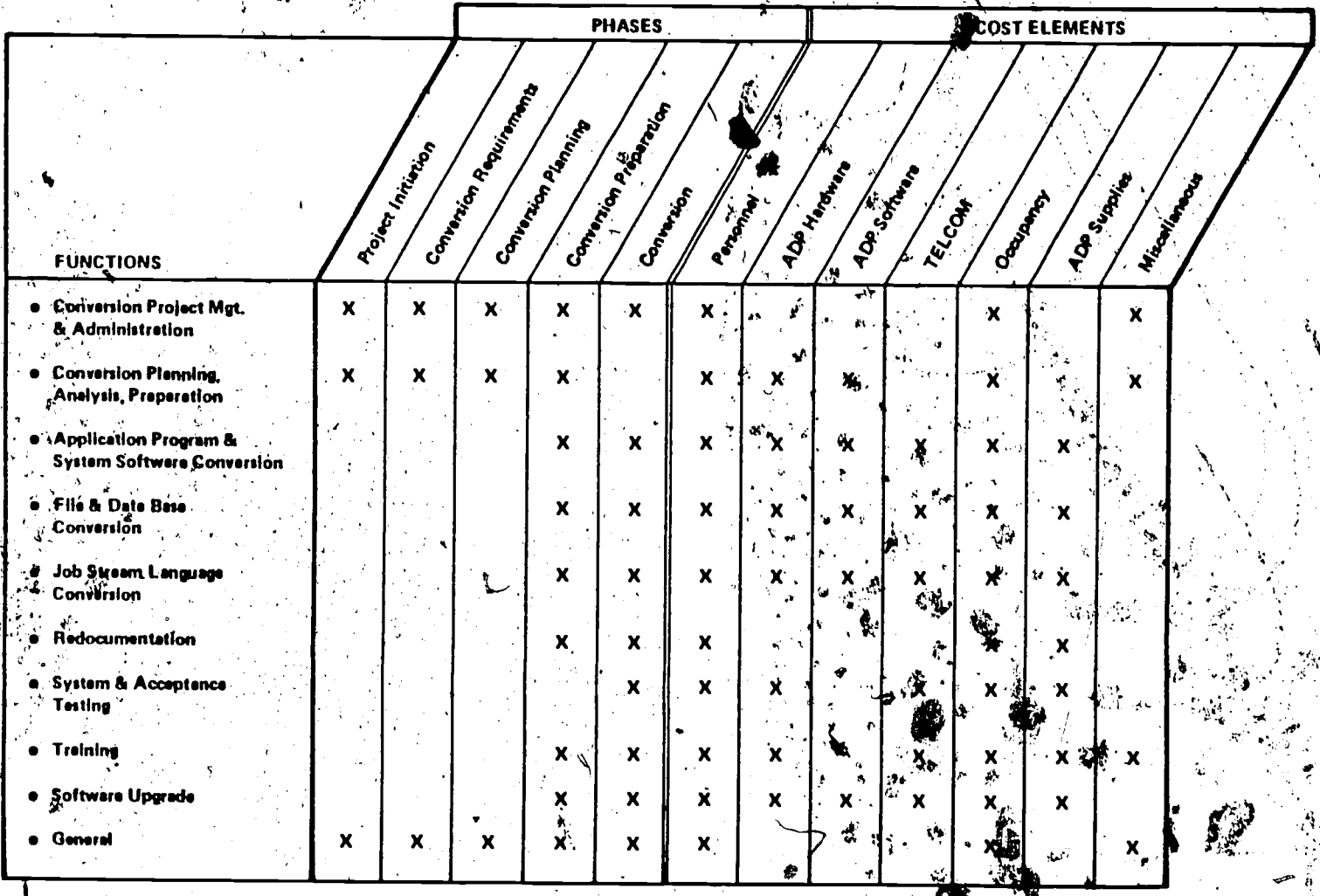
- General - is designed as a default category with which to identify functions not specifically addressed above. Examples of functions that could be included in this category include facilities maintenance, production control, and security functions.

C.4.3 PHASE DIMENSION

The phase dimension corresponds to the software conversion phases described in the body of these guides. Phase dimensions are useful in large projects in providing a logical and somewhat sequential grouping of conversion activities that provides better upper management control through the use of milestone approval points. Through a standard assignment of software conversion activities to phases, historical costs from many projects may be recorded in a consistent manner and used for future cost estimates, and to develop and validate cost estimation models. It is important to note that the definition of phases will result in some overlap. That is, as one phase is being completed, activities in the next phase are already being performed. The software conversion phases identified in the cost structure include:

- Project Initiation Phase - where the decision is made to undertake a conversion effort,
- Conversion Requirements Phase - where the detailed investigation and identification activities are performed,
- Conversion Planning Phase - where the conversion plans and schedules are developed in detail based upon requirements defined in the previous phase,
- Conversion Preparation Phase - where the activities that are required to begin the conversion process are completed,
- Conversion Phase - where the activities identified to perform the transition of software from the source environment to the target environment is accomplished,
- Post Conversion Phase - where the conversion team is reassigned to normal duties and then post conversion project analysis is conducted.

While costs may be incurred prior to the appointment of a project manager in the project initiation phase, or after a post-conversion analysis, they are not included as estimates in the software conversion project cost. Activities in these areas fall outside the perspective of viewing conversion as a "project." The conversion project costs, i.e. those that are incurred from the time a project is started through completion are the most important. More detail concerning the specific activities included in each software conversion phase can be found in the body of these guides. The relationship between the cost element, function and phase dimensions is depicted in Figure C-4.



X = Cost Likely to Occur

RELATIONSHIP OF PHASES

AND COST ELEMENTS TO CONVERSION FUNCTION

Figure C-4

C.4.4 TIME DIMENSION

The time dimension identifies the calendar period in which costs are expected to be incurred. The time dimension is included in the cost structure for budgetary purposes to assist in project planning and control, and to aid in present value cost analysis for relatively long software conversion efforts. The detail incorporated in the time dimension should reflect the use of the cost information by project management and the ability to accurately estimate costs. Thus, during project initiation, software conversion costs used for a cost-effectiveness analysis may be estimated for the next four quarters, and annually thereafter Prior to the commencement of the conversion phase, however, costs may be required to be estimated for each month for project control purposes In general, software conversion costs should be estimated at least by fiscal year and for periods not shorter than a month.

C.4.5 LOCATION DIMENSION

The location dimension identifies the geographical site where a function of the software conversion is being performed. It addresses personnel, equipment and occupancy resources, the price of which may vary by location Thus, the use of a location dimension aids the conversion costing methodology by allowing the estimation and analysis of geographic cost differences relative to the total conversion cost figure. The location dimension should be included with software conversions that involve multiple sites.

C.4.6 PRODUCT/SERVICE DIMENSION

The product/service dimension is used to allocate the cost of the conversion to specific operational objectives performed by the facility These objectives could be stated as ADP services (e.g. timesharing, batch processing), programs supported (e.g. anti-aircraft missile, solar energy) or applications processed (e.g. general ledger, payroll, disbursements, personnel). Where more than one product classification is appropriate different product dimensions may be material. This dimension will allow the project manager to estimate the cost to convert each individual system or conversion unit.

C.4.7 ORGANIZATION DIMENSION

The organization dimension identifies the component, agency, department or division that performs functions of the project. In this respect it assists in the identification of the full cost of a project by providing a structure definition that extends beyond the budget concerns of the primary organization. The organization dimension also aids in the identification of inter-and intra-governmental support in performing conversion functions.

The identification of the conversion cost structure is the first step in the development of the cost of a software conversion project. Through the use of cost structure dimensions, the identification of the full cost of the project, the estimation of the individual cost detail, and the analysis and application of the estimated costs can be assisted.

C.5 ESTIMATION OF COSTS

Once the cost structure has been identified for the specific conversion project, estimates of cost must be developed for the structure detail. This section presents this cost estimation process in both a general and specific format.

It is difficult to identify a single, universally acceptable approach to estimate conversion costs The estimation technique used will vary with the degree of accuracy required, characteristics of the software conversion project, and the use of the cost data during the conversion phases. The basic steps required to estimate costs include the following:

- o Identify the Conversion Cost Structure Detail Appropriate for the Project - This is accomplished by using the multidimensional cost structure described in the previous section. The cost structure can assist in the cost estimation process by dividing the conversion cost into manageable pieces.

- o Estimate Resources - The next step in the cost estimation process is to identify the quantity of resources required to perform a given conversion function. The cost element dimension provides the list of resources, while the function dimension identifies the workload requirements. Since resources will rarely be 100% utilized, an adjustment should be included in the resource estimate to provide excess capacity whether in terms of man-hours, processing time, or space requirements.

