Chapter 12

Computervision

According to a 1994 *Wall Street Journal* article, Philippe Villers decided to start a technology company shortly after listening to the minister at Concord, Massachusetts' First Parish Church extol Martin Luther King's accomplishments a few days after he was murdered in April 1968. Villers felt he needed to do something meaningful with his life and that there were two options – either become a social activist or start a company, make a lot of money and then use that money to change the world. Luckily for what eventually became the CAD/CAM industry, he chose the second path.[1]

Villers was technically well qualified to start Computervision, Inc. or CV is it was generally known. Born in Paris, France, he came to this country via Canada in the early 1940s to escape the Nazis. Villers had an undergraduate liberal arts degree from Harvard and a masters degree in mechanical engineering from MIT. He worked for several years in General Electric's management training program followed by stints at Perkin Elmer, Barnes Engineering and the Link Division of Singer-General Precision with increasing levels of project management responsibility. At the time he decided to establish Computervision, Villers was Manager of Advanced Products at Concord Control in Boston.

Villers spent much of his spare time in 1968 meeting with a group of business and technical associates including Steve Coons and Nicholas Negroponte (founder of the MIT Media Lab). Realizing that it takes more than good technical ideas to build a successful company, Villers decided to find a partner with more business experience to help jump start the enterprise. Martin Allen, who had been Villers boss at Link was a natural choice for this role. Allen was a mechanical engineer from the University of California who had previously worked for TRW, Martin-Marietta in addition to Singer-General Precision. The plan was for Allen to be the company's president while Villers would be senior vice president.

For the first few months in early 1969 while the company was in the process of obtaining its initial outside funding, Villers was the president of the company. At that point Computervision was being funded by Villers' friends and relatives. Eventually, the company was able to raise about a million dollars from a small New York venture capital fund called the Targa Fund, partners at Paine Webber Jackson and Curtis and the Diebold Group. At that point Allen joined the company as president and Villers switched to senior vice president as the two had previously agreed. Another of the company's early venture capital backers was Ampersand Ventures which made a significant financial commitment in 1970. By coincidence, that firm also was one of the initial backers of Prime Computer in 1972. Little did they know at the time how these two companies would end up on a collision course in the late 1980s.

For the next decade the relationship between the two founders appears to have been a very workable arrangement. As the company's senior vice president Villers was the person most responsible for driving Computervision's product development strategy. While Allen would stay with the company as either CEO or chairman until the late 1980s,

[1] Wartzman, Rick, *Wall Street Journal*, June 1, 1994

Villers left in 1980 as discussed later to form first Automatix, Inc., a robotics and machine vision company, and subsequently Cognition, Inc., a mechanical CAE firm.

CV's early product strategy

The original Computervision product strategy involved designing and producing several hardware products in order to generate revenue while the company created the initial release of its CADDS (Computer-Aided Design and Drafting System) software. Three people were recruited to head up hardware development: David Friedman was responsible for the Interact terminal, Joe Sliwkowski the Compucircuit photoplotter and Ken Levy the Autolign semiconductor mask aligner. The first two programmers hired to develop the CADDS software were Robert Blauth and Bert Bruce. Blauth would eventually take on responsibility for all the company's research and development.

Villers technical specialty was the design of high precision electro-mechanical devices. In the 1969 time frame, the electronics industry was entering its first surge of significant growth powered by new integrated circuit technology. One of the major problems facing the semiconductor industry was producing the masks that were used to manufacture the silicon wafers that each contained multiple copies of the circuit being produced. Using a technology called "photolithography" an integrated circuit is made of multiple layers of material and each layer required one or more masks which had to be precisely aligned with the others.

While today's 12-inch wafers contain literally hundreds if not thousands of individual circuits in 1969 a 4-inch wafer might have contained a few dozen at most. But the technology available four decades ago was much cruder than what we have today and there was the need for devices that could quickly and accurately align individual circuit artwork to produce mask sets. The manual methods that were then available were slow and susceptible to error. At the time, this work had to done to the precision of a micron and operators worked with high-powered microscopes to align the masks.

Villers designed the Autolign automatic mask aligner for the semiconductor industry with the expectation that it would be the company's "bread and butter" product until its engineering design and drafting products were ready for market. For the company's first several years this proved to be the case as revenue was dominated by Autolign products. Computervision produced the Autolign product by purchasing manual aligners from Kulicke & Soffa and adding its own electronics and drive mechanisms.

The Compucircuit, on the other hand, was designed from the ground up by Computervision engineers. Prior to the advent of computer-based systems, printed circuit boards (PCBs) were produced by either manually drafting the board's circuit traces and pads using stick-on tape on sheets of mylar or plotted on Rubylith peelcoat material using a sharp knife mounted on the plotter head. Typically these layouts were twice or four times the size of the actual board. Each layer of the circuit board required a separate artwork sheet. These circuits layouts were then photo reduced to actual size and used to manufacture the circuit boards. Other than the scale and precision of the artwork, it was quite similar to the way integrated circuits were produced. The Compucircuit plotted the printed circuit layout directly on film at the same scale needed for production, eliminating the photo reduction step. It was both faster and more accurate than the earlier procedures used to produce PCB artwork.

The third hardware product, the INTERACT, was intended from the start to be a key element of the company's CAD/CAM solution. This device was a combination of a digitizer and a plotter and was the company's only interactive terminal. Villers describes it a "Large Interactive Surface" that shared the electronics of a storage tube-based terminal. The operator could copy a sketched part, view it on a CRT screen, make editing changes and plot the results. The first Interact was shipped in 1970 to Sperry Gyroscope. Eventually this system was returned to Computervision where it was displayed in the company's lobby for a number of years. Computervision claimed that this particular unit had 28,000 operating hours with just 3% downtime. Various version of the INTERACT were manufactured until around 1980.

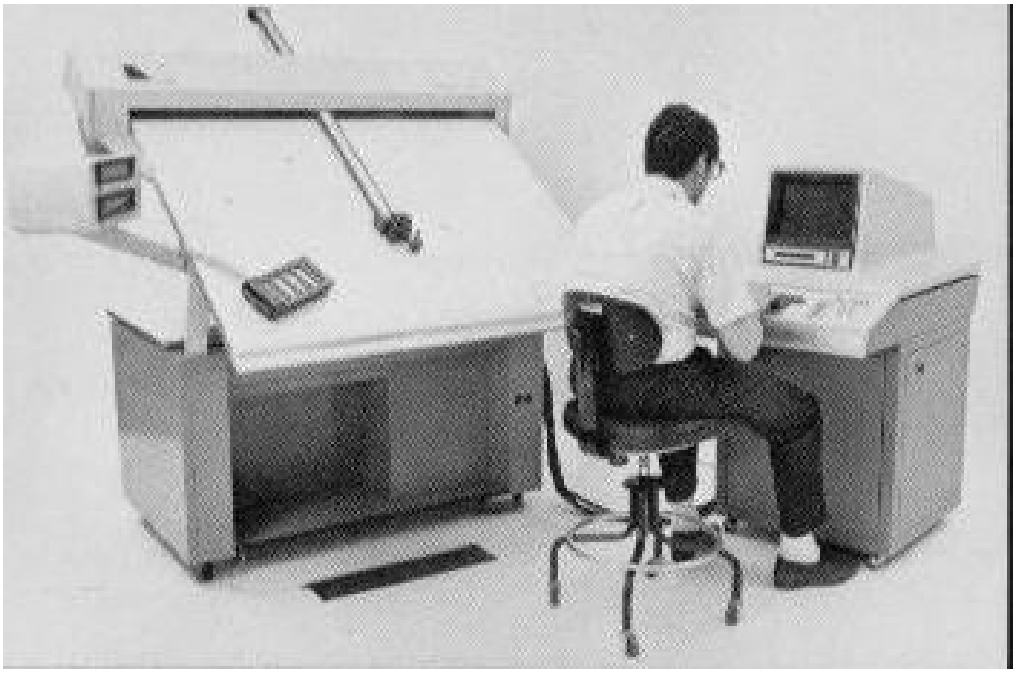

Figure 12.1
Early Computervision Interact Terminal

The initial Computervision product strategy was to operate the Interact terminal with software running on a time-sharing system. The Compucircuit photoplotter was intended to operate with data generated on-line using a remote computer system or with data stored on magnetic tape. The time-sharing concept proved to be impractical due to the slow 300 baud communication speeds then available and the unreliability of computer utilities. About a year after the company started, the plan changed and Computervision began using the new Nova 16-bit minicomputer from Data General.

Off to a fast start

Computervision was one of the dominating companies in the CAD industry throughout the 1970s and most of the 1980s, at one time having a 35% to 40% market

share. Several developments had come together by 1970 to make the commercial CAD systems business a viable endeavor. Minicomputers from companies such as Data General, Digital Equipment and Scientific Data Systems were being sold at manageable prices, low-cost storage tube display terminals were commercially available or companies could build their own terminals with storage tube displays procured from Tektronix, digital plotters were available from CalComp and several other firms and many of the fundamental software concepts for two-dimensional and three-dimensional graphics had been published in technical proceedings. The basic technology pieces were in place. The major task was to develop reliable software that would do enough of the design and drafting task so as to be accepted by the user community.

The company got off to a quick start by focusing on what can best be described as production drafting. Early systems were particularly well tuned to the needs of drafters as exemplified by the company's INTERACT workstation. Although both Allen and Villers had mechanical engineering backgrounds, the early Computervision systems were targeted at electronics users, especially companies that wanted to automate the production of printed circuit board artwork. Technically, the process for preparing this artwork on a computer was a relatively straightforward two-dimensional task, particularly as compared to subsequent activity related to three-dimensional mechanical design. There was also the need to produce a variety of non-scaled schematic drawings documenting the logic of the PCBs.

The Computervision CADDS system was both a radical departure from traditional practice but still a process that drafters could identify with, particularly with the use of the INTERACT workstation. PCB artwork generation and schematic documentation typically involved placing a substantial amount of duplicate graphical entities such as the mounting hole pattern for an integrated circuit on a PCB layout or the symbol for a transistor on a schematic diagram. Even early CAD systems proved to be extremely productive when working with duplicative symbology. Computervision's CADDS system was quite effective when used for these tasks. Once a PCB layout was created using the computer, photographic quality copies could be generated by outputting the information to a Compucircuit photoplotter. This device created the artwork on a sheet of photographic film by exposing apertures describing each type of connection pad or line trace. The film was then developed and used in the same manner from that step on as film produced from photographing manually taped artwork.

Most of the first 200 Computervision systems sold were used for PCB artwork generation. Integrated circuit artwork generation was similar in many respects to PCB drafting in the early 1970s. IC artwork was typically produced on large sheets of grid paper with the different layers of the circuit shown in different colors. These drawings were then used as the basis for producing detailed large-scale artwork master on a material called peelcoat. This process involved cutting through the top layer of the material and then carefully removing the material representing the circuit layer in question. From that point on the process was similar to PCB artwork where the sheets were photographically reduced to be used as production masters except that the IC people referred to producing this final artwork as "mask making."

Two trends were driving semiconductor companies to automate the IC mask making process in the early 1970s. First, integrated circuits were becoming far more complex. This was about the time that Intel's Gordon Moore declared that integrated

circuit density was doubling every 18 months – a trend now known as Moore's Law. Design and production personnel could see a time when it would become almost impossible to continue using manual artwork creation procedures due to the growing complexity of circuits. The second issue was perhaps even more important. The mask making process was switching from traditional photographic reduction techniques to the use of new devices that were driven by digital data. Companies had to produce a digital record of the circuit layout in order to drive these machines.

Computervision saw the IC market for their CADDS systems as a logical extension of the PCB electronics market and the company added semiconductor mask making capabilities to its software. While Computervision dominated the market for PCB artwork and schematic drafting, in the early 1970s, Calma similarly dominated the IC market. The two companies frequently competed in both areas of the overall electronic market with Computervision typically winning the larger PCB business while Calma, as described earlier, winning a majority of the IC business. The Autolign products were typically sold independently of the company's CADDS systems.

Personnel and organization

During Computervision's first decade Villers was responsible for most of the company's internal operations, especially those related to product development while Allen handled external activities. Both were typically involved in presentations to potential investors. Even though Villers was responsible for the initial idea to establish a company to manufacturer the hardware and software products described above, he seems to have had few problems actually reporting to Allen. This may well have been a result of the fact that Villers had worked for Allen earlier at Link.

Over the years, Computervision was particularly successful in recruiting an excellent team of technical and business managers including Phil Reed and Ken Versprille. Villers was personally instrumental in bringing Sam Geisberg, a brilliant Russian mathematician who would later start Parametric Technology Corporation, to the United States in 1974 to work for Computervision. Sam's brother Vladimir initially immigrated to Israel but subsequently moved to the United States and also joined Computervision.

Computervision went public the first time in December 1972 and was listed on the New Stock Exchange under the CVN ticker symbol in 1979.

Computervision becomes a computer manufacturer

Rarely when analyzing a company's history is it possible to point to a single event or decision and claim that it was the determining turning point in the enterprise's future. Computervision's decision to build it own computer systems may well have been such an event. For the first few years it had used Nova computers purchased from Data General. These were relatively inexpensive machines but Computervision believed that it could both increase its profit margins and produce a computer better tuned to the needs of its customers by building its own machines.

A west coast company had reverse engineered the Data General Nova computer and produced a chip set that enabled companies such as Computervision to manufacture similar machines at a far lower cost than what they were paying Data General. Villers saw this as a low risk strategy compared to the company designing its own computer

which apparently was an option being considered. Around 1978 the company began manufacturing a computer called the CGP-100 where CGP stood for Computervision Graphics Processor. This led to the construction of several large manufacturing facilities along with the installation of machinery and equipment for building and testing these machines. Needless to say, Data General was not happy about this development and tried to get Computervision to consider new machines it was working on by offering attractive business terms. As different from what would probably happen today, there does not appear to have been any lawsuits over misappropriated intellectual property.

The CGP-100 was designed by a group of computer design engineers who were referred to as "Computer Gypsies" because they tended to move from company to company in the Boston area designing minicomputers as they went. They apparently did a good job because it was difficult for Computervision's programmers to tell the difference between a Data General Nova and the CGP-100. This new machine was a 16-bit minicomputer with a memory that was expandable to 512K words. It supported a 14 million word disk drive and other standard peripheral devices such as magnetic tape drives. As mentioned earlier, Computervision terminals utilized Tektronix storage tube displays. The company was quick in moving to the 19-inch versions once they became available in the mid-1970s. These terminals used a 11-inch by 11-inch tablet or a large free-standing digitizer for user interaction as well as the previously described INTERACT plot-back digitizer.

In 1978 a base CGP-100 system with a 512-word memory sold for $140,000 while interactive terminals went for $40,000 to $65,000. The three-dimensional mechanical design and drafting software described below cost $10,000 while NC software was another $5,000. With this pricing structure one could conclude that in the 1978 timeframe, Computervision was primarily a computer equipment manufacturing company that happened to also sell CAD software.

Cobilt expands CV's manufacturing

Computervision acquired Cobilt, a manufacturing of integrated circuit mask making equipment, in 1971. Cobilt was founded in 1970 by Peter Wolken, Gerd Schlieman, Allan Fleming and Fred Schultz. This acquisition was intended to both increase the company's manufacturing capabilities in a rapidly growing market as well as enable Computervision to sell more comprehensive systems into the semiconductor industry. Kenneth Levy, who was responsible for Computervision's Autolign product, was initially put in charge of the Cobilt division. By 1977, with Sam Harrell running the division, it was generating $18.2 million in annual revenues, nearly 40% of the company's total.

Levy left Cobilt in 1975 and founded KLA Instruments (today KLA-Tencor, a major manufacturer of semiconductor production equipment) where he was CEO until 1999 and chairman of the board until 2006. Wolken and Harrell both eventually joined Levy at KLA.

Although revenues increased rapidly, Cobilt was never particularly profitable and around 1980 Computervision began selling it off piecemeal. Most of Cobilt was eventually sold to Applied Materials in 1981 for $14 million. Computervision was plagued with lawsuits resulting from its ownership of Cobilt and it would take until 1984

to settle them all. The company reported a $10 million loss that year attributed to putting the last of the Cobilt claims behind it.

