NETWORK HOME OFFICE

by

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MASTER OF SCIENCE

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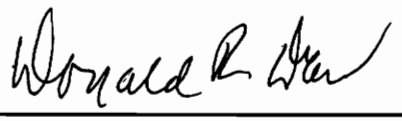
APPROVED:

R. J. Beaton, Chairman



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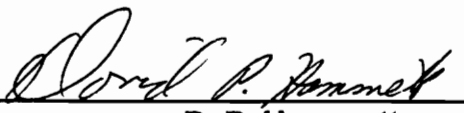

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(ABSTRACT)

The network home office project design is based upon a systems engineering model in the context of the life cycle. This design allows Lockheed Martin Corporation employees the opportunity to work at home and communicate with the program network at the site office via computer. The network home office provides greater job flexibility for employees while reducing overhead costs for Lockheed Martin.

A definition of needs justifies the establishment of this design. Advanced system planning provides detailed requirements for operation, maintenance, and support of the system. A system functional analysis allocates requirements from the system to subsystem components. Life-cycle cost analysis is performed on the system to determine system cost-effectiveness. Detail design requirements define the system, subsystem, and office specifications. Human factors engineering is applied to the system, to ensure high productivity. The system is tested and evaluated for optimal performance. Recommendations for future enhancements are presented.

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1) INTRODUCTION

The network home office design is based upon the systems engineering process model in the context of the life cycle. The design of this system includes the incorporation of all required computer hardware devices, software programs, office equipment, and office space. The design is based around the life cycle of the system that includes cost, maintenance, management, usability factors, and retirement. Human factors engineering will be employed in the design of the home and site office configurations. The project, as a whole, serves as a complete model for the design and implementation of a network home office.

Project Background

The design of the network home office requires a various number of background subjects. A computer and network architecture background is required for the design of the computer hardware at the main office that serves all of the remote office locations. Software engineering skills are necessary to specify the correct software for the communications and information exchange between employees. Aspects of computer vision theory help determine the optimal way to exchange visual information between the main and remote office sites. Human factors engineering plays a large role in both the site and home office designs to accommodate the employee and management needs. Systems engineering is the framework in which all of the different design

aspects are contained. Systems engineering defines design cost, maintenance, and management over the life cycle of the system.

Project Objective

The objective of this project is to design a network home office for a new Lockheed Martin program containing a group of employees. The motivation behind such a design is to increase job satisfaction and convenience for the employees, while reducing costs and increasing productivity for the employer. The design of this system is accomplished using the system engineering process.

The project explains the structure of the systems engineering methodology used in the design of the network home office. The project design phases are explained in specific detail, starting with the conceptual design phase, then the preliminary design phase, and closing with the detail design phase.

2) SYSTEMS ENGINEERING METHODOLOGY

The design of the network home office is based upon a systems engineering process. A life-cycle approach to the design is pursued, where the project development evolves through different phases before it becomes a properly functioning system. These phases include the design and development phase, the production phase, the operational phase, and the support phase. Figure 1 illustrates the project system life-cycle, starting from an original need and ending when the product becomes obsolete.

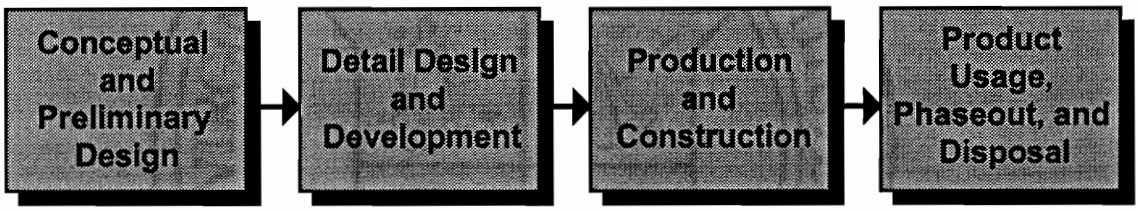

Figure 1. Project system life-cycle.

The key to systems engineering design is the simultaneous design of the three main aspects of the project, the design process, the manufacturing process, and the establishment of a support system. The definition of need defines the scope of the project from which the conceptual design arises. The conceptual design will begin to define necessary requirements for manufacturing and logistics support development. By including all aspects of project design, the final product will have increased performance and effectiveness while being easier to maintain and more cost effective.

Conceptual System Design

The conceptual design of a system is the first phase of system design in the systems engineering process. Figure 2 serves as the process flow for the conceptual system design. A definition of need is established in this phase to define potential system requirements. From these needs, a feasibility study is performed that includes research on system operational requirements, the definition of a system maintenance concept, and an analysis of the needs to determine that will be addressed for further design. Advanced product planning follows the feasibility study and lists the plans and specifications for technical and management requirements. Technical requirements are listed as specifications, while management requirements become a part of the program management plan.

The definition of need arises from a desire for a new product that either does not exist or improves a currently existing one. It is important that there is an identified need for the proposed design so that there is no wasted effort or duplication of design. Other aspects of need include the date of installation and operability, the available resources required needed for investment, and the priority of how important the project implementation is.

A feasibility analysis defines the need for the system and evaluates different approaches that can be applied in the system development. These studies will define potential design technologies and system applications. The feasibility analysis also considers the costs of various technology options so

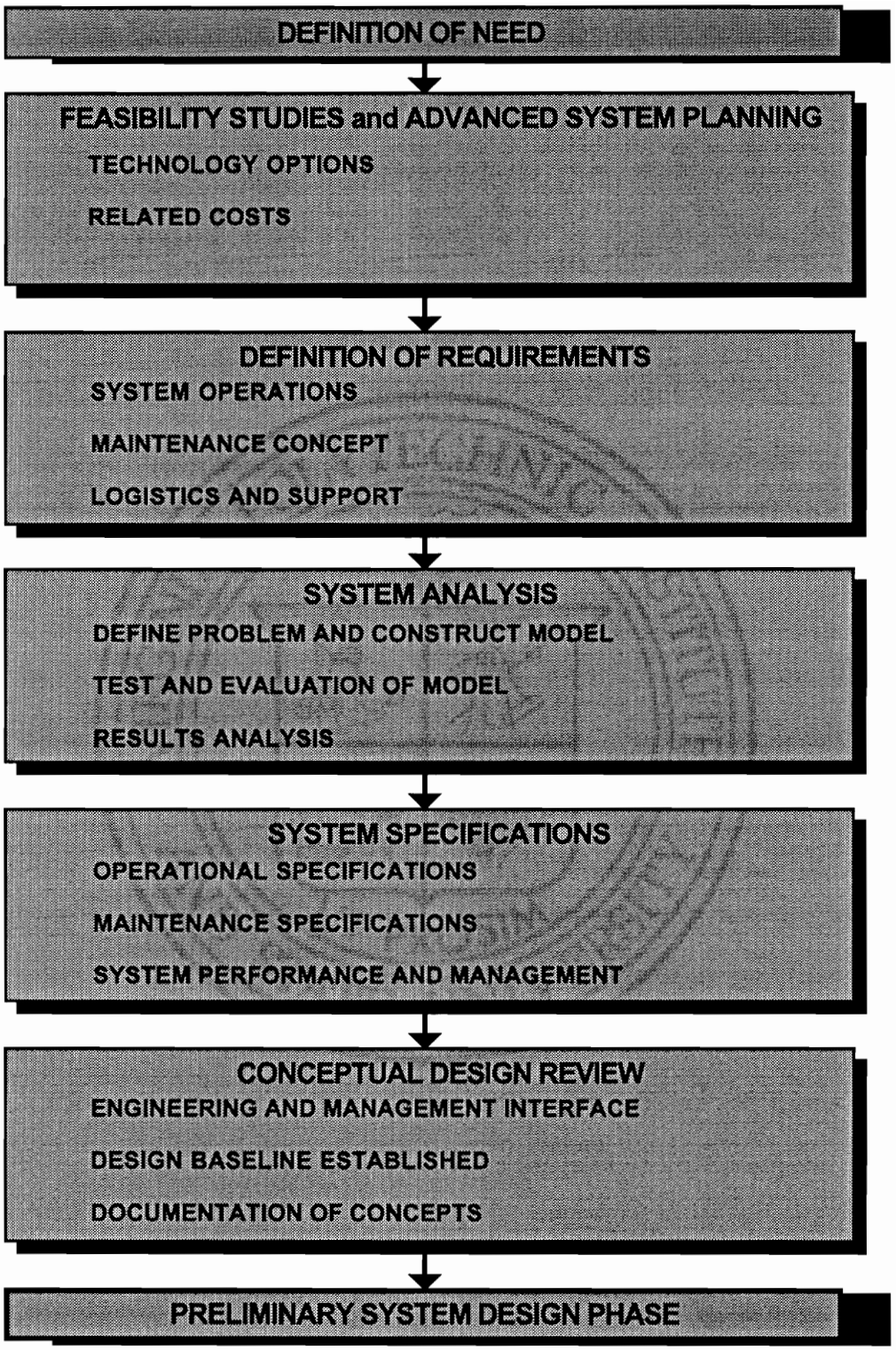

Figure 2. Conceptual system design flow.

that the final system is cost-effective. System operational requirements are derived from the feasibility analysis and advanced system planning. These requirements include operational behaviors, maintenance planning, and identify design specifications and constraints for the system. The mission objectives of the system are defined along with performance parameters, the physical design, and usage requirements. Operational distribution and life cycle factors are addressed and define the quantity and life of the system. Effectiveness factors define the systems efficiency depending on the environmental conditions which are also stated.

The system maintenance concept is addressed and involves factors that are derived from the system operational requirements. The levels of maintenance and respective responsibilities are defined concurrently with maintenance policies that dictate what maintenance is necessary and when. Major elements of logistic support are listed in the concept with factors of effectiveness that relate to the operational environment.

The preliminary systems analysis is performed using the guideline established by the previous conceptual design parameters and a determination is made on how these guidelines can be accomplished. The problem is first defined so that the major issues can be addressed in order of importance. Feasible alternatives are identified so that no potential design is ruled out. The evaluation criteria is defined and through modeling techniques, an optimal design is selected for further development. The modeling is performed by varying all possible inputs over all possible environments.

The specifications of the system are derived from advanced system planning and the feasibility analysis. These parameters cover all aspects of the system, from the operational characteristics to the maintenance requirements. System performance, management, support and documentation needs are also addressed.

The conceptual system design is finalized via a formal design review which covers the whole system and ensures that all design requirements are included and agreed upon by the design group. The design review allows for the identification of major design problems and the ability to correct any flaws. It serves as a forum for all members of the design group to attend and ensure that the design suits the needs of everyone. Due to the fact that the design review occurs early in the system life-cycle, it allows for improvement of the design through listing design specifications and user responsibilities, thus saving costs incurred by discovering any system design problems later.

Preliminary System Design

The preliminary design of a system is the next step of systems design in the systems engineering process. Figure 3 shows the process flow for the preliminary system design. Established system-level requirements are expanded to include quantity and quality of design requirements. The first step in the preliminary system design phase is the system functional analysis. Once the functions and requirements of the system are defined, the allocation

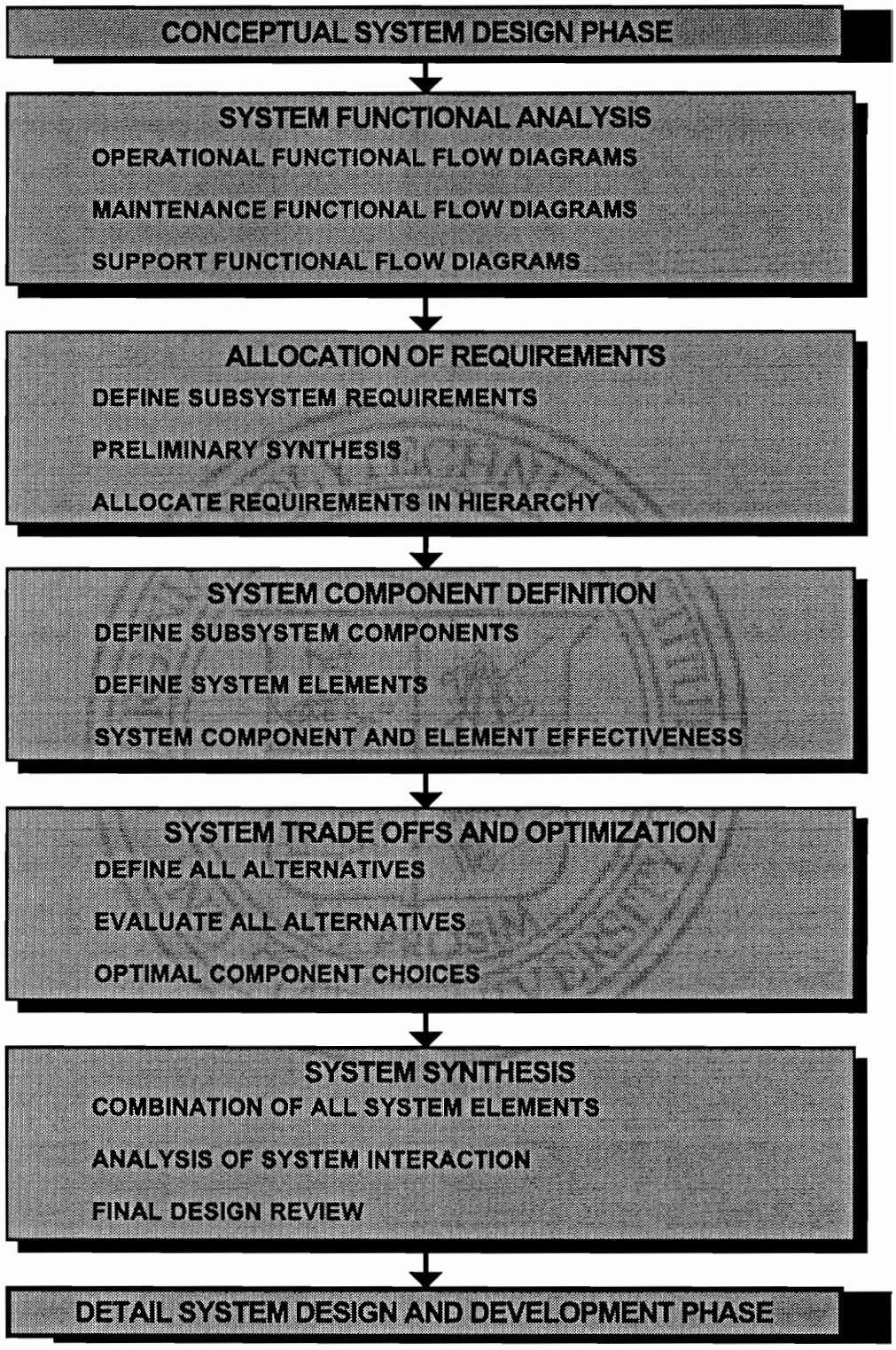

Figure 3. Preliminary system design flow.

of requirements and definition of system components are performed to fulfill the design needs. The system then is optimized by exploring various trade-off options and alternative process evaluations. The individual components are combined into the entire system via synthesis where each component is defined as a working member of the system. The system design is reviewed again in the preliminary design phase to assess the system.

The system functional analysis identifies the design requirements for every level of the system. Functions are defined to accomplish specific objectives and the means to work these functions make up the contents of the system. This approach ensures that all aspects of the system design are addressed, all elements of the system are defined, and all relative needs are provided. The analysis defines the relationship between the operational and supportive needs with the resources available to meet those needs. The entire system functional analysis is performed in a sequential order so that all interface designs and component relationships are stated.

Functional flow diagrams are a graphical process that defines the entire system as one process flow. The need defines the basic system requirements which define the top level functions that define the first, second, etc. level functions. The identified functions cover operational flow, maintenance requirements, and life cycle performance. The resulting diagrams are an extensive description of the system that define the baseline from which lower-level requirements are established. These requirements include aspects of

hardware, software, personnel, maintenance, logistics, and other system design parameters.

The allocation of requirements lists the distribution of the top-level requirements to the lower system levels. The system is broken down into different components that are defined according to what items are required for each component so that it supports the overall system performance. The requirements lists contain effectiveness factors, system performance attributes, system support requirements, and life-cycle cost factors. The allocation listings serve as guidelines for the system design so that the system fulfills the needs defined in the conceptual design phase from the top-level down to the specific components.

With a number of different factors involved in system design, what is required to meet one parameter may prevent the completion of another parameter. The system design then must be evaluated for potential trade-off design options so that the system can be optimized given the available resources and technology. Given the allocated system parameters, the available design alternatives are evaluated to derive the best feasible approach. A model is used for determination of an optimal design given all potential design tradeoffs. The model should include all major design aspects with enough detail to perform a sufficient analysis.

System synthesis occurs when the parts of the system are combined into a functional whole. Each component of the system is specified as how it

operates as an individual module and then how it interacts with other modules. This synthesis of components allows for evaluation of system effectivity. The evaluation can be broken down to parameter impacts or interaction between two system modules.

The system design review in the preliminary design phase is structured much like the review in the conceptual design phase. More emphasis is placed on system interaction and design functionality. The desired result from the review is that the system will perform in a useful and satisfactory manner.

Detailed System Design

The detailed system design phase involves exact definition of system components for operations, maintenance, and support. In this phase, the lower-level components are described as are all elements of the system. Hardware and software components are specified to exact requirements. A model is developed for testing to prove design validity. The system is finally tested and evaluated and redesigns are performed based on results. Figure 4 shows the process flow for the detailed system design phase.

The system must be designed for performance, reliability, capability, and producibility. It must be supportable, economically feasible, and acceptable to the users. The system design must satisfy these requirements while remaining compatible with the original operational and maintenance requirement specifications. The final design must be an optimization between

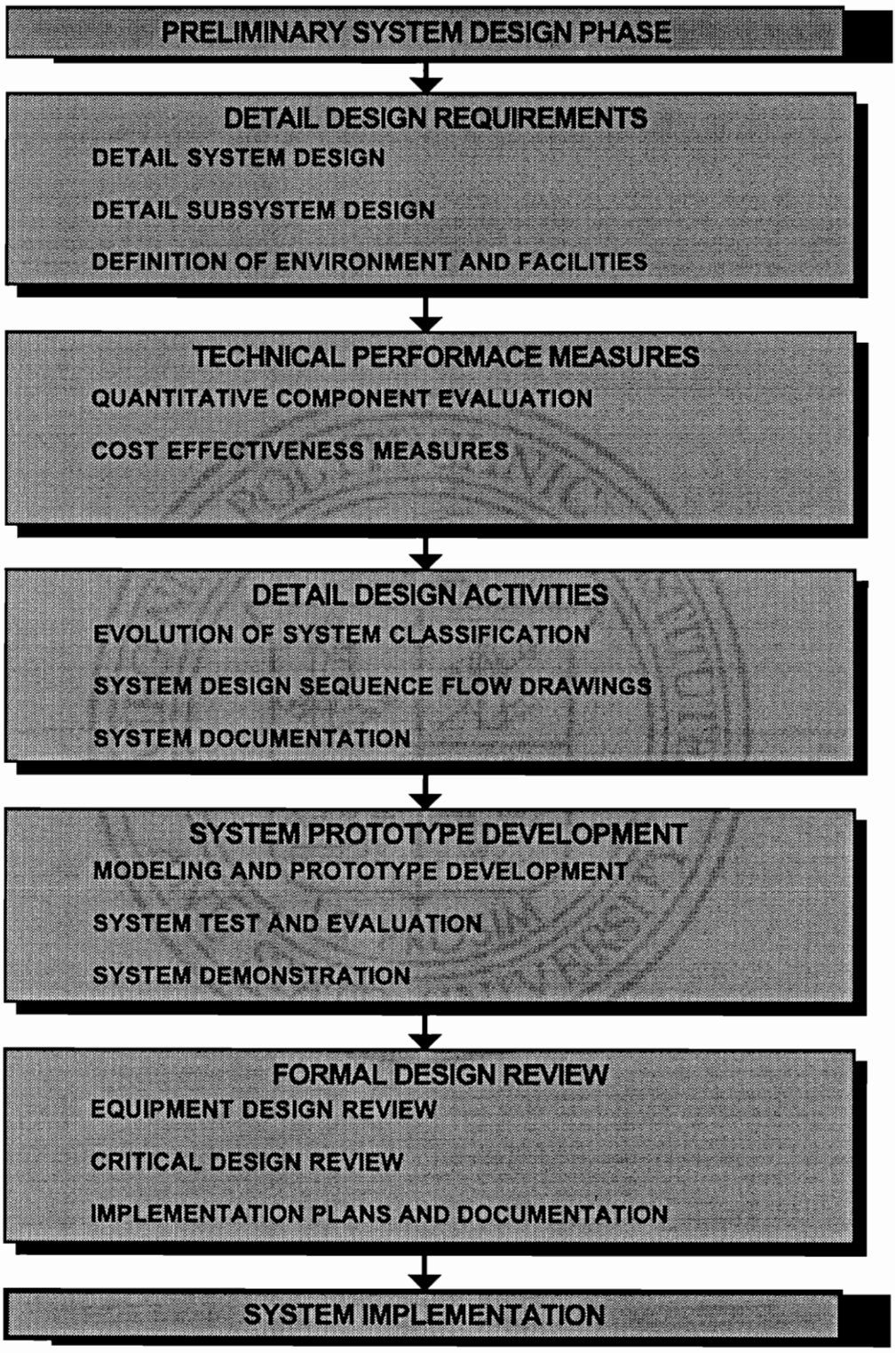

Figure 4. Detailed system design flow.

all possible design factors and remain within reasonable cost and effort so that overdesign and underdesign are avoided.