- o Estimate Unit Price - The price of a given resource (or cost element) unit must be estimated The price may be dependent upon the conversion function performed (e.g skill level required), location and time period. Price can be affected by inflation factors, government discounts, or quantity discounts. Multiplying quantity times price will give the cost of a single cost structural unit.

The estimation process is not static throughout the conversion project. The use of cost estimation models and techniques at the beginning of the conversion project may be sufficient to provide the accuracy for a limited cost-effectiveness analysis. Later in the project, a

given cost estimation model may not provide the accuracy necessary to estimate the structural cost units. The degree of estimation will also change during the conversion project phases. For a large conversion project, costs may be adequately expressed to the nearest $1,000 during the project initiation phase. Later, costs may be required to the nearest hundred dollars The dimensional levels of detail that are material can also change during the project. When dealing with broad conversion strategies it may be possible to estimate at a gross level of detail. Later, increasingly finer levels of detail will be defined. Cost estimation techniques that address a gross detail level may not be appropriate to use in estimating the lower detail levels of the conversion cost structure. The estimation process described in this section must be used with common sense and adjusted to fit the characteristics of the individual project and its changing requirements for cost information during the project phases.

As a basis for the specific cost estimation process, the following section presents a general discussion of cost estimation techniques that may be applied.

C.5.1 ESTIMATION TECHNIQUES (GENERAL)

The cost estimation techniques can be used to supply the cost figures for the cost data defined by the conversion cost structure. Cost estimation techniques may be simple, such as using a previous conversion project's supplies cost and adjusting for inflation; or complex, as in the case of a parametric software conversion cost model. The following general techniques may be used to estimate costs:

- Standards - The use of standards relies on estimates for resource quantities and price that have been systematically developed in the past. These standards then become stable reference points from which new tasks can be calibrated. Due to rapidly changing ADP technology, past performance standards, such as a standard for conversion productivity (e.g., number of lines converted per workday), should be examined before they are applied to estimate resource requirements for current systems.

- Modeling - Modeling techniques attempt to predict cost or resource requirements for the proposed system without the use of a full-scale development and trial period. Modeling techniques, such as the Federal Conversion Support Center cost estimation model, are useful during the early phases of the conversion project planning process to provide an estimation of cost. As such, they can be useful during preliminary cost-effectiveness analyses to determine the cost impact of proposed alternatives.

- Historical Cost Application - The use of historical costs is generally limited to the refinement of future conversion phase cost estimates based on cost data collected for recently-completed conversion phas^ If historical cost records have been maintained, for example, the cost of regularly scheduled management review meetings, these costs could provide the basis for developing accurate cost estimates for use throughout the project.

C.5.2 SOFTWARE CONVERSION COST ESTIMATION MODELS

The difficulty in accurately estimating the cost of software conversion has led to the development of cost estimation models to provide a simple solution to the estimation problem. While a complete description of the use of models is beyond the scope of this appendix, the models summarized below serve as an overview to provide guidance as to the models currently available at the time of the publication of this guides that have significant application to federal conversion and the strength and applicability of each. The use of software conversion estimation models should prove beneficial in the early phases of the conversion where only gross detail is required and accuracy is not critical. These models should be used only with a thorough understanding of the basis upon which the model was developed, the cost elements, functions or phases covered by the model, and the projects in which the model output has been validated.

- Federal Conversion Support Center Model - The Federal Conversion Support Center (FCSC) model was developed in 1980. The FCSC model is primarily a parametric software conversion cost estimation model The model features an excellent breakdown by functions which facilitates cost estimation. The model includes most cost elements, and it explicitly states those elements it does not include. The model is sufficiently flexible to handle most complex conversions, and covers essentially all phases of a conversion effort. While the FCSC model has not been extensively validated at the time this guide was prepared, it appears to be the best software cost estimation model available from public sources.

  - The FCSC model has several distinct advantages. Although incomplete, this model does have a comprehensive treatment of costs. The FCSC model was designed to be applicable to a wide range of conversions and there are plans for future enhancements. On the other hand, the coefficients and values assigned for DBMS and other complex conversions are untested. Subjective assessments

are required in certain cost areas and it does not recognize effects on conversion costs of over-assignment or under-assignment of personnel. The applicability of the model appears to be universal.

- Project Management Control System II - Project Management Control System II (PMCS), which is also known as the Navy Model, was developed by Naval Data Automation Command (NAVDAC). It is a parametric software conversion cost estimation model which is based on batch-to-batch COBOL conversions similar to those performed in the 1970's at NAVDACs (then Data Processing Service Centers). PMCS is based on four similar conversions encompassing over 100 man-years of work. These conversions were primarily business oriented, batch, COBOL systems. PMCS is primarily oriented towards professional staff-days, not towards dollars. It excludes discussion of costs such as administration, data entry, computer operators, and supervisory time which can be significant in government ADP operations, but not the associated costs. PMCS includes a management reporting system and automated manpower estimating aids. Reports produced are, however, primarily a recompilation of data provided by the user.

  PMCS is relatively easy to use, validate, and refine, and is apparently not limited by hardware (assumption of the model's developers). It contains excellent coverage of the phases of a conversion effort. PMCS is based on data of questionable statistical value, because some of the original data was discarded. Furthermore, the model is based on major conversion efforts and thus may not be clearly applicable to small and medium-sized conversion efforts. PMCS can be used for batch-to-batch, business-oriented, COBOL to COBOL, flat-file to flat-file conversions.

It is not always possible to draw a distinction among the cost estimation techniques described above. They do have one common factor in their use of historical information to predict future events. It should be evident that if software conversion cost information can be recorded in a detailed and consistent manner, for historical purposes, the accuracy of the cost estimation process, in general, can improve.

C.6 ANALYSIS OF THE COST DATA

Just as estimation techniques vary according to the requirements of the project for which costs are estimated, the analysis techniques that are appropriate for each situation depend upon the characteristics of the project and of the decision being addressed. This

section describes several analysis techniques that are applicable to a wide range of situations. The applicability of each technique is dependent upon factors such as the phase, function and alternatives analyzed for a particular project. It is important to understand the value and the limitations for each technique before attempting to use them for making decisions.

Certain cost concepts and analysis techniques discussed in this section must be performed to satisfy the requirements of specific directives. Where applicable, the discussion of cost analysis includes a description of how the costs are related to relevant directives.

C.6.1 COST CONCEPTS DEFINITION

The framework and procedures that are presented in this appendix for developing costs are based upon the concept of full costing. That is, by defining the full costs of a project in a detailed manner (i.e., multidimensional structure) it will be possible to derive cost classifications from a single cost base. This is important in responding to directives, since the format and classification of this cost information may vary. The cost concepts addressed below have been the source of confusion in the application of cost information. While each concept is briefly discussed, a full definition can best be obtained from financial and accounting reference material.

- Direct/Indirect Costs - Costs may be classified as either direct or indirect. The purpose of identifying costs as direct or indirect is to assign all costs as precisely as possible to the specific product, service, customer or other cost objective they support. Some costs are easily assigned directly to a product or service. For example, the cost of programmers that are dedicated to convert a specific application is a direct cost of that application. The most common direct costs are for labor and supplies. Other possible direct costs include travel, purchased services and service center charges for items such as printing.

  Indirect costs are costs that cannot be directly related to a product or service, or costs that are insignificant or difficult to measure. Examples of items that are often classified as indirect costs are low cost supplies such as paper clips; the labor costs of receiving, storing and distributing materials and supplies; depreciation of buildings and general purpose equipment; utilities; and general and administrative expense for financial management and other services that benefit the entire organization. Indirect costs may still be assigned to specific cost objectives but the assignment is through an allocation process. The total indirect cost is spread among all cost objectives according to criteria such as number of people or total budget dollars.

Because separating full costs into direct and indirect costs permits a careful assignment of costs to specific products or services, it is useful for conversion budgeting and project monitoring applications. A clear separation of costs assists managers who are responsible for controlling resources and costs that are associated with projects under their supervision. Awareness of the true cost of providing or receiving services permits managers to make informed decisions.

- Constant/Current Dollars - The purchasing power of a dollar during one year is not necessarily the same as the purchasing power of that dollar during some future year. Inflation means that more dollars will be needed in the future to purchase the same goods that are purchased with less dollars today. The term "constant dollars" should be equated to "constant purchasing power," that is, the price of a resource in terms of the purchasing power of a dollar in some base year. Current dollars represent the actual cost outlays in the year they are expensed, and show the effect of inflation on the constant dollar value.

Since both constant and current dollar estimates may be required during the project (e.g., constant dollars for economic analyses, current dollars for budgetary submissions), the software conversion cost estimates should be developed in such a way as to support both requirements. This is accomplished by estimating software conversion costs using constant (base year) dollars. By applying inflation factors to these estimates, current dollar figures can they be determined for each future year.