While manufacturing photoplotter and semiconductor mask making equipment was important, it did not go to the heart of the company's business the way building its own computers did. Not only did designing and producing these computers require the company to establish a substantial production capability but it also required that it assume responsibility for the computer's operating system and software development tools. And it had to do so without the ability to spread those costs over the much larger number of machines sold by primary computer manufacturers such as Digital Equipment and Data General.

Computervision got into the hardware manufacturing business at a time when minicomputers were rather straightforward machines. Within a few years, the technology became far more complicated and when the company attempted to make the transition from 16-bit to 32-bit computers, the economics of the situation started working against it. Extracting itself from the computer manufacturing business eventually damaged the company's finances to the point that Computervision became the target for a hostile takeover by Prime Computer as described below.

New software broadens Computervision's mechanical capabilities

For the first few years, Computervision focused almost entirely on electrical design applications such as the layout of printed circuit boards. While the initial CADDS software was capable of doing mechanical drafting, it did not have the three-dimensional modeling capabilities that customers were starting to ask for. In the process of competing for business at Boeing, Computervision ran into competition from a small software firm in San Diego, California called System Science and Software – more frequently referred to as S^3.

While most of this company's business activity was focused on scientific and technical projects for federal government agencies, it had acquired a CAD software company called Integrated Computer Systems. Started by Patrick Hanratty, ICS had developed a package called INTERAPT. As described in Chapter 15, the acquisition of ICS led to a lawsuit against Hanratty who did not stay with the company after it was acquired by S^3.

The CAD software business unit at S^3 was struggling at the time and when Computervision offered to buy that operation, the deal was executed fairly quickly. As part of buying this business activity from S^3, Computervision inherited the lawsuit against Hanratty which was still pending. Dave Albert who was heading this operation, Jerry Devere who had helped start ICS and about ten others moved to a new office facility in Rose Canyon, north of San Diego, and began working on porting S^3's INTERAPT software to the Data General computers Computervision was using at the time.

Albert remembers the relationship with Computervision getting off to a fairly rocky start. Phil Villers visited the new office shortly after they had moved in and made it clear that he had opposed the acquisition and wanted to close the office. Meanwhile, the company settled the lawsuit with Hanratty by licensing his then current ADAM package and paying him a monthly retainer for about a year.

The new mechanical design and drafting software, now known as CADDS 3, was introduced in 1973. Most of the work was done in California although some user interface functions were developed at Computervision's headquarters in Bedford. For the next several years, the San Diego and Bedford programming groups worked together on enhancing CADDS 3.

Towards the end of 1975, Computervision decided that it wanted to consolidate its CADDS programming activity in Bedford and offered the San Diego staff new positions in Massachusetts. By now there were about 30 people in the Rose Canyon office. While some people accepted the offer to move back east, most did not. Under Albert's leadership, they stated to form a new software company. Before that idea had proceeded very far, the team decided to join Calma and stay in southern California. Computervision was not happy about them joining a competitor but, contrary to some misconceptions, never sued Calma over hiring Albert and other core members of the San Diego team.

Indicative of how small a world this really is, Albert was vacationing in New Zealand in the spring of 2003 and stayed at the local equivalent of a small bed & breakfast. Upon leaving he went to sign the guest book and found the Villers had been there about a month earlier.[2]

Computer becomes dominating force in CAD industry

In May 1975 Computervision hired Ken Versprille[3] soon after he received his Ph.D. from Syracuse University. While at Syracuse Versprille worked closely with Steve Coons, the developer of the Coons Patch used for defining surface geometry. As described in Chapter 2, Versprille's Ph.D. thesis involved the development of a more advanced technique for defining surfaces known throughout the computer graphics industry as NURBS or Non-Uniform Rational B-Splines.

Computervision's growth had been fairly rapid in the early 1970s and by 1974 the company's annual revenues were over $25 million and the business was nicely profitable. 1975 saw the United States in the midst of a recession and sales dropped to $21 million and the company incurred a $4 million loss. At this point, there were two schools of though within Computervision's management. One group felt that the company should hunker down, reduce expenses as much as possible and wait out the recession. The other group, led by Mike Cronin, lobbied for increasing research and development as well as expanding sales so that when the recession ended, Computervision would have the strongest product portfolio in the nascent CAD industry and would be able to grow faster than its competitors. This latter approach won out and Versprille along with perhaps 20 other programmers were hired. It proved to be the correct strategy in that Computervision sales increased rapidly in the late 1970s and by 1980 the company's annual revenues were nearly $225.

Hired as a senior programmer, Versprille's initial assignment was to make the CADDS 3 software more three-dimensionally oriented. The first versions of the package required defining geometry on two-dimensional planes which were then projected into

[2] David Albert interview September 19, 2003

[3] Various reference to Ken Versprille are based on a series of telephone interviews with the author during July and August 2003

three dimensions. This was about a year-long project which was followed by a similar task to improve the geometric creation of three-dimension splines.

Another project around this same time involved changing the graphics display routines from integer arithmetic to floating point. An integer method had been used by the San Diego development group to maximize graphics performance except that it failed when model values exceeded predefined limits. In Bedford, they redid these routines using a normalized floating point technique that enabled models to span greater dimensions while sacrificing little in regards to performance. The new software enabled the Computervision programmers to create a technique they called "bounding boxes." These defined the minimum and maximum values that could be expected for the part being designed. The result was that images could be scaled by a factor of two by using extremely fast shifting operations. One problem with this technique was that these minimum and maximum values had to be defined when the design of the part was initiated.

Versprille points out that the programming staff in Bedford was relatively small and that everyone had to do everything. This resulted in a group of developers who were broadly familiar with full range of the company's software products. As Computervision grew, new hires tended to be given assignments that had them focusing on narrow segments of the software. One result was that early employees tended to end up in staff positions where their responsibilities encompassed broad segments of the company's product line.

Computervision in the late 1970s

In 1978, Computervision was still being run by Martin Allen as president and CEO while Phil Villers was a senior vice president in charge of long term strategic planning. Michael Cronin had responsibility for several marketing and R&D activities, Sam Harrell was running the Cobilt operation, Dave Friedman was vice president of engineering and Bob Gothie was vice president of marketing. Field sales in the United States was headed up by Ralph Shubert who reported to Gothie. By the late 1970s the company's focus had switched from electronic design to mechanical applications with a moderate amount of activity in the AEC field.

Sales were handled by a direct sales force in the United States and much of Western Europe while distributors were utilized in Japan and other countries. The typical system sold for between $250,000 and $400,000 and the company had an installed base of approximately 500 systems. Major customers included General Electric (45 systems), Ford Motor Company (10 systems), General Motors, Boeing, Pratt & Whitney and McDonnell Douglas. Overall, sales were increasing fairly rapidly except for the previously mentioned dip in 1975. Revenues in 1978 were nearly $72 million. By this point the company's software development staff consisted of about 120 individuals.

The primary computer system was the company's own CGP-100 described early along with terminals utilizing Tektronix storage tube displays. The basic two-dimensional software used for electrical applications such as PCB layout was now known as CADDS 2 while the three-dimensional mechanical software was referred to as CADDS 3. Among the important features contained in CADDS 3 were:

- Both two-dimensional or three-dimensional design modes.
- Cross sections of three-dimension parts.

- B-spline curves and surfaces.
- Concept of parts and sub-parts.
- Finite element mesh generation based on GIFTS (developed at the University of Arizona).
- Drafting with automatic dimensions, tolerances, labels and notes.
- Isometric views.
- Interactive generation and editing of NC tool paths.
- User development language called Parametric Element Processor (PEP).
- Data communication with mainframe computers.

Life After Computervision

Phil Villers left Computervision in January 1981 after the company rejected two new venture proposals he had made. The first was for a low-cost system that would combine a computer and terminal into a single integrated system. This concept was similar to the engineering workstation being developed at the time by Apollo Computer and several other companies. Villers believes that the failure to do so was one of the major factors that eventually led to Computervision's decline in the CAD/CAM industry.[4] Earlier, in the summer of 1980, Villers had made a proposal for the company to expand into robotics and artificial vision systems for manufacturing companies.

Upon leaving Computervision, Villers started Automatix, a company focused on robotics and artificial vision. (Actually, the company may have been stated somewhat earlier in 1980.) He was president until 1984 and then chairman of the board until 1986. In 1985 he founded Cognition, a software company that developed and marketed mechanical engineering design software that could be used by engineers, especially during the concept design phase of a project. He remained president of that company until 1988. As this is being written, its president and CEO is Mike Cronin who was in charge of sales for Computervision throughout most of the 1970s.

When Villers left Computervision in 1981 he was worth over $80 million. Having met the goal he set for himself in 1968 he decided to do something significant with this money. He and his wife Katherine took half that money and established the Villers Foundation. Known today as Families USA Foundation, it has been active in lobbying the federal government to provide better healthcare for the nation. In 1994, when the Clinton administration was engaged in trying to develop a universal health plan, Villers and Families USA were in the middle of trying to develop support for the plan. This activity was of sufficient visibility that the *Wall Street Journal* ran a feature article on the foundation and Villers in its June 1, 1994 issue.[5]

[4] Personal communication with Philippe Villers October 22, 2003
[5] Wartzman, Rick, *Wall Street Journal*, June 1, 1994

Villers has spent recent years running Families USA from his home in Concord, Massachusetts while the organization's staff is in Washington. Today, the foundation, which describes itself as non-partisan but definitely leans towards Democratic positions, is actively involved in Medicare-related issues. Villers has been a delegate to several national Democratic conventions, is a member of the ACLU President's Committee and Amnesty International USA's Executive Directors Council. He is also president and a board member of GrainPro, a company making hermetically-sealed grain storage units for developing countries. One may or may not agree with his politics, but everyone should admire his commitment and energy devoted to giving back to a society that has given much to him.

Hardware and software developments in the late 1970s and early 1980s

By 1980, Computervision was dominating the turnkey CAD systems industry. According to Daratech, the company shipped 620 systems in 1980 or 44% of the industry's total.[6] During this period, Computervision's research and development activity swung into high gear. Some of the major projects were:

CGP-200 – The CGP-100 computer proved to have less than desired graphics performance. To enhance its capabilities in this area Computervision developed a specialized graphics processor, the Graphics Processing Unit (GPU) to handle two-dimensional and three-dimension graphic manipulations. The combination of the GPU and a CGP-100 was marketed as the CGP-200 and CGP-100 was eventually dropped from the company's product line.

CGP-200X – This was an upgraded and repackaged version of the CGP-200. It was Computervision's primary computer system starting around 1982.

Instaview – Although Tektronix had added limited refresh capabilities to its storage tube products, it was becoming obvious that more interactive graphics capabilities were needed by CAD users. Computervision's answer was the Instaview which was introduced at the November 1978 AUTOFACT conference in Detroit. The was a monochromatic 512 line raster terminal that Computervision sometimes described as a 1024 line unit. In reality, static images were displayed at 512 line resolution while dynamic images took advantage of the full 1024 resolution. Text was displayed on the left side of the screen in an area where graphics was excluded. Primary user input was via a 17-inch by 24-inch tablet containing a user-defined 427 button menu. The Instaview C was introduced in several years later. It supported 64 colors at 512 line resolution. A high resolution version, the Instaview HC was subsequently introduced with 1280 by 1024 resolution and 262,000 colors.

APU – The Analytic Processing Unit or APU was Computervision's answer to the trend towards 32-bit computers for CAD support. Initially, it was not intended to replace the 16-bit CGP machines but rather to be directly linked to those machines and provide 32-bit processing for analytical tasks such as finite element analysis. Development took much longer than expected and this device never lived up to expectations. From a performance point of view, it was in the same category as a Digital

[6] *Worldwide Shipment of CAD Systems for 1980*, Daratech

VAX 11/780 except the 11/780 had been on the market for over four years by the time the APU went into beta test.

CADDS 4 – This new version of Computervision's CADDS software was required to take advantage of the graphics processing capabilities of the CGP-200 and the Instaview terminals. This version of the software had enhanced graphics capabilities such as geometry creation in any plane, not just a plane orthogonal to the current view.

CADDS 4X - This software upgrade was needed to take full advantage of the new processing capabilities of the CGP-200X and the APU. Customer deliveries began in the latter part of 1983, nearly two years late by some estimates.

MEDUSA – In November 1982, Computervision acquired Cambridge Interactive Systems, the Cambridge, England company responsible for the development and support of MEDUSA. The software was also being marketed outside of Europe by Prime Computer. Computervision began marketing MEDUSA running on Digital VAX computers and continued to support Prime's sales of the package. MEDUSA was an effective drafting program that had decent three-dimensional capabilities. According to Jim Barrett, Computervision's president at the time, this was Computervision's first step towards offering customers the choice between bundled turnkey systems and modular software.

Until 1984 Computervision used the Designer designation for its different systems based upon the previously described hardware and software products. At the low end was the Designer M which was Computervision's entry level system, introduced in November 1981, which could also be utilized as a remote system. As a remote system it was referred to as the Designer R. It consisted of a CGP-80 computer and either CADDS 2, CADDS 3 or CADDS 4 software. The CGP-80 was a reduced capability version of the CGP-100 that was used to support CADDS 2 and CADDS 3. A higher performance CGP-180 was used to support CADDS 4. With prices starting at $100,000, these systems could support either one or two Instaview M terminals which were specifically configured to work with the Designer M product line.

Prior to 1982, Computervision's primary product was the Designer IV which consisted of a CGP-100 processor, CADDS 3 software and typically two to six terminals. Although CADDS 4 software would run on a Designer IV system, there were advanced features in that software that required a CGP-200 to be utilized. Starting in 1982, the Designer V became the company's primary product line. It replaced the CGP-100 with the newer CGP-200 which provided better Instaview support. The last system in this product line was the Designer V-X which incorporated the CGP-200X processor and supported CADDS 4X software as well as the APU.

Overhauling CADDS software

By 1978, it was apparent to some of Computervision's development staff that CADDS 3 was being pushed to its limits and that an entirely new software product was needed – one with a better database architecture and improved graphics. It was also apparent that a new generation of computer hardware and operating systems was just over the horizon. A group of four individuals; Ken Versprille, Bill Stanley, Tom Jaskowitz and Roger Roles, put together a plan for a new CAD/CAM system they initially called CADDS 4. Indicative of the relatively open management style of Computervision at the time, the four were given a chance to pitch their plan to the

company's executive management. According to Versprille, they made a technical pitch ignoring the business issues surrounding such a decision and were shot down.

They were determined that a new system was necessary for the future health of the company and after licking their wounds, went back for another shot at convincing management that this was the right thing to do. This time they were successful and were given the task of proceeding with developing a new system fundamentally from the ground up. Since the Instaview terminal was just about ready to be shipped, the CADDS 3 people had the significant task of adapting that software to work with the new raster graphics technology.

Bill Stanley totally redesigned the CADDS database to use a concept of records and sub-records while Versprille worked on the graphics portion of the system. CADDS 3 graphics used a separate file for each view and wrote the graphics directly to the display terminal. This was a fairly common technique for storage tube-based graphic systems since images could not be changed except by erasing and rewriting the image. The new CADDS 4 software used a three-dimensional display file concept that was more conducive for use with raster displays where individual elements could be moved, deleted or changed at will.

Overall, the CADDS 4 software was a significant improvement over CADDS 3, particularly for three-dimension mechanical and engineering design. A change made in one view of a model, was immediately reflected in other views and geometry could be created on any arbitrary plane. Computervision also split the software into numerous different modules for marketing purposes.

The CGP-200 eventually proved to be somewhat underpowered for three-dimension graphics and planned software developments such as solids modeling. As a consequence, the company enhanced and repackaged the CGP-200 and introduced it as the CGP-200X in 1982. In order to take advantage of its new capabilities a revised version of CADDS 4 was required. This version of the software was known as CADDS 4X and it was the primary Computervision product throughout the balance of the 1980s and into the early 1990s.

The Analytic Processing Unit (APU)

By 1980 it was fairly obvious throughout the CAD/CAM industry that computers more powerful than contemporary 16-bit minicomputers were going to be needed to support the next generation of software that would be more database and solids oriented. At about the same time, a new crop of 32-bit computers such as the DIGITAL VAX 11/780 and Prime 750 were becoming more widely used by CAD software vendors. Computervision was well aware of this trend but also recognized the difficulty of making the transition from its current 16-bit CGP machines to a new generation of 32-bit computers.

