Chapter 11

CALMA

Author's n*ote: I was employed by Calma from February 1972 through October 1973 as a salesman, initially at corporate headquarters in Sunnyvale, California and subsequently in the Boston, Massachusetts area. Much of the early part of this chapter is based upon that personal experience.*

Calma Company was founded in Sunnyvale, California in1964 by Ron Cone, a former engineering vice president at CalComp, Cal Hefte, a distributor of CalComp equipment in the Bay Area, and Jim Lambert who was Cal's partner. The company's initial product was a device for digitizing oil and gas well strip charts. Subsequently, Calma began manufacturing large digitizers which could be used to capture data for other computer applications ranging from mapmaking to integrated circuit manufacturing. In this regard, it was very similar to Auto-trol Technology (See Chapter 9).

The typical Calma digitizer was 48-inches by 60-inches and used what was technically called a restrained cursor. The cursor mechanism was controlled by cable devices in the X and Y directions. These were well designed units that enabled the user to quickly navigate across a document taped to the digitizer table. The X and/or Y axis could be individually locked which made the units particularly applicable to digitizing semiconductor or printed circuit board (PCB) designs which tended to consist of predominately orthogonal shapes at the time. There was also an X/Y display module which showed the current cursor location and an alphanumeric and function button keyboard for entering commands and related data. Output was either punch cards or magnetic tape.

By the early 1970s, none of the three founders were actively involved with the company although Cone was still chairman of the board. The president was Bob Benders who had been hired from Lockheed's operation in Sunnyvale a year or two earlier. Benders had grown up in Europe during World War II and had a reputation as a tough but fair manager. He became president in 1971 and deserves much of the credit for making the company an industry leader by the end of the 1970s.

The initial Calma digitizers used hardwired logic. When Benders came on board, he personally directed the redesign of the product line to replace the hardwired logic with a computer based control methodology. The computer the company selected was the Data General NOVA 1200, the same computer being used at the time by Computervision. It was a 16-bit machine much like Digital's PDP-11. The early systems had a 12K memory expandable to 32K (words, not bytes). As with the earlier hardwired units, output was either to punch cards or magnetic tape. These digitizers were called CALMAGRAPHIC systems and they sold for $25,000 to $55,000 with the high-end units incorporating disk storage capabilities.

It was a fairly logical extension of the CALMAGRAPHIC product line to add a graphics terminal to the system so that data could be viewed and edited as it was being recorded. In mid-1969 the company hired a brilliant young programmer named Josef (Joe) Sukonick who had recently earned a PhD in mathematics from MIT to put together the software needed to create an interactive graphic system. The system he developed, mostly by himself, was called the Graphic Data Station or GDS. Introduced in 1971, it was similar to the disk-based CALMAGRAPHIC system with the addition of an 11” Tektronix storage tube display. As data was digitized, it was displayed on this terminal. Graphical data could be edited using the digitizer cursor mechanism and control functions were entered using a keypad device.

Figure 11.1
Bob Benders

The GDS systems were well designed from a hardware point of view. Two features were important to the company’s sales efforts. CALMA built its own high-speed interface to the Tektronix display rather than use a slower industry standard interface. The result was the far faster display of graphic information on the display screen than what most competitors could accomplish. Storage tube displays required that the entire image be redrawn if anything changed on the screen other than adding data.

If the user deleted a line, the entire image had to be repainted. Digitized circuit layouts consisted of fairly dense data and repaint times would have been annoyingly long without this specialized hardware. The second feature was that the system was very stable. It was possible to disconnect the main power cord, stopping the system cold, and then plug the power back in. The system would continue right from where it was when it lost power. Try that with today’s PCs!

The total system configuration complete with the GDS software for integrated circuit mask making but without a large plotter sold for a little less than $100,000. Additional workstations were $35,000 each and large flatbed plotters cost as much as $68,000. The system was designed to support up to six workstations.

It would probably be useful at this point to describe how integrated circuits were designed and fabricated in the early 1970s since the process is much different today. The first step was to create a functional design of the circuit in the form of a logic diagram. There were a few computer programs available at the time that helped designers analyze timing issues and the logical integrity of the circuit. The next step was to make a drawing of the circuit on large sheets of grid paper, using a different color to represent each layer of the circuit. This was similar in many respects to how printed circuit boards had been designed for a number of years.

The integrated circuit diagrams were several hundred times the size of the final semiconductor chip. In early 1972, these drawings were often 48-inch by 60-inch in size or larger. The next step was to produce a mask of each circuit layer the size of the actual circuit. Typically, there were four to eight different layers of material that were used to produce a circuit. Each mask master was carefully cut into a sheet of peel coat material (a popular brand was Rubylith, which is still used for graphics art applications) using a device that was somewhat like a reverse digitizer except that it was manually operated. If the operator wanted to create a rectangle, he or she would cut the four lines that made up the rectangle through the top material but not through the base material. The rectangular area was then created by removing the peel coat material within the scribed lines. This was a very time consuming process and easily susceptible to error.

The next step was to photographically reduce these sheets of peel coat material, each representing a different layer of the circuit, to the actual size of the integrated circuit. This was done using large fixed format cameras. The physical masks used for manufacturing the circuits were produced using a precise instrument called a stepper. This basically took the source film of the circuit layer and reproduced it as many times as would fit on a mask the actual size of the wafer. The typical wafer size in the early 1970s was four inches or less in diameter as compared to today's state-of-the-art 12-inch wafers.

There were several problems with this approach for producing mask sets used to manufacture integrated circuits. First, it was slow and prone to error. Although there were photographic techniques that could be used to verify the accuracy of the individual masks, problems often remained undetected until a test batch of circuits were produced.

Second, circuits were becoming increasingly complex. This was about the time that Intel's Gordon Moore came up with Moore's law which stated that the number of logical elements on a semiconductor chip was doubling every 18 months. The size of memory chips and microprocessors was starting to grow rapidly and it was fairly obvious that within a few years the industry would need a sheet of paper the size of a basketball court to lay out new circuits. Chips such as memory circuits had a large degree of repetitiveness to them but the existing manual process treated each memory cell as a separate element.

Third, instrument manufacturers were starting to produce equipment for making masks that were driven by digital data. The only way to use these instruments was to convert the artwork to a digital format. The result of these three issues was an industry ripe for automation.

Calma becomes a major provider of systems to semiconductor industry

Calma's vice president of sales was Tom Cain, an ex Navy Captain who lived in Bethesda, Maryland. He had been hired because much of CALMA's early digitizer sales had been to government mapping agencies such as the Army Topographic Command and the Air Force Aeronautical Chart and Information Center. I was hired by CALMA in February, 1972 to pursue business in the California and Arizona semiconductor industry. At that time, Calma had sold just one two-station GDS system to Intel. The company had literally no sales literature, no marketing and was up against several aggressive competitors in Applicon and Computervision.

Calma had the advantage that it was right in the middle of Silicon Valley. It also took a different approach to this market than Applicon and Computervision did. Calma focused on the manufacturing side of the semiconductor companies while Applicon, especially, focused on designing chip layouts. Applicon was represented on the West Coast by Dick Spann, one of the company's founders and a former Lincoln Laboratory software developer who eventually became president of Adage while Computervision was represented by Bob Gauthie who went on to be that company's vice president of marketing.

By late 1972, the functional capabilities of the GDS system had expanded considerably from when the first system had been sold to Intel. Initially, all it could handle was horizontal and vertical lines. Just doing 45° lines was a challenge. But the basic cell oriented architecture Sukonik had implemented was a solid design. Sukonick and the programmers who subsequently joined the company had the ability to add capabilities to the system without slowing down its basic display operations. This cell orientation also enabled the development team to expand the system to handle drafting applications including the ability to place text adjacent to or inside a symbol, justified horizontally and vertically. In a number of small incremental steps, the GDS system was becoming a basic drafting system.

Meanwhile, Benders worked hard at keeping the cost of CALMA's products under control. For example, the company was reluctant to increase the memory of the Nova 1200 from 8K to 12K words as the requirements of the GDS software grew. Computers used magnetic core memory at the time, not semiconductor memory, and an extra 4K words added several thousand dollars to the cost of a GDS system.

