

ImagePlus as a model for application solution development

by C. D. Avers
R. E. Probst

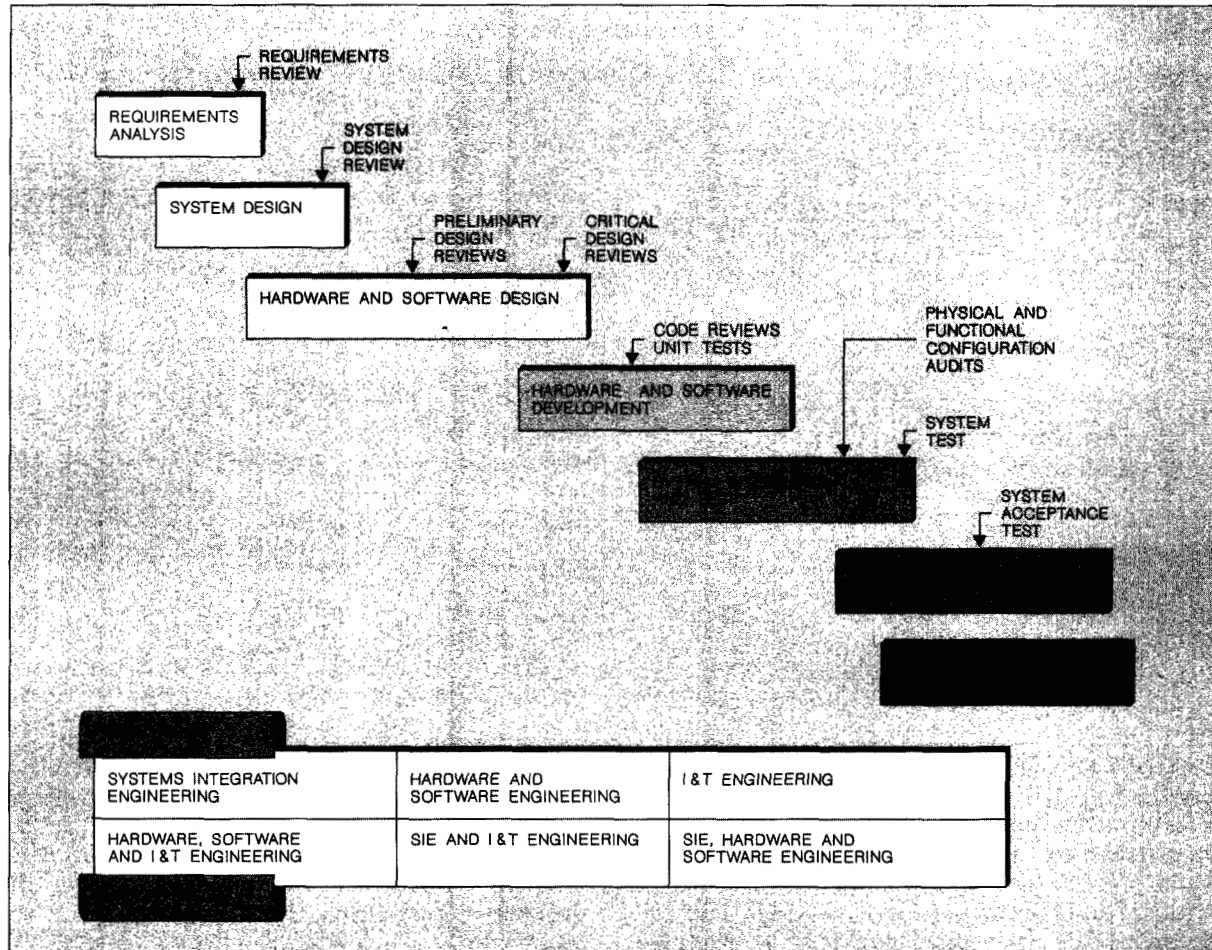
An early effort by IBM to use system integration services to assist in solving complex problems for commercial customers involved developing an Image system for USAA, a large financial services association. USAA had well-defined and stringent requirements for a policy services application that required enhancements to existing products to provide the necessary function and performance. Key problems solved included managing a storage hierarchy to handle image size objects, the use of optical storage as a low-cost storage medium, and the capability to compress and decompress images rapidly at a workstation to allow high-speed paging through documents. Additionally, the registering and indexing of documents and management of work flow and recovery issues were undertaken. The effort was a good example of the new role of application solution development in that the solution was developed in conjunction with a specific customer, but has developed into a product. The particular solution described in this paper became IBM's ImagePlus™ MVS/ESA™ product. Although the specific technical issues were different, the same methodology was used to develop ImagePlus for the System/36 and Application System/400®.

Systems integration is the comprehensive process of determining operational requirements, defining specific objectives that must be achieved to meet those requirements, and assembling various technologies, products, and services to deliver a total system solution that will fulfill the defined objectives over the total life of the system.

This concept or process is not new. If the process is put in the context of a general contractor, one can visualize the application of this process in the construction of buildings, railroads, and other physical structures. The concept of systems integration in the information systems business has been employed by agencies of the U.S. Government, primarily the Department of Defense, NASA, and the Federal Aviation Administration, for the last three decades. IBM, through its Federal Sector Division (FSD) and its precursors, the Systems Integration Division (SID) and the Federal Systems Division, has been providing systems integration services, primarily to the federal government, for over thirty years. Applications include air traffic control, space, defense, and other information processing applications. Only recently has this method of system acquisition taken a strong foothold in the commercial information systems business. In 1985, IBM decided to use the capabilities of SID to assist in solving complex problems for commercial customers. Thus it is through this process of evolution in the information systems busi-

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Figure 1 Systems integration performance phase—engineering roles



ness that SID moved from providing system solutions almost exclusively to agencies of the federal government to being a system integrator for many of IBM's commercial accounts.

