

Chapter 10

Bentley Systems Incorporated

Author's note: While in other chapters, individuals are typically referred to by their last names, in this chapter the five Bentley brothers are referred to by their first names. The term "Bentley" refers to the company, not an individual. I periodically acted as a consultant to Bentley Systems Incorporated from 1994 through 2003. Portions of this chapter are based on that personal experience.

One of Intergraph's major customers in the early 1980s was DuPont's engineering department in Wilmington, Delaware. Keith Bentley had gone to work at DuPont after receiving a BS in electrical engineering from the University of Delaware and an MS from the University of Florida. DuPont was using its Intergraph systems for producing electrical diagrams for its process plants. Usage, however, was limited by the high per seat cost of adding more capacity.

Keith believed there was a lower cost alternative and set out on his own time to develop a software package called PseudoStation that enabled a user to access Intergraph's CAD software from a low-cost DEC VT-100 terminal equipped with a graphics card or a Tektronix storage tube terminal. PseudoStation proved to be particularly cost effective when DuPont designers wanted to simply make changes to existing drawings such as changing some text on a drawing.

In 1983, Keith left DuPont to work with his brother Barry in California at a company called Dynamic Solutions. Before leaving DuPont, Keith negotiated an agreement with the company under which he received marketing rights to the software in return for which he would provide technical support to the company's PseudoStation users. On the way to California, Keith stopped in Huntsville and offered the software to Intergraph. According to Keith, "I would have sold [PseudoStation] to Intergraph for \$5,000, and that would have been that. [That I didn't] is one of a series of lucky coincidences....."¹ The software was first shown publicly at an Intergraph users meeting in Huntsville in 1983 after Keith joined Dynamic Solutions.

Los Angeles had a large number of Intergraph installations and soon Keith and Barry found a receptive audience for PseudoStation. Keith founded Bentley Systems Incorporated to continue development work on the software and arranged to have Dynamic Solutions market the package in exchange for work he did on the latter company's software. Actual sales of PseudoStation began in June 1984.

At this point, Keith became convinced that what Intergraph was doing on a VAX, he could do on a IBM PC/AT. This new version of the software was soon known as MicroStation and was shown on a Compaq 286 at an Intergraph users meeting in Orlando, Florida in the Spring of 1985.² Soon Keith and Barry sold their interest in Dynamic Solutions and relocated back to Pennsylvania, initially to Philadelphia, then Lionville and subsequently to Exton. By then they had sold 350 copies of the terminal-based PseudoStation. Scott Bentley joined BSI to handle the business end of the company and he was subsequently joined by a fourth brother, Ray Bentley.

¹ Solomon, R. E., "Those fabulous Bentley Brothers, MicroStation's building blocks," *MicroStation Manager*, June 1992, Pg. 76

² *A-E-C Automation Newsletter*, August/September 1989, Pg.13

In January 1987 Intergraph purchased a 50 percent interest in Bentley Systems for \$3 million and announced that MicroStation would be marketed on both UNIX and PC platforms. A four-person board of directors was established with Intergraph having two seats on the board and Keith and Barry Bentley having the other two. One problem with this arrangement was that each party owned exactly 50 percent of the business and had half the board seats. Many joint ventures split something like 49/51 so that there is a clear controlling interest. This would prove to be a problem for Bentley a few years later.

By mid-1989, there were multiple versions of MicroStation being sold:³

- MicroStation PC for DOS-based personal computers.
- MicroStation MAC for the Apple Macintosh II workstation.
- MicroStation 32 for UNIX workstations including those produced by Intergraph.
- MicroStation GIS, also for 32-bit Unix workstations.

An OS/2 version of MicroStation was also developed, primarily at the request of a Midwestern DOT. According to Keith the company spent more money on development with less return in revenue than on any other project. It is not clear if this DOT ever used the OS/2 version of the software.⁴

MicroStation's primary attractiveness for the Intergraph user community was its close mirroring of Intergraph's IGDS command structure. As stated by Dr. Joel Orr:

“...If you are familiar with IGDS, you will feel completely at home with MicroStation. In fact, you will probably be amazed at the completeness of MicroStation's implementation of IGDS.” Orr went on, however, to critique the software's user interface. “If you never worked with IGDS, Microstation's human interface takes some getting used to. The system is designed for production. You can sketch, design, play around with it, but its primary features are speed, power, and ease of use (contrasted with ease of learning).”⁵

At this point in time, numerous industry observers such as Ed Forrest believed that the Apple Macintosh was the machine of the future, especially for architects and engineers because of its user interface. According to Forrest:

“MicroStation Mac software is a new, original, popularly-priced, high performer for the model-design-draft automation field. Nothing I know of at this point comes close. The software behaves as if the Macintosh was designed exclusively for it; while the Macintosh acts as if a software worthy of its capabilities as a 'humanized' engineering workstation is finally here.”⁶

At the time, MS-DOS PC and UNIX workstation interfaces were keyboard intensive compared to the mouse-driven Macintosh. Porting MicroStation to the

³ *A-E-C Automation Newsletter*, August/September 1989, Pg.13

⁴ Interview with Keith Bentley, June 29, 2006

⁵ *A-E-C Automation Newsletter*, August/September 1989, Pg.19

⁶ *A-E-C Automation Newsletter*, August/September 1989, Pg.20

Macintosh appeared to be a smart move at the time. This market never really took off, however, mainly because Apple never put adequate marketing and hardware development resources behind it. One potential problem for Bentley was the company's plan to install hardware locks for the Macintosh version of its software at a time when customers were reacting adversely to similar plans coming from other software vendors.

By the summer of 1989, 20,000 copies of MicroStation were in use. Its price at the time was \$3,000, comparable to AutoCAD. MicroStation was subsequently ported to the HP 700 series of engineering workstations in early 1992 as well as other UNIX machines.

Bentley takes on the appearance of a real company

Once Intergraph began selling Bentley's MicroStation software in 1987, Bentley basically stayed in the background, focused on software development. The company spent little effort creating media awareness of Bentley as a business entity. This began to change in the summer of 1992. Shortly after that year's A/E/C SYSTEMS conference, Bentley invited representatives of most of the publications covering the CAD industry to the company's headquarters in Exton, Pennsylvania. Although some Intergraph executives were there, the event was fundamentally run by Bentley employees and managers.

The company was very open about its plans for future software products in spite of the fact that several editors for AutoCAD-centric publications were present. At the time, there was no indication that the tight relationship between Intergraph and Bentley would blow up within two years. Bentley executives led by Keith Bentley, made it clear, however, that AutoCAD was seen as the primary competitive product.

1992 also marked the point at which Bentley began to focus more intently on co-existing with AutoCAD. The company added the capability to MicroStation to directly import AutoCAD .dwg files using the Marcomp AutoDirect toolkit. Marcomp was a small software company that specialized in reverse engineering the .dwg file format. It was subsequently acquired by Visio in 1997. Called AutoCAD Access, it was packaged with several other MicroStation enhancements as a no-cost upgrade for existing MicroStation Release 4 users. Bentley and Intergraph referred to this upgrade as MicroStation Nexus.

Further indication that Bentley was increasingly focused on competing with Autodesk was the company's support of a book that targeted AutoCAD users who were making the transition to MicroStation. Titled *MicroStation for AutoCAD Users*, it was written by Frank Conforti and Ralph Grabowski. The next step occurred when Intergraph initiated a trade-in program for AutoCAD users. For \$500 per license turned in customers would receive a copy of MicroStation, MicroStation Nexus and the book.

In 1992, Intergraph sold \$79 million worth of MicroStation. Mid-1993 saw the launch of MicroStation Version 5. This release, priced at \$3,790, involved a substantial amount of development effort that resulted in the following major enhancements:

- The porting of the software to Windows NT on Intel platforms with a support commitment for Intergraph's Windows NT implementation of NT on Clipper workstation that were expected later in 1993.
- The ability to write .dwg files as well as read them.

- User interface enhancements including the capability to group customization features in “workspace shells” for different users and applications.
- Hypertext-based on-line user documentation.
- Drafting enhancements including associative hatching and persistent geometric constraints.
- Composite vector and raster documents along with raster editing capabilities.
- New surface modeling features including expanded use of NURBS surfaces.
- Improved visualization tools including pattern mapping.

At this point in time, I felt that for the money, MicroStation was a better buy than the then current version of AutoCAD.⁷

Bentley splits from Intergraph

By 1992, Intergraph executives began to realize that the nature of its business was starting to change. Up until that point, MicroStation was a tool that helped Intergraph sell large integrated systems. Overall, this one software package made up only a moderate portion of the total dollar revenue of a typical system sale. Hardware, application software and services made up far more. Intergraph primarily saw its competition being other large systems vendors such as Computervision, IBM and EDS/Unigraphics.