Technical performance measures are applied to evaluate the entire system or one of its components. To achieve a balance between engineering and management requirements, an analysis of all the integrated elements is performed. The system must be cost-effective and is tested for this characteristic by being broken down into individual components to present system effectivity per life-cycle cost.

The design is surveyed for acceptable results. If the results are good, then the design is documented, modeled, and tested. If the tests are positive, then the system is ready for operation. If, at any point in the testing, the results are unacceptable, the process flow returns to the design and definition of the subsystems that make up the design.

The formal design review is the last step before system implementation given that the system is acceptable. The review is broken into two separate reviews, the equipment design review and the critical design review. The equipment design review covers the system functional diagrams, system prototypes, and engineering models. Human factors, reliability, and support analyses are all accounted for in this review. The critical design review is after the detail system design phase but before production. This review entails the producibility of the design, allows for changes due to the equipment design

review and prototype testing. Once the formal design review is complete, the system is ready for production and implementation.

3) CONCEPTUAL SYSTEM DESIGN PHASE

Definition of Need

Lockheed Martin is looking to diversify its business by pursuing more commercial projects to complement the current load of government projects. With the shrinking of the defense budget, the procuring of commercial contracts is vital to the continued success of the company. There also is an effort at Lockheed Martin to cut costs in order to remain competitive with other businesses.

The type of project defines the number of available options with regards to the location of the office. With the government contract programs, the projects being worked on are classified and all project related work must be left at the site due to its classified nature. This restriction limits the employees' place of work, because all project work must be performed on site. The only solution for a government contract project is to establish a secure site office where all employees must work and where all work performed must remain.

With most commercial programs, the projects being worked do not require any sort of special secure classification. For these programs, the employee has the option to take work away from the office and work on it off site. There is more flexibility in working a commercial project in both the handling of the material being worked on and where it is worked.

Due to rising overhead costs, Lockheed Martin is looking for new ways to cut back on overhead. By keeping overhead costs down, contract proposal cost estimates to potential customers are reduced, making Lockheed Martin more competitive in both the government and commercial sectors. Personal illness and personal business hours taken by employees contribute to the overhead cost pool. If the number of hours taken by each employee for personal illness and personal business were reduced, overhead costs would fall.

The work force of today is quite diverse and with this diversity comes a variety of different employee lifestyles. While some employees are able to work an 8-hour day and 40-hour week every week, others need more flexibility in their work schedule. There are a number of reasons as to why this flexibility is necessary. Employees with children must fit child care schedules into their working week. When a child is sick, the employee stays home with the child, costing the company personal illness hours. Employees that are attending school occasionally need to take personal business in order to attend class or take a test. All employees that have doctor or dental appointments during the day need to take personal business hours to attend. A flexible work schedule allowing the employee to work a 40 hour week without the requirement of working every day or always during core hours would reduce the number of overhead hours taken and save on costs.

With the available technology in telecommunications for business use, more employees are being offered the opportunity to work out of their homes and telecommute to work each day. Lockheed Martin has never offered their

employees this option due to the classified nature of the work involved with the government contracts. With commercial contracts, this option is now a possibility.

Employees working out of their homes offers a significant number of advantages for both the employees and Lockheed Martin. The employee enjoys the convenience of not having to commute to work every day and is able to spend the day at home with the family, potentially saving child care costs. The employee also is available to perform daily business or personal appointments on a flexible schedule which alleviates the need to take personal business hours during the work day. Lockheed Martin saves on site office costs by not having to rent as much office space along with the accompanying utility cost savings. With all of these advantages, an overall cost savings would be readily apparent to Lockheed Martin while allowing the employees greater job flexibility and satisfaction.

Lockheed Martin is working on acquiring more commercial contracts that would make the application of a networked home office a feasible alternative. The network home office project consists of a program site office and a home office for each employee in the program. The site office would serve as the base of operations for the project where the project managers or project leads would work along with any required technical support. The site office would contain a computer lab that consists of the best equipment required by the project where all employees could finish reports for presentation. The computer lab would also serve as the network hub where all home employee

communications would be routed through. A presentation room would also be located at the site office for demonstrations to the customer or for program meetings that require the personal attendance of all employees.

The home office is established an area in the employee's house that is dedicated as solely office space. The home office needs to be set up as one of two standardized work stations provided by Lockheed Martin that would exist in every employee home. The employee would be allowed to choose between a smaller or larger home office configuration, depending on the available space the employee has at home. The cubicle will contain shelf, drawer, and cabinet space for employee work related belongings, be equipped with a proper amount of lighting, and be comfortable enough to make the cubicle a productive work area.

The network home office will consist of the following capabilities for both the site and home office configurations. The user will be able to send and receive electronic mail (email) containing messages from other employees in the program. Each personal computer (PC) will have fax capability so that the PC can send and receive fax messages. The computer network will be set up to allow all employees to share documents over the network. This will allow one employee to work on a document, save it, and then another employee can load in that same document and continue work on it. Each computer will also have video conference capability. The site office has a presentation room for large conferences with all employees or for meetings with the customer. The video conference capability will allow a small number of employees the ability

to talk to each other in person and share and relevant video data. The network home office program should allow the employees in the program to perform almost all of the same functions at home that are normally performed at work without any inconveniences.

One example of the necessity for all of this accompanying technology is if management needs a document to be presented to a single customer that has stopped by the site office. The manager could easily email the employee at home who is working on the document. The employee could then communicate with the site office via the video conference link and tell the manager where to find the document in the network for the customer to look at. Once the document is brought up at the office site, the home employee could then present the document via video to the customer.

For the site office, the available hardware will need to consist of enough personal computers to support management and technical support along with the necessary computers for the computer lab and presentation room. All of these computers will contain the appropriate networking hardware that will enable each PC to communicate with another. The computers also will need the capability to send and receive fax messages. The printers in the computer lab will be capable of handling any print request and produce high quality documents that are professional in nature. The accompanying site office software will allow all computers to perform the above tasks required by the hardware with an easy-to-use user interface.

The home office will consist of a personal computer with the necessary network hardware to be able to telecommunicate with the network at the site office. These PCs will also have fax capability. The home office also will have a printer for hard copy output for draft work. The accompanying software will behave like the site office software. The personal computers at both the site and home offices will have enough processing speed to be able to handle the demands placed upon it by the peripheral hardware and software without any noticeable processing lag on the screen.

The network home office design is intended to attract quality personnel to Lockheed Martin by offering a flexible work schedule. The network home office will also save overhead costs for the company thus making it more competitive when proposing for commercial contracts. The system is to be implemented for a newly created in-house commercial program by January 1996. The January date is when the program starts up so all office equipment must be established and all software must be operational at both the site and home offices by that date.

Feasibility Studies and Advanced System Planning

The feasibility study consists of evaluating the different components required for the system design and what technical alternatives are available. It also shows whether or not the network home office system is feasible when compared to a typical site office program configuration. Advanced system planning allows the evolution of the system to occur while documenting

technical requirements in the form of specifications and management requirements in the form of a management plan. This serves as the foundation for the systems specification process.

Computer Communications Architecture

In establishing the home office network, the communications involved are broken down into three main parts: the computers, the networks that the computers are connected to, and the applications that the computers run. The communications between two computers involving the three main parts is shown in the Figure 5. The network layer is involved with the information

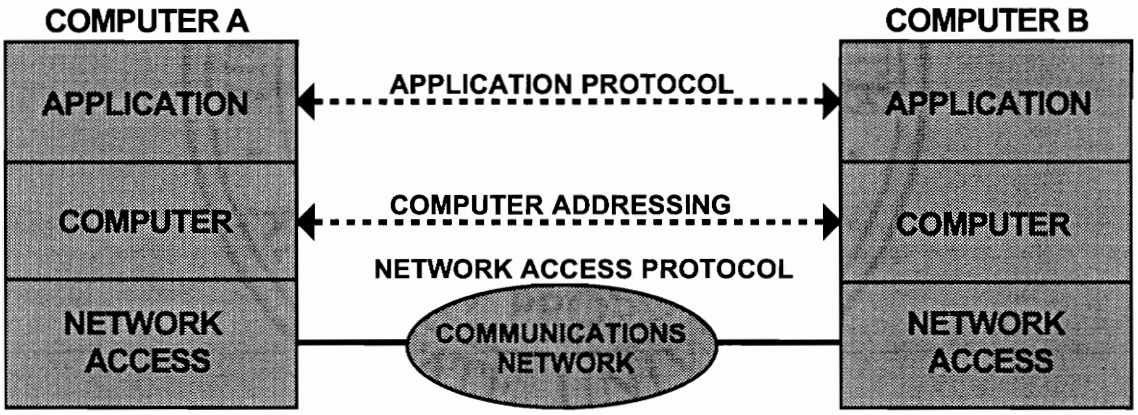

Figure 5. Computer communications three part model.

exchange between the computer and the network. The software used to accomplish this communication is dependent on the selected network hardware. The computer and computer software provides the network with

addressing information so that the data will be transferred from the computer to the proper destination. The application layer contains the necessary software to accomplish the required tasks and interface with the user to acquire the data. This is the standard method of computer interaction in a network setting and is a reasonable configuration for the network home office.

Electronic Mail Capability

Electronic mail is a means of communication that allows user to write and send messages to each other over a telecommunications network. It is an effective application because it does not require the recipient of the message to be available when the message is sent unlike a telephone call. It also eliminates the need for the use of paper which saves on cost.

Network electronic mail is comprised of five main modules. The interaction of these five modules is shown in Figure 6. The employees will need a terminal interface software product module to manage user interaction with the computers. The mail messages are stored as files so a file handling software module is necessary. An electronic mail services module allows the user to handle the mail messages for the purposes of reading, deleting, forwarding, or other mail capabilities. A communications module is necessary for the site and home office computers to interact with one another and a module to specifically transfer the mail files is also required. Electronic mail is a simple and effective way for employees to transfer information without requiring that all parties be present at the computer for communication.

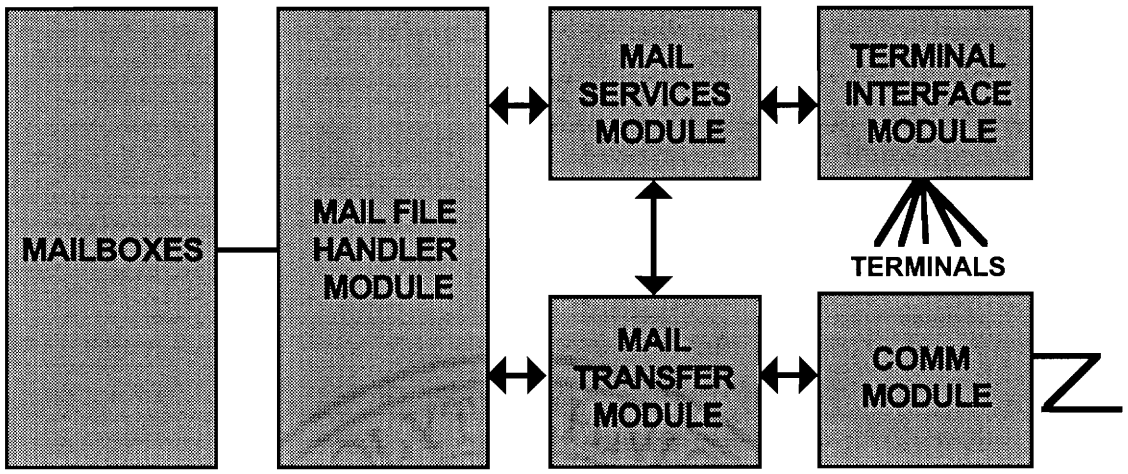

Figure 6. Electronic mail module interaction.

File Sharing and Transfer Capability

File sharing and transfer are defined by a file transfer protocol (FTP) that allows the transfer of files from one user to another. The FTP operates by transferring files, knowing the data in the file, the file structure, and any file attributes. It must interact with three different members of the system in order for the file transfer to be successful. A user interface must exist to receive input from a user or other application program. A communications link between other FTPs also must exist to transfer the files. For FTP to access the file, a file manager interface is required.

File transfer protocols are defined by the features that they contain and protocol mechanisms that are used. Basic features common to FTPs are

listed and defined as service features or protocol features. There is a level of access control in most FTPs that require the user to enter a userID and a password to gain access to the system. A processing mode is defined by the FTP as to how requests are handled. Usually the mode is immediate, where the system will process a command once it is received. FTPs consist of a file naming function that identify the source and destination of the transfer file. An error recovery model is available within FTP to survive a error in transfer without a system crash. File attributes and statistics are communicated between each system with FTP so that the receiving terminal understands the type of file it is receiving.

For the network home office, each personal computer must have a format of FTP installed so that the employees will be able to exchange files over the network. This enables the employees to share common documents with one another and allows management or the customer to receive documents or data files as necessary. The file transfers must be quick and accurate with minimal error.

Document Fax Capability

The process of faxing a document involves the transfer of written media from one location to another, with both input and output being on paper. Another method of faxing documents is via personal computer with one computer transferring a file to another. The recipient of the file has the option of either viewing the file on the monitor or printing the file. This method of file

transfer involves the same characteristics of file transfer protocol that the file sharing and transfer capability does. Documents to be faxed by the system will exist with given file attributes that will differentiate it from other files for transfer.

The fax capability for the network home office will allow the user to transmit any document created on the home office system to any other employee with a fax modem. The program employees will also be able to send a fax to multiple locations at once or at a time chosen by the sender. The recipient shall have the option to view the fax on the monitor or send it to the printer upon receipt of the fax.

Video Conference Capability

The video conference capability of the network home office system allows the employees to conduct live video/audio conferences through their personal computers. With this capability, the users of the system have the ability to hold small meetings, conferences, or give presentations as required by program management. Video conferencing enables the employees to communicate with each other on a more personal level when necessary due to the fact that each employee is located at a separate home office.

Site Office Configuration

The site office serves as the hub of all program activity. Program managers will be required to spend time at the site office to serve as a point of

contact between the contractor and the customer. Technical support personnel will also need to work at the site office and take care of any business matters that cannot be handled over the home network office system. The existence of a computer lab for document preparation and a presentation room are the only additional requirements for the site office.

The site office is available for employees to work at if they cannot accomplish their specific task over the network system. Since there is limited work space at the site office, the capabilities of the network home office should be complete enough so that the employees will rarely have to work in the site office computer lab.

Home Office Configuration

All of the home office configurations shall be standardized to two designs, allowing the employee to choose the one which best fits in the employee's home. Human factors engineering will be implemented in the design of the home office work area to promote an efficient workplace. The home office consists of a personal computer for the user with communication capabilities on a separate phone line to handle the various data transfers established by the system. A printer will be provided for the employee to create draft copies of any documents required for work.

Cost Analysis

Implementing the network home office system will cost about the same as starting up a standard program, where all employees work at the site office. The required office furniture would be the same. For the network home office, the office furniture would be installed at the employee homes rather than the site office. A smaller site office will save on rental and utility costs for the network home office. The required hardware and software would be a bit more expansive for the network home office. Where the computer requirements would be the same for both program scenarios, the home office carries the extra cost of more printer purchases and video conferencing hardware. Electronic mail features and file transfer currently exist at most all programs. The network home office communicates via modem on an independent phone line where on-site programs communicate solely though the network.

Cost savings that cannot be calculated readily are overhead charge savings, since employees can now work their flexible schedules around appointments. Employee productivity at home is another random variable that is positively influenced by convenience but contains potential negative influence with no supervision. A boost or loss in employee productivity affects contract costs. While there will be a slightly higher start-up cost with the purchase of additional equipment and phone lines, the system will save money over time.

It is recommended that the network home office be pursued to completion. The cost-based risk involved at a high level seems minimal when

compared to the similar risk in starting up any site office program. The potential cost savings involved are not only based on office space rental and utility savings, but the positive effects on employee productivity. There are concerns of hardware and software costs for the network home office, however, these same variables also exist in site office programs. Implementing the network home office is a highly effective means for Lockheed Martin to remain competitive with costs and obtain a more diverse and higher talented work force.

Definition of System Requirements

The definition of system requirements is broken down into two sets of requirements for the different aspects of the project. The system operational requirements define subjects such as the amount of equipment and personnel along with the location of the system. The maintenance support requirements are concerned with system upkeep and a plan for repair when the system goes down. Maintenance requirements also cover the areas of logistics and support, which define the feasibility and effort levels of the performed maintenance. Other factors, such as usage of the system, system effectiveness, and support policies are all covered by the listed requirements.

System Operational Requirements

The system operational requirements define a projection of how the system is to be developed and how it will be used after production. The

engineering of this product is defined by a number of different boundaries. These boundaries include the mission definition, performance and physical parameters, usage requirements, operational deployment, operational life cycle, system effectiveness, and system environment. The definition of the operational requirements will also determine the amount of support required for the system.

Mission Definition

The main mission of the network home office is to establish an effective system program where employees work out of their homes as opposed to commuting to a site office. The accomplishment of this goal also satisfies two minor goals for the system: to provide a more flexible workplace for the employee and to cut back on overhead costs for Lockheed Martin. A successful network home office will improve the productivity of the program it is applied to and attract top candidates to Lockheed Martin who are looking for work in similar network home office based programs. The system accomplishes these goals by offering those employees with busy schedules the opportunity to fit a 40-hour work week around their lifestyle. Employees who may not have been able to work a traditional 8-hour day due to personal constraints are now able to work a full week with the flexibility offered by working at home.

Performance and Physical Parameters

The network home office will consist of a site office and as many home offices as there are employees. Each employee will have one personal computer with the required communications hardware to exchange data with the network at the site office and a printer for draft copy output. Every home office setup will consist of an ergonomically designed workspace that will house the necessary hardware. The chosen computers for the program will be fast enough to effectively run the system software yet as inexpensive as possible to save on cost.

The site office will contain one room for each program manager or technical support personnel. These rooms will contain identical equipment to that which is located at the home offices with the exception of the site offices will not need printers. The site office computer lab will be large enough to contain one-tenth of the program employees, with one computer for each potential employee in the lab, one high quality and low quality printer, and any other unique hardware items required by the program such as a scanner. The network linking all of the home offices to the site office will be located in this room. A presentation room will exist at the site office that will seat every program employee and provide standing room for another ten. This room will contain the required equipment to present any topic using either an overhead projector or personal computer.

