SEAGATE TECHNOLOGIES: OPERATIONAL HEDGING

On July 10, 1997, Ron Verdoorn, Executive Vice President of Seagate Technologies and Chief Operating Officer of its Storage Products Group, was reading the capital appropriation request for the *Barracuda 9LP* and the *Cheetah 9LP*. The *Barracuda 9LP* and *Cheetah 9LP* were two of Seagate's new high-end disk-drive product families that were scheduled to go into volume production in the first calendar quarter of 1998. The capital appropriation request called for a $103 million capital investment in two final assembly facilities, one for the *Barracuda* and one for the *Cheetah*, and one joint test facility. The capacities of the new facilities would enable the execution of the master production plan, which was derived by the Material Division based on the sales forecast by the Marketing Division.

While the capital investment plan was definitely reasonable, Ron was wondering whether the plan would provide Seagate with a sufficient hedge against demand uncertainty, which was intrinsic to the sales forecast in the highly volatile disk drive industry.

Company Background

Seagate Technology, Inc. is a data technology company that provides products for storing, managing, and accessing digital information on the world's computer and data communications systems. At more than $8.9 billion in revenue for its fiscal year ended June 27, 1997, Seagate is the largest independent disc drive and related components company in the world. (Selected financials are shown in Exhibit 1.) Founded in 1979, the Scotts Valley, California-based company had shipped more than 100 million disc drives by 1997.

Seagate designs, manufactures and markets disc drives for use in computer systems ranging from notebook computers and desktop personal computers to workstations and supercomputers, as well as in multimedia applications such as digital video and video-on-demand. Seagate leads the disc drive storage industry offering the broadest product line including disc drives with 2.5, 3.5 and 5.25inch form factors and capacity points up to 23Gigabytes. The company sells its products to original equipment manufacturers ("OEMs") for inclusion in their computer systems or subsystems, and to distributors, resellers, dealers and retailers.

Seagate has pursued a strategy of vertical integration and accordingly designs and manufactures rigid disc drive components including recording heads, discs, disc substrates, motors and custom integrated circuits. It also assembles certain of the key subassemblies for use in its products including printed circuit board and head stack assemblies. Products are manufactured primarily in the Far East with limited production in the United States and the Republic of Ireland.

As of June 27, 1997, Seagate employed 111,000 persons worldwide, approximately 93,000 of who were located in the company's Far East operations.

Disk Drive Technology

Magnetic disc drives are used in computer systems to record, store and retrieve digital information. Most computer applications require access to a greater volume of data than can economically be stored in the random access memory of the computer's central processing unit (commonly known as "semiconductor" memory). This information can be stored on a variety of storage devices, including rigid disc drives, both fixed and removable, flexible disc drives, magnetic tape drives, optical disc drives and semiconductor memory. Rigid disc drives provide access to large volumes of information faster than optical disc drives, flexible disc drives or magnetic tape drives and at substantially lower cost than high-speed semiconductor memory.

Although products vary, all rigid disc drives incorporate the same basic technology (Exhibit 2). One or more rigid discs are attached to a spindle assembly that rotates the discs at a high constant speed around a hub. The discs (also known as media or disc media) are the components on which data is stored and from which it is retrieved. Each disc typically consists of a substrate of finely machined aluminum or glass with a magnetic layer of a "thin-film" metallic material.

Rigid disc drive performance is commonly measured by four key characteristics:

1. Average access time (expressed in milliseconds–"msec"), which is the time needed to position the heads over a selected track on the disc surface;

Professor Jan A. Van Mieghem prepared this case as a basis for class discussion rather than to illustrate either the factual, effective or ineffective handling of a managerial situation. Portions of it are based on Seagate's 1997 10-K form. Selected data in the case are based on estimates.

2. Media data transfer rate (expressed in megabits per second), which is the rate at which data is transferred to and from the disc;
3. Storage capacity (expressed in megabytes or gigabytes–"MB" or "GB"), which is the amount of data that can be stored on the disc; and
4. Spindle rotation speed (commonly expressed in revolutions per minute–"rpm"), which has an effect on speed of access to data.