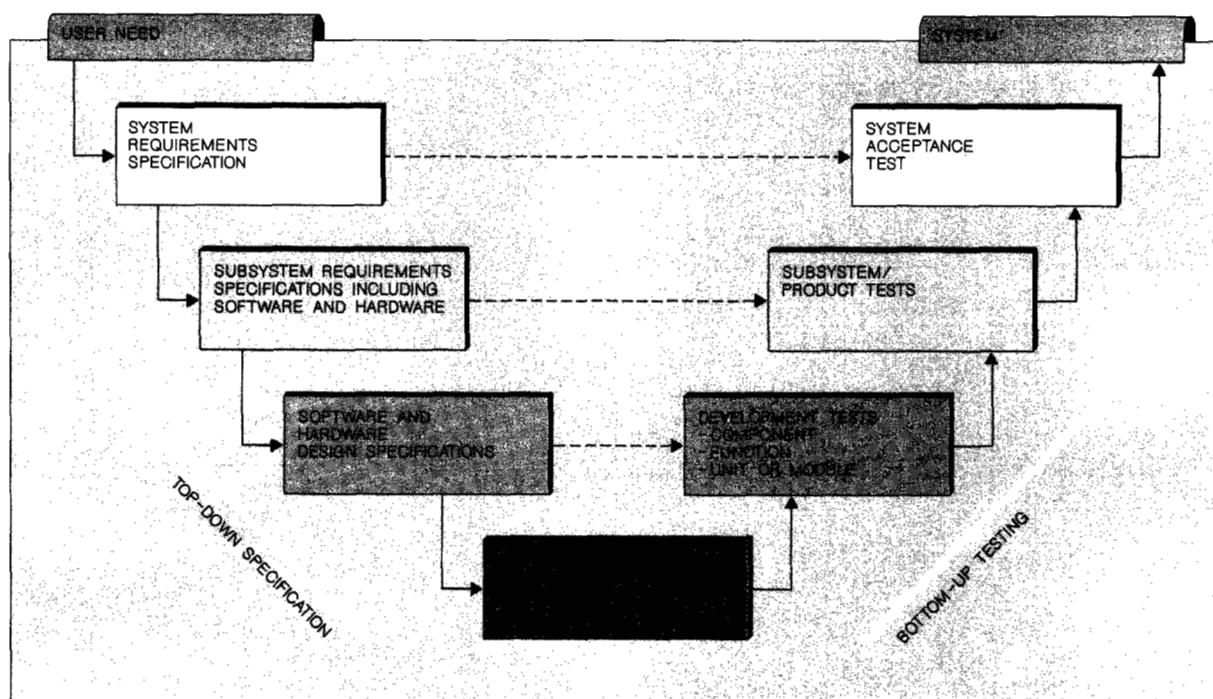
First, the process of systems integration is reviewed, including the roles of each of the major organizations that are fundamental to the performance of a project and the benefits to our customers. Next, the application of the process to the development of the ImagePlus™ system is described. Finally, we show how the ImagePlus project at USAA (United Services Automobile Association) has become the prototype for many new application solution development projects for a wide range of our customers' needs. (A similar project at Citibank in the same time frame has also become a prototype.)

The systems integration process

Systems integration is a comprehensive approach to solving a customer problem. It addresses all aspects of the solution, including collection of requirements, design, development, manufacturing, installation, and maintenance. The systems engineering approach to systems integration is a top-down, or requirements-driven approach, i.e., it starts from requirements and works toward the solution using appropriate technology. This approach differs from the product development approach, which is bottom up—that is, a technology-based solution that develops a product for general application.

The role of the systems integrator spans the life of the system, as shown in Figure 1. IBM must, as an

Figure 2 System development and test relationships



essential ingredient in the overall success of a project, have an in-depth understanding of the customer's business. IBM works closely with the customer to translate business needs into a complete set of system requirements before a system design can be defined. Iterations to both the requirements and system architecture can be expected but must be carefully controlled. With the system architecture defined, external and user interfaces are further defined. The system is decomposed into several subsystems, and the subsystems are decomposed into hardware units and software modules. The overall system requirements are suballocated to each element of the system.

Many alternatives are considered in the specification and design of each element of the system. Through competitive analysis, make or buy decisions are made. Off-the-shelf products from other manufacturers are procured by IBM and integrated with IBM products. Subcontractors and vendors are selected through a rigorous source-selection process.

During the development phase, preparations are made for integration and test of the system. As illustrated in Figure 2, testing is conducted at the

unit and module, subsystem, and system level to ensure compliance with the requirements and design specifications at each level. The technique of phased delivery of units and code modules is employed to facilitate an early start of testing and the orderly build-up of system elements.

The development of requirements and design specifications can be visualized as a "top-down" process with functions allocated to the subsystems but traceable back to the overall system requirements specification.

Well before the system is installed at the customer location, preparations are made for training of customer personnel, including the users and those responsible for system operation and maintenance.

Roles and responsibilities. The manager of a systems integration project leads a multifaceted team. Key members of the team will report directly to the program manager, but the success of the effort is also dependent on outside organizations: other groups within SID and throughout the corporation, suppliers, subcontractors, and the customer's organization.

The program manager interacts with many technical and business disciplines. Given the responsibility and authority, the program manager controls the resources, manages interfaces, and provides overall direction to the project. A program management plan is prepared at the outset of the project to delineate all key aspects of the project. Subordinate plans are submitted to the program manager for approval, and the program manager is kept advised of status and issues, so that corrective action can be implemented in an orderly and timely manner.

Although the program manager retains overall responsibility for project planning, control, and risk assessment and management throughout the entire program, the organizational roles of primary importance shift from organization to organization as the project passes from one phase to another (Figure 1).

The role of systems engineering is shown in Table 1. The definition of requirements, system architecture, system interfaces, trade studies of various implementation alternatives—all establish groundwork for the work to follow. In the end, it is systems engineering that ensures acceptability and usability of the system.

Software and hardware development engineering groups are the next to take the lead role during the implementation phase of the program. The responsibilities of software engineering are listed in Table 2. Development engineering is heavily involved during the initial phases of the program and remains involved during the integration, test, and deployment phases to perform problem analysis and correct deficiencies. Should portions of the development work be subcontracted, these organizations will provide technical leadership to the subcontractor.

Integration and test are the responsibility of an organization that is set apart from the development group as a means of providing the appropriate checks and balances in the overall process leading up to customer acceptance. As can be seen in Table 3, this group is involved from the early stages of the program.

Throughout the entire program, the systems integration organization is supported by many organizations, among which are procurement, quality assurance, safety, reliability/maintainability/availability, human factors engineering, plans and controls, and integrated logistics support. Systems integration requires a total team effort.