The plan was to develop a 32-bit computer that would attach to one or more CGP machines and could be used for computationally intensive tasks such as solids modeling, finite element analysis and database management. This computer was called the Analytic Processing Unit or APU. On occasion it was also referred to as the Auxiliary Processing Unit and some industry observers occasionally called it an Attached Processing Unit. Mostly it was simply referred to as the APU. While the company did not plan to initially port all of CADDS 4X to the APU, that was the long term plan. From a performance

point of view, the APU, which had a 225 nanosecond cycle time and a 16KB cache memory, was somewhere between a VAX 11/750 and a VAX 11/780.

By now Computervision was a fairly substantial company and it tried a matrix management approach for the APU project. This did not work very well and the company's top management realized not much was being accomplished. The lack of progress was causing credibility problems with customers and financial analysts. In either late 1982 or early 1983 a crash project was put in place to ready the APU for the November 1983 AUTOFACT conference. Masood Zarabian was put in charge of a new team of programmers with Ken Versprille as the technical lead. The team moved to a separate building in order to focus specifically on the task at hand. Several problems became apparent fairly soon. One was that the hardware engineers (the computer gypsies mentioned earlier) who had designed the APU had left Computervision. Another problem was that the software work done to date had redundancies and gaps in what had been accomplished. For example, there were two separate groups working on compilers for the APU.

Computervision customers who had access to early versions of the APU were somewhat underwhelmed. According to a Merrill Lynch report around this time, "The predominant complaint of CV users who have evaluated the APU is that it is too little, too late in terms of CPU horsepower and does not improve the response time of the workstation."[7]

Zarabian, however, was proving to be an effective manager. Versprille relates the story of one employee who was quite ill who Zarabian kept on the company payroll longer than perhaps was required. This resulted in the programmers pulling together behind someone they perceived to be a leader they could follow. Zarabian also felt that they needed to focus on three goals regarding APU software: 1) prove to the analysts that the APU was a viable machine and that Computervision strategy was valid, 2) create a deliverable product that could help drive the company's revenues and 3) do it right once the first two objectives had been met. It took about ten months, but the team had a working system by the end of 1983, nearly two years after it was initially expected.

One of the major problems the development team faced was the instability of the APU hardware. The machine consisted of four primary circuit boards and due to either design or manufacturing problems there was an excessive amount of crosstalk between these boards which would cause random machine failures. These problems were never fully resolved and the APU had a minimal impact on the company's fortunes. It was too little and too late and really did not solve one of the biggest problems facing users and that was improving the performance of interactive tasks such as calculating the intersection of two surfaces. One of the major problems was the difficulty Computervision had getting third party software firms to port their software to the APU. Packages committed for delivery included ADAMS (dynamics), UNIRAS (finite element analysis), ADLPIPE (piping analysis) and COSMOS (finite element analysis).

There was one aspect of the APU software project that would eventually have a major impact on Computervision and some of its staff from this period. Zarabian and Versprille brought over a team of programmers from the CADDS group to initiate the development of a solids modeler on the APU. There were nine programmers in the group and the manager was told to recruit another nine. After some number of months they

[7] Merrill Lynch Report, September 14, 1982 as noted in Weisberg personal papers

determined that very little had been accomplished because the group was working on other tasks of interest the project leader. Versprille and Zarabian ended up firing the manager, Vladimir Geisberg, who then went to work at Prime Computer developing solids modeling software there.

Phasing out computer manufacturing

In August 1982 Allen gave up his titles of president and CEO to James Barrett, a former Honeywell vice president. Allen's comment at the time was that he "wanted someone who came from the multi-million dollar corporate environment and who had experience competing against IBM."[8]

Well before the APU began shipping, Computervision realized that a new approach was needed regarding the company's long range plans for computer platforms. In late 1982 Computervision told a number of computer vendors that the company would eventually shift from building its own minicomputers to using industry-standard workstations which could be networked together. This was not a decision made lightly. David Friedman, the vice president responsible for hardware engineering, and Bob Callaway, the vice president of manufacturing, particularly fought the idea.

Throughout the first half of 1983, the decision of which workstation vendor to go with swung back and forth between Apollo Computer and Sun Microsystems. The other contenders were quickly eliminated for either technical or business reasons. A key sticking point in the negotiations was that Computervision wanted manufacturing rights in order to keep its plants busy. Apollo had been around several years longer than Sun and had already signed up Auto-trol Technology, Calma and Mentor Graphics as OEM customers. A major advantage Apollo had in this competition was that it was located in Chelmsford, Massachusetts, just a few miles from Computervision's headquarters in Bedford. Sun, of course, was out in Silicon Valley.

There were two other major differences between the two companies. Apollo had been founded in 1980, before some of the standards that swept the computer industry in the 1980s became well established. As a consequence it developed its own operating system, AEGIS, which while it was UNIX-like was not truly UNIX. In a similar manner, Apollo's networking was based upon a proprietary token-ring methodology. These were good technologies but they were not industry standards. Sun, on the other hand, was fully committed to industry standards and used the Berkeley version of UNIX and Ethernet networking. The other major difference between the two companies was that Sun was more willing to have Computervision actually manufacture much of the workstations it would be selling.

In June 1983[9], a Computervision purchasing manager called Sun's president, Vinod Khosla, and told him that they were going with Apollo. Khosla and Scott McNealy who was vice president of manufacturing at SUN at the time, took a redeye flight to Boston that night and showed up uninvited in the Computervision lobby the next morning. They insisted in calling everyone in the company they knew, but no one was in a position to help them get the procurement decision reopened. Finally, one vice president convinced them if they left the lobby and returned to Sun's local sales office in

[8] *Business Week*, December 20, 1982, p. 76C

[9] Although some sources put this call in July 1983, I have personal notes that as of the June, 1983 NCGA Conference in Chicago, I was already aware that Computervision had decided to use Sun hardware.

Boston, Barrett would call them. They got the call several hours later and according to Khosla, Barrett's comment was: "We have decided and here is why. You are a 40-person company and you have an incomplete product. We love your technology, but there is no way you can supply it. Apollo is the standard in the industry, well financed and well managed."[10]

Khosla and McNealy did not give up and convinced Barrett to give them another shot at Computervision's business. The result was that Sun succeeded in replacing a shocked Apollo as Computervision supplier of workstation technology. Sun was awarded a $40 million contract for workstation components. Under the deal, Computervision actually built the workstations using its own Instaview graphics technology. At this point in time, Computervision had far more capability in the graphics area than either Sun or Apollo, particularly more than Sun.

Needless to say, porting CADDS 4X to the Sun workstation was a major project that probably took a lot longer than initially contemplated. Five months later, at the 1983 AUTOFACT Conference in Detroit, all Computervision was able to demonstrate was a standard SUN 11/120 workstation connected to a CADDS 4 system via an RS-232 link. For software, they were able to download a CADDS drawing and view it on the Sun workstation. The statement made at the conference was that the company would have two-dimensional drafting running on the Sun platform sometime in 1984. They were able to do this by the May 1984 NCGA Conference in Anaheim, California.

The software they demonstrated at that conference, however, was quite different from CADDS 4. It used icon-based menus and may well have been an early version of Medusa ported to the Sun platform. Not much progress had been made by the time of AUTOFACT in October 1984 which was also held in Anaheim, although the company was able to demonstrate a fairly simple two-dimensional NC application. One of the problems they were having was that these Sun workstations had 50MB disk drives which were not large enough to support both the drafting and NC software – one or the other.

A year later, at the November 1985 AUTOFACT Conference in Detroit, Computervision still was not able to demonstrate CADDS 4X running on a Sun-based workstation. To put this situation in its proper perspective, CADDS 4X consisted of more than five million lines of code, mostly written in an older version of FORTRAN. The first step in the porting process was simply to rewrite this older code in Fortran 77 and then port it to the Sun platform running UNIX. Zarabian was asked once again to manage a time critical project and he had the programmers working two shifts. It was probably another six months, however, before the company was able to ship CADDS 4X running on the Sun-based CDS 3000.

The mid-1980s are a period of transition

1984 was actually a great year for Computervision. Revenues soared 39% from the previous year to $556 million and the company earned $75 million. A sizable portion of this was as a result of winning a $99 million U.S. Navy contract in late 1983. Also in 1984, Computervision acquired GRADO in West Germany, a developer of PCB design software, and Organization for Industrial Research (OIR), a vendor of group technology software. The latter never made much of impact on CV's customers and was sold to International Technigroup in 1991.

[10] Harvard Business School case study, Professor Amar Bhide, December 14, 1989

As of mid-1985, the company's management consisted of the following key individuals:

- Martin Allen – Chairman of the board
- James Berrett – President and CEO
- Phillip Reed – Senior vice president and COO
- Richard Keiger – Vice president, finance and treasurer
- Robert Gothie – Vice president and group executive, North American Group
- Peter Chaison – Vice president, business development group (responsible for GRADO and the Metheus joint venture)
- Richard Paulson – Vice president and group executive, product group
- David Friedman – Vice president and general manager, product technology
- Thomas Sancha – Managing director, Cambridge Interactive Systems
- Masood Zarabian – Vice president and general manager, Applied Technology Division
- Bard Solomon – Vice president and general manager, OIR
- Ken Ledeen – Vice president and general manager, Personal Systems Business Unit.

In May 1984 Computervision held a major press conference in Boston to announce a new product strategy consisting of three major components.

CDS 3000 – This was the initial nomenclature for Sun workstations running Computervision software. Prices ranged from $35,000 for a basic workstation to $75,000 for a server version. Five software packages were announced at the May press conference including schematic data capture for electrical design, drafting, space planning, technical publications (actually Interleaf software) and a viewing program called FactoryVision. Database software from Rational Technology was also planed for the CDS 3000. Software prices ranged from $4,500 to $12,000.

The plans as of May 1984 were to begin deliveries in November. Sales of the CDS 3000 hardware took off rather slowly due to the lack of deliverable Computervision software. The company also began selling Sun workstations as Medusa terminals where the Medusa software actual ran on DIGITAL VAX computers but by mid-1985 CIS had ported the software to the Sun platform and it was being sold as Medusa/3000.

CDS 4000 – The bulk of Computervision's sales at this point in time consisted of CGP-200X minicomputers driving Instaview workstations, both monochromatic and color, and running CADDS 4X software. The APU was typically considered an option for this configuration. Previously this configuration had been referred to as the Designer V system. A new release called CDS 4000 Revision 2 with Ethernet and SNA communications support was planned for July shipment. Prices started at $250,000 for a system with two color workstations and basic CADDS 4X software.

In 1985, Computervision began selling Sun workstations as CDS 4000 terminals as an alternative to the Instaview units with the expectation that they would soon be able to directly support CADDS 4X software. By mid-1985, a boundary representation solids package, Solidesign, was fairly well integrated into CADDS 4X except that it did require

that an APU be part of the configuration. On occasion Computervision still referred to these systems under the Designer VX nomenclature.

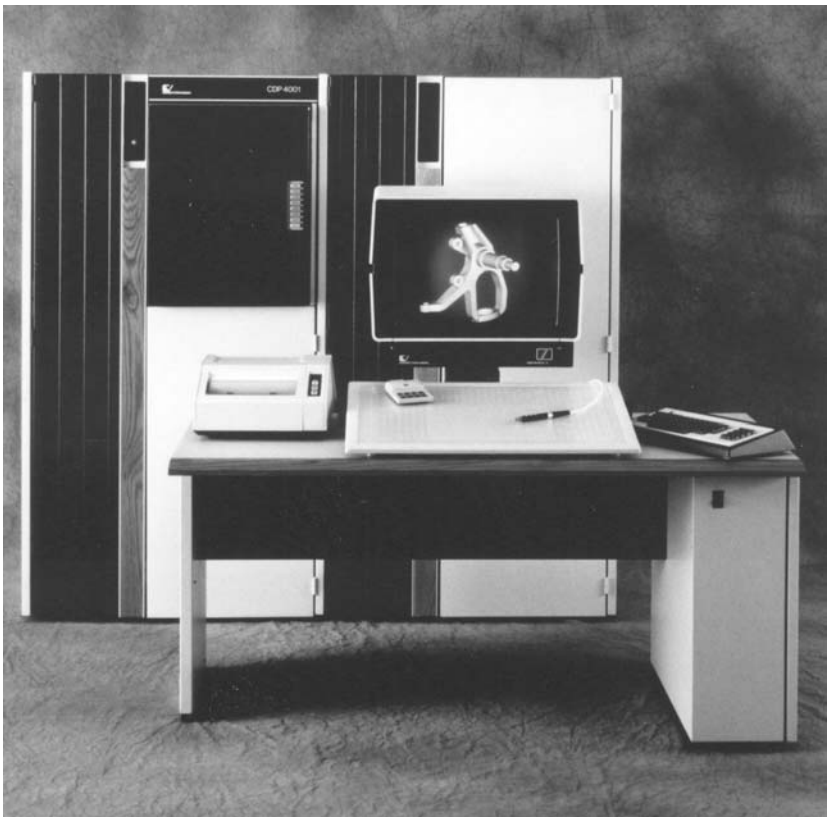

Figure 12.2
CDS-4000 System with Instaview Terminal

CDS 5000 – In 1983 Computervision signed an agreement with IBM to resell that company's 4300 series computers, primarily as database management machines. Running the VM/CMS operating system, these systems could support up to 64 simultaneous CDS 4000 users accessing databases up to 40 GB in size. Announced prices ranged from $485,000 to $650,000. The company initially referred to its software for these computers as Product Database Management although later they picked up the more industry standard term of Product Data Manager.

The general impression was that Computervision was trying to offer something for everyone and glossing over the difficulty of making it all work together. Reselling IBM mainframes seemed to be a particularly difficult stretch for a company that primarily was used to having engineers selling design and drafting systems to other engineers.

Personal Designer – Complicating this product mix, in September 1984 Computervision began shipping its first PC-based system, the Personal Designer System. With MicroCADDS software developed by Seattle-based 4-D Graphics, a Personal Designer System including a PC/XT sold for $13,580. Bezier curves and surfaces added

$2,800 to the price tag. A PC/AT version was also available at $17,890 and customers could purchase just the graphics hardware and software for $9,980 if they wanted to install the system on a PC they already owned. There was no ability to share data with either a CDS 3000 or CDS 4000 system although a CADDS viewing program was available.

The Personal Designer, which eventually was joined by a number of other PC applications, resulted in the company establishing its first domestic dealer channel. Although this was much more comprehensive software than what Autodesk had at the time, the price tag eventually proved to be too high for the product to be generally competitive with AutoCAD. In June 1985, a three-dimensional architectural design package developed by one of the company's French customers was added to the Personal Designer product line. Called Personal Architect, the software sold for $9,200.

The first major restructuring

If 1984 was a great year for the company, 1985 was a disaster. Revenue dropped to $441 million and the company incurred an $81 million loss. As these losses began to mount, Computervision laid off 950 people during the first part of 1985. By the end of the year it had laid off a total of nearly 2,000 people and closed its Sanford, Maine manufacturing plant as it began to de-emphasize the manufacturing of its own computer system. By mid-1985, it was obvious that Computervision was repositioning itself to be able to react more quickly to changes in the computer hardware end of its business by turning to standardized products made by other firms.

The problem was that with CADDS, Medusa, Personal Designer, Metheus, CDS 3000, CDS 4000, CDS 5000 and a myriad of other products, Computervision simply had too much on its plate. As I wrote in an Auto-trol report at the time, "CV is a company in transition and it does not seem that the transition is going well."[11]

Robert Gable became chief operating officer and vice chairman in September 1985 and Jim Barrett, as president and CEO, planned to focus on strategic issues and relationships with major customers. This setup lasted just six months and in March 1986 Gable replaced Barrett as president and CEO. Barrett went on to become chairman and CEO of Honeywell-NEC Supercomputers, a joint venture that planned to market very large computers in the United States.

Computervision works to get back on track in 1986 and 1987

In 1986 Computervision's business regained some of the momentum it had lost in 1985 as revenues recovered to $494 million and then in 1987 they grew another 14% to a record $565 million although profits of somewhat less than $20 million in 1987 were far below the $75 million the company had earned in 1984. By the end of 1986, nearly 60% of the company's business was international and it would increase in subsequent years until it reached 67% in early 1992. The weak 1985 results, however, were probably a major reason behind James Barrett's departure as president and CEO and his replacement by Robert Gable who had been COO. Gable had been a director of Computervision since 1974 and had joined the company full time in 1985 after a long career with Kidde, Inc.