Read/write heads, mounted on an arm assembly similar in concept to that of a record player, fly extremely close to each disc surface, and record data on and retrieve it from concentric tracks in the magnetic layers of the rotating discs.
Upon instructions from the drive's electronic circuitry, a head positioning mechanism (an "actuator") guides the heads to the selected track of a disc where the data will be recorded or retrieved. The disc drive communicates with the host computer through an internal controller. Disc drive manufacturers may use one or more of several industry standard interfaces, such as SCSI (Small Computer System Interface).

Disk Drive Market

Rigid disc drives are used in a broad range of computer systems as well as for multimedia applications such as digital video and video-on-demand. Users of computer systems are increasingly demanding additional data storage capacity with higher performance. They use more sophisticated applications software, including database management, CAD/CAM/CAE, desktop publishing, video editing and enhanced graphics applications, and increasingly operate in multi-user, multitasking and multimedia environments. Additionally, there is a sizable market for rigid disc drives in the existing installed base of computer systems, some of which require additional storage capacity.
The computer system market includes four segments: desktop personal computers, mobile computers, workstation systems and server/multi-user systems.

THE PERSONAL COMPUTERS (desktop and mobile) market in 1997 was characterized by a minimum storage requirements for entry-level personal computers of 810MB to 1.7GB of formatted capacity with seek times ranging from 12.5msec down to 10.5msec. The entry-level capacities continue to increase. In addition, users of personal computers have become increasingly price sensitive. Seagate's objective for the desktop and mobile personal computer market is to design drives for high-volume, low-cost manufacture.

Smaller footprint systems, such as mobile, laptop, notebook and ultra-portable computers require rigid disc drives in form factors of less than 3.5inches that emphasize durability and low power consumption in addition to capacity and performance characteristics found in their desktop functional equivalents. Personal digital assistants and hand-held pen-based computers may use 1.8inch or 2.5inch hard disc drives or flash memory such as a PCMCIA card for additional memory. These mobile applications also emphasize low power consumption as well as very high degrees of durability.

WORKSTATION SYSTEMS include high performance microcomputers, technical workstations, servers and minicomputers. Applications are compute-intensive and data-intensive so that workstation systems typically require rigid disc drive storage capacities of 2GB and greater per drive, average seek times of 8msec and rotation speeds of 7,200rpm to 10,000rpm. Due to the leading edge characteristics required by end-users of workstation systems, manufacturers of such systems emphasize performance as well as price as the key selling points.

SERVER/MULTI-USER SYSTEMS are large systems that include mainframes and supercomputers. Typical applications such as business management systems, transaction processing, parallel processing and other applications require intensive data manipulation. Also included in high-end applications are systems designed for video-on-demand and near-line storage. Users of these systems generally require capacities of 4GB and greater per drive with average seek times of 8msec and rotation speeds of 5,400rpm to 10,000rpm. End-users of large systems are less concerned than users of smaller systems with the size, weight, power consumption and absolute cost of the drive.
As with workstation systems, the OEM typically designs drive products into these systems with emphasis on performance, reliability and capacity. In this market segment, data storage subsystems are used containing large numbers of disc drives. Because data integrity is paramount, high device reliability and maintainability are key features. Mainframe, supercomputer and digital video systems also benefit from very high data transfer rates (up to ten times that in small computer systems).

With the proliferation of multimedia applications, the demand for increased drive capacities has and continues to increase at an accelerating rate since sound and moving pictures require many times the storage capacity of simple text.

Disk Drive Products

Seagate's products include over 50 rigid disc drive models with form factors from 2.5 to 5.25inches and capacities from 1GB to 23GB. Seagate believes it offers the broadest range of disc storage products available. It provides more than one product at some capacity points and differentiates products on a price/performance and form factor basis. Seagate typically devotes its resources to developing products with industry leading performance characteristics and to being among the first to introduce such products to market. The company continuously seeks to enhance its market presence in emerging segments of the rigid disc drive market by

drawing on its established capabilities in high-volume, low-cost production.

The *Marathon* and *Medalist* disk drive product lines are targeted for the personal mobile and desktop computing market, respectively, while the high-end workstation and server/multi-user systems market is served with the *Barracuda, Cheetah* and *Elite* product families.