The future for Intergraph, however, appeared to be more software focused as the handwriting was on the wall that hardware was going to be a smaller piece of the company’s business – not immediately but probably within a few years. In that scenario, MicroStation would become a significantly larger piece of Intergraph’s business but it only controlled 50 percent of Bentley. At that point, Intergraph approached the Bentleys about acquiring the portion of the company it did not own.

According to Keith, the amount Intergraph offered was far below what he felt the business was worth. His response was: “If that is all you think the company is worth, why not sell us your 50 percent interest at that price?”⁸ Intergraph declined the counter offer and threatened to compete directly with Bentley with new technology it would develop, presumably its new Jupiter technology as described in Chapter 14. Bentley’s counter was that if Intergraph offered a competitive product, then the exclusivity clause in the original marketing agreement would be null and void and that Bentley would market MicroStation independent of Intergraph.

Intergraph believed that it was in a commanding position since most MicroStation users were its customers and its sales force was in close contact with these organizations. In 1993 the differences between the two companies reached the point where they decided it would be best for each to go its separate way. Discussions over how best to do this continued for several months but by early 1994 it was no longer a secret within the industry that the two companies would be parting company.

Like most divorces, this one was not particularly pretty. The announcement was made at Intergraph’s Spring 1994 user group meeting, IGUG. At earlier Intergraph user

⁷ *Engineering Automation Report*, August 1993, Pg. 3

⁸ Interview with Keith Bentley, June 29, 2006

group meetings, Bentley personnel were frequently involved in presentations and demonstrations of new software. In 1994 the company was pointedly not represented. Instead, Bentley set up product demonstrations in a vacant shopping center a short distance away from IGUG that the company called “MicroStation Mall.”

A number of software vendors who competed with Intergraph for applications business and hardware vendors joined Bentley at the mall. During his IGUG Keynote, Jim Meadlock, Intergraph’s president and CEO, announced the new arrangement between the two companies. Meadlock pointed out that Intergraph would retain its 50 percent interest in Bentley except the company’s board of directors would be expanded to five individuals and that Greg Bentley, who had recently joined Bentley, would join the board. That effectively gave the Bentley brothers control over the jointly owned company.

A key aspect of the agreement between the two companies called for Bentley to take over all marketing and sales responsibilities for MicroStation effective January 1, 1995. Intergraph would continue to resell MicroStation and was expected to be the primary distribution channel for this software for the foreseeable future. Dealers would obtain MicroStation directly from Bentley and Intergraph applications from that company.

The expectation was that there would quickly be a growing number of MicroStation applications available from independent software firms. Although this did happen, it never took on the dimensions that it did at Autodesk. A major concern among users was the perceived lack of a single point of contact in the future. Intergraph countered by stating that it would continue to support all hardware and software it sold.

The excitement among Bentley personnel at IGUG was very high. They believed that on January 1, 1995, Bentley would be like a new startup, except one with 150,000 users, a quality product and a 110-person development and support organization.⁹

Establishing a real software business

For ten years Keith and his brothers only had to worry about developing software. Now they had to put together a real company in a matter of months that would take on sales, marketing and support of MicroStation. When Greg Bentley joined the company in 1994, he brought with him some valuable experience running a software company. Previously he had built Devon Systems into a successful vendor of financial analysis software for the investment community.

As head of distribution he set out to establish a value-added reseller (VAR) organization. To handle this task, Bentley hired Warren Winterbottom who had held the same position at Intergraph until about a year earlier. Within a year the company had signed up 135 VARs in North America as well as many in foreign countries. In addition to Winterbottom, Bentley hired a number of Intergraph employees who had been involved in the marketing and support of MicroStation while working for Intergraph including Jean-Baptiste Monnier, Dick Fox and Brad Workman. Other new hires from other companies included Yoav Etiel (ISICAD), Peter Brooks (ANSYS) and Rebecca Ward (CADCentre).

Fairly quickly Bentley organized itself into three operating units:

⁹ *Engineering Automation Report*, June 1994, Pg. 2

- A development group under Keith that also included Barry and Ray as well as Steve Knipmeyer as vice president of software development. Interestingly, Eitel and his product marketing activity was placed within this group rather than the distribution organization.
- A distribution group under Greg with Winterbottom running North America and Fox responsible for Europe.
- An operations and services group under Scott.

Bentley set out to make its distribution organization different from Autodesk's. Whereas Autodesk had multiple dealers in a given geographic area competing with each other, Bentley intended to have fewer dealers who could focus on competing with the AutoCAD resellers rather than other MicroStation dealers. Also, there would no longer be restricted accounts. Bentley's dealers could compete directly with Intergraph's sales force wherever they wished.

With Autodesk clearly identified as the company's primary competitor (eventually Intergraph would be placed in the same category), Bentley set out to differentiate itself. While Autodesk prided itself in the number of third party software developers it had, Bentley made it clear that it planned to work with a limited number of strategic partners.

The company also began to emphasize the direct support of users. AutoCAD customers were required to contact their local reseller for support. Bentley, on the other hand, had established a Comprehensive Support Program (CSP) several years earlier and wanted its employees, even developers, to be in touch with users. Bentley was publicly on the record as stating that it planned to continue supporting multiple platforms including the Macintosh and a variety of UNIX platforms. Autodesk, meanwhile, was quickly becoming a Windows only vendor.

Software development was a two-prong affair. Some applications were being developed by strategic partners as described below while other programs were being developed in-house. The internally developed software included:

- **MicroStation Modeler** – a solids modeling package initially intended for mechanical design that was built on Spatial Technology's ACIS geometric kernel. Bentley had begun demonstrating this package in early 1994 and began shipping it, including thin shell parts and assembly management, in early 1995.
- **MicroStation PowerDraft** – a lower cost version of MicroStation intended for production drafting users who did not need all the design capabilities in MicroStation. PowerDraft, which began shipping in the spring of 1995, had a list price of \$1,950. Bentley stated that it saw PowerDraft as competing directly with AutoCAD, not with AutoCAD LT. It included a BASIC user development capability for the development of customer applications.
- **MicroStation Review** – an easy-to-use package for redlining and revising MicroStation drawings. This package also sold for \$1,950.
- **MicroStation Masterpiece** – a visualization package that incorporated ray tracing and radiosity tools. It was licensed from Spotlight Graphics, a company run by Peter Segal, which was subsequently acquired by Bentley. Masterpiece sold for \$1,450.

Bentley also committed to maintaining support for MicroStation on Apple platforms with the announcement in early 1995 that a version of the software optimized for the Power Macintosh (using the Power microprocessor jointly developed with IBM and Motorola) would be available within a few months.

Within a year from the announcement that it was going separate ways from Intergraph, Bentley had grown to 275 employees, and 350 resellers worldwide and had nearly \$100 million in annual revenues. The company claimed that over 500 independent software companies were developing MicroStation applications.

Internally, the focus was on implementing object-oriented technology. This was being done in two steps. The first was to add object technology to the MicroStation Development Language (in reality, much of MicroStation was written in MDL). This was initially called Objective MDL and subsequently renamed ProActiveM. The next step was to add object technology to MicroStation itself, resulting in Objective MicroStation. The terminology for this latter package was subsequently changed to ProActiveM VM where VM stood for Virtual Machine.

The original plan was to release a preliminary version of the object-oriented software to external developers later in 1995 and a user version in mid-1996. The programming effort turned out to be far more complex than originally contemplated and these products were subsequently replaced by MicroStation J as described below. Bentley also joined an industry initiative, the Design & Modeling Applications Council (DMAC), that was set up to work with Microsoft in adding three-dimensional extensions to Windows Object Linking and Embedding (OLE) technology.

It became somewhat clearer by mid-1995 that Intergraph's development of its new Jupiter technology as described in Chapter 14 was a significant contributing factor to the breakup between the two companies. This was partially because key Bentley individuals such as Keith had not been invited to participate in defining the new Intergraph technology. The conclusion they came to was that Intergraph was developing Jupiter in order to eliminate the need for MicroStation to support its applications. At Intergraph's IGUG meeting in Huntsville in May 1995, it was obvious that the split between the two companies was far from friendly. During his keynote address, Jim Meadlock included Bentley in a list of Intergraph competitors and there was virtually no mention of MicroStation during the talk.

