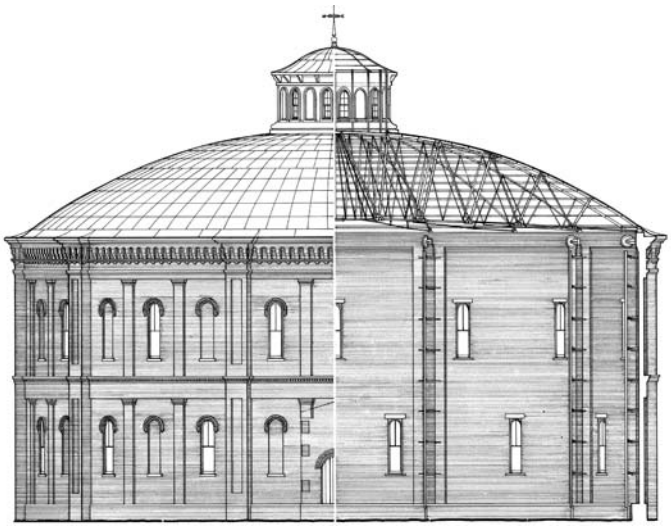

SOCIETY FOR INDUSTRIAL ARCHEOLOGY

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Tour E – Roots of High Tech

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This is a tour that looks on some of the beginnings of the high tech industries. It is also shows that Change Is the Constant, as we look at companies and even whole industries which have changed dramatically over time. We'll be focusing on the roots of four industries: semiconductors and semiconductor equipment, electronic systems and computers, storage systems, and aerospace. We'll briefly touch on biotech, although the equivalent of Silicon Valley for biotech ("DNA Point?") is centered in South San Francisco.

From downtown San José, we'll proceed up Market St which turns into Coleman Ave. We'll cross the Guadalupe River and if you look closely you can see the trail that runs from downtown. We'll pass by the former Southern Pacific rail yard, to the west of Coleman. Part of the yard has recently been redeveloped as a shopping center. To the east, there is a large park that was originally homes, but they were purchased and torn down by the airport for both safety and noise pollution reasons. Just behind the shopping center is the bright red and silver new Caltrain maintenance facility. Caltrain serves commuters on the Peninsula, and has a few runs all the way down to Gilroy. It is operated by AMTRAK under contract to the Peninsula Corridor Joint Powers Board.

Adjacent to the south end of the airport is one of the former FMC plants. FMC was one of the oldest manufacturing companies in the Valley, starting in 1884 with the invention of a pressure sprayer for the orchards by John Bean. The company branched into all sorts of machinery for the canning and food industries. It was renamed Food Machinery Coporation in 1928 shortly after it acquired the Anderson-Barngrover Company. Anderson-Barngrover had introduced the first automated continuous-stream cooking and cooling system for canned food in 1920. Later it became Food Machinery and Chemicals Corporation. During WWII, FMC built Landing Vehicle Tracked (LVT) for the military. This line of business continued to grow and ended with the building of the Bradley Fighting Vehicle. On aerial photos of the Coleman plant site, one can see the figure-8 shaped test track for the Bradley, though the track may be gone soon in redevelopment efforts. After various corporate reorganizations the military part of the business was sold to BAE Systems, and most of the San José operations were closed. Part of the plant site is being redeveloped by Arcadia Homes. FMC got into the chemