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Stephen Cox
Winzler and Kelly, Consulting Engineers, s-cox@pacbell.net

Renee Dulfer
Agilent Technologies, renee_dulfer@agilent.com

David Han
United States Marine Corps, HanDR@mfr.usmc.mil

Ubaldo Ruiz
University of San Francisco, uruiz@usfca.edu

Steven Alter
University of San Francisco, alter@usfca.edu

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Communications of the Association for Information Systems

TDG ENGINEERING: DO WE REALLY NEED ANOTHER UPGRADE?

Steven Cox
Renee Dulfer
David Han
Ubaldo Ruiz
Steven Alter
School of Business and Management
University of San Francisco
alter@usfca.edu

ABSTRACT

This case covers an important decision of a type that confronts many managers. Several years ago TDG Engineering upgraded its IT network infrastructure, and now experienced and trusted employees are recommending yet another upgrade. The question at hand is whether this upgrade is justified, and how long the new capabilities will last before another request for yet another upgrade.

In addition to addressing issues about the importance of infrastructure and the justification of IT investments, this case provides an example that illustrates concepts related to system life cycles, the alignment between business strategy and IT strategy, and the uncertainties related to whether IT investments will be successful.

KEYWORDS: IT investment, network, IT infrastructure, system life cycle, work system, local area network, wide area network, network case study

I. INTRODUCTION

TDG Engineering[1] is a consulting engineering firm that provides multi-discipline engineering, surveying, and environmental services to public and private sector clients. It was founded in 1978 by three engineers who wanted to leave previous employers that didn't provide the excitement and challenge of building a company. Today, the firm is has over 240 employees spread among five mid-West offices and two off-shore offices in Asia. TDG uses information systems to market its services, manage its finances and personnel, and create and share project documents such as drawings, specifications, and reports.

[1] This case was prepared for use in classroom discussion rather than to illustrate effective or ineffective handling of a business situation. The case presents occurrences and issues from a real business situation. Names and some data and other details in the case have been disguised.

Bob Darnell, the "D" in TDG Engineering and the current CEO, was not surprised when Arlene Pierson asked to meet with him about company's IT infrastructure. For the last several months Pierson and several other key managers had been discussing shortcomings in that area. Pierson had been with the company for 9 years and had a strong track record as an engineer and as a manager. Any recommendation of hers would be taken seriously. But the economy was slowing and Darnell wondered whether this was the time to make new investments that might not yield immediate bottom line returns. Furthermore, he had recently read an article about frequent disappointments with IT systems. He vaguely remembered that TDG had had some problems when it installed an earlier version of the network around five or six years ago, and he wanted to make sure that history wouldn't repeat itself in that way.

> "So let me get this straight. You and Joe and Ken believe that our IT infrastructure is just about maxed out, and that we will really have some problems exchanging information among our offices and with our clients if we don't do something soon. Didn't we just have this conversation about three years ago? I thought that the upgrade to the wide area network was going to last us a long time. Granted, we have grown in the last three years, but not that much."

Pierson expected this type of objection from Darnell, who had always done an excellent job of making sure that the company had the financial strength to weather occasional shifts in the market. She was convinced that infrastructure upgrade made sense for the company even though some of the benefits were rather intangible.

"You're right Bob. You attended a number of IT Committee meetings three years ago when we proposed to upgrade to the wide area network we use now. Everyone was reasonably convinced that that upgrade would be a long-term solution. We simply didn't anticipate that the usage of the wide area network would be so extensive. It was kind of like a new highway connecting two cities. We provided new capabilities and traffic increased quickly. Traffic increased on the WAN not only from direct increases in internal and client traffic, but because the Internet became ubiquitous, indirectly increasing traffic for research, downloading data and software, and exchanging electronic versus paper documents. Clients are starting to assume they should have access to the most current design documents and project plans. It's been just a few years, but the network is clogged."

Darnell believed it was important that the company provide the tools employees needed to do their work efficiently, and he certainly believed in taking care of client needs. On the other hand, he wanted to be careful with discretionary investments and wanted to make sure there was real commitment to attain important benefits from any investments the firm made.

> "OK, let's assume that the network is getting saturated. Instead of just saying we should build a bigger network, how about looking at whether part of the problem is because the network is being used for unimportant things or because too many people are trying to use it at certain times. I know our people don't tend to goof off surfing the Web, but I'm also aware that most of us use the network sometimes for buying tickets and other personal stuff. I have no idea whether that kind of thing contributes much to the load on the network, but I would like you to take a look at how we are using the current set-up before we go off and make new investments. See if we could schedule the usage differently or if we could eliminate some of it to reduce the load on the network."
>
> "In fact, why don't you take it a step further. Get together with a few managers who have been here for long time. Take a look at how this network evolved and how we really attained business benefits from each of the upgrades we did. And also see if you can describe some of the things that went wrong in our previous efforts. I want to make sure we get real bottom line benefits from

any upgrade, and I certainly don't want to spend a lot of money on something that may not work."

Pierson's current project was in the middle of a crunch and she was far from thrilled about receiving an additional assignment, but she saw the value of doing her homework. If she were Darnell she probably would have made a similar request.

She took a few minutes to round up her files from the previous upgrade, and quickly found the memo justifying that upgrade. The memo started by saying that the upgrade would help attain a number of broad corporate goals related to the way TDG wanted to conduct its business. Those goals, which still seemed to apply today, included the following:

- TDG intends to provide technical competency and project staff resources competitive with that of major international firms, while maintaining a high level of personal service and project involvement by the firm's senior management.
- TDG intends to sell and deliver all the firm's services from any of its offices.
- TDG intends to staff projects and balance workloads by sharing human resources between offices.
- TDG intends to centralize only the business functions in which centralization increases efficiency, improves decision making, or helps in coordination; otherwise, business functions will be performed and managed at the local offices.

The business had done well during the last three years and part of its success was probably related to the ways in which the wide area network supported those goals.

The memo justifying the previous upgrade also contained a summary of how the firm's IT infrastructure had evolved. Pierson believed that she and several other managers could make a good case for the new upgrade by updating that summary based on what had happened in the last three years, and then explaining the extent of the current capacity problems.

Two weeks later Pierson and her colleagues met to put together their arguments in favor of an upgrade. Because Darnell wanted to understand how TDG had reached its current situation, they decided to summarize the history and then explain their request for the upgrade. To make the history as straightforward as possible and to tie in the upgrade request, they decided to explain the history as three successive generations of a data network with a fourth generation to come if their proposal would be accepted. They would identify these generations based on the core technology for the generation:

#1, "SneakerNet" and Modems;
#2, Local Area Networks;
#3, Wide Area Network;
#4, the proposed Virtual Private Network.

They would briefly summarize four phases[2] within each generation, would summarize the impacts on work systems, and would try to figure out how past lessons might be reflected in a plan for the proposed upgrade.

A week later Pierson and her colleagues met with Darnell to provide the background he wanted and to lay the groundwork for a major upgrade. The following sections describe the history they were able to uncover and the main points they hoped would lead to a project that would build a new version of TDG's data network.