Usage Requirements

The network home office system will be available for employee use on a 24-hour basis with the exception of required downtime for system maintenance. The network will be able to handle twice the maximum number of employees at any given time due to the potential that all employees could choose to work similar hours. This also allows the program room for growth so the addition of more employees will not overburden the network. Each employee will have access to the site office for use of the computer lab or to pick up supplies for the home office.

The home office equipment is to be used by the employee according to the employee's personal schedule. The home office system will be used for a minimum of 40 hours per week by each employee as required by the program unless the employee has made other arrangements with management. The home system will be able to perform over 40 hours for overtime work and personal use. The employee will logon to the site office network thorough the use of a password protected personal logon to ensure that only valid Lockheed Martin personnel have access to the system. For security purposes within the home, all cabinets and drawers will be equipped with locks on them.

Operational Deployment

The network home office will contain a total computers equal to one-tenth of the total number of employees plus one computer for each employee's

home office and one computer for each manager and technical support person at the site office. The number of low quality draft printers will equal the number of employees for each home office. There will be one high quality printer at the site office along with the network server hardware to support the home offices. All required program software will be installed on the site office network and will be accessible by all home offices. The home office personal computers will be equipped with telecommunications software to gain access to the network.

The location of any home office is not to exceed sixty miles from the site office for reasons of home office maintenance service. Employees are expected to report to the site office as required by management given proper notice. The network home office is to be fully operational by the start of the program in January 1996. For the purposes of testing the system, the employees for the program shall be selected by the first of October and each employee home will be equipped with a home office set up no later than the first of December.

Operational Life Cycle

The network home office will be in operational use for as long as the program is operational. If more employees are hired onto the program, additional home office packages will be established in the new employee houses. Conversely, if any employee leaves the program, the home office will be removed from that employee's home. The system inventory will be

monitored by program management with regards to home office set ups and office supplies for the home and site offices will be purchased as necessary. When the program ends, all of the home office set ups will be placed in storage or transferred to another program based on the network home office system as needed.

The system will be used by all program employees and maintained by the program technical support. The length of employee use of the system is defined entirely by the length of time the employee works in the program. If customer system interaction is required by the program, then the customer will have access to the network from their office location.

System Effectiveness

The network home office shall be effective enough to serve all program employees at the same time with no considerable lag in production time by the network. The system will be available on a 24-hour basis for all employees minus downtime for system maintenance. The mean time between maintenance shall be no less than 150 hours with an acceptable maintenance downtime of no more than four hours to correct any problem within the system, add software capabilities, make backups of the network, or clean the hardware, etc. The failure rate of a home office should not exceed one failure per week for the total number of home offices.

Technical support will be available during the day from 7 AM until 7 PM to handle any maintenance requests. The requests will be serviced immediately if the problem exists at the site office or if an employee calls in for a service request in enough time for the technical support to travel to the employee's home office and complete the maintenance. Employee calls for maintenance during off-hours or the weekend will be handled during the next business day if there is no emergency. In the case of an emergency, technical support will be on-call to provide assistance.

The operators of the system will need to have a solid knowledge of personal computer use and telecommunications concepts. The employee will be expected to be able to perform small maintenance tasks on the home office with the help of technical support via phone or electronic mail, if the problem is easy to solve. Otherwise, the employee will be expected to know the system software required by the program.

The home network office will be highly efficient. The users of this system shall not have to experience any noticeable delay in system performance, regardless of the load upon the system. When logging onto the system, the home user must wait until the communications connection is established between the home and site offices before use while the site office user needs only to wait for logon connection to the network.

System Environment

The site office will be a climate controlled environment with proper settings for temperature and humidity to prolong the life of the computer and network hardware. A ventilation system will be installed at the site office to filter out dust and other minute harmful particles. The electrical supply for the system will be stabilized with the use of surge suppressers and an universal power supply (UPS). The office cubicles will be constructed from modular office furniture.

Home office users are given a choice of two different workstation designs that will also be constructed from modular office furniture. Other environmental factors, such as room temperature, humidity, and air cleanliness will vary due to the different homes the offices are located in. Employees will be advised to keep their home office within certain environmental bounds to extend the life of the computer and peripheral equipment as long as possible.

Human factors engineering will be incorporated into the design of the office workstations. The design will ensure that seating, work surface, and shelving are at proper respective heights to produce an optimal work area. Lighting will be installed onto the workstation for a more productive reading area. The choice of the location for the office in the homes is up to the employee and should be based on noise, lighting, and comfort factors if possible.

Maintenance Support Requirements

System support plays a large role in the overall success of the network home office. If the reliability of the home office equipment or the quality of the maintenance service is poor, there will be a lot of lost time for a given employee. The lost time would nullify any potential overhead cost savings and decrease employee job productivity. If the maintenance personnel do a poor job in supporting the network at the site office and the network crashes, then the whole program productivity comes to a stop. A solid and complete maintenance plan is essential for the system to be cost-effective.

The maintenance support requirements define the levels and responsibilities of maintenance support, the effectiveness and environment of the maintenance, and general overall repair policies. The requirements define a baseline for supportability requirements that include human factors concepts of usability, reliability, maintainability, and likability. For the network home office, there are three levels of maintenance to be considered. Organizational maintenance is performed at the site office by the technical support and includes basic equipment testing, monitoring, cleaning, and replacement of minor components. Home office employees will be required to perform similar tasks on their systems. Intermediate maintenance is to be performed by the site office technical support team. This level of maintenance covers major repair or component replacement. The technical support will be required to perform all intermediate maintenance tasks, whether the work is at the site

office or at a home office. Producer maintenance will consist of complex equipment repair to be performed by personnel outside of the network home office program. The equipment to be repaired will be sent off site on repaired on site as required.

Organizational Maintenance

This level of maintenance is broken down into two different parts. The main part is maintenance performed by the technical support at the site office. The other part is a plan for the other employees to perform organizational maintenance on their home office systems. By giving the employees the responsibility of performing minor maintenance tasks, it reduces the chance for home office system failure and lessens the need for visits from the technical support for intermediate maintenance.

At the site office, the computer lab terminals, printers, and other hardware peripherals will need service. The network server, management office computers, technical support computers, and presentation equipment complete the list of hardware requiring service at the site office. The organizational maintenance will be performed entirely at the site office location by the technical support personnel.

The support personnel are to perform daily visual inspections on the site office equipment to ensure that everything is in working order. Components that need to be cleaned will be serviced during these inspections. Technical

support personnel will need to perform various operational tests on the computer equipment at given time intervals to test for system integrity. If minor adjustments or repairs are needed, they are to be performed by the technical support. If parts need removal or replacement, such as keyboards or printer toner cartridges, the technical support will perform these tasks.

The home office employees are to perform identical tasks for their systems. Each employee will keep a maintenance log on the system for their office that lists maintenance performed and problems encountered. If parts need to be replaced that the employee does not have in the home office supply, technical support personnel will be required to provide assistance.

Intermediate Maintenance

Intermediate level maintenance will be performed only by technical support personnel. The maintenance is to be performed on site if the equipment that needs attention is located at the site office. If the equipment is a part of an employee's home office, a member of the technical support team will be sent out to investigate the problem. Depending on the size of the program, the technical support team will be supplied a vehicle by Lockheed Martin. For smaller programs, the technical support will be reimbursed for the use of their personal vehicles for service visits.

The support personnel will perform detailed inspections of computer hardware that is malfunctioning at both site and home offices. When servicing

home offices, technical support will bring any necessary test and repair equipment along with spare parts so that the faulty item can be repaired at the home office and not need to be brought back to the site office. Any equipment in need of major service, repair, adjustment, or modification will be serviced by the technical support. The technical support will also take care of hardware calibrations for computer hard drives, video cameras, etc.

Producer Maintenance

In the case that a piece of equipment fails and cannot be repaired by the technical support team, it will either be repaired on site or sent away to the producer of the product for repair. The type of work required by producer maintenance would be complex repairs or adjustments of the computer hardware, major calibrations of the equipment, or complete rebuilding. Most of this work will be performed at the location of the producer of the failed piece of hardware.

Technical support will not be trained to handle these types of maintenance requests due to the infrequency of occurrence. The home office consisting of a computer, monitor, modem, printer, and video interface will not require many major repairs due to the reliability of the equipment. This assumption is made due to the available technology in these items. At the site office, the only pieces of equipment that might have major problems are the network server and any specialty pieces of hardware specific to the program. Since the need for producer maintenance is not great, it is not worth the cost in

either hiring technical support with producer maintenance experience or training current technical support personnel to graduate to that level.

Logistics and Support

Logistics and support tasks are to be performed by the technical support team. These functions are non-technical and serve the system by ensuring that it is running smoothly. Task items that fall under this category include keeping inventory on computer supplies, such as printer ribbons, and ensuring that a supply of each item is available at all times. Another task is to monitor the home employee maintenance logs to make sure that operational maintenance is being performed and recorded. The technical support team will also monitor system performance and suggest to management if the system needs upgrading.

The technical support team is expected to perform any secretarial demands placed upon the program by management, the customer, or the other employees. The mean time between maintenance for the system is low and the number of technical support shall be large enough to handle the program maintenance, logistics, and support. One of the technical support team members will be assigned a systems operator position that will consist of an equal mix of maintenance and support duties. These support duties are to include keeping employee records on the system up-to-date, notifying the employee of any corporate policies or regulations that must be adhered to, and keeping track of special program events, training, or demonstrations.

Maintenance Personnel

The maintenance tasks are to be broken down into three separate technical support positions that meet the needs of every level of maintenance. Depending on the size of the program, the jobs entailed by each of the three positions will be performed by one to as many support personnel that the program requires. The positions assigned are system operator, system technical expert, and system support. Each position has a unique set of tasks assigned to it and there are a number of tasks to be performed by every position depending on the amount of maintenance required by the system at any given time.

System Analysis

Given the baseline design for the network home office, a system analysis scenario is performed to determine how the system requirements can be met. Each component of the system is analyzed by running the entire system through various test scenarios. Component alternatives are defined and by running input data of potential situations through the system model, optimal choices for the system components are made. This analysis will also point out the best ways to handle different problems and provide a basis for operational and maintenance procedures. From this analysis, the system is fundamentally defined and is ready for further design and refining as it progresses through the system life cycle.

The model to be constructed for analysis will be a new program with a total population of 25 employees. From this group of employees, one is the program manager, and two are technical support. Of the two technical support personnel, one is the system operator and the other is the system technical expert. All 25 employees have home offices for the model program. The manager and technical support personnel work at the site office during the day. The computer lab at the site office consists of the network server, a laser printer, a scanner for digital imaging, and three computers for employee use. Each home office consists of a computer, a low-quality printer, and modem to connect with the site office.

The analysis begins with the user interface to the system. The network home system must be efficient and reliable. If the system is slow and unreliable, the home employee will become frustrated with the slow response time and down time. The two major available personal computer (PC) systems at a low cost are IBM PCs and Apple Macintoshes. Since both computer systems are nearly identical in performance and comparable in cost, IBM PCs are chosen due to the fact that Lockheed Martin uses a much greater quantity of IBM PCs and current employees are familiar with the IBM PC operating system. To satisfy processing requirements, a PC with a 486 processor is chosen. It is fast enough to handle most all of the available PC software and the performance difference between it and the Pentium based PCs is not significant enough to justify the added cost. To handle all of the application software and store home user data, the PCs have been chosen to have 8

megabytes of Random Access Memory (RAM) and a 500 megabyte(MB) hard drive. The design and testing of user interface software is usually a major aspect of the human factors work for products controlled by microprocessors [Cushman, p.205]. The popular graphical user interface (GUI) for PCs is a software tool called Windows by Microsoft. It is a mouse-driven icon-based utility which is user-friendly and easy to use.

For file sharing capability, file transfer, fax capability, and email, a fax modem is required. To minimize the system delay, a fax modem with a 28,800 bits per second (bps) transmission speed is chosen. The cost for this modem is not much more than the cost of a 9600 bps modem which is the minimum required transmission speed for fax capability. The 28,800 bps modem will process data at a rate three times as fast as the 9600 bps modem and twice as fast as a 14,400 bps modem for a moderate extra cost. The extra cost is justified by the fast transmission speed that will help keep the transmission delay between the site office and the home office to a minimum.

To handle the video conferencing capability, the computers will require a monitor with speakerphone, video camera, video board, and audio board. The monitors are chosen to be a 17" diagonal SVGA over smaller and VGA models due to a noticeable improvement in the video conferencing capability and more space in which to place the various windows for conferencing and other applications software. The home office printers will be ink-jet for these printers are cheap and provide output quality that is sufficient for rough drafts. The advantage top using ink-jet over dot-matrix is that ink-jet printers have greater

graphics producing capability and they provide consistent copy quality. The ribbon for a dot-matrix printer tends to wear out quickly and the printer output quality declines.

This constructed model will be sufficient to serve the needs of the 25 employee program network home office. If a problem should arise at the site office, the technical expert is present to solve it with analysis software and hardware knowledge. If a problem occurs at a home office requiring intermediate maintenance, the technical expert drives to the home office with the necessary tools to solve the problem as soon as possible. If while during this time, a problem occurs at the site office, the system operator is available to handle any system faults. The system operator is also monitoring the network server for processing time, user maintenance, and any problems. While not performing these tasks, the system operator can perform any secretarial duties requested by the manager. If the system is down and the employees need to proceed with work due to a deadline, the software allows the employees to connect with each other to transfer data and information and bypass the network.

This model scenario analysis proves that the network home office is a viable system for operation. The selected components for the system satisfy the needed requirements and are recommended for further design. With faster equipment the confidence of the system being delay free is very high but the associated cost will be high as well. By choosing equipment that might not be the top of the line, like the 486 PC versus the Pentium PC, cost is saved and

there is not enough of a decline in performance to justify spending the extra money. Other trade-offs include the selection of the printer. The choice for this model is an ink jet printer to produce rough copies only. If the home user needs to make a rough copy of a graphic file, the dot matrix printer output might not be satisfactory. Ink jet printers cost slightly more than dot matrix printers but will allow for better graphical output.

Risks that need to be noted are the potential overflow of maintenance problems for the technical support team. The network home office system mean time between failures is designed to be very low through the choice of very reliable hardware devices. However, there is always a probability that, in this case, three errors occur within a close time span, and with only two technical support personnel, one problem will have to wait, costing the company system down time for that particular home user. Another risk is the home office environment. While management can establish acceptable environmental limits for the home office, it is not possible to monitor the employee homes without significant added cost. This risk is lessened knowing that the equipment at the home offices is designed by the manufacturers to operate in differing environments without failure.

The final system analysis decision is that the network home office be further pursued for implementation. The model parameters meet the defined needs which will define the system specifications. The risks can be overcome with further development of operations and maintenance procedures.

System Specifications

The system specifications for the network home office are a result of the defined operational and maintenance concepts along with the observations from the system analysis. The network home system is a system to be employed by a Lockheed Martin program where all of the program employees work at home offices and communicate with the site office via a network server. The site office houses the management and technical support personnel. A computer lab and presentation room are available for employee use at the site office.

The operational requirements for the network home office are that the home office employees have a computer that can communicate with the site office and be able to share and transfer files, send and receive fax documents, send and receive email, and have the capability to communicate via video conferencing. The home office will also consist of a fax modem to perform the data transfers and an ink jet printer for draft work. The home office workstation is designed using modular furniture and is designed to promote a productive work environment. The network server must be efficient enough to serve all program employees simultaneously with no more than a 5 second delay in any data transfer.

The maintenance team is to consist of a number of system operators, technical experts, and technical support depending on the size of the program. For the 25-employee model program, both a technical expert and systems

operator will be required. The maintenance team will perform organizational maintenance at the site office and both organizational and intermediate maintenance at the site and home offices. Any producer maintenance will be performed by the product manufacturer. Home office employees are expected to perform daily organizational maintenance on their systems to prolong the home office system life and reduce the fault probability. The system operator will monitor the system for performance and perform secretarial duties. The technical expert will perform system maintenance and drive to home offices as necessary. The technical support will assist the system operator and technical expert as needed.

The home offices interact with the site office as shown in the system functional diagram in Figure 7. All of the major components of each office are listed along with the interface requirements.

The system shall perform so that there is no long delay in data transfer. The video conferencing exchange should be accurate and understandable. All data files should be accessible by all employees. The system will be available for all hours of the day.

Conceptual Design Review

The network home office is complete through the conceptual design phase. The need is identified and the network home office system is built

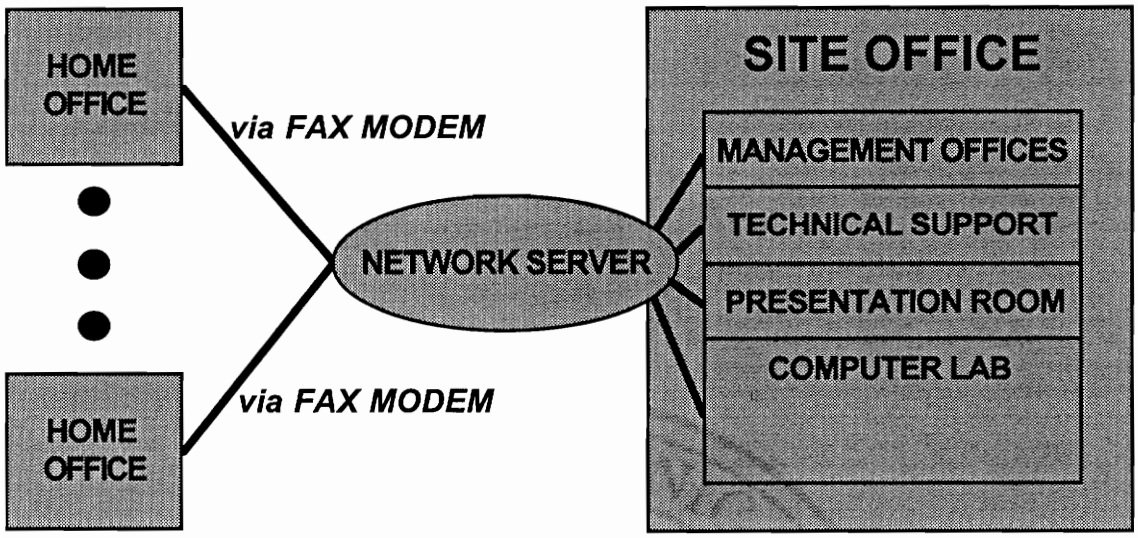

Figure 7. System functional diagram.

around this defined need. Evaluations are performed on the system to derive operational and maintenance requirements and system analysis is performed to ensure the system is valid. The technical baseline for the project now exists and work on the preliminary design phase now begins.

4) PRELIMINARY SYSTEM DESIGN PHASE

The preliminary system design of the network home office translates the system-level requirements defined in the conceptual phase into specific qualitative and quantitative design requirements. A functional analysis of the system provides flow diagrams for both operational and maintenance functions. Requirements allocation establishes a hierarchy of the system components with specific design criteria attached to each component. With the boundaries of the system design now established, trade off studies are performed to optimize the system with cost restraints in mind. When the system design approach is acceptable, a final system synthesis combines all of the system elements for study on how the different parts of the system impact each other. The system design is reviewed for correctness before detailed system design and development is performed.

System Functional Analysis

The system functional analysis identifies design requirements for each hierarchical level of the system [Blanchard, p. 55]. A function is defined as a single action performed on or by the system that covers operational, maintenance, and support functions through the use of system hardware, software, and other system equipment. This system analysis is performed to identify the various system and subsystem functions, the method in which the functions are performed, and the means necessary to perform them. The

functions for both operational and maintenance analysis are listed in the form of a system flow chart.