In 1984, Computervision and Metheus Corporation of Hillsboro, Oregon formed a joint venture to design and market CAE products for the electronics industry.

[11] Weisberg personal papers

Computervision made a $220,000 investment in what was called Metheus-CV, Inc. and loaned the joint venture $10 million. This operation never really got off the ground and, in 1985, Computervision wrote off its investment in Metheus-CV and in 1986 consolidated the activities of the joint venture with its own operations.

From a software development point of view, 1986 saw significant progress in porting the five to six million lines of CADDS 4X code to the Sun platform running UNIX. This new version of the company's flagship software retained the older user interface involving typed commands or the selection of these commands from a tablet menu along with new capabilities involving on-screen icons and pop-up menus. CADDS 4X's 2,000 commands were logically organized into panels of 24 icons each. Switching between menus was facilitated by stacking the menus on the screen like a deck of cards so the user could rapidly move from one menu to another by clicking on the portion showing. The UNIX version of the CADDS 4X software took advantage of the multi-tasking and multi-window capabilities of the SUN operating system. As an example, an NC part programmer could see tool path geometry while at the same time view the text version of the tool path.

By June 1986, there were 15 customer sites running beta test versions of the Sun software and by the end of the year, the company was able to claim that the porting was virtually complete. The major exception was some of the more advanced NC software which would take until sometime in 1987 to complete. The new UNIX version of CADDS 4X was file compatible with the CDS-4000 version of the software, at least from its ability to read and write data files without translation. Users of older CADDS 3 and CADDS 4 systems were faced with the need to install at least one CADDS 4X system and translate data to that format before they could move on to the UNIX version.

On April 30, 1986 the company re-branded the CDS-3000 Sun workstations under the CADDStation label. These units consisted of Sun produced CPUs and Computervision graphics controllers along with the latter company's console packaging. This approach was intended to meet two objectives. First, Sun Microsystems still did not have particularly strong graphics technology. Second, by producing as much of each workstation as it could, Computervision kept a significant portion of its manufacturing infrastructure in operation, avoiding shutting down additional plants and taking substantial writeoffs. Probably the most significant aspect of the Sun relationship was that Computervision would be able to improve the performance of its workstations in step with the rest of the computer industry as Sun periodically introduced new higher-performance workstations and servers.

The CADDStations initially came in several different flavors utilizing Motorola 68010 and 68020 microprocessors with performance in the 2 to 4 MIPS range. Computervision sold these systems with both monochromatic and color displays and as diskless units as well as fully configured with disk drives and cartridge tape units. The nomenclature was 31X or 32X where the 31 referred to a 68010 microprocessor and the 32 referred to a 68020 microprocessor while the X was replaced by an M for a monochromatic display, a C for a color display and an S for a server. CADDStation hardware prices ranged from $14,000 for a very basic diskless unit to nearly $100,000 for a fully configured high-performance color workstation. Typical CADDS 4X systems probably averaged about $70,000 per seat at the time including software. In 1986 there was still debate within the computer industry regarding the relative effectiveness of the

Ethernet networking being used by Sun compared to token-ring networking promoted by Apollo and IBM. By early 1987, CADDStations represented approximately 50% of Computervision's revenues.

One of the primary design objectives for the CADDStation was to make the unit's graphics capabilities software compatible with Sun Microsystems' own workstations. This way, customers would be able to run standard Sun applications on the Computervision hardware. In general, it seems that the company met this design objective although some packages probably required that SUN software such as SunCore and SunGCI be added to the configuration.

During 1986 Computervision's Cambridge Inactive Systems subsidiary continued to enhance Medusa, particularly in regards to platform support. The company now supported Digital's VAXstation II/GPX workstation, MicroVAX computers and Sun workstations. The company said that its cooperative marketing program with Digital was going well but its 1986 annual report ignored Prime Computer's sales of Medusa.[12] CIS also launched a relational database management system integrated with Medusa graphics. Called Assembly Modeler, by early 1987 it was in use for plant design applications at 30 European customer sites. Also, Computervision reported that it had sold a joint ownership interest in Medusa Revision 4.06 for approximately $5.3 million but did not identify who the buyer was.[13]

The company's Personal Systems business took off in 1986 with revenues up 75% over 1985. Computervision introduced a low-cost two-dimensional drafting package, microDraft, during the year. It also launched Revision 2.1 of Personal Designer with on-screen menus. In addition, the company continued selling Personal Machinist and Personal Architect. In late 1986 the company announced a bi-directional translator between Personal Designer and the CADDStation-based CADDS 4X software. *Computer Aided Design Report*, which was not known for its superlatives, declared this package had "become of the best mechanical CAD/CAM program running on a personal computer."[14]

In April 1987, Computervision set a Federal Systems Division under Robert Blauth. At the time, the multi-billion U.S. Navy CAD 2 procurement activity was getting into high gear.

There was no question but the CADDS 4X software was where the bulk of the company's interest was and where most of the development resources were being directed. CADDS 4X encompassed a broad array of software including:

- Finite Element Modeling
- Mechanical Simulation
- Physical Properties and Engineering Calculator
- Basic Surface Design
- Advanced Surface Design
- Imagedesign (color shaded image generation)
- Solidesign II
- Drafting and Dimensioning

[12] Computervision 1986 Annual Report
[13] Ibid
[14] *Computer Aided Design Report*, December 1986, p. 9

- CVNC (numerical control tool path generation)
- Electrical Schematic Design
- Autoboard SMT (PCB layout from its Grado acquisition)
- Building and Civil Sciences (a wide variety of AEC applications)
- Plant Design
- Mapping

Although Computervision's primary focus was mechanical design, the company was the second largest vendor of AEC applications by 1987 trailing only Intergraph in market share. As of mid-1987 the company was still selling CAD 4000 systems built around its own proprietary computer system. The APU term had long fallen into disfavor and it was now simply referred to as a 32-bit virtual memory central processor.[15]

Prime takes over Computervision

On Sunday, December 27, 1987, Prime Computer's president and CEO Joe Henson, sent a letter to Computervision's president Robert Gable stating that the following day Prime would initiate an unsolicited $13.50 per share tender offer for all of Computervision's outstanding stock. The offer represented just 70% of Computervision's revenues the prior year. This move probably did not come as a total surprise to Computervision's management in that Henson said that he had been urging such a merger since 1985.[16] Computervision had taken some steps to prevent a takeover without the company's concurrence. During 1987 Computervision's stock had traded in a range of from about $7 to $23, the latter value being before the major stock market crash in October. Just before the Prime offer, Computervision's stock was slightly over $9 so Prime's offer was attractive to the company's stockholders. Prime stated that it would pay for the acquisition out of its $500 million in available cash, most of which was the result of a convertible debenture offering the prior February.

Although the CAD industry was going through some consolidation at this point in time, this would be the largest acquisition by far up until then and the first one in which a public company was taken over in a hostile acquisition. Prime was about twice the size of Computervision, but just slightly more profitable. Henson had joined Prime in 1981 when it was a $365 million company and had grown it to be an almost $960 million vendor of high end minicomputers. About $175 million of Prime's revenue was CAD/CAM related except that little of that reflected Prime developed software.

Most of Prime's CAD revenue came from the sale of 50 Series computers supporting software such as Medusa, PDMS (Plant Design Management System developed by CADCenter in Cambridge England) and Ford Motor Company's in-house developed PDGS package. The company had entered the personal computer CAD market in October 1987 with the acquisition of Versacad (See Chapter 20). Prime had been slow in moving to the rapidly emerging client/server architecture and did not have any engineering workstations in its product line except for machines from Sun Microsystems and Silicon Graphics that it had recently begun reselling.

The bottom line was that Prime was in good financial shape but the future did not look particularly bright – hence the acquisition of Computervision would position the

[15] Computervision Consultant Reference Guide, 1987
[16] *Wall Street Journal, Decenber 28, 1987*

company in the rapidly growing systems business. Apparently, Prime's top management and the company's financial advisors did not realize the dynamic changes the turnkey CAD/CAM systems business was on the verge of going through.

Henson's position was: "The [CAD/CAM] industry is undergoing consolidation in the number of players. That being the case, we made the judgment that we had to get larger, and it became attractive to examine external means of growth…. In our view, Computervision, even more than Prime, can't remain independent."[17]

As often happens in this type of situation, Computervision rejected Prime's offer as being inadequate although its stock had been selling for just $9 just prior to Prime's offer. One of Computervision's first defensive steps was to threaten to make a major acquisition of its own as a way of raising Prime's cost for the takeover to an unacceptable level. Prime raised its offer to $15 per share with a "final offer," both parties fired off lawsuits and press releases.

One major defensive tactic Computervision threatened to put in play was a technique called a "poison pill." In effect, this provision in the company's bylaws would have dramatically increased the number of shares outstanding once a bidder acquired a 20% interest in the company. Computervision had put this provision in place on February 11, 1987 making it appear that the company was expecting a hostile takeover threat, although perhaps not from Prime.[18] Prime also objected in court to what it called an excessive level of severance compensation for top executives forced out by the acquisition. In its lawsuit, Prime attempted to get both of these issues overturned. At this point, Computervision claimed that it was in discussions with other, more friendly, companies who might acquire the company. No one ever came forward to claim that they were seriously considering making an offer for Computervision.

Finally the two sides sat down and worked out a deal that ended up with Prime acquiring Computervision for $15 per share or a total of $435 million. All this took less than six weeks – but it was a hectic six weeks. On January 28, 1988 the two companies signed a "Plan of Merger" agreement that made Computervision a division of Prime Computer. Nearly everyone the media interviewed seem to think that this was a good deal for both parties. Robert Herwick of Hambrecht & Quist said "This is a good fit. I think the deal is a steal. Henson should be congratulated." Even Phil Villers, one of the co-founders of Computervision and at this point president of Cognition chimed in with: "I'm realistic enough now to know that to be a world leader, you have to be much bigger than Computervision is now."[19]

In retrospect, while Prime management had a good idea of what that company's problems might be going forward, it does not appear that they appreciated the extent to which Computervision's CAD/CAM business would be changing in the near future or for that matter, how Prime's computer business would change. These were issues all the traditional turnkey vendors had to face: the need to unbundled software, the lost revenue when customers began purchasing standard workstations from the computer vendors, the need to support multiple platforms and the impact the personal computer would have on this industry.

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[17] *Computerworld*, January 11, 1988
[18] Computervision 1986 Annual Report
[19] *Computerworld*, February 2, 1988

Computervision as a Prime Division

There were relatively few immediate changes when the acquisition was finalized. Martin Allen was out as Computervision's chairman since that company ceased to exist as a separate entity but the company's CEO, Robert Gable, stayed on. Initially, Prime said that layoffs would be avoided and redundant personnel would be absorbed in other positions. It was made clear from the start that the company would split the combined company into two roughly equal in size divisions, one focused on CAD/CAM products and the other focused on Prime's traditional minicomputer markets. In early March, it did so and appointed Robert Fischer, who was running Prime's CAD division, to head the Computervision Division of Prime as well continue running Prime's efforts in this area. To no one's surprise, Gable resigned to "pursue personal interests."

While CADDS was clearly Computervision's flagship product, Medusa was more important than many outsiders realized. In Europe it represented nearly half of Computervision's business.[20] Since Computervision had acquired CIS, the two versions of Medusa had diverged significantly. The Computervision version ran on Digital VAX computers and Sun workstations while the Prime version ran only on Prime 50 Series computers. There probably was a market need for both Medusa and CADDS much as a number of years later Dassault Systemes would sell both CATIA and SolidWorks and UGS would sell both Unigraphics and Solid Edge.

Medusa was considered by many to be easier to use than CADDS and it worked with standard off-the-shelf hardware such as Digital VAX computers and Tektronix display terminals. While CADSS 4X had quite comprehensive surface geometry capabilities, Medusa was more targeted at the design of industrial machinery.

In a *Computerworld* interview Fischer stated that the plan was to develop a single version of Medusa and offer it on multiple platforms. It took until November 1990, but Medusa Release 12 provided the converged capability and added support for SUN and Digital workstations as well as Prime and Digital minicomputers. Fischer also alluded to plans for making another significant acquisition (see section on Calma acquisition below) and plans to introduce an Oracle-based data management solution called the Project Control System.[21] There was one major problem with this latter part of the game plan, the software ran on Prime 50 Series computers which were not particularly compatible with Computervision's existing product lines. Given time, bringing the two companies together probably would have resulted in some substantial cost savings through the elimination of redundant overhead expenses, duplicative office facilities and a larger combined sales and service presence in key markets.

On the other hand, bringing the two R&D teams together proved to be a particularly difficult task. As Versprille describes it, even in the company cafeteria the Prime people would sit on one side of the room while the Computervision people sat on the other side. While Prime did not have any software developed in-house comparable to CADDS 4X, under Vladimir Geisberg it had developed its own solids modeling package, PrimeDesign, introduced in April 1988. Computervision likewise had developed a solids-based package separate from the basic CADDS software called Solidesign II. There was a feeling among some of the former Computervision employees that Prime had copied some of the Solidesign II code in developing PrimeDesign.

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[20] *Computer Aided Design Report*, April 1988 p. 1
[21] *Computerworld*, March 7, 1988

Organizationally, Prime put Geisberg in charge of software development for the Computervision division. This did not sit too well with people such as Versprille who left before the end of 1988.

Strategically, there was a major dichotomy in Prime's direction. The company wanted to continue to be a manufacturer of computer hardware equipment even through it lacked the mass necessary to compete with the likes of IBM and Digital. Fischer was quoted at a Daratech workshop as saying, "One cannot become a large and profitable software only-company. If you look at some of the examples in the industry, you'll find that few have. Secondly, it is difficult to become large and profitable over a very long period of time as a remarketer of somebody else's hardware."[22] Yet that was the path down which Computervision was proceeding when Prime decided to take it over.

By early October 1988 it was clear that digesting the Computervision acquisition was going slower than initially expected and that revenue and earnings were suffering as a result. This led to a major management change. Joe Henson announced that he would be stepping down within a few months and that Anthony Craig, an IBM veteran who had most recently been running GE Information Services, had been hired to replace him.

Henson claimed that he had told the board the previous year of his plans to step down but it seems more likely that David Dunn, Prime's chairman, and the company's board of directors were gently forcing him out due to the difficulties the Computervision acquisition was causing and the lower than expected business results. A little over a year later Henson re-emerged as chairman and CEO of Legent Corporation, a systems software firm.

It is also interesting to note that in early October 1988 Prime initiated two anti-takeover moves of its own. It implemented a provision granting each stockholder one additional share of stock for each share owned if the company was acquired in a manner the board of directors did not approve. It also approved a "golden parachute" plan for executives in case of a hostile takeover. It seems clear from these moves that Prime management was expecting a hostile takeover attempt such as the one MAI Basic Four would launch the following month.

Adding Calma to the mix

As if integrating the Prime and Computervision business units was not enough of a challenge, in October 1988 Prime decided to acquire the mechanical CAD portion of Calma from General Electric (See Chapter 11). GE had made it clear nearly a year earlier that it was looking for a way to gracefully exit the CAD industry and had already sold Calma's integrated circuit business to Valid Logic. Once it became clear that GE was trying to unload Calma, the company's revenues plunged precipitously. IDC estimated that Calma did $133 million in CAD/CAM/CAE[23] of which perhaps $90 million was in mechanical CAD. This latter figure had dropped to an estimated $50 million by the time Prime stepped into the picture according to Daratech.[24]

While Prime had spent $435 million to acquire Computervision or a little less than one times revenue, it was able to pick up Calma's $50 million in revenue for a pittance, probably only a few million dollars. As part of the deal, Prime assumed the

[22] *Computer Aided Design Report*, April 1988, P. 1
[23] *Computerworld*, October 17, 1988
[24] *Computer Aided Design Report*, November 1988 p. 9

responsibility for supporting Calma's installed base of 800 customers and other liabilities and GE agreed to buy some unspecified number of CAD systems from Prime in the future.