The major manufacturing problem the company had in those days was testing the hardware after a GDS system had been assembled. The primary component was a large back panel that contained all of the system's interconnection logic including the high-speed graphics interface and interfaces to peripheral devices such as plotters and digitizers. These panels were wire wrapped meaning that each end of wire was manually wrapped around a specific connector. Although the women who did this work were careful, errors did creep in and they were quite time consuming to find. CALMA used its system checkout process as a primary means of training field engineers. It served that purpose fairly well but it still took weeks to check out each system. The advantage of using a wire wrapped approach was that design changes could be made quickly and if necessary, incorporated into systems already in the field.

Calma supported a number of different output devices. The typical system included either a CalComp drum or flat bed plotter or a Xynetics flat bed plotter that were used to produce check plots. The CalComp flat bed plotter could also be equipped with a cutting mechanism to produce IC mask masters using the peel coat material described earlier. The Xynetics plotter, on the other hand, was a very fast pen plotter that used a magnetic technique to hold and move the plotting mechanism. Calma also developed software to drive optical devices such as those manufactured by the D. W. Mann Corporation, for producing mask layouts. By mid-1973, Calma had sold GDS systems to a number of semiconductor manufacturers and service companies that handled mask making tasks for the industry. In addition to Intel, customers included National Semiconductor, Motorola, Rockwell, MicroMask and Transmask.

At this point, the company was generating sufficient revenue that it was able to beef up its engineering and software development activities. One of the first steps was to create an edit station that used a Computek tablet and stylus instead of a large digitizer as the user input device. Substantial progress was also made in expanding the GDS software to include basic drafting and printed circuit board layout and artwork generation. In addition, the development of a mapping application was initiated under the direction of Roger Sturgeon. One of the industry's first user-oriented development languages, the Graphics Programming Language or GPL, was introduced in 1974 and the ability to handle integrated circuit elements at any angle followed in 1975.

The development of a new mechanical CAD system

As mentioned in Chapter 12, Calma hired David Albert and many of the former Computervision programmers in San Diego in 1976. Most of these individuals had turned down Computervision's offer to move to the Boston area when that company decided to consolidate its software development operations. Initially, Albert and his associates considered starting their own software company and one of their first potential clients was Calma. In addition to Albert, the primary members of this team were Jerry Devere, Glen Peterson, Ron Ianneta, and John Kaufman. Art Colmeyer, who was the head of Calma's R&D activity at the time suggested that they join Calma as employees rather than work as contractors. After several months of negotiations, the San Diego group became part of Calma and set about developing a new CAD system.

The resultant product, called DDM (Design Drafting and Manufacturing), was introduced in 1977. Users could display up to six independent views of a three-dimensional model and a change to any one view would immediately be reflected in the other views. Geometric construction operations could be initiated in one view and continued in another view. Hidden-line software was particularly fast and model views could be displayed with hidden lines suppressed or displayed in a separate line font. Hidden lines could be displayed differently in the six independent views and the six viewports could also have separate scaling. A user interacted with the system using either a digitizer-equipped workstation or a design/edit workstation that utilized a tablet and stylus or pen. All commands were displayed on the digitizer or tablet menu. These menus were supplemented by keyboard command entry and a programmable 32-function keyboard.

DDM was initially written to run on Data General computers, much like the company's other systems. It was written in FORTRAN V and used a modified version of Data General's Real Time Disk Operating System (RDOS). Each workstation incorporated two displays, one for graphics and one for alphanumeric data. This setup was dictated by the fact that the Tektronix storage tube displays then in use were not conducive to showing rapidly changing alphanumeric information. It was a similar configuration to what Calma used for its other applications. The alphanumeric screen primarily provided user prompts including a list of options for the command currently being executed.

Fast system response time had been a hallmark of Calma systems since the early 1970s and DDM was consistent in regards to this software and hardware characteristic.

DDM may well have been the first mechanical CAD system that stored geometric data in a double precision 64-bit format. The company's sales literature claimed that DDM could display three-dimensional models faster than competitive systems could display two-dimensional images.

A user development language called DAL (Design Analysis Language) was an integral part of DDM from the start. DAL provided user access to all DDM commands unlike some competitive systems which restricted which functions could be incorporated into user programs. DAL was also used to group repetitive sets of commands so they could be executed in one operation, incorporate scientific formulas into geometry creation operations, and interface DDM to existing FORTRAN programs. DAL created an intermediate object code that did not require recompilation each time it was executed. Instead, it ran in a interpretive manner similar to the way BASIC programs were run at the time. These programs could be saved in a library and executed by name or by assigning them to menu items. The company's promotional literature claimed that productivity increases in the area of 7 to 1 were typical and that improvements of 50 to 1 were being achieved using specialized DAL programs.[1]

DDM was basically a wireframe modeling system with surface geometry capabilities. The surface geometry software was developed working with people at the University of Utah and it handled planes, cylinders, surfaces of revolution, ruled surfaces, tabulated cylinders and sculptured or free form surfaces. Surface geometry was an optional package which was required for the hidden line removal operations described above. See Figure 11.2. Among the other DDM applications provided by Calma were packages for doing kinematics and finite element modeling as well as numerical control tape preparation. The latter program generated tool paths for profiling, pocketing, lathe operations, and 3-axis and 5-axis surface machining.

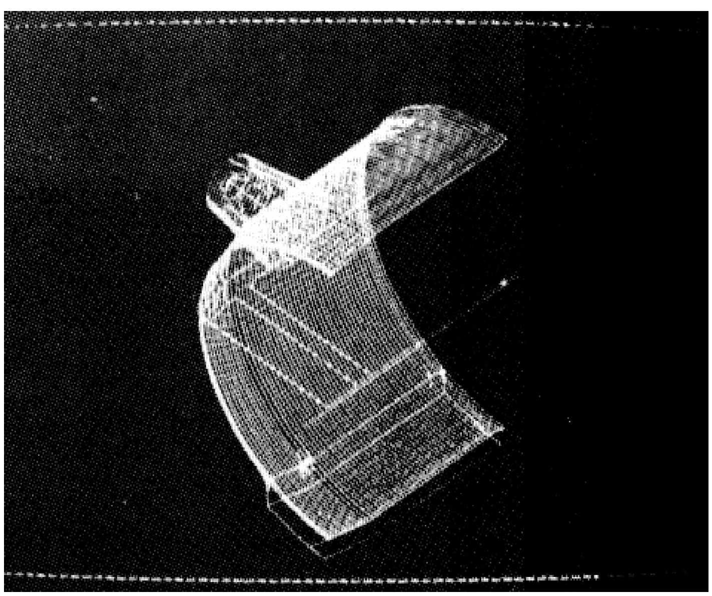

Figure 11.2
Calma DDM Surface Geometry

[1] *DDM from Calma* – undated company brochure after acquisition by United Telecommunication in 1978

Sale of Calma to United Telecommunications

On August 31, 1978, Calma was acquired by United Telecommunications for approximately $29 per share or about $19 million. United Telecommunication is known today as Sprint Corporation, a major provider of mobile phone services. The following table shows the Calma's financial growth through the 1970s. The company's fiscal year ended August 31st. The major problem is that the company never seemed to have much cash (less than $20,000 on August 31, 1977) and accounts receivable were typically huge, often running over 150 days of sales.

Fiscal Year	Revenue	Earnings
1971	$670,000	($293,000)
1972	1,586,000	179,000
1973	3,462,000	412,000
1974	6,146,000	562,000
1975	6,919,000	438,000
1976	9,484,000	747,000
1977	14,279,000	1,230,000

After United Telecommunications acquired Calma, it took a hands off approach to the company's management. The existing management team stayed in place including:

- Bob Benders – President
- Lemuel Bishop – Vice president, finance
- Dr. Arthur Collmeyer – Vice president, research and development
- Eugene Emmerich – Vice president, marketing
- Paul Kemp – Vice president, sales

In late 1979, the company's primary business continued to be systems for electronic artwork generation for both integrated circuit design and PCBs. Calma was perceived by most observers at the time to be the largest vendor of graphic systems to the semiconductor industry. GDS software was ported to 32-bit Data General computers in 1978 and the company began offering software to support electron beam pattern generation machines. This was followed in 1979 by the introduction of high-resolution color graphics terminals and support for high-speed electrostatic plotters. A typical storage tube workstation of that era is shown in Figure 11.3.