Operational Functional Flow

Figures 8 through 10 illustrate the network home office system functional flow for operations. The blocks are defined with what actions are accomplished by the system. Top-level functions represent broad levels of system operation. These function levels are defined by lower levels of sub-functions which are defined by even lower levels of sub-functions if necessary. The result is that every possible function performed by the system is listed in the operational functional flow format. From these functional definitions, requirements are allocated that define system components.

Maintenance Functional Flow

Stemming from the operational functional flow, the maintenance functional flow is a description of maintenance actions that are performed on the system by the technical support. Activities that are software or administration based are handled by the system operator. Hardware maintenance and cleaning actions will be taken care of by the technical expert. The maintenance flow starts with very general maintenance tasks of what needs to be done. Depending on the results of the maintenance and analysis, further tasks may need to be performed. The maintenance flow stems from the

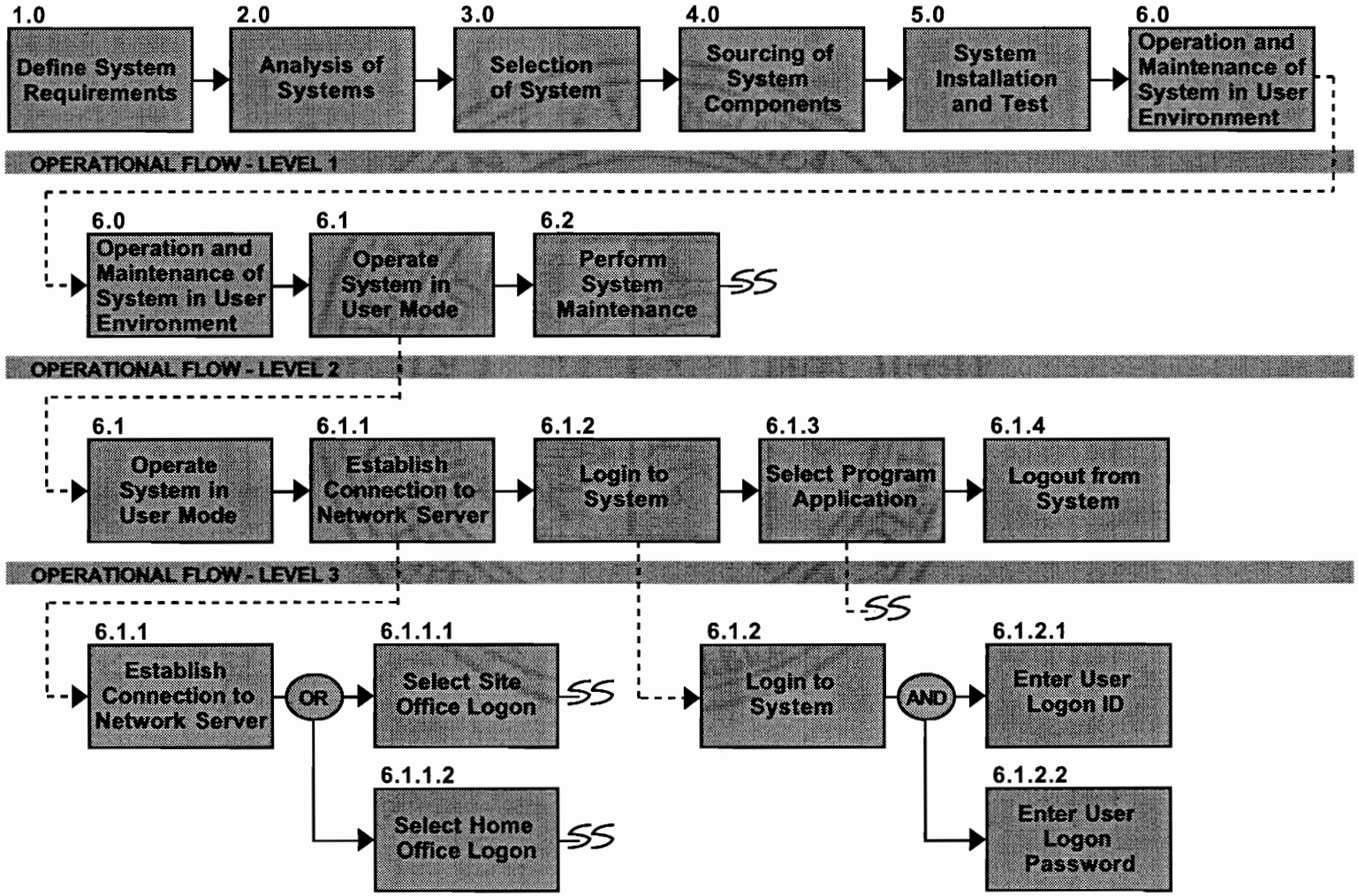

Figure 8. Operational functional flow diagram.

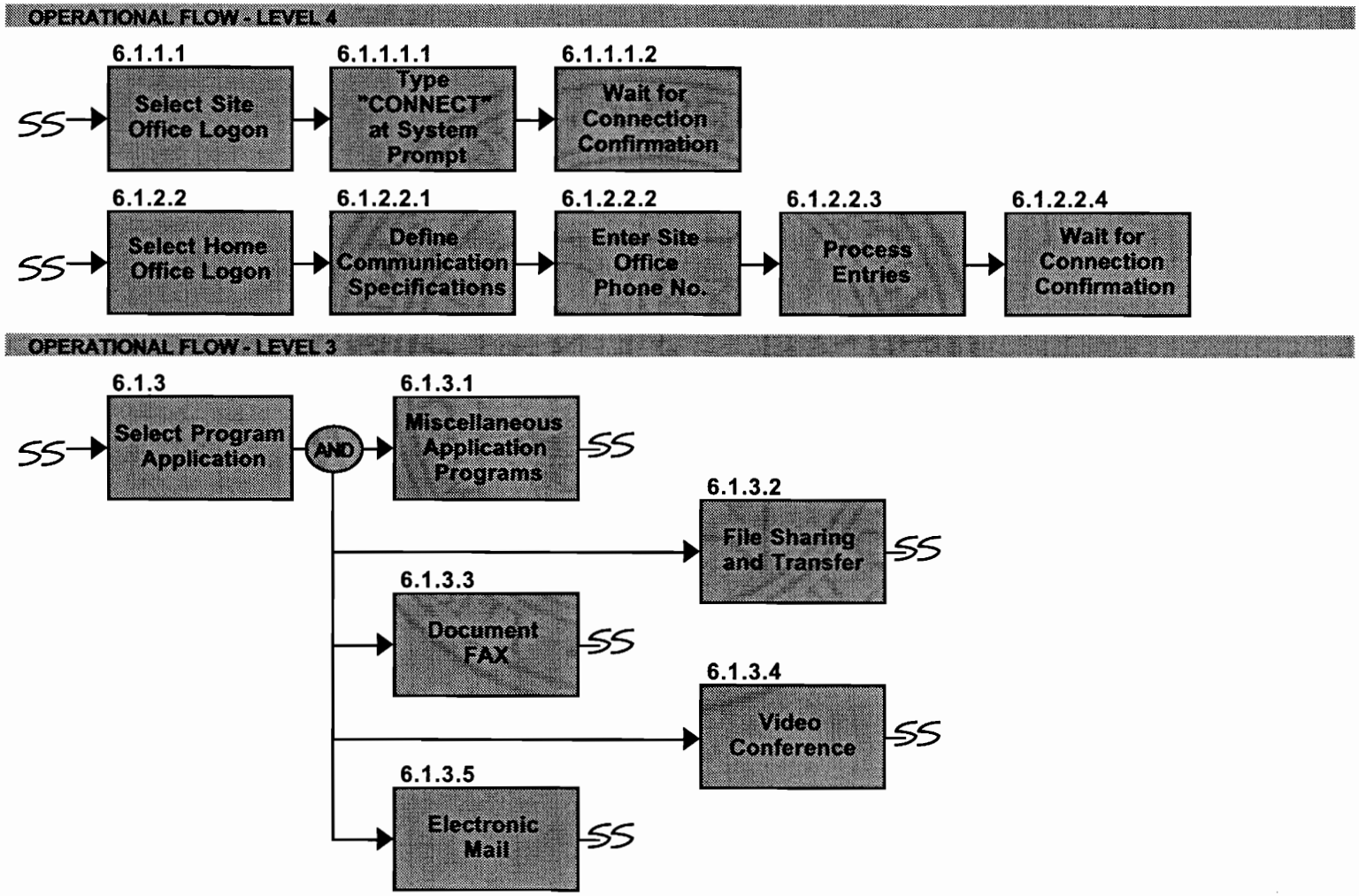

Figure 9. Operational functional flow diagram.

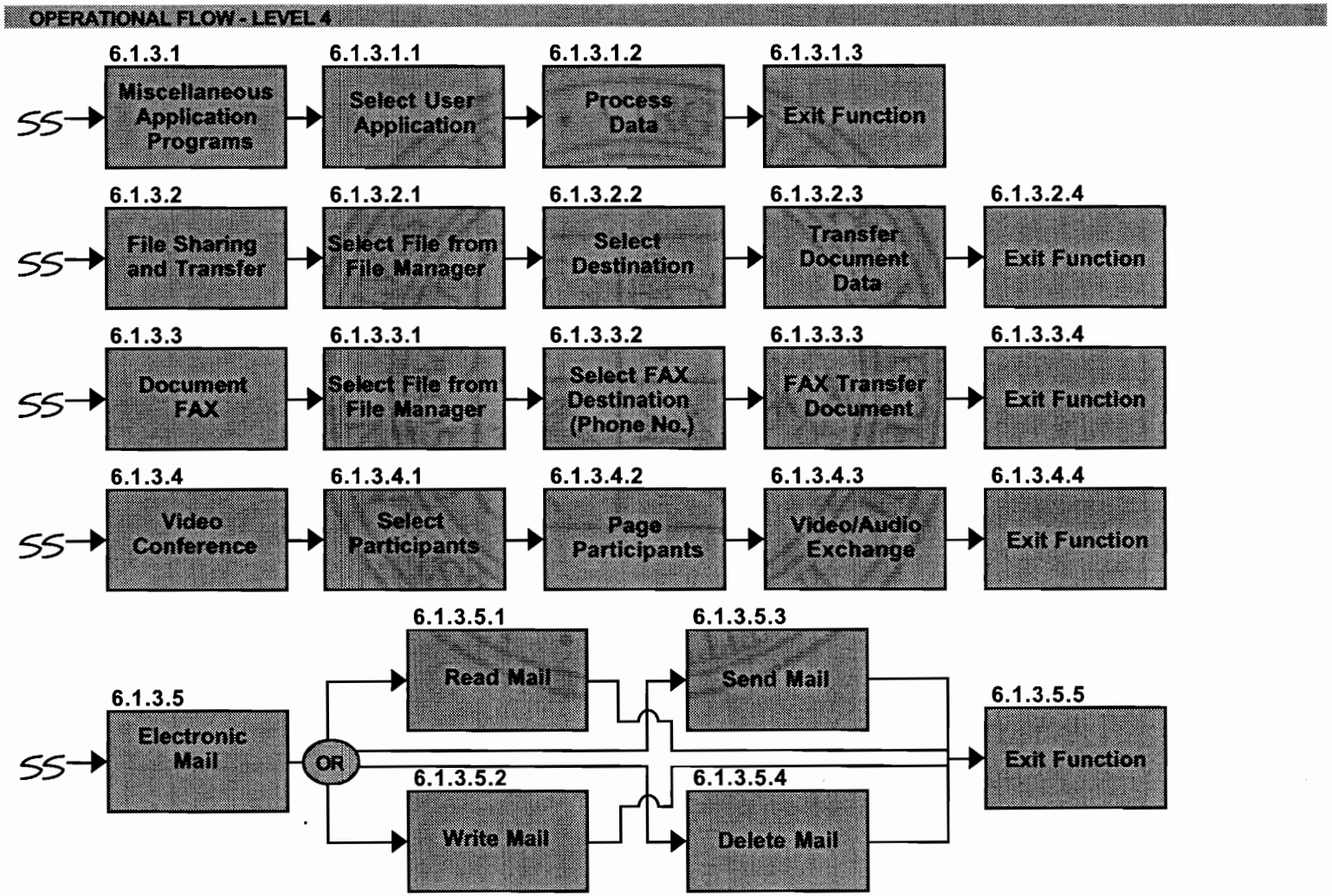

Figure 10. Operational functional flow diagram.

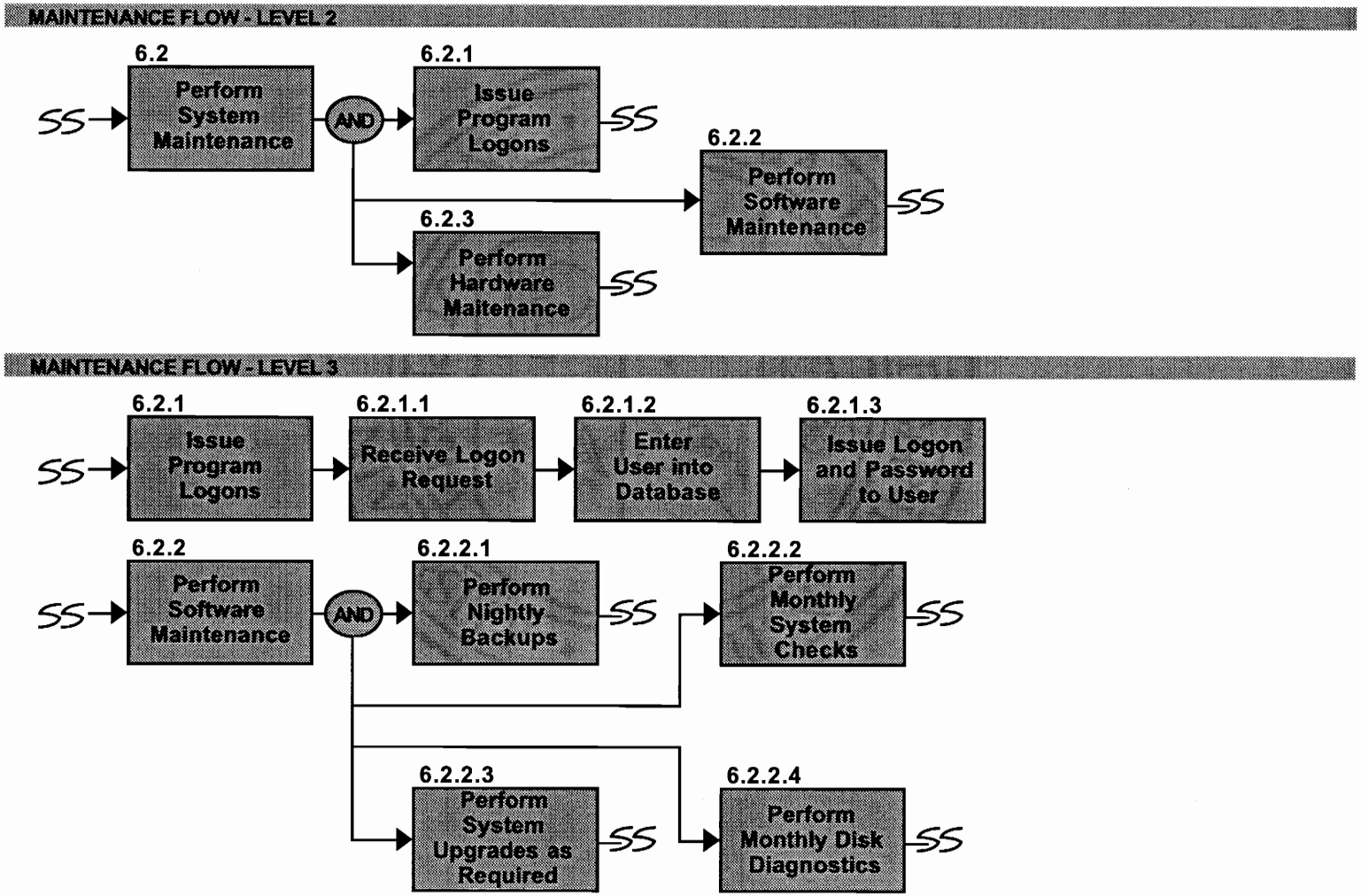

Figure 11. Maintenance functional flow diagram.

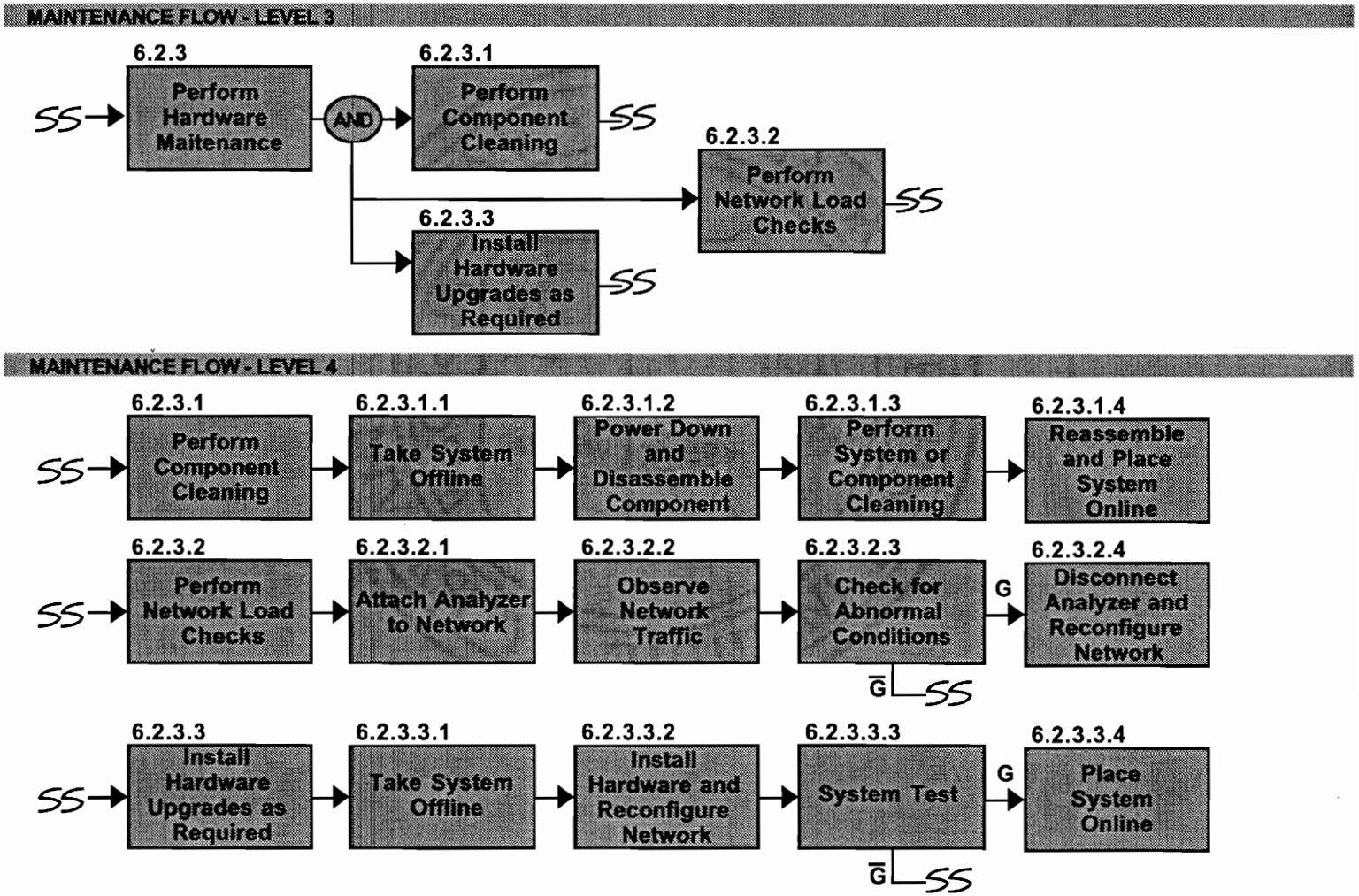

Figure 12. Maintenance functional flow diagram.