Table 1 Systems integration engineering responsibilities

Analyze and specify system requirements	Systems integration engineering development and management plan System requirements specification Software requirements specifications Subsystem requirements specifications Concept of operations Trade study reports System requirements review System design review (SDR) Preliminary design reviews (PDRs) Training plan List of deliverables User manuals
Define system concept of operations	
Define system interfaces—external and user	
Define system/subsystem architecture	
—Allocate performance requirements	
—Model system performance	
Perform design tradeoffs	
Develop the system and subsystem design	
Manage the system technical baseline	
Support design/development/integration and test	
Coordinate specialty engineering	
Interface with product labs	
Ensure system acceptability/usability	

Table 2 Software engineering responsibilities

Support requirements analysis, architecture definition, performance allocations, design tradeoffs, SDR, PDRs	Software development and management plan Software design specifications Software critical design reviews Software product specifications Software releases
Define software architecture	
—Within processors and end-to-end	
Determine existing vs new software development	
Estimate software size, schedule, cost	
—Plan and define software build increments	
Perform software design, development, and unit testing	
—Software design inspections: code inspections	
Support integration and test	
Provide technical guidance to software subcontractors	
Perform software problem analysis and error correction	

Table 3 Integration and test engineering responsibilities

Support requirements analysis and system testability analysis Development system/subsystem test plans and procedures —Map requirements to test plans Estimate integration and test scope, schedule, cost Perform subsystem integration and test Perform system integration and acceptance testing Manage system installation and transition	Integration and test development and management plan Test plans and procedures Test reports Installation, integration, and check-out plan Cut-over plan
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The benefits of systems integration

Customers realize many benefits when they choose to acquire a new capability via a systems integrator.

Single point of responsibility. In much the same way that a general contractor is responsible to the customer for all aspects of a building project such as the requirements analysis, design, selection of materials, selection of skilled workers and subcontractors, and completion of the project according to specifications, the systems integrator for an information system or application solution is responsible to the customer for all aspects of the process leading to the successful completion of a project. This includes development of a comprehensive set of requirements, planning, design, acquisition, management control, training of the customer's personnel, installation, and continuing support during the operational life of the system.

Risk management. The systems integrator assumes responsibility for management of all risks associated with the project. Whenever possible, the systems integrator and the customer prefer a fixed-price contract. The fixed price protects the customer from the cost impact of surprises during contract performance. To offer such an arrangement to a customer, the systems integrator must have a detailed knowledge of the customer's needs, the system requirements, and the technology, products, skills, and subcontractor base that are required to achieve the objectives. The systems integrator will identify specific risks and evaluate the potential impact of those risks in the earliest phase of the program. Throughout the performance period, these risk areas will receive particular management attention, and alternative strategies will be implemented when required.

Application of customer resources. By utilizing a systems integrator, the customer minimizes the in-house resources required to implement a new system. Thus, a customer can apply in-house personnel to the main line of business, rather than building a large information systems organization. It is essential, however, that the customer involve knowledgeable users of the proposed system in the translation of business needs into specifications of system requirements. The systems integrator can provide the wide range of skills required throughout the life of the program.

Cost advantages. The experienced systems integrator can offer the most attractive cost for system implementation through the use of proven program management techniques. The various elements of the system will be selected in a methodical manner. Off-the-shelf products will be selected, where possible, to minimize the schedule and cost risks of development. Vendors and subcontractors will be selected by a competitive process, and they will be required to comply with procedures and quality standards established by the systems integrator.

Finally, the systems integrator is not limited to a preconceived solution but will provide one that is cost-effective and that is responsive to the customer's needs and objectives. The systems integrator applies knowledge of the customer's business, applicable technologies and products, and proven processes for requirements definition, design, development, and subcontract management, as well as overall program management and control, to ensure success of the systems integration project.

Systems integration applied to USAA policy service

USAA (United Services Automobile Association) is a company that has always had a commitment to customer service. Since its beginning as a small mutual insurance company founded by a group of military officers, it has always prided itself in its service to its members. Even as it has grown, it has managed to keep its dedication to service. Additionally, it has a very low expense-to-premium ratio. It is a technically oriented company and has used technology to keep its expenses down and service level up. A strategic objective of USAA is to develop a paperless office.

The application which they chose for applying image technology on a large scale was policy service. In

particular, they wanted the capability of capturing mail by scanning as it arrived in the building. From that point they wanted to index the material, route it through the office, store it, retrieve it, display it, and archive it, as appropriate. The archiving was to replace paper files, thus simplifying retrieval, and was to be a permanent storage medium.

USAA had been piloting this type of system with a computer-assisted microfilm unit and had done a large amount of human factors evaluation. They had obtained significant feedback from the operators. They had a well-thought-out operational concept and a fairly complete set of requirements that were demanding but realistic. All of these factors, along with their commitment and reputation, made them an ideal account for joint solution development.

Joint development. Prior to our decision to work with USAA on this effort, IBM had been studying various approaches to integrating use of images directly into a business application, as opposed to casual office use, and had recently announced a family of image components including a display and scanners.

The opportunity to do joint development with USAA was seen as an excellent opportunity to work with an informed customer, test the validity of the studies, validate the utility of our image components, and develop an understanding of the use of image capability, especially as it applied to the insurance industry. Although USAA operates quite differently from other insurance companies, primarily because of its central operation with few field locations, the functions associated with policy service (e.g., new customer applications, address changes, modifications to existing policies, etc.) are still reasonably common to those of other companies.

Finally, IBM felt that working on a real systems integration contract with schedule deadlines and cost constraints would accelerate the solidifying of product requirements and therefore accelerate the introduction of IBM's image products.

Even before the complete set of requirements was collected, it was recognized that in order to meet the solution objectives, many IBM product development organizations would be required to make changes to their components. Because of the complexity of the management problem and the need to clearly define functions and interfaces, SID was chosen as the integrator for the system.

Table 4 IBM locations that were involved in ImagePlus

Division	Location
Systems Integration Division	Gaithersburg, Maryland Boca Raton, Florida Princeton, New Jersey
Application Business Systems Application Solutions Division	Rochester, Minnesota Bethesda, Maryland Dallas, Texas
Communication Systems	Research Triangle Park, North Carolina Yamato, Japan
Entry Systems Division	Boca Raton, Florida Winchester (Hursley), England
General Products Division	Tucson, Arizona Santa Teresa, California
US Marketing & Services	Charlotte, North Carolina Gaithersburg, Maryland San Antonio, Texas Sioux Falls, South Dakota
System Products Division	Toronto, Canada Lexington, Kentucky
National Service Division	Gaithersburg, Maryland

The SID Gaithersburg site had overall responsibility for the systems integration and program management. It was the single point at which all activities came together. In so doing, SID had responsibility for managing and coordinating contributions from a subcontractor, the customer, and the IBM locations listed in Table 4.

Requirements. USAA had a well-developed set of business needs. They directed that the system make maximum use of existing and standard components and that the deployment of the image system have minimum impact on existing operations. Schedule and cost objectives were based on key business measurements.