The company was also starting to develop a significant presence in the mechanical CAD market as well as selling systems for mapping and engineering design. In these latter areas major customers included Brooklyn Gas and Electric and Ontario Hydro. Calma was growing rapidly with sales nearly doubling every twelve months and with about 500 employees, 1979 revenues were estimated to be about $40 million. This was about the same revenue level that Applicon, Auto-trol Technology and M&S Computing (Intergraph) had at that time.

Figure 11.3
Calma Digitizer Workstation with Storage Tube and Alphanumeric Display Console

Expanding DDM into the AEC Market

In early 1980 Calma was organized into two business units, a Microelectronics Division with Collmeyer as vice president and general manager and a Mechanical Division with Ronald Hill in the same position. The Mechanical Division was also responsible for the development and marketing of systems targeting the AEC market. Although older Calma system could be used for basic drafting applications, there was a need for more advanced design technology, especially in the process plant design area.

The plan was to develop a series of design applications for the AEC market that would use DDM as underlying geometric modeler. The project was called CADEC (Computer-Aided Design/Drafting/Documentation for Engineers and Constructors). Modules under development included architectural drafting, civil engineering including terrain modeling, structural and process engineering including flowsheets, P&IDs, piping, mechanical, electrical and HVAC. It was a rather ambitious undertaking and one which did not have a lot of industry visibility. The lead manager for this effort was Jim Lambert who held the title of Director, AEC Systems.

By mid-1980, CADEC had progressed to the point where Calma had six beta test sites using the software, three in the United States and three international. The lead American user was Stone & Webster in Boston. Eventually, CADEC would morph into Calma's Dimension III product described below.[2]

General Electric enters the picture

In December 1980, less than 30 months after it had acquired Calma, United Telecommunications agreed to sell the company to General Electric for up to $170

[2] *A-E-C Automation Newsletter*, August 1980, Pg. 6

million in cash. This consisted of a $100 million cash payment upon closing of the sale and up to $70 million payable in the 1985 timeframe based upon Calma's revenue during the subsequent four years. United had decided that Calma's systems manufacturing business simply did not fit in with its other computer services activities.[3] Even without the additional payment, this was fairly nice profit on the latter company's $19 million investment.

Prior to the deal closing in early April 1981, the Federal Trade Commission expressed concern that GE's ownership of nearly 23 percent of Applicon and its acquisition of Calma were anticompetitive. While it is not clear that its subsequent actions were the result of a direct request from the FTC, GE soon announced that it would sell the 1.2 million shares of Applicon that it owned within the next 12 months. 1980 had been a good year for Calma. Revenue was up to $62 million, the company entered 1981 with a $17 million backlog and Calma's 1,000 employees were ensconced in a new facility in Milpitas, California that included a 204,000 square foot manufacturing plant.[4] On a revenue basis, the company was competing for third place in the industry with Intergraph, chasing after Computervision and Applicon which held first and second position.

One of the first steps taken to provide GE resources to Calma was to establish a communications link between Calma's DDM software and software offered by General Electric Information Services Organization. GEISCO was one of the leading time-sharing companies at the time and offered its customers NC post-processing services among other applications. It also offered APT part programming on a timeshared basis. While these services were available to all manufacturing companies in one fashion or another, having both Calma and GEISCO under one corporate roof provided addition marketing clout for Calma's sales organization.

Acquiring Calma was not a random move on the part of GE. The company was in the process of putting together a group of corporate organizations to market products and services for what it referred to as the "Factory of The Future." The company's position was that computer and communications systems were going to have a major impact on how manufacturers designed and produced products in the future and it intended to be a major force in that market.

In retrospect, it was a totally rational concept and one that eventually proved to be true. Under Jack Welch, the corporate attitude at GE was that a company was either number one or number two in a particular market segment or you got out of that business. GE proceeded to pour millions into Calma to expand its product development and marketing activities but it was never able to make the company profitable. During the seven years it owned Calma, losses ran as high as $50 million annually.

While United Telecommunications had taken a fairly hands off approach towards managing Calma, GE set out fairly quickly to make it a "GE" company. This did not set well with many of Calma's managers. A good example was Harvey Jones who had joined the company in 1974. After a stint in the company's development organization, Jones took on increasingly important roles in the sales and marketing of Calma's electronic design and artwork generation products. After receiving an MBA from MIT's Sloan School, Jones was promoted to vice president of business development for the

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[3] Barbetta, Frank, *Electronic News*, December 8, 1980, pg. 1
[4] *Electronic News*, April 6, 1981, pg. 91

General Electric's Factory of the Future

Jack Welch became chairman of GE on April 1, 1981, about the same time that the company completed its acquisition of Calma and announced the factory of the future business initiative. GE is deservedly respected as one of the best managed companies in the world. That does not mean that everything it touches turns to gold. The factory of the future is an excellent example that even well managed companies can screw up on occasion. When GE launched its plan, it seemed like the ideal company to do so since it not only sold a wide variety of technical products, but it also was a major manufacturer in its own right with plants that made everything from household appliances to locomotives.

The plan was to bring together in a single organization all the technical components needed to automate industrial factories. Several of the necessary products lines including industrial drives for operating metal and paper mills and controls for milling machines were already part of GE's extensive product line. Other elements, such as robotic equipment, would be sold under license from other manufacturers and some, such as factory floor communications systems, would be developed internally. Calma would provide the tools to design the products these automated factories would produce. GE's top management perceived this as an opportunity to provide large industrial companies with "one-stop" shopping.

The automation group, formally called the Industrial Electronics business group, was initially run by Donald Grierson, a GE executive who clearly was on a fast track within the company. Prior to taking on this assignment he had held five different positions at GE in five years. While he was perceived within the company as being a thoughtful strategist, he left something to be desired when it came to the details of running a business and the automation group was a very complex business. Part of the problem might have been the fact that while the group's headquarters was in Charlottesville, Virginia, the operating activities were scattered around the country. In the early 1980s, many of the tools we take for granted today for running decentralized organizations simply were not available. Grierson was definitely enthusiastic about the potential in this area. In one press release he is quoted as stating that "GE intends to 'blast productivity figures through the roof.'"[5]

In retrospect, GE's eventual failure in this area can be attributed to trying to do too much too quickly. The company set very high revenue goals and promised prospects a suite of advanced products that took far longer to develop than initially contemplated. The result was that some of these products, such as a factory communications system, were plagued by reliability problems. The company initially promised prospects that it would guarantee complete factory automation solutions including equipment such as machine tools for which it was simply acting as a reseller. When it came time to deliver on such promises, GE got cold feet.

[5] Calma press release, May 5, 1981

The automation group lost over $120 million between 1982 and 1984 according to *Fortune*. This was far more than what GE had planned when it launched the initiative. Grierson left GE in July 1985, initially to become a private investor and eventually to join ABB Vetco Gray, an oil services company, where he was president and CEO until 2002. He has also been on the board of directors of Parametric Technology since 1987. As described below, Calma was separated from the automation systems group in 1984 and eventually, GE took a much more low key approach to the whole subject of factory automation systems. Nearly 20 years later, one can look back at its efforts in this area and see that the company was simply ahead of the market's willingness to accept such a broad overhaul of its fundamental manufacturing infrastructure.[6]

Microelectronics Division. Shortly after GE acquired the company, Jones left Calma to co-found Daisy Systems, one of the first workstation-based computer-aided engineering (CAE) companies. After a stint as vice president of sales and marketing and then as president of Daisy he went on to become president of another CAE start-up, Synopsys – a major CAE firm. This was the type of talent the company could ill afford to loose but something that would occur repeatedly over the next few years.