Later that afternoon, Bentley invited IGUG attendees to hear its side of the story at an off-site meeting held on the University of Alabama campus. Greg Bentley, by now the company's chairman, laid out the issues that were driving the two companies farther and farther apart. The bottom line was that Bentley felt that Intergraph's focus on Jupiter would eventually eliminate the need for MicroStation. Since most of the current MicroStation based applications had been developed by Intergraph and would eventually be replaced by Jupiter applications, Bentley was faced with the task of either developing replacing applications itself or finding third party software firms interested in doing so. A few such applications were demonstrated at the 1995 IGUG meeting but it was obvious that Bentley had its work cut out. This friction between the two companies led to a number of lawsuits that would drag on for years.

At the same time, Bentley began to aggressively push its Comprehensive Support Program (CSP) which distinguished it from Autodesk. CSP provided software upgrades as part of the service, the same service that customers received from large turnkey

vendors as part of their maintenance contracts. By April 1995, 20,000 MicroStation licenses out of a total of 170,000 were covered by CSP agreements. This number would escalate rapidly in coming years.

Bentley's moves into the application arena

Once Bentley established its independence from Intergraph, the company set out to become a vendor of a broad range of graphic and data management applications rather than just a vendor of basic CAD software. At the time, Autodesk was also making the same moves. Bentley took a two prong approach to establishing a position in the application area. On one hand, the company began building up its internal development staff while on the other hand, it established a number of "strategic relationships" with a group of independent software firms between 1994 and 1996.

Jacobus Technology – One of the first such strategic relationships was with Jacobus Technology of Gaithersburg, Maryland. Jacobus was a developer of process plant design and visualization software founded in 1991 by Alton (Buddy) Cleveland, Vern Francisco, Chet Tabaka and Jerry King, all of whom previously worked at Bechtel, the global engineering and construction company. While at Bechtel, primarily with the company's Power Division in Gaithersburg, they had developed a plant design package tailored to Bechtel's specific needs, 3DM, and a visualization package, Walkthru.

Cleveland, who would eventually become a senior executive at Bentley, graduated from John Hopkins University in 1972 with a degree in operations research. After several years developing engineering analysis software for Bechtel he was given the task of installing the first CAD system at Bechtel's Gaithersburg office in 1980 - an Intergraph IGDS system that used a DEC PDP 11/70 computer. 3DM was developed about the same time that Intergraph was working on its Plant Design System (PDS). The intent was to develop software that was more tailored to Bechtel's needs and was less complex than PDS. Walkthru followed a few years later. The significance of these developments was demonstrated by the fact that Cleveland was appointed a Bechtel Fellow, a fairly significant honor.

Like many other companies, Bechtel felt that it could generate some incremental revenue by selling internally developed software on the open market. Bechtel Software Incorporated was established to do this with 3DM and Walkthru but was never very successful and ended up just selling the software in special situations. When Bechtel decided not to fund further development of these packages, the individuals listed above established Jacobus.

The new company's product strategy was to use object-oriented software technology to create basic plant design technology it called JSpace and then to build task-specific applications around this core. Initially, the plan was to work with both Autodesk and Bentley. The company grew slowly over the next few years. An interference detection package that worked with both MicroStation and AutoCAD was released in mid-1992.

The initial core of JSpace was completed in 1993 and several applications were subsequently added including JT/ID for interference detection and JSpace Viewer for animation and visualization. These were followed by JSpace Vantage, a low cost model review and query package, and JSpace Vista which extended the Vantage package into more of an information delivery and decision support system. The company provided

underlying technology to software vendors such as Rebis as well completed products to end-user organizations including Bechtel, DuPont and Rust Engineering.¹⁰

In late 1994 Bentley made a minority investment in Jacobus (approximately 25 percent) and the company became a “strategic affiliate.” Supposedly, this was not intended to be an exclusive relationship but fairly soon it became such. By early 1997, Bentley had made additional investments in Jacobus and held a majority interest in the company. Rebecca Ward moved over from Bentley to Jacobus as vice president of strategic accounts.

WorkPlace Systems – This activity started off as a joint venture between Bentley and Primavera Systems. The intent was to offer life-cycle solutions for facility asset management using software from these two companies as well as technology and consulting services from a European company, Opti Inter-Consult, which was an earlier Bentley subsidiary. George Church, who had previously been with Intergraph, was president of WorkPlace Systems while Tuomo Parjanen, the former head of Opti Inter-Consult managed WorkPlace’s European operations.

GEOPAK – The AEC software industry is full of examples where an architectural or engineering firm created software for their own use, recognized that it had general value and began to sell the software to other A&E firms. Few have been successful, primarily because they never realized that the software business is a lot different than running an A&E firm.

GEOPAK which was in North Miami Beach, Florida at the time was a clear exception. It was established in 1984 by Beiswenger, Hoch, and Associates to develop and market civil engineering software for Intergraph IGDS systems. One of the company’s first software efforts was a program for calculating right-of-way geometry. The software was called GEOPAK for Geometry Package and the name stuck.

In 1990, it was set up as a separate company, but still sharing facilities with Beiswenger, Hoch, and Associates. The result of this close relationship was that a programmer working on a new GEOPAK software feature could simply walk down the hall and talk to several project engineers to get their opinion as to the best way of doing the particular task in question.

The company was run by Gabe Norona, whose father, Francisco Norona, was the president of Beiswenger, Hoch, and Associates. As MicroStation replaced IGDS as Intergraph’s primary graphics systems, GEOPAK’s focus shifted also. Norona realized that the PC would soon become the primary computer platform in the civil engineering market and began focusing GEOPAK’s development efforts on that version of MicroStation. By 1995, GEOPAK was a serious alternative to Intergraph’s InRoads civil engineering software and Bentley quickly struck a deal with Norona for GEOPAK to become a strategic affiliate.

The GEOPAK software covered a broad spectrum of civil engineering applications including digital terrain modeling, survey, roadway design, site design, bridge design, drainage, reinforced concrete design and construction management.¹¹

BRICS – BRICS was a Belgium developer of architectural software that Bentley also acquired a minority interest in. BRICS had developed an architectural modeling package that formed the basis for Bentley’s TriForma product. This relationship did not

¹⁰ *A-E-C Automation Newsletter*, December 1994, Pg. 2

¹¹ *A-E-C Automation Newsletter*, August 1997, Pg. 6

pan out and Bentley eventually gave back its interest in the company in exchange for the source code to the architectural software. In the late 1990s Brics became a provider of Internet-based information management solutions in addition to its architectural software and changed its name to Bricsnet. It lasted for a few years before failing during the Dot Com bust.

NetSpace Systems – This was a wholly owned Bentley subsidiary located in Huntsville that was responsible for marketing mapping and asset management software to the utility and telecom industries.¹² It initially had about 30 employees and was headed by Andrew Coe. Early software products built on top of MicroStation GeoGraphics included ESpace and GSpace for the electric and gas distribution industries.¹³

Bentley’s “Coming Out Party”

At the A/E/C SYSTEMS ’95 conference in Atlanta, Georgia, Bentley came across as a major player in the AEC CAD industry with a show presence comparable to that of Autodesk and Intergraph. In fact, company employees talked about this as being the company’s “coming out party.” Bentley garnered a substantial amount of attention with giveaways, a design competition and a 1995 Ford Probe door prize.

It turns out that up until this conference, Greg Bentley and Jim Meadlock had never actually met. Carl Howk, the publisher of *A-E-C Automation Newsletter* at the time, relates how he walk over to Greg at the Bentley booth and asked Greg to come with him. The two proceeded over to the Intergraph booth where Howk introduced the two and claims that they actually had an amicable chat.¹⁴

This conference was also marked by the announcement of a three-way deal between Bechtel, Jacobus and Bentley under which Jacobus acquired rights to previously mentioned 3DM and WalkThru packages developed by Bechtel. In turn, Bechtel received rights to future Jacobus software products and Bentley became the distribution channel for Jacobus software. Bechtel also agreed to standardize on MicroStation and to purchase \$2 million of Bentley products over the next three years.¹⁵

Bentley begins building a document management business

By mid-1996, it was obvious that managing CAD data would eventually become nearly as important as creating it in the first place. Bentley’s first step in this direction consisted of two packages. TeamMate operated as an integral part of MicroStation and was available to users whenever MicroStation was loaded. OfficeMate, on the other hand, was a standalone version of TeamMate that could access files on its own and could be used to manage non-MicroStation files as well as MicroStation files. An important characteristic of this software was that the programs were able to manage reference files including symbols and text fonts linked to the drawing files being viewed.