II. GENERATION #1: "SNEAKERNET" AND MODEMS

Like many small and medium sized firms in its industry, TDG could not afford to deploy information technology on a widespread basis until the introduction of the PC in the mid-1980's. By the late 1980's, TDG had purchased a number of PCs and deployed them in each of its offices. As the number of workstations increased and business processes became more

[2] The Appendix summarizes a four-phase model describing the life cycle of a work system.

computerized, the need to communicate and share data increased rapidly. In 1992, TDG began looking at how to provide easy access and efficient data transfer among users within individual offices and between office locations.

Around that time TDG was using computers in a relatively small number of functions, such as word processing, accounting, and specialized engineering analyses. The production of engineering drawings was just beginning to move from the drafting board to computer-aided design (CAD). Most of the computers were to be shared by multiple employees. For example, a computer purchased for the electrical engineering department might be set up in a separate work area so that all the members of the department could use it. In general, the whole idea of a data network sounded like something that only big companies could afford.

Instead of taking the form of a data network, this first generation relied on people rather than electronic connections. (Figure 1) Within the same office, a user literally transferred data onto a floppy disk and handed the disk to another user. Some people in the computer industry dubbed this approach "SneakerNet". Data transfer between different offices involved sending diskettes to the post office and overnight delivery services. In addition, for small files and urgent transfers a few computers were connected to telephone lines through modems. Towards the end of the period of using SneakerNet, a corporate bulletin board system (BBS) was created to allow files to be uploaded and downloaded from a central location.

PHASES OF SNEAKERNET

Initiation. SneakerNet did not have a clear cut initiation phase; there was no functional specification or project plan. In the early 1990s each department made requests for whatever computers and software seemed to be needed. If the request was approved, the computer was purchased and installed. There was little thought or discussion about how data would be shared or transmitted between computers, either before or after computers were installed.

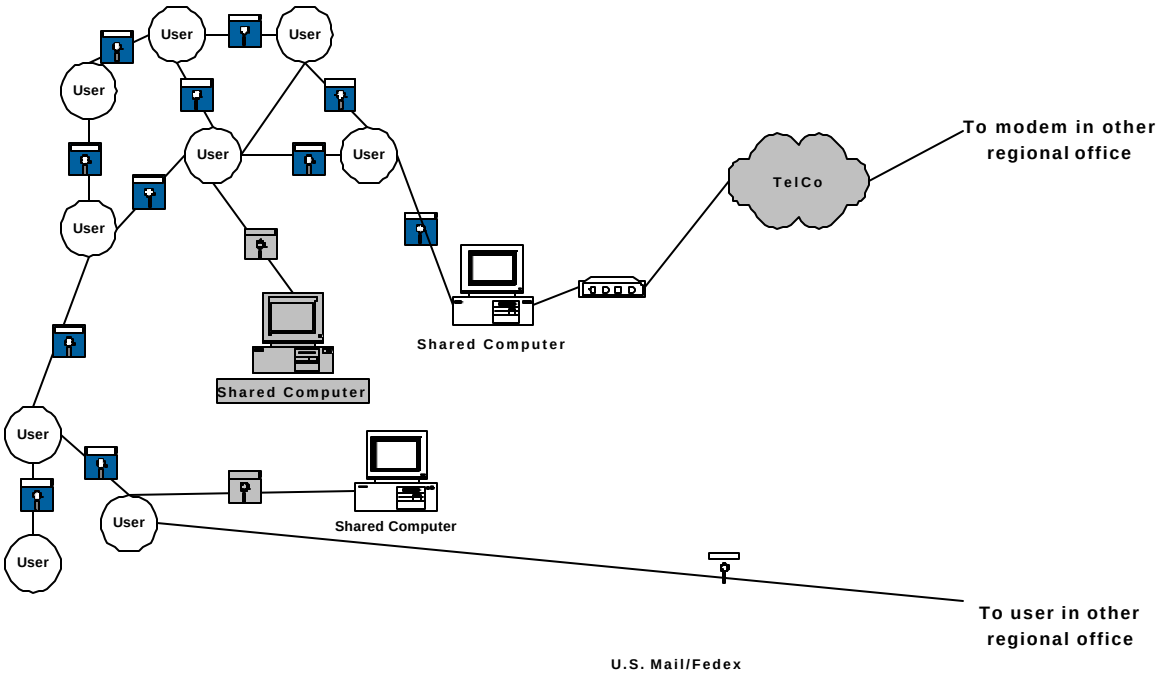

Figure 1. SneakerNet

Development. The development of SneakerNet occurred with almost no real analysis or system design. The computers already existed, and external modems were attached to a few of them. Telephone lines were installed. Communication software was installed and configured on the computers that were connected to modems. The bulletin board system was set up and configured. Much of the development phase and all system testing occurred almost concurrently with the implementation phase since no training was required.

Implementation. As with development, implementation was quite informal and involved no significant planning, training, or rigorous testing. Employees simply started exchanging floppy disks. The modem connections and bulletin board system were tweaked as needed to get them to work properly. Users figured out how to use these capabilities by reading the documentation, demonstrating features to each other, and doing small experiments to figure out what would work.

Operation and Maintenance. Given its simplicity, SneakerNet required little direct effort beyond the ongoing effort to keep personal computers and software running. Several "power users" in each office handled what little operational support and maintenance was required.

EFFECTS OF SNEAKERNET ON WORK SYSTEMS

At first, SneakerNet seemed reasonably effective. Employees were sharing computers spread around each office, and it seemed natural that they would take their data with them. Diskettes worked well for sharing data because the data files were small. There were few problems related to incompatible data formats because only a small number of software applications were being used. Sharing of data was a straightforward process of giving or mailing someone else a diskette.

As more employees discovered the advantages of using computers and became proficient in using them, the demand for the workstations skyrocketed. People had to start reserving time to use them, scheduling their workday around when it was their turn to "get on the computer". Allocating computing as a scarce resource created a lot of frustration and had negative effects on productivity. At the same time, the use of Computer-Aided Design (CAD) software was increasing rapidly in the industry, and more and more TDG clients started requiring electronically prepared drawings. These two factors motivated the firm to buy personal computers for individual users. Within several years, the firm went from having one computer for every five to ten users to having a computer on almost every desk.

As the use of computers became part of everyone's typical workday, SneakerNet started to become an obstacle to productivity. Sharing drawing data, memos, and other computerized information became commonplace, and many users were exchanging diskettes almost every day. As sharing continued, various diskettes contained different versions the same data and it became difficult to determine which version of the data was the current and correct version. This uncertainty caused serious problems with workflow tracking and there were many incidents of working on outdated versions of a project's design.

SneakerNet also couldn't help users share peripherals, particularly printers and plotters. Only a few users' computers were connected to output devices. These users suffered frequent interruptions when their colleagues needed to "print a file or two". In addition, the size of CAD files increased to the point that a diskette could only hold one or two drawing files. Sharing a set of project drawings could involve the creation and distribution of a dozen or more diskettes, a time-consuming task that compounded the problems associated with version control. To complicate matters further, there was no standard computer configuration. TDG owned several different brands and versions of word processors, spreadsheet programs, and CAD software. The resulting incompatibilities impacted productivity, timeliness, and quality of some work negatively.