The *Barracuda* family of 3.5inch drives was first introduced in 1992. At 7,200rpm the Barracuda had the highest rotation speed of any drives produced at that time. In fiscal year 1997, Seagate introduced two new products in the Barracuda family, the Barracuda 4LP and the Barracuda 4XL, with 4GB and 4.5GB respectively. The Barracuda 4XL, which began volume production during the fourth quarter of fiscal 1997, was designed to provide a balance of price and performance for the workstation market as it matures.

In August 1996, the Company announced the 3.5inch *Cheetah* family—the world's first disc drives to offer rotation speeds of 10,000rpm for increased data throughput and lower latency times. The *Cheetah* drive is focused at the very high performance segment of the market. Volume production of the Cheetah 4LP and the Cheetah 9 began in the third and fourth quarters of fiscal 1997, respectively. Seagate is going to announce the fifth generation *Barracuda 9LP* and the second generation *Cheetah 9LP* in early fall 1997, with volume production scheduled to begin in the first calendar quarter of 1998.

Finally, the Elite product line covers the high-end 5.25inch market. In the third quarter of fiscal year 1997, production commenced on the Elite 23, a high performance, 5.25inch disc drive with 23GB of formatted capacity, a rotation speed of 5,400rpm and mean-time-between-failures (MTBF) of 500,000 hours.

Disk Drive Industry and Competition

The rigid disc drive industry is intensely competitive, with manufacturers competing for a limited number of major customers. In addition to the product performance dimension described earlier, the principal competitive factors in the rigid disc drive market include product quality and reliability, form factor, price per unit, price per megabyte, production volume capability and responsiveness to customers. The relative importance of these factors varies with different customers and for different products.

Seagate experiences intense competition from a number of domestic and foreign companies, some of which have far greater resources. In addition to independent rigid disc drive manufacturers—Quantum and Western Digital Corporation being the two most important independent competitors with 1997 revenues of $5.3B and $4.1B, respectively—Seagate also faces competition from present and potential customers. The latter include IBM, Toshiba, NEC and Fujitsu Limited who continually evaluate whether to manufacture their own drives or purchase them from outside sources. These manufacturers also sell drives to third parties, which results in direct competition with Seagate. IBM's Storage Division, for example, has successfully invested in mobile disk drive technology and has now captured a 40% share of the global mobile disk drive market.

The rigid disc drive industry is characterized by ongoing, rapid technological change, relatively short product life cycles and rapidly changing user needs. This, together with intense competition, has manifested in an industry with a history of declining prices. The price per megabyte of disk storage has dropped at a steady pace of about 40 percent per year from 1980 through 1995–even faster than the price drop for computer memory chips. (Exhibit 3). In addition, the famous volatility of demand for computer products and peripherals translates into highly fluctuating demand for disk drives. Seagate often must accommodate changes in orders of up to 20% within only two weeks of production.

Competitors offer new and existing products at prices necessary to gain or retain market share and customers. To remain competitive, Seagate believes it will be necessary to continue to reduce its prices and aggressively enhance its product offerings. In addition, Seagate's ability to compete successfully will also depend on its ability to provide timely product introductions and to continue to reduce production costs. The company's establishment and ongoing expansion of production facilities in Singapore, Thailand, Malaysia, China and Ireland are directed toward such cost reductions.

Product and Process Development

Seagate's strategy for new products emphasizes developing and introducing on a timely and cost effective basis products that offer functionality and performance equal to or better than competitive product offerings. Seagate believes that its future success will depend upon its ability to develop, manufacture and market products which meet changing user needs, and which successfully anticipate or respond to changes in technology and standards on a cost-effective and timely basis. Accordingly, the company is committed to the development of new component technologies, new products, and the continuing evaluation of alternative technologies.

The upcoming introduction of the two new products under discussion, the *Barracuda 9LP* and the *Cheetah 9LP*, were thus in line with Seagate's ongoing strategy. The *Cheetah* boasted the faster seek time (5.2 vs. 7.1msec) and higher throughput rate (21 vs. 15.3Mbytes/sec). The *Barracuda*, on the other hand, was 15% more energy-efficient and enjoyed the *Barracuda* family's reputation for a high level of reliability. While the primary market for the *Cheetah* is in enterprise

servers, both drives appeal to high-end workstation users for graphics imaging applications. At about $1090 for a 9.1Gbyte drive, the pricing for the new Cheetah family would be approximately 15% above the industry-leading *Barracuda* series.