- Inflation - Inflation is the rise in the general level of prices over time. Inflation complicates financial planning and cost analysis because it creates uncertainty about future prices. Current and past rates of inflation may be measured by means of price indexes, which are percentage comparisons of the prices of selected commodities and services between two periods of time. Future rates of inflation can only be estimated. Once the future inflation rate is estimated for the years of a conversion project's life, the rate is applied to all future costs to adjust those costs for projected price increases. Because inflation affects the prices of goods and services to be acquired in the future, it is an important consideration of full costing during any planning or estimating for items that are subject to price changes. Labor, supplies and utilities are examples of items that

may be affected by inflation. The total costs estimated for each year in the conversion project's life are adjusted by applying an annual inflation factor to each total. Software conversion cost estimates should be able to reflect costs in actual dollar expenditures expected in each year of the project for budgetary purposes. Anticipated variations in the inflation rate should be addressed through sensitivity analysis.

- Wash Costs - The cost of some items may be the same regardless of which of two or more alternative courses of action are selected. Although the amount of the cost may be important, it will not affect the outcome of a cost comparison among the alternatives. Such costs are referred to as wash costs. For example, if two options are for the government to purchase and operate certain equipment or to purchase the equipment and hire a contractor to operate it, the purchase cost of the equipment is a wash cost. It may be a major part of the total project cost but the cost is the same for the two alternatives and will, therefore, not contribute more to the total cost of one alternative than the other.

  Under a concept of full costing, all costs should be included whether a wash cost or not. This is because a total cost is important for budgeting decisions. Also, it is difficult to correctly identify a wash cost, since cost components may vary with the alternative selected. For example, the cost of management is often considered a wash cost; however, a software conversion in a distributed processing environment may require more task managers and higher travel and administrative costs than a software conversion in a centralized processing environment. Another reason for including wash costs in the conversion costing methodology is that the scope of the project may change during conversion planning preparation. Costs which were correctly assumed to be a wash, now may have a cost impact on the project decisions. By addressing the full cost of a project, all cost areas would have been included, whether a wash cost or not.

C.6.2 ANALYSIS TECHNIQUES

Cost analysis techniques are methods of using previously-defined and estimated cost data to make management decisions. The nature of the decision determines the techniques that are most appropriate for each situation. The following are examples of analysis techniques that are valuable for management decisions.

- Present Value Analysis - Present value analysis is used to reflect the diminishing value of money with time. Present value analysis equates future costs to their present worth. Its primary value is in the assessment of alternatives that have different cash flows and different durations.

- Sensitivity Analysis - Throughout the costing process, various assumptions are made concerning the cost data used. These assumptions include inflation factors, cost estimation, workload, etc. As part of the cost analysis process, these assumptions should be evaluated to determine if changes in any one assumption will change the outcome of the analysis.

- Break-Even Analysis - Break-even analysis is used to study cost relationship between alternatives.

- Ratio Analysis - Ratio analysis is a cost comparative process which may be used to compare cost data within an alternative, among alternatives or with standard cost data.

- Risk Analysis - Risk analysis is a technique that uses probabilities to assess the potential for alternative outcomes. By assigning probabilities to each alternative and multiplying by the expected cost or outcome value of that alternative, a total, expected value can be determined. In a software conversion project this technique is important in contingency planning to develop a plan that assesses potentially harmful events in a cost-effective manner.

These techniques are intended only as examples of the analysis methods that are available for use during the project. The use of these techniques, including their strengths, weaknesses and applicability to project decisions can be obtained from a review of financial reference material. It is important to remember, however, that the use of various techniques may yield conflicting results. It is improper to adopt a single analysis method for use in all applications. The analysis methods must be applied judiciously, with a knowledge of each method's limitations.

C.7 APPLICATION OF THE COST DATA

The end objective of the conversion costing methodology is support of project management decisions. As illustrated in Figure C-1, the application of software conversion cost information is directly related to the manner in which costs have been defined using a dimensional cost structure. These dimensions allow the application of a single cost basis to a variety of project decisions and activities. In this section the

application of costs to specific conversion project decisions and activities is summarized for each phase of the conversion. While some cost impact may be shown for every software conversion activity, this section is designed to highlight those tasks which are most dependent upon the costing information. An overview of economic considerations is given in Figure C-5 and summarizes the cost detail contained in the body of the guides.

C.7.1 PROJECT INITIATION PHASE

Project initiation is the phase in which the requirement for a software conversion is determined. The major product of this phase is a preliminary feasibility study that includes the cost estimates of conversion alternatives, a comparison and analysis of these alternatives based on cost and technical factors, and a recommendation of a proposed alternative. Accompanying this recommendation should be preliminary project plans that will accomplish the alternative courses of action. Cost activities during this phase include:

- Analyze the Project Characteristics and Develop the Unique Project Cost Structure - It is critical to develop the specific cost structure which is material to the project under investigation. This will require analysis of the basic characteristics and goals of the conversion project, and development of a specific cost structure which will form the framework for future cost estimates, cost evaluation criteria, and cost tracking. This is a major activity which will require careful planning to assure that the correct structure has been developed which will allow continuous use throughout the software conversion effort.

- Establish a Preliminary Conversion Project Budget - The cost structure should be used for budget preparation by identifying the estimated project costs for the following phases in terms of various costs elements and functions. Also, the scheduling of these expenses should be established by assessing the priority (cost-effectiveness) of the project relative to other projects under development.

- Estimate Project Resources - The project budget estimate and schedule can be matched to determine the availability and utilization of personnel skill categories to be used. Adjustments in personnel strength can be made to keep the project within budget and schedule, or to request additional funds.

Approval of the preliminary feasibility study signifies the completion of this phase.

	SOFTWARE CONVERSION PHASES					
	PROJECT INITIATION	CONVERSION REQUIREMENTS	CONVERSION PLANNING	CONVERSION PREPARATION	CONVERSION	POST-CONVERSION
SIGNIFICANT COST CONSIDERATIONS (OTHER THAN DIRECT LABOR FOR CONVERSION)	• Project Planning Aids • Employee Hiring Expenses	• Software Documentation Expenses	• Technical Advisory Services	• Site Preparation • Equipment Acquisition Expenses • Training Expenses • Freight and Installation Charges for Office Equipment • Employee Hiring Expenses	• Telecommunications • ADP Supplies • Hardware User Charges • User Training Expenses	• Equipment Salvage Values • Personnel Relocation Expenses • Freight and Transportation of Office Equipment
ACCURACY REQUIRED	• Gross Estimates Based on Conversion Models	• Estimates Refined Using more Accurate Parameters	• Accuracy Increased Using Work Breakdown	• Actual Costs Used to Improve Accuracy →	→	→
COST STRUCTURE DETAIL REQUIRED	• Summary Level of Detail	• Summary Level of Detail	• Lowest Level of Detail Required →	→	→	→
DECISIONS/ACTIVITIES SUPPORTED BY THE SOFTWARE CONVERSION COST INFORMATION	• Assess Project Priority • Determine Project Strategy Cost Effectiveness • Develop Rough Project Schedules • Provide Cost Information for Hardware Acquisition Decisions	• Assess In-House Resources • Determine Feasibility of Conversion Tools • Identify Resource Constraints • Refine Project Budget • Prepare Software Conversion Study	• Develop Reporting Mechanism for Costs • Refine Plans • Plan RFP's • Develop Training Plans • Identify Facilities • Formulate Conversion Plan	• Secure Approval for Conversion Budget • Assemble Personnel • Obtain Facilities • Obtain Contractual Support • Track and Report Project Status	• Monitor Contracts • Track and Report Project Status	• Analyze and Assess Project Performance

ECONOMIC CONSIDERATIONS BY PHASE

Figure C-5

C.7.2 CONVERSION REQUIREMENTS PHASE

During the conversion requirements phase, the conversion process is analyzed and methods and techniques are selected to accomplish the effort. The culmination of this phase is a software conversion study that includes an assessment of the current software environment, a program inventory, and evaluation of contractor's assistance and a recommendation as to the use of conversion tools. A specific costing activity during this phase is:

- Project Planning and Staffing - Conversion cost information can be used to assist in project personnel planning by determining the best mix of project personnel and determining the most cost-effective project strategy to follow. Cost trade offs between skill levels, person-hours required, and personnel expenses can be evaluated for each function during the project. While this impact on costs is important, it should be evaluated against management considerations such as expected turnover, skills back-up, critical staffing positions, employee development and the like. Furthermore, cost estimates can be used to assist in evaluating alternative project execution strategies such as length of phases, use of contractors, and use of software conversion tools. For each project management alternative considered, a cost estimate should be developed to assist in evaluating the impact of that approach. The final project management approach selected should be based upon the lowest total overall cost to the organization, given the constraints of the organization, and the potential for satisfying the mission needs.

Approval of software conversion study marks the end of this phase and provides information that feeds the conversion planning phase.