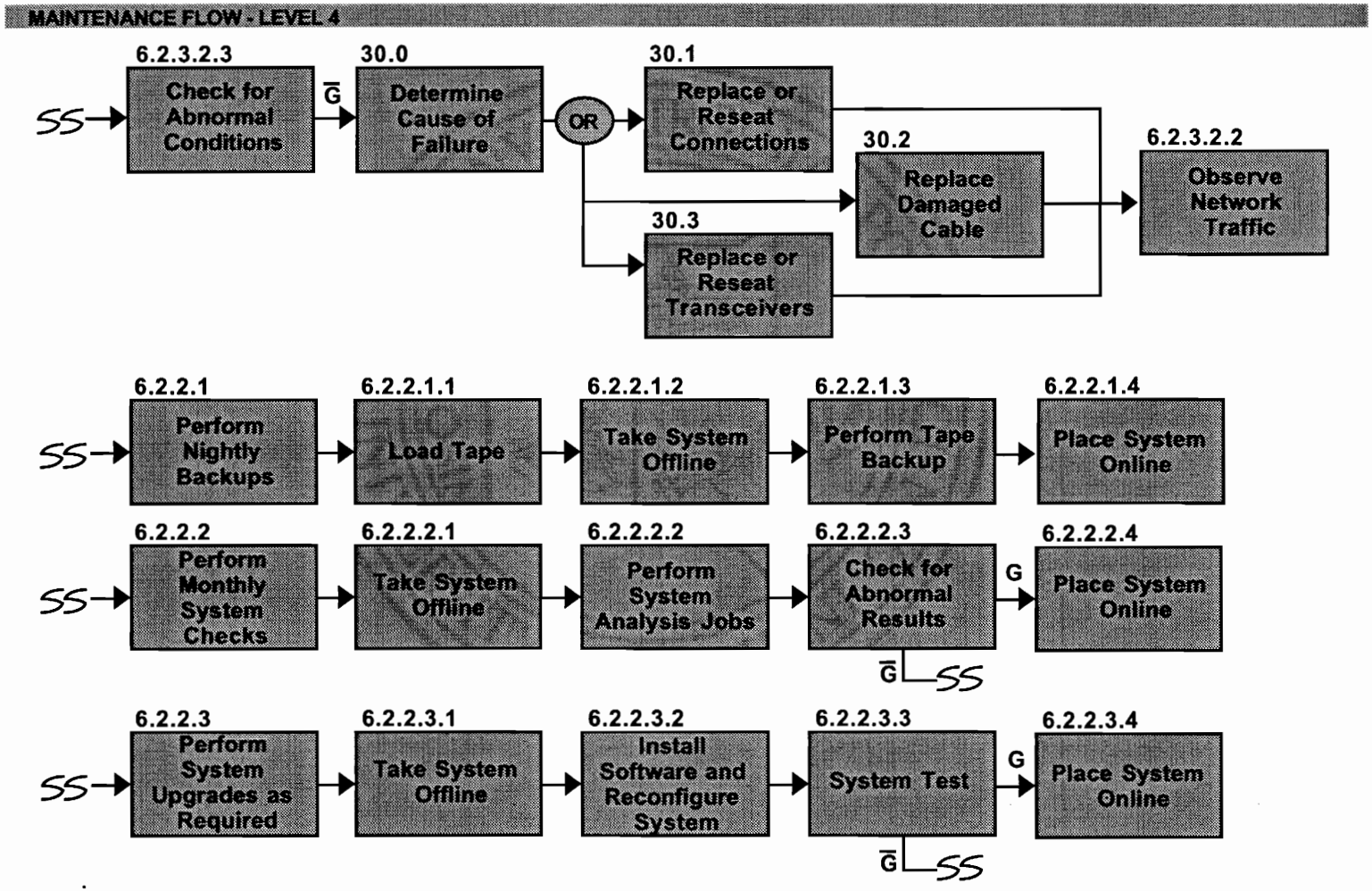

Figure 13. Maintenance functional flow diagram.

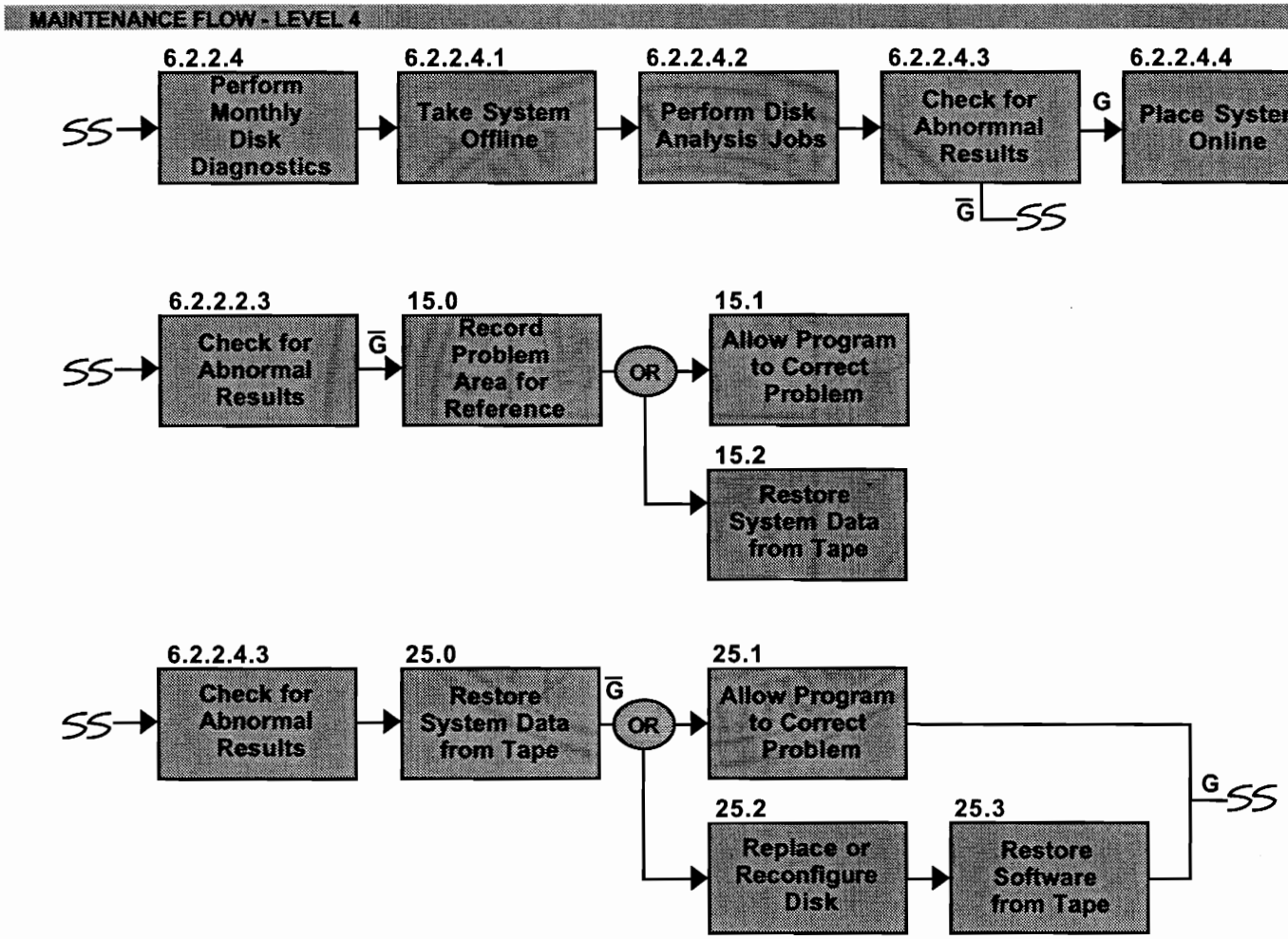

Figure 14. Maintenance functional flow diagram.

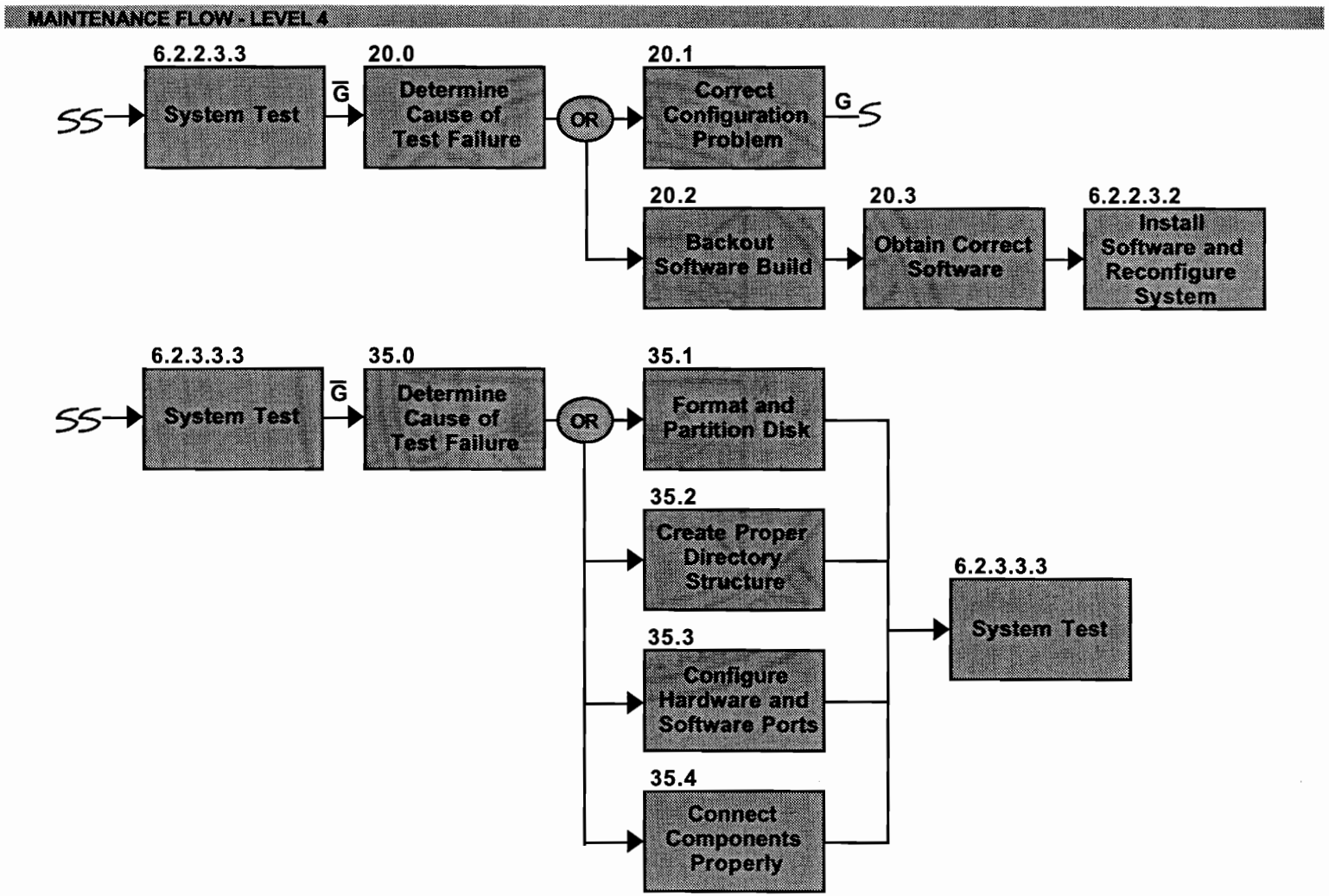

Figure 15. Maintenance functional flow diagram.

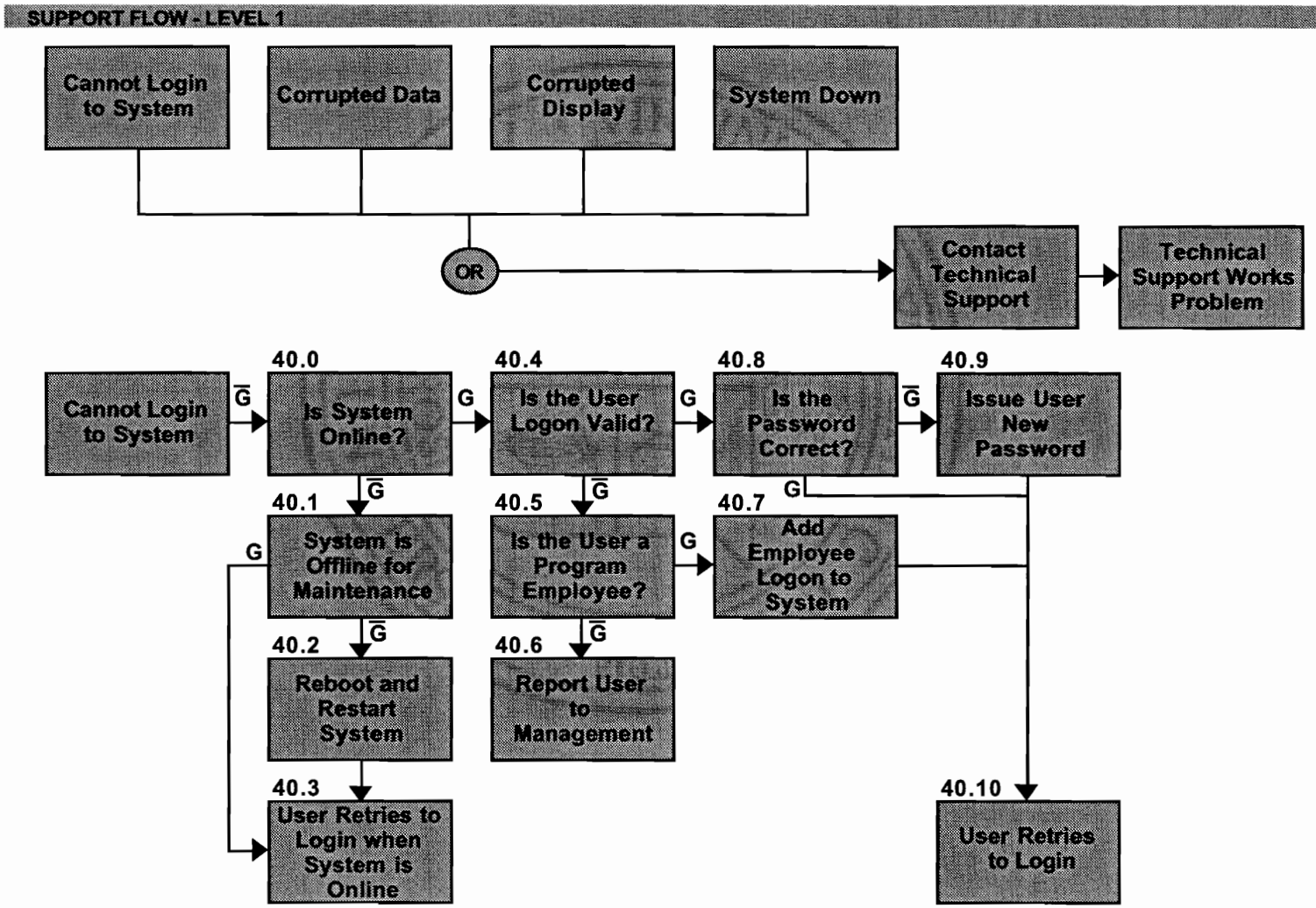

Figure 16. Support functional flow diagram.

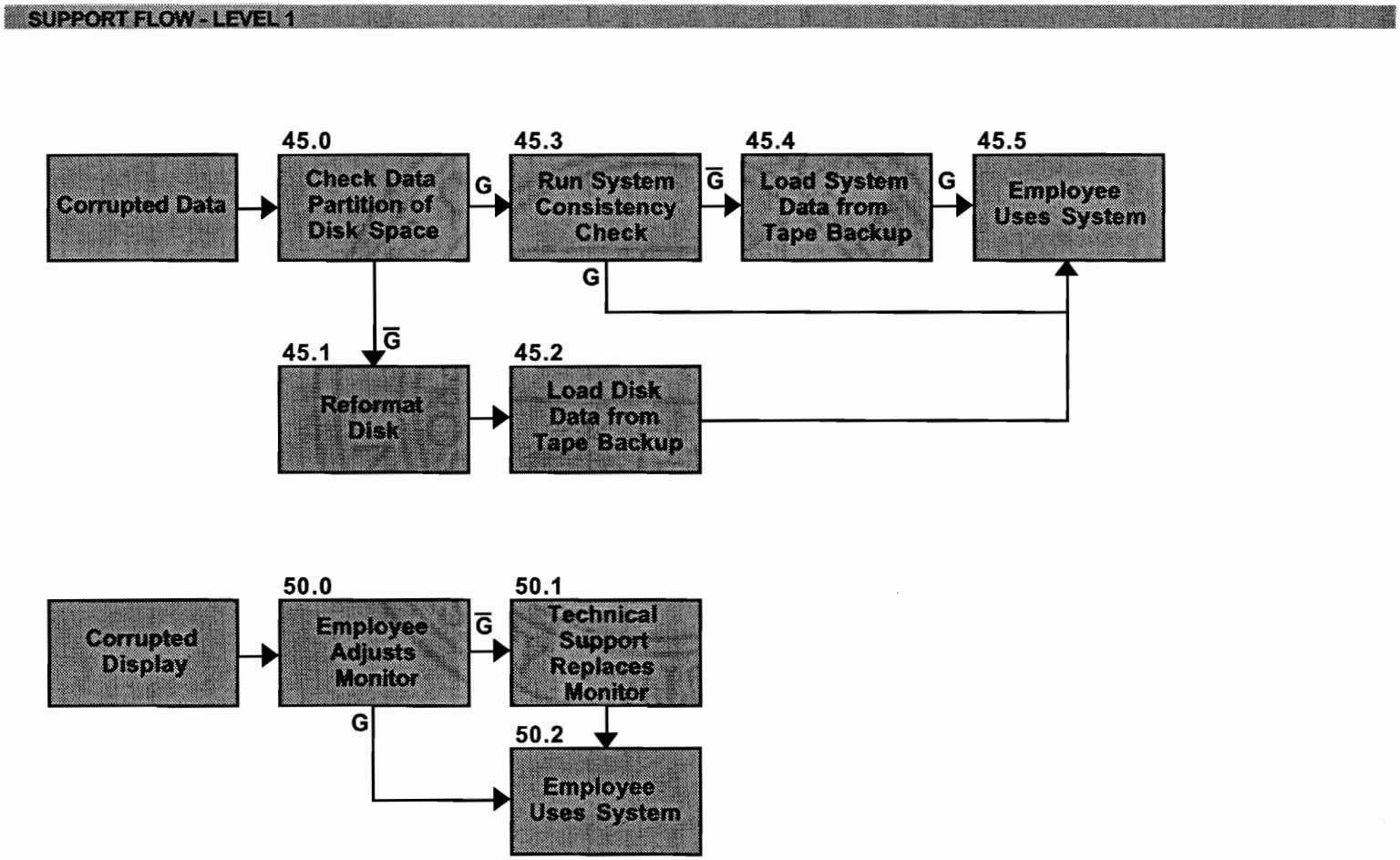

Figure 17. Support functional flow diagram.