As a key functional requirement, USAA specified a storage hierarchy for image and character data, i.e., direct-access disk storage for rapid retrieval of active data, an on-line optical library, and shelf storage for long-term storage and disaster recovery. The system had to accommodate distributed storage and retrieval of image data across four geographically separate locations.

Many of the performance requirements were attached to activities that the system users could observe, including display time for the first image page, display time for subsequent pages, time required to scan a page and index a document, etc. Decomposition of three requirements led to specific allocated performance requirements for each subelement of

the system, e.g., the optical library, communications network, image processor, workstation, etc. Operational requirements also included usability, reliability, system availability, and serviceability.

Many alternatives were carefully analyzed to achieve a comprehensive set of systems requirements that met business needs and achieved the proper balance of function, performance, flexibility, cost, and schedule.

Development. Specifying, as design objectives, that the system make maximum use of existing components, including thousands of 3270-type displays,

Development activity included selecting and testing the library and optical drives.

that it interface with software being developed by USAA, and that it not be disruptive to existing applications as well as provide interconnectivity to existing facilities both local and remote led to a system partition shown schematically in Figure 3. The detailed implementation is shown in Figure 4.

The Folder Application Facility (FAF) is the software that USAA was developing for indexing and work flow. This application was installed in the same processor partition as the existing policy service applications in an existing IBM 3090 system, separate from the processor that would handle the images. The Object Distribution Manager (ODM) and the storage management software, including the Object Access Method (OAM) were installed in an IBM 4381 processor. Figure 4 shows that the FAF terminals interface with the applications host directly. The host interfaces with the Image Storage and Retrieval Subsystem (ISRS) through an FAF to ODM interface. The FAF data terminals and the ImagePlus workstations were implemented as two separate terminals to preserve the existing inventory of 3270 terminals and

also to isolate the elements so that normal processing could occur in the absence of the image subsystem. It was also decided that image data should be treated the same as any other in terms of security, recovery, and other systems services, and that ISRS should operate in a Multiple Virtual Storage/Enterprise Systems Architecture (MVS/ESA™) environment. The OAM was a modification to the Data Facility Products (DFP) to give it the capability to handle large objects. Finally, ODM is the traffic manager and interface between FAF, which indexes and routes documents, and OAM, which manages the storage of the documents. Interconnection to remote workstations was provided by the channel attachment of communication controllers as shown in Figure 5.

The configuration illustrated in Figures 3, 4, and 5 satisfied the business needs and functional requirements.

The requirement that the system provide for archiving as well as short-term storage to allow display at a reasonable rate led to the decision to use optical storage as part of a hierarchical storage management system.

The storage subsystem is illustrated in Figure 6. The system is capable of storing images on magnetic DASD, in an optical library, and finally, with removal of the optical cartridges from the library, on the shelf. This capability of staging allowed USAA to determine and set its own approach to storage management, e.g., how long it would reside on the different media, how recovery and backup would be handled, and the ability to store different resolution levels at different points in the system. Because of the large object size (about 50 kilobytes for a compressed binary, 200 dpm, 8 1/2- by 11-inch page) and the use of write once optical storage, modifications were required to the storage management software. These software changes were incorporated into the storage management software to provide management of image data using the same system software as used in managing coded data.

Development activity associated with the storage subsystem included selecting and testing the library and the optical drives. The interface to ODM was defined, and code was written to allow the handling of large objects. The IBM 8232 LAN Channel Station as storage controller, based on the IBM 7532 Industrial Computer, was selected, and code was written to manage the library and the stand-alone optical drives used for backup.

The management of the movement of images within the ISRS and the communications with FAF required SID to develop another module, ODM. All folder activities are handled by FAF. Physical storage of images is managed by OAM. All manipulation of images in the workstation is handled by workstation software. Thus the role of ODM is an interface among all of these components. A router and a file server, ODM has the responsibility to ensure that all operations are in synchronization and that documents are accurately registered between FAF and OAM.

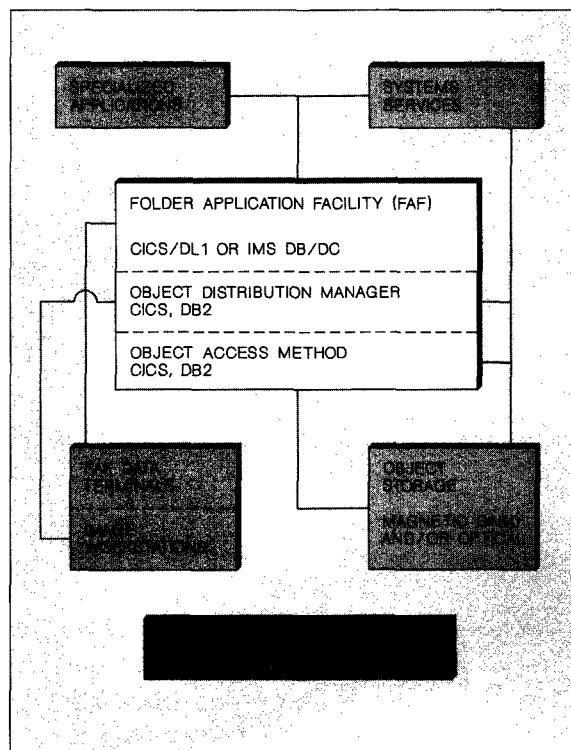
The requirement that the operator receive the image of the first page of an image document on the image display in five seconds or less and to see subsequent pages in one second or less for planned work required further refinements to ODM, the workstation, and the network. The ability to "flip" pages in a random manner after a document was retrieved was also deemed essential for an underwriting application and put further demands on the workstation.

Changes to the microcode in the IBM 3174 Subsystem Control Unit were necessary to increase the block size to be handled and thus improve throughput.

To improve the response time in a planned work environment, the queuing activity taking place in FAF is sent to ODM so that ODM can determine the location of requested information in the storage hierarchy. If the information is located in the optical library or on the shelf, ODM will issue the command to move it to magnetic storage prior to the time it is needed by the operator. This action is, of course, not possible in a random inquiry by an operator. However, it was felt that compared to having to call a customer back after an inquiry into the current archive, the slower response time of the library would still be acceptable for *ad hoc* requests.