Seagate develops new disc drive products and the processes to produce them at six locations: Longmont, Colorado; Moorpark and San Jose, California; Oklahoma City, Oklahoma; Bloomington, Minnesota; and Singapore. Generally speaking, Longmont, Moorpark, and Singapore are responsible for development of 3.5inch form factor drives intended for desktop personal computer systems. San Jose is responsible for development of 2.5inch form factor drives intended for mobile personal computers. Oklahoma City is responsible for development of 3.5inch disc drives with capacities and interfaces intended for use in minicomputers, super-microcomputers, workstations and file servers. Finally, Bloomington is responsible for 3.5inch and 5.25inch products principally intended for use in systems ranging from workstations and super-minicomputers to mainframe and supercomputers as well as new markets such as digital video and video-on-demand.

In addition to developing new products and components, the company devotes significant resources to product engineering aimed at improving manufacturing processes, lowering manufacturing costs and increasing volume production of new and existing products. Process engineering groups are located with the disc drive development groups and the reliability engineering groups in locations listed above. Most of Seagate's volume production, however, is done in locations remote from these groups and the development of the volume processes is completed at the volume manufacturing sites.

Manufacturing Strategy

Seagate's manufacturing managers face difficult challenges. Because of surging global demand, their facilities very frequently are running at full capacity. Changes in technology and short product life cycles force frequent equipment purchases. Long equipment acquisition lead-times often require that capacity decisions be made six months in advance of need. And establishing manufacturing capacity in anticipation of highly volatile market demand is critical to bottom line performance.

The key elements of the Seagate's manufacturing strategy are high-volume, low-cost assembly and test; vertical integration in the manufacture of selected components; and establishment and maintenance of key vendor relationships.

Because of the significant fixed costs associated with the production of its products and components and the industry's history of declining prices, the company must continue to produce and sell its disc drives in significant volume, continue to lower manufacturing costs and carefully monitor inventory levels. Toward these ends, Seagate continually evaluates its components and manufacturing processes. It is paramount that Seagate rapidly achieve high manufacturing yields in new production processes and obtain uninterrupted access to high-quality components in required volumes at competitive prices. Also, it often is desirable to transfer volume production of disc drives and related components between facilities, including transfer overseas to countries where labor costs and other manufacturing costs are significantly lower than in the U.S., principally Singapore, Thailand, Malaysia and China.

Manufacturing Processes

Manufacturing of disc drives is a complex process, requiring a "clean room" environment, the assembly of precision components within narrow tolerances and extensive testing to ensure reliability. The first step in the manufacturing of a rigid disc drive is the assembly of the actuator mechanism, heads, discs, and spindle motor in a housing to form the head-disc assembly (the "HDA"). The assembly of the HDA involves a combination of manual and semi-automated processes. After the HDA is assembled, a servo pattern is magnetically recorded on the disc surfaces. Upon completion, circuit boards are mated to the HDA during final assembly and the completed unit is thoroughly tested prior to packaging and shipment. Final assembly and test operations take place primarily at facilities located in Singapore, Thailand, Malaysia, China, Ireland, Minnesota and Oklahoma. Subassembly and component operations are performed at facilities in Singapore, Malaysia, Thailand, Minnesota, California, Northern Ireland, Indonesia, Mexico, China and Scotland. In addition, independent entities manufacture or assemble components for Seagate.

Volume production of the two new products, the *Barracuda 9LP* and the *Cheetah 9LP*, would require investment in new final assembly and test capacity. Given the different technology, each family's HDA and printed circuit board final assembly needed its own product-specific equipment. Both families, however, could be tested in one facility. Disk drive testing involves connecting the drive to intelligent drive testers (IDTs), fast computers that perform a set of read-write tests. IDTs can quickly switch over between testing a *Barracuda* and a *Cheetah* (both take approximately the same amount of tester time).