To be blunt, this deal was done primarily to acquire Calma's customer base and was only slightly influenced by the opportunity to acquire additional technology. Calma's DDM (Design, Drafting and Manufacturing) software ran on Apollo workstations and Digital VAX computers. Prime's Computervision Division was deeply committed to Sun Microsystems, particularly for its CADDS software and was not particularly interested in also supporting Apollo workstations at the same time. It did have some experience with Digital hardware which was used to support Medusa.

Fischer stated that Prime would operate Calma as an independent business unit for at least a year after the acquisition was completed. This deal was subject to government approval and was not expected to actually close until late 1988. At that point Prime intended to "enhance the Calma product for at least a couple of years" and "support the product for at least five years after the merger." Fairly soon after the acquisition was completed, Prime began encouraging DDM users to migrate to its CADDS and Medusa product lines. As part of the deal, Prime also acquired Calma's Dimension III plant design software. This they continued to support and market well into the 1990s.

An important aspect of the deal with GE was that Prime was to be given preferred vendor status at GE. With the acquisition of Calma, Prime became the second largest CAD/CAM vendor after IBM. This ranking was based upon the sale of hardware as well as software and services into this market sector.

Battle with Bennett LeBow for Control of Prime

By early November Prime was making progress, although perhaps somewhat slower than originally contemplated, in digesting its Computervision acquisition and was gearing up to take over what was left of Calma when a new battle for control of the company erupted. MAI Basic Four, a California company a third the size of its intended target, initiated an unsolicited offer to acquire Prime Computer for $20 a share or $970 million. Prime's stock was selling for about $15 per share prior to the offer being announced. The actual offer was really more than this amount since Prime itself had about $500 million in debt that would have to be assumed by MAI Basic Four.

This was the era of junk bonds and corporate raiders who were taking over companies with high interest rate bonds and other financial vehicles and then dismantling these companies for quick profits. One such wheeler and dealer was Bennett LeBow who had taken over a company known as MAI Basic Four and was its board chairman. MAI Basic Four was a conglomeration of several companies, most notably MAI (Management Assistance, Inc.), a distributor of IBM-compatible peripheral equipment, and Basic Four, a manufacturer of small business computers. LeBow was also involved in takeovers of Western Union and the Liggett Group, a cigarette manufacturer. For the most part, LeBow would buy companies in financial trouble using third party financing and very little of his own money. He would then slash overhead, turn them profitable and then sell them off, entirely or in pieces. Although his business methods did not generate a lot of friends, he was successful at what he did.

LeBow and his partner, William Weksel, were not strangers to the CAD industry. In the early 1980s they had acquired a controlling interest in Information Display

Incorporated, a graphics equipment manufacturer that was moving into the CAD systems business. This did not turn out well and IDI filed for bankruptcy in 1984. Subsequently, Weksel ran into legal trouble regarding insider trading and the overstatement of financial results regarding IDI.

Prior to initiating this hostile takeover, Bennett and Weksel had indicated that they were interested in selling their 43% stake in MAI Basic Four through the firm of Drexel Burnham Lambert. This latter company was one of the powerful forces behind the junk bond craze and Michael Milliken, who subsequently went to jail for securities fraud, was the driving force behind this portion of the company's business. Drexel Burnham Lambert indicated that it was prepared, together with its investment partners, to provide $650 million in short term bridge financing and as much as $875 million in junk bond financing to facilitate the takeover of Prime. Complicating this unsolicited offer was the fact that MAI Basic Four had actually approached Prime earlier in 1988 and inquired if Prime would consider acquiring it. Prime responded that it was not interested.

When the offer was initiated, it was not clear if MAI Basic Four was serious about taking over Prime or simply was looking for a way to force Prime to acquire it or to pay it a fee to simply go away. The latter technique is typically referred to as "greenmail." Prime took the acquisition threat quite seriously, however. One of its first steps was to promote Anthony Craig to president and CEO immediately rather than continue the transition process whereby he was to take over from Joe Henson several months later. This was followed by both sides firing off lawsuits in court. MAI Basic Four tried to get Prime's anti-takeover provisions rescinded while Prime tried to find out more about how MAI Basic Four was actually going to fund the acquisition.[25] A federal judge in Massachusetts enjoined the tender offer until MAI Basic Four could provide an audited financial statement from Drexel proving that it had the ability to finance the deal.

The resulting company, if the deal was done on LeBow's terms, would have resulted in a company with $1.5 billion in debt and total revenues of $2.1 billion. LeBow claimed that this new enterprise would earn $200 million annually which would more than cover interest on the debt that was estimated to run upwards of $140 million annually.[26] Given that both MAI Basic Four's and Prime's minicomputer businesses were under tremendous competitive pressure from client/server systems and PCs, it was highly unlikely the company would have been as profitable as expected. According to one individual who was at MAI Basic Four at the time, the initial thought of the company acquiring the much larger Prime Computer had people excited, but as it dragged out it started to have a negative impact on morale and became quite distracting.

In late December 1988 MAI Basic Four claimed that owners of more than 50% of Prime's stock had tendered their shares although this claim was viewed with some cynicism. Prime was incorporated in Delaware and that state's securities laws required that shareholders tender 85% of the outstanding stock in the case of a hostile takeover. While the Prime takeover of Computervision had been reasonably civil, LeBow's raid on Prime turned virulent. When LeBow suggested to David Dunn, Prime's chairman and Craig in a letter that a negotiated transaction would be in everyone's best interest, the response was biting. Dunn's response cited wrongdoing by LeBow, Weksel, and to

[25] *Computerworld*, November 28, 1988
[26] *Computer Aided Design Report*, December 1988, p. 6

Drexel's recent agreement "to plead guilty to multiple felonies, several of which involved the use of insider information."[27]

By the end of January the amount of stock tendered had risen to over 70%. Although this hostile takeover initially took Prime's employees by surprise, they soon rallied behind Craig with buttons claiming "No LeBow" and an employee group called "Employees Against the Takeover" was formed. Prime even orchestrated a rally at which 2,000 employees heard Massachusetts governor Michael Dukakis assail MAI's plans.

By early February 1989, Prime's stock was slightly over $20 per share and there was talk of a white knight coming to the company's rescue. One firm mentioned in this context was Ford Motor Company which had recently seen its arch rival General Motors acquire Ross Perot's Electronic Data Systems. MAI Basic Four extended its offer to mid-February and announced that it had an additional financial backer, Merrill Lynch & Company. Opinions by security analysts varied all over the landscape. Stephen Dube of Shearson Lehman Hutton, Inc. said "I think we are going to see an end to this battle very soon," while an unidentified analyst stated in regards to Ford "Yes, they're Prime's biggest customer, but I don't think they want to buy the company. I think the MAI acquisition is going to happen."[28]

One of the interesting sidelights to the battle for control of Prime in 1989 was the purchase by David Dunn, Prime's chairman, of a large $4 million mansion in San Diego. According to the *Computer Aided Design Report* this house had been built by Earl Gagosian, the founder of the Royal Inns hotel chain. Gargosian and everyone who subsequently owned the mansion suffered financial reverse after buying the mansion.[29]

In mid-April, the heat was building on Prime and the MAI deal looked as if it might be gaining momentum. Prime, acknowledged as much when it announced that it had directed its investment bankers to look for alternative buyers. The Massachusetts court that had issued an injunction against MAI proceeding with its tender offer until it got financial data on privately-held Drexel, announced that the injunction would be lifted ten business days after MAI sent audited 1988 financial statements for Drexel to Prime shareholders. This would allow MAI to proceed in Delaware court to void Prime's poison pill provision that allowed shareholders to buy additional stock at a discount during a hostile takeover. MAI said the Drexel financial statements would be in the mail as early as May 1, 1989. At this point it looked like the battle would culminate in a proxy fight at Prime's June 14, 1989 annual meeting.[30]

In mid-May Dunn challenged LeBow to either make good on his original $20 per share offer worth $970 million by June 2nd or call it off. Prime even offered to waive its poison pill provisions. MAI's immediate response was only that it was evaluating all aspects of its offer. Then on June 1st, MAI reduced the price it was willing to pay for Prime to $19.50 per share for shares outstanding as of April 12, 1989. This was about 75% of the total stock in the company. Employees' stock options would be converted to a combination of junk bonds and preferred stock with a value of $21 per share although the true value of this portion of the offer was probably worth a lot less. This revised offer

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[27] *Computerworld*, January 9, 1989
[28] *Computerworld*, February 6, 1989
[29] *Computer Aided Design Report*, May 1989 p.15
[30] *Computerworld*, April 24, 1989

reduced the amount of cash MAI Basic Four would have had to come up with by $375 million.[31]

In early June, the two parties finally sat down face-to-face but about all they agreed to was to disagree. Wall Street analysts refused to speculate on the probable outcome of a business deal that was taking on the characteristics of a soap opera. Prime upset MAI and LeBow by postponing its annual meeting from June 14th to July 26th. MAI claimed that this could derail its proposed takeover of Prime in that MAI's financial commitments for the deal expired on July 31st.

While LeBow was continuing to fine tune and extend his offer, Prime's management was continuing its search for a white knight to rescue it from his clutches. They eventually found the company's "savior" in J. H. Whitney & Company, an investment banking firm which on June 23, 1989 agreed to offer $21.50 per outstanding share of Prime and to issue $22 in junk bonds for each of the remaining shares (i.e. employee options). Financing for the deal was to come from Shearson Lehman Hutton Holdings, Chemical Bank and First National Bank of Boston.

The deal was dependent upon Prime's shareholders tendering their stock, but this time with the approval of the company's board of directors. The actual acquiring company was a new entity, DR Holdings, formed by Whitney for the express purpose of executing this transaction. (DR stood for the initials of two Whitney partners.) Whitney claimed that it was interested in Prime as a going concern. According to Don Ackerman, a Whitney partner, "We are *not*, I repeat, *not* interested in breaking up Prime and selling off its parts." This is not what industry observers would have expected if MAI had been successful.[32]

As a last gasp, MAI Basic Four in mid-July offered to buy just the Prime minicomputer business for $450 million in cash and $150 million in bonds which probably were worth a lot less than their face value. This would have returned the company to roughly its original state prior to Prime's acquisition of CV. In retrospect, the company's management probably would have been better off accepting this last minute offer and moving forward with just the former Computervision portion of the business and other elements of its CAD software product mix.

On July 26th Prime delayed its annual meeting once again until August 9th. For a time, it looked as if the Whitney offer might unravel as Prime reported mediocre financial result for the previous quarter with a loss of $19 million and revenue down 7%. (A few weeks later MAI Basic Four would report that it had lost $46.2 million in the same quarter and its sales had dropped 30% to $51.8 million.) Considering the confusion over the MAI takeover and the search for a friendly acquirer, this probably should have been expected.

Chemical Bank and First National Bank of Boston put pressure on Whitney to raise additional equity to fund Prime's ongoing needs. In late August, the Whitney buyout was finally completed as 91% of Prime's shares were tendered. The entire LeBow episode took nine months to run its course and when it was over it was hard to identify any winners other than the lawyers and investment bankers. One significant effect was that Prime's top management was almost totally focused on fending off LeBow at a time

[31] *Computer Aided Design Report*, July 1989 p.15
[32] *Computerworld*, June 6, 1989

when they also had their hands full trying to fit together the Prime, Computervision, Calma and VersaCAD pieces of this complex vendor of software and hardware.

Recovering from the MAI Basic Four assault

As part of the Whitney takeover Anthony Craig was replaced as Prime's president by James McDonald, the former chairman of Gould Inc., a one-time battery manufacturer that had tried unsuccessfully to expand into a number of high tech businesses. He had previously spent 21 years with IBM. McDonald's primary task was to try to make some senses out of a convoluted software product line that ran on a hodgepodge of computer systems including Sun workstations, IBM PCs, Digital VAX computers as well as Prime 50 Series machines.[33] As part of the acquisition by Whitney, Russell Planitzer, who had been a Whitney general partner since 1981, replaced Dunn as chairman. The new management made repeated statements that all the company's product lines would be maintained but it was obvious that changes would not be long in coming.

Even the principals involved perceived this to be a fairly risky deal. In order to protect itself from the possibility of the reconstituted Prime eventually filing for bankruptcy, Whitney had set up a new entity, DR Holdings, to actually hold the stock in Prime. In addition, Shearson Lehman Brothers, at the time a division of American Express, loaned the company $500 million to help finance the buyout of Prime's stockholders. This was supposed to be a short term bridge loan which turned out to be a much longer term investment. When Prime eventually had problems paying even the interest on these notes in 1991, the interest payments were added to the loan balance.

Shortly after the deal culminated, Prime re-established the Computervision brand for the CADDS portion of its business. Interestingly, this was done after a group of users presented the company with a 400-signiture petition to do so at Computervision's September 1989 user group meeting. On the downside, Prime announced at about the same time that it would lay off 2,500 employees or about 20% of its worldwide staff. Planitzer claimed in a *Wall Street Journal* article that the layoffs would enable Prime to repay its bank debt in four to five years.[34] The company was reorganized into four business units: computer-aided design and manufacturing (Computervision), minicomputers, customer support and international operations.

By the second quarter of 1990, it looked as if Prime might be making a comeback. Although it was now a private company, Prime provided customers and employees with a limited amount of financial data. During the quarter, the company had operating profits of $50.1 million on revenues of $403.5 million. Unfortunately, interest expenses ate up all but $8.6 million of those profits. Prime claimed that CADDS sales during the quarter were 19% higher than for the comparable quarter a year earlier when the company was in the midst of its struggles with MAI Basic Four.[35]

Computervision acquires Premise

In April 1991, the Computervision division of Prime Computer acquired the assets of Premise, Inc. a small Cambridge, Massachusetts software firm whose primary product was a conceptual design package called DesignView. This software targeted

[33] *Computer Aided Design Report*, September 1989 p.13
[34] *Computer Aided Design Report*, November 1989 p.16
[35] *Computer Aided Design Report*, September 1990 p.15

conceptual designers with a package that supported both dimension driven and equation driven design. Design View ran on both PC and workstation platforms. It was a two-dimensional sketching and modeling tool for engineers with a comprehensive constraint management capability.

The software worked with Microsoft's Excel and Word packages. Originally, Design View sold for $1,895[36] but by the time Computervision entered the scene the price for the PC version was down to $895 while the SUN and Digital versions went for $1,295. The company announced that it planned to keep Premise's original development team including president and founder Jon Hirschtick who eventually left Computervision and founded SolidWorks.

The CADDS 5 era begins

As of mid-1991, Computervision had perhaps 40,000 seats of CADDS software installed worldwide. Of these, about a third were second generation proprietary hardware systems that were fundamentally obsolete while the balance utilized some version of a Sun-based workstation.[37] A new generation product was badly needed as well as some new business practices that would make the company more competitive.

In 1985 Computervision began a significant development effort to create a new parametric, feature-based assembly modeler. The work was temporarily put on the shelf while the company's programmers were involved in porting the existing CADDS software to UNIX. Eventually it was merged with work being done at Prime and dubbed CADDS 5. In the interim, work continued on CADDS 4X.

In October 1990, Computervision introduced CADDS 4X Revision 6.0 which included a new Assembly Design module as well software for thermal analysis. Assembly Design enabled multiple users to work on the same product design, although not necessarily on the same part. If one user checked out a part for viewing and editing, other users could only view the part. The price for this client/server package was $8,500. The company also added raster editing and viewing software to CADDS 4X based on a technology and marketing agreement with FORMTEK.

ThermaLab was a new interactive thermal analysis package that included the capability to both create a finite element model and analyze the resulting model. This package sold for $10,000. Revision 6.0 also included Solidesign II which was Computervision's first attempt at incorporating history-based design in its software. The history tree created by Solidesign II could be edited and the model re-run to implement desired changes. The release also included enhancements to other CADDS packages including NURBS Surface Design and the CVNC machining software. [38] In April 1991, the company changed the name of the core CADDS 4X package from Design and Drafting to Solid Designer to reflect the fact that CADDS 4X now included the Solidesign II software module. At the same time, Computervision reduced the price of this core module from $24,500 to a more reasonable $15,500.[39]

In April 1991, Computervision began beta testing CADDS 5 at 11 customer sites and initiated early introduction sales to 30 customers beginning in July of that year.