C.7.3 CONVERSION PLANNING PHASE

The conversion planning phase is used to develop the detailed task schedules and resource requirements needed to accomplish the conversion. At the completion of these activities a formal conversion plan is submitted to upper management for approval to continue with the project. This formal conversion plan should include cost-related considerations such as a summary of the conversion budget, a description of the proposed cost-tracking mechanism, and analysis of the cost-effectiveness of proposed conversion aids, and a justification for the use of contract personnel. Specific costing activities during this phase include:

- Prepare Action Plans - Cost information can be used in project planning and budgeting to establish a project task schedule (e.g., PERT-COST and PERT-TIME) that allows

for the development of the project in a cost-effective manner. Important considerations at this time should be the estimated deployment date relative to the expected operational benefit. The project duration reduction may increase costs as more overtime or contract employees are used. This increase in cost, however, may be justified if the project can become operational sooner, thereby decreasing operational costs. The cost structure provides the cost detail for project functions to allow for this evaluation.

- o Refine Budget - The budget application of cost information will aid in identifying the costs for the current phase, updating project costs for subsequent phases, and submitting the budget for the following year's effort.

- o Formalize Conversion Approach - This activity is the further refinement of the conversion plans developed in the previous phase. At this point, software conversion cost estimation models should be compared against a task-by-task conversion plan to determine the adequacy of resources (quantity and skills) to complete the conversion within a suitable time-frame. At this time, the program manager should examine the alternative approaches which are available to convert to the new system. These approaches may include complete redesign of the system, line-by-line translation, etc. The program manager will need to evaluate the most cost-effective conversion alternative based upon factors such as the age of the existing software (if appropriate), the remaining life of the system, and whether it currently satisfies user's requirements. Furthermore, the cost impact of the use of outside conversion services, personnel or tools should be evaluated using the cost information.

- o Develop RFP and Evaluation Criteria - If external support is to be acquired, the conversion costing methodology can be used to estimate costs, identify critical cost areas, and provide a cost evaluation criterion that considers the impact in all relevant cost areas (price and other cost factors). Vendors should be required to submit cost data in a format that can be included in the project's cost structure. The conversion costing structure should then be used to evaluate vendors based on total project costs that incorporate both direct vendor charges and other agency project costs associated with using that vendor. This will require that the cost evaluation criteria used in the RFP be well documented

to allow evaluation of proposals based on lowest project cost. Technical considerations, such as quality, can be more easily related to costs through the use of a total conversion costing methodology. There are certain service acquisition guidelines (FPMR, FPR, etc.) which address the cost elements or functions which are allowable in making acquisition decisions. Since these may be open to interpretation, it is recommended that oversight organizations be contacted to approve the cost elements included in acquisition evaluation criteria.

Approval of the conversion plan identifies the completion of the conversion planning phase.

C.7.4 CONVERSION PREPARATION PHASE

During this phase, the conversion manager accomplishes the activities required to assemble the personnel and acquire the facilities and conversion tools needed during the conversion effort. Costing activities during this phase include:

- Vendor Evaluation and Selection - Vendor selection should be based on technical and cost considerations that account for the impact of a particular vendor's price and other cost factors on the total cost of the project. A detailed cost structure would enable the conversion costing methodology to provide detailed resource cost information for each vendor to assist in the validation of cost proposal and to assure an adequate quantity of resources have been proposed. For example, if support staff is included in the proposal, a detailed cost structure would identify the level of skills, person hours, and salary proposed by each vendor. In this way, significant deviations between vendors may be addressed. Finally, the conversion costing methodology can be used, through sensitivity analysis, to identify the cost areas most critical in the vendor's proposal evaluation and selection. These areas could then provide a basis for incentive clauses in the acquisition contracts.

- Establish Deployment and Delivery Schedules - The timing of the deployment of the converted software and delivery of the proposed resources affect software conversion. There will exist various approaches and possible timetables for accomplishing deployment and installation. Each schedule may have cost impacts in terms of the potential net benefits derived from the project. The cost trade off objective involved in this scheduling effort should be the lowest total cost of the project.

- o Develop Plans and Budgets - Through the use of historical project costs contained in the conversion costing methodology, the project budget, task schedule and resource assignments can be developed for the conversion phase. Cost considerations such as the use of overtime or contract personnel, short-term rental of additional equipment, and space, and the impact of disrupted agency workload should be addressed.

When preparations are complete the conversion phase begins.

C.7.5 CONVERSION PHASE

During this phase, the actual conversion of software from the source to the target environment is accomplished. This phase will contribute to a significant amount of the total conversion cost but will have relatively few requirements for cost information other than the following activity:

- o Evaluate Conversion Effort Against Conversion Plans - The conversion costing methodology can provide a detailed cost structure with which to accumulate actual cost data that can be used to compare actual cost performance data with historical estimates. In this way differences can be easily identified for further analysis, and the full cost impact on the project can be evaluated. This will require that the acceptance cost data be recorded consistent with the cost structure.

Acceptance of the final converted system, fully documented and tested, marks the end of the conversion phase.

C.7.6 POST-CONVERSION PHASE

The post-conversion phase is designed to provide an assessment of the completed project and prepare the organization for future software conversions. As such it is a continuous process with no clearly defined end point. The use of software conversion costs during this phase consists of the following activities:

- o Post-Conversion Analysis and Assessment - The analysis of project performance should be performed as part of a post-implementation audit. The conversion costing methodology can assist in this validation by providing an historical cost basis and audit trail against which actual performance data can be measured. If actual system performance significantly deviates from planned system performance, the conversion costing methodology can help identify the cost areas and reasons for the differences. The function and product dimension of the

cost structure can assist in projecting user's charges and evaluating the cost-effectiveness of changing user's requirements, and their impact on these user charges.

- Satisfy A-12 Requirements - OMB Circular A-12 requires development of annual agency long-term plans to support budget submissions. Such plans project agency requirements for five years or longer. Conversion costing methodology is directly applicable to conversions considered in these plans.

- Agency Budget Submissions - Similar to A-12 requirements, conversion costing methodology supports agency budget actions.

- Satisfy A-76 Requirements - OMB Circular A-76 requires regular assessments of agency commercial-industrial type activities to weigh the benefits of continual government operation against contractor operation. ADP services fall under the provision of A-76. Conversion costing methodology can be usefully applied to any agency A-76 studies conducted during the post-conversion phase.

- Satisfy A-109 Requirements - OMB Circular A-109 requires cost analyses to be performed for major system acquisitions. Large scale agency hardware replacements are frequently considered to fall under the provisions of OMB Circular A-109. The conversion costing methodology will directly support A-109 conversion cost assessments.

- Satisfy A-121 Requirements - OMB Circular A-121 prescribes the initiation of business-like procedures that require agencies to account for the full cost of operating a DP facility, to allocate all costs to users according to services they receive, and to share excess DP capacity. These costs, when developed, rarely include the costs of conversion and lead to under resourcing conversion staffs. By maintaining the conversion costing methodology and accounting for cost incurred according to its structure throughout the life of the project, the cost information used in satisfying A-121 should be available. The conversion costing methodology provides the structure, through the use of organization and product dimensions, for allocation of conversion costs to users according to service provided.

APPENDIX D
CASE STUDIES

SUMMARY

This appendix contains eleven case studies of software conversion projects at Federal agencies. Some projects had been completed; others were in planning and execution stages when these studies were developed. They provide additional insight into software conversion problems and illustrate that management attention is necessary to improve conversion efficiencies. Readers of this guide may find situations analogous to their agency conversion environments and take action to preclude repeating mistakes made by others.

AGENCY 1 EXPERIENCE

BACKGROUND

The organization discussed is an element of a federal agency and is a user of the agency's computer system (approximately 10% of machine time). The organization had an in-house staff of programmers and analysts to develop and maintain its automated information systems. The ADP department of the agency acted as a service bureau to other departments and organizations in the agency.

Because of saturation, the agency decided to upgrade its IBM 360/65. A competitive procurement resulted in selection and installation of a UNIVAC 1100/43 system. Because of the results of the competitive procurement, the organization, as well as other users of the hardware executed a non-code compatible software conversion.

This conversion experience illustrates problems associated with such a conversion as well as problems facing users of a large, "service-bureau" type of operation.

THE CONVERSION

Application programs on the IBM 360/65 were written in COBOL, PL1, FORTRAN, Assembly Language and RPG. Approximately 75 percent were written in the latter language. Little, if any, software documentation existed for the IBM applications. There were many user enhancements which were pending but not incorporated in the old software because machine saturation precluded development and test time.

The decision to upgrade was made in the 1975-1976 time frame. Conversion planning started in mid-1977 and the target hardware was installed in mid 1978.

Soon after selection, UNIVAC made computer time available through Remote Job Entry (RJE) stations. This service was convenient, and facilitated the conversion. However, this service was not used to optimum advantage in accomplishing early training and software conversion. The failure to use this resource to full advantage ultimately contributed to conversion slippage.