Product life cycles of disk drives were already short (high volume products introduced in 1995 were sold for about 6 to 7 quarters), but were expected to drop even further. The two new products were planned to be in volume production only for the four quarters of 1998. The capital investment to build production capacity was significant and had two components: larger production capacity required larger space requirements and tooling costs, leading to an (approximately) linear increase in the

capital expense (CapEx) in addition to the significant fixed costs—estimated at about $40 million—associated with commissioning and starting up the three new facilities that was independent of size. These linear components of the CapEx were expressed in terms of a capacity cost for an aggregate, *annual production rate* (APR) of one thousand units[1]. A good estimate of required production rates for each product was thus paramount to a well-sized capacity investment plan. Given the frequency with which Seagate made such investments, an extensive *Capacity Requirements Planning* (CRP) process had been developed over time to assist capital investment planning.

Capital Investments and "Sales-plan Driven Planning"

To support its growth and frequent new product and technology introductions, Seagate made investments in property and equipment in fiscal 1997 totaling $920 million. This amount included $301 million for manufacturing facilities and equipment related to subassembly and disc drive final assembly and test (FA&T) facilities in the United States, Far East and Ireland.

Capital investments are the result of an extensive Capacity Requirement Planning (CRP) process, which intermeshes with the production planning process. (See Exhibit 5 for a representation of the production and capacity planning process.) Seagate's monthly "demand-planning" cycle begins with individual marketing and sales product managers using their specialized knowledge of local markets to estimate sales potential for the following twelve, or even twenty-four, months. These estimates capture both planned purchases by major OEMs as well as possible orders by distributors, resellers, dealers and retailers. Obviously, some of theses estimates are more reliable than others and the accuracy of these forecasts degrades sharply beyond the immediate quarter so that significant uncertainty in total demand remained. The *demand forecast* represents the combined estimates of the monthly, worldwide demand for each individual product. Conceptually, the demand forecast captures demand uncertainty by a probability distribution over likely demand scenarios.
Total demand[2] for the two new products was forecasted to be most likely about 600,000 units, as shown in Exhibit 4. Given that the two products were (imperfect) substitutes, total demand was relatively reliable with about plus or minus 100,000 unit error estimate. There was however significant uncertainty regarding the adoption of the Cheetah and thus the ultimate mix: A pessimistic scenario (with likelihood estimated at 25%) would demand only 150,000 *Cheetah's* and 350,000 *Barracuda'*. The optimistic scenario (likelihood of 25%), however, called for 450,000 *Cheetah's* and 250,000 *Barracuda*'s.

Through a process of aggregation and negotiation, the marketing and sales division summarizes the demand forecast in a *sales plan*. The sales plan may adjust the most likely or the average demand scenario to account for additional factors such as end-of-life cycle effects of unannounced products on the sales of the products they supersede. Senior managers also may decide to curtail production of products whose margins have fallen below profitability hurdles or to adjust the mix of capacity or material constrained products.

The sales plan is then passed to the master production schedulers in the materials division who construct a preliminary Master Production Schedule (MPS). The MPS spells out monthly production quantities ("build proposal") for each product, based on the sales plan and current and future finished goods inventory status. The MPS is then "exploded" to subassembly production schedules for each individual factory location and forms the basis for their component manufacturing and materials acquisition decisions.

Before the MPS is finalized, each facility performs a feasibility check of the preliminary MPS. Usually within one day, vice presidents of the various manufacturing plants contact the MPS schedulers to suggest changes to the MPS if needed. After a few iterations, and all within three days, the final version of the MPS is set, signed of by Ron Verdoorn and the senior VPs of Components and Materials, and transmitted to each manufacturing facility. Each manufacturing facility thus receives an estimate of required production rates and plant managers can adjust capacity when needed. As such, the sales plan and MPS serve as an efficient coordination tool for corporate wide capacity planning.

It is rare for a production facility to fail to meet the output levels required by the final MPS, and a production facility has several options when a proposed MPS appears to be infeasible. If the infeasibility is detected early enough, the plant manager can inform the MPS schedulers and production can be shifted to other facilities. Alternatively, equipment may be flown from one facility to another, which occurs frequently when product lines are shifted among manufacturing locations. Senior managers, who can determine whether the cost of moving the equipment is justified by the profitability of the product, must approve these decisions. Sometimes, however, constraints on equipment and material availability caused some demand to remain unfilled. During 1995, a shortage of media forced Seagate to ration supply among its customers and market segments.