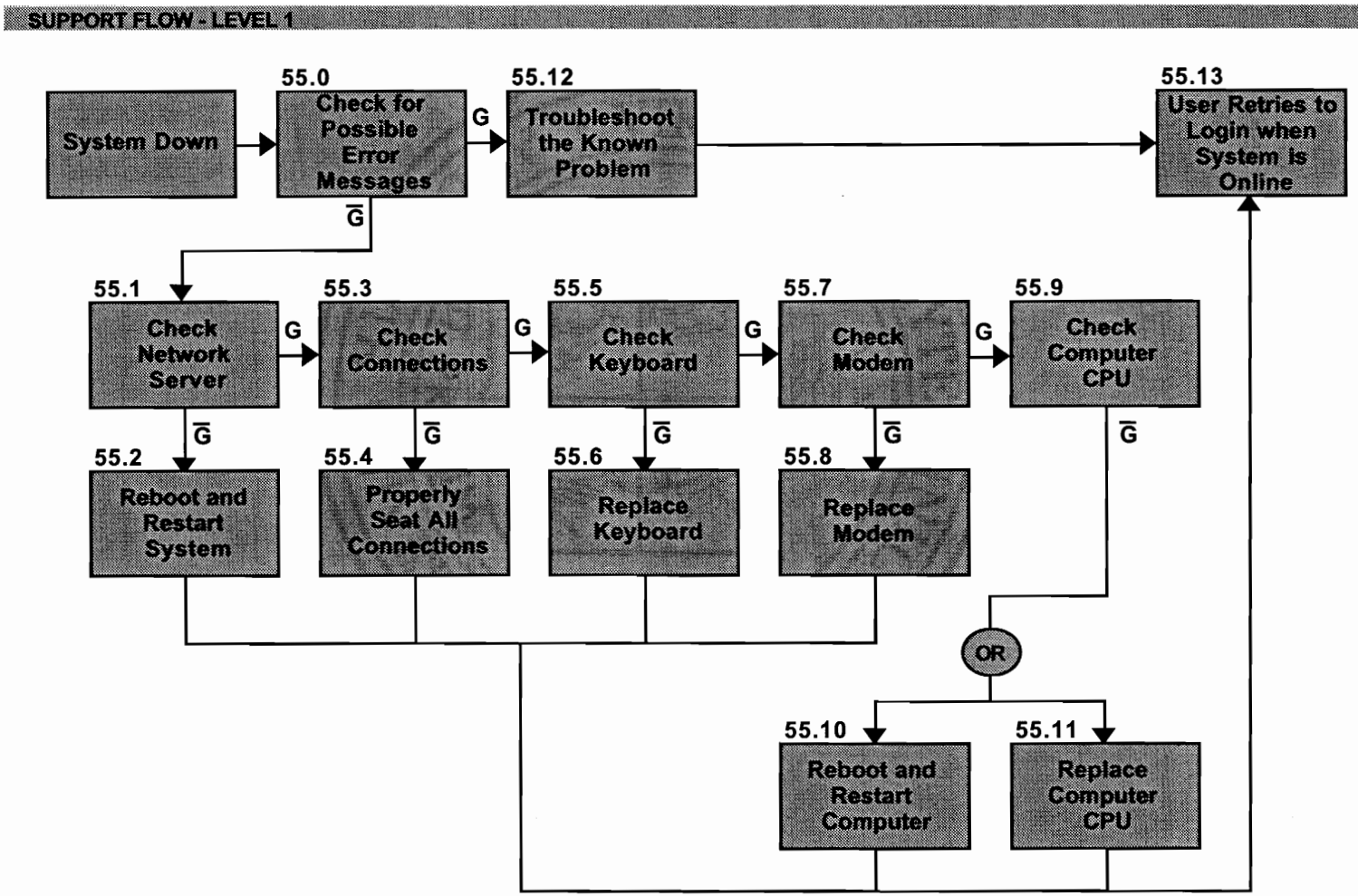

Figure 18. Support functional flow diagram.

operational flow in Figure 8, function number 6.2 to greater detail in Figures 11 through 15.

Support Functional Flow

System support is required when there is a fault in the system. The support procedures are performed by the technical support team. Figures 16 through 18 define a scope of potential user problems when trying to use the network home office system. If any of these problems occur, technical support is called to work the problem. Each problem is broken down into a set of steps taken by the technical support on what needs to be done to solve the problem.

Allocation of Requirements

The allocation of requirements breaks the network home office down into components from the system level. This is done to ensure that the combination of all of the system components produces the desired levels of performance, reliability, and maintainability for the system itself. By establishing the hierarchy of the network home system along with system requirements, potential system components are then defined and from the number of available options, an optimal system is selected.

The system parameters included in the requirements allocation include system effectiveness factors, system performance parameters, system

maintainability and supportability, and life-cycle cost parameters. Figure 19 shows a breakdown of the network home office from the system level down to

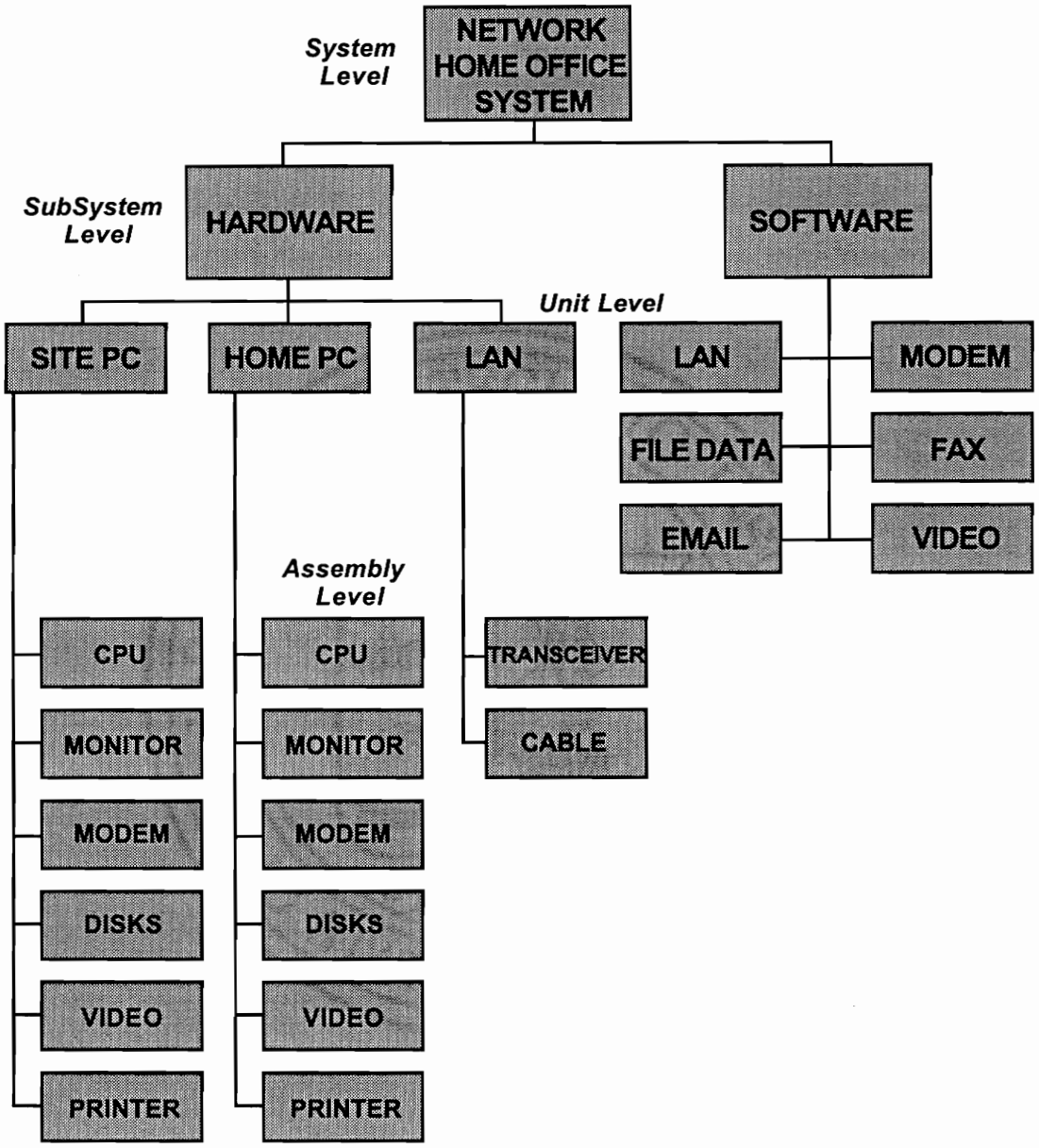

Figure 19. Network home office system hierarchy.

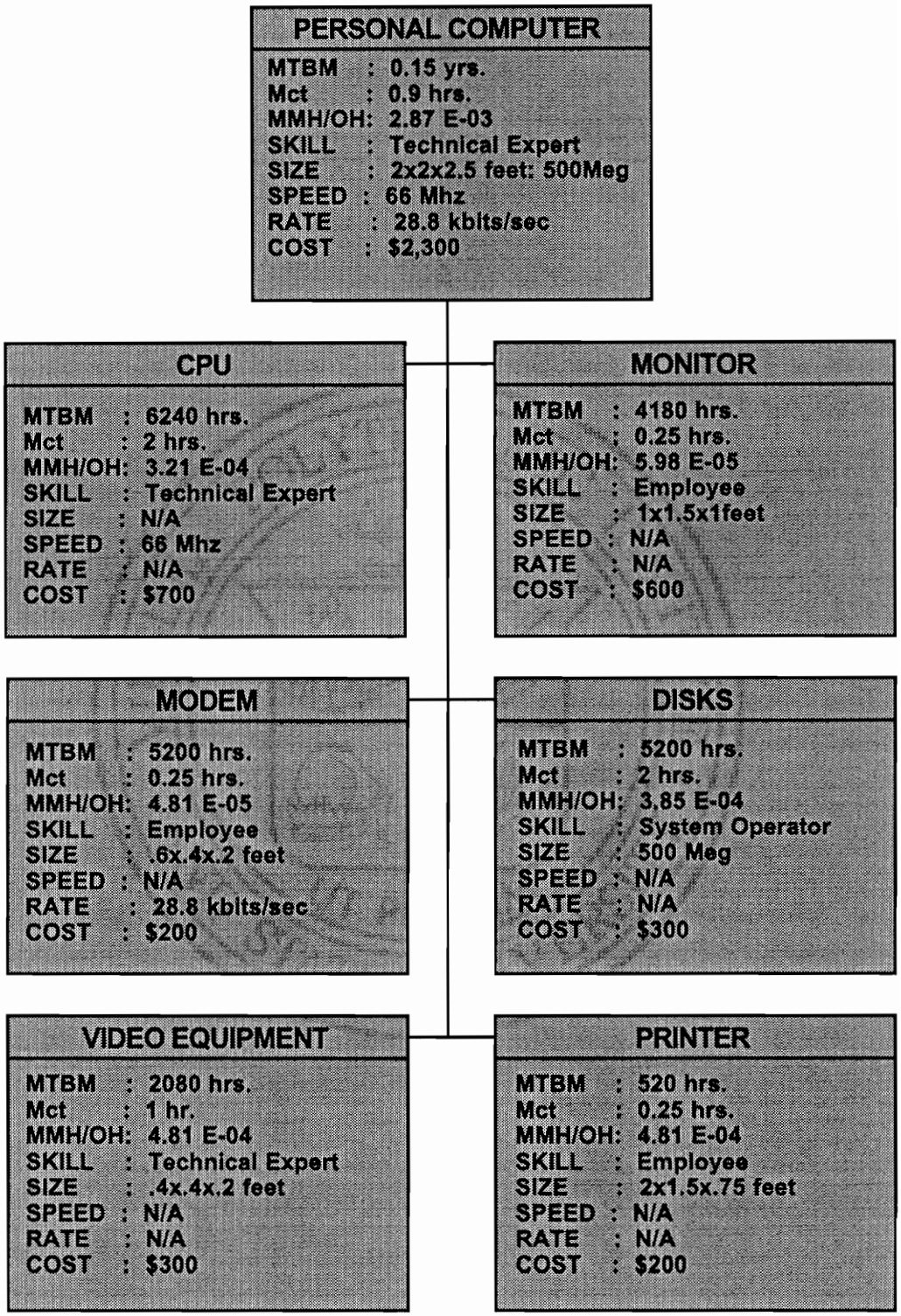

Figure 20. Personal computer requirements and allocation.

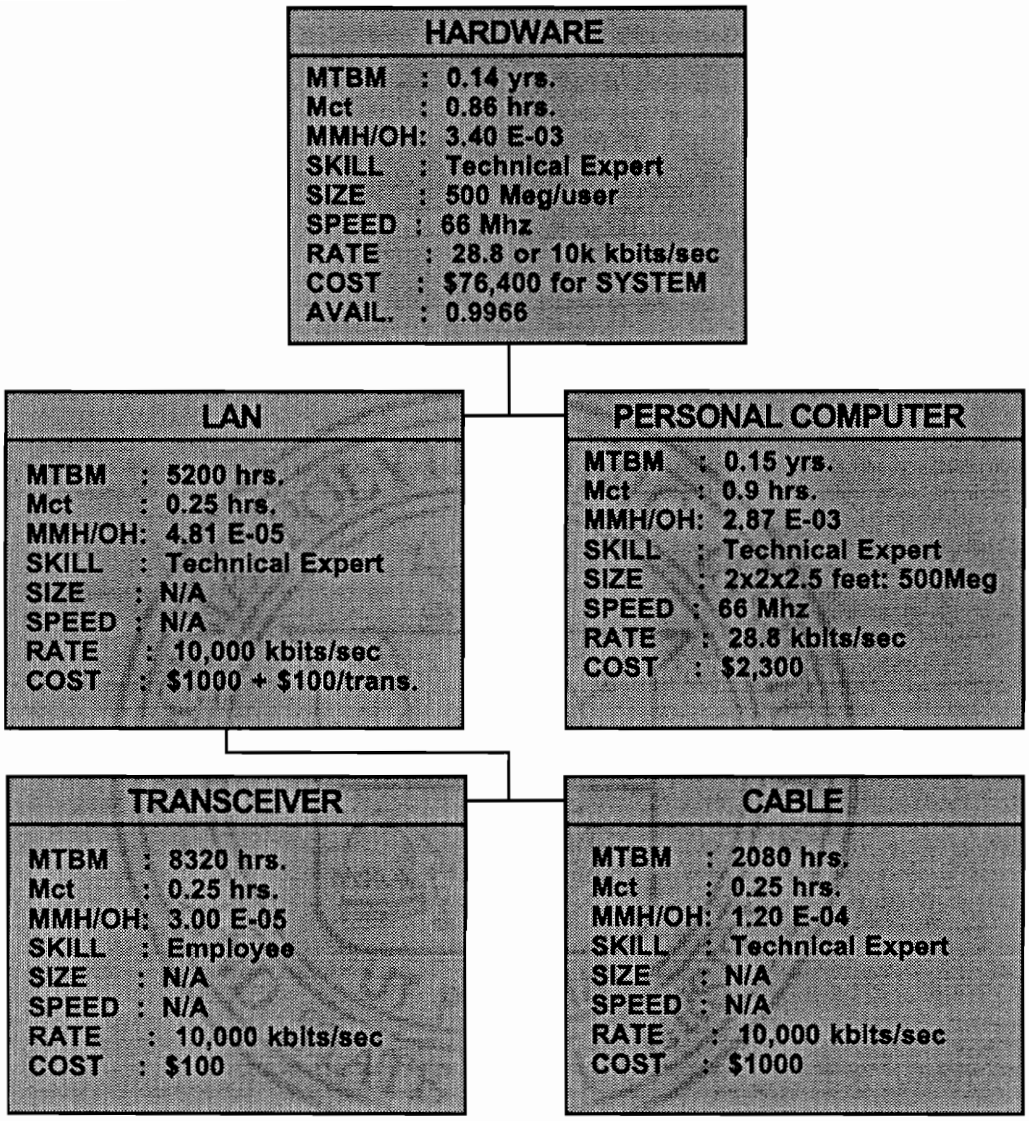

Figure 21. Hardware and network requirements and allocation.

the component level. Figures 20 through 23 expand the component level to show the allocation of required system parameters. Figure 20 shows the requirements breakdown for the personal computer setups. Figure 21 combines the computer setup with the LAN network breakdown to define the

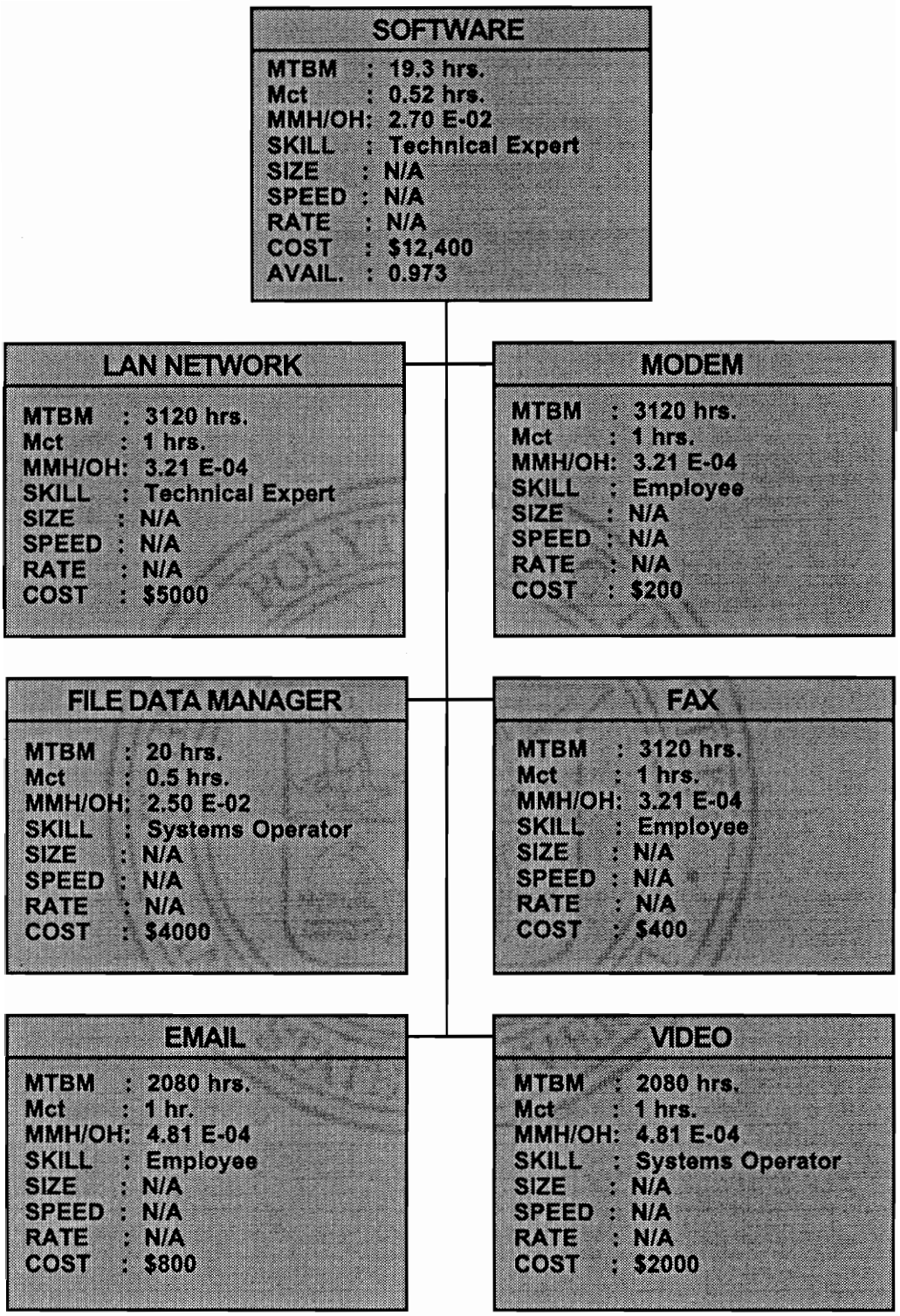

Figure 22. System software requirements and allocation.