In a keynote address at A/E/C SYSTEMS ’96, Keith emphasized the pending impact the Internet would have on the design community. During the keynote he

¹² *A-E-C Automation Newsletter*, December 1996, Pg.12

¹³ While most software companies that offered geospatial packages referred to this market as GIS for Geographic Information Systems, Bentley tended to call it Geoengineering it that the company saw it as a blend of CAD, geographic and data management technologies.

¹⁴ Personal conversation, January 2005

¹⁵ *A-E-C Automation Newsletter*, June 1995, Pg.10

demonstrated the ability of MicroStation to access component data over the Internet, insert the data into a drawing file and then manipulate that data as if it had been created locally. The tool for doing this was called Engineering Links.¹⁶

Around this time there were the first rumblings that Intergraph wanted to divest itself of its share of Bentley. The company announced that it had retained an investment banker, Robinson-Humphrey of Atlanta, to establish a value for its interest in Bentley and possibly find a buyer. Nothing came of this effort. As described below, Bentley would eventually file for a public offering and then withdraw that filing due to unfavorable market conditions.

The product line matures

In the fall of 1996, Bentley began packaging combinations of Bentley and third-party software modules in industry specific bundles using the “Engineering Office” nomenclature. The first four of such bundles and their prices were GeoEngineering (\$7,250), Mechanical (\$5,995), Building Design (\$5,995) and Plant (\$7,995). The Mechanical Engineering Office included MicroStation Modeler, TeamMate, MasterPiece, SRAC’s COSMOS/M PowerDesigner, MDI’s ADAMS/MS Motion and Baystate Technologies DRAFT-PAK.

It was also around the same time that Bentley launched Bentley SELECT, a support and software subscription service that effectively replaced the previously described CSP program. One aspect of the SELECT program allowed customers to lease Bentley software for periods as short as three months. This was particularly attractive to architectural and engineering firms whose workloads fluctuated as new projects were initiated.¹⁷

In late 1996, the company held a symposium on ProActive Engineering in Orlando, Florida to which it invited senior managers from companies using MicroStation. Nearly 400 showed up. Discussions focused on issues such as increasing enterprise productivity rather than focusing on just personal productivity and how networking was no longer an ancillary function but was the key element around which systems of the future would be built. Bentley used the symposium to announce a suite of enterprise-oriented software products collectively referred to as the “Engineering Back Office.” The centerpiece of this strategy was a new line of middleware programs called “ModelServer.”

The implementation of the ModelServer strategy was predicated on a three tier software architecture. The presentation layer was the interactive software most visible to the user, the application layer was the software that manipulated design data and the storage layer consisted of the file and database programs that managed the data. The assumption was that changes could be made to software in one layer without having to modify software in the other layers.

Initially there were three ModelServer software products:

¹⁶ Around this time, Bentley’s marketing department began generating a large number of conflicting names for various Bentley software products and services. As an example, one aspect of the previously mentioned Objective MicroStation was a tool called ProActiveM that enabled a component vendor to include programs for manipulating the company’s component data. More than once I asked the company to produce a guide that would help analysts and writers keep these different names straight.

¹⁷ *Engineering Automation Report*, October 1996, Pg. 12

ModelServer Publisher – This server-based software converted MicroStation and AutoCAD files to a Web-based format that could be viewed by standard Web browsers such as Netscape and Internet Explorer. The receiving computer did not need a copy of MicroStation or AutoCAD to view these images. Another key characteristic of this software was that the drawing images produced by ModelServer Publisher could not be modified by the person viewing them. There were two versions of this software – a single active user version that incorporated Netscape’s FastTrack Server and sold for \$9,995 and a multi-user version that incorporated Netscape’s Enterprise Server and sold for \$24,995.

ModelServer Continuum – MicroStation users could store both graphical and non-graphical information in a relational database and then extract applicable data to meet the needs of a specific work session. When the user was through making changes to the data, ModelServer Continuum would then update the database with the changed data. A typical application using this software was MicroStation GeoGraphics. Rather than developing this program entirely in-house, Bentley took advantage of Oracle’s Spatial Data Option to provide some of the capabilities in Geographics. A beta test version began shipping in April 1997.

ModelServer TeamMate – The TeamMate product described earlier was a file based solution. ModelServer TeamMate was a server based implementation that supported both MicroStation and AutoCAD documents.

Bentley planned to publish Application Programming Interfaces (APIs) for each of the ModelServer applications in a specification known as Open Engineering Connectivity.¹⁸

Bentley matures as a company

By 1997, Bentley was doing \$160 to \$170 million in annual revenue with Intergraph representing just 13 percent of the company’s sales.¹⁹ At A/E/C SYSTEMS ’97 in Philadelphia, Keith Bentley participated in a joint keynote address with Jim Meadlock, Intergraph’s CEO, and Carol Bartz, Autodesk’s CEO. The key Bentley announcement was that the company was working on a Java-enhanced version of MicroStation to be known as MicroStation J. The intent was to create object-oriented software that would be less platform dependent than existing packages were. In effect, a Java enabled version of MDL called JMDL was developed and MicroStation/J replaced the previously described work on Objective MicroStation (subsequently renamed ProActiveM VM).

A key part of the plan involved licensing the Java Virtual Machine source code from Sun Microsystems so that a Java virtual machine could be built directly in MicroStation. Bentley’s new schedule was to have MicroStation/J and Java-based applications in the hands of users during the first quarter of 1998. Meanwhile the company continued to make incremental enhancements to the basic MicroStation program and a wide range of industry-specific applications.

Like most complex software projects, this one took longer than expected and Bentley eventually released MicroStation/J in the latter part of 1998. Not only did this version of MicroStation incorporate Java technology, it also implemented the Parasolid

¹⁸ *A-E-C Automation Newsletter*, December 1996, Pg.12

¹⁹ *A-E-C Automation Newsletter*, October 1997, Pg. 4

solid geometry kernel. A significant difference between traditional Java applets and those written in JMDL was that the JMDL applets could work with persistent data. Java typically did not store objects on the client machine. Therefore, it was difficult to write Java programs that created and managed large models. By using JMDL, the data, as well as the procedures incorporated into an applet, became part of the design database. This database could then be stored locally or on a server, but, most importantly, it did not require access to the server from which the applet was originally obtained.

MicroStation/J also included raster editing capabilities from HMR (another company Bentley had invested in), the ability to obtain symbology over the Web and insert it into drawings and models, surfacing of three-dimensional models, improved item selection, the ability to produce three dimensional views with edges highlighted, improved photorealistic shading speed and a wide variety of data exchange routines. For \$4,795 a customer not only received MicroStation itself but also one of five application packages the company called Engineering Configurations; TriForma, Modeler, GeoGraphics, CivilPAK or Schematics.

New applications begin to flow

Bentley seemed to shift into a higher gear towards the end of 1997 with new products being introduced at an accelerated pace. In December 1997, Bentley acquired the remainder of Jacobus which it did not already own and Jacobus became a wholly owned subsidiary. PlantSpace encompassed two groups of software products, programs that could be used to manage plant design software whether that design data was created with Jacobus software or not and programs for designing process plants. Most of this software was developed using the company's JSpace object-oriented software technology.

PlantSpace Enterprise Navigator converted plant design data from multiple sources into a common database that could then be displayed using a variety of viewing packages. Fairly powerful navigation tools were provided so that a user could view a section of the plant or a particular process line that ran throughout the plant. PlantSpace Interference Manager enabled users to perform interference detection even where the data was created by a variety of different design systems. Another package was called PlantSpace Schedule Simulator. It worked with project planning software such as Primavera's Project Planner and Microsoft's Project to visualize the actual construction sequence of a project. There were other PlantSpace software products based on JSpace that help user organization manage plant design information.

The PlantSpace design packages covered the full spectrum of plant design applications including a database-oriented P&ID product, piping design, pipe support design, equipment layout, structural, HVAC and electrical raceways. Most of these packages sold for \$3,000 per copy or less. A complete plant design suite of software packages could be put together at a fairly reasonable cost.²⁰

A new term began to be used by Bentley in the fall of 1997. At its second ProActive Engineering Symposium, this time held in Palm Springs, California, the company emphasized the "Bentley Continuum" to approximately 500 attendees. This was a far more comprehensive idea than the way the term was used in regards to the previously mentioned ModelServer Continuum. In effect, it described a cooperative

²⁰ *A-E-C Automation Newsletter*, February 1998, Pg. 6

working relationship between technology vendors and technology users that could potentially help these users stay ahead of their competitors. This symposium was followed up a few months later by a similar meeting in Rome, Italy.

