Angka Giliran : ....

UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 1996/7

October/November 1996

AGW604 - MANAGEMENT INFORMATION SYSTEM

Time : [3 hours]

INSTRUCTION:

Please make sure that this examination paper consists of NINETEEN (19) printed pages before you begin.

There are three sections to this examination paper. Sections A and C are COMPULSORY. Answer any TWO (2) questions from section B.

SECTION A

1. Answer True or False for the following statements. Write T (True) or F (False) in the blanks provided and detach the first two pages of this examination paper, write your "angka giliran" at the top right hand corners and attach them to your answer script. Marks will be deducted for wrong answers.

a. ___ Transaction processing system (TPS) are major sources of information for other systems in the organization.

b. ___ The competitive advantage conferred by strategic information systems usually ensure long-term profits.

c. ___ The agency theory of the impact of information systems on organizations states that the information systems help firms lower costs by substituting technology for labour.

d. ___ The sociological theory of the impact of information systems on organizations states that information technology has strong independent power to transform organizations.

e. ___ Information systems should be directed towards making decisions rather than supporting decision making.

f. ___ Cooperative processing is the process of transferring applications from large computers (mainframes) to smaller ones (microcomputers).

g. ___ Time sharing is an operating system capability that allows many users to share computer resources simultaneously by allocating a fixed slice of time to each user.

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h. ___ Object oriented programming is based on the concepts of separating data from the procedures.

i. ___ A distributed database is one which is not centralized in one location.

j. ___ One purpose of a database is to serve multiple applications with as few physical representations of data as possible.

k. ___ Data integrity and security are more difficult to enforce in a distributed database environment compared to a centralized one.

l. ___ In a simplex transmission data can be transmited in both directions but can only travel in one direction at a time.

m. ___ Connectivity is the ability of computers and computer-based devices to communicate with one another in a meaningful way without human intervention.

n. ___ In the development of information systems, the critical success factor approach is used at the design stage.

o. ___ Business process redesign is also called rationalization of organizational procedures.

p. ___ Although the system life cycle approach is time consuming, it compensates for that by its ability to respond flexibly to changes in user requirements.

q. ___ One value of CASE tools is that they allow an IS department a great deal of flexibility because they do not enforce standard development methodologies.

r. ___ IS specialists tend to be more concerned with processing efficiency whereas end users tend to be more interested in solving business problems.

s. ___ The intention of DSS should be to allow the decision making session to be completely in the control of the end user.

t. ___ Expert systems are especially well suited for managerial problems because managers can more easily communicate their requirement to knowledge engineers.

[20 marks]

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SECTION B

Answer any TWO (2) questions.

2a. Computer-aided software design, reusable code, prototyping and so on have reduced the time frame for developing and implementing a new system. With this in mind, will firms still be able to capture a sizable competitive advantage by being the first in the market with such a system? In your opinion, will any such advantage be sizeable or last long enough to warrant the risks inherent in such an endeavour? Explain.

[10 marks]

b. As a marketing/sales manager of a small retail goods manufacturing firm you are faced with the loss of your most important account, a nationwide discount store chain, unless you adopt its EDI standard. For the size of your firm, this would entail a substantial investment. What options might be available to you?

[10 marks]

3. Why is it so difficult to define the requirements of an Information System? Briefly discuss the approaches that can be used by analysts to assist managers in defining the requirements.

[20 marks]

4. Briefly describe the prototyping approach as a development methodology for information system. What are its advantages and limitations?

[20 marks]

5a. What do we mean by information system failure? What kind of problems are indicators of information system failure?

[10 marks]

b. What strategies can be used to overcome user resistance to system development projects?

[10 marks]

SECTION C.

The case (which was distributed before the examination) for this section is given in the appendix.

6. For the Corning case, answer the following questions.

a. Use the competitive forces and value chain models to analyze the Corning Telecommunications Division. What competitive forces did Corning have to deal with? What were the strategic advantages of switching to a flexible manufacturing system for optical waveguides?

b. What were the problems with Corning's existing manufacturing system for optical waveguides? How serious were they? What management, organization, and technology factors contributed to these problems?

c. What management, organization, and technology issues had to be addressed to implement a flexible manufacturing system successfully?

d. What criteria would you have used to determine whether Corning should invest in this project?

[40 marks]

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APPENDIX

CORNING TELECOMMUNICATIONS DIVISION (A): THE FLEXIBLE MANUFACTURING SYSTEMS PROJECT

Andrew Boynton, University of North Carolina at Chapel Hill and the International Institute for Management Development (Switzerland), Michael E. Shank, Renaissance Vision

Driving across the Gibson Bridge toward his office in July 1990, Bob McAdoo, senior vice president and head of manufacturing for the Telecommunications division of Corning, Inc., thought about the appropriations request he would be discussing with his staff on Friday morning. The division was requesting $5 million for a new planning and scheduling system plus a reconfigured information system to cope with manufacturing changes at its Wilmington, NC, plant, where Corning made optical waveguides. Such a sum was not an incidental capital investment. Moreover, exactly what they would be getting for the money was hard to say. The budget for hardware and packaged software was dwarfed by the costs of design work and consultants. The consultants would be designing a system that had never been built before, and after problems with the last systems-development project, ATLAS, the idea of breaking new ground in software was troubling (ATLAS, even though it was a well-understood business data system, had been two years late and millions over budget.) In addition, no one could tell McAdoo if the proposed Flexible Manufacturing System (FMS) would work once it was designed, writen, and implemented. All they would say is that they "didn't think the plant could continue to work without it."

OPTICAL WAVEGUIDES

Optical waveguides are glass fibers that allow communication by light rather than electricity. On fifth thinner than a human hair, the core of these fibers can carry more than 16,000 simultaneous phone conversations (compared with 24 for copper wire). Unlike copper, optical fiber can also carry information in both directions (sending and receiving) simultaneously. Fibers can transmit light more than 100 miles without regeneration and operate 20,000 feet under water with a 40-year life. Despite their close resemblance to fishing line when coated, fibers can withstand 1 million pounds per square inch of tensile stress. Optical fiber can also carry more information much faster than copper wire. Fiber's carrying capacity of 1.8 billion bits per second can transmit the Encyclopedia Britannica and the Bible around the earth together in less than 2 seconds.