Electronic communication between offices also expanded during this period. Many dedicated telephone lines were installed as managers began to see the convenience and speed of transmitting files via modem. In one office, 11 individual telephone lines were attached to individual workstations. Telephone bills escalated.

III. GENERATION #2: LOCAL AREA NETWORKS

By the mid-1990's, costs of network hardware, software, and support had fallen considerably, and local area networks (LANs) were becoming more widely deployed by small and

mid-sized engineering firms. At this point, TDG decided that investing in LAN technology would solve most of the problems associated with SneakerNet and would help take advantage of previous and ongoing investments in workstations and software.

TDG began deployment of LANs in several of its offices in late 1994. These LANs connected individual workstations to a file server, to shared peripheral equipment, and to each other as illustrated in Figure 2. The file server provided central data storage. The network also enabled sharing printers and plotters. Linking the individual workstations meant that users could use email to communicate with one another. The offices were linked via telephone modems, and an Internet gateway allowed for email communication outside the company.

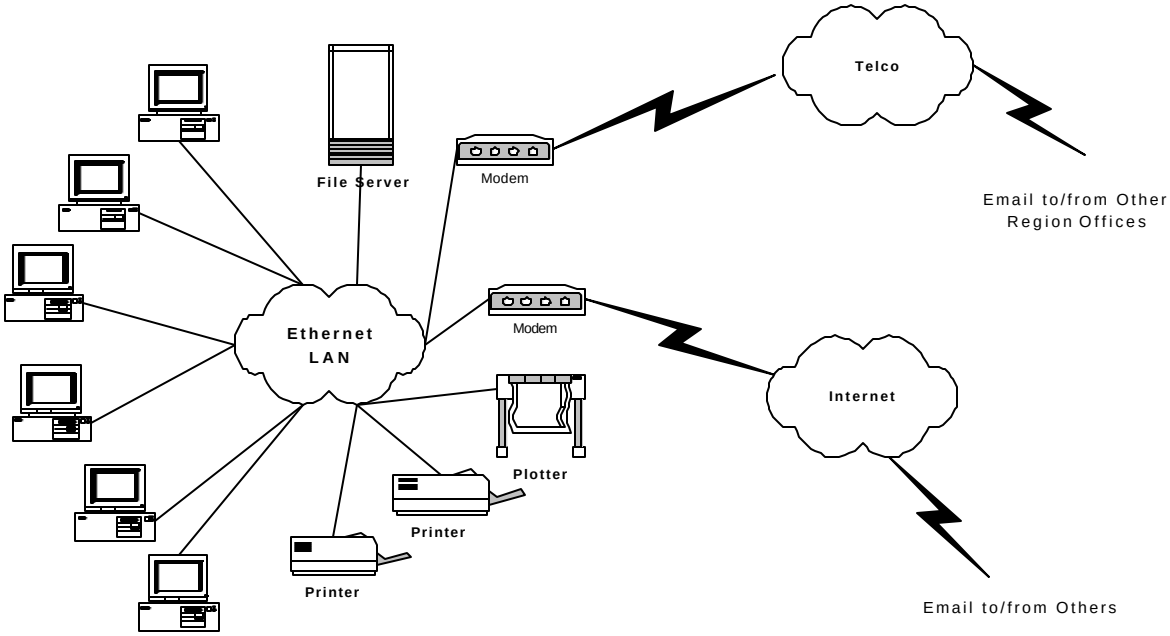

Figure 2. Local Area Network

PHASES OF THE LOCAL AREA NETWORK

Initiation. The LAN projects began in a completely decentralized manner. Typically, several power users in an office got together and tried to persuade the local manager that a LAN was needed. If they convinced the local manager that a LAN might be a good idea, they typically took the next step of preparing a proposal describing what was going to be purchased, who was going to install it, how much it would cost, and what benefits would result from the purchase. Typically, the proposal outlined the general capabilities to be provided by the LAN, summarized the benefits, and provided a brief project plan. The power users worked with a vendor to put together the technical aspects of the proposal.

The specifications for each local LAN were developed largely by representatives of users that it would ultimately serve. However, instead of starting with a business problem, such as "What business processes do we want to improve, and how might LAN technology be used to make these improvements?" the power users seemed to put the technology first by asking the question "If we create a LAN, what business processes will be improved?" The issues addressed in most of the specifications included:

- Making data sharing more reliable than it was with SneakerNet.
- Enhancing communication with email.
- Making it easier to share printers and plotters.
- Beyond these steps, intending to wait and see what other uses evolved.

TDG corporate executives got involved in evaluating the LAN proposals when they saw that different offices were considering the same problem. In addition to considering the merits of the individual proposals, they attempted to achieve a reasonable degree of consistency and compatibility between offices. Rapidly changing technology during the two-year period in which the LANs were implemented made this compatibility difficult to achieve. The technology approved for the first LAN was viewed as obsolete by the time the last LAN project was initiated.

Development. The development phase of each LAN deployment was outsourced to a local vendor. The detailed requirements analysis was typically done concurrently with the initiation phase as part of the proposal used to gain approval for the LAN investment. The vendor typically provided a turnkey "solution" including installation of cables, hardware, software, workstation set-up, and testing.

These installations generally went well. However, the lack of in-house technical knowledge required a high level of trust that the vendor was actually delivering a network that met the detailed system requirements. This trust wasn't always deserved. For example, long after the LAN was installed in one office, a user discovered that a hard disk drive was missing from a file server. It turned out that the vendor configured the system to make it appear that the drive was there and simply took money paid for the drive.

Although documentation of the LAN was typically a requirement of the vendor's contract, very little documentation was actually produced. This lack of documentation later proved problematic when different vendors were hired during the operation and maintenance phase.

Implementation. The implementation phase of for each LAN typically emphasized implementation planning and training. Little or no effort was spent on other implementation steps such as careful conversion from a previous business process to a new business process. This problem received little attention because SneakerNet was rather unstructured and could continue if necessary.

The effort spent on implementation planning varied from office to office. Typically, the main planning issues in this phase involved network administration and user training. After meetings with managers and users, the office's power users typically met with the vendors to produce the local implementation plans.

A critical issue in the implementation involved the ownership and management of network administration tasks such as network security, user accounts, data backup, and help desk functions. Until the deployment of the LANs, almost all of TDG's information systems had been "homegrown" and maintained by power users. When the LANs were deployed, it really wasn't clear who would provide basic network administration and maintenance. Asking the power users to be network administrators would cause conflicts because the same individuals also had significant project and client responsibilities and were expected to maintain a high percentage of billable hours. Any of their time devoted to maintaining the network would be charged to overhead. Excessive amounts of time might have negative impacts on meeting project deadlines. On the other hand, it was not clear whether it was practical or desirable to outsource some or all of the network administration, especially since it wasn't clear how much outsourcing would cost or how responsive vendors would be.

In most offices, power users were trained to perform basic network administration tasks. These users attended vendor-taught classes that covered a variety of subjects at many different levels of detail. There was little "hands on" training or verification of skill acquisition. It became apparent that the power users quickly forgot much of what they learned in the training classes. As a result, their effectiveness as network administrators was often quite limited.