The personnel changes came fast and furious as other long term Calma players decided that the GE administrative environment was not for them and as GE brought in its own people, some from within GE and some new hires. In June 1981, Jeffery Lane was brought in from Boeing as manager of advanced product development and John Benbow was hired from Dataskil to be vice president of research and development. Art Collmeyer, who had been with Calma since 1974 and was vice president and general manager of the company's Microelectronics Division left before the end of 1981 to start Weitek, one of the first fabless semiconductor manufacturers. Jim Girand, who had been vice president of sales for this division took over Collmeyer's job. He stayed around until early 1983 at which point he also left to join Weitek. Roger Sturgeon, who had joined the company in the early 1970s and had been responsible for developing the GDS II system left, along with Tom Bakey, to join TRICAD, a new startup targeting the AEC market. This latter company was subsequently acquired by Auto-trol Technology in November 1984.

In the fall of 1981 Calma replaced Applicon as SDRC's preferred CAD/CAM partner. GE and SDRC agreed to establish five Productivity Centers in the United States and Europe equipped with Calma CAD/CAM systems along with GE robotics equipment and NC controllers. Customers could either hire SDRC to handle design and manufacturing projects or could do it with their own personnel. GE's strategic objective, of course, was to raise the level of awareness among its customers for this new breed of technology in the hope that it would become the primary supplier of design and factory automation tools to those companies.[7]

At the November 1981AUTOFACT conference in Detroit, Michigan, GE's master plan for Calma and the factory of the future began to take shape. A number of new CAD products were demonstrated in a scaled down version of a Productivity Center as well as a preview of a new solids modeling package, DDM/Solids. GE supposedly spent

[6] Petre, Peter, "How GE bobbled the factory of the future," *Fortune*, November 11, 1985, Pg. 52
[7] *Anderson Report*, November 1981, pg. 1

$1.6 million on this one trade show.[8] In January 1982 GE acquired a 48 percent interest in Structural Dynamics Research Corporation (SDRC) and began integrating SDRC's mechanical CAE software into the Calma product line.[9] In addition to this arrangement, GE acquired a majority interest in CAE International. It was now 51 percent owned by GE and 49 percent owned by SDRC. The word being spread was that GE was prepared to invest over one billion dollars in its factory of the future initiative and that CAE International and Calma were key elements of that plan.

The general concept was that SDRC would provide the tools for conceptual design and analysis, Calma would provide the systems for converting those designs into the information needed for manufacturing them and other GE divisions would provide factory automation.[10] It was a great concept that never seemed to quite come together. Confusing the situation described above was the fact that Calma had recently announced its own solids modeling software called DDM/Solids. This package was initially implemented on 16-bit Data General systems and subsequently ported to 32-bit DEC VAX machines. The product never took off and was replaced by an agreement for Calma to market SDRC's GEOMOD. It turns out that DDM/Solids was not really a solids modeler but simply produced shaded images of surface defined models.[11] For the next several years, the two companies had separate sales organizations that only loosely coordinated their activities.

Calma's marketing personnel sometimes got carried away when describing the company's products and business developments. For example, in December 1981 Calma announced that it had established an AEC division and claimed that it was "the only CAD/CAM maker with a division totally dedicated to the AE&C market."[12] That probably came as a surprise to competitors such as Computervision and Auto-trol Technology that were already organized in a similar manner although they may never have used the term "division.." The head of Calma's AEC Division was Dr. Ronald Hill who had joined the company in 1978. Hill was previously with Tektronix.

Broadening the Calma's product line

Starting with its earliest computer-based systems in 1971, Calma had used Data General computers. In the fall of 1982, the company was still using Data General Eclipse computers but was exploring the possibility of supporting both Apollo workstations and DEC VAX computers, especially for its mechanical and AEC software products. There were three versions of the Eclipse hardware at this point. The Series 1000 was a single cabinet configuration that supported two workstations, the Series 2000 was a single or dual processor system that supported up to six workstations while the Series 170 was a low-cost single workstation system introduced in September 1982. Calma provided high resolution (1280 by 1024) color and monochromatic workstations plus a low resolution (640 by 512) color unit. Calma's typical workstation had two displays, one for graphics information and one for alphanumeric data. The exception was the Series 170 which utilized a single screen configuration. The typical Series 1000 and Series 2000 system

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8 Petre, Peter, "How GE bobbled the factory of the future," *Fortune*, November 11, 1985, Pg. 52
9 *Anderson Report*, December 1981, pg. 2
10 *Anderson Report*, September 1982, pg. 3
11 *Computer Aided Design Report*, October 1986, Pg. 14
12 Calma press release, December 1, 1981

sold for about $125,000 per seat not including a plotter output device while the 170 was priced just under $100,000..

The DDM software included optional modules for finite element modeling, solids modeling and plastic injection mold design and analysis. The solids module used a boundary representation technique that created models compatible with existing DDM databases. The company also tried to blend its mechanical and electronics activities together to some extent by introducing DDM/PC, a software package that supported printed circuit board design using the same data base that was used by DDM for mechanical design.

In addition to its dominating position in the electronics CAD market and a growing involvement in the mechanical sector, Calma was also pushing ahead in the AEC market, especially in regards to process plant design. The company's primary product in this area, initially released in 1981, was called Dimension III. This was the production version of what had earlier been called CADEC. Release 2 of the Dimension III software began shipping in early 1982. It included automated piping design based upon user input of pipe specifications and routing.

In mid-1982, the Dimension III product suite was expanded with packages such as electrical schematics, including the generation of signal net lists and from-to reports, civil site preparation, general mapping and steel layout, design and detailing. Although the company offered two-dimensional architecture and facilities layout programs called Calma-Draft Architecture and Calma-Draft Facilities Layout, Calma never pursued the pure architectural design and drafting market with any vigor.

Figure 11.4
Calma Dimension III Systems – Rich Tate, Calma Applications Engineer

The microelectronics portion of the product line continued to use the overall GDS nomenclature. Specific applications included CARDS for printed circuit board design and analysis. It incorporated design rule checking, interactive routing and support for up to 64 layers. A subsequent version called CARDSII added hybrid circuit design capabilities. CHIPS was the comparable software for the geometric design of integrated circuits while STICKS was the company's first attempt to develop a symbolic design methodology for VLSI circuits. STICKS was subsequently renamed CustomPlus. The company was an early user of Apollo workstations which when combined with a logic design system called CIRCUITS, sold for $75,000.

One area where Calma was an industry pioneer was in the use of voice recognition for the entry of user commands. Introduced in 1980, it initially required the use of Calma's Vector Memory Display (VMD). With the availability of GDS II Release 4.0, voice input was available with all Calma raster terminals. The early voice recognition system had a vocabulary of 100 commands. Few organizations ended up using this technology, however. In 1982, Calma also introduced its first communication networking package called CalmaNet which could link together a variety of systems and applications.

In the fall of 1982 Calma's sales force was still operating independently of GE but *The Anderson Report* expected GE to raise the level of contact these sales people had among its customers. In its September 1982 edition, the newsletter stated:

> "The rate of growth in the microelectronics area is slowing but Calma is well positioned with DDM based products to take advantage of the high growth in the mechanical application. We predict GE/Calma will be the first or second ranked supplier of turnkey CAD/CAM systems by the end of the decade. IBM has more sales muscle but GE is better positioned in terms of products for the automated factory."[13]

Bob Benders initially stayed on as president of Calma under GE and the R&D budget doubled to 25 percent of revenue.

Early signs of problems

In early 1983, Jim Girand left to join Wietek and Ken Tisovec became vice president of sales. Then in April 1983, Calma announced what would be become a continuing series of staff reductions. It was just 40 employees but the move was not a good sign. At the same time, Bob Benders resigned as president of the company he had headed for nearly 15 years. Benders was replaced as president in March 1983 by Robert Smuland, a 25-year GE veteran. Like Schlumberger and its Applicon subsidiary, GE seemed to believe that any experienced executive could manage a company such as Calma even though that person was new to a rapidly changing high tech industry.

In fairly short order, an entire new management team was recruited from other GE divisions including:

- Dr. Mark Baron as vice president of research and development (from GE's Microelectronic Center),
- Dr. Charles Cheeseman as vice president of marketing and product management (from GE's Electronics Systems Division),

[13] *Anderson Report*, September 1982, pg. 6

- George Senn as vice president of operations and product support (from GE's Nuclear Control and Instrumentation Department),
- Gerald Knudson as vice president of sales (from GE's Medical Systems Operations) and
- Richard Overholtzer as vice president of finance (from GE's Nuclear Business Group).