Optical fibers behave like "light-pipes." Because of their differences in composition, the refractive index of the core is higher than that of the outer coat (cladding). As a result, light rays travelling through the core will be reflected back into the core if they stray from a straight line and bounce into the core/cladding interface. Consequently, light stays in the core even when the fiber is bent.

The two types of fiber were multimode and single mode. Multimode was primarily used for local building-to-building and intrabuilding wiring, where its comparatively large core size contributed to reduced installation costs. Multimode was available in several glass and coating designs, which when combined with various optical performance levels, resulted in a wide and increasing variety of stock-keeping units (SKUs).

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Single-mode fiber was used primarily by telephone companies. Initial applications were for long-distance telecommunication applications by companies like MCI, AT&T, and Sprint. New types of fiber and coatings, and declining systems costs after 1983, led to many new applications by regional telephone companies (e.g., Bell South), cable television companies, and long distance communication companies. Given the efforts by telephone companies to emphasize product standardisation and compatibility of competing vendors products, fewer single-mode than multimode fiber SKUs existed. Single-mode fiber represented approximately 90% of the market volume.

Corning sold almost all of its fiber to optical-fiber cablers. A few cablers accounted for approximately 80% of Corning's sales, with 200 customers making up the remaining 20%. Essentially, cablers packaged the optical fiber in a variety of materials to protect it during installation and to limit the effects of its installed environments. From a materials point of view, cablers added little to the value of the fiber, and the fiber itself was a large portion of the cost of fiber cabling. Excess capacity plagued the cabling industry, and barriers to entry were low. Telephone companies' purchases comprised 70% of the optical-cable market, and these companies were adept at creating a level playing field through specification standards and purchasing strategies. Product quality and service were important to the phone companies, but these parameters were viewed largely as requirements for entry. Bidding to attract the phone companies' business was fierce. Overall, profits for optical cablers tended to be low, which was consistent with the financial performance they achieved when these same cablers had been copper-wire cablers.

As the costs of fiber optic systems declined, phone-company fiber-cable installation migrated from long-haul telecommunications trunks (e.g., MCI) through regional telecommunications (e.g., Bell South) interoffice trunks joining central-office switching systems to feeder cales connecting central-office switches directly to large businesses or to residential neighbourhoods (see Figure 1).

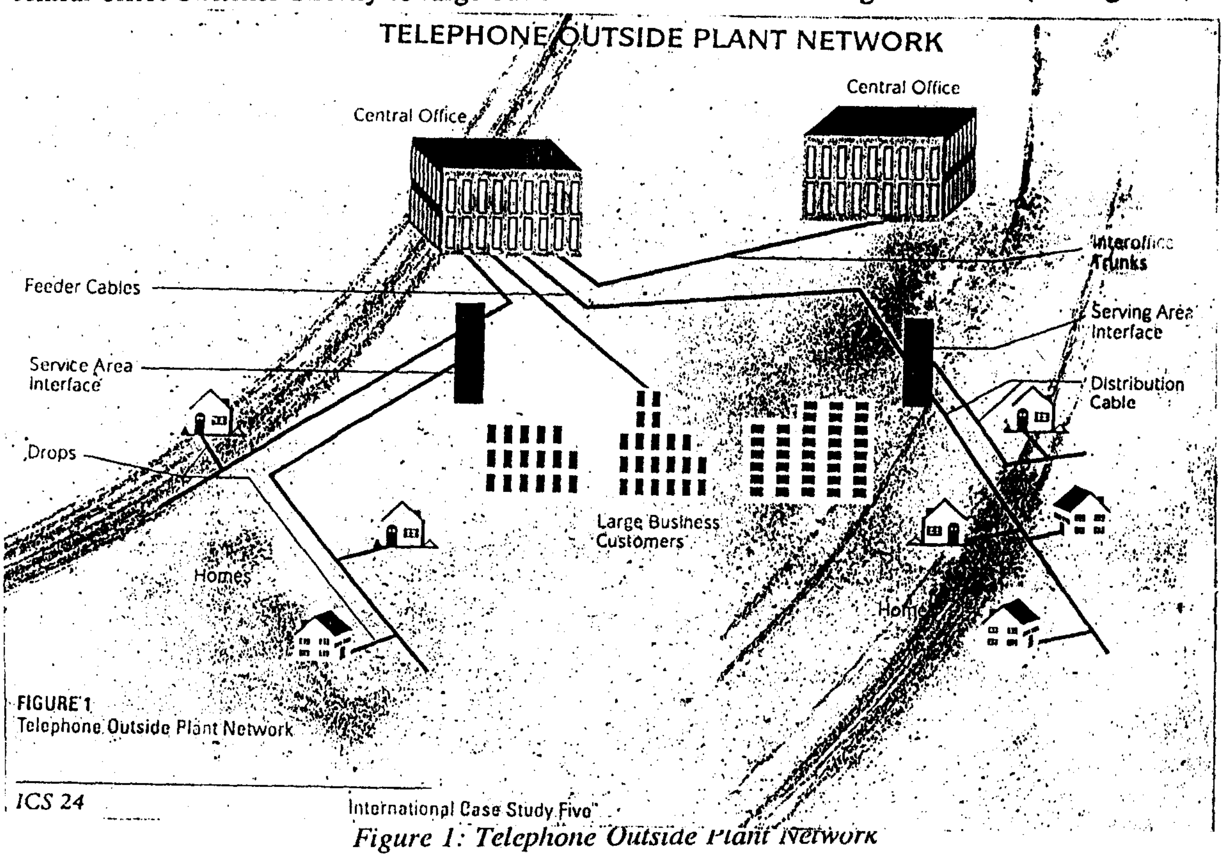

Figure 1: Telephone Outside Plant Network

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Phone companies were betting that optical system's costs would decline to the degree that they would be no different than the costs of a copper wire system for final telephone line connections to residences (distribution and drop cables). When the fiber could be installed to the home, the phone companies would be able to take advantage of fiber's unlimited capacity to provide a raft of new information services such as video entertainment on demand, home shopping, and home education. This development would allow the phone companies to become the aggressive, high-growth information firms they had envisioned at the time of divestiture.