The organization decided to convert and redesign applications concurrently into a Data Base Management Systems (DBMS), System 2000. It was anticipated that all applications could be converted before the IBM system was released. However, this did not occur. Although the IBM hardware had been removed in late 1980, as of January 1981 the conversion was still in progress and expected to take an additional year. The loss of this hardware resulted in a line for line conversion of some old

applications without redesign and without parallel testing. Nine major DBMS applications were active with approximately 400,000, 40-60 character records. Four similar applications remained to be built.

Information system users of the system were not sympathetic with conversion problems and continued to demand enhancements. No systems were frozen during conversion. Higher-level management was extremely interested and involved through hardware acquisition and installation. Thereafter, there was little interest or backing for any processes which would have eased conversion, i.e., freezing development.

Conversion was accomplished in-house. The conversion staff lost personnel without replacement due to a hiring freeze. Summer hire students were used as programmers but their short employment period did not compensate for personnel shortfalls. In retrospect, it was recognized that some contractual support should have been provided for personnel loss contingencies, even if not exercised.

Before conversion started, code conversion was expected to be the most difficult processes In fact, code conversion was straightforward. However, old programs were heavily dependent on IBM utilities and the conversion staff encountered extreme problems in applying UNIVAC utilities, which differed considerably from those offered by IBM.

The IBM systems programmers had detailed knowledge of the source system and were extremely helpful to the organization's application programmers. Target systems programmers were new and lacked agency insight and experience. System programming support to the applications programmers dropped dramatically during conversion. Associated problems in debugging and adapting to the target software delayed conversion by approximately six months and extended parallel testing.

Conversion costs were not tracked but were estimated to have consumed 3 person-years of effort.

MANAGEMENT LESSONS

In summary, lack of planning led to an underestimation of conversion resources and precluded early training and conversion on the RJE station. Conversion managers did not anticipate the need to handle unforeseen problems such as differences in software utilities and inexperienced systems programmers. These problems were compounded by not freezing development and incorporating new user enhancements in conjunction with the conversion.

AGENCY 2 EXPERIENCE

The following is a case history of a software conversion experience that took place from 1974 to 1980 at a federal agency.

BACKGROUND

The agency operates a large centralized service bureau computer system serving various agency departments and other government agencies. Saturation caused the agency to convert from an IBM 360/65 to two IBM 370/155's, and then to an AMDAHL in 1979. Approximately 55 percent of the code was FORTRAN, 45 percent PL¹, and 5 percent COBOL. In every case, migration of application programs was to code-compatible machines. However, there were conversion problems in converting to the AMDAHL that are useful as learning vehicles, particularly from the perspective of a service bureau operation.

THE CONVERSION

The agency allowed one year for planning purposes but considered that two years would have been better. The biggest problem in conversion planning was obtaining user's input. Neither users, nor anyone else, knew the status of all the available programs. Purging outdated code, old test code and duplicate programs was a difficult exercise. Although users were charged a pro-rata fee for service and machine time, resources were not applied to storage. Hence there was no incentive to cause users to remove unwanted code or data from the inventory.

One person was assigned to the conversion full-time and served as project manager. While the conversion was viewed as successful, it was considered that better coordination and interaction with users and managers could have been effected if more people had been dedicated to project management activities. Such assignment was precluded due to the agency charging scheme. User's charges were based on normal, day-to-day operating costs such as machine use, line costs, utilities, and programming services. There was no built-in overhead to cover project management personnel required for software conversion. Continuous negotiations had to be conducted with users to provide the extraordinary project management resources associated with the conversion. Essentially project management resources were understaffed.

Adequate documentation on application programs was unavailable. This condition was due in part to the nationwide spread of users who were responsible for developing their own application programs. Additionally, users continued to develop and enhance systems throughout the conversion. These factors, coupled with the outdated code in the inventory, caused difficulties in developing software conversion specifications.

High level management was primarily interested in hardware procurement and installation. The next level of management (functional information system users) were primarily interested in keeping applications under development.

Some planning is now in process for the next conversion. The use of software standards is being stressed along with documentation. Given the limited control the processing center has over user's applications, the achievement of acceptable use of software standards and documentation was questionable.

MANAGEMENT LESSONS

In summary, there were problems with high level management involvement, user's support, program specifications, detailed planning and project management resourcing. Had these problems existed in a non-code-compatible environment, serious problems would probably have resulted. The selection of a code-compatible machine resulted in the conversion being accomplished in an acceptable time. However, the conditions that could have caused problems for a non code-compatible conversion still existed.

AGENCY 3 EXPERIENCE

BACKGROUND

The agency is responsible for management of world-wide cargo traffic. A significant functional area involves port cargo operations. For some time port cargo operations were supported by a management information system (MIS).

Dual Burroughs 5500 computers were operating at two area headquarters locations, one on the East Coast, and the other on the West Coast. The B5500 computers were linked to IBM 360/20 terminals located at offices at various ports (e.g. Seattle, New Orleans) The MIS handled movement control, manifests, container transhipments, and other traffic management applications generally oriented to export cargo, as well as retrograde cargo.

Growth in cargo movement administration had saturated the B5500 computers. Given the age of these computers and the IBM 360/20 remote job entry (RJE) terminals, continued reliance on this equipment posed a risk to system reliability. Software enhancements were difficult to introduce, particularly on-line applications. While the MIS was originally a standard batch-oriented system, the B5500 computers would support remote terminals. Differences in the degree of saturation at each area headquarters had resulted in some capability for on-line applications on the West Coast. However, all applications were batch on the East Coast, due to the inability of the B5500 to process the higher cargo volumes in an on-line mode. Because of these conditions, in the mid 1970's, the organization decided to upgrade the system with the following objectives:

- o Modern equipment,
- o On-Line applications,
- o Sufficient processing capacity to handle extraordinary cargo movements loads,
- o Improved redundancy and reliability,
- o Standard applications on both coasts,
- o Stand alone capability at various ports.

THE CONVERSION

Planning started in the summer of 1978. Honeywell Level 6 computers were selected as the target hardware. The initial planning resulted in a systems concept which was approved in October 1978. The

concept called for replacement of the B5500 computers as soon as possible with dual Honeywell Level 6 computers at the two area headquarters, and replacement of the IBM 360/20 terminals with single Honeywell Level 6 computers The concept also provided for transfer of some of the non-time sensitive, historical, high-volume applications to the agency headquarters for processing on a HIS 6060 mainframe which was already in place. The combination of modern hardware and revised application processing covered all system-upgrade objectives.

After the concept had been approved, detailed planning commenced in early 1979 and continued for six to nine months Thorough planning, early in the project, was recognized as necessary to successfully execute the project. This planning was accomplished by a management team which was organized for the purpose. Planning was a continuing function, ongoing midway through the conversion, and was expected to continue until the conversion was completed. There were always unforeseen events which had to be compensated for and which required revised plans.

Automated (PERT) planning tools, available through Honeywell, were tried without success. Planners felt that the extra effort to enter all of the project data did not result in automated planning aids which were any better than those manually-produced.

PROJECT MANAGEMENT

The management team was essentially a project management effort. Originally it was envisioned that the team could be dissolved after it had planned the schedule and identified all activities and actions which had to be accomplished (e.g., equipment selection and acquisition, software conversion, communications specifications, and training). The team was temporarily dissolved, but it soon became apparent that the project was losing coordination and direction. Formal project management was reconstituted on a permanent basis before any adverse developments occurred.

SOFTWARE

There were over 900 source programs to convert. Most were written in COBOL-64 and 68 except for a few FORTRAN applications. No new user enhancements were introduced during the conversion. The conversion was essentially a line for line conversion modified by introduction of some Honeywell input-output and transaction handler routines used as a matter of expediency. An automated Honeywell tool was used to convert B5500 applications to be transferred to the HIS 6060 mainframe. This tool was modified in-house to convert the target software to be placed on HIS Level 6 computers. New enhancements and redesigns, primarily on-line applications, were scheduled for development after the conversion.

The old B5500 system documentation was often incomplete, causing problems in planning and in developing conversion specifications. The new system will be completely documented using government standards. Documentation was ongoing concurrent with software conversion.

MANAGEMENT AND USER'S INVOLVEMENT

Top agency executives backed the project from its inception. Management understood the operational advantages of a speedy conversion and the problems associated with the conversion. This management support was also conducive to good functional user's cooperation. The project management interacted regularly at all user and management levels to keep these parties appraised of progress and involved in meeting requirements.

FUNDING AND RESOURCES

Because the project was well planned in the beginning, adequate resources were identified, programmed and budgeted to support the equipment, communication, site preparation, and training. The software conversion was accomplished with in-house resources.