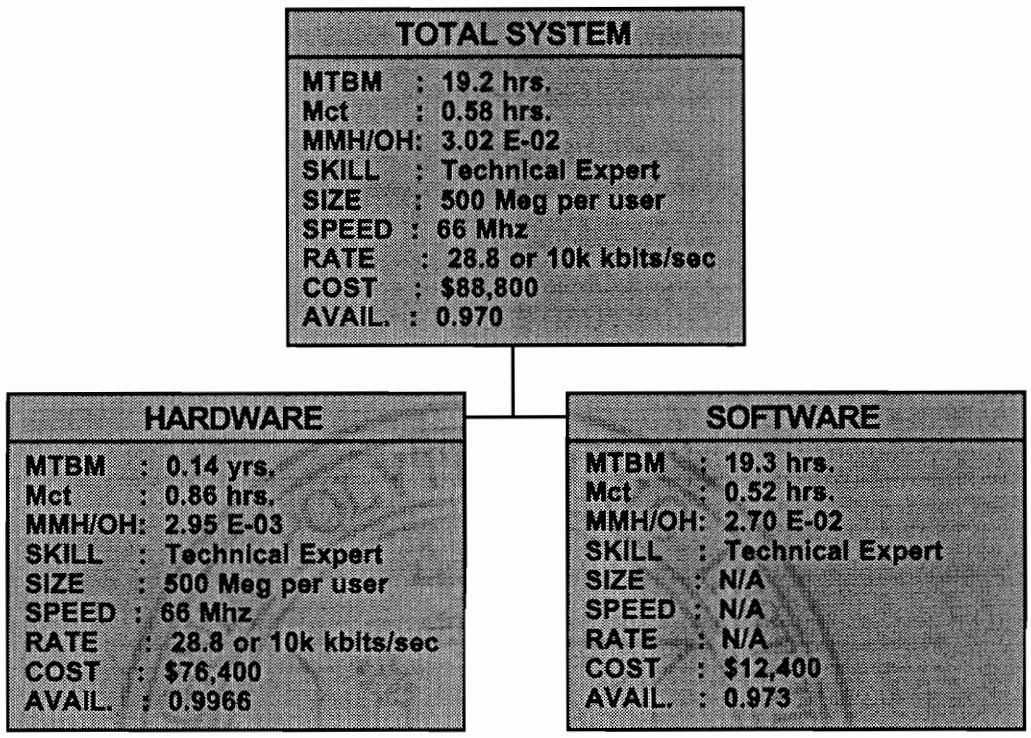

Figure 23. Total system requirements and allocation.

hardware. Figure 22 defines the software and Figure 23 combines both hardware and software to define the total system. The previous figures define all of the requirements for the network home office based on system experience with the products. In Figure 23, the MTBM defines the system mean time between maintenance. At 19.2 hours, the system will be down approximately two times during a 40-hour work week. The Mct represents the mean corrective time that the maintenance is performed in. The Mct value of 0.58 hours translates to the system being down one-half hour each time the system is down. Overall, the system is down for one hour in any given work week. The variable, MMH/OH, stands for man maintenance hours per system

operation hours. Thus, for every 33 hours spent on the system for operations, one hour is spent on maintenance for the system. The system availability of 0.97 reflects the system being available for all but one hour for every forty hours worked.

Calculations for Figures 20-23 are based off both hardware and software performance statistics and past performance characteristics within currently existing programs. The MTBM, Mct, and MMH/OH data for each individual component are then compiled into the hardware and software unit data via weighting each statistic based on the frequency of maintenance and time needed to complete maintenance in a given year. The final values are calculated by adding the weighted components together. The totals for both hardware and software are combined in an identical method to produce the overall system statistics.

The system cost is for the previously defined program size for 25 employees, which includes one manager and two technical support personnel. Each employee receives a home terminal and with three site terminals for management and technical support, the total PCs is set at 28. Add three more for the computer lab to reach a total of 31. This is the bulk of the system cost. The addition of network cable for the LAN and the transceivers to allow network communications, and the system total arrives at the listed value of $88,800.

System Component Definition

From the allocation of requirements, potential components for the system are listed that are to be compared for both effectiveness and cost. The allocation of requirements defines the parameters of the network home office. This narrows the potential component choices for the system.

The computer selections for the system personal computer must run at a speed of at least 66 MHz. The available products that meet this specification are a 486PC, a Pentium PC, and the Apple Macintosh. The monitor selection is only limited by the $600 price that most SVGA computer monitors cost. The 28,800 bps modem selection is made so that it meets the requirement necessary to fax documents and cost at $200. The hard drive selection, which is built into the computer cost, must meet the 500MB disk storage space criteria listed in the requirements allocation. A larger size hard drive would certainly store more data, but the cost criteria would not be satisfied. The video camera component to mount on the computer monitor must cost no more than the $300 allocation. The printers for the home offices only must cost below the allocated $200. This precludes the purchase of any unnecessary expensive printers for each user and limits the purchase to either an ink jet or dot matrix printer.

For the network configuration, the transceivers must be able to transmit 10,000 kbits per second and cost no more than $100 each for the network home office. The cable must also transmit data at the 10,000 kbit per second

rate. Both ethernet and fiber optic cable are capable of transmitting data at this rate, but the cost for fiber optic cable runs well above the cost constraint listed in the requirements allocation.

There are a number of commercial software packages available for all software aspects of the network home office. The potential cost of developing any of these tools within Lockheed Martin would greatly exceed the cost of purchasing the software and licensing for each user in the network home office program. If Lockheed Martin decides to pursue developing the network home office system over a multitude of programs, then the in-house development of such software would be cost-effective. For the design of just one program, commercial off-the-shelf products provide a more inexpensive way to achieve the software requirements defined by the system.

System Trade Offs and Optimization

The above section on system component definitions defined all potential hardware and software choices for the network home office. Due to the constraints placed on the system by the requirements allocation, there are only a few options available for each component when it is feasible to select from available components.

The network home office system is designed to choose the components that satisfy all of the operational requirements at the lowest possible cost. This reasoning is sound for the purposes of gauging the cost for a basic network

home office without any other requirements placed upon the system by the program that is using it. The technology that a given program starts with and uses is the hardware and software that is the baseline for design of whatever product or service the program is in charge of producing. The program predefines the necessary hardware and software for completion of the project before the project is worked. This same philosophy is applied to the network home office. The program in the network home office example defines the minimal requirements in order to have an operational network home office system. Programs that employ this system might have the need for better componentry to complete their projects. This improved hardware and software have a higher associated cost. The network home office example is stated in order to project the lowest cost possible for implementation of such a system.

The choice of computer to fit the system requirements would be an IBM compatible 486PC with a processor speed of 66 MHz. The Pentium computers had a higher associated cost and were eliminated even though they met the performance requirement. The monitor selection for the network home office is a 17" SVGA monitor which is capable of handling the video conferencing technology while remaining at the $600 price requirement. The modem selected is capable of the 28,800 bps requirement necessary to fax documents. The hard drive selected has 500MB disk storage as listed in the requirements allocation. The video camera component selected to mount on the computer monitor is chosen and cost no more than the $300 allocation. For the home office, ink jet printers were chosen over dot matrix printers due to

their capability for better graphical output for the same price that is at the $200 allocation.

For the network configuration, the transceivers chosen are able to transmit 10,000 kbits per second and cost no more than $100 each for the network home office. Ethernet cable is the selected network cable for the network home office since it is the only candidate that met both the 10,000 kbps data rate and cost requirements.

System Synthesis

By combining all of the hardware components specified in the system trade offs and optimization section, the network home office design is combined to work as one system with functions defined in the system functional analysis. The combination of all hardware and software products provides a system that is able to manipulate data with no noticeable lag to the user. This is due to the 10,000 kbps data rate transfer provided by the network. The home user will only be able to achieve a 28.8 kbps data rate due to the fact that all data transfers are performed over the home office modem. This slower home office speed is still sufficient to perform all network home office user options.

With the system being down approximately one hour during a typical 40-hour work week, the home user is only inconvenienced for that time and can easily make up for the lost hour during another work day. If portions of the

maintenance are scheduled ahead of time, the home users can work any personal business during that time.

Final Design Review

The network home office is complete through the preliminary design phase. The operational, maintenance, and support functions are all listed by the use of flow diagrams that determine the list of needed system requirements. The system requirements defined what available hardware and software technologies fit the needs of the system. The candidates are compared for both performance and cost to determine the optimal component choices for the network home office. With the system completed through the preliminary design, more work is done to define the system environment and judge the system performance in that environment. This is performed in the detail system design and development phase.

5) DETAIL SYSTEM DESIGN AND DEVELOPMENT PHASE

The detail system design and development phase is concerned with the defining of all system components and the environment that they are used in. The system is described by breaking it down into subsystems that are further broken down to the component level. The modeling of the home office is completed in the detailed system design phase. Human factors engineering and cost concerns play major roles in defining the home office work area. While the employees for the system will vary from program to program, the maintenance personnel for technical support need to have certain skill sets that are defined. Technical performance measures are design related factors assigned to the system that define what the goals of the system are and how those goals are achieved. Life cycle cost of the system is established and the system cost-effectiveness is defined from the system cost. Final detail design activities include the proposed design configuration of the home office for the example program of 25 employees and evaluation of that system for effectiveness. The network home office design is passed through a formal design review that summarizes the operability of the system and its plans for implementation. After this phase, the network home office is ready for system implementation and implementation plans are defined.

Detail Design Requirements

The network home office is effectively composed of two major subsystems, the site office and home office. Each subsystem contains

specific hardware and software components that are required for system operation. The home office is configured with one 486 IBM PC with a microprocessor speed of 66 MHz. The PC is equipped with a 500MB hard drive for data storage and a 28.8 kbps fax capable modem for data transmission between the home and site office. For graphical display, each PC comes with a 17" SVGA monitor equipped with a video camera fixture on the top of the monitor for video conferencing. An ink jet printer is included with the home office for the employee to produce rough drafts of any project documents. Each network home office PC will be installed with all of the required program software to run the necessary applications for both the networking capabilities and any program specific applications. The network connection exists for data transfer between employees.

The site office consists of one computer for each program manager and technical support. These computers are identical to the ones located in each home office. There is also a computer lab that houses three personal computers along with a laser printer and a scanner for scanning paper documents for fax purposes. The three lab computers are also identical to the home office computers. All of the computers at the site office use the laser printer for output and the laser printer is also used by the home office users when a final copy of a particular document is needed.

The site office houses the file server computer that is defined as the personal computer for the system operator. The other components that comprise the network are also located at the site office. The ethernet cable

required to connect all of the site office terminals to the network is capable of handling 10 Mbits per second. The transceivers required for the reception and transmission of all user data also are capable of transmitting data at the 10 Mbit per second rate.

The network home office is to be used on small computer-based programs for initial implementation. If the network home office proves successful, it will then be applied to larger programs and other programs that require more additional hardware that is not computer related.

The system software for this system is all commercial off-the-shelf (COTS) software. The software packages are capable of running the data interaction on the network, handling any required file interaction by the users, transferring data over the modem between home and site offices, faxing any program documents, having a video conference between at least two users, and allowing the user to handle electronic mail. This software running on the listed system hardware represents the essential components needed for a network home office.

The employee is responsible for all damage not due to regular wear on both the office furniture and the computer equipment. They are also responsible for equipment theft and loss. This is required to ensure that each employee takes care of the home office and does not take advantage of this benefit. Employees are able to use their home PCs for personal use as long as the employee's personal business requirements (disks, paper, etc.) are not

being provided for by Lockheed Martin. Lockheed Martin will cover all phone charges associated with the operations of the network home office. The employee will be required to pay for electrical costs. While paying the electrical bills will add to employee cost, the costs will not be significant and will make the employee more frugal in usage of electricity. There is no easy way for Lockheed Martin to monitor and pay for electrical uses due to the network home office. By having the employee pay for electrical costs, the potential of employee abuse and overuse of electricity is avoided. Each employee that participates in the network home office is bound to work at least 18 months before requesting a change to a different Lockheed Martin program per corporate policy.

Home Office Model

The home office model needs to be a productive work area in order for the network home office program to be efficient and cost-effective. The employees are given a choice of two workstation designs for their home office work area so that all employees are satisfied with their home office work environment given the space they have for the workstation. Human factors engineering plays a large role in the development of the network home office work area so that it is not only a productive place to work, but an enjoyable place to work. Good system design requires the proper integration of human factors along with the hardware, software, data, and other elements [Blanchard, p.434].

There are three main areas in human factors that are taken into consideration. Anthropometric factors are concerned with human physical dimension and how the network home office work area is to be designed so that it is comfortable for all sizes of employees. Physiological factors, which involve how the employee reacts to the home office environment are important to the comfort of the work area. Psychological factors take into consideration the employee's needs of what the work area should provide that directly impacts employee attitude and motivation.

The employee performs a number of job operations in any given day. These job operations may include running a piece of spreadsheet software or holding a video conference. Job operations are broken down into job duties. Job duties for the above examples would be preparing a spreadsheet document or contacting the other employees to be in the video conference. Job duties are composed of job tasks. The above example job tasks are entering data into the spreadsheet or entering the names of the employees to be paged for conferencing. The focus is on the job tasks in order to satisfy human factors engineering design requirements.

For the usage of a computer terminal, the most relevant anthropometric dimensions define what the user experiences for both static and dynamic factors. Static factors that are important in computer usage are sitting eye height, finger width, and sitting arm height. Dynamic factors that are important include user preferred viewing angle for both the computer monitor and video camera, functional reach for each finger to the keyboard, and functional reach

for the user arm to the mouse [Cushman, p.269]. Most all of the tasks performed at the network home office work area involve computer interaction in the sitting position. Design specifications for the work area based around these factors produces a comfortable anthropometric work environment.

Human sensory factors are also important in the location of the network home office work area within the employee home. The selected room must be quiet for the employee to concentrate on the project work. The monitor output must be loud enough for the employee to comprehend the output. These two factors are up to the employee to control. The employee must provide a quiet work area in order to work proficiently. The employee also has control over the monitor volume so that it can be adjusted to a proper level. The work area must face away from any direct sunlight that will affect both the monitor display and the video camera. If sunlight were to fall on the monitor, the employee would have a hard time reading the display for the luminance of the monitor would pale in the sun's light. If the sun were to shine into the video camera, it would obstruct all other images and the receiving user would see a white or very bright unrecognizable image. The work area must however be illuminated enough for the employee to use the computer and read the displays and text documents. The illumination level for the work area is set to 100 foot-candles of light that is the recommended amount for business machine operation (computers) by the MIL-STD-1472 military standard, [Blanchard, p.444].

There are a number of physiological factors that affect human productivity. Most of these elements are environmental in nature and are

controllable by the employee. The room temperature must be maintained at a level so that the employee is comfortable and the equipment works without higher risk of failure. While it is recommended that the room temperature range from 65 to 75 degrees Farenheight, it is up to the employee to decide what level is comfortable. The humidity level should be low for the safety of the computer equipment but it is up to the employee to decide what levels of humidity are tolerable. Dust is harmful to computer systems and can shorten the life of the hardware components over time. While this is considered important, the life expectancy of modern computer equipment is high enough to outlast the length of most projects. The introduction of dust into the home offices shortens the life of the hardware but not enough to justify the addition of strict cleaning maintenance. Employees will be informed on how to clean their home systems and that cleaning is recommended. However, the cleanliness of the work area is ultimately controlled by the employee.

Psychological factors include stress, low motivation, and attitude among others. These factors cannot be controlled by the network home office directly. The only way to affect these factors are to provide a good system for the employee to use and a good environment to work in. The network home office strives to provide this scenario, although the preferences of each employee differ.

The location of the employee with respect to the monitor or visual display terminal is important for the user to maintain focus and alignment of the eyes [ANSI, p.31]. The computer shall be located so that it sits at a distance of 12 to

16 inches from the user. This allows the user a comfortable viewing distance from the monitor and an equal distance to either side of the monitor for documents being worked on. This alignment is more efficient for the user since the viewing distance is the same for both monitor and documents.

The slope of the keyboard shall be between 0 and 25 degrees [ANSI, p.37]. By including a pull out adjustable keyboard rest from under the corner work surface, the user has the option as to what height and angle the keyboard sits at. Care will be taken to ensure that the keyboard rest is a sturdy device so that the keyboard does not rock when being used. All keyboards provided for the network home office will be of the QWERTY configuration.

The final design of the network home office workstations that best satisfy all of the human factors requirements and standards are a corner design and a smaller straight design shown in Figure 24 and Figure 25 where the work area is shaped like the capital letter L for the larger design in Figure 24. For this design, the computer resides in the corner of the work area and a pull-out keyboard stand is accessible from underneath the corner work surface. The legs of the letter L are work areas for the employee and a spot for placement of the ink jet printer. Holding up one of the legs is a three-drawer stand with room for manuals, documents, and files. The other leg of the L contains a pencil drawer underneath it for storage of smaller items. Over each leg work surface, there is a flipper door cabinet for storage of larger items, such as books and boxes. The entire work area is framed by two large panels that define the capital L shape and stabilize the ends of each work surface leg. The chair

chosen for the home office is a cushioned, adjustable chair with rollers. This chair provides the employee comfort along with the option of adjusting the seat height to account for different sizes of users.

For the smaller workstation design in Figure 25, a straight configuration is chosen. This is to allow employees with smaller living areas to fit an office in their house without it taking up to much space. The design will consist of two work surfaces attached to each other at the middle. Each surface will have an overhead cabinet and light. Depending on the choice of the user, the file cabinet and pencil drawer can be on the left or right side and the computer with keyboard stand will exist on the side that the file cabinet is not located. Due to the space limitations, the user will have to use the keyboard stand for the width of the work surface cannot comfortably hold the monitor and the keyboard. The printer can then be placed in the opposite corner from the computer, still leaving a reasonable amount of workspace left for the employee for reading or writing.

The dimensions of both workstations are chosen to produce a comfortable work area for a range of employees from the 5th percentile female to the 95th percentile male. While the work area may also be fine for people outside of this range, the design of the workstation is guaranteed to be within specification for those within the user range. For the large workstation, the corner work area is to be 24 inches deep and 24 inches wide for each side of the corner. The legs of the L are both 24 inches wide by 36 inches long. The entire work surface is 30 inches high. These dimensions satisfy the minimal

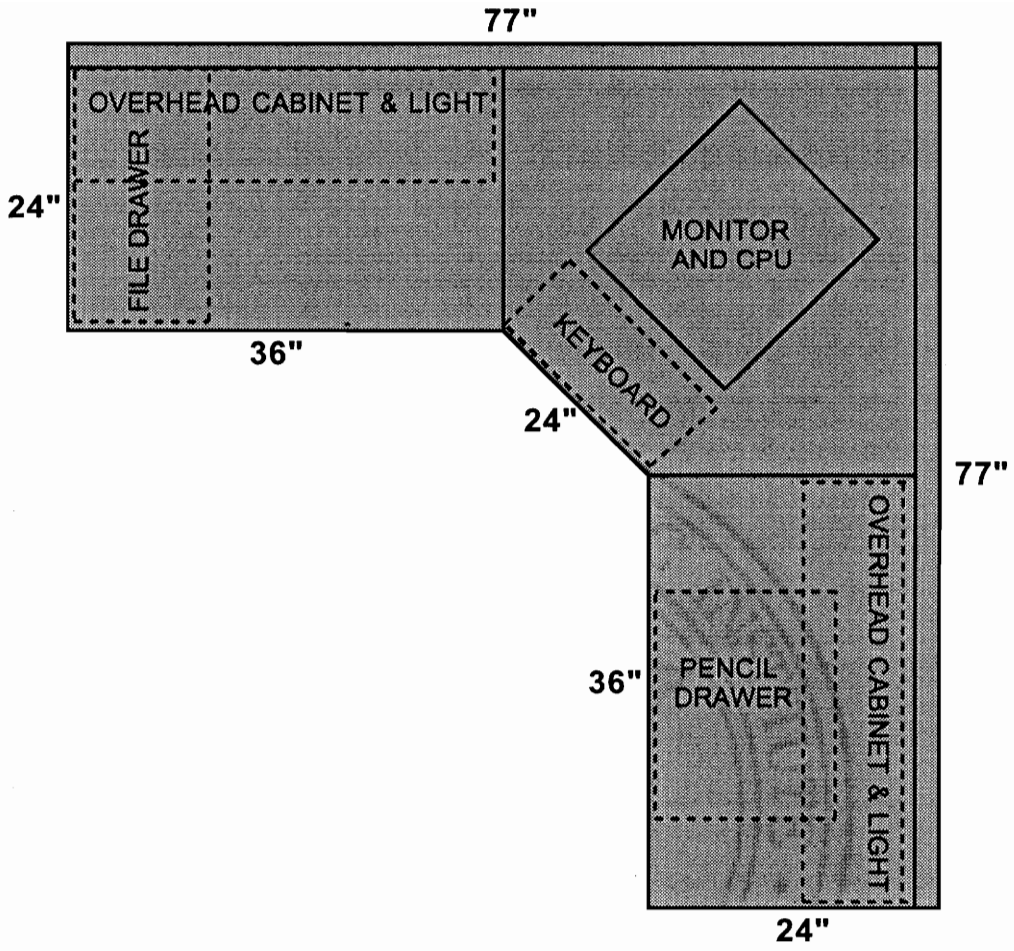

Figure 24. Large home office work area top view.

requirements of 23.5 inches for depth, 20 inches for width, and 26.2 inches for height [ANSI, p.45]. The additions of the pencil drawer and keyboard rest restricts the height in those areas by only 3 inches that still places the office design in specification limits. For the small workstation, each surface is 24 inches wide by 36 inches long and all other height and depth specifications are identical to that of the larger workstation.