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[36] *Computer Aided Design Report*, December 1988, Pg. 11
[37] *Computer Aided Design Report*, August 1991, p. 10
[38] *Anderson Report*, October 1990, p. 2
[39] *Anderson Report*, April 1991, p. 10

CADDS 5 grew out of a combination of the existing CADDS 4X software and Prime's PrimeDesign solids package. In early releases of the software, it was necessary to translate geometric data between the wireframe and solids modules. While this translation was mostly hidden from the user, there were other issues. One problem was that the display screen had to be cleared and the image regenerated when the user went from wireframe mode to solids mode.

Commercial shipments of CADDS 5 Release 1 began in October 1991.[40] CADDS 5 included feature-based parametric modeling, variational geometry, constraint modeling, sketching and an intelligent user interface – all the capabilities mechanical users were looking for in contemporary design software. The software was broken into more modules than before called Inter-Operable Packages. These included DesignView ($3,000), View and Markup ($3,000), Design and Drafting ($3,500), Solid Modeling ($6,000) and Parametric Design ($12,500). A bundle of modules including wireframe, basic surface and solids design, CGM plotter output, and the ability to use other applications once they were available was sold as the Premium Engineering Package for $24,500. This did not include drafting which pushed the price somewhat higher.

A typical Sun SPARCstation 2 had a list price of around $33,000 so a complete CADDS 5 seat would have set a customer back nearly $60,000. While this was expensive by 1991 standards, large customers were typically able to negotiate significant quantity discounts. CADDS 4X users could upgrade to the Premium Package for $9,800 except that the upgrade fee would be waived if the customer was using SPARC-based workstations and ordered the upgrade prior to December 31, 1991.[41]

CADDS 5 was not simply an enhanced version of CADDS 4X. It was new software written in C and C++. Probably the most significant improvement was the incorporation of dimension-driven solids modeling that put it in the same general class of design programs as PTC's Pro/ENGINEER. The company was four years late in doing so, however. The other major enhancement was a new user interface which employed the push-buttons and scroll-bar techniques described in the MOTIF specification published by the Open Software Foundation. When a menu icon was selected, information appeared on the screen that helped walk the user through that particular operation. This was very beneficial to new users just learning the software but experienced users probably felt that it slowed them down.

Computervision's introduction of CADDS 5 had several flaws beyond the normal bugs that one expects with new software that slowed down its acceptance. There were probably more than a few customers who felt that they deserved to receive the new software as part of their maintenance agreement and should not be required to purchase it as an upgrade. Eventually, Computervision made the transition fairly painless from a financial point of view. Technically, there were two serious problems facing users wishing to switch to the new software. Probably most significant was the fact that many of the applications customers had been using with CADDS 4X were not yet available to work with CADDS 5 and would not be for some time. The second problem was that even though the user interface was significantly improved, it was quite different from what users were familiar with. This resulted in the need for fairly significant retraining.

[40] Computervision Form S-1, June 5, 1991, p. 45
[41] *Anderson Report* July 1991, p. 2

Eventually, Computervision facilitated the transition by providing a CADDS 4-like interface as a user selectable option.

Work on CADDS 5 Release 2 began well before Release 1 hit the streets. In reality, it probably consisted of capabilities the company would have liked to have included in Release 1 but had to defer due to the pressure to begin shipping a new software package. Release 2 which included analysis, assembly design and manufacturing applications started beta testing in March 1992 and early sales to key customers in April.

One of the important aspects of Release 2 was the ability to import CADDS 4X designed parts and use that data in building CADDS 5 assembly models. This greatly reduced the operational difficulties of moving from CADDS 4X to CADDS 5 in situations where there already existed a large amount of design data in the older format and/or a desire on the part of the customer to continue using existing CADDS 4X systems. The expectation as of early 1992 was that many customers would continue to use CADDS 4X and CADDS 5 in parallel for some extended period of time.

New CADDS 5 modules and applications were launched on a regular basis. In mid-1992, a new NURBS-based free form shape design package was introduced for $15,000 along with a new integrated engineering analysis module with auto-meshing capabilities for finite element analysis users. The latter package could be used with or without the CADDS 5 Parametric Design module with prices starting at $14,000. For major automotive and aerospace users, these prices were acceptable as long as the software did what it was intended. For general product manufacturers, these were fairly steep prices and one of the reasons Autodesk and PTC started taking more and more business away from the Computervision. The company's product rollout schedule envisioned having all CADDS applications compatible with CADDS 5 by mid-1993

On November 4, 1991, as part of the CADDS 5 initiative, Computervision launched a software development initiative called CV-DORS (Developers Open Resource Software). Verspille was hired back by Zarabian to run CV-DORS. This was a set of object-oriented software libraries which provided access to Computervision's core technology including wireframe, surface and solids geometry. There were three targeted uses for this technology: 1) Computervision's programmers would benefit from having better development tools, 2) third party software firms could use it to develop applications that interfaced to the CADDS 5 database and 3) other firms could develop stand-alone applications that used CADDS 5 as a graphics engine. It could be used to create programs compatible with CADDS 5 or to create stand-alone applications that simply incorporated the company's graphics technology. The routines could be called by C, C++ and FORTRAN programs.

Computervision established a CV-DORS business unit with the express purpose of finding software companies to use this product. The cost was $50,000 for a developer's license while run time licenses started at $2,500. A typical customer was Imageware, a vendor of advanced surface design software. It licensed CV-DORS ISSM (Integrated Surface and Solids Modeler) in order to develop a direct interface to its Surfacer 3.0 product. Some of the other early adopters of CV-DORS were PDA Engineering (finite element modeling), Wisdom Systems (knowledge-based engineering design), Silma (robotic programming) and Point Control (NC software). End users included Aerospatiale, Alcoa and Rolls-Royce.

In July 1992 Computervision announced a significant new application called Concurrent Assembly Mock-UP or what was typically simply called CAMU. Users could assemble models of complex products containing thousands of parts, work on many parts simultaneously and quickly view how changes affected the rest of the assembly. This was one of the first of a new generation of product navigation tools to be introduced to the CAD/CAM industry. CAMU sold for $9,500 per license.

Additional product and business developments

Subsequent to the leveraged buyout by J.H. Whitney & Co., Prime went through a number of management changes. The key individuals as of early 1992 were:

- Russ Planitzer resigned from Whitney in November 1991 to devote full time to the company as chairman of the board.
- Jack Shields joined the company in January 1990 as president and chief operating officer and became CEO in January 1991, replacing James McDonald. Prior to joining Prime, Shields had been with Digital for 28 years.
- Kathy Cote who had been with the company since 1986 was president of PrimeService.
- Mike Forster was president and general manager for Europe/Middle East/Africa. He joined the company in 1988 after 23 years with IBM.
- Delbert Lippert was executive vice president, general international area and operations. He joined the company in July 1990.
- Don McInnis was vice president and general manager, CADDS Business Unit. McInnis joined Prime in May 1990 after 13 years with Digital where he was vice president of that company's Engineering Systems Group. McInnis took over this position after Robert Fischer, who had been running the Computervision Business Unit, left in November 1990. Fischer joined SDRC as a senior vice president a few months later. (See Chapter 17)

While Prime's Computervision business unit was struggling to get CADDS 5 off the ground, the company's finances were deteriorating at an accelerating rate. In the second quarter of 1991, Prime reported a $349.7 million loss after taking a special charge of $329.5 due to accelerating the amortization of goodwill that had resulted mostly from its acquisition of Computervision. While this did not have an impact on the company's cash position, it did result in a weaker balance sheet.

The larger problem was that total revenues, especially from the company's 50 Series computers, had declined 13% to $352.8 for the quarter compared to the same period in1990. Even the Computervision business unit's revenue dropped by 9% due to unfavorable foreign exchange rates and purchase delays due to customers waiting for CADDS 5 Release 2 prior to making purchase decisions. *Computer Aided Design Report* summed up the situation fairly well in September 1991 when it stated that "Everything seems to depend upon CADDS 5 becoming a smash hit."[42] For all of 1991, the company had revenues of just over $1.2 billion, down about 6% from the prior year's $1.3 billion. These figures exclude the sales of Prime 50 Series computers.

[42] *Computer Aided Design Report*, September 1991 p.16

In the early 1990s Prime was facing several major trends that were changing the face of the CAD/CAM industry. Perhaps the most important was the move away from proprietary turnkey system to unbundled software running on industry standard platforms. Prime recognized this trend and took two difficult steps in response. One was to begin the switch from manufacturing its own workstations using a SUN CPU core to running on standard Sun workstations while the other was to unbundled its software.

A major second trend was the move away from expensive UNIX workstations to DOS-based personal computers. Although Prime had the second largest selling PC CAD package after AutoCAD in VersaCAD, it was slow in porting its CADDS product line to the PC platform and eventually lost significant market share to Autodesk. In fact, in mid-1990 the company was moving in the other direction when it launched a SunOS version of Personal Designer.

The third trend was the introduction of feature-based parametric modeling. Although CADDS 5 was a step in the right direction, it was late to market and lagged PTC's Pro/ENGINEER functionality-wise. In one attempt to consolidate its operations, Computervision closed the VersaCAD facility in Huntington Beach, California and consolidated VersaCAD development work with the Personal Designer activity in Bedford.

By 1992, the company had ceased manufacturing its own workstations that previously had been used to support CADDS software. CADDS 5 ran on standard Sun workstations and work was underway to port the software to Digital workstation by the end of 1992 and to Hewlett-Packard workstations in 1993. Computervision was coming to grips with the concept that software needed to be designed and implemented on the assumption that it would run on multiple platforms when released rather than developing it on one platform and then subsequently porting the software to other platforms.

Other CAD companies were struggling with the same issue. It was a difficult challenge but one that needed to be surmounted if the company was to keep up with the rapid changes impacting the computer industry. Much of the decrease in CAD/CAM revenues was attributable to the fact that the company was no longer manufacturing its own high-margin workstations and was reselling standard Sun workstations whose prices were on a continuing downward unit price trend. As with other traditional turnkey vendors, the volume of software sales was not increasing rapidly enough to offset the decrease in hardware revenue.

The product line becomes more and more complex

Prime's CAD/CAM business unit consisted of five product lines. CADDS and related products made up 72% of the unit's 1991 revenues with about 49,600 seats installed, Medusa made up 15% of revenue with 13,000 seats installed, Dimension III (Calma's AEC product) amounted to 5% of revenue with 8,800 seats installed, PC CAD (Personal Designer and VersaCAD) products made up an additional 5% of revenue but with over 100,000 seats installed while the company's GIS products (System 9) brought up the rear at 3% of revenue and just 300 seats installed. From an organizational point of view, the Medusa and Calma portions of the product line were managed as part of the same product group.

At this point in time CADDS 5 ran on Sun Workstations, Medusa ran on Sun and Digital workstations and Prime 50 Series minicomputers, Theda electronic design

software (included with the CADDS data) ran on Sun workstations, Dimension III ran on Digital and Hewlett-Packard computers and workstations, the System 9 GIS software ran on Digital and Sun hardware, the company's new Product Data Management software ran on IBM, Digital and Sun hardware while the Prime-developed PDM package, PrimeControl, ran on Prime 50 Series machines. In addition Prime was also marketing Ford's internally developed PDGS automotive design software that ran on 50 Series computers and Lundy display terminals although Ford was responsible for maintaining the software component of these systems. Combined with the PCs used to support Personal Designer and VersaCAD, the company had an incredible spectrum of hardware platforms to support, none of which ran all the software products and none of the software products ran on all the different hardware platforms the company was supporting.

The service and support of third party hardware as well as Prime and Computervision computer systems had become a major business activity by 1992. Prime was servicing hardware manufactured by Sun, Intel, MIPS, Wellfleet, and Tatung as well as its own products with a staff of over 3,000 individuals working out of 250 field locations around the world. This part of the business, which generated about 25% of the company's revenues, was consistently profitable and helped fund the rest of the company's operations. As of early 1992, 44% of this service revenue came from maintaining Prime 50 Series computers.

Growth of Product Data Management

Starting in 1990, Prime began placing increased focus on Product Data Management software although the company often used the term EDM or Engineering Data Management. The initial EDM product consisted of four modules: EDMVault for data storage, security and access control; EDMProjects for project definition, revision control and release control; EDMProgramming for customized application development and EDMClient for user access to the EDM database. With a Prime provided Sun server, a complete system cost $160,000.[43]

EDMClient was subsequently renamed EDMNavigator. In October 1991, a more competitive version of the EDMVault software intended for use by five to 25 individuals was offered for $24,900. One catch to this lower cost pricing was that only one user could access the software at a time. By 1993, Computervision was doing $20 million annually in PDM software and services. The EDM products could handle AutoCAD, Pro/ENGINEER and CATIA data as well as CADDS and Medusa files.

Although Medusa and Dimension III between them represented approximately 20% of the company's revenues, they appeared to be receiving a disproportionate smaller amount of management attention and R&D resources. It was still a distraction and the company probably would have been better served if it had focused all of its development resources on CADDS 5. The problem was that the company needed every dollar of revenue it could generate and the fear was that capping Medusa, in particular, would have cost it valuable revenue.

The other development conflict was between Personal Designer and VersaCAD. Personal Designer was not simply a PC version of CADDS but had its own user interface and database. It was perhaps the most comprehensive mechanical design package

[43] *The Anderson Report*, July 1990, p. 12

available on the PC at the time, but it was much higher priced than the competition. VersaCAD was a simpler package and priced more competitively but it was not the "in-house" product and once the California development group was closed down it ceased to get the development and marketing attention it deserved.

By 1992, Prime was fully committed to selling both unbundled software and packaged systems of both hardware and software. The company's customer base read like a who's who of global manufacturing companies including Audi, Fiat, Ford, Rover Group, Aerospatiale, Boeing, Rolls Royce Aircraft Engines, General Dynamics, Raytheon, Ericsson, General Electric, John Deere and Ingersoll Rand. Prime had 385 direct sales people selling CAD/CAM products as well as a growing group of value added resellers and distributors. It was one of the first large-scale CAD/CAM vendors to develop a VAR channel for its mainstream products.

Computervision goes public once again

In June 1992, privately-held Prime made the announcement that it planned to initiate a new public offering of its stock and to rename the company Computervision. At this point Prime had four primary areas of business; its CAD software activity anchored by its CADDS product line, the sale of computer hardware in support of its CAD business, the maintenance of a wide range of hardware products including Prime 50 Series machines, legacy CADDS systems, the newer Sun-based systems it had been selling in recent years as well as support of other hardware products from a variety of manufacturers and, finally, the manufacture of 50 Series computers.

The plan was for the new Computervision to retain the first three of these business activities and to sell the Prime 50 Series manufacturing activity to a management group that would apparently retain the Prime name. When the dust settled, Computervision would consist of an $800 million CAD business and an unrelated $300 million hardware services business. Of the CAD portion, approximately 25% was CAD/CAM software while the balance was somewhat evenly split between the sale of Sun workstation and the maintenance of the company's installed base of CAD systems.

The terms of the this new public offering initially had the company selling 15.8 million shares of stock at $18 to $20 dollars per share. Both *Computer Aided Design Report*[44] and *Engineering Automation Report*[45] commented that they felt this price was too high and would probably have to come down in order for the offering to be consummated. Computervision also planned to issue $300 million in three and five-year notes to pay off $323.5 million of existing debt. A key element in the offering was an agreement by Shearson Lehman Brothers to convert its $290.5 million debt into15.3 million shares of the refinanced company. DR Holdings would retain 16.9 million shares of stock in the company.

The overall result was that Computervision would be about equally owned by DR Holdings, Shearson Leahman Brothers and the public while the company's debt would have been reduced from $843 million to $359 million. Although substantially lower than before, this would still be much higher than the debt of any other CAD company, most of which were debt free. DR Holdings, whose only asset was its Computervision stock, would be left with over $500 million of debt. Interest on this debt ranged from 13% to

[44] *Computer Aided Design Report*, July 1992, p.13
[45] *Engineering Automation Report*, July 1992, p. 3

15.5% and DR Holdings was committed to pay it off by 2002. Unless Computervision turned out to be particularly profitable and have its stock price increase significantly, it would be very difficult for DR Holdings to avoid eventual bankruptcy.