Even after the above changes, the response time was marginal for the first page display and for subsequent page display time requirements as well as for random page flipping. A special image adapter was developed that did resolution modification, compression, and decompression in hardware. The system is based on placing the compression as close to the source or end use of the data as possible. To minimize the number of unique interfaces, the workstation handles all scanners, printers, and displays by using a common adapter and one set of workstation software. To improve response time, two versions of the image are generated at scan time, 100 and 200 pels per inch (ppi) versions. The 100 ppi version is stored on

Figure 3 ImagePlus functional overview

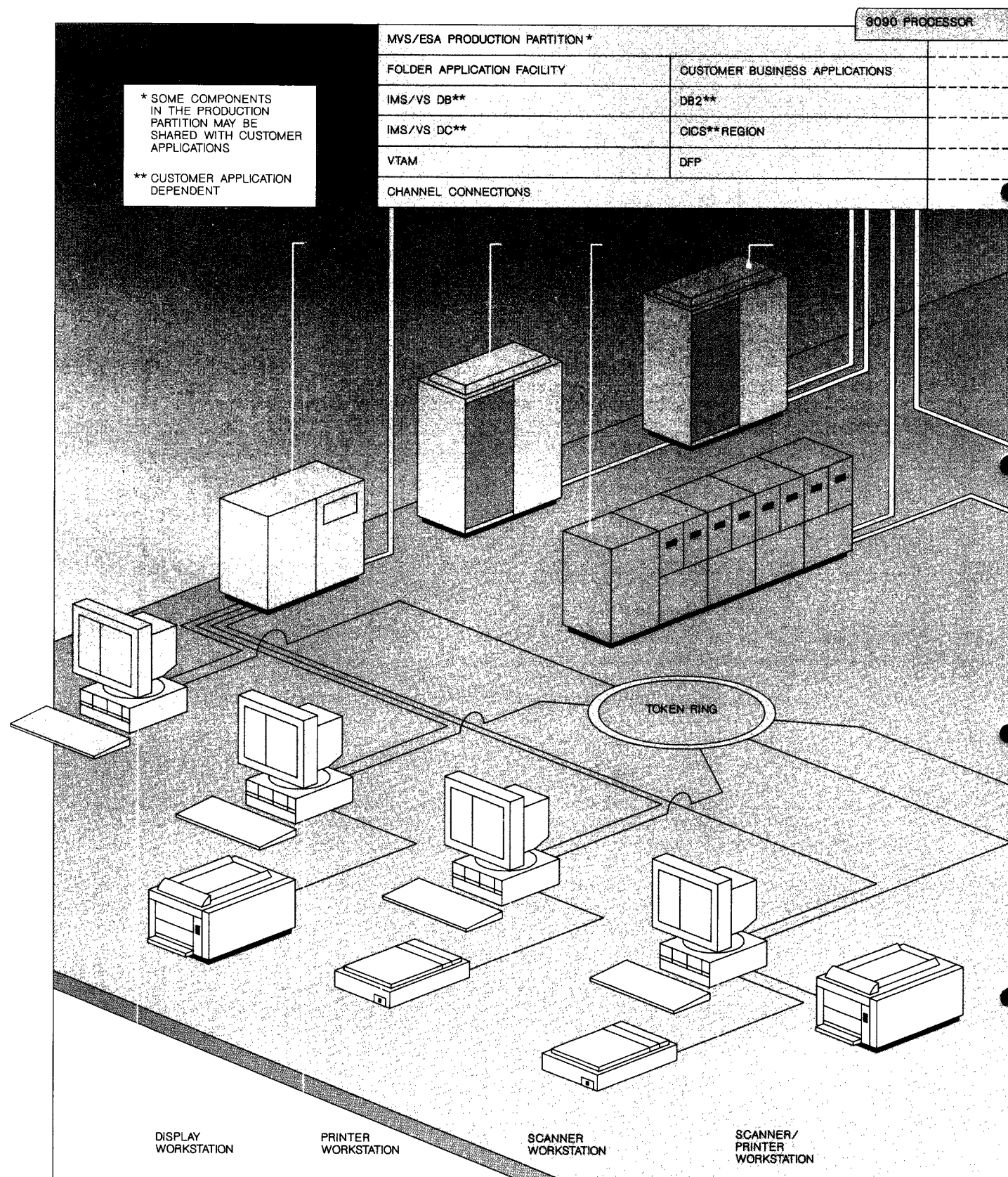


magnetic DASD only and the 200 ppi on optical media only. This separation gives improved display performance by keeping recently acquired data on DASD. The 100 ppi data are erased after a document is processed; however, the 200 ppi version is still available on optical storage if required at a later time.

Finally, for the longer documents associated with special underwriting situations, the document is brought from memory and stored on a hard disk. The initial set of pages is handled by the image processing card, and the decompressed images are stored on workstation DASD. After a page is decompressed by the image adapter, the decompressed image is held on workstation DASD to allow rapid, random, page flipping through a document.

The workstation configuration used is shown in Figure 7. This configuration consists of a separate image display. In addition to developing the interfaces to the image card, device drivers had to be written to interface with the various scanners and printers.