The other major training concern involved basic user understanding of LAN capabilities and of how to use the LAN and the associated email system. The user training consisted of lecture-style presentations with questions and answers about the LAN in general, and hands-on demonstrations of the email system. These training sessions may have alleviated some worries, but seemed to do little to really educate users. Almost all real user understanding and competency came from actually using the network. Despite the ineffectiveness of the formal training attempts, basic user competency developed quite rapidly and no major training-related problems occurred.

Operation and Maintenance. The operation and maintenance phase for the LANs focused on keeping the LANs operational and providing support. This work included network

administration tasks (network security, user accounts, data backup, and help desk functions) plus efforts to keep various combinations of hardware and software operating together properly. Maintenance consisted mainly of installing software patches and repairing minor bugs in the way the LAN was configured. Documentation of procedures was minimal. In some offices, these tasks were completely outsourced; in others the tasks were handled by a combination of in-house staff and outside consultants.

The different combinations of hardware, network operating systems, and email software in the various offices made it challenging to keep the LANs running smoothly. Some of the LANs crashed and had to be re-started frequently. Incompatibilities of email software on different LANs made it difficult to communicate between offices and over the Internet, requiring the development of many workarounds.

The success of ongoing operation and support seemed to depend on who performed these functions and the quality of outside vendors. LANs were best maintained when their operation and support functions were either completely outsourced or handled by a dedicated in-house IT technician with help from an outside consultant. The LAN with the worst reliability problems was in an office that tried to operate and support its LAN through a combination of power users and outside consultants. In that office, IT support responsibilities often clashed with the power users' project responsibilities, with negative effects on quality, financial performance, and staff morale.

Several offices found it difficult to identify high quality vendors for LAN operations and support. Some vendors lacked qualified technicians. In some cases the LAN technician turned out to be a recent high school graduate who was good with computers, but lacked any formal training or industry credentials. In other cases, the technicians were skilled, but not able to deal successfully with the multiple combinations of hardware and software associated with the LAN. In some offices it took about two years to weed out the unqualified vendors and standardize LAN hardware and software so that it could be supported successfully. With minimal documentation of how the LAN was set up and why, the process of improving LAN operation and support was difficult and time-consuming.

EFFECTS OF THE LANS ON WORK SYSTEMS

The LAN deployments affected work systems in the local offices significantly. By using a LAN, employees within an office could easily share data. SneakerNet problems associated with having multiple versions of the same file were eliminated. A central location for data storage allowed for frequent and reliable back up of data. Email access allowed users to communicate across time zones, thereby facilitating more flexible work schedules. Data files, albeit with size limitations, could be sent as attachments to email between offices or to clients and their consultants.

The deployment of LANs also produced significant side benefits. These deployments served as a catalyst for standardizing the software used by the firm. Successful use of the LANs required that data be better organized and properly archived. With project data accessible to all users, people were motivated to learn how to use more software applications, raising the overall level of user proficiency in CAD, word processing, spreadsheets, and other productivity-enhancing software. The dedicated telephone lines from the SneakerNet days were eliminated, resulting in substantially lower unit costs for data communication.

Users quickly became accustomed to using the LANs to share data within their local offices. This success led to new demands for better ways to share data with users in other offices and with clients and consultants. The email system served as the basis of this application. Unfortunately, limitations such as the low data rate of the modems and the size limits on email attachments significantly reduced the effectiveness of data transfer. It was frustrating that sending copies of files as attachments reintroduced SneakerNet-like problems with version control.

While the LANs provided a means to send Email, they did not provide for Internet access at the desktop. Therefore, users could not access information on the Web or use FTP (File Transfer Protocol) sites to upload and download data. Web-access workstations with their own dedicated Internet connections were scattered around the offices and were shared by multiple users, much like the workstations of the SneakerNet era.

The deployment of LANs addressed a number of TDG's goals related to how it wanted to conduct its business. Just using the LAN for more effective data communication helped TDG compete against much larger firms and remain ahead of local competition. The LANs were operated and managed locally, requiring minimal corporate support or overhead. In addition, despite its limitations, the email system supported the firm's goal of being able to sell all services from all offices and using human resources effectively regardless of location. To a greater extent than ever before, TDG was able to move data, not people.

IV. GENERATION # 3 - A WIDE AREA NETWORK

The deployment of LANs demonstrated the importance of effective data communication within and between offices. In 1997, only three years after the LANs replaced SneakerNet, TDG decided to embark on its largest single IT project ever, the deployment of a wide area network (WAN). All other considerations aside, this project had become feasible in 1997 due to drastic reductions in the cost of networking equipment, software, and telecommunication rates in previous years. This cost reduction, coupled with significantly improved reliability of network operating systems and increased competence of technical support resources, convinced company executives and senior managers to invest in a $150,000+ project, the firm's largest single IT investment. The budget used to justify the investment is shown in Table 1. It covers the three largest offices, which were brought up first. Each of the other offices were later added to the WAN for about $5,000 in hardware, $5,000 in consultant costs, $2,000 software, and recurring frame-relay circuit costs of about $500 per month.

Table 1: Budget Used to Justify the Wide Area Network

Estimated Initial Investment

Item	Quantity Number	Unit	Unit Cost	Total Cost
Prepare Network Implementation Document	1	IS	$ 3,000	$ 3,000
Upgrade LAN's to standard WindowsNT NOS				
Region 1- new NT server, NT server/client software	1	IS	12,000	12,000
Region 2- expand existing NT server	1	IS	15,000	15,000
Software- all locations (Exchange, Norton Anti-virus)	1	IS	16,000	16,000
Consultant Labor- all locations	1	IS	10,000	10,000
Subtotal, Upgrade LANs				$ 53,000
Install WAN Infrastructure				
WAN Connections	1	IS	10,135	10,135
Remote Access Servers (3 regions)	3	EA	3,380	10,140
Internet Firewall Package	1	EA	7,000	7,000
New Exchange Servers (2 regions)	2	EA	3,500	7,000
Upgrade Exchange Server (1 region)	1	EA	2,800	2,800
Frame Relay Lines (2 regions)	2	EA	1,150	2,300
Full T-1 Line (1 region)	1	EA	1,050	1,050
DSL Line to ISP	1	EA	550	550
ISDN Lines for Remote Access	1	IS	1,765	1,765
Subtotal, WAN Infrastructure				$42,740
Subtotal, Hardware, Software, Consultants				$ 98,740

Contingency	15%			14,811
Total, Estimated Initial Investment				$113,551
Estimated Monthly Recurring Costs				
Frame Relay Lines (2 regions)	2	EA	$ 575	$ 1,150
T-1 Line (1 region)	1	EA	675	675
DSL to ISP, including ISP account	1	EA	399	399
ISP account	1	EA		
ISDN Remote Access Lines	5	EA	174	870
Total, Estimated Monthly Recurring Costs				$ 3,094

The WAN interconnects the LANs in the local offices. It uses frame-relay technology and accesses the Internet using digital subscriber line (DSL) connections. (Figure 3). With the WAN, users can access the file servers and peripherals in any office and browse the Internet from their desktops. The WAN also enables the use of a groupware application (Microsoft Exchange) to provide messaging, scheduling, task management, and contact management functions. Remote users can access the WAN via dial-up connections. The cost of using frame-relay technology to connect the firm's two Asian offices to the WAN was prohibitive, so these offices still rely on Internet email and FTP for exchanging data.