If anything, this team was probably overqualified for managing a subsidiary the size of Calma. In addition, they had little experience with CAD technology and the commercial software industry. Lief Rosqvist, who had moved to the U. S. in 1982 from Sweden to be Calma's vice president of marketing was switched to vice president of business planning and development. Not every new executive came from within GE. David Richards was hired away from Arrigoni Computer Graphics to head up the company's AEC business unit. Other key individuals were Jerry Devere who was now running the San Diego software development operation in place of David Albert and Dr. Malcolm Davies who was vice president of the AEC products group and would later leave and become a senior executive at Autodesk.

Calma's product line becomes more complicated

June 1983 saw Calma re-emphasizing its commitment to Data General hardware when it announced that GDS II would be supported on DG's Eclipse S280 minicomputer. Calma's nomenclature for this machine was the P 4280. The situation became somewhat clouded in September 1983 when Calma added the TEGAS suite of electronics CAE software after its acquisition of CGIS, an engineering subsidiary of Communications Satellite Corporation (COMSAT) located in Austin, Texas for $14 million. TEGAS ran on Apollo workstations which Calma was already using to support some of its mechanical design and schematic capture software packages. Around the same time, Calma established an R&D group called Calma Advanced Systems in Troy, New York at Rensselaer Polytechnic Institute. It is interesting to note that GE's primary technology center for the "factory of the future" was just a few miles away in Schenectady.

In the hardware area, Calma made another major change in direction and signed an OEM agreement with Ramtek worth $20 million over a period of several years for that company's 2020 color raster displays. Calma had been using Lexidata graphics hardware for its raster terminals and would continue to do so for several more years as it phased in the Ramtek products. The Apollo portion of the company's product line was called the D 3200 Series. It encompassed three types of nodes, S (Standard), D (Distribution) and P (Peripheral). The latter two were basically server nodes. Because much of Calma's software was written to support separate graphics and alphanumeric displays, the D 3200 S nodes included a separate alphanumeric display.

According to Dataquest, Calma's revenue in 1983 was $210 million of which $105 million was mechanical, $82 million was electronics and $23 million was AEC. Over half the mechanical revenue and a significant portion of the electronics revenue came from sales to other GE divisions. Revenues for 1984 were expected to be in the range of $250 million.[14] In reality, 1984's revenues ended up being essentially flat or

[14] Personal notes dated November 19, 1984

down somewhat compared to 1983 and 1983 may well have been the company's high water mark.[15]

The relationship between GE, Calma, SDRC and the jointly owned CAE International was confusing at best to outside observers. At the National Design Engineering Show in Chicago in March 1984, Calma and CAE International announced a jointly developed mechanical CAE software product based upon SDRC's I-DEAS modeling and analysis software including SDRC's GEOMOD solids modeler. A direct translator between the two product lines was promised for delivery in October while IGES translators were scheduled for release in May. Starting in 1985, Calma began selling another SDRC software package, GEODRAW, which enabled users to directly dimension and annotate solid models created in GEOMOD. There was no bi-directional associativity in that changes made in GEODRAW were not reflected in the source GEOMOD model.

This software was available on both VAX and Apollo hardware. The plan contemplated that designs developed in GEOMOD could be transferred to Calma's DDM system for detailed design and documentation while SDRC's analysis software would be used to evaluate these designs. The CAE International software was sold either bundled or unbundled while Calma's DDM software continued to be sold only bundled with computer and graphics hardware. In addition to the plans for tying the software from the two firms more closely together, it was also announced that a single sales organization would replace the previously independent CAE International and Calma sales forces focused on the mechanical market. The word was that this latter move was directly in response to input from Jack Welch.[16]

New relationship with IBM

In 1983 Calma began discussing with IBM the possible use of the latter's computers as the database management element of its systems. According to Dr. Charles Cheesman, Calma's vice president of marketing and product management, "Now, because of new technology, it's time for engineering to link in the analysis programs and to do background processing (whether analysis or data base management). That takes a big, husky CPU."[17] In June 1984 Calma announced that it would resell IBM's 4300 Series computers together with Calma software for data management applications. This was similar to an agreement Computervision had with IBM for the same type of application.

Later in 1984 Calma expanded its European operation by buying a 108,000 square-foot facility near Dublin, Ireland that had originally been built for Trilogy Ltd., the Gene Amdahl company that had planned to build computers using wafer-scale integrated circuits.

The fall of 1984 also saw the introduction of new DDM software for generating families of parts. The new software was called Parametric Analysis Level (PAL) and worked in conjunction with DDM's DAL software. To generate a family of parts the user first designed a sample DDM part with the PAL software engaged. PAL recorded a DDM

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[15] *Computer Aided Design Report*, December 1984, Pg. 9

[16] Vinton, Bob, "GE's CAEI/Calma Opns. Introduce Turnkey System," *Electronic News*, April 2, 1984, Pg. 79

[17] Unfortunately, I was unable to find the source of this quote

session and created a variable table that listed widths, lengths, thicknesses and other key dimensions. After completion of the sample part, the PAL recording was converted into a DAL program.

When the user needed a new part, this DAL program would be initiated, values entered for the variable dimension and the DAL program executed to generate the desired part. Although similar DAL programs could be created directly by users, PAL did not require knowledge of DAL programming, making it a more efficient technique that could be used by any DDM knowledgeable user. PAL was initially available on DEC VAX and Data General systems in early 1985 and was priced at $17,500 including installation and training.

In November 1984 Smuland was replaced as president of Calma by a former IBM executive, Dr. Daniel McGlaughlin. McGlaughlin, who had been recruited by GE several years earlier. He had been vice president of corporate information systems at GE prior to being assigned responsibility to run Calma. Smuland moved over to GE's Marine and Industrial Engines and Service Division as vice president and general manager.

At the same time as the management change, the company reduced its workforce by 15 percent or 305 employees. While Smuland had reported directly to Don Grierson, a new organizational structure was put in place which had McGlauglin reporting to a newly-established Calma board of directors made up of five senior GE executives. It's chairman was Edward Hood, Jr., the vice chairman of GE, who reported directly to Jack Welch. McGlaughlin had an excellent background to head Calma with a Ph.D. in electrical engineering from Case-Western Reserve University and 24 years of experience at IBM.

Overview of Calma's product line in late 1984[18]

In late 1984, Calma was offering software for three markets, electronics, mechanical and AEC. As described elsewhere, the primary electronics package was GDS II which still ran on Data General computers. The GDS II software suite included CHIPS (IC design), CARDS (PCB design) and STICKS (IC conceptual design). The TEGAS logic simulation software ran on Apollo workstations. DDM was targeted at the mechanical market while Dimension III was the AEC product.

Calma provided three computer platforms. The Series D was based on Apollo workstations. At this point in time, just the DN460 and DN660 machines were supported. The Series P consisted of Data General ECLIPSE computers while the Series C systems were DEC VAX machines. Each of these product lines consisted of a core module referred to as the System Base Group or SBG. To this was added various peripheral devices and in the case of the Data General and DEC computers, graphic terminals.

A variety of monochromatic and color terminals were available. By late 1984, workstations with both a graphics display and an alphanumeric display, the RB-1010 and the RC-1010, were being phased out and were being replaced with single screen units, the CDS-70X and the CDS-80X. The latter units were powered by Motorola 68000 microprocessors and were equipped with 1280 by 1024 monitors. An Ethernet capability called CALMANET was available to link all these different systems together. During this period it was never clear as to which was the preferred platform although it was obvious

[18] Based on author's personal notes

that the Data General portion of the product line had a very limited future. It seemed as if Calma was willing to simply let the customer chose between Apollo and DEC hardware.

DDM software was being sold in four versions, DDM-100 for drafting, DDM-200 for design, DDM-300 for manufacturing and DDM-400 for schematics. Perhaps this package's strongest feature was its DAL language which impressed even the company's competitors. DDM/Solids was no longer being marketed. Instead SDRC's GEOMOD software was the primary solids modeling package pushed by Calma. The company was also pushing a data management package developed by SDRC called Data Management Control System (DMCS). This software would later morph into SDRC's Metaphase (See Chapter 17). Dimension III was basically DDM software with AEC extensions written mostly in DAL. These applications included piping design, electrical schematics, steel detailing, etc.