The cable television market also used single mode fiber, to improve picture quality and channel capacity and as a defensive posture against the phone companies, who were interested in entering the home entertainment video market. Cable TV's mass deployment of fiber had lagged the phone companies by five years, but growth since 1988 had been strong.

Beyond the phone companies and cable TV markets, another large and growing segment was premises wiring-banks, corporate offices, universities, hospitals, industrial complexes, and brokerage houses. These customers made up the market for multimode fiber. Standards had not progressed as far in this segment, and several different multimode glass and fiber designs serviced the market. Given the lack of concentrated purchasing observed in the phone company segments, the buying patterns were not as orderly. Many fiber cablers and systems integrators would often bid on the same premises job, and quote turnaround times and cable lead times were key determinants in establishing the winning bidder.

Cablers passed these segment pressures directly to Corning and other suppliers - AT&T and Spectran. While Corning an AT&T devoted a large percentage of their fiber capabilities to single mode, Spectran owed its existence to the multimode market. Spectran used attractive pricing, rapid quote turnaround, and competitive lead times to attract business.

Another interesting segment was the undersea telecommunications market. Transoceanic cables had been developed and installed linking the U.S with Europe and Japan. Undersea cables were installed around the perimeter of Italy in time to be used for transmitting the recent World Cup Soccer matches. In this applications long length, low loss, high strength fibers were used to reduce the installed system cost. Increased interest was developing in an altered single mode fiber design, which optimised optical performance at longer wavelengths, thus resulting in lower loss fibers and further reductions in installed system cost.

Beyond these current markets, new segments were on the horizon for fiber, including fiber for tethered weapons, navigation, and sensor applications. Product designs were still being finalised, but it was clear that new glass and coating designs beyond today's product lines would be required to meet these segment's requirements.

Waveguides at Corning Incorporated

Corning, Inc., in 1990 was composed of four primary sectors, Specialty Glass and Ceramics, Communications, Laboratory Services, and Consumer Housewares. Specialty Glass and Ceramics marketed over 40,000 specialty materials, including eyeglass materials, and auto-emission filters. The Communications sector produced optical fiber, opto-electrical components for fiber networks, video display glass, and liquid crystal displays. Laboratory Services provided clinical testing, life-science research, and environmental testing services. Consumer Housewares produced such well-known products as Corning Ware, Revere Ware, and Corelle dinnerware.

In 1989-90, the Communications sector contributed approximately 21% to Corning's revenues and 37% to its profits, increases of over 35% in both categories. A significant contribution to

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corporate profits came from optical waveguides. Corning's quality and delivery had consistently provided a significant profit margin on this product.

Corning developed the first technically feasible optical fiber in 1970. The company then worked for eight years refining the technology and developing a proprietary low-cost manufacturing method. Despite years of only moderate interest from telephone companies and cablers, Corning funded the research and, in 1979, built a manufacturing plant in Wilmington. The plant operated for three years producing only samples and small orders for pilot projects before its first major order was received, which followed the deregulation of the telecommunications industry in 1982.

At the time, MCI announced plans to build a nationwide fiber-optic network and ordered one hundred thousand kilometres of fiber from Corning. The order, ten times larger than any prior one, was for a new type of singlemode fiber that was still experimental at the company. To meet MCI's requirements, therefore, Corning moved a new generation of fiber technology from the lab to the plant floor, installed new production equipment, and embarked on one of the largest plant expansions in Corning's history. By 1986, sixteen years after proving the commercial feasibility of optical fiber, Corning's fiber-optics operations were running twenty-four hours a day and turning a profit.

The MCI order was quickly followed by others as competition in the telecommunications industry developed. In 1983, Corning funded the largest expenditure request in its history, $100 million, to expand the Wilmington plant to meet rapidly increasing demand and install Corning's fifth generation of fiber-optic manufacturing technology. Corning's dedication to its new technology and its willingness to invest allowed the company to compete with larger rivals such as AT&T and "Japan, Inc.," to become a world leader in waveguide manufacturing. In 1991 Corning Communications, having initiated a "total quality" effort to measure the performance of all business and manufacturing processes to determine competitive capabilities, was pursuing the Baldrige Award.

The initial growth phase, fueled by the needs of long-distance companies, had appeared endless, and to remain an industry's technological leader, Corning had averaged changes in production machinery every 12-24 months. In the second half of 1986, however, as Corning continued to increase its production capacity, the initial growth stopped. The market for long-distance lines was saturated, and increasingly customised fiber-optic, especially multimode, orders from the cable industry changed the demands on Corning's waveguide plant. By 1990, these new demands were not optimally satisfied by the manufacturing and information systems at the plant. By early 1991, construction to again increase the size and capacity of the plant substantially had begun, and this effort required the attention of everyone in the factory to maintain existing production levels.

Current Manufacturing and Information Systems

In the Laydown stage, a machine called a "lathe" systematically coated a ceramic rod with a precise chemical deposit buildup to make a "blank" (Figure 2). During the process, the inner chemical buildup formed what would be the core of the optical fiber. The chemicals were then changed to build what would become the outer coat (clad) of the fiber. The completed bland (or "perform") looked like a large cigar.

In the Consolidation stage, the blank was heated in a furnace to remove water and impurities, and to consolidate the porous blank into pure glass. The blank purified in the Consolidation stage next moved on to the Draw stage. In Draw, the blanks ("glass cigars") were placed in holders, and a small furnace heated the extreme tip of each blank, causing the melted tip to drop down a tower. The tip pulled along a small strand of optical fiber from the blank, which was threaded through a machine that applied different chemical coatings to the outside of the fiber and measured its width. At the bottom of the tower, a tractor pulled the fiber at a preset rate, and the fiber was collected on a take-up reel.