When Computervision's stock offering finally occurred on August 14, 1992, the terms were far different than what had been proposed a few months earlier. Twenty-five million shares of stock was sold to the public at $12 per share rather than the $18 to $20 originally intended. Even this proved high and almost immediately the price of the stock fell below $10 per share. The company also sold $300 million in notes due in five to seven years. In addition, the company was unable to negotiate acceptable terms for selling the Prime 50 Series manufacturing business to a group of managers and, instead, decided to simply shut down that operation. This meant that users of Medusa or Ford Motor Company's PDGS software who were running on Prime computers would have to look for another platform.

One result of the lower offering price was that Shearson Lehman Brothers had to take a $177 million pre tax loss to offset the lower value of its existing loan to the company. After the offering, Shearson owned about 13% of the company, DR Holdings about 33% and the public 54%. Interest expenses on the company's debt dropped from $122 million annually to about $53 million which the company's president, Jack Shields, said was a manageable number well below Computervision's cash flow. With the price of the stock below $10 per share, it appeared almost certain the DR Holdings would end up filing for bankruptcy and they did so a short time later.

Within weeks, the situation turned from bad to worse. On September 29, 1992 Computervision announced that revenue for the third quarter would be below the prior year's quarter and below its expectations. The stock immediately plunged over $3 per share and subsequently dropped as low as $4.75. On October 22, 1992, the company announced revenues for the quarter just ended of $234 million, down 16% from 1991 and an operating profit of just $700,000. The company actually reported a net loss of $88 million due to costs associated with laying off 700 or 11% of its employees and the previously described recapitalization. Needless to say, the stockholder lawsuits were not long in coming.

Getting back on track

The November 1992 AUTOFACT Conference in Detroit was sort of Computervision's coming out party as a public company once again. The company had a large booth and Jack Shields was a highly visible presence at the show. The company announced that it would support Microsoft's Windows NT operating system but no commitment was made as far as which products this would involve or when such software would be released. They did show CADDS 5 running on DECstation 5000 workstations and promised Hewlett-Packard Series 700 UNIX workstation support within six months. Computervision was starting to be more amenable to third party component software. In addition to licensing raster software from FORMTEK, the company was also using HOOPS graphics software from Ithaca Software even though Autodesk owned 20% of the company at the time. The latter package enabled Computervision's programmers to substantially improve graphics performance.

One of the difficulties in porting CADDS 5 to these new platforms was that the software had over 2,000 global variables (data items that could be shared between

software modules) and Digital had to redo its compilers four times before they could handle Computervision's software according to Versprille. Computervision development personnel felt that HP was the better platform but since both Shields and McInnis had come from Digital it was no surprise that the latter company's workstations got priority. By the third quarter of 1992, CADDS 5 sales began exceeding the sales of CADDS 4X and by March 1993 the company had shipped 5,500 seats. The primary CADDS 5 product was the Premium Engineering package which sold for $19,500. In addition customers could purchase subsets of the functionality under the brand name of CVware.

Computervision was pushing hard on the fact that CADDS 5 was a "hybrid" modeler. By this, they meant that users could model using traditional wireframe and surface geometry techniques or they could use the new solids-based parametric modeling capabilities of the software when applicable. The company's marketing department pushed the idea that competitive packages such as Pro/ENGINEER could only work with the parametric approach.

By 1993, the company's sales in the United States represented just 20% of its CAD/CAM business. Europe was 65% and Japan represented the other 15%. Since the company went public in 1992, it picked up million dollar plus orders from Citroen, Fiat, Jaguar, Texas Instruments, General Electric and Aerospatiale. Sales were rapidly shifting from the company's direct sales force to resellers. By March 1993 there were 300 such dealers with 350 sales people trained to sell Computervision products. The intent was to generate 30% of the company's CAD/CAM revenue through the reseller channel by early 1994.[46]

In an attempt to bring Medusa and CADDS 5 closer together, Computervision introduced a package called CVdesign. Users could move two-dimensional Medusa data to CVdesign, perform three-dimensional modeling tasks and then return the data to Medusa. This way, CADDS 5 large library of applications could be made available to Medusa users.

In other software areas as of March 1993, Computervision was continuing to promote THEDA for printed circuit board design, especially for products that were a combination of electrical and mechanical components. Calma's DDM software had been capped several years earlier but the company was continuing to sell Dimension III into the process plant design and shipbuilding markets as well as older CADDS AEC packages which were being converted to CVware applications. A new program was CVpvs, a visualization package built around HOOPS.

While the company was trying to rationalize its product line, it still had too many irons in the fire. According to *Engineering Automation Report*:

> "We still think that they are in too many different markets and that they should focus on the manufacturing industries where they have the most significant market share. They do have a strategy to bring Medusa and CADDS 5 closer together with less redundant software development. We would like to see them accelerate this effort."[47]

[46] *Engineering Automation Report*, March 1993, p. 6
[47] *Ibid*

While the company's product activity was becoming better focused, it was not exciting Wall Street. By April, 1993, Computervision stock had dropped to $3 and the board felt it was time for a change. For the quarter ending April 4th revenue was down 19% to $221 million and the company had a $10.4 million loss. Jack Shields was terminated by the company's board of directors and Russ Planitzer took over as president and CEO. This was Planitzer's first job as a senior operational manager of a major company. In addition, Delbert Lippert who was executive vice president for international operations was replaced by Cathy Morrison, Bruce Ryan who was vice president and general manager of U.S. operations was moved to a staff position and was replaced by David Lemont. (Lamont would later become chief operating officer of ICAD and then president of architectural software startup Revit.)

Planitzer mover quickly to put his stamp on Computervision. Doug Smith was made vice president of strategy and development while Garth Evans was promoted to the new position of vice president of worldwide field operations. Smith would subsequently become vice president of finance and administration in early 1995. Barbara Kaye Marx was hired away from Hill and Knowlton to take over as head of corporate communications. Marketing was reorganized into four business groups headed by Vincent Chaillou (Architecture, Engineering and Construction), Jay Atlas (Aerospace), Chuck Harris (Automotive) and Lawrence Gozzard (mechanical machinery). Atlas was hired away from Digital while Harris came from Hewlett-Packard. A new dealer organization called CVselect was set up under Pierre Violo to work with the reseller channel.[48]

These moves didn't have an immediate positive impact on the Computervision's financial results as revenue for the second calendar quarter dropped 26% from the year before to $217 million and the company sustained an $8.8 million loss. Over half the reduction in revenue came from lower hardware sales as the company began to reorient itself to being primarily a software and services company.[49]

Within a few months, there were signs that Computervision might be turning the corner. The company had been under tremendous competitive pressure from PTC as that company realized that Computervision's installed base was ripe for replacement by more up-to-date technology. CADDS 5 was improving with each release and long term customers began to be more comfortable with the company. One account in particular gave indications of a turn around in attitudes. Alcatel, a French manufacturer of telecommunications equipment had been a Computervision customer for some time but had recently installed 20 seats of Pro/ENGINEER. In a head-to-head competition Computervision won a order for up to 200 seats of CADDS 5 software.

According to *Engineering Automation Report* the three factors that impressed Alcatel were CADDS 5's ability to work with both explicit and parametric geometry, its CAM software and the previously mentioned CAMU package.[50] Other major orders in late 1993 included one valued at $4.5 million from Rover Group in England, a $5 million order from Hyundai in Korea for shipbuilding software (Hyundai had over 3,000 seats of

[48] *Engineering Automation Report*, July, 1993, p. 15
[49] *Engineering Automation Report*, September, 1993, p. 5
[50] *Engineering Automation Report*, November, 1993, p. 4

CADDS and Medusa installed) and $3.5 million order from window and door manufacturer Anderson Corporation.[51]

Perhaps the most significant announcement in late 1993 was the fact that Computervision was stopping the resale of all computer hardware. From now on customers would have to purchase workstations and servers from the hardware manufacturers themselves or from resellers. The company had been losing nearly $50 million per year reselling mostly Sun hardware.

Computervision took a $515.5 million one-time charge, $365.6 of which came from exiting the hardware business while the rest were costs associated with restructuring the company and the planned reduction of headcount from 4,700 employees to 2,700 over an 18 month period. Although revenue continued to drop, down to $184 million in the September quarter, the company's cash position continued to improve and it reported $50 million in the bank.[52]

At AUTOFACT that November, Computervision announced that it would support Silicon Graphics and Digital AXP workstations by mid-1994 and that new EDM software including a Design Document Manager and a Design Release Manager were available and that the entire EDM suite would be ported to Windows NT in early 1994. The company even demonstrated a prototype virtual reality system using SGI hardware and dVISE software from a company called Division.

Trying to regain historical momentum

By early 1994, the CAD/CAM industry was entering a new stage of maturity that was defined by:

- The end of the turnkey systems era with customers buying software and hardware products separately.
- Suites of software packages that utilized a single database without the need to translate geometry as users moved from one application to another.
- Design, analysis and manufacturing software that was feature-oriented and made extensive use of parametric relationships.
- Customer demands that software from one vendor needed to work with software packages from other vendors.
- A shift from expensive UNIX workstations to Pentium-based PCs running Windows NT.
- The prices for both workstations and PCs were dropping rapidly making software an growing portion of users investment in CAD/CAM technology.
- A move away from these systems being used by a small cadre of specialists to their being used as a primary design and analysis tool by a larger group of casual users.
- The shift away from direct sales forces to the use of resellers.

[51] *Engineering Automation Report*, February, 1994, p. 13
[52] *Anderson Report*, November 1993, p. 3

- Just over the horizon, an entire new category of lower cost mid-range CAD packages utilizing component software technology was getting ready to be launched.

Organizationally, 1994 started off at Computervision with Atillio Rimoldi replacing Don McInnis as vice president of research and development. Rimoldi had earlier worked for Computervision but for the past ten years had been with Intergraph in Europe, most recently running that company's European Mechanical Competence Center. Masood Zarabian along with McInnis and Ken Versprille, who had rejoined the company a few years earlier, left as part of a corporate down-sizing in early 1994.

In February 1994, I spent several days visiting Computervision for an *Engineering Automation Report* profile. A planned 30 minute meeting with Russ Planitzer ended up running nearly two hours and I came away impressed by both his plans for turning the company around and his focus on what this technology could do for the company's customers if applied correctly. My conclusion:

> "Right upfront, we think that Computervision might be the high-tech turnaround situation of the decade. It will not be pretty and there will be a lot of broken pieces when they are through, but CV is taking many of the right steps in trying to get this business turned around…Why are we optimistic about CV – in fact more so than most of the other people that cover this industry?.... probably more than anything else, it is looking beyond the immediate problems and seeing what could be if the company executes its current strategy effectively."[53]

Was I overly optimistic? – probably, but not by much. The company had a real shot at succeeding but it would take almost perfect execution to pull off the turnaround and in the end, the company simply was not up to it. Of the $660 million Computervision expected to do in 1994, CAD/CAM software and consulting services made up about $320 million, the balance was the service business it inherited from Prime. With a huge base of CAD/CAM systems installed at major manufacturing firms around the world, Computervision was still a force to be reckoned with. But this installed base was under ferocious attack by the competition, especially PTC.

Computervision was moving fast to slim itself down for the battles ahead. By the end of 1993, it had already terminated 1,000 of the 2,000 people it planned to lay off as a result of exiting the hardware resale business and the company had vacated nearly 900,000 square feet of manufacturing and office space. The problem was that is still had to pay rent on much of this property.

Computervision also began shedding business activities that were secondary to its primary mechanical CAD/CAM markets. The System 9 mapping software was sold to UNISYS and the THEDA electronic design software was in the process of being sold to Japan's Zuken. It was no surprise that the company was focusing its sales and marketing on the automotive and aerospace industries along with manufacturers of industrial machinery. Manufacturers of consumer products were of secondary interest primarily because Computervision lacked the styling software these companies wanted.

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[53] *Engineering Automation Report*, March 1994, p. 6

Software development was also undergoing significant changes under Rimoldi. In particular, the company was attempting to reduce the duplication of effort in supporting its large portfolio of applications. Medusa and CADDS 5 were beginning to share core technology where applicable, especially in areas such as drafting and visualization. The use of component software technology such as HOOPS also facilitated the company's ability to support multiple workstation platforms. In addition, there was renewed interest in providing customers with more reliable software. CADDS 5 Release 5.0, which was in development in early 1994, was intended to have far fewer problems than earlier versions. One step in accomplishing this task was the effort underway to remove old obsolete modules from the source code. Rimoldi claimed that this latter work would reduce the size of CADDS 5's source code by 20%.

At the end of 1992, CADDS 4X still made up half the company's new CADDS licenses. By early 1994, this was down to 20% as the company struggled to facilitate the transition process for customers. Initially, Computervision did not realize how disruptive moving from CADDS 4X or earlier versions of its software to CADDS 5 would be for customers. By 1994, the message had been received and the company was providing users with written guidelines for making the transition and how to integrate parametric design into a user's product development process. Computervision even implemented a CADDS 4X user interface option for CADDS 5 users who wanted to stay with something they were familiar with during the transition.

One marketing tool Computervision was implementing at the time was a strategic plan for partnering with its customers called "Product Development Diagnostic" or PDD. The objective was to compare customer design procedures with other companies in the same general industry. This was a form of "benchmarking" that Computervision hoped would distinguish it from other software vendors given its huge installed base of users from which it could draw comparative information.

Although customers and prospects were charged for this consulting work, it was clear that the primary purpose was to get these companies to buy more Computervision software and to use it more intensely. One key feedback that Computervision received from early PDD assignments was the need to improve software quality, an input the company claimed it was taking to heart.

In addition to improved reliability, CADDS 5 Release 5.0 also incorporated improved parametric modeling capabilities that made it more competitive with PTC's Pro/ENGINEER. One key enhancement was the fact that associativity between the solids model database and drawings was now bi-directional. Hidden line removal performance for large assemblies was as much as eight times faster than in prior versions. Release 5.0 also incorporated optimization functions based upon parameters such as mass properties and constraint equations. As an example, if one dimension of a box changed, then other dimensions would change so that the volume or surface area of the box remained constant. The company was starting to invest an increasing amount of its development resources on PDM software. Overall, Computervision seemed to be making the proper moves to regain its former momentum in a rapidly changing industry.

As mentioned earlier, however, if Computervision was to be successful with its turnaround plans, execution would be key. Business execution in any high tech industry usually calls for management consistency, especially in sales. This was one area where Computervision started to show some chinks in its armor. In May 1994, Patrick Clark

replaced Garth Evans as vice president of worldwide sales and Ted Dysdale was hired as vice president of North American sales. A few months later, Evans assumed a similar position at ICAD to what he had at Computervision while David Lemont became ICAD's chief operating officer. Francois Duliege took over as vice president of sales and marketing at the company's San Diego Business Unit which was now responsible for the Personal Designer and VersaCAD product lines. Drysdale had been president of a company called ASP Express while Duliege had been managing director of Computervision's French subsidiary.

Meanwhile, the company continued to receive million dollar plus orders from its traditional customers such as Ford, Rover, GE Transportation and Hyundai as well as new customers such as China Aerospace Corporation. By fall of 1994 the company was shipping CADDS 5 on both IBM RS/6000 and Digital Alpha workstations. The company was also broadening the capabilities of its PDM software to handle non-Computervision data files. As an example, at the EDMS Vision 94 Fall User Forum in Cincinnati sponsored by The Kalthoff Group, the company demonstrated a version of its Configuration Navigator that could handle Pro/ENGINEER data files.

Striking out in a new direction with PELORUS

Since the early 1970s, Computervision had had a software development operation in the San Diego area. This was the group that did the early development work on CADDS 3 and more recently had taken on the responsibility of supporting the company's PC software including Personal Designer and VersaCAD. For some time, leading up to the mid-1990s, this group was understood to be working on a project called "Liberator" that was going to be the company's AutoCAD "killer".

As this project progressed, the company's management concluded that the most significant work being accomplished in San Diego was the underlying technology being used by the software developers. A decision was made to productize that technology as a graphics application development platform and licenses it to third party developers as well as use it in-house to create new specialized applications.