Figure 4 ImagePlus/MVS/ESA configuration



MVS/ESA OBJECT MANAGEMENT PARTITION	
OBJECT DISTRIBUTION MANAGER	
CICS REGION	DB2
VTAM	DFP/OAM
CHANNEL CONNECTIONS	

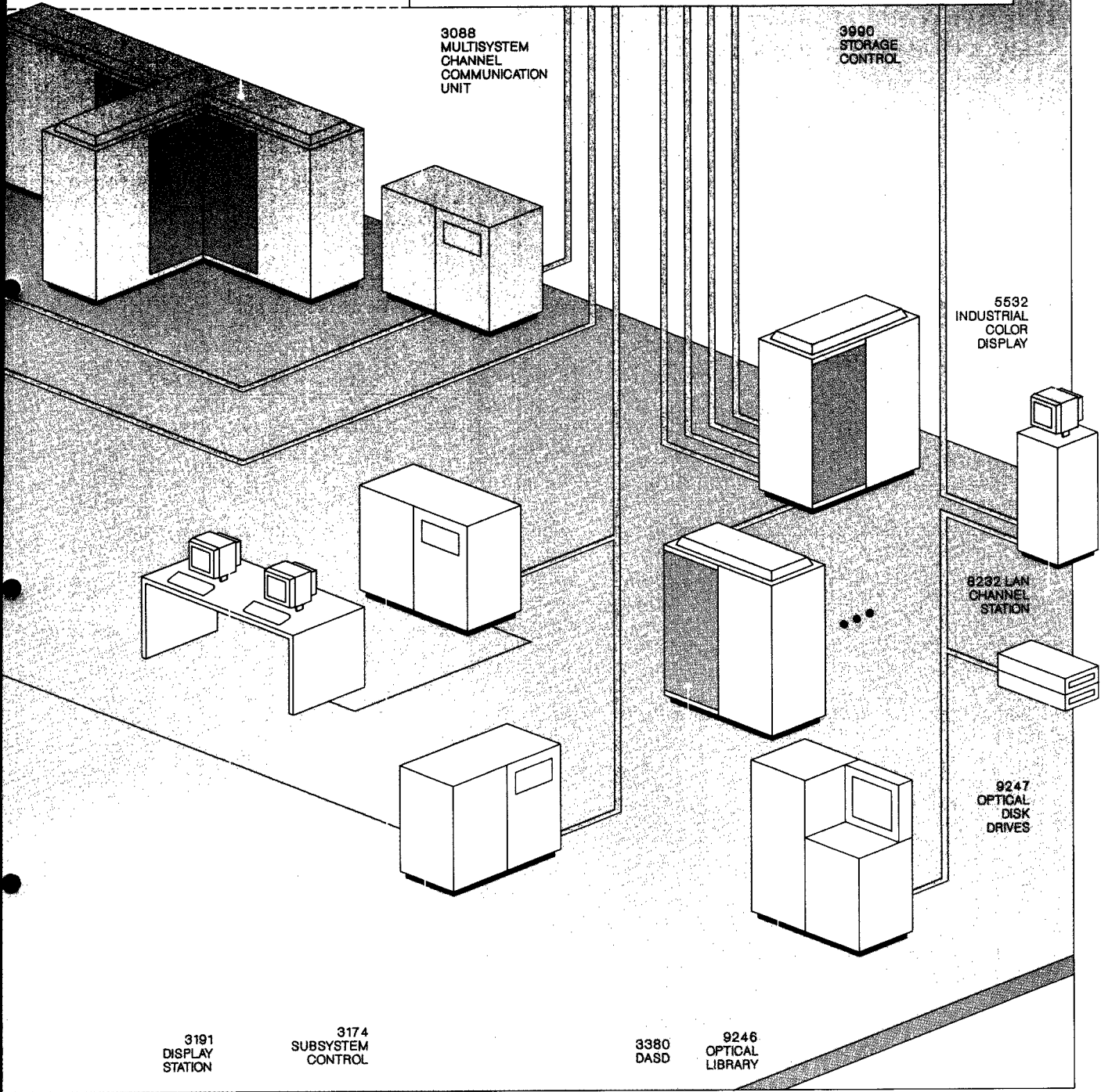
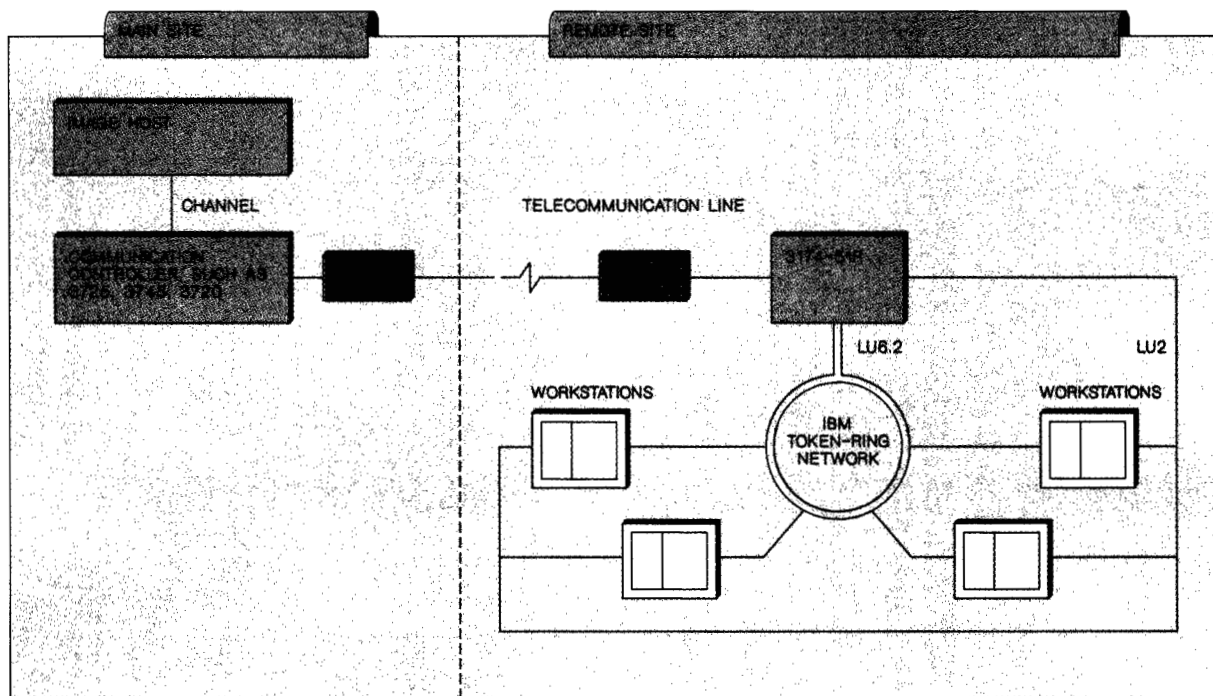


Figure 5 Remote workstation configuration



Because of its use in a production environment, a keypad was used rather than a keyboard to make processing simpler for the operator of the image terminal. Note that Advanced Program-to-Program Communications for a personal computer (APPC/PC) was used to provide compatibility with Systems Network Architecture.

Test and integration. Testing of a complex system requires the test to start at the lowest level of assembly and progress upward until all subsystems have been tested as individual units and as a system. This progression is required so that problems can be found at a level where they can be isolated and corrected most efficiently.

The starting point for the test of the image system was the image workstation. These tests initially treated the workstation as a stand-alone device without communication capability to the image host.

Tests were run to validate the user interface and interaction between the image manipulation functions on the image adapter and the various printers, displays, and scanners. The types of tests performed

included scanning and displaying a document. These tests verified the image adapter and the individual devices. Similar tests were made with the printer, which also demonstrated the capability to perform resolution modification from 200 ppi to 300 ppi.

Test code was written to simulate the FAF code, perform folder functions, and test the interaction between FAF and the ISRS. Other tests were run in the Gaithersburg integration facility prior to installation in the customer's facility. Further tests and integration were completed in a manner consistent with the phased delivery shown in Figure 8.