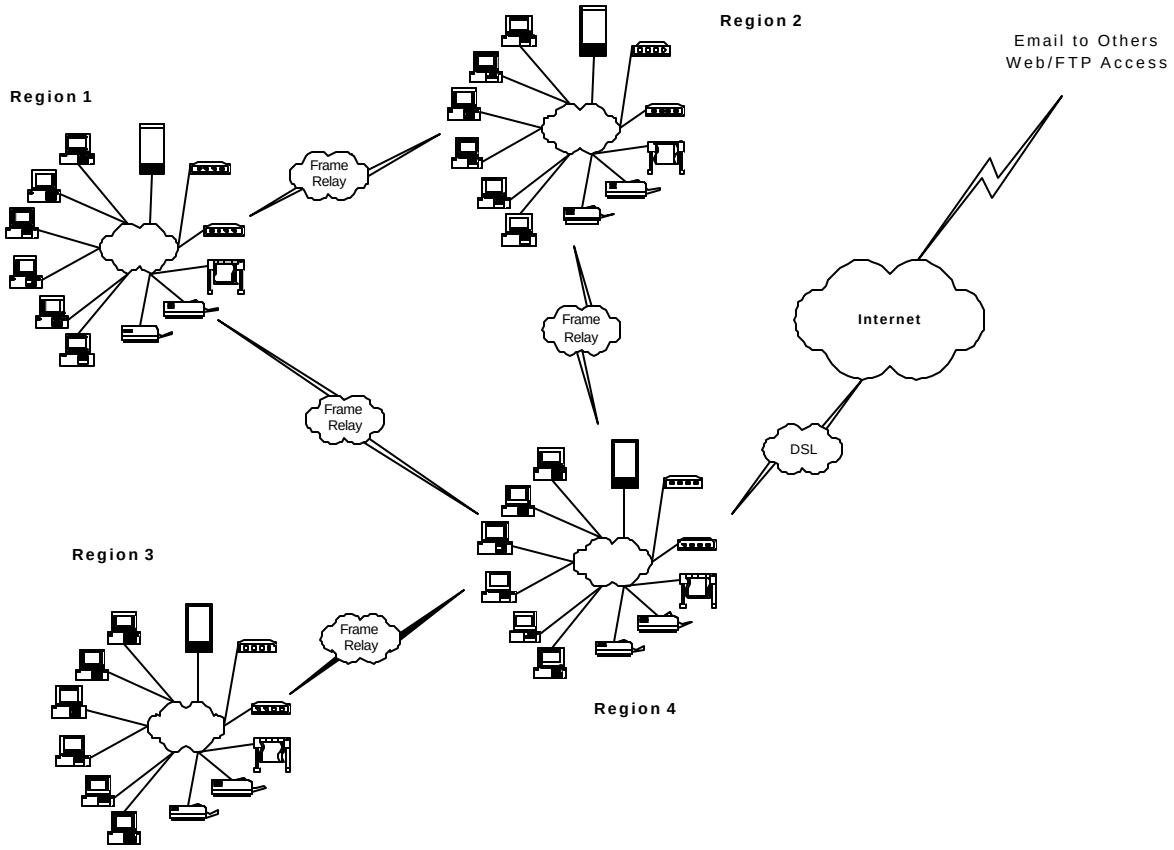

Figure 3. Generation 3: Private Wide Area Network

PHASES OF THE WIDE AREA NETWORK

Initiation. When TDG started to consider the possibility of moving to a WAN, its executives concluded that any such project should only be done as part of a larger corporate IT plan and would have to be planned and coordinated carefully. By its very nature a WAN had to be implemented at a corporate level. Lacking a central corporate IT staff, the firm created an IT Committee consisting of the firm's one full-time IT technician, power users from each office, a few managers, the firm's comptroller, and its CEO. The purpose of this committee was to determine the firm's IT needs, make recommendations, and periodically discuss IT-related developments.

When the IT Committee initially met, it carefully focused on what the firm wanted to accomplish using technology rather than on the type of technology that should be used. This approach was more systematic and business-oriented than the way the LAN deployments had been undertaken. The committee did its best to articulate how the company wanted to operate and what role IT might play in accomplishing those operational goals. This analysis led to two discoveries:

1. The WAN was the key infrastructure that had to be in place before other desired information system improvements could be implemented.
2. Some shortcomings of existing IT systems had to be eliminated before implementing the WAN. The most important of these improvements involved standardizing network operating systems and application software.

After the IT Committee analyzed the important "big picture" issues, it was ready to start defining the requirements for the WAN. The major requirements included:

- Inter-connect the LANs at mainland U.S. offices to allow sharing of data within and among offices and to continue sharing of peripheral equipment.
- Provide desktop Internet access for all users.
- Provide a reliable email platform with robust groupware applications.
- Provide dial-up remote access to each office's LAN, thereby supporting employees and contractors working at client sites and at home.

Starting with these general requirements, the Committee interviewed a large number of consulting firms that might be able to do a feasibility study of available technology to determine the technical alternatives and estimate project costs. It selected a company called Larchmont Consulting.

Larchmont prepared a study summarizing the technical alternatives, their costs, and the advantages and disadvantages of each. The IT Committee's chairman, one of TDG's senior managers, became the WAN project manager. He worked with Larchmont to develop a project plan outlining the tasks, schedule and cost for acquiring, installing, and implementing the WAN.

Development. The WAN project was sole-sourced to Larchmont, which prepared the detailed requirements analysis, arranged for the installation of frame relay and DSL technologies, programmed and installed routers, configured the groupware application software, and tested the system. Larchmont also supplied basic documentation summarizing the WAN configuration and its associated IP addresses and other important parameters.

Clarification of Larchmont's responsibilities and those of the various TDG offices was an essential aspect of this part of the project. Larchmont would be responsible for the routers, the data circuits, and the configuration of the groupware application. The local operations and support personnel would be responsible for the LANs and the server hosting the groupware application software. This separation of responsibilities helped achieve a high level of coordination between Larchmont and the local support staff.

The installation of the WAN went smoothly and was finished on time and within budget. From design to completed installation took about four months. The actual installation took about two weeks. About three people were involved on the consultant's end - a project manager, a MS Exchange technician, and a router technician. One in-house person at each office also worked about a week, full-time, assisting the consultant with the installation. Debugging took about a

week, with the same consultant and in-house people working part time to fix problems that cropped up. The senior manager overseeing the project spent a few days during design and procurement, and about the same amount of time during installation/debugging. No other major resources were required to install the WAN.

Implementation. The planning for the implementation focused on two key areas, user training and conversion. The WAN project manager worked with Larchmont to develop an appropriate plan.