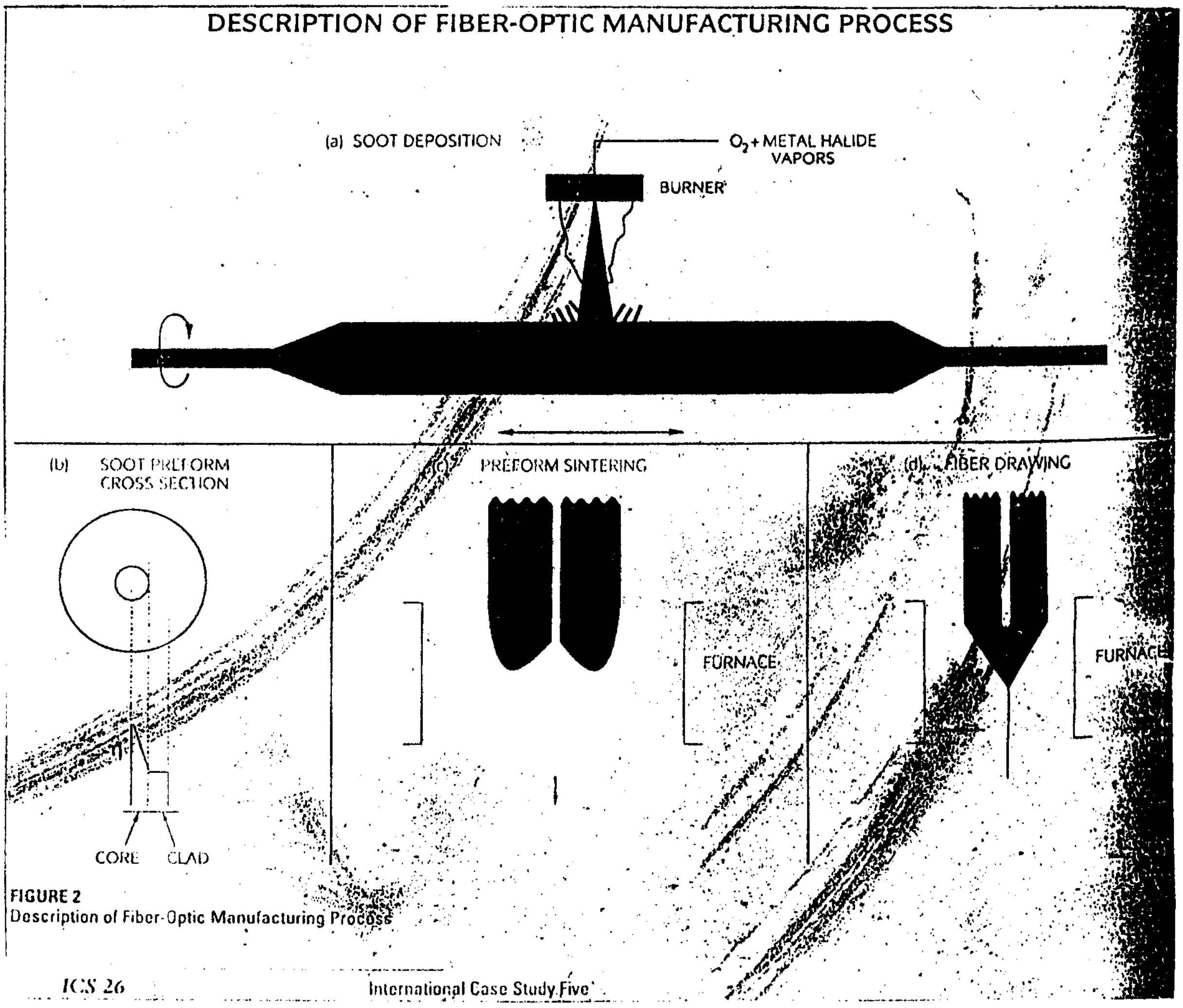

Figure 2: Description of Fiber-Optic Manufacturing Process

From Draw, the bulk reel of optical fiber moved to Off Line Screening (OLS), where tensile strength was measured. The reel then traveled to Measurement for a large battery of optical tests. The fiber was measured and cut to standard lengths and,in the Wind stage, taken off the special measurement spools and rewound on shipping spools.

Mike Jordan, planning and scheduling supervisor, had briefed Bob McAdoo on the complexity of production scheduling at the Wilmington plant: "In making waveguides, the process is different from standard production like making automobiles. With cars, ten Chevy engines and then Chevy bodies make ten Chevy cars, with some quality reworking. Here, in optical waveguides, we can mix ten batches of the same chemicals under the same conditions with the same computer-controlled processes. Sometimes well" get seven batches that can sold; sometimes we"ll get ten. Each batch will differ slightly from the other batches. For example, the maximum length of optical fibers will vary as bad sections are cut out. Glass-geometry precision will differ slightly from batch to batch. So we don't know how many saleable end products we'll get because of differences in selection yield. We also don't know how many end products will be Oldsmobiles

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and many will be Chevys due to the distribution of characteristics. Luckily, we can substitute Oldsmobiles for Chevys here. Customers will take a higher quality cable for the same price. But this substitution costs us money. Selection, distribution, and substitution complicate the planning process."

Manufacturing waveguides required highly exact, computer-controlled systems, but the early emphasis on standard fiber products with few modifications for the long-distance companies had resulted in a system limited to keeping costs how while maintaining efficiency and high quality. The system was designed to control manufacturing at each step of the production process (Laydown, Consolidation, etc.). The primary function of the information system was to identify equipment and process problems in each individual production stage.

The tight controls coded into the system allowed few modifications in the system allowed few modifications in the product or production process. To get around the product and process controls, a small percentage of the plant's production was run as "experimental" products. Each production process had to be individually "tricked" into letting new products move through the system. The products were moved manually through the entire production process with computer overrides at each step. For example, new or customised products with diameters or lengths that were different from standard fibers required engineers to override set specifications in the Draw and Measurement systems. Since all fibers looked essentially identical to the naked eye, special fiber reels were identified with colored dots and batch numbers to flag them as requiring special processing. The manual intervention was not only time consuming and labor intensive, but also prone to human error.

Computer overrides often conflicted with standard costing information and with constants in production algorithms. Thus costs could not be accumulated on special orders and new products. Inappropriate algorithm constants resulted in incorrect production information, and reported yields exceeded actual process inputs.

Information was captured by the system on each of the individual processes but was used to control only that process. No information was passed along by the system to the next production stage. Operators even keyed in reel identification numbers manually at each stage. This division of production information system that employees called, along with the associated computers, "stovepipes" of information. Each stovepipe was monitored and controlled by a separate staff (the stovepipe's "feudal lord"). Computers stored highly summarized information on products completed and in inventory.