STATUS

Preparation for conversion started in the fall of 1979. Actions during this phase included assembling and modifying the software conversion tools, site preparation and installation of target computers. Conversion actually started in early 1980. All conversion was to be completed by late 1981. Individual subsystems would undergo parallel testing until all users and managers were satisfied. Parallel testing operations would be supported by existing resources. As of January 1981, the project was on schedule. This condition was primarily due to good planning, active project management and user and management involvement and support. The source computers were scheduled for release in the fall of 1981 at Western Area and the spring of 1982 at Eastern Area.

MANAGEMENT LESSONS

This case history illustrates that the advantages of achieving high level management and functional user's support, development freezing, good planning, and adequate project management can result in an efficient software conversion accomplished on time and within budget.

AGENCY 4 EXPERIENCE

BACKGROUND

The federal agency interviewed was responsible for bi-monthly mailings of computer output, and had definite schedule restrictions. The agency was running its systems on old UNIVAC/Spectra hardware. During the 1975 time-frame, management decided that the system was saturated and further enhancements of the current system would no longer be effective. A Honeywell computer was selected as the target hardware.

The Spectra was running over 20 systems consisting of 270,000 lines of assembler code, and 30,000 lines of COBOL. Conversion was to be to COBOL/68. The agency had adequately documented its system according to FIPS PUB-38.

THE CONVERSION

A conversion project team with 19 programmers/analysts was organized. Tasks included conversion, maintenance, and operations with 50 percent effort on conversion and 50 percent on maintenance.

One special consideration and concern in this project was the conversion of compressed assembler code with over 600 file formats and 100 different record types. Because record control bits were used to identify field length and absence of data, the conversion from EBCDIC to Honeywell BCD was of critical concern.

Contractor services for conversion assistance was for a cost plus fixed fee (CPFF) contract at a cost of $1.7 million. Assembler Language to COBOL/68 automated tools were developed by the contractor. These tools were fairly successful but manual coding for special extensions was still required. Another tool was used to compress data files.

Of the twenty systems to be converted the ten smallest were converted first. During their conversion, significant problems became apparent. Some converted programs were far less efficient on the target hardware than the source hardware. Midway through the conversion effort, target hardware was changed to an IBM 3231, and the remaining 10 systems were converted to this hardware The IBM software was compatible with that of the source software and conversion was much simpler.

Prior to the conversion, the agency had provided back-up services with a time-sharing firm in case conversion hardware facilities went down. The agency was also prepared to keep and maintain the old Spectra hardware until all systems were converted.

MANAGEMENT LESSONS

While adequate planning was spent in converting master files and development of test data, little effort was expended in developing and analyzing benchmark criteria. This was exemplified by one system's 14 hour run time on Honeywell target hardware compared to 55 minutes on the IBM target hardware.

Software conversion managers did not participate in hardware procurement decisions In both instances (conversion to Honeywell and to the IBM), the software manager was notified after the hardware was procured. This left inadequate time for planning. The software project manager was also unable to prevent users from ordering enhancements. The conversion team was able to deal with this, but the project would have been easier, had software been frozen. Upper management did intercede, at times, when user's requests were unduly affecting the conversion effort.

Financial planning was also inadequate. Though the contractor came within budget, there would have been a cost-overrun had the target hardware not been changed to a code-compatible configuration.

AGENCY 5 EXPERIENCE

BACKGROUND

The organization interviewed was responsible for maintaining up-to-date information on world-wide activities, and distributing this information to field offices around the world. This organization was one element of many within the agency.

The information files, which constituted the bulk of the automated effort, were extensions of applications that had been maintained for many years on punch card accounting machines. These files were migrated to an IBM 360/40, which was acquired in 1969, and placed on a DBMS.

In 1973, the vendor supporting the DBMS cancelled support. This resulted in a decision to convert to another DBMS. Conversion was to be completed within 6 months.

Situation at Project Initiation

- Batch applications, approximately 75 percent of a sequential workload, were running on an IBM 360/40 3 shifts a day, 7 days a week.
- No programmers, users or analysts were trained in the new DBMS.
- There was a programmer and analyst staff of 18.
- The staff, which had recent conversion experience before was still in place.
- High-level management agreed to halt all enhancements to existing applications This caused user's support of the project, at least to the extent that they couldn't pressure the ADP staff to continue enhacements and new developments.

THE CONVERSION

A straight redesign conversion was planned without incorporation of new user's enhancements.

A project management team was established. The supervisor of the analysis and programming section was the team-head, assisted full-time by the lead systems analyst. The most competent developmental and maintenance programmers (approximately four) were added to the team full-time. One input-output control technician was also added full-time.

The complete lack of any staff trained in the new DBMS was a serious problem. This problem was compounded by the lack of experience in newly-trained programmers, and the short project deadline. Coordination with a mobile training team revealed locations where new DBMS training was scheduled. Coordination with organizations scheduled to receive new DBMS training produced a few slots to train project team members as early as possible. The training team also cooperated by adjusting their schedule to provide on-site analyst, programmer and user training to most of the remaining conversion team approximately one month after project's initiation. This was sufficient to accomplish the conversion.

No contractor's assistance was used. The most complex system was chosen for the initial conversion. It was assumed that if the project management team could convert that application, the remaining applications would be problem free. This approach produced successful results.

Freezing new user's enhancements and system development provided enough computer time for training and conversion except for two two-week periods late in the conversion process. Arrangements were made with back-up computer facilities to provide processing time during those two week periods. Small teams of computer operators, maintenance programmers and a system programmer were dispatched to run production reports and applications.

At the conclusion of the six-month period, the conversion was complete. However, all converted applications had not processed in parallel for a two-month period to allow debugging and assure quality control. Parallel testing operations continued for two additional months. Moreover, while documentation was an ongoing effort during conversion, full sets of systems documentation were not completed until approximately four months after the conversion effort.

Unbudgeted conversion costs were mostly absorbed by cancelling or limiting projected travel and carefully monitoring operating costs for the remainder of the fiscal year. A mid-year request for shortfall-funding provided the additional funds necessary to cover all costs.

MANAGEMENT LESSONS

This conversion, which was essentially accomplished on time, received high-level management support, and benefited from the freezing of new enhancements and development. Full-time project management and an experienced staff had the insight and authority to overcome problems associated with a short conversion deadline and inadequate training.

AGENCY 6 EXPERIENCE

BACKGROUND

In 1973, the agency developed 15 administrative data base management system applications supporting agency training. These applications were run at night as batch on a Honeywell (HIS) 635 computer, the daytime hours being primarily reserved for on-line student use of the hardware system. There was no requirement for student access to the administrative applications. However, the staff and faculty did require access at times during the day.

Besides the training-related administrative systems, there were approximately 300 various agency installation-unique COBOL programs which were processed, as required, at night on the HIS 635.

By 1974, the on-line demands of all users exceeded the capacity of the HIS 635 system. Efforts to upgrade, sole source, were denied and competitive hardware procurement and software conversion contracts were pursued. To resolve saturation problems the agency was permitted to upgrade the hardware to an HIS 6080 System as an interim measure pending completion of the competitive procurement.

THE CONVERSION

UNIVAC won both the hardware and training-related administrative application conversion contracts. A UNIVAC 1100/11 was selected to process the COBOL and administrative applications. A UNIVAC 1100/12 was selected to provide time sharing service to the student body. Separate from UNIVAC, another contractor was awarded the contract to convert the agency unique COBOL programs.

It was decided to redesign the administrative DBMS applications to another DBMS offered by UNIVAC and to convert the COBOL programs line by line.

There were problems with development of the UNIVAC DBMS software conversion specifications. Users were not interested in collaborating in the specification definition effort. They were relatively satisfied with the existing DBMS applications. Since the input and output would remain essentially unchanged, the users were not inclined to emphasize to the conversion planners the subtle but important insights or considerations relating to timing of reports or relationships of certain reports to others. While these relationships were probably understood by the in-house team that developed the specifications, they were not adequately stressed, and ultimately not comprehended by the contractor. Futhermore, the original software documentation was outdated or nonexistent. This condition contributed to conversion specification inadequacies.

Conversion from one major DBMS to another resulted in an extremely complex software design effort The complexities of the project, when coupled with specification shortfalls, resulted in disputes with the contractor, project slippage and generated considerable unanticipated involvement in the conversion process by the in-house staff of programmers and analysts.

The agency insisted that the UNIVAC contractor develop complete software documentation based on FIPS Publication 38. The contractor sought release from this requirement. Disagreement over contractual conditions relating to documentation requirements and specification shortfalls resulted in slippage of the conversion effort approximately 9 months past release of the HIS 6080. This condition precluded parallel testing of some applications.

Disagreement over contractual levels of effort with the second conversion contractor over a lack of COBOL programs documentation led to disputes which resulted in contractor conversion of approximately 90 percent, rather than all of the software. Twenty-four, or 10 percent of the applications, were converted in-house. The contractor did not provide any documentation. The agency intended to write the documentation in-house but recognized that in reality some or all of the program documentation would never be developed.