About the same time, Bentley announced that it was replacing the ACIS geometric kernel in MicroStation Modeler with Parasolid from EDS due to performance and functional shortcomings with ACIS. The plan was to add Parasolid capabilities to MicroStation itself, not just to the Modeler product.

In late 1997, Bentley announced a new SELECT release of MicroStation called MicroStation SE. It incorporated digital signatures, photorealistic rendering, raster image viewing and other capabilities that previously were extra cost options. MicroStation SE was only available to SELECT clients and new customers. If existing users wanted this upgrade they had to sign up as SELECT customers.

Bentley also added a new strategic affiliate, HMR. This company was a developer of raster editing software including a program called Descartes. HMR's Image Manager software was a component of the newly released MicroStation SE software.²¹ The HMR software fit in well with Bentley's efforts to expand its presence in the mapping market. At this time, Jean-Baptiste Monnier was vice president of geoengineering products at Bentley. The company initiated a series of annual symposiums covering its mapping technology at the Keystone Resort in Colorado.

One of the major problems facing users of this technology at the time was the lack of top management support among user organizations. I was a speaker at one of these symposiums and remember asking the attendees "How many of your top executives understand what it is you are trying to do?" and having just one hand in an audience of several hundred go up. The Bentley's credit, over the next several years the company invested heavily in trying to get the message out to the executive management of the companies it served.

In the area of architectural design, the company's new flagship product was MicroStation TriForma, a three-dimensional building modeling application first introduced in April 1996. By mid-1998, this software was in its third release, incorporated the Parasolid geometric kernel and was slowly gaining acceptance among architects around the world. Architects, in general, were having a more difficult time moving from drawing-centric design to model-centric design than were their mechanical engineering counterparts. Brad Workman, was Bentley's vice president of building engineering products at the time.

The GEOPAK portion of the company's product line was also maturing rapidly. Of the 45 state highway departments using MicroStation in the spring of 1999, 15 were also using GEOPAK as compared to 21 who were using Intergraph's InRoads software. GEOPAK was increasingly being used to design complex facilities such as the highway interchange shown in Figure 10.1.²²

²¹ *A-E-C Automation Newsletter*, December 1997, Pg. 14

²² *A-E-C Automation Newsletter*, May 1999, Pg. 6



Figure 10.1

Palm Beach International Airport Interchange designed by Belswenger, Hoch & Associates using GEOPAK

A new concept in data management

ProjectBank, announced in late 1998, was a new Bentley technology initiative that was intended to enable multiple individuals to work on the same engineering model, record the history of all changes made to these models and even enable a project to integrate MicroStation and AutoCAD models in a single database. At the company's Proactive Engineering Symposium in Philadelphia that year, Keith Bentley spent nearly his entire 90 minute keynote describing how ProjectBank worked and its benefits.

Most of the then current design packages allowed collaboration at a file level, where individual components or information within each file could be used by just one individual at a time. Other users were effectively "locked out" from making changes to the model until it was released by the first user. Although there were some products on the market that informed other project participants when a file relevant to their work was changed, there were few tools that allowed collaboration at a component level within a file or set of files and enforced synchronization of changes to these components.

One of the underlying technical problems was that design data was typically stored in files and most software was set up to work with entire files. When one person checked out a file for modification, all other users were locked out until the file was checked back in. With ProjectBank, several users were able to simultaneously work on the same files at the same time. The software warned them whenever their individual work interfered with what someone else was doing. A key aspect of this software was its ability to create a list of all actions made on a design project. It tracked information

associated with each transaction including the user name, the date and time, a description of the change and exactly what the change was. If a project manager was trying to understand why a change was made, it was possible to unwind the project back to a particular point in time. It was much like having a web browser forward and back button on the design software.²³

ProjectBank Server was the server-level software that controlled access to a ProjectBank. One of the key characteristics of this software, which differentiated it from more traditional relational databases, was that the ProjectBank Server tracked the changes that were made to each component, who made them, and what other components were affected by these changes. Changes were basically tracked as individual "transactions."

Using a transaction-oriented project management methodology provided a number of advantages including rolling back a design to an earlier stage, marking project milestones and archiving the design at particular points in time. Since these transactions were stored at the component level, users could go back and review all of the changes that were made to a particular part in a mechanical assembly or a manufacturing cell on a factory floor, who made them, and, hopefully, why the changes were made.

ProjectBank was expected to go into beta testing in early 1999 and to be available as a released product later that year. It was not intended to be a separate product but rather, an extension of MicroStation/J. As with most complex software projects, things did not move as fast as expected nor did customers accept this new concept as quickly as Bentley had hoped. The software was finally released in March 2000 except that it only supported MicroStation. AutoCAD support was still off in the future. The changes Autodesk made to file structures in AutoCAD 2000 did not help the situation. *A-E-C Automation Newsletter* commented on the difficulty Autodesk and Bentley were having working with each other's data:

“That brings us to an interesting subject. Would it be beneficial for Autodesk and Bentley to cooperate on exchanging internal AutoCAD and MicroStation file formats rather than treating them as confidential intellectual property? Granted, the two companies are fierce competitors, but they both spend considerable effort reverse engineering each other's data. If this manpower could be put to work on creating new applications solutions, it would benefit both companies and the user community, many of whom use both packages.”²⁴

ProjectBank as a stand-alone product eventually was incorporated into MicroStation and was subsequently known as “Design History.”

Transportation management

In mid-1997, Bentley purchased the specific portions of Graphic Data Systems Corporation (GDS) that were associated with intelligent transportation systems from Convergent Group. See Chapter 19. Together with GEOPAK, Bentley established a new affiliate called GEOPAK Transportation Management Systems Inc. (GEOPAK-TMS).

²³ *A-E-C Automation Newsletter*, July 1999, Pg. 3

²⁴ *A-E-C Automation Newsletter*, April 2000, Pg. 4

The president of this new company was Ray Pittman who had been associated with GDS since the early 1980s when it was a McDonnell-Douglas product.

Initially, Bentley envisioned pursuing a broad range of intelligent transportation activities including real-time roadway and traffic monitoring, analysis, display and permitting/routing as well as inventory management. In succeeding years, the company's efforts increasingly focused on the routing and permitting of oversize and overweight vehicles.²⁵

Bringing the strategic affiliates in-house

By early 1999, Bentley had grown to over 900 employees and had over 300,000 copies of MicroStation in use worldwide. Equally impressive was the fact that two-thirds of these users were covered by SELECT agreements. After an infusion of outside cash in Bentley, Intergraph, which by now represented only five percent of Bentley's revenue stream, owned just 40 percent of the company. With six or seven different Strategic Selling teams and a number of strategic affiliates, management of the company was starting to become unwieldy. Bentley reorganized its internal operations into two basic activities, Model Engineering and Geoengineering and brought several of the previously mentioned affiliates in-house.

Model Engineering incorporated the company's TriForma, PlantSpace and MicroStation Modeler products. As part of this move, the company's Jacobus affiliate was incorporated into the Bentley organization and Buddy Cleveland, the president of Jacobus, became a senior vice president at Bentley in charge of the Model Engineering business unit. This restructuring also resulted in the de-emphasizing the company's earlier interest on the mechanical design market. Modeler was repositioned as software to be used in conjunction with plant and manufacturing facility design. Bentley not only provided the software for designing a process plant but also provided the software needed to design specialized equipment.

Geoengineering continued under senior vice president Jean-Baptise Monnier but now also included former affiliates NetSpace and GEOPAK Transportation. Workplace Systems remained an independent unit as did two partially owned affiliates, HMR and GEOPAK. Corporate marketing continued to be the responsibility of Yoav Etiel.

ProjectWise - A new generation of information management tools

Tracking Bentley's nomenclature for its information management products can try a man's soul. As described above, Bentley introduced its initial version of TeamMate, a client-server approach to document management, in 1996. This software formed the basis of ActiveAsset Manager, a three-tier product, introduced in 1997 by the company's strategic affiliate, WorkPlace Systems. This in turn led to Bentley's introduction of its ModelServer family of project engineering IT tools which formed the basis for ProjectWise.

In January 1998, Bentley introduced ProjectWise, a pre-configured engineering information management solution which enabled users to quick start the implementation of data management software. Then, in June 1999, the company launched ProjectWise Release 2.2, a more robust version of the software together with an enhanced set of deployment services. In addition, Bentley announced that advanced ProjectBank features

²⁵ *A-E-C Automation Newsletter*, August 1997, Pg. 8

including the ability to “version” and “difference” different designs, the AutoCAD schema, support for cascading ProjectBanks, and access control would all be delivered via ProjectWise.