A new mechanical system built around a solids modeling core was under development by the company's San Diego software operation under the guidance of Devere. Other developments included a new workstation using a Ramtek 2020 display, a factory floor communications network GE was jointly developing with Ungermann-Bass, a personal computer-based system and a new data management system to replace DMCS.

A typical color Apollo DN660 workstation with DDM or Dimension III software had a list price $67,500. Data General systems started at $170,000 while a VAX 11/780 system cost over $500,000. CDS-80X color workstations for the latter two types of systems were $60,000 while monochromatic CDS-70X units were $40,000 each.

Start/Stop business momentum

Although GE had acquired Calma primarily to drive the factory of the future, the company was starting to make significant strides with its AEC products. Calma won a major competitive order for Dimension III systems from Ingalls Shipyard in Pascagoula, Mississippi, signed a multi-year contract with Fluor Corporation and sold a $2.7 million system to Chicago's Commonwealth Edison. The company continued to invest in developing its plant design technology including signing an agreement with Imperial Chemical Industries to market ISOGEN, an software solution for creating isometric piping diagrams although it was mid-1986 before Calma actually began shipping an ISOGEN-based package.[19] In late 1985, the company signed a $7.8 million deal with China National Import Corporation for 60 Apollo-based Dimension III systems to be used at13 locations for modernizing power and process facilities.

Early 1985 saw Calma begin to respond to the market demand for updated GDS II systems. A 32-bit GDS II workstation incorporating Data General's MV-4000 computer and a Lexidata color display was introduced in January. Called the GDS II/32, it was priced at $95,000, 30 percent less than the list price of the older system it was intended to replace. This was not a stand-alone system – it required connection to an existing 16-bit GDS II system for background tasks such as plotting.[20]

In April 1985 Calma pulled out of the NCGA Conference in Dallas and the show floor space was used by SDRC and GE/CAE. About the same time, Welch approved a $100 million cash infusion in Calma with specific instructions to become the number two

[19] Calma press release, June 24, 1986
[20] *Computer Aided Design Report*, February 1985, Pg. 13

company in the CAD industry or at worst number three and to do so within three years. It never happened.

To expand its mechanical market coverage, Calma introduced a sheet metal package that could be used with existing assembly modeling software. What was really confusing, however, was the previously mentioned plan to market SDRC's GEODRAW, a two-dimensional drafting package that supported GEOMOD solid models. This was clearly competitive with DDM drafting software.

By the fall of 1985, Calma was aggressively pushing the Apollo portion of its product line. Virtually all of its software packages except for GDS II were available on these workstations including DDM, Dimension III, TEGAStation and T-BOARDS. While competitors such as Auto-trol Technology were promoting Apollo's lower cost systems, Calma emphasized the high-end DN660. Systems based on this color workstation were priced between $72,000 and $112,000 per seat.[21] By mid-1985 the company had installed a total of 1,600 systems of all types at 800 customer sites. The typical system probably had an average of four to six seats meaning that there were somewhere between 6,400 and 9,600 Calma users worldwide.

After going through the major layoff in late 1984 and another one in the spring of 1985, Calma surprised most of the industry a few months later in August 1985 with the announcement that it was going to increase its R&D organization by 50 percent and in the process hire 200 engineers by the first quarter of 1986. At the time, approximately 450 of Calma's 1,800 employees were engaged in product development activities. Most of the existing R&D staff was located at either corporate headquarters in Milpitas, at a software development facility in San Diego or at a facility in Austin, Texas. Calma also had access to GE's corporate research facility as well as other divisional research laboratory's throughout the company. In the 1985 time frame, GE in total spent over $2.1 billion annually on research and development.

Trying to get Calma back on track

The early part of 1986 may have represented a highpoint in GE's attempt to get Calma back on track. *The Anderson Report* described quite clearly in its February 1986 issue how GE had stumbled with its acquisition of Calma.

> "GE clearly over estimated the market for 'the factory of the future.' Buyers were not willing to risk major changes that could cripple production lines if the changes didn't work.[22] Although GE is a leading technology company, they did not understand the CAD/CAM business. In a traditional manufacturing operation, if you throw more money in, more product comes out the end. Not so in high tech. GE provided plenty of money, but not computer savvy managers. As a result the technical staff at Calma was decimated." [23]

[21] Calma press release, September 19, 1985

[22] The same comment was made 15 years later by many analysts who commented on the collapse of the e-commerce boom in 2000.

[23] *The Anderson Report*, February 1986, pg. 3

It took some time, but McGlaughlin was starting to have a positive impact on the company. He hired Stuart Elder from IBM to take over research and development activities and by early 1986 had hired half of the new 200 engineers mentioned above. McGlaughlin was also working hard to control costs. He had reduced headcount from 2,400 employees to about 1,600 and the company's revenues were holding steady at a little over $200 million.

Electronics products continues to struggle

The biggest problem at Calma was that its market share in the electronics-related area was slipping and was showing signs that it would continue to deteriorate. From 45 percent of the company's business in 1984, it shrunk to 35 percent in 1985. While the company still had a 70 percent share of the integrated circuit layout business, that market was quickly shifting to a new generation of CAE technology. Calma was critically slow in reacting to the change in technology, possibly because of GE's focus on the mechanical manufacturing market. Another negative factor was that the automated testing of integrated circuits was taking on increased importance. Systems that incorporated logical definitions of such circuits were more able to provide information for testing than graphics-centered solutions such as Calma's GDS II could.

In early 1984 the company announced the Apollo-based TEGAStation that incorporated software it had acquired the prior year from Communications Satellite Corporation. Both Apollo DN300 and the DN420 systems were offered. TEGAStation consisted of over a dozen application packages for schematic capture, simulation, test and analysis at prices ranging from $25,000 to $90,000. The company also introduced a new printed circuit board package called T-BOARDS. Unfortunately, it eventually proved to be too little too late. The GDS II system, which was the heart of the company's electronics product line, was available just on Data General computers and that platform was rapidly falling out of favor with high tech users who preferred the new generation of UNIX workstations from companies such as Apollo and Sun Microsystems.

In addition to the problem of platform inconsistency, Calma had to overcome the fact that its primary competitors in the electronics market were no longer the traditional turnkey CAD systems manufacturers such as Computervision and Applicon. The new competition was companies such as Mentor Graphics and Cadence that had two advantages – they were pure software plays and did not have the need to support an expensive hardware design and manufacturing infrastructure and this was the only market they were interested in.

The latter factor cannot be over-emphasized. At Calma, as was the case at other companies pursuing multiple markets, there typically was a constant debate over which market to allocate resources to, whether for product development or sales and marketing. At Mentor Graphics and Cadence, there was no such debate – the resources were directed at the needs of the electronics market without question. It is interesting to note that when these companies were first launched, their software packages did not handle the physical layout of integrated circuits. Rather, they produced input for Calma's GDS II software which continued to handle those functions for many users.

By 1986 GDS II and related applications were finally available on Digital VAX systems in addition to the Data General computers which had been supported since the early 1970s. The 32-bit version was referred to as GDS II/32. See Figure 11.5. One of the more interesting hardware components offered by the company was an optional attached processor called the Fast Mask Engine or FME. This unit was designed to handle specific design tasks such as design rule checking and integrated circuit mask resizing. The FME was developed by Silicon Solution Corporation of Menlo Park, California working on an exclusive agreement with Calma. The basic FME hardware started out in May 1984 with just 750 KB of memory and a 80 MB disk. It was subsequently upgraded to a system consisting of a Motorola 68010 microprocessor, 125 MB of main memory and a 160 MB disk drive. The FME could exchange data with a GDS II system either through an on-line direct link or off-line using magnetic tape as the exchange medium.