The stovepipe infrastructure of the current system did not allow potentially useful information to be shared across production stages. The different systems had dramatically different field definitions and sizes, which offered little opportunity to integrate the data across the stovepipes. For example, measurement information from the OLS stage could not be used to eliminate later quality checks or to determine sampling strategies in the Measurement stages. The systems provided no means of feeding information forward or backward in the production process. Information on fiber defects discovered in later process steps required manual intervention, communication, and correction. Information gathered in prior stages, such as diameter measurements and usable fiber lengths determined in Draw, was unavailable to Measurement technicians, who might spend hours searching reels for a long usable fiber. Consolidating information from the different systems resulted in unacceptable delays in providing production information. In short, the stovepipe systems did not allow the plant to maximize the use of its capital-intensive equipment.

Designed to meet high demand for a few products, the system did not tract work in process. All orders were matched to inventory. However, when a relatively stable supply of a few products

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had moved through the system, supervisors had been able to coordinate production based on inventory levels.

As the number of products multiplied and became more customised, and as customers demanded shorter lead times, a "Sneaker Patrol," the plant's production and scheduling staff, had become responsible for determining what was in the plant and adjusting production schedules in an attempt to meet customer orders. The 4-week production plan listed the number of blanks of each product type to start. As orders came in or were canceled and as the yields changed in the production process, the Sneaker Patrol made schedule revisions. Currently, numerous daily schedule changes and comprehensive changes were made weekly to the 4-week plan.

Pressure to increase responsiveness can be seen in the fact that, in 1988, Corning fiber salespeople put pressure on Wilmington to respond in less than one day with delivery and cost information for customer; in 1991, they were pressuring Wilmington to respond in less than four hours. In 1991, Wilmington had a several-hour goal and monitored performance to meet that goal.

All changes which were based on information that was often two days old, were projected by hand. Most information was gathered and transmitted by the production staff, the Sneaker Patrol, walking through the plant with clipboards and changing the colored and numbered dots on different carts of fiber reels. This process was being stretched to the limit as the Wilmington plant continued to add new fiber products and prepared to add additional capacity.

Mike Jordan, who as planning and scheduling supervisor, was also head of the Sneaker Patrol, explained how the process was being stretched: "A customer was buying multimode product of long length. This is not a standard product, so we have to begin a 'yellow dot experiment,' where the particular yellow dot indicates 'produce long-length multimode'. The customer calls back in a few days and says he doesn't want the long-length. Because we can't waste good in-process fiber, I have to go out and take off the yellow dot from this particular experiment and produce this in-process fiber for stock. The next day, the same customer calls and says he wants a different band-width multimode. I then have to run out again and find some in-process fiber of that band width by looking around the plant and then put a yellow dot on that to indicate the length the customer wants. Can you imagine this happening many times each day? It does!"

The same information gathered for scheduling was used to quote order lead times to customers. Quoting a lead time on or two days longer than a competitor could lose an order. Missing a deadline or shipping incorrect product violated one of Corning's top cultural values. Currently, a significant percentage of customer orders were for shipment in less than 5 days, but he plant took over 6 days to complete most of the orders, even though the production process required significantly less time. All other delays were caused by the logistics of moving between operations (a minimal amount of time) and scheduling conflicts and inefficiencies.

Mike O'Koren, the Wilmington plant manager, described the plant as computer intensive but reliant on "people intervention" and "customised people processes". "The customers are wanting more one-of-a-kind orders with shorter lead times. Our record of error-free shipments and past turn around time has made customer service a competitive advantage. Maintaining this advantage is crucial to our success. Right now we don't have a system in place that allows us to shrink lead times. The only way we do it now is with what people do in their heads. We promise orders based on what we think is on the shop floor. We've been stretched pretty thin. As our volume increases and the number of product choices multiplies the people system is going to break down".

Reliance on customised people processes and mutual production adjustments between feudal lords

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and the Sneaker Patrol had created a large informal communications network in the plant. Production processes had evolved to conform to this network.

Jordan estimated that the plant could accept orders for 10% more fiber a month if quote times could be reduced through the scheduling of a "made-to-order" manufacturing system. He explained that, in the information environment he envisioned, he could be much more effective: "I want to be able to sit at home or in the office and, on the PC, identify what fiber is in stock or anywhere on the floor. Now I have to check what is in the inventory or on the floor to see what is there. Today we have almost zero visibility about ware in process".

Jordan hoped, however, that any new systems wouldn't be as difficult to implement as the last systems project with which he had been involved: "Although this is my vision for fast response to our customer requests, the last information system project I was involved with, ATLAS, left me with a healthy dose of skepticism. ATLAS has worked out great, but not without some pain. Now we can see all orders, which customers place through the sales force at corporate, in 5 minutes. Before ATLAS, it took over 24 hours for us to get an order. I felt the project was badly under sourced. The system was being designed for multiple uses in multiple divisions. Coordination between all parties was difficult. Senior management in our sector didn't buy in initially, and without that pressure brought to bear, the project stagnated. It didn't work until we at Wilmington held our ground, insisted on getting the resources required, and fought for the project to be completed-the right way. After we at Wilmington started kicking, the guys at corporate got involved and insured that corporate IS (Information Systems) put the resources on the project for our sector. We learned a great deal during ATLAS, and it is a real lifesaver now. I just wonder if new systems will be as difficult to implement."

On a recent visit to the Wilmington plant, McAdoo had spoken with O'Koren about the effect of the proposed new information system on the people who composed the informal communications network. O'Koren thought the new system would provide tremendous benefits to customers, but he was less enthusiastic about the effect on plant personnel: "Many people have done nothing but act as information transmitter in this network since the business was started. They feel very threatened. I think they're going to have to learn new jobs".

McAdoo noted that, as O'Koren was speaking, a large fish on his PC's aquarium display had turned and eaten several smaller fish.

The Appropriations Request

The decision to request $5 million to revamp waveguide manufacturing (see Figure 3) had not been straightforward. On the one hand, the waveguide project has always been a high-risk, high-return project. Historically, large appropriations requests had been granted, and they had paid off. On the other hand, the configuration and timing of the local-loop market appeared as uncertain as the long-distance market had in 1970.