To make longer-term equipment purchases and install new capacity, plant managers submit a Capital Appropriation Request that must be approved by senior managers.

[1] While actual production was planned in terms of a *daily going rate*, capacity planning for investment purposes was done on an aggregate basis.

[2] The following demand, margins and cost data are estimated.

The *Barracuda* and *Cheetah* Capacity Investment

The "sales-plan driven planning" process for the two new products thus *coordinates* capacity decisions to the single sales plan (and associated master production plan) that marketing, manufacturing and financial managers have approved. Consistent with cost incentives, the current Capital Appropriation Request on Ron Verdoorn's desk asked for the minimal cost capacity plan to enable the production plan: a *Cheetah* FA facility with an annual production capacity of 300,000 units, a *Barracuda* FA facility also with a 300,000 unit capacity and a testing facility with a corresponding 600,000 unit capacity. A capital appropriation of $103 million was requested. In addition to the fixed $40million, the CapEx of $103 million included the linear capacity sizing costs of $30,000 per one thousand units of annual production rate (APR) in the *Cheetah* final assembly facility, whereas the more cost-efficient *Barracuda* FA facility would require a modest $20,000 per one thousand APR. The testing facility, however, would be more expensive at about $80,000 per thousand APR, reflecting the cost of many expensive IDT's.

New high-end drives such as the *Cheetah* and *Barracuda* are the "bread and butter" of Seagate. Such high-end drives are relatively immune from competition and were estimated to command average unit contribution margins of about $400 and $300 for the *Cheetah* and *Barracuda*, respectively, throughout the production cycle. Given the high demand uncertainty of the two product families, Ron was wondering whether the current capital appropriation request, which implemented the most likely sales forecast, should be approved or whether he should "adjust" the capacity investment to provide Seagate with a better operational hedge against uncertainty.

Exhibit 1: Selected Financial Statement Data

(Data in thousands):

Fiscal Year Ended	June 27, 1997	June 28, 1996	June 30, 1995	July 1, 1994	July 2, 1993
Net sales	$8,940,022	$8,588,350	$7,256,209	$5,865,255	$5,195,276
Gross profit	2,022,255	1,581,001	1,373,385	1,170,821	909,872
Income (loss) from operations	857,585	286,969	459,301	473,097	-195,442
Income (loss) before extraordinary gain	658,038	213,261	312,548	329,685	-267,605
Net income (loss)	658,038	213,261	318,719	329,685	-267,605
Total assets	6,722,879	5,239,635	4,899,832	4,307,937	3,470,970
Long-term debt, less current portion	701,945	798,305	1,066,321	1,176,551	941,882
Stockholders' equity	$3,475,666	$2,466,088	$1,936,132	$1,634,700	$1,228,829