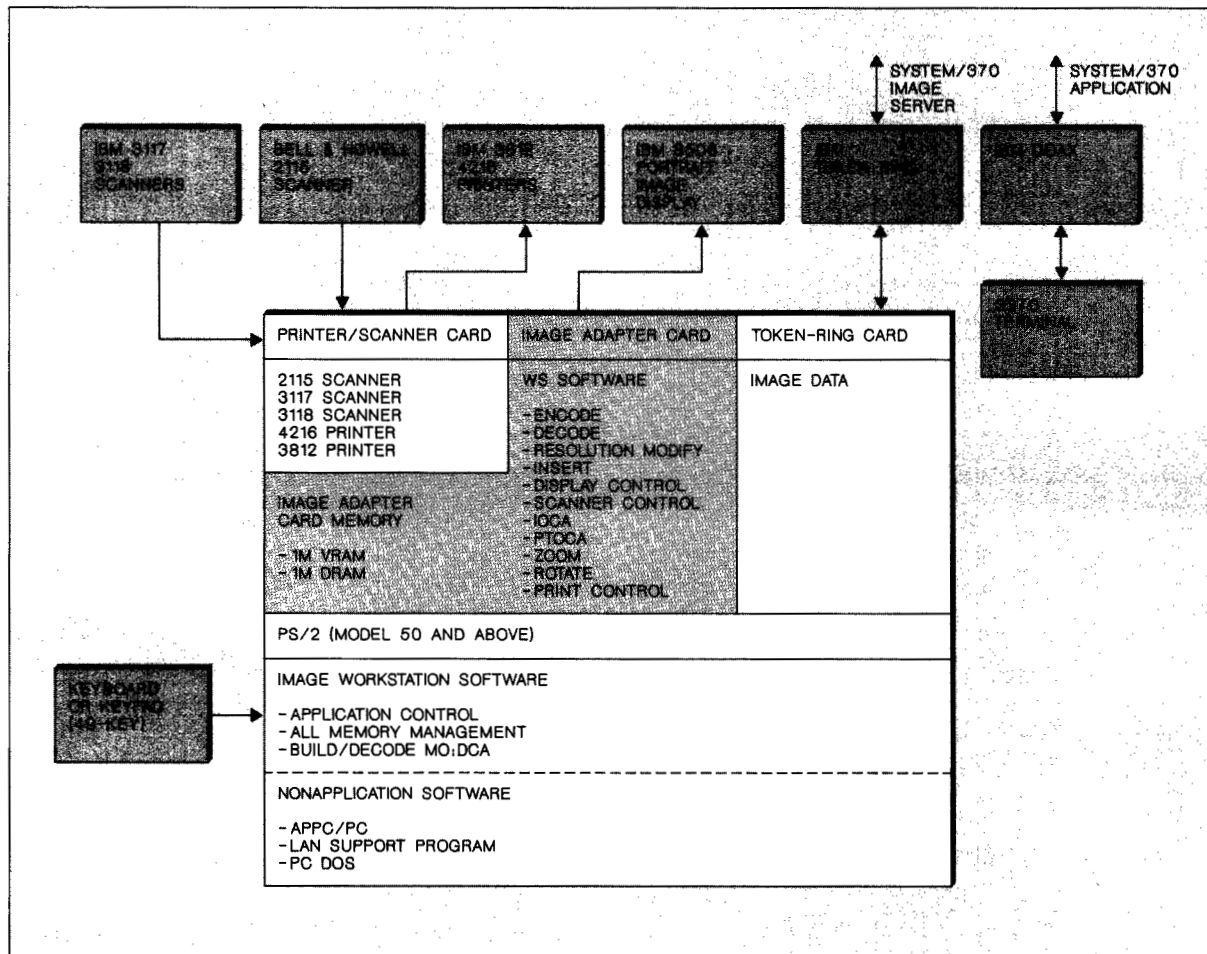
Installation and production. Figure 8 illustrates the step-by-step manner by which the system was installed and tested in the customer's facility. The approach is to do stepwise increases in function, after collection of data at each point and assurance that activity has met its goals, and then to proceed on to the next step.

The steps are reasonably self-explanatory. Step 1 emphasized user acceptance of the workstation from a quality and usability point of view. Step 2 was a

The diagram illustrates the IBM 8232 Storage Management Architecture. At the top, the **MVS/ESA HOST** is connected to **DB2 STORAGE MANAGEMENT GROUPS** (indicated by a dashed box) and a **250 PSL** (Primary Storage Library) unit. The host is connected to four channels: **CHANNEL A**, **CHANNEL B**, **CHANNEL C**, and **CHANNEL D**. Each channel is connected to an **IBM 8232** unit, which contains two **POCA** (Primary Optical Control Assembly) units. Each POCA unit is connected to an **IBM 7532** unit, which is further connected to **SCSI** and **RS232** interfaces. The SCSI interfaces are connected to **SCSI-A**, **SCSI-B**, **SCSI-C**, and **SCSI-D** respectively. The RS232 interfaces are connected to **RS232 PRIMARY** and **RS232 ALTERNATE** lines. These lines are connected to **IBM 9246 OPTICAL LIBRARY** units, which contain **LMSI DRIVE** (Library Management System Interface Drive) and **FILENET CONTROL ELEMENT** components. The optical libraries are connected to **IBM 9247 OPTICAL DISK DRIVES**, which are further connected to **LMSI DRIVE** units. The entire system is managed by **SMS INSTRUCTIONS** (Storage Management System Instructions) which control the **STORAGE SHELF (OPTICAL CARTRIDGES)**.

volumes and was the beginning of productivity measurements. Step 5 tested the remote workstation capability and installed workstations to cover all logical

Figure 7 Workstation with portrait display



offices. Finally, in Step 6, the emphasis is on installing the remainder of the workstations for production processing.