It was estimated that all software conversions could have been accomplished in-house for the same effort spent in resolving all contractual software conversion issues.

Analyst and programmer training on the new system was considered sufficient but was conducted too early. Maintenance programmers lost their technical edge due to too much elapsed time between training and delivery of the contractually-developed DBMS software for their maintenance.

Formal processes were established and adhered to regarding review of contractor performance and recording user acceptance of converted applications. These processes assisted in conversion by improving understanding, reducing slippage and monitoring costs.

Full-time project management had not been exercised in the pre-conversion phases and resulted in planning shortfalls (e.g., inadequate software specifications and training). To remedy this the software conversion process operated under the project manager concept. This was considered invaluable in resolving unanticipated issues. It was also considered essential that a contractor have a full-time project manager throughout the project. This had been the case until the contract was extended to compensate for slippage. At that time, the contractor project manager's position was abolished in an attempt to reduce costs. Thereafter, internal contractor coordination and management problems developed and adversely impacted productivity.

MANAGEMENT LESSONS

This case history illustrates the need to have software well documented. Documentation facilitates conversion planning, development of software specifications and contractual statements of work. The need to maintain full-time project management throughout a conversion was also shown. Management recognized the need for software documentation but experienced problems with the contractors who resisted delivery of documentation.

AGENCY 7 EXPERIENCE

BACKGROUND

The agency is responsible for the regulation of a major industry. To administer the programs necessary for compliance with its regulatory responsibility, the agency utilizes the services of its data processing division to track various equipment, licenses, and applications, monitor violations, and other administrative functions such as payroll and personnel.

Aging hardware and systems growth resulted in a conversion from a UNIVAC 3 to a Honeywell 6023 computer system. Conversion consisted of some 30 systems encompassing 260 programs written in SALT (assembler) and translated into COBOL.

Planning for the conversion began in late 1973. By that time replacement parts for the UNIVAC 3 had become difficult to obtain and often required cannabilizing other UNIVAC 3 systems. The workload had reached a point that the agency rented time on a UNIVAC 1108 to handle its UNIVAC 3 overflow. The agency developed specifications for its conversion after holding discussions with conversion specialists. Separate hardware and software conversion RFPs were prepared and released in 1975. Honeywell won the hardware selection while another contractor was awarded the software conversion project.

THE CONVERSION

Under the terms of the software RFP the agency was to provide system documentation, programs, test data and machine time to contractors. The specifications, however, allowed the contractor to request virtually unlimited levels of detailed documentation, and that test data be in contractor specified format. These conditions placed unanticipated workloads on the conversion project team. Program acceptance was based upon successful execution of 90 percent of code. However, no performance specifications were required. As a result, processing that had previously required two shifts on the UNIVAC required three shifts on the Honeywell. This condition indicated that the software was inefficient in design.

Some 2,000 data files ranging from 2,000 records to 7-8 million records per file were required to be converted. To convert these files, the agency had to temporarily acquire a minicomputer at an additional cost of $25,000. A "bit to byte" format change had to be accomplished because of software differences between source and target systems and caused considerable problems for the agency.

The conversion staff consisted of seven full-time and two part-time personnel who handled the data conversion effort along with

two full-time (on-site) contractor personnel for 12 months. The number of contractor personnel working off-site was unknown. What was initially estimated as a 9-12 month conversion effort actually required two years (in addition to one year spent in planning and procurement) for a total of 21 man-years of effort. Both the schedule and budget ($1 million) were overrun.

Because of continuing growth, the agency again upgraded to a Honeywell 6640 in 1978, and in late 1979 upgraded to a Honeywell 6660. These migrations, being code-compatible, were accomplished with negligible problems.

While existing systems and operations documentation was adequate, the contractor was required only to document the operational procedures (run manuals) for the H6023. System/program documentation was left up to the agency.

There were no ongoing plans for future conversions although the agency had upgraded hardware twice since the conversion to the Honeywell 6023.

MANAGEMENT LESSONS

The conversion and budget overrun were indicative of poor initial planning. Also, the software conversion contract was constructed to the contractor's advantage which adversely impacted the conversion staff efforts. This resulted in loss of project management control over the contractor, produced programs with exceptional run times (indicative of poor software design), and caused delivery of inadequate software documentation.

AGENCY 8 EXPERIENCE

The following is a case history of a software conversion experience at a federal agency that started in late 1976 and was still ongoing in February, 1981.

BACKGROUND

The agency was heavily involved in simulation and modelling. There were approximately twenty major models running on a UNIVAC 1108 using EXEC 8, Level 33. The models were large-scale, mostly written in FORTRAN, with some COBOL used. The twenty major models consisted of approximately 200,000 lines of code in FORTRAN and 50,000 lines in COBOL. Other models and systems doubled the lines of code to approximately one-half million.

In late 1976, ADP personnel determined that the system was saturated; models were taking too long to run. A hardware RFP was released in February 1979. UNIVAC won and a UNIVAC 1182 was installed. The source and target system machines were expected to run in parallel for approximately six months. The RFP required a pre-installation test facility nine (9) months before the new mainframe was installed.

THE CONVERSION

Prior to releasing the RFP, all models were scanned and code was analyzed for vendor specific extensions. Problems were noted in two areas:

- Word size,
- Representation of character type data.

It was decided that software conversion would be done by in-house personnel. Contractors would require too long to familiarize themselves with the models Agency functional users were also the programmers, were the most familiar with their own models, and considered best able to perform the conversion. Additionally, documentation was inadequate and outdated, adding to the difficulties of indoctrinating contractors on mechanisms of the models. Automated tools were also examined but determined to be ineffective.

A detailed software conversion requirements study was not performed. In-house personnel were expected to handle the conversion in addition to their regular duties; no specific planning or thought was accomplished to address the difficulties associated with this option. Software conversion was thought simple and no major problems were expected. A project team was not organized, and no cost estimation was performed.

The conversion itself proved to be straight forward because a code-compatible machine was selected. UNIVAC was the only respondent. Operating systems were very similar and few problems were encountered during the conversion. However, management personnel did not plan adequately for site preparation. Because of delays in getting GSA approval for site preparation, the 1182 had to be installed in a UNIVAC facility. GSA, as of February 1981, had yet to approve the site preparation.

MANAGEMENT LESSONS

The agency was extremely fortunate in obtaining a code-compatible machine In spite of a previous conversion experience that had proven very difficult, conversion requirements were relegated to a minor role. No planning or cost estimation was performed.

Also, the lack of adequate model documentation would have impacted on conversion if a non code-compatible machine had been selected. The models, maintained by users who understood the code and model scheme, contain modifications that were rarely documented. Despite the potential conversion problems posed by this lack of documentation, program documentation was not being pursued.

AGENCY 9 EXPERIENCE

BACKGROUND

This agency was in the planning and procurement stage of a software conversion to meet increased mission needs and requirements. Their applications were being processed on a variety of hardware configurations within the agency, consisting of a Honeywell 635, two IBM 3032s, a Honeywell 6000 and a Honeywell 6060. In addition, a DEC2020 and five PDP 11/70s were included in their hardware inventory.

PLANNING

Although the planning and procurement process had been on-going for two and a half years, the RFP has not yet been awarded; thus target hardware was still unknown as of February 1981.

It was estimated that the conversion effort itself would take two years and that the total conversion process including planning and procurement, would last four and a half to five years.

Various off-the-shelf automated tools were currently being evaluated to handle the common compiler driver language types. For example, plans called for automatically converting COBOL/68 to the more efficient COBOL/74. In addition to COBOL their basic software packages in use included FORTRAN, PL/1, SIMSCRIPT, GYPSIE (graphics), SPSS, as well as a variety of ad hoc query/update routines.

STAFFING

Although the bulk of the conversion was to be accomplished by in-house personnel, provisions called for a one-year task order type contract to be awarded for assistance as needed, during the conversion. It was projected that one third of the conversion would be accomplished by the use of automated tools, one third through recoding, and the remaining one third would require some degree of redesign.

There were 675 people assigned to the agency data center, 600 of whom were programmers. Approximately 100 project officers, and their staffs would be responsible for actually accomplishing the conversion. Each project officer would be assigned responsibility for one or more systems. Reporting to each project officer would be a variety of programmers and analysts. It was projected that 200 people would be involved at any one time in conversion duties. Two million dollars was budgeted for an estimated 400 man-year effort.

MANAGEMENT LESSONS OR OBSERVATIONS

For a conversion of this magnitude, it was planned significantly far enough in advance to allow adequate time for staffing, identifying, and evaluating activities. However, two major shortfalls were observed:

(1) The budget of $2 million appeared extremely low. A more realistic budget was estimated at $6 - 9 million.