Source: Seagate Technologies 1997-10K

Exhibit 2: Disc Drive Technology

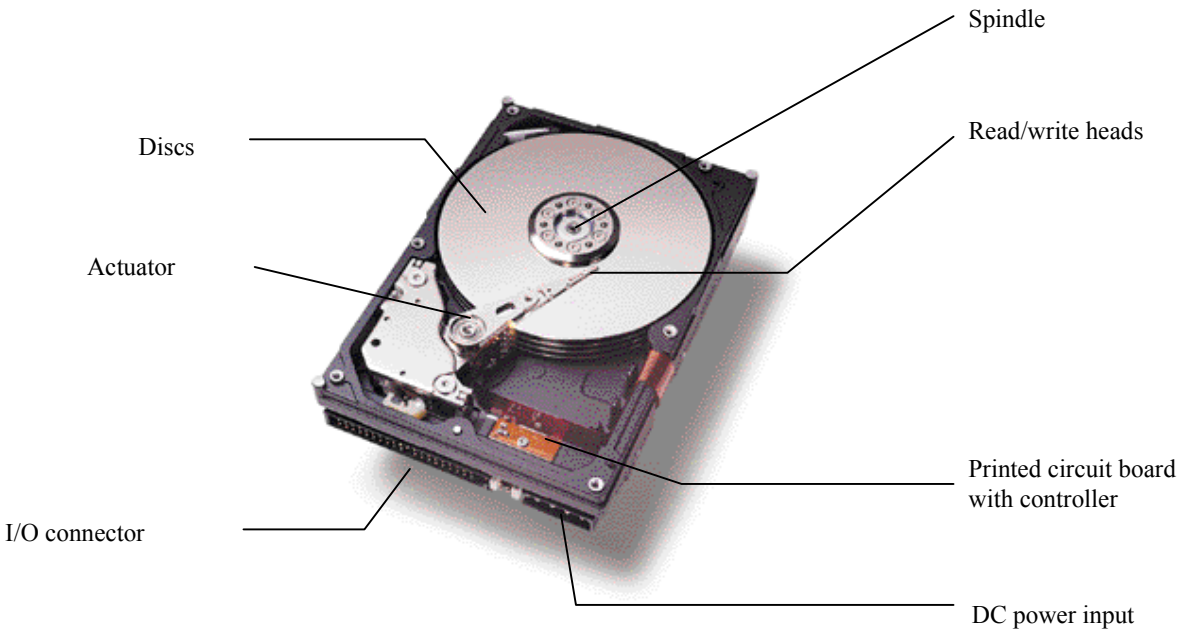
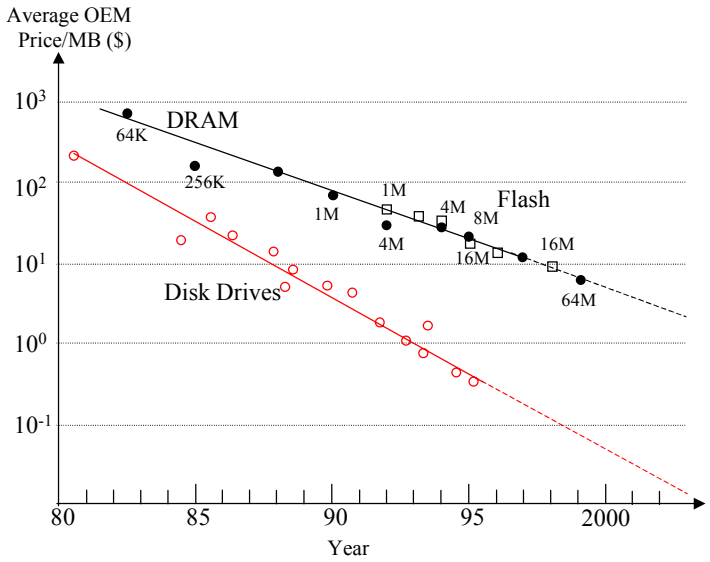