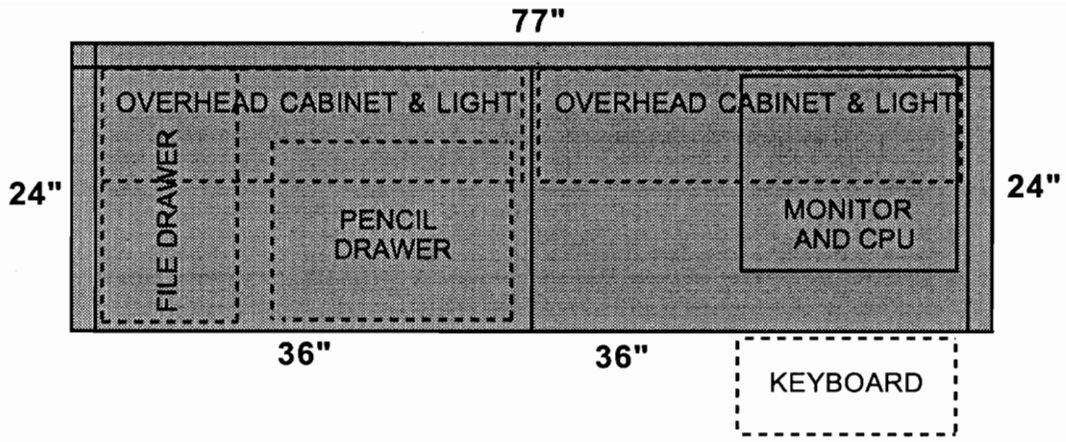

Figure 25. Small home office work area top view.

The selected seat has an adjustable height of 16 inches to 21.25 that falls within the ANSI guideline range of 16 to 20.5 inches [ANSI, p.52]. This range allows for the aforementioned 90% user range to be comfortable in the desk seat while working at the workstation. The depth of the seat falls within ANSI standards as does the height. The selected seat also provides lumbar support for the user.

Maintenance Personnel

The three types of maintenance personnel required to support the network home office are a technical expert, a system operator, and technical support personnel. Every program needs at least the first two positions. The addition of more technical support personnel is dependent upon the additional hardware and software requirements placed upon the system by the particular

program. The size of the program also determines the number of added technical support. The guideline used for the network home office is that each program must have a technical expert to deal with the hardware problems and a systems operator to deal with software and administrative problems. Technical support personnel are provided to assist the technical expert and system operator as required and there should be one extra technical support person for every fifteen people over twenty within a program. The sample program has only 25 employees, therefore there is only need for a technical expert and a systems operator. However, if the size of the program was 40 people, then it is advised to hire another technical support person.

The maintenance personnel are to be available at the site office from 7AM until 7PM during the work week. The maintenance personnel are to ensure that those hours are covered each week while adhering to a 40-hour work week for each member of the maintenance team. The maintenance personnel will also be on-call to solve any emergency maintenance or support requirements as necessary.

The tasks involved with each position and the background requirements are listed below for each position:

POSITION:	Technical Expert
EXPERIENCE:	5+ yrs. in network H/W and S/W related maintenance
EDUCATION:	BSEE, BSCS, BSSYSE with computer skills
JOB TASKS:	1. Capability to reset the system after downtime.

2. Run software to test system health/robustness.
3. Interact with employees to respond to service requests and system questions.
4. Maintenance for logons: create new logons, delete old logons, and compress library.
5. Preventative maintenance checks for system S/W.
6. Perform system upgrades of new software products and develop methods to utilize and test new system functions.
7. Preventative maintenance for system hardware.
8. Perform system upgrades with new hardware products and develop methods to utilize and test new system functions.
9. Ability to travel to user sites to handle anomalies.
10. Interface with manager, customer, employees, and other maintenance personnel daily.

POSITION:	System Operator
EXPERIENCE:	3+ years in network software related maintenance
EDUCATION:	BSEE, BSCS, BSSYSE with computer skills
JOB TASKS:	Identical to those of the technical expert except for job tasks 7 and 8.

POSITION:	Technical Support
EXPERIENCE:	Familiarity with computer network systems

EDUCATION:	BSEE, BSCS, BSSYSE with computer skills
JOB TASKS:	Assist both the technical expert and system operator with tasks 1 through 10 as required.

Technical Performance Measures

Technical performance measures are used to evaluate the design related factors for the system as a whole or any of its components. The system is assigned characteristics that are important to its success. These characteristics are judged in importance of effectiveness out of one-hundred percent with the characteristics with the larger share of the percentage being more important.

For the network home office, there are four system characteristics that are important for the success of the system program. These characteristics are system availability, system performance, system usability, and speed of implementing the system. The percentages of importance for these four characteristics is thirty, thirty, twenty-five, and fifteen respectively.

For system availability, the system is designed to be available at all times during the day with exceptions being made for maintenance and potential system faults. The availability is the percentage of time that the system will be available to the users. From the section on requirements and allocation, the system availability is 97% which is highly satisfactory. For a twenty-four hour day, the system is down for only approximately 45 minutes.

The performance of the system was defined so that the user would not be able to notice a lag in the data display on the monitor when accessing data from the system. The response time of the system is a summation of the transmission delay, the processing delay, and the propagation delay. The transmission delay is the number of bits in a transaction divided by the transmission rate. A typical page of data contains approximately 1 kilobyte of information. With the network operating at a speed of 10 Mbps the transmission delay is 0.0001 seconds. Processing delay is the number of instructions divided by the clock speed of the computer's CPU. With a CPU processing speed of 66 Mhz, the processing delay for the network home office is considered negligible. Propagation delay is the distance the data has to travel divided by the propagation rate. The propagation rate for telephone lines that the data will be traveling over between the home and site offices is $2x10^8$ meters/second. Making an assumption that the furthest employee from the site office will be no more than 100 miles away, the propagation delay is approximately 0.0008 seconds. The response time is these three values added together which equals 0.001 seconds delay. With only a millisecond delay, the employee will not notice a delay in screen displays.

System usability is determined by the human factors engineering that goes into the design of the office and the selection of software to be used by the system. These criteria are satisfied by the previously defined home work area and by controlling the user environment as much as possible. COTS software is selected to be user-friendly and effective and be mouse driven.

These considerations make the network home office a good environment to work in with an effective set of tools to work with.

The speed of implementation of the system is important for Lockheed Martin in securing more commercial contracts. If the system can be established within six months after winning a contract, it is successful. The network home office implementation plan is arranged so that the system can be established within a six month time frame.

Life Cycle Costs

The concept of life cycle cost for a given system is founded on considering the various costs associated with the system from the defined need to final phase out. By considering life cycle cost throughout system development, it is easier to design the system to be economically feasible. Total cost visibility is the inclusion of all system related costs. These costs include operations cost, personnel cost, hardware cost, software cost, supplies cost, maintenance cost, and acquisition cost for the network home office.

The cost of operations for the network home office is where the major cost savings occur when compared to a typical site office program. Operations costs include office rental, utilities, and taxes. For the Washington DC metro area, which covers cities and towns such as Springfield, Tysons Corner, Fairfax, and Falls Church, the average rental price for office space is $2.00 per

square foot per year. Utilities and taxes for this area come to $1.25 per square foot per year, making the total cost of office rental $3.25 per square foot per year. For each person, it is advised that 200 square feet per person be allocated. For the prototype of a 25 person site-based program, 5000 square feet would be necessary at a total cost of $16,250 per year. For the network home office only the manager and two technical support personnel are required. If more space is added to include two more people, an office to hold five people would be required. According to the above cost figures, the rental price for the office is only $3,250 per year. A cost savings of $13,000 is realized by using the network home office!

Added costs to the network home office are due to phone installation and charges. For each user of the network home office, a second line needs to be installed for data communication. Bell Atlantic services the Washington DC metro area and charges $42 as a base charge for jack installation plus $64 an hour for actual time spent for installation. Bell Atlantic states that it takes them a half-hour for most all phone jack installations. The total cost for each installation would then be the $42 base charge plus a $32 installation time charge plus applicable taxes. The total for each home is approximately $80. Monthly phone fees for an unlimited local line are $20.51 a month. Adding taxes and other miscellaneous fees, the cost becomes $25 a month and $300 a year. For the 25-employee model, the first year cost for installation and one full year of phone service would be $380 an employee for a total of $9500. For each following year, the cost covers phone service only at $300 a year for each home office employee for a total of $7500.

Personnel cost for both the site-based program and network home office program would be identical since personnel salaries would not be affected by work location. For 25 employees earning an average of $40,000 a year, the total cost would be $1,000,000 in total salary. Potential cost savings for the network home office are achieved by savings in overhead costs. For a current program at Lockheed Martin, the average personal illness and business time taken per person per year was 44 hours. There is no way to predict the amount of personal time taken by employees working in the network home office system. It is assumed that this time would be less due to the fact that appointments during normal working hours that would cost the company overhead time would now be a part of the employee free time. Since the employee works at home, it would be easy to take an hour off during the day and make it up that night. If just 12 hours were trimmed from the total overhead time of 44 hours at the defined salary, a cost savings of $231 per employee or $5775 per program per year is realized.

The hardware cost is already established in Figure 21 for a total cost of $76,400 per hardware system and the total system software cost from Figure 22 is $12,400. This provides a total network home office system cost of $88,800 for hardware and software components.

The supplies cost for the system would be equivalent to the supplies required by a typical site-office set up with the exception of printer ink cartridges for all of the home office ink jet printers. If there are 25 ink jet printers for the

system prototype that need to be replaced four times a year, then 100 printer cartridges are required. At $20 a printer cartridge, the total supply cost for the printers is $2000 a year. Other office supplies common to either office system of pencils, pens, paper, etc. have been summarized at a $2500 annual cost.

The maintenance costs are included in the salaries for the technical support. All of the maintenance software is included in the software costs and for spare parts for the network and home offices, an average assumption of $5000 cost per year is made. This cost includes purchasing maintenance equipment for system testing and potential replacement costs for faulty equipment.

The acquisition cost for the network home office is no different from any site-based office. Equal amounts of furniture must be purchased for either program and the installation costs would be similar if not identical. For the home office in the network home office system, costs were determined based upon the furniture required by the system home office configuration.

Figures 24 and 25 show the necessary components for a home office. For cost pricing purposes, the most expensive scenario is considered where all home users select the large workstation configuration in Figure 24. For each user that chooses the small configuration, the home office furniture cost will decrease. The office is broken down into parts with assigned prices for each part. The chair, not shown in Figure 24, is also included in the total furniture acquisition costs. The chair, which meets all of the listed ANSI

standards costs $278. The workspace prices are $305 each for the rectangular work surfaces and $549 for the corner work surface. The file cabinet is $359, the pencil drawer is $99, and the keyboard stand is $99. The two overhead cabinets are $550 each and the accompanying two lighting fixtures are $290 each. The two panel walls holding the work surfaces are $364 each and the hardware components to attach the two walls at the corner costs $16. The maximum total office cost for the home office is $3578 per office. For 25 home employees, three site offices for the manager and technical support, and three computer lab offices, the total number of required offices are 31 offices. The maximum total acquisition cost of the office furniture is $110,918.

For the network home office, the costs for the first year of the program include the hardware and software purchases, the furniture acquisition, employee salaries, office rental, supplies, and maintenance. This is a total first year cost of just over $1.2 M dollars. For following years, the cost only includes employee salaries, office rental, supplies, and maintenance. This cost comes to a total of around $1.03 M dollars.

The savings realized with the network home office are savings in rental costs and overhead costs. Rental savings would be $13,000 each year. Overhead cost savings would be $5775 each year. Added costs for the network home office would be the $2000 in printer cartridges and the $7500 yearly phone charges. A total of $9,275 a year is saved by opting to develop a program around the network home office.

System Prototype Development

For a program of twenty-five employees as defined in earlier examples, the network home office would consist of the following equipment. The site office contains one computer for the manager, one for the technical expert, and one for the system operator that acts as the network file server. The computer lab houses three computers, a laser printer, and a scanner. The network hardware includes the transceivers for communication and the necessary cable to link the site office computers.

The home offices consist of a modular work area that contain the computer and an ink jet printer. The office comes with a chair and should be placed for optimal production.

The computers are PC compatible 486 machines with a 66 Mhz processing speed. The computers have 8 Meg of RAM and a hard drive with 500MB of disk space. Each computer contains a fax modem, monitor, and video camera for the monitor. Running on a second phone line for each home office, the COTS software allows communication between all of the computers in the system.

Formal Design Review

The formal design review of the network home office consists of the equipment design review and the critical design review. All of the equipment

for the network home office is listed in the system prototype development. The critical design review involves a review of all members on the review board and provisions are made to correct the design as necessary and proceed with the project implementation. The implementation timeline is as follows:

TIME	ACTION
May 1995	Review of Network Home Office system design. Decision made to implement the system.
June 1995	Place orders for all equipment including hardware: personal computers, network interfacing, printers, modems, and video equipment along with the software to run on the system. Purchase office furniture for site and home offices.
July 1995	Install computers at site office. Establish network server and establish the network for the site and home users.
August 1995	Set up mock home sites within the site office and test software interaction and network behavior.
September 1995	Continue with system integration, check, and testing (IC&T) for the network home office.
October 1995	Hire system program personnel. Begin to assemble home offices at the employee homes. Test network interaction with completed home offices.
November 1995	Continue with home office installation and testing.
December 1995	Run network home office system demonstration to ensure that all users are able to access the system and not

	experience any processing faults.
January 1996	Network Home Office system is ready for implementation on the program it was selected for.

6) FUTURE RECOMMENDATIONS

There are a number of technological improvements that could be made to the network home office program, depending on how much added cost the program is willing to accept. The current network home office program provides each employee with a ink jet printer at home and a scanner at work to read in paper documents for faxing. The ink jet printer could be replaced by a combination fax-scanner-printer. This would alleviate the employee from having to travel to the site office to scan in paper documents, but would cost approximately $400 a machine versus the $200 per ink jet printer. The total added cost for the 25 home employees would be $5000.

With improvements to the Pentium microprocessor, the program may decide to upgrade from a 486 IBM PC to the Pentium model. Depending on the other desired features needed by the program, there will be a considerable cost increase by selecting Pentium PCs over 486 PCs.

The network configuration could be improved with the addition of a few items. While these items do add cost to the system, there will be increased efficiency and usability due to these changes. By choosing to communicate over the Internet instead of networking over the phone lines, the program receives increased reliability and an easier way for employees to communicate with each other though their home offices. The program will have to gain access to the Internet which will produce added cost and time required to establish the program.

In the near future, the telephone companies will be providing communications via the integrated services digital network (ISDN). ISDN will provide communications at rates up to 56 kbps. This increase in transmission capability will provide users of the network home office an even quicker means of sending and receiving data. ISDN is still in the process of being established for all users in the United States. When it becomes available, it provides a network home office program with another improved communications option.

Adding a multiplexer at site eliminates the problems incurred when one employee dials in while another is still establishing a connection to the network. Currently, the second employee must wait until the line is open. With a multiplexer, many employees can dial in at the same time and still connect. The number of employees depends on the capability of the multiplexer. Again, this bonus in usability comes with added cost.

The network home office provides cost savings to Lockheed Martin in the form of rent and utilities savings and less overhead time expenditures. With just the existence of one network home office, those savings are placed into hardware and software procurement for the program. Instead of just one network home office program, a number of network home office programs could share the same general site office location.

The inclusion of more than one network home office program site office in the same building is logical for more space and cost savings are realized.

The programs could share one larger, more efficient computer lab with costs being saved on the elimination of duplicate items needed by different programs. The presentation room could be shared by each of the programs. This leads to space cost savings and a more efficient use of available space by all of the programs.

Another similar idea would be to place all of the network home office project's site offices in the top floor of a two-story building, leaving the first floor for one large computer lab, one large presentation room for formal presentations and a small number of normal size rooms for technical meetings required between Lockheed Martin and the customer.

7) CONCLUSIONS

The network home office is a feasible project to undertake. With the outlined costs over the life cycle of the project, the network home office saves Lockheed Martin approximately $9,000 a year when compared to a site office based project. These cost savings will enable Lockheed Martin to provide the same services at a lower cost to the customer.

The network home office also offers increased job satisfaction for the employees. By working out of their homes, the employees are able to incorporate their daily personal business schedules into their work schedule. It allows employees who are parents the option of watching the children while working which saves on child care costs. By not having to drive to work and back each day, the employees save on car related expenses such as gas and maintenance. The elimination of a commute also saves the employees a great deal of time each week that would normally be spent on the roads, potentially stuck in traffic.

New responsibilities are bound to come up with the implementation of the network home office. The maintenance personnel are expected to perform duties ranging from hardware maintenance to system operation to certain secretarial duties to make the system work. Management will have to find methods to evaluate employee performance. One caveat of working at home with the lone requirement to work a 40 hour week is that the employee may not work a 40 hour week every week since they are not being monitored by

management and other employees. Management will have to monitor employee performance to ensure that the required work is being done. Employee recognition will be another important topic for management to consider due to the fact that face-to-face contact will be limited to a video screen and perhaps a once every other week team meeting. The affects on the employees with respect to live human interaction may also factor into employee morale. Some employees may need constant live interaction to be more productive. Honesty is another factor that must be monitored with respect to usage of the second phone line for calls to places other than the site office. Since the network home office has not been implemented on a large scale, there are a number of human and job factors yet to be determined.

With the current state of computer technology, the network home office is quite feasible and is starting to be implemented by some companies today. Due to the rapidly changing face of the work force and the requirements that these changes bring, new ways to accommodate these employees will be necessary. On a larger scale, with the world population rising, steps will need to be taken to make more efficient use of space in the future. An increase in population produces an increase in traffic and pollution from that traffic. With local highways already running over maximum capacity, steps need to be taken here to control the traffic level. The network home office provides the means to take these steps by reducing the amount of daily traffic, eliminating the need for large office space, and allowing employees the ability to fit their work within their lifestyles while saving costs for the employer and customer.

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