ProjectWise managed MicroStation files, files created with MicroStation applications such as TriForma and GeoGraphics, AutoCAD files, Microsoft Office files (Word, Excel and PowerPoint), and other corporate information. These documents were stored in their native formats in a central server or on distributed servers. Users did not need to know where a particular document was stored since the system understood how to find it. When an architectural or engineering design file was accessed, the system also knew which reference documents were attached to that file and accessed those documents as well.

ProjectWise initially came in two flavors: Extranet which enabled team members around the globe to access secure project data and WorkGroup which was designed for project teams where all the individuals were part of a single organization. The major difference was that the WorkGroup version was not Web enabled to the extent that the Extranet version was. Surprisingly, Bentley chose to use Sybase database management software to support ProjectWise. Prices started at \$19,500 for the WorkGroup version and \$50,000 for the Extranet version.

It should be pointed out that during 1999 and 2000, there was a tremendous amount of interest in developing Internet based solutions for managing AEC project data. Companies sprang up left and right and venture capitalists invested over \$500 million in startups such as BidCOM, Blueline Online, BricsNet, Framework Technologies and Cubus.

Bentley rebuilds relationship with Intergraph

Since 1994, the business relationship between Bentley and Intergraph seemed to be little more than an armed truce. The sniping and legal disputes were usually kept behind closed doors but occasionally it would spill out into the open. It appeared that the relationship might be improving when, in May 2000, Bentley acquired Intergraph’s InRoads civil engineering software along with related applications, InterPlot and Digital Print Room and the I/RAS raster editing applications.

Bentley paid Intergraph \$35.4million for this software, \$14 million up front and the balance over time. There were approximately 100 Intergraph employees involved in developing and supporting these applications, a number of whom were subsequently hired by Bentley. The agreement also called for Intergraph to continue acquiring MicroStation/J and related applications from Bentley for resale to its customers.

With InRoads, InRail, and a variety of related surveying applications together with GEOPAK, Bentley now controlled most of the large scale civil engineering market in the United States and a significant portion internationally where Infracore (see below) was a major competitor. During the previous several years, Intergraph had made a number of its applications CAD system neutral. In particular, InRoads' users could work with AutoCAD as easily as they could work with MicroStation. Bentley’s management assured customers that the company planned to continue the marketing and support AutoCAD-compatible applications. Seven years later that is still the case although AutoCAD support tends to be several releases behind. There was some concern that

Bentley had taken this step because of a falling out with its strategic affiliate, GEOPAK. The company went out of its way to assure the media that this was not the case.

The Intergraph networked plot server products covered by the agreement included InterPlot and Digital Print Room. Bentley believed that in the growing engineering/construction/operations (E/C/O) e-business arena, the information integration role served by digital drawing dissemination would become an increasingly important factor. The Intergraph raster conversion products also fit into Bentley's new e-commerce strategy as described in the next section. The software facilitated the creation of digital "CAD" representations of existing hardcopy engineering drawings. The acquired products included I/RAS B and I/RAS Engineer, both of which had significant market share. This software was originally developed by Intergraph's ANA Tech subsidiary.²⁶

Viecon – A full court press on project extranets

By mid-2000, Bentley seemed to be doing very well. The company's software was being used for everything from major airports to Olympic stadiums to nuclear power plants to 100-story office towers. Bentley's software was used by 18 of the 20 largest transportation design firms, 16 of the 20 largest process and petrochemical design firms, 12 of the 20 largest building design firms and 19 of the top 20 power plant design firms. In addition, many utilities, process and petrochemical firms and large manufacturing companies used Bentley's software as their in-house standard for engineering, construction and operation activity. In the transportation field, 47 of the 50 state Departments of Transportation used MicroStation.

This focus on large user organizations, a number of whom had over 1,500 MicroStation licenses installed, led Bentley to adopt business and product development procedures that specifically targeted large organizations. Autodesk had sold more copies of AutoCAD than Bentley had of MicroStation but the typical organization using AutoCAD tended to be smaller than Bentley's customers.

Bentley was continuing to put substantial development resources behind ProjectBank. This Java-based technology was intended to enable architectural and engineering organizations to manage design data at the component level. The effort was expected to eventually lead to a new design paradigm which was frequently referred to by Bentley personnel as "Engineering Component Modeling" or ECM. The use of ProjectBank to manage design at the component level went beyond the support of just MicroStation. Bentley was a strong proponent of an industry initiative called aecXML would eventually enable ProjectBank technology to work with design data irrespective of the tools used to create the data.

Meanwhile, the entire AEC industry was chasing a dream called "project extranets" as described above. There were two primary reasons for this interest – first, designers were creating massive amounts for project data that no longer could be managed just with an operating system's file management tools and, second, distributed project teams were becoming a common practice. Large petrochemical companies were starting to ask how they could effectively manage terabytes of project information.

At this time there were over 100 firms offering some form of Internet service to the AEC market. Some of the VC-funded extranets were starting to tout user success stories involving managing thousands of documents created by tens of firms with

²⁶ *A-E-C Automation Newsletter*, June 2000, Pg. 1

hundreds of registered users. The impact these companies were having on the AEC market was clearly shown at A/E/C SYSTEMS 2000 in Washington in June 2000 where nearly the entire show was dominated by extranet companies with neither Autodesk nor Intergraph present with CAD-related demonstrations.

There were two types of project extranets being used in mid-2000. One involved self-hosted extranets where a design firm, contractor or owner/operator managed the computer hardware and software used to support the extranet. The other approach was to use a Web hosting service that specialized in construction industry-related activity to host and support the extranet. The companies engaged in this latter approach were referred to as Application Service Providers or ASPs. An ASP provided both access to the software and data storage facilities.

Self-hosted extranets utilized applications which were purchased from a software vendor while the Web hosting services usually charged fees based on the number of projects being managed and/or the number of individual users. In general, the self-hosted solution typically was most applicable to large organizations working on multiple projects while the hosting services enabled smaller firms to economically utilize the technology.

Bentley set out to provide both levels of technology and service. The company planned to offer a series of Web-based services under the name *Viecon* (pronounced “v-con”). As initially conceived, *Viecon* consisted of three major initiatives:

1. *Viecon.com*, an ASP service for document management and project collaboration,
2. *Viecon Licensing* which provided for the licensing of Bentley software on a by-person, by-project and by-month basis, and
3. *Viecon Platforms*, a local version of the software that would enable E/C/O companies to create their own in-house extranets.

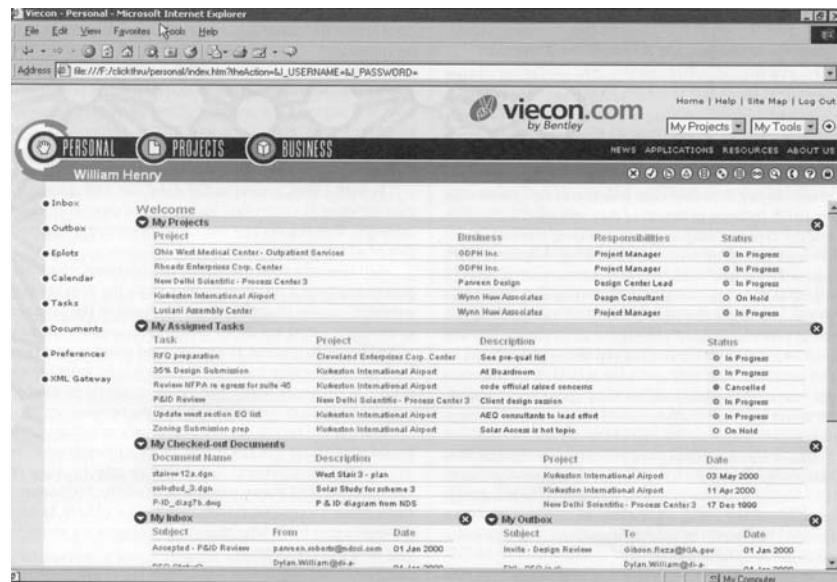


Figure 10.2
Typical Viecon.com screen image

At first, Bentley planned to provide Viecon.com to its SELECT subscribers at no additional charge. The company began to invest in the computer resources needed to provide this service. The Platforms version was expected to be available by late 2000. What was not particularly clear was how Viecon was different from the existing ProjectWise product and why the company simply did not make ProjectWise more Internet compliant. Bentley also worked out a deal to provide Viecon technology to the American Institute of Architects' AECdirect service which never got off the ground.