Solution development

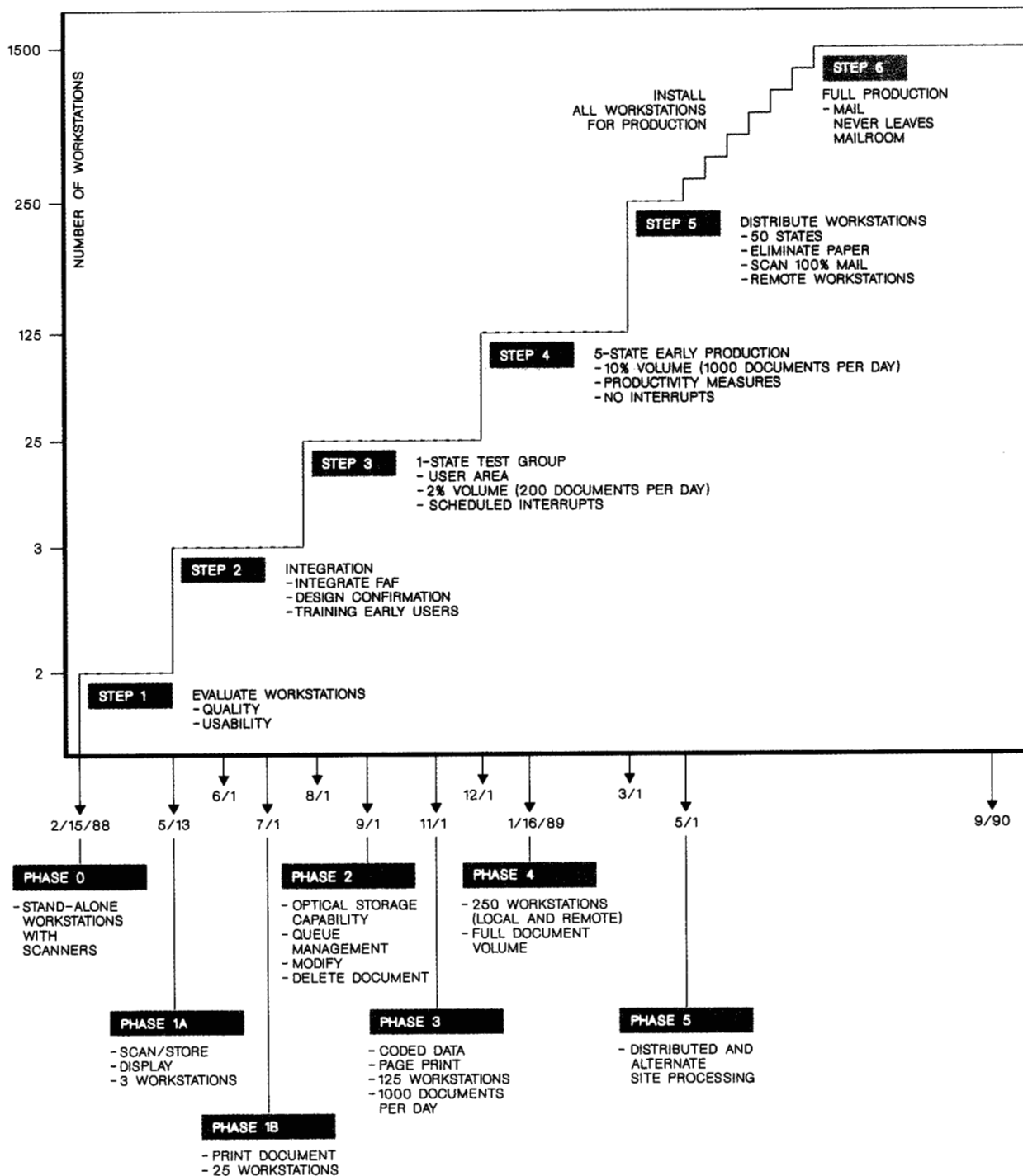
IBM is engaged in a concerted effort on behalf of our customers to develop many new application solutions, with the primary objective of making our customers more competitive. The Systems Integration Division provided early leadership as the systems integrator for many of these application solution development efforts, working closely with customers, other IBM organizations, and IBM's Business Partners.

Solutions are being developed in every major business area. These efforts are market-driven, as evidenced by the participation of key customers in these projects. The solutions are application-driven and are worldwide in scope and applicability.

The ImagePlus model serves as the prototype for many of these projects.

As embodied in the ImagePlus solutions, each application solution is a comprehensive offering that transcends the normal IBM product offerings to include specialized hardware and software applications, communications, systems integration, education, distribution, and support services. A solution is based

Figure 8 Installation and production plan



on an architecture and industry knowledge that is enhanced by the participation of one or more key customers.

The Image Steering Committee in IBM is the precursor to the Worldwide Opportunity Council, which is the focal point for all of the application solution projects to follow. The Image Steering Committee provides executive guidance to the ImagePlus projects and serves as a focal point for resolving issues that arise between the various IBM organizations that participate in the projects.

The Worldwide Opportunity Council is chaired by the General Manager, Application Solutions line of business. The Council prioritizes and selects new opportunities targeted for IBM leadership that are worldwide in scope, and monitors progress of ongoing projects. The council resolves inhibitors that arise across IBM's various lines of business and coordinates strategies through the corporate planning process.

In many cases, the Systems Integration Division had a leading role in the development and integration of new application solutions and the initial customer installation. SID Professional Services and similar IBM groups throughout the world then took the lead in the distribution and installation of the solutions to many customers. Indeed, the early ImagePlus projects provided the path for the application solutions efforts to follow.

Acknowledgments

The authors would like to thank all of the members of the Image Systems organization formerly in SID who provided IBM with leadership for the development and integration of ImagePlus, and for the path marked for all future application solution efforts.

ImagePlus and MVS/ESA are trademarks, and Application System/400 is a registered trademark, of International Business Machines Corporation.

Carl D. Avers *IBM Federal Sector Division, 6600 Rockledge Drive, Bethesda, Maryland 20817.* Mr. Avers was manager of Image Systems for the former IBM Systems Integration Division in Gaithersburg, Maryland, which was the organization responsible for systems integration of the MVS/ESA and AS/400 ImagePlus application solutions. He joined IBM at its former Federal Systems Division in Bethesda in 1965. He has held a number of technical and management positions related to military and commercial systems development, communications technology, and signal processing. Currently he is international program manager at Federal Sector Division headquarters. Mr. Avers received his B.S. in electrical engineering in 1964 and his M.S. degree in 1965 from West Virginia University. He is a senior member of IEEE and a member of Tau Beta Pi and Eta Kappa Nu.

Robert E. Probst *IBM Application Solutions Division, 101 Orchard Ridge Road, Gaithersburg, Maryland 20878.* Dr. Probst is the manager of the Image Solutions Development organization. He has held a variety of management and technical positions since joining IBM at Poughkeepsie, New York, in 1966. He has spent the last five years working on applying digital image technology to solving problems associated with paper-handling in large financial institutions. Dr. Probst received his B.S. in electrical engineering from Lafayette College in 1959. He received his M.S. and Ph.D. in electrical engineering from Carnegie Mellon University in 1960 and 1963, respectively.

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