Based on the firm's experience deploying its LANs, the formal user training for the WAN and new groupware application was designed as only an introductory overview and answering questions. Users at each office attended a half-day training session that explained what the WAN was, how it worked, and how it would be used for various business tasks. The features of the groupware application were also reviewed during this session and self-teaching reference books distributed. This approach seemed to work well. The experience users had gained since deployment of the LANs was directly applicable to the WAN and new groupware application. Users quickly attained system understanding and competence.

The largest implementation challenge was conversion from the existing email system to the new groupware application. In two years, the firm had gone from having no email system to using email as an essential part of internal and external communication. The implementation plan included the steps and sequencing necessary to switch email platforms without interrupting email services. This process went off without a hitch, even though it required coordination with three Internet Service Providers (ISPs) and using two different network operating systems and two email software packages that had some incompatibilities.

Operation and Maintenance. The separation of responsibilities established during the development phase was helpful in establishing responsibilities for operation and support of the WAN. By now, the growing pains associated with local support of the LANs were basically history and each office had a reliable support system. It seemed only logical that Larchmont, which had developed the WAN so successfully, should continue supporting its operation and support. This approach seemed to work well, both in terms of high reliability and reasonable cost. During this period the firm spent about $2,000 per month on consulting costs associated with operation and maintenance of the WAN and about $2,000 per year in WAN software upgrades.

Maintenance of the WAN and groupware application typically involves the installation of software patches and upgrades. In addition, several circumstances required incremental enhancements to the WAN:

- Virus attacks, particularly those using email attachments, required the installation and support of a virus protection package.
- The volume of data grew significantly after the initial WAN deployment, requiring upgrades and close attention to the maintenance of data back-up systems.
- Increased traffic, particularly Internet access, required close attention and frequent troubleshooting to ensure that as much bandwidth as possible was available at all times.

EFFECTS OF THE WAN ON WORK SYSTEMS

In the three years since the WAN was installed TDG has made major strides towards achieving the operational goals that motivated that effort. It is now able to sell and deliver all of its services from any of its offices. The WAN allows a much higher quality of communication between users working in different geographical locations, and thus contributes towards more effective working relationships. More and more information is now exchanged electronically rather than in printed form, which streamlines review, revision, and re-use of the information.

Attaining more effective collaboration required ongoing changes in the details of communication plus much greater care in how shared data is organized and stored.
Achieving effective collaboration using the WAN required that employees in all offices increase their proficiency in the use of groupware and other software applications. Achieving greater access to shared data required much more coordination in the way specific documents were named and organized. Users in different offices had to agree on a standard directory structure for

organizing data files. Without this directory structure, users in one office couldn't find files without first having to call a user in another office to find out where the files were located. Once the directory structure was standardized, the location of files seemed more intuitive and the amount of time spent on inter-office data coordination was significantly reduced.

Deployment of the WAN also drove home the fact that TDG's business had become highly dependent on its IT infrastructure. The firm was at substantial risk of suffering a significant loss if a disaster were to occur that damaged or destroyed any key component of the WAN or of an office LAN. As a result, TDG asked Larchmont to prepare a disaster recovery plan. This plan includes instructions for restoring operating systems and restoring data from backup tapes. It also identifies key hardware components for which spares should be pre-purchased and available on-site.

LESSONS LEARNED IN THE FIRST THREE GENERATIONS

As we look forward we should try to recognize and apply the lessons we have learned from the first three generations of our data communication network. These lessons were :

- The development of TDG's information systems should be based on our strategic and tactical goals as a company. Instead of speculating about how a particular technology might improve our processes, it is better to consider where our processes need improvement and then to identify specific system changes that would best achieve these improvements.
- Our IT Committee was (and is) effective at developing broad goals and general guidelines for information systems. Effectiveness is due primarily to the composition of the committee, which includes representatives from a broad range of backgrounds and positions within the firm.
- Sole-sourcing the development of complex information systems yielded better results than trying to coordinate multiple vendors. Careful qualification and selection of vendors is essential for successful system development, operation, and maintenance.
- At TDG the most effective user training occurs through hands-on use or participation in a system. Training efforts are best spent on an initial overview and on resources tailored to individual user abilities and preferences, such as learning from books, on-line training, or attending classes.
- At TDG a combination of in-house and outsourced support staff provided reliable and efficient operation and maintenance of information systems.
- Standardization of hardware and software improves the effectiveness of IT support resources.
- Basic system development documentation and operational documentation are important, not only for ongoing operation, but as references for new staff and vendors, and for future system enhancements.

V. PROPOSAL FOR GENERATION #4 – A VIRTUAL PRIVATE NETWORK

Today, TDG is at the limits of the WAN's capabilities. Data traffic between offices increased significantly due to vastly increased collaboration on marketing efforts and project execution. In addition, everyone seems to expect the use of high-resolution digital images that multiply the average data file size. And the increase in traffic between offices pales in comparison to the increased use of the Internet. The use of Internet-hosted project collaboration web sites is increasing rapidly and much project communication between TDG and significant clients and their consultants now takes place over the Internet. These project sites provide a secure, managed location where project documents can be stored and retrieved by project team members. Examples of project Web sites are buzzsaw.com, projectcenter (bricsnet.com), and teambuilder (e-builder.net) A typical site provides a user and administrative interface, tools for viewing and marking documents, and alerts users when information is added or changed. Currently about 10 percent of clients use these sites, but these clients represent about 30 percent of our revenue.

The increased traffic on the WAN is beginning to cause congestion and unsatisfactory performance due to insufficient bandwidth. The shortfall is most pronounced at the end of the

work day, when data is transferred to update project web sites or project consultants, and on Friday afternoon and Monday morning, when timesheets are due from employees.

We propose converting to a virtual private network (VPN) that sends data securely between offices using the Internet. Instead of using a private frame-relay network, each office will have a high-speed connection to the Internet. The VPN technology will be used to build virtual data "tunnels" between offices through the Internet. The resulting network is shown in Figure 4.