Users cheer MicroStation V8

In 1998, the ProActive Engineering Symposiums morphed into a more traditional user conference. Over 2,500 users, resellers, development partners and Bentley employees attended the third annual Bentley International User Conference (BIUC) in Philadelphia September 17-21, 2000. The company used the conference to announce a major management restructuring. Keith Bentley, who had been the company's CEO since it was formed in the mid-1980s, relinquished that title to his brother Gregg. With Gregg the CEO, Keith assumed the title of Chief Technology Officer.

In reality, this is how the company had been functioning in recent years. Another significant change was that the company was reorganized into three divisions - operations under Malcolm Walter (who also became the company's COO), software under Buddy Cleveland and The Viecon Network under George Church. At the same time, Yoav Etiel, who had been Bentley's vice president of marketing since the mid-1990s, left Bentley and joined Bricnet as Executive VP of Worldwide Marketing.

The highlight of the conference was the unveiling of MicroStation Version 8 which incorporated numerous long-desired enhancements and was scheduled for release around mid-2001. Bentley had been promoting the concept of gradual software evolution for the prior several years. The downside of this approach was that it inhibited radical change. MicroStation had the same basic data structure in 2000 that it had in the early 1980s, when it was based on Intergraph's IGDS. MicroStation simply had not been keeping up with the day-to-day needs of users.

Some of the significant enhancements incorporated into V8 were:

- Expanded coordinate storage from 48-bit integer to 64-bit floating point.
- Expanded the number of levels per file from 63 to virtually unlimited.
- Expanded the maximum file size from 32MB to 4GB.
- Expanded the maximum size of an individual element from 768 words to 64K words.
- Expanded the maximum cell (block) size from 64KB to virtually unlimited and dropped the then current six-character limit on cell names.
- Allowed an unlimited number of reference files.
- Expanded the number of vertices in a string from 101 to 5,000.
- Added Spatial's deformable surface modeler to MicroStation's Parasolid core.
- Added dynamic hatching and patterning.
- Utilized TrueType text fonts.

On top of these changes, MicroStation V8 was intended to work with both DGN (MicroStation) and DWG (AutoCAD) files. A user could read an AutoCAD file, make changes to it using MicroStation commands and then save it as either a MicroStation or

AutoCAD file. Likewise, a MicroStation drawing could be saved as an AutoCAD file. This was a level of interoperability that the CAD industry has not seen previously.

There were literally dozens of additional enhancements planned for V8, many of which brought cheers from a standing-room-only BIUC crowd at an evening presentation.²⁷ Few present that evening realized that it would be 13 months before V8 was officially released to the user community. During that time, MicroStation V8 changed somewhat from what was described at BIUC or perhaps these new capabilities simply were not discussed at that meeting.

The released V8 demonstrated a deep commitment to Microsoft technology. Support for UNIX and Apple versions of MicroStation was history as was Bentley's use of Java. While V8 still supported applications written in C, C++, and Java, the company dropped Java as a development language in favor of VBA (Visual Basic for Applications) and C#. V8 also represented a change in how the company provided ProjectBank-like technology.

Up to this point ProjectBank had only been used by a small number of MicroStation customers, mainly because it required the use of a special application server and stored its data in a format foreign to MicroStation. To access the special set of files stored on the ProjectBank server, users had to go through client-side ProjectBank software installed on their MicroStation workstations. ProjectBank had to maintain two sets of data, one on the server and one on the local client. Analyzing the differences between the two before changes could be submitted to the server was a time consuming process.

The new V8 file structure enabled the design history to be integrated directly into the design file. This eliminated the redundant set of data required by ProjectBank. Although MicroStation users could simply save their changes, V8 also provided a ProjectBank-like Commit function that created a special folder within the design file. After that, when the user performed another Commit, MicroStation recorded a copy of all the elements that had changed since the prior Commit. In addition to recording what had changed, who changed it, and when it was changed, users could also enter a short textual note to record why something was changed. This addition to the DGN file format enabled a transaction-based approach, preserving the complete history of each CAD file, so it could be "rolled back" to any point in its creation sequence.²⁸

Changing the business model

The launch of MicroStation V8 also represented some changes in Bentley's organizational structure and business practices. By late 2001, Bentley was a \$200 million per year company that was growing about 15 percent annually. It was the second largest privately owned software company according to some sources.

Based upon this growth Bentley realigned its software teams into two groups: Create, led by Brad Workman, VP of Engineering Information Creation; and Manage and Publish, led by Bhupinder Singh, VP of Development. They both reported to Buddy Cleveland. On the Create side, MicroStation and its related portfolio of design tools were client applications focused on the user. Viecon, Bentley's project-specific website or

²⁷ *Engineering Automation Report*, October 2000, Pg. 2

²⁸ *Engineering Automation Report*, November 2001, Pg. 1

Extranet, was the hosted service for the Manage portion of the equation. And ProjectWise continued as Bentley's server-side solution for Publishing.

In a separate move that made Bentley the leading supplier of civil engineering software solutions worldwide, the company announced in October 2001 the completion of its merger with GEOPAK Corporation. Prior to the merger, Bentley had distributed GEOPAK products worldwide and owned a 25% stake in the company. Gabriel Norona, president and CEO of GEOPAK, became Bentley's senior vice president, Civil, and in this role took on the responsibility for the civil software Bentley had acquired from Intergraph including InRoads.

With V8, Bentley offered its customers three ways to acquire software:

- Traditional fully paid-up licenses with or without maintenance support (SELECT).
- Subscription-based licensing of MicroStation or other Bentley applications (includes SELECT). Subscription licensing was approximately 1/18th of the cost of the fully paid-up license fee per month.
- Subscription-based licensing of Portfolios—entire suites of Bentley software for a vertical market. At the time, there were portfolios for Building, Plant, Civil, and Municipal.²⁹

Bentley as a mature company

By now, Bentley was becoming a reasonably mature business enterprise. The 2001 fall BIUC was postponed due to the events of September 11th and was rescheduled for late May, 2002 in Atlantic City, New Jersey. It drew keynote speeches from Rudy Guliani, the former mayor of New York and Walker Lee Evey, the program manager for the rebuilding of the Pentagon.

In late April 2002, Bentley filed a registration statement known as an S-1 with the U.S. Securities and Exchange Commission for its long-awaited initial public offering or IPO. Two significant pieces of information were missing from the document as filed – the total number of shares that would be outstanding after the IPO and what the initial stock price would be.

The Bentley S-1 was a large document, over 150 pages in length along with numerous accompanying appendices. The size reflected the then current skepticism concerning corporate financing and the SEC's attempt to ensure that potential investors had all relevant information before purchasing shares in a company. By comparison, when Autodesk went public in 1985, its prospectus was 38 pages, while Auto-trol Technology's in 1979 was 44 pages. Bentley's S-1 was complicated by the need to discuss in depth financial issues involving the company and Intergraph, GEOPAK, HMR and Rebis.

A careful reading of the S-1 revealed:

- Bentley's revenue had edged up from \$157 million in 1997 to \$203 million in 2001, representing slow but fairly steady growth. The company had been moderately profitable, losing money in 1998 and 2002 but making money in 1997, 1999 and 2001.

²⁹ *Engineering Automation Report*, November 2001, Pg. 1

- While some people thought that Bentley was simply making an investment in Rebis when they purchased an interest in that process design software company, it was now clear that Bentley intended to acquire Rebis. In January 2002 Bentley purchased 12.5% of Rebis for \$5 million, placing a value of \$40 million on the company. Upon completing the IPO, Bentley planned to purchase the balance of Rebis.

- The complex historical relationship between Bentley and Intergraph was spelled out in detail in the S-1. Ten years earlier, Intergraph was totally responsible for the marketing and sales of MicroStation. By mid-2002, only about 2 percent of Bentley's revenue was channeled through Intergraph.

- In March 1996, Bentley initiated an arbitration proceeding against Intergraph related to royalties it was due between 1987 and 1994. In March 1999, that disagreement was settled with Intergraph paying Bentley \$27.4 million in cash and stock. This settlement also had the effect of reducing Intergraph's ownership of Bentley to 33 percent.

- The prospectus made it very clear that Bentley was in the midst of making two major changes to its business model. The most significant was the shift from selling fully paid up licenses to a subscription model with a wide variety of options for customers. In 2001, subscriptions paid on a monthly, annual, or longer basis amounted to 67% of Bentley's revenue. The other key change was a switch from nearly total dependency on resellers to a new distribution model in which Bentley's own sales force dealt directly with many major customers.