In September 1985 a new subsystem was added to the FME that used multiple 68020 microprocessors that further reduced the time it took to do complex integrated circuit analyses. In mid-1986 an updated version of this device was introduced that communicated with a GDS II/32 system via an Ethernet connection. The FME performed design and electrical rule checking five to ten times faster than a dedicated VAX 11/780. It also was able to handle plotting about four times faster.[24]

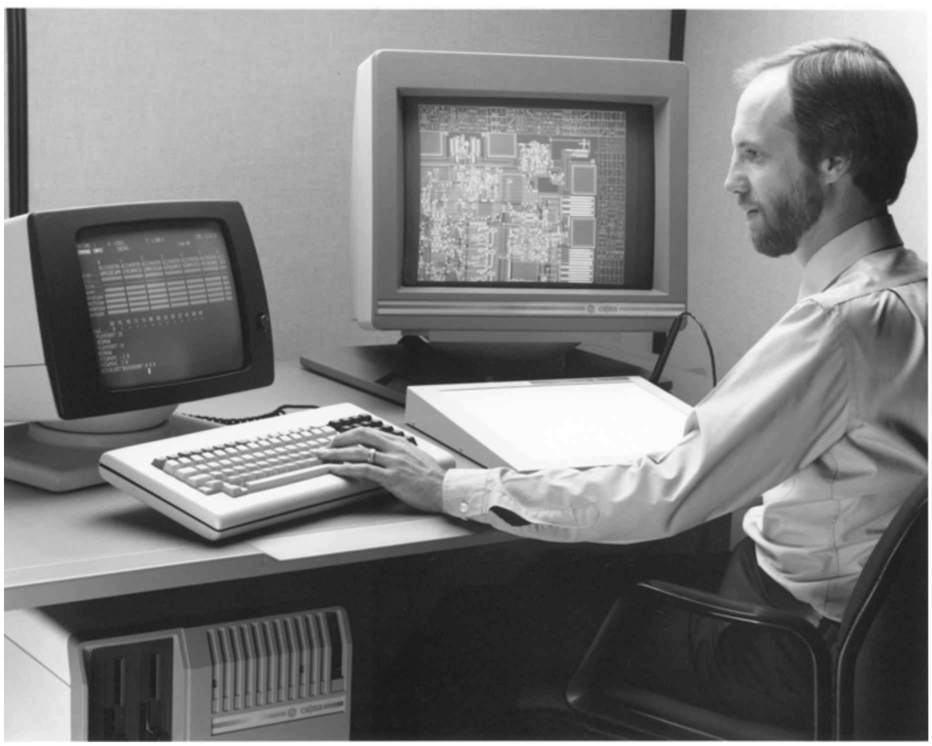

Figure 11.5
GDS II/32 System

Calma also expanded the use of Apollo workstations to support its electronic software. In addition to TEGAStation, the company introduced the BOARD Series of printed circuit board engineering and design products in July 1986. There were three packages in this series: BOARD Designer, BOARD Editor Plus and BOARD Expeditor. BOARD Designer was a comprehensive schematic capture, placement, routing and

[24] Calma press release, July 31, 1986

manufacturing output solution while BOARD Editor Plus provided the same capabilities less the routing and manufacturing output. The latter package was specifically intended to be used on low-cost workstations such as the Apollo DN3000C. BOARD Expeditor was a high-performance routing node for handling large complex boards. The BOARD Series was also supported on the Apollo DN660.

Figure 11.6
Calma BOARDS Series Running on Apollo DN3000

As the semiconductor design industry was moving away from manual circuit layout to more automated techniques, GE's R&D Center in Schenectady, NY developed an advanced silicon compiler. At an IEEE Solid State Circuits Conference in February 1987, Dr. Sharbel Noujaim described how this software was used to design two CMOS devices in three working days. One device contained 35,000 transistors while the other contained 15,000. GE claimed that other software techniques would have taken six to eight months and manual procedures a year. It is not clear if this software was ever commercialized by Calma.

Calma's mechanical products mature

Although Calma was not taking the mechanical market by storm, sales of its DDM software were slowly edging up. By 1985 this sector represented over $100 million in revenue for the company although it is not clear how much of this business represented the resale of SDRC solids modeling and analysis software. DDM software was being supported on DEC VAX and MicroVAX hardware as well as on Apollo workstations. Prices ranged from about $58,000 to $90,000 per seat. A MicroVAX II implementation of DDM was introduced in October 1985 with a two-seat configuration selling for under $150,000. These systems included a new graphics terminal, the GPS100. At the same time, SDRC's I-DEAS and Calma's Dimension III were made available on this platform.

Calma also introduced a PC/AT system capable of handling two-dimensional drafting tasks in October 1985. Called DraftStation, it could extract model data from larger DDM systems and handle drafting-type tasks. The software was developed for Calma by IBM's Boulder, Colorado laboratory, the same group that developed IBM's FastDraft product. DraftStation cost $27,450 for a complete hardware and software configuration.

The hardware consisted of an Intel 80286 PC/AT with 512KB of memory, a math co-processor, a 20MB disk, a high-resolution (1024 by 1024) 19-inch display, a 32-bit graphics processor and a tablet. Other IBM-compatible peripherals could be added as well as Hewlett-Packard 7000 Series plotters. The DOS 3.1-based software contained a fairly comprehensive set of drafting functions including the ability to execute Boolean operations on geometric entities and import text such as a bill-of-material information from a word processing system.

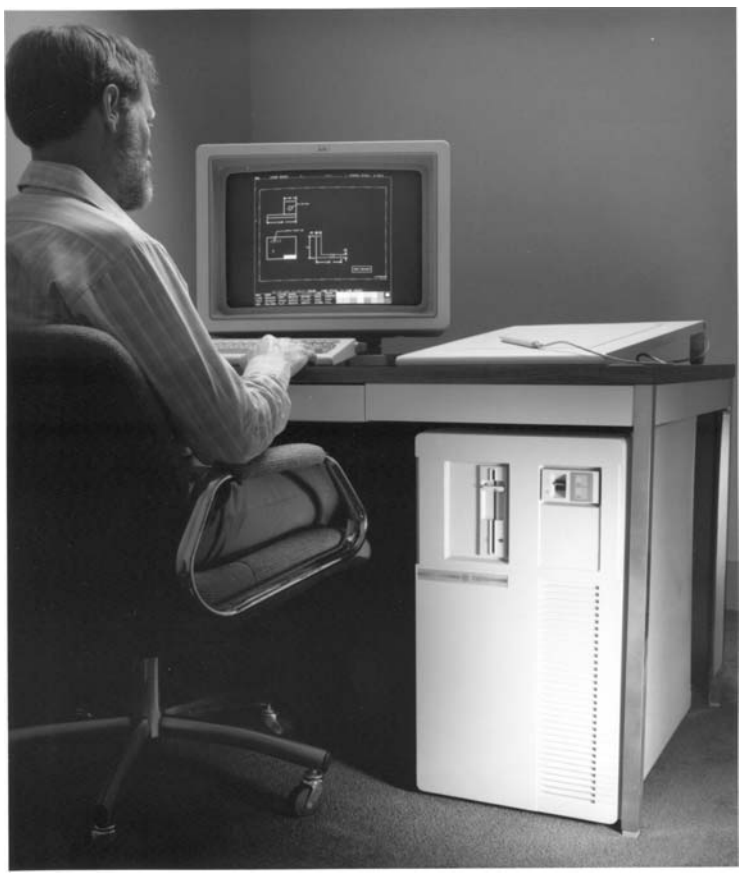

Figure 11.7
PC/AT-Based DraftStation

It is not clear why this system was promoted predominately as a mechanical drafting system and not as a low-cost AEC or electrical schematic design system also.

Calma pushed the idea that the DraftStation software could be learned in as little as a week and that formal classes were not necessary. In addition to Calma's own sales force, DraftStation was sold by General Electric Supply Company's (GESCO) 700-person sales force. Although it appears to have had greater functionality than Autodesk's AutoCAD had at the time, it also cost more than twice as much for a complete system. Calma realized this disparity fairly quickly and about six months after DraftStation began shipping it reduced the system price for a new higher speed configuration to $21,950. The new system used PCs with Intel's new 8-MHz processor rather than the 6-MHz device used initially.

Around the same time, Calma published a report that compared manual drafting with a popular software package (presumed to be AutoCAD) and DraftStation. The report showed that in the hands of an experienced user, DraftStation was about four times as productive as manual drafting and about three times as productive as an advanced AutoCAD user. Calma also claimed that DraftStation required much less training. Whether or not these statistics were accurate, the less expensive AutoCAD product still significantly outsold DraftStation.