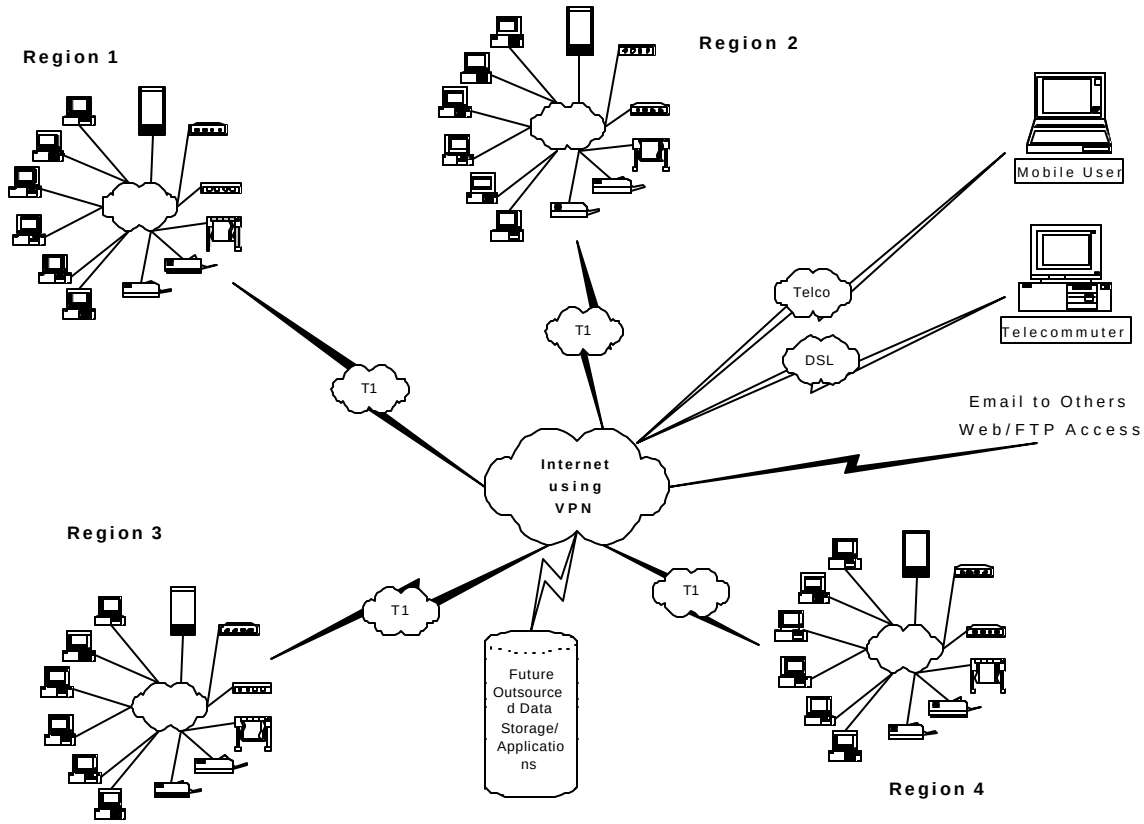

Figure 4. Generation #4: Virtual Private Network Using the Internet

Moving to a VPN would solve the congestion problem and would also provide new opportunities to use our data more effectively to meet our strategic and operational goals. In particular, it would provide:

- Higher data transmission speeds between offices.
- Much faster Internet access, with greater reliability due to having multiple connections rather than a single connection).
- Cost-effective connectivity with the Asian offices
- Easy connectivity to new offices, remote users, and telecommuters, with flexibility as to the type and speed of the connection.
- Potential ability to outsource IT functions to Internet-based vendors who might be able to provide data storage, software applications, web hosting, and other services.

One side effect of moving to the VPN would be a more centralized IT effort. Each phase in the WAN project involved more centralization than TDG had had previously. The VPN project would continue that trend, which is inconsistent with TDG's organizational structure and financial performance measures. For example, although the firm's executive management makes the high level decisions related to investments in firm-wide IT systems, most of the costs for the projects and for system operations would appear on the profit and loss statement of the local offices. Furthermore, until recently overall responsibility for the firm's IT infrastructure generally rested with Harold Parini, who was also responsible for marketing, project management, and local office management functions. IT issues that competed for his attention often tended to reach an undesirable level of urgency before they were addressed. This delay is becoming a problem because IT systems are now used in almost every aspect of the firm's business. Computer support staff and consultants are vital to day-to-day operations. The ability for these IT support resources to work on systems remotely and collaborate with each other is key to the reliability and cost effectiveness.

PROPOSED PHASES OF THE VPN PROJECT

Initiation. In moving to the next generation of the data communication network TDG should apply the lessons learned from the initial deployment of the WAN. Based on preliminary analysis and discussion with several vendors we currently believe that an Internet-based virtual private network will be the preferred approach.

Our preliminary discussions with Larchmont indicate that the VPN technology has a proven track record and that a VPN project would definitely bootstrap on the standardization and technology upgrades required for the WAN project three years ago. Assuming that we make a three-year commitment, the likely monthly cost for the VPN for the five mainland offices will be around $1000 per office per month. Expenses for installation and some new equipment such as firewalls for the mainland offices will total around $15,000 to $20,000. Remote users needing occasional access to local LANs for e-mail or to work at home a few hours a week will probably be able to use a different VPN service designed for that purpose. That type of service will probably cost around $1500 to set up and a minimum monthly charge of around $200, although that amount could be exceeded easily, even at the current rate of $.04 per minute.

Although we feel comfortable with these preliminary estimates, we recommend selecting an external consultant (probably Larchmont) to conduct a feasibility study to identify areas where our business needs and strategies would be better served by improving our infrastructure. It would not be enough to just make a technical recommendation about how to increase the bandwidth for each office. Instead, the consultant should travel to all of our mainland offices to talk to user representatives and visualize each situation first hand, although it would be adequate to contact users in the overseas offices by telephone. The consultant should produce a written feasibility study identifying potential improvements and explaining how those improvements would benefit our key business processes. The feasibility study should include cost estimates for several alternatives if several different approaches might be used.

The IT Committee should review the study and create a proposal that explains business benefits and identifies estimated costs and benefits. The recommendation would go to the Executive Committee for approval.

Development. Based on our current understanding, we would probably outsource the development to a single vendor just as we did with the original WAN deployment. Assuming we go with a VPN, the vendor would arrange for the installation of new data circuits, obtain hardware and configure it for the VPN, and document and test the new network. The vendor would also assist with installing remote access software on laptop computers and on employees' home computers so that they can conveniently log on to the Internet and then onto the VPN from wherever they happen to be working.

Implementation. The implementation would bootstrap on what everyone already knows from using the WAN. Training would probably consist of providing an overview of the remote access software and then letting users learn by doing.

We think the implementation will be easy because most employees will be very enthusiastic about the way remote access could improve the quantity and quality of work done while away from the office. We should probably sweeten things a bit more by supporting

telecommuting through installation of high-speed Internet connections in the homes of certain employees who consider the possibility of telecommuting several days a week as a significant benefit.

To minimize risks, we would probably continue operating the current WAN until the new VPN is working properly. Just to be sure, we would probably do a formal acceptance test in each office. We believe that most of the changeover from the current WAN to the VPN will be invisible to the users.

Operations and Maintenance. We assume that operation and support of the VPN will be similar to our methods with the current WAN. However, growth of the network and increasing numbers of remote users and telecommuters will probably require an increase in in-house and outsourced support resources. The abilities of in-house IT staff will have to be increased through formal and on-the-job training. The hours budgeted for outsourced IT support will increase by about 25 percent. Remote access software will allow in-house staff and consultants to work on systems in other locations, thus allowing IT support resources to be shared by several offices. Sharing will change how the support is managed and accounted for.

DISCUSSION QUESTIONS

1. How has the deployment of successive generations of data networks enabled changes in basic work practices at TDG? In what ways do these deployments address TDG's goals for IT-related systems?
2. Compare the justifications of the first three generations of the data network. Explain why each of these justifications seems adequate or inadequate in relation to TDG's situation at the time each major change was being considered.
3. What criteria should TDG use in deciding whether to proceed with the virtual private network and in selecting among possible technical and vendor alternative for that network?
4. Assume that TDG's management insisted on having a cost-benefit analysis including return on investment, net present value, and payback period. Identify the items that you would include in the costs and in the benefits and explain how these dollar amounts might be estimated.
5. How did the successive generations of data networks affect the organization's balance between centralization and decentralization? In what ways were these impacts desirable or undesirable?
6. What are the advantages and disadvantages of relying so heavily on vendors for project work and technical expertise? Should TDG continue with its current degree of outsourcing?