Overall, Bentley came across in the prospectus as a well managed company with significant products and customers – a far different situation than what investors had seen a few years earlier during the dot com boom and bust. The company's financial situation was in fairly good shape although it was apparent that Bentley needed an infusion of cash in order to continue to grow through acquisitions.

Market conditions didn't appear favorable for a technology-oriented IPO so on September, 16, 2002, Bentley initiated the required steps to withdraw its registration statement. According to Greg Bentley:

“In the face of a market that has now apparently turned outright hostile to software company IPO's, Bentley has decided to remove the distractions and restrictions that accompany the IPO process and focus instead on managing our business which continues its growth and profitability. Bentley management remains confident in the Company's prospects and plans to reconsider the IPO when appropriate market conditions eventually return.”

As of 2007, no IPO has yet occurred, primarily because the company does not appear to need an infusion of cash at this time. Unlike most private companies, Bentley publishes an annual report on its web site, although without profit details. In 2006, the company had revenues of \$389 million, and between 2005 and 2006 spent over \$200 on product development and acquisitions. At this point, Bentley had over 2,500 employees focused on four primary market

segments, architectural design, process plant design, civil engineering and geospatial.³⁰

Infrasoft – The third leg of Bentley’s civil product line

Since Bentley acquired Infrasoft in 2003, this probably a good place to describe that company and its predecessor, MOSS Systems, Ltd. This story started in the United Kingdom in 1973, when three county councils in southern England decided to develop their own highway design software. These councils are much like the state DOTs in the United States. At the time there was little software available for roadway design, particularly software developed to meet UK standards.

The first release of the group’s design software occurred in 1975. Like most other engineering solutions in those days, the package, known as MOSS, was batch oriented and ran on both mainframes and large minicomputers. In 1983, five of the original developers left their government jobs and formed MOSS Systems, Ltd. to develop and market the software to government agencies and private engineering firms. Within a few years, 49 out of the 50 county councils in the UK were using MOSS.

MOSS Systems' international sales activity was initially concentrated in other English speaking countries. The company entered the U.S. market in the late 1980s, signing distribution agreements with McDonnell Douglas and Auto-trol Technology³¹. McDonnell Douglas sold Prime and Digital minicomputer versions of the software while Auto-trol sold Apollo (later Hewlett-Packard) and Sun versions. The Auto-trol activity spurred Moss Systems to create an interactive implementation of the software with a graphical user interface. By the early 1990s, Auto-trol had taken over all of the North American distribution activity, but new sales were few and far between. Elsewhere around the globe, MOSS Systems was doing far better, with sales activities in over 50 countries.

Richard Fiery was one of the application engineers supporting MOSS at Auto-trol in the early 1990s. As a registered PE with a BS and MS in civil engineering from the University of Virginia, Fiery decided to go back to school and work on an MBA. At the University of Pennsylvania’s Wharton School of Business, one of his class projects was to put together a business plan for a new enterprise. Part of the project involved writing a private placement memorandum for the venture. Fiery's plan was for a business enterprise that would take over the distribution of MOSS in North America. This was to be Infrasoft. Fiery won an award for the best business plan submitted along with a \$50,000 grant to get it started.

His first step was to convince MOSS Systems and Auto-trol to allow Infrasoft to take over the sales and support of MOSS. This was apparently relatively easy to do since Auto-trol was de-emphasizing its AEC activity and MOSS Systems wanted to jump start its business in this part of the world. A number of Auto-trol employees who had been involved in the sales and support of MOSS joined Fiery in establishing Infrasoft in 1994.

About a year after Infrasoft set up shop in Danvers, Massachusetts, word began circulating that MOSS Systems was for sale. The expectation was that one of the major CAD players would acquire the company because of its underlying technology and large

³⁰ <http://www.nxtbook.com/nxtbooks/bemagazine/ar2006/index.php>

³¹ I was responsible for the sales and support of MOSS at Auto-trol from 1985 through 1991.

worldwide installed base of users. Infracsoft, with just 10 employees at the time, offered to acquire MOSS System which had nearly 100 employees. It took almost 16 months to consummate the deal, but Infracsoft put together the financing and took over MOSS Systems in December 1996. Fiery recruited a strong board of directors including Dave Arnold - the founder and former CEO of Softdesk, James Burnley - former US Secretary of Transportation, and Viggo Butler - former CEO of Airport Group International. Other than the original founders who were looking to retire, Infracsoft retained virtually the entire MOSS Systems staff in the UK.

Starting well before the first computer was used for roadway design, engineers have used a technique involving cross-section templates to design highways and calculate earthwork quantities. It was no surprise when most software packages including InRoads and GEOPAK (in a somewhat modified manner) implemented the same basic technique. The problem with this approach is that while it works adequately for straightforward sections of highway, the template method is difficult to apply when designing complex roadways such as those encountered when working on multi-level interchanges or widening urban expressways.

The original MOSS developers took a significantly different approach. They decided to describe all geometry, whether it was existing terrain, proposed alignments or drainage channels, in the form of three-dimensional strings. A string is nothing more than a linked set of three-dimensional points in space. The result is an extremely flexible data structure that is amenable to virtually any design situation. Examples of roadway design strings would be the centerline of the highway, the edge of shoulder, the bottom of curbs, the top of curbs and the outer extent of earthwork. While most of these are defined by the user, some, such as the outer extent of earthwork, are calculated by the software.

Infracsoft renamed the original MOSS software the MX Series with modules for road design (MXROAD), pavement renewal (MXRENEW), railroad engineering (MXRAIL) and site engineering (MXSITE). It worked with both AutoCAD and MicroStation although during the late 1990s, Infracsoft tended to prefer working with Autodesk since Bentley was a direct competitor with GEOPAK. Figure 10.3 shows the use of MXROAD to design a typical roadway intersection.

Bentley announced in January 2003 that it planned to acquire Infracsoft and a few months later the deal was completed. To some extent, Bentley may have made this move to keep Autodesk from acquiring Infracsoft and competing more effectively in the civil marketplace.

All three civil product lines were managed by Gabe Norona and development efforts were initiated to create new highway design applications that would eventually merge the best characteristics of packages into a new suite of civil engineering programs.

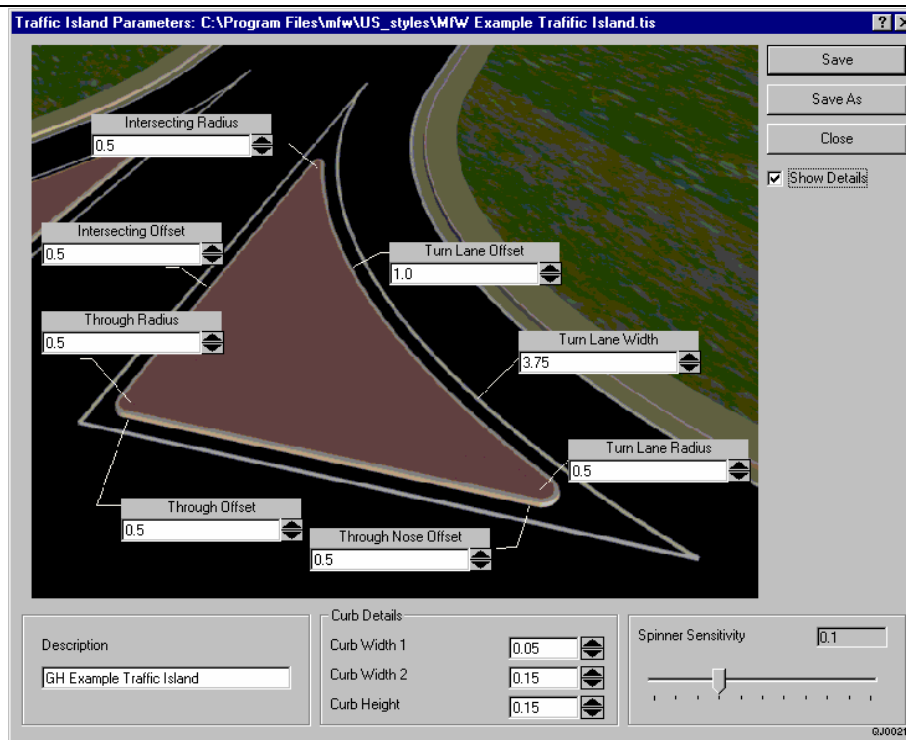


Figure 10.3
Use of Infracore's MXROAD to design roadway intersection