(2) User and system documentation was not satisfactory. Although standards were being examined, this critical area had not been stressed. Lack of acceptable documentation would most probably complicate future conversion efforts.

AGENCY 10 EXPERIENCE

BACKGROUND

The agency interviewed was responsible for maintaining an inventory of equipment and supplies at locations throughout the world. The agency maintained statistics on equipment failure, and adjusted the maintenance schedule as indicated by these statistics. Programs were written in COBOL and Assembler, and the data base management system was TOTAL 7. The primary environment was in on-line/real time mode.

Management decided to upgrade the system in late 1977, and plans were made to release an RFP to procure new equipment. The source machines were IBM 360/40's. IBM 4331 machines were selected as replacements.

THE CONVERSION

Approximately two years of planning was performed prior to release of the Requests for Proposals. During this planning phase, though target hardware was unknown, the following activities were performed:

- A project management team was assembled,
- Programs were inventoried,
- Schedules and milestones were determined,
- Management hierarchy was developed,
- It was determined that conversion would be performed in-house by users (programmers and functional users were the same),
- Formal test procedures were developed.

The conversion went fairly smoothly. Software was not completely frozen, however, and some incorporation of new user enhancements was accomplished. Some problems were encountered with vendor extensions operating on the 360/40's. Weekly meetings, held with the project management team and programmers, kept all participants aware of problems that other personnel encountered.

At the conclusion of the conversion, the agency initiated a system to examine both the positive and negative aspects of the conversion in the interests of facilitating future conversion efforts.

MANAGEMENT LESSONS

The major shortfall noted in this conversion effort was a lack of cost analysis and accounting. Though progress was tracked, costs were not. Thus, the agency had no detailed knowledge of the actual conversion costs to use in planning and estimating future conversions.

Planning activities appeared to be adequate and these plans were implemented during the conversion. The following activities were cited as being beneficial to the effort:

- Developing bar charts depicting milestones; these were easy to follow.
- Developing and implementing a conversion-reporting and management hierarchy; personnel knew who to report to.
- Holding regular meetings; information was disseminated to the staff.
- Availability of adequate documentation.

AGENCY 11 EXPERIENCE

BACKGROUND

In June 1981, a federal agency was in the planning and preparation stage of a software conversion. Due to problems with the aging CDC 3300 computer, the agency was preparing to convert applications to a AMDAHL 470V/7A computer.

PLANNING AND PREPARATION

The agency planned to convert 600 programs estimated at 700,000 lines of code encompassing approximately 24 major applications. All applications were business-oriented in nature. Processing was batch but was expected to shift toward some on-line DBMS with the recent acquisition of IDMS on the AMDAHL.

Due to hiring freezes and budget constraints, the ADP staff was short of six full-time programmer/analysts. Because of this manpower shortage the agency was conducting preliminary negotiations for contractor's conversion assistance. The contractor would have responsibility for selection and/or development of any automated tools to be used.

The user's community, consisting of 14 major functional users had been notified of the upcoming conversion. Functional users were cooperative and constructive but plans did not anticipate a heavy user involvement in the conversion. Current plans called for off-site unit testing at another computer facility, with system and parallel testing being conducted on the AMDAHL.

The conversion manager was not assigned full-time and had to direct not only the conversion project but also conduct normally assigned duties as well.

The team had no prior conversion experience, and as a result, no comprehensive conversion plan was developed. Although the planning process was still being formulated, the entire scope of the planning effort had not been determined. It was estimated the conversion effort, excluding planning, would take 18 months, and that the total conversion process, including planning and preparation, would take 2 and a half years.

MANAGEMENT OBSERVATIONS

Considering the scope of this conversion, this agency did reasonably well in their planning, preparation and identification of many potential conversion problem areas. They assigned conversion priorities. They recognized the importance of freezing software development and maintenance but were also aware that the demands and mandates of users would likely preclude any total freeze. They, therefore, instituted change

control procedures to facilitate conversion with new user enhancements where freezing could not be accommodated. Moreover, their lack of conversion experience forced them to recognize the need for contractor's assistance. However, lack of conversion experience coupled with a non full-time conversion manager resulted in some problem areas being overlooked. Among these were:

- Selection of conversion technique(s) still remained to be resolved (i.e., determining the programs that lend themselves to translation by automated tools, recoding, or that will require a complete redesign; particularly in view of the recent acquisition of IDMS).

- Data communications and its attendant requirements with agency RJE stations were completely overlooked.

- Adequate training, critical to a smooth and successful conversion, especially when converting to non code-compatible hardware, had not been planned.

- No overall top management-conversion plan had been developed. Rather, planning had been fragmented.

- No contingency planning had been developed (e.g., determining how the agency would cope with losses or transfers in team and staff personnel).

APPENDIX E
GLOSSARY

Activity	Distinct software conversion work that is accomplished within a phase; examples of activities would be organizing a software conversion team, budgeting for software conversion.
Application Programs	Programs developed for functional users; to be differentiated from system (operating) programs.
Application System	One or more applications programs which together form an information system for an agency. Examples are payroll, personnel, supply inventory, equipment maintenance.
Automated Tool	Software to aid in software conversion by converting some or all of the old source software to the target software. An automated tool could also be used in an intermediate step, e.g., converting assembly language to COBOL on a source machine for subsequent conversion to COBOL on a target machine.
Data File	Agency information stored in a format used by automated information systems.
Emulate	Use of firmware to allow original code to run on target hardware No functional change.
Functional User	User of an automated information systems that supports an agency operational function (e.g., personnel, finance).
Operation Control Stream Language	A generic term for Control Language, e.g. IBM's Job Control Language (JCL)
Parallel Testing	Parallel testing consists of operating the converted target software in a parallel, operational mode with source software to ensure that the old and new systems conform functionally and that the new source systems run in an acceptable operational mode with other systems.

Phase	A distinct period of time in a software conversion project where certain activities are performed. The completion of all activities in the phase leads to the next phase, e.g. conversion planning should precede conversion preparation which should precede actual conversion.
Program	Smallest amount of stand alone, executable code.
Project Manager	The full-time manager of a software conversion project.
Project Team	Personnel appointed or assigned to participate in a software conversion project The project team size and skills can change by phase, depending on the project requirements Team members can be assigned from agency resources or from outside resources (i.e. consultants, contractors).
Recode	A translation of source code to an equivalent line of code on the target hardware such that the functional specifications remain the same. May be accomplished manually or with automated tool(s).
Redesign	A change in system specifications, including different algorithms to accomplish the same function as source code. No change to functional specifications.
Reprogram	A functional translation where some or all new code is produced utilizing new logic where necessary. No change to functional specifications.
Resource Utilization	A measure of work units needed to process the current workload or the source system.
Simulate	Use of specialized code to allow original source code to run on target hardware. No change to functional specifications.

Software Conversion	The transformation, without functional change, of computer programs or data elements to permit their use on a replacement or changed ADP equipment, environment, teleprocessing service or system.
Software Conversion Manager	The agency staff member who, next to the conversion project manager, has the greatest technical interest in the status of the software conversion project. This guide assumes that the software conversion manager will have normal responsibilities for day-to-day software operations and lack sufficient additional time to manage the software conversion project. A full-time project manager will thus be assigned and work with the software conversion manager during conversion.
System Software	A set of programs that encompass or support the operating system.
Task	Sub-elements of work related to conversion activities. For example, tasks related to converting an application system could include converting the source code, data files or job stream language.
Test Data	Data that is used to test software. Unit test data usually is constructed to test technical aspects of software and does not necessarily correspond to actual data. Systems test data normally represents operational data. Parallel test data usually is operational data.
Top Management (Top agency executives)	Organizational levels of management above the ADP level with broad authority and oversight over many or all agency operations; top management has authority for approving budgets and allocating resources.
Translate	A change in language or version only (e.g., COBOL/68 to COBOL/74) No change in functional or detail specifications. (FCSC definition).

Translocate	No change in function or detail specifications and no change in language. (FCSC definition). Occurs on a code-compatible conversion.
Unit Testing	The compilation, execution and testing of each target program with its test data. Unit test data technically tests the software and does not necessarily correspond to operational data.

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11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

This guideline was developed to provide federal ADP managers a better understanding of the entire process of software conversion. Software conversions have life cycles with distinct phases and activities that occur in each phase. Understanding the order or sequence of a conversion and of the associated costs should help managers to plan and execute software conversions efficiently, effectively, and with minimum operations disruption to federal agencies. Although extensive references were consulted in preparing this guideline, the most important sources were interviews conducted at 14 federal agencies that had completed or were involved in software conversion projects. These interviews influenced the structure and organization of this guideline in an attempt to present, in logical order, activities that must be performed to achieve a successful conversion.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

conversion costs; conversion execution; conversion planning; conversion preparation; conversion requirements; documentation; project management

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