In early 1995, this new development architecture was given the name "PELORUS" which is a device resembling a compass used by mariners to determine the location of a ship at sea. PELORUS was implemented using the latest software development techniques and standards such as STEP, OLE, object brokering, dynamic linking as well as standard graphics interfaces including Microsoft Windows and Motif. The software consisted of a large number of individual object-oriented tools that could be dynamically linked together when an application was loaded. These tools could be assembled into application-oriented suites that supported data management, modeling, user interface and graphics display functions using a program called the PELORUS Tool Engine. It was expected that most programmers would create applications using Microsoft's Visual Basic although a more comprehensive capability was available for programmers who wanted to work in C or C++.

A key feature of PELORUS was that applications created using this development platform did not need an underlying graphics systems such as CADDS 5 or AutoCAD in order to execute. In addition, applications developed with PELORUS were supposed to be interoperable. To ensure that this occurred, Computervision planned to test programs

created by independent developers and once certified that they met the company's interoperability standards, would be designated as "PELORUS Powered."

The first PELORUS application was a Process & Instrumentation Diagram package called DesignPost P&ID. It was developed in partnership with Framatome S.A., a French nuclear engineering company. It was intended to be the first of a series of applications carrying the DesignPost label. It was priced at $2,500 and was targeted for shipment in March 1995. Similar packages intended for use with AutoCAD or MicroStation sold for perhaps $1,000 but required a copy of the underlying CAD package in order to function, raising the cost per seat to more like $5,000. Planitzer told the media and analysts not to expect significant revenue until 1996 or 1997 and that by 2000 the company's revenues would still be more than 50 percent CADDS based.[54]

One of the major shortcomings of PELORUS as initially announced was the lack of solids modeling and surface geometry capabilities. In April 1995, a major joint development effort with Mercedes-Benz AG was announced under which Mercedes-Benz would use PELORUS to develop a new generation of automotive modeling and styling applications. At the time the company had about 2,100 CAD seats installed, 1,200 CATIA and 900 an internally developed design package called SYRKO.

Under the agreement, Mercedes-Benz was to invest 150 man-years of effort over a three-year period adding SYRKO design capabilities to a suite of PELORUS-based applications. The project was to start with Mercedes-Benz installing 100 PELORUS development licenses. As the applications were developed, this was to lead to as many as 3,000 run-time licenses. Computervision would then sell these applications to Mercedes-Benz suppliers and other manufacturers.[55]

Also in early 1995, Computervision announced a drafting package based upon PELORUS technology called DesignPost Drafting. The plan seemed to be to attack AutoCAD with this package, especially in the mechanical drafting arena. The software was defined as being "event driven." If the user was in the middle of creating a string of lines, he/she could interrupt that process, open another drawing file, perform some function and then return to the first drawing and pick up right where it was interrupted. The software, which was priced at $2,995, also included dimension driven geometry, parametric equations, built-in symbol libraries and direct access to AutoCAD DWG data. It sounded almost to good to be true and that turned out be the case.[56]

PELORUS never really got off the ground. Few copies of DesignPost software were ever sold and the Mercedes-Benz agreement never resulted in marketable software. While Mercedes-Benz was excited about the potential of PELORUS when this relationship was launched, it soon became disenchanted as PELORUS failed to live up to its advertised capabilities. In summary, PELORUS never produced the technology and revenue that was expected and it turned out to be a major distraction from the companies main CADDS business.

Getting the CADDS business back into high gear

By mid-1995, business was looking up for Computervision. The focus was now on what the company called EPD or Electronic Product Definition and the company's

[54] *Engineering Automation Report*, February 1995, p. 1
[55] *Engineering Automation Report*, April 1995, p. 5
[56] *Ibid*, p. 11

PDM tools were now being sold under the Optegra brand. The marketing of the EDP concept was particularly well done with the focus on what customers were achieving with Computervision's design and data management software rather than on the tools themselves. The company produced several booklets to explain how contemporary technology, when used effectively, could enhance the profitability of manufacturing and engineering organizations.

For a while, business picked up significantly. The company received a $9.4 million order from Hughes Space and Communication for CADDS 5, CAMU and DesignPost software. This was followed by an $8.2 million order from United Defense (the producer of the U.S. Army's Bradley Fighting Vehicle). The most significant order was a $25 million deal with Airbus Industrie, the commercial consortium owned at the time by Aerospatiale, British Aerospace and Daimler-Benz Aerospace. This involved over 1,500 seats of design and data management software. Vickers Shipbuilding and Engineering ordered $11.9 million of software and services and Rover another $9 million over three years. There were also $1 million orders from TVS Suzuki, Jaguar, Nokia and Volvo.

The August 1995 issue of *Engineering Automation Report* contained an update on Computervision's three-part business strategy. The first component of this plan was to continue going after automotive, aerospace and shipbuilding accounts with a combination of CADDS 5 and Optegra PDM software. The second thrust was to pursue the low end CAD market with PELORUS-based design and drafting applications sold through a dealer channel as well as by the company's direct sales force which would sell these low-cost packages in large quantity to major accounts. The third area of interest was to sell PDM solutions (what the company referred to as EDM or Enterprise Data Management) to companies that were using competitive design software. At this point, neither the company nor analysts following the company realized the extent to which PELORUS was a house of cards ready to tumble down. In October, the company hired Ed Wagner, the former president of Boston Communications and vice president of marketing at Rasna to head up what was now being called the PELORUS Business Unit.

Other than PELORUS, the other products the company was pushing in addition to CADDS 5 were Optegra applications such as Configuration Navigator, CAMU and the PVS visualization software. I was particularly impressed by CAMU – "While other companies offer configuration management, workflow and data vault capabilities, no one else has a package similar to CAMU that can work with multiple data formats."[57] Overall, Computervision's financial results were starting to show this renewed energy and focus. For the quarter ending June 30, 1995 the company had revenues of $131 million and earnings of $7.1 million after interest payments on its huge debt. In spite of the fact that the company's non-CAD service revenue was contracting faster than expected, Computervision planned to begin paying off some of this debt by the end of the year. The following quarter, revenues slipped to $125 million while earnings were up to $8 million. In the fourth quarter revenue inched up to $131 million while earnings before special charges were $12.7 million.

Much of this positive sales momentum continued to be in Europe. One example of this was a strategic alliance the company announced with Russia's Tupolev Aviation Company which planned to use CADDS 5, CAMU and Optegra to help design a new

[57] *Engineering Automation Report*, August 1995, p. 1

executive jet. In December the company issued an additional 13.8 million shares of stock in a secondary offering and paid off $125 of debt reducing its annual interest payments by $15 million. At about the same time, Kathleen Cote who had been managing the company's service business unit was promoted to president and chief operating officer. The company's stock ended 1995 at $14 per share.

Trucking along

As 1995 moved on into 1996, few significant announcements were coming out of Computervision. The company seemed to be focused on basic tasks such as improving its product portfolio as well as beefing up sales around the world. In April 1996, new Optegra modules for handling workflow requirements and standalone data navigation were added to the company's product line. Around the same time, the company announced a large $26 million contract with Peugeot. The significance of this order was that Peugeot was a user of CATIA V4 software as well as CADDS 5. Then in May, the company promoted Salahuddin Kahn to the position of vice president of product development and hired former SDRC vice president Rock Gnatovitch as vice president of marketing.

During 1996, Computervision's overall revenues continued to slide as the company's business of servicing legacy Prime and Computervision hardware dried up. In the second quarter revenues were down to $119 million but the company stayed comfortably in the black with earnings of $10.7 million.

In July 1996, Computervision provided the media with a preview of CADDS 5 Release 6.0 which was scheduled for release in the fall. The key enhancements were an improved three-dimensional sketcher that was capable of working with arbitrary planar surfaces, improved parametric design capabilities including an enhanced ability to edit model history and improved machining operations. The company had been selling a version of DesignView which it had obtained when it acquired Premise in 1991as a two-dimensional sketcher. The problem was it that its integration with CADDS 5 left much to be desired. Release 6.0 was intended to fix this deficiency.

At the same time, *Engineering Automation Report* noted that PELORUS development was "moving slower than expected."[58] In spite of this, functionality such as the three-dimensional sketcher was being implemented to be used by both CADDS 5 and PELORUS. Computervision also announced that it was dropping HOOPS as its graphics engine in favor of internally developed technology, probably because Autodesk now owned Ithaca Software, the developer of HOOPS. The company was focused on increasing its North American sales. The direct sales force totaled 126 people with plans to expand to 150 in the near future.

In September 1996, Computervision decided that its service business was a distraction and that it was time to focus strictly on CAD/CAM software and consulting services. The company agreed to sell its service business to an investment group headed by J. F. Lehman & Company for $125 million. Computervision was to receive $100 million in cash when the deal closed and planned to use those funds to pay down outstanding debt. The cash portion of the purchase agreement was subsequently reduced to $65 million. Computervision hoped to reduce expenses by $20 million per year.

[58] *Engineering Automation Report*, August 1996, p. 10

Two other developments were significant in late 1966. Kathleen Cote became CEO and Russ Planitzer returned to his previous position as non-executive chairman of the board. Computervision also spent $3 million to acquire a small UK software firm, 3rd Angle. Headed by John Stevenson, this company was developing a new mid-range CAD package built around a Parasolid core.

For 1996, Computervision had CAD revenues of $303 million compared to $287 million the year before. Significantly, software license revenue increased by 17% to $192 million. Towards the end of the year the company closed million dollar plus deals with Boeing, Solar Turbines, Volvo and Bath Iron Works. Computervision also signed a joint marketing agreement with EDS which resulted in a $54 million contract to provide software and services to Roll-Royce Aerospace Group and Allison Engine Company. This relationship did not sit very well with the marketing people at EDS Unigraphics and they soon issued a press release downplaying the significance of the EDS/Computervision relationship. EDS and Computervision then issued a joint press release stating that they had signed a ten-year agreement "to pursue defined opportunities for product development solutions in the global aerospace and manufacturing markets."[59]

The end of the road

The deal to sell Computervision's service business to J.F. Lehman never took off and was terminated in March 1997. As a fallback position, Computervision signed a non-binding letter of intent to sell 51% of the services business to M. D. Sass Investors Services with the intent of rebranding that portion of the company as Computervision Services International (CVSI) with James Regan as president of CVSI. At this point the company's revenues began to plummet and losses were starting to pile up. For the first quarter of 1997 the company had revenues of $77.8 million and a loss of $33.4 million. The company continued to announce significant contract awards but they were smaller than in prior years - $1.6 million from Westinghouse, $1.1 million from Tupolev Aviation and $1 million from Magneti Marelli in Italy were typical.

In June 1997 I visited Computervision to try to understand where the company was and where it was heading. It was obvious that the failure to sell the services business to J. F. Lehman at an attractive price was a major setback and trying to come up with an alternate strategy absorbed a tremendous amount of management time. The most significant news was the effective termination of the company's highly touted PELORUS project. PELORUS was supposed to result in a new object-oriented development platform for Windows-based design and drafting applications including the surface modeling being developed by Mercedes-Benz. That simply did not happen and what was left of PELORUS was being combined with the software developed by 3rd Angle to form a new mid-range product. The balance of the company's development activity was being focused on integrating Optegra modules using a common user interface, Release 7.0 of CADDS 5 with new interactive surface design technology and porting Medusa 3.0 to Windows NT and re-pricing it in the range of $4,300.

Financial results for the second quarter did not show much improvement. Revenues increased to $88.5 million but the company had a $51.2 million loss after taking a $45 million restructuring charge. By the end of September, the company's stock

[59] *Engineering Automation Report*, December 1996, p. 15

was selling for a little more than $2 per share and the company's bonds were selling for 50 cents on the dollar.

In October 1997, Computervision asked me to come to Bedford so they could brief me on a new software packaged they planned to launch at AUTOFACT in early November. The intent was to have an article describing this software, to be called DesignWave, in the November issue of *Engineering Automation Report*. This package was based on the software acquired from 3rd Angle along with some, but not much, PELORUS functionality. It was designed to run on both Windows 95 and Windows NT and it implemented the Windows user interface paradigm. DesignWave handled feature-based solids modeling using a Parasolid geometry core. I thought a new package from the ground up was a better strategy that trying to cram CADDS 5 into a PC. The software had a number of well conceived capabilities and I expected that it would give products such as SolidWorks and Solid Edge a run for their money if it were marketed aggressively.[60]

DesignWave was to be launched on November 4, 1997 at a press conference the morning AUTOFACT opened. With a room full of editors and analysts, Wayne George, the DesignWave marketing manager, strode to the podium and said "And at eight o'clock this morning, Computervision announced that was being acquired by Parametric Technology Corporation." With that statement Computervision ended the press conference leaving everyone in shock. PTC planned to acquire Computervision, subject to shareholder approval, for $490 million, $260 million in stock and the assumption of approximately $230 million of debt. The purchase closed in early 1998. The nearly 30-year history of one of the major companies in the industry thus came to an end.[61]

PTC's plans for Computervision were to slim down its staff by laying off 500 of the then current 1,200 employees and to continue supporting CADDS 5 and Medusa for some indefinite period of time. Long term, they made it very clear that the objective was to encourage these customers to move to Pro/ENGINEER. PTC also planned to build a major account marketing and sales program around Computervision's perceived success in this area. The expectation was that expenses could be cut to $100 million in 1988 while revenues would be in the area of $120 million. These were actually fairly conservative goals. There didn't seem to be much of a future for DesignWave in that PTC management led by CEO Steve Walske did not think much of Windows-based mid-range solutions built around Parasolid.

See Chapter 16 for a discussion of how PTC handled Computervision's CAD products, the surprise discovery a of a gem of a PDM solution called Windchill hidden among the rubble and how key Computervision managers ended up in senior management positions at PTC. Medusa was sold to Germany-based CAD-Schroer in early 2002 and VersaCAD was sold to Archway Systems (see Chapter 20) in October 1999. In 2004 PTC was still generating $30 million in annual sales from prior Computervision and Calma software including about $4 million in new license revenue – mostly CADDS 5 that was being used on long term projects.

Why did Computervision eventually fail?

For many years, Computervision had reasonably good products, an aggressive sales force and competent management. So why did the company eventually fail. I

[60] *Engineering Automation Report*, November 1967, p. 6
[61] *Engineering Automation Report*, December 1997, p. 1

believe that there were three primary reasons this occurred. The first was the company's decision in the mid-1970s to build its own computer equipment. While this move initially improved the company's gross margins, it created a mindset that Computervision was a hardware manufacturing company that happened to sell engineering design and drafting software.

When management attention in the late 1970s and early 1980s should have been focused on creating a new generation of solids-based design software, they were distracted by the effort spent on trying to move the company's computer technology into the 32-bit era. Once Computervision decided to use industry-standard workstations and servers, extracting itself from the extensive manufacturing infrastructure it had established proved to be very costly. Computervision was not the only company to face this problem. Auto-trol Technology, Applicon, Gerber, and Intergraph all went through the same exercise and other than Intergraph, none did it successfully.

The second reason the company ended up a shell of its earlier self were the two hostile takeovers, a successful one by Prime and the unsuccessful one by MAI Basic Four. The Prime acquisition might well have worked out successfully if given a chance but just as the company was making progress in melding the Prime and Computervision businesses together it was hit with the unexpected hostile tender offer from Bennett LeBow. I still have a hard time understanding why Prime felt it necessary to bring J. H. Whitney & Company into the picture. LeBow's financing seemed shaky towards the end of the takeover fight and it is entirely possible that if they had waited him out, he may well have just faded into the sunset. But they did not do that and when the dust settled, Prime was saddled with greater debt than the company could handle. From then on, financial issues dominated the management of Prime and then Computervision after its second IPO. The company was never able to get its head above this financial Albatross.

The third problem area was the difficulty customers had in making the transition from CADDS 4X to CADDS 5. When initially released, CADDS 5 had far too many technical problems and many of the applications customers had come to depend upon were only available for use with CADDS 4X. The transition from one to the other was difficult and many customers felt if they were going to go through such a difficult upgrade why not look at alternative products on the market. Those that did frequently ended up buying software from other companies including Autodesk, PTC, SDRC and EDS Unigraphics.

In addition, the money spent on the abortive PELORUS project could have been better spent elsewhere, acquiring Calma may not have been worth management's time and effort and even the acquisition of Cambridge Interactive Systems and Medusa may have been a bad idea. None of these issues, however, were of the magnitude of the other problems described above. Computervision probably even could have survived the transition away from manufacturing its own systems but the financial impact of two hostile takeovers was more than any company could have withstood.