Figure 11.8
Dimension III Running on Apollo DN3000

The surprise at the time was probably the company's AEC business which represented close to $30 million in revenue in 1985. Dimension III was available on the same platforms as DDM and was priced comparably.[25] In June 1986, the Dimension III software was ported to the Apollo DN3000 workstation. Because the software had originally been developed for Calma's dual screen workstations, a secondary alphanumeric terminal was needed to run this software on the DN3000 as shown in Figure 11.8. Towards the end of 1986, Calma won a $19.5 million order from the U.S.

[25] *The Anderson Report*, February 1986, pg. 3

Bureau of Reclamation in Denver for 51 MicroVAX systems supporting 95 workstations. This probably represented the high point of the company's AEC business.

Other GE divisions continued to target the graphics market. One example was the company's Silicon Systems Technology Department in Research Triangle Park, North Carolina. In May 1986 it introduced the Graphicon 700, a high-performance three-dimension graphics processor that performed over 30 million floating point operations per second. It could render about 13,000 polygons per second using a 1280 by 1024 display with a 16-bit Z buffer and up to 16 MB of local memory. The Graphicon 700 was priced at $65,900 without a CRT monitor or about $33,000 in quantities of 100.

Calma Launches New Version of DDM

In September 1986 Calma introduced a new version of DDM called the Prism/DDM system. This was essentially version 3.0 of DDM. The most significant enhancement was the incorporation of a CSG (Constructive Solid Geometry) solids modeler in the basic Prism/DDM software. Once a model was completed the software created a boundary representation of the data from which surface and wireframe versions could be derived. This information, along with various types of attribute data was stored in a double precision database. The incorporation of basic solids modeling capabilities in Calma's own product was not intended to negate the companies previously established relationship with SDRC for integration of the latter company's design and analysis software with DDM. Prism/DDM also sported a new user interface that utilized a combination of new on-screen menus together with prior user interface features.

The new solids capability was incorporated into Prism/DDM's NC capabilities. The software's Interactive Tool Path module enabled a user to define tool paths, feed speeds, etc. and see the results of these decisions on the machining of the part. The software simulated tool movements using a color visualization representation of the solid model with the removed material highlighted. The intent was provide tools that would enable the NC programmer to optimize the NC operation while avoiding problems such as gouges, differences from the original model and collisions with tooling fixtures.

The machining visualization software was developed at GE's R&D Center in Schenectady, NY by Dr. Weiping Wang. Initially, the software was only available on systems using the Graphicon 700 terminal. It was early 1988 before the package was available on standard Apollo and DEC workstations.[26] The same GE organization also developed a sheet metal verification program called SHEETS.

Prism/DDM was offered on the same VAX and Apollo platforms as was the earlier version of DDM with the exception that the MicroVAX II version supported GE's new Graphicon 700 display system. The list price for the software was $29,000 per seat. A three seat Prism/DDM system using a MicroVAX II and conventional Calma graphics terminals sold for $69,000 per seat while the same configuration with the Graphicon 700 sold for $91,500 per seat. Apollo based systems sold for $51,800 to $78,500 per seat.

Treading water and then sale to Valid and Prime

After the launch of Prism/DDM, Calma went about trying to establish some market momentum without much success. In March 1987 the company laid off 25 people at its San Diego research facility while at the same time hiring more sales people. The

[26] Calma press release, March 31, 1988

company stated that it was cutting back on internal hardware development since it planned to increasingly depend on GE's Silicon Systems Division for that technology. The company also killed a database management project code named "Genus" with the comment that it would use DBMS products from other sources.[27] In May of that year the company introduced a "project walk through" software package for the Dimension III AEC market utilizing the Graphicon 700 display. This application was priced at $50,000 for both the display hardware and the walk through software.

In August 1987 Calma segmented its Prism/DDM software into seven functional modules with prices ranging from $2,500 to $10,000 per module. The seven modules were Prism/Draft, 3-D Modeling, Surfacing, Sub Modeling, DAL, DAL/Fortran, and Hidden Line. The entire suite sold for $27,900. An Apollo DN3000 system with just drafting software was priced under $25,500 as compared to the company's previous starting price of $56,000. The objective was to be able to compete more effectively with other companies that were unbundling their software. Similar unbundled prices were also established for Dimension III software.

By late 1987 it was becoming obvious that Calma was unlikely to become a dominating player in the CAD/CAM industry. Employee headcount had dropped to 900 and revenue was down to $180 million in 1987. The company lost about $26 million in 1986 and $20 million in 1987 according to *The Anderson Report*.[28] While Calma was making some progress with its mechanical and AEC product lines, its electronics business was under tremendous pressure from Daisy, Mentor Graphics and Valid Logic.

The Data General-based GDS II software might have had a cult-like following within the semiconductor industry, but fewer and fewer IC products were being designed using the techniques implemented in this system. The company still claimed that as of late 1987, over 70 percent of all integrated circuits ever developed had been designed using GDS II technology. That was probably accurate but totally irrelevant considering how fast design technology was changing.

On September 15, 1987 Calma announced EDS III which was an extension of its older GDS II/32 integrated circuit physical layout software. A key aspect of this announcement was the fact that the package, written in the C programming language, was to be available on Sun, Apollo and DEC workstations. Sun was rapidly becoming the preferred design platform in the electronics industry and although Calma utilized over 40 Sun workstations internally for software development this was the first software product the company offered on that platform.

As well as selling turnkey EDS III systems, Calma planned to sell this software unbundled. The EDS III system incorporated new design management tools that could access legacy GDS II data files. Calma began shipping EDS III in January 1988 but customer acceptance was slow to get off the ground. The electronics sector, under senior vice president Bruce Gregory, now represented just 25 percent of Calma's business or about the same portion as its Dimension III AEC business.

On top of its faltering electronics business, Calma was also in the midst of making the transition from being a graphics hardware manufacturer to a software business. Every company that went through the same transition had tremendous difficulties – financial, sales, marketing, engineering and personnel management. Calma was no exception – it

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[27] *Computer Aided Design Report*, March 1987, Pg. 10
[28] *The Anderson Report*, march 1988, Pg. 3

just happened to hit the wall earlier than Applicon, Auto-trol, Computervision or Intergraph. By March 1988, rumors were starting to swirl that GE might be ready sell the company. According to McGlaughlin, "The company is taking a proactive role in looking for synergistic relationships."[29]

In April 1988, GE began breaking up Calma. It sold the electronics portion of the company's product line, which had about $40 million in annual revenues in 1987 and about 2,700 users, to Valid Logic. By comparison, Valid had revenues of $67 million in 1987 and over 4,500 users. After reviewing the company's financial statements, industry analysts concluded that Valid had paid only about $3 million for Calma's electronic design product line.[30]

The party line was that Calma would now focus on just the mechanical and AEC markets. That position didn't last very long. On October 18, 1988, GE announced that it was selling what was left of Calma to Prime Computer which had acquired Computervision earlier in 1988. While Calma had done about $90 million in mechanical CAD business in 1987, its 1988 revenue in this area had plunged to no more than $50 million according to Daratech's Charles Foundyller. Based upon the analysis of the Valid deal, Prime probably did not pay very much for what was left of Calma. When GE wanted out of something, it just wanted out.

As part of the deal, Prime became a preferred vendor within GE. The actual sale was consummated in January 1989. Little work subsequently went into enhancing Prism/DDM and its related applications and over the next several years customers either switched to Computervision's CADDS software or Medusa or changed vendors and went with competitors including Parametric Technology Corporation, McAuto or Applicon.

Dimension III, on the other hand, seemed to have nine lives. It survived the Prime acquisition, the eventual resurrection of Computervision and even PTC's acquisition of Computervision. Although it was not enhanced to any significant extent, Dimension III stayed in use at a number of customer sites such as Ingalls Shipbuilding well into the late 1990s.

After the Prime acquisition of what was left of Calma, McGlaughlin went to work for Equifax, initially to head up their IT activity. He eventually became president and CEO in 1996 and held that position until January 1998.

[29] *The Anderson Report*, March 1988, pg. 3
[30] *Computer Aided Design Report*, November 1988, Pg. 9