Tom LaGarde, manager of IS at the Wilmington factory, had been heavily involved with the preparation of the request. He discussed with McAdoo how the implementation effort would be managed: "At the highest level, we have a review board consisting of senior managers at corporate that meet twice a year to make sure the project is not out of sync with the company. We have been asked to submit appropriation requests twice a year after the initial request is approved. As we present each request, we have to establish where we've been and where we are going and establish how much money has been spent and what will be needed. We brought in Global Analysis, a Big Five consulting firm, because we felt our corporate IS group, thought talented, did not have the experience for this type of project. We're using a computer based tool to plan, tract, test, and manage the project-a tool that connects each project person. There is a great deal of technical risk beyond the sheer size and complexity of the project. We have no experience with the relational database technology, which has to provide rapid and flexible access to great quantities of information. The other dimension of technical risk is the finite forward-scheduling component-which has never been develop before. We will break the project into seven teams of 5-7 people form about five organizations-contract programming houses, Global Analysis, corporate Engineering and IS, Digital, and the Wilmington factory. As for my organization, I'll have to provide support for the project. At the same time, the plant must have other information needs met. Combine this with a major plant expansion and the plant at capacity, and the difficulties inherent in the implementation became clear".

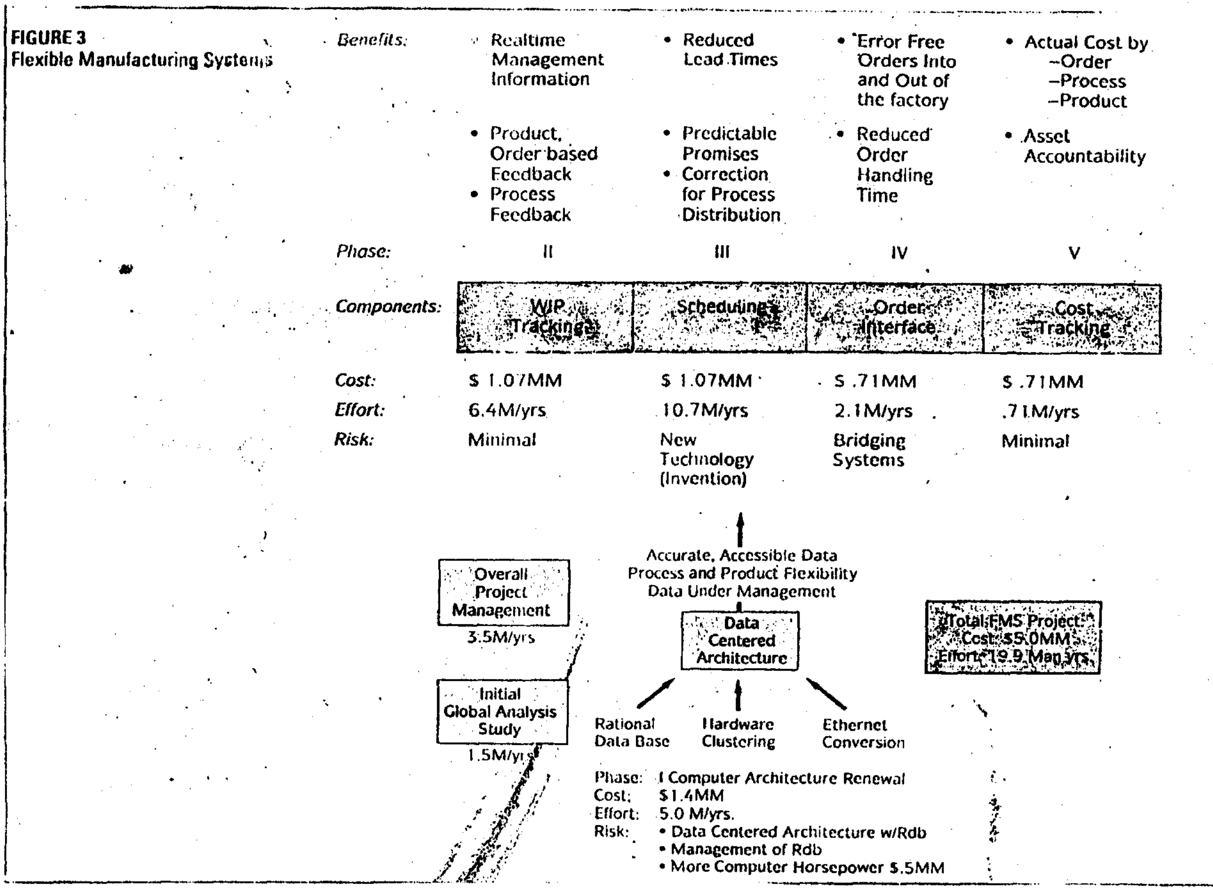

Figure 3: Flexible Manufacturing Systems

McAdoo picked up the appropriations request sitting on his desk to read through the body of the proposal. He knew he had to make a case to William Cunningham, manager of the entire Communications sector, to invest this much money on an information system. Furthermore, $5 million would require approval at the chairman level. Would changing the way information was managed at Wilmington convert a factory designed to produce standard products into a flexible manufacturing facility? Were there other, better, alternatives to FMS? McAdoo and his staff had considered the option that Corning not put any more money into waveguides. They had also looked for, but no found, some other way to fix the current problem. The staff believed in FMS, after all, they had spent the last year in intensive analysis and design. But did they understand the industry forces, and did these forces require the type of strategy suggested by FMS? Finally, would the system work? How, given the ATLAS project delay and cost, could he recommend an information-systems project of this magnitude of this strategic importance?

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McAdoo wanted to make sure his staff had thought through the issues carefully before he made a decision. Did his staff have answers to the myriad of important questions? Sighing, McAdoo got up and started the long walk to the meeting with his staff. He would then have the weekend to think things over but on Monday he had to meet with Cunningham and make a recommendation on FMS.

FIGURE 4
Abstract from Appropriation Request

Background

This is the first information systems project of this scope and scale undertaken by the Communications sector. Extensive outside assistance is planned to conduct the project because of its size and technical complexity. After several months of review and negotiations, we selected the consulting firm of Global Analysis for their expertise in building manufacturing support systems and methodology for conducting Business Area Analysis. We are extremely satisfied with that decision.