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APPENDIX: PHASES IN A WORK SYSTEM'S LIFE CYCLE

From a business viewpoint, any system, regardless of whether or how it uses IT, goes through one or more iterations of four phases:[3]

[3] Source: Alter [2002]. These phases are the basis of a revised life cycle model presented in Alter [2001]

- Initiation is the process of stating the problem and how a new IT-based system or major upgrade of a previous system should help.
- Development involves acquiring, building, and/or modifying the systems (IT and non-IT) and other resources required to perform the required functions.
- Implementation involves making the new system operational in the firm.
- Operation and maintenance is the ongoing operation of the IT-based system and the entire work system, plus activities related to solving problems solving as they arise.

Each of these phases is discussed in more detail in what follows.

INITIATION

The initiation phase is the process of clarifying the reasons for changing the work system, identifying the people and processes that will be affected, describing in general terms what the changes will entail, and allocating the time and other resources necessary to accomplish the change. This phase may occur in response to obvious problems, such as unavailable or incorrect data. It may be part of a planning process searching for innovations even if current systems pose no overt problems. When the work system involves software, errors and omissions in this phase may result in software that seems to work on the computer but needs expensive retrofitting after initial attempts at implementation in the organization. Unless the initial investigation shows the project should be dropped, this phase concludes with a verbal or written agreement about the proposed system's general function and scope, plus a shared understanding that it is economically justified and technically and organizationally feasible. Depending on the situation, this agreement might be general and informal, or might be quite specific in identifying budgets, timelines, and measurable objectives. Key issues in this phase include attaining agreement on the purpose and goals of the proposed change and making sure that the likely benefits far exceed the likely costs in terms of time and resources. The larger the project the more desirable it is to document specific expectations along with a plan for accomplishing genuine results (as opposed to just performing specific activities at specific times). Regardless of how formal the agreement is, the details of the desired changes will be worked out in the development phase.

DEVELOPMENT

The development phase is the process of defining, creating, or obtaining the tools, documentation, procedures, facilities, and any other physical and informational resources needed before the change can be implemented successfully in the organization. This phase includes deciding how the work system will operate and specifying which parts of the work will be computerized and which parts will be manual. In projects that involve new hardware, the hardware must be acquired and installed. In projects that involve creating software, development includes producing detailed specifications of what the users will see and how the software and data operate on the computer. After the software programs and documentation are created and debugged, the entire system of hardware and software is tested.

Completion of development does not mean "the system works." Rather, it only means that the tools, documentation, and procedures were produced and that computerized parts of the work system operate correctly on computers. Whether or not the computerized parts of the work system actually work adequately will be determined later by how the entire work system operates in the organization. Key issues in this phase revolve around creating or obtaining all required resources in a cost-effective manner and, if necessary, demonstrating that tools and procedures actually meet the requirements. Completion of this phase means that the tools seem to function properly. Whether the work system will absorb or reject the desired changes is determined by the next phase.

IMPLEMENTATION

The implementation phase is the process of making the desired changes operational in the organization, which in the case of e-business might be a virtual organization involving a number of different companies. Implementation activities include planning, training of work

system participants, conversion to the new work methods, and follow-up to ensure the entire work system operates as it should. Ideally, the bulk of the work in this phase should occur after development is complete, meaning that all tools and procedures are ready and that all software was tested and operates correctly on the computer. This phase ends when the updated work system operates effectively in the organization.

An initial step in this phase is detailed planning for the conversion from the old way of doing things to the new. After work system participants are trained, the actual conversion to the new work system occurs. This step usually raises issues about how to convert to a new process with minimum pain and how to deal with political questions and changes in power relationships. In all of this, success of the computerized parts of the work system is determined partially by features and partially by the development and implementation process itself. The likelihood of success drops if this process cannot overcome the inertia of continuing current business processes or if the implementation itself causes resistance.

If a work system's development phase created or modified an information system, some parts of the conversion involve the changeover to the new or modified information system and other parts of the conversion may be changes in practices that are The implementation phase is the process of making the desired changes operational in the organization, which in the case of e-business might be a virtual organization involving a number of different companies. Implementation activities include planning, training of work system participants, conversion to the new work methods, and follow-up to ensure the entire work system operates as it should. Ideally, the bulk of the work in this phase should occur after development is complete, meaning that all tools and procedures are ready and that all software was tested and operates correctly on the computer. This phase ends when the updated work system operates effectively in the organization.

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OPERATION AND MAINTENANCE

This final phase involves keeping the work system operating effectively by monitoring its performance and making minor changes that do not require a major project. When an information system plays a major role in a work system, someone must make sure that it continues to operate, that it provides benefits, and that desired changes are at least considered. This phase continues until the system is terminated or until major changes are required. At that time a new iteration of the four phases starts; management allocates resources to initiate a project; the new initiation phase ends with specific ideas about what should change; the new development phase begins, and so on. Operation and maintenance may not seem as intellectually intriguing as development, but by typical estimates it absorbs the majority of a firm's information system expenses.

ABOUT THE AUTHORS

Stephen Cox is the Executive Vice President in charge of IT Systems Planning with Winzler & Kelly, Consulting Engineers. He has a BSE from the University of Pennsylvania and is completing a Professional MBA at the University of San Francisco School of Business and Management.

Renee Dulfer is the Marketing and Sales Manager for Large-Signal Analysis Solutions at Agilent Technologies. She has a BS in Electrical Engineering from California Polytechnic

University of Pomona and is completing a Professional MBA at the University of San Francisco School of Business and Management.

Captain David Han is an S-4 Logistics Officer in the 23d Marine Regiment, 4th Marine Division, Marine Forces Reserve, United States Marine Corps. He has a BBA-Information Systems Management from The University of Memphis and is completing a Professional MBA at the University of San Francisco School of Business and Management.

Ubaldo Ruiz is the Plant Manager at Mendocino Forest Products. He has a BS in Business Management from the University of Phoenix and is completing a Professional MBA at the University of San Francisco School of Business and Management.

Steven Alter is Professor of Information Systems at the University of San Francisco. He holds a B.S. in mathematics and Ph.D. in management science from MIT. He extended his 1975 Ph.D. thesis into one of the first books on decision support systems. After teaching at the University of Southern California he served for eight years as co-founder and Vice President of Consilium, a manufacturing software firm that went public in 1989 and was acquired by Applied Materials in 1998. His many roles at Consilium included starting departments for customer service, training, documentation, technical support, and product management. Upon returning to academia, he wrote an information systems textbook whose fourth edition was published in August 2001 with a new title, *Information Systems: Foundation of E-business*. His articles have appeared in *Harvard Business Review, Sloan Management Review, MIS Quarterly, Interfaces, Communications of the ACM, Communications of the AIS, CIO Insight, Futures, The Futurist,* and many conference transactions.

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