Exhibit 3: Price Trends of Hard Disk Drives versus Semiconductor Memory



Source: Dataquest

Exhibit 4: Demand Forecast

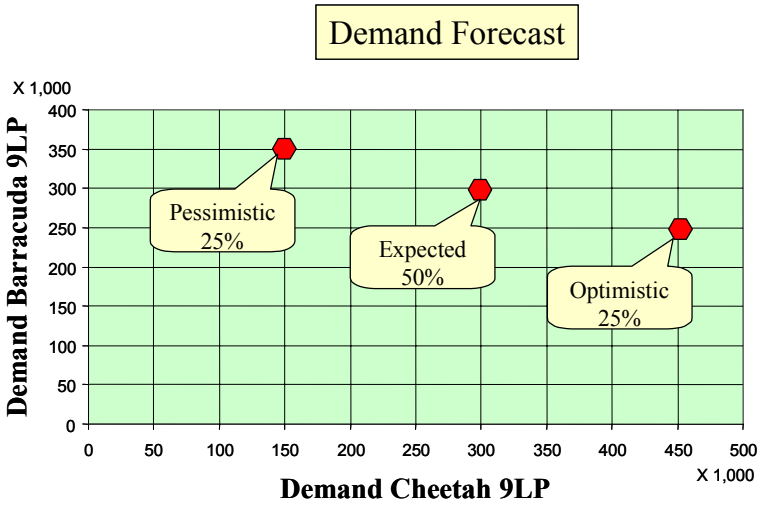
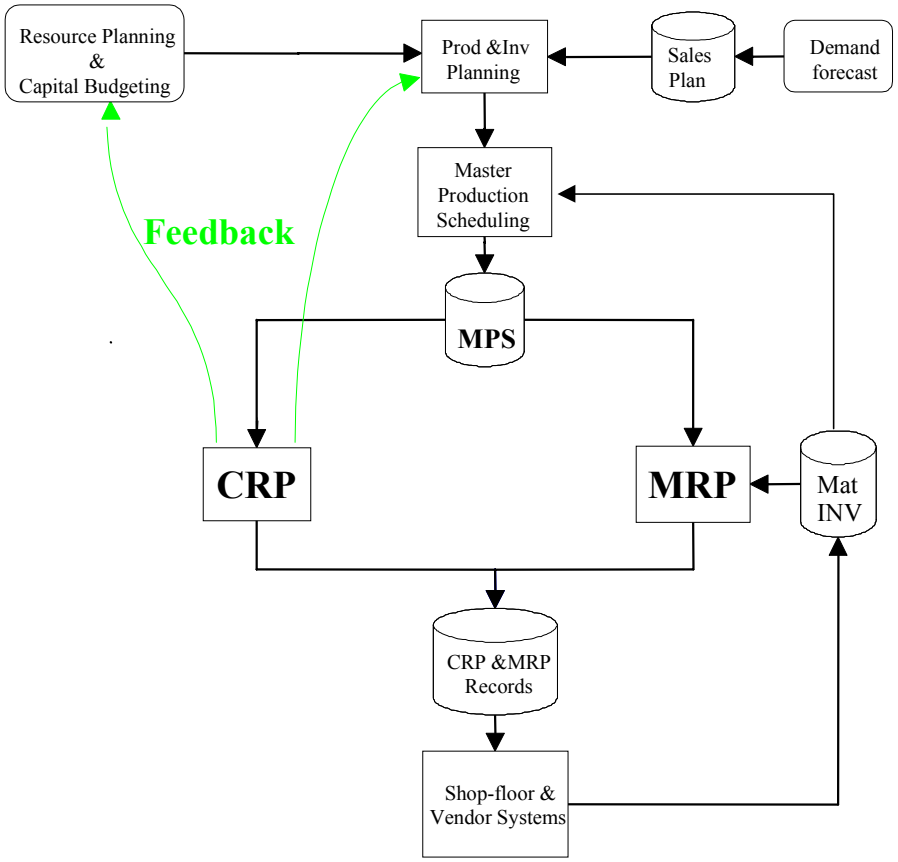


Exhibit 5: Production & Capacity Planning



Legend: CRP = Capacity Requirements Planning
MRP = Materials Requirements Planning
INV = Inventory

Guiding Questions as Preparation for Class Discussion:

1. What is Seagate's corporate strategy and how does its manufacturing strategy and processes support it?
2. What are Seagate's major risks? How does it manage those risks?
3. Critically evaluate Seagate's product and process development strategy, which calls for development in its respective product/process center in the U.S. and then exporting the developed process to a site in the Far-East for high-volume production.
4. Draw a process flow diagram of the 2 product final assembly and test manufacturing process. Superimpose on the diagram in Exhibit 4 a region showing the combinations of Cheetah and Barracuda production quantities that would be feasible if the current CAR capacity proposal were implemented. What is the expected profit and ROI under this investment? (Given the short product life, assume the firm is making its decisions for a single time period of length one year, at the end of which manufacturing capacity will have zero salvage value.)
5. Given the uncertainty in the demand forecast (in the form of the three points), would you adjust the capacity plan to provide an optimal hedge against uncertainty? That is, is there a better capacity plan that maximizes expected profit? Draw the new feasibility set on your diagram: what shape does it have? What is the expected profit and ROI now? Are both financial measures in agreement as to the recommended course of action? If not, what do you recommend? Interpret your recommendation in intuitive terms: what are you "hedging" and why is your recommended plan to be preferred?
6. In broad conceptual terms, what are the advantages of "sales-plan driven capacity planning?" What is "wrong" with that practice and how would you improve on it?