Coming began the analysis with Global Analysis on October 4, 1989. The objectives of the study were to develop a data architecture to serve as the foundation for FMS and to define a planning and factory scheduling system for the manufacture of optical waveguides. This study was completed on plan, March 23, 1990, and serves as the basis for defining the requirements of the systems that are planned for construction under this Appropriation Request.

Request

The vision for Flexible Manufacturing Systems is that every product made on the factory floor can be traced to a customer requirement, production forecast, or specific order (inventory or customer). This contrasts with our present system, which does not have this capability. In the current system, products are not tracked until they reach inventory. All current production is made for inventory, not for customer orders. Tracking production and linking specific product with customer orders is currently done manually. The FMS project constructed to automate and enhance that capability consists of two major components:

1. Information systems for planning, scheduling, tracking, and fulfilling customer order requirements in the factory.
2. A major renewal information infrastructure to include the plant computer network, the computer architecture, and plant databases:

   The project will run from the 1989 planning stage through completion in 1993. Personnel from Corning, Global Analysis DEC, and other outside contractors will be engaged in all phases of the project. Global Analysis will receive between 30 - 40% of the funds. The project will take approximately 19.9 man years to complete.

Project Structure

The FMS project can be partitioned into five major phases:

- i. Computer Architecture Renewal
- ii. Ware-in-Process Tracking
- iii. Scheduling
- iv. Order Interface

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v. Cost Tracking

Each of the FMS phases consists of several projects that complete the implementation.

Phase I. Computer Architecture Renewal

To describe the computer architecture renewal, we have coined the term "Data Centered Architecture". This means an architecture for information management that is founded on the relationships between the fundamental elements of information that the business uses to operate (e.g., orders, products, processes, and equipment). These are key assets of the business and critical to operations. The Wilmington computer architecture is designed to serve the accessibility and accuracy of that asset. The new computer architecture will result in a data system that is highly accessible and places the key data assets under management to the benefit of all information-system users. The Data Centered Architecture will serve as a flexible information resource through an access structure that is known to all and accessible from any computer system in the Division.

In addition to a new design for the information system, there are three major technology components in the new architecture: (1) Digital Equipment Corporation's RDB database, which will manage the data, (2) Hardware Clustering, which allows direct access to the database by the plant manufacturing computers, and (3) Ethernet, which allows network access to the database by all business, process-control, and personal computers.

Phase II. Ware-in-Process Tracking

This phase consists of a system that links factory-floor machine events to the central database and provides user programs for data reporting and analysis. Individual orders, products, blanks, and fibers can be tracked in manufacturing, and process results can be analyzed quickly. The WIP Tracking phase will introduce the "Shop Order" into the factory as a tracking mechanism to link all products on the factory floor to a customer requirement. This information is not currently available. WIP Tracking also provides the shop-floor information required for the Scheduling and Cost Tracking phases of FMS.

Phase III. Scheduling

The scheduling system being developed for FMS takes into consideration three key attributes if the process of manufacturing optical waveguides. The manufacturing process produces a *distribution* of saleable optical fiber in terms of the performance capabilities of the product as opposed to discrete end products. In Waveguide manufacture, there is the capability to *substitute* fiber of one characteristic for another. A characteristic of fiber-optical performance is that a fiber of higher performance can be sold against a lesser requirement. Finally, the manufacturing process itself provides *variable* output.

The scheduling system is a finite-capacity-planning system. In conjunction with process results from the WIP Tracking system, it will characterize the process distribution using actual historical data and allow the planner to predict with a set degree of certainty what the process output will be. The historical record will be used as the basis of the capacity plan, and this will yield a daily schedule for manufacturing. The Shop Orders specified in the schedule will checked regularly to compensate for any unexpected process variability. This systematic approach to scheduling will result in reduced lead times for orders and a method for creating reliable and predictable promises for fiber to the customer, which in turn can result in shorter quoted lead times.

Phase IV. Order Interface

The plant has an interface to the corporate business data system (ATLAS) for both the initiation of orders and the fulfillment of orders for shipping. The FMS Order Interface will allow the plant to act on an order requested by the customer by delivering the order to the planning and scheduling systems established by the Scheduling Phase. In addition to glass and coating, information on optical, strength, and length requirements plus any other special labeling, invoicing, packing, or handling requirement will be communicationed and checked for each order. The Order Interface is a systematic method to ensure the plant's ability to fill orders in an error-free manner. There is a risk associated with bridging the two systems together, but this is recognized and will be a major focus of systems maintenance.

Phase v. Cost Tracking

The Cost Tracking phase is primarily a reporting function that takes advantage of the Shop Order tracking mechanism and its linkage to actual machine hours recorded in the database by the WIP-Tracking phase. Cost Tracking will allow cost information to be automatically loaded into the FACTS corporate financial system. Also, it is essential in determining the cost of developmental products and the cost of all products generated for government contracts.

Flexible Manufacturing Systems Diagram

Figure 3 identifies the Benefits, Cost, Time, Effort, Risk, and Technology of each phase of the project and the time, cost, and effort for the total project. It also portrays the fundamental nature of the Data Centered Architecture to all components of FMS.

Alternatives

There are alternatives to FMS. One is to maintain the status quo. However, the manual nature of our current planning and scheduling system in the face of increasing product-complexity does not meet the quality requirements that we have set for ourselves as an organization. Failure to select the correct fibers on a major order in 1989 made this clear. Another option is to build the new planning and scheduling systems without the information-systems renewal. This would result in a degree of benefit in plant scheduling but would not deliver the Lead-Time Reduction, Cost Tracking, or Accountability for Flexibility in adapting to new products and processes critical to the "make-to-order" business environment. Other options include increasing inventory or putting products on consignment at customer sites. Both of the options may significantly shorten lead times.

The business strategy that the Communications sector has put in place requires the Total Quality information systems that FMS delivers. A customer-order-based focus throughout the organization is fundamental to the ability to detect and exploit opportunities that are strategically targeted. FMS delivers the manufacturing practices and information systems that will enable that focus.

Energy, Impact, Environmental Control, and Raw-Material Statements

This project will result in no significant additional energy consumption, will not result in the need for any environmental control, and will not result in any additional raw-material requirements.

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Corning Telecommunications Division (B): FMS Eecutive Summary

Background

As a world leader in the optical-fiber industry, the Corning Optical Waveguide Business has grown in recent years, both in volume and in the number of different products manufactured. Despite the technical complexity of fiber manufacturing, competitive pressure continues to require shorter lead times for product delivery.

The Business computer systems in place at the Wilmington Plant have been developed over the past decade and, as in many high-growth industries, have generally been incrementally improved (as opposed to redesigned) in an attempt to keep pace with changes in the business. These systems are no longer capable of optimally providing the level and kind of support needed to facilitate Corning's continual plant expansions in the industry; therefore, a new system capability is required. This capability has been named Flexible Manufacturing System (FMS).

The need for a new systems capability to support optical-fiber manufacturing at Wilmington is being driven by several factors, particularly:

- Market Demand for Shorter Lead Times
- Product Proliferation
- Current System Inflexibility
- Renewal of the Computer Architecture

The FMS project is a multi-year effort to provide enabling manufacturing systems for a high-volume, high-product-count, short-lead-time, "Make-to-Order" business environment. It involves the reconfiguration and integration of our plantwide computer network and data architecture and the implementation of new information systems. The FMS project goal is to allow the plant to manufacture directly to customer requirements. The intent is to provide the Optical Waveguide Business with the proper information support system for planning, scheduling, operations management, and control and to create a business systems that is flexible enough to handle the rapidly changing aspects of the optical-fiber business.

Through FMS, the demand for shorter lead times will be fulfilled by a real-time order-promising capability at the factory and increased efficiency in manufacturing scheduling. The impact of product proliferation will be reduced by building information systems that utilize a common database to eliminate the redundant and complex data structure of the existing systems. The current systems inflexibility is the motivation to implement a new integrated information system for the manufacturing operation.

Benefits

The functional requirements of FMS have been developed by building a comprehensive description of the business needs identified by members of the Communications sector in Business Management, Sales and Customer Service, Production Supervision, Process and Product Engineering, Advanced Fiber Products, Computer Services, Quality Engineering, and others. The benefits that FMS will deliver are based on the requirements of the overall organization.

The goal of FMS is to allow the plant to manufacture directly to customer requirements. When a customer orders a product through ATLAS, it will be promised using a real-time capacity model, scheduled in the factory by Planning and Production, visible to the Operator on the floor, and

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checked before it leaves the plant to the exact specification it received at order entry into the ATLAS system.

The primary benefits of the FMS system are listed in Exhibit 1. These benefits highlight the system's potential contribution to our:

- Flexibility to adapt to new products and production processes.
- On-demand information on orders, production and inventory.
- Cost tracking for orders, experiments and custom products.

FMS will address several areas of responsiveness that are imperative to the survival of the business. Our Sales/Customer Service organizations have seen that reduced lead time can be a competitive edge. Customers know our price and quality. Many orders are now sold on the ship-date commitment. The requirement to compete in this environment is unavoidable. FMS will increase responsiveness in quoting, promising and filling orders, decrease manufacturing processing time and allow more rapid new product and process introductions. Through FMS a new technology in processes and products, we can continue to expand the business by addressing niche markets and finding new fiber applications.

Our business strategy is to provide unparalleled value to our customers through Customer Service, Total Quality, and Low Cost. FMS's ability to reduce lead time is a Customer Service advantage that will prevent the loss of market share and potentially result in increased market share. FMS will enable Total Quality efforts to provide the organization with the data required to measure all aspects of manufacturing. Making the right product at the right time will result in manufacturing efficiency and reduced cost.

It is envisioned that portions of FMS could be installed in other manufacturing facilities. FMS has been designed to facilitate that opportunity. It views the output of each process step as an end product, so that it could be applied to a smaller manufacturing organizations as well.

Corning Telecommunications Division (C)
FMS Progress Report

Jim Reid, n charge of managing Corning's Flexible Manufacturing Systems Project, assessed the status of the project. "We now have 4 project teams instead of the original 7. With production at capacity and construction for expansion starting, we haven't been able to test modules as we've developed them. We are now focusing on some critical technical issues and the relational database is proving to be a real bear. It is supposed to function for 24 hours a day, 7 days a week. It is taking us longer to get the system to run efficiently from the database than we had thought. The relational technology takes too much time to do all the joins. With the CPU cranking away, it takes up to 20 minutes for screens to appear for ware-flow tracking. Our goal is a 10-second response time. Now we are looking at ways to recreate the database structure-to have less reliance on tables and logical joins and simply create permanent fields for information we know we will want. This isn't show-stopper or even close, we just have to learn the technology and manage it better.

To our relief, we have a simulation completed for the finite-forward-scheduling module. We designed the module on a PC and then tested it with a month of real factory information. The calculation only took 40 minutes on the PC to schedule the entire factory, and it did it well. This was a new-invention area and we're sailing through.

We also have developed a central repository on the Mac using database technology. This repository contains standards for screens, data definitions, code definitions, etc. As we develop a module, we put information about the module in the repository. All project teams have access to the repository, and we've been able to use about 80% of the modules we've designed for different parts of the overall system. Each project team gets all the information about naming files, fields and designing screens from the repository. Our ability to coordinate and share knowledge is a real strong point. Another problem had arisen when we discovered we couldn't buy a package for process manufacturing. It didn't work. We aren't tracking large batches in small numbers; we have thousands and thousands of batches of fiber running through. No package could handle it. Now we have to develop it from scratch. Most packages want to treat each fiber blank as a batch, but each fiber blank for us turns into many different fiber products for our customers. Our custom system will have to take into account this complexity, but we think we can handle it".

Tom LaGarde, manager of Information Systems at the Wilmington factory, commented on the progress thus far: "Jim [Reid] has been shorted some resources from my staff due to other expectations. Despite these difficulties, he has done a masterful job. Jim's development teams are moving at a pace faster than the organization can assimilate the new FMS technology. The plant is slowing Jim down. His resources are very expensive, so he has decided to spread the resources out over a longer period of time to better time his technical development efforts with our organizational learning capacity. There is also more and more attention being given to the plant expansion, and this slows Jim down. Jim is competing for resources with all these activities going on and has decided to develop FMS in a serial fashion rather than a parallel fashion-saving money for Corning and keeping pace with what parts of FMS can be adopted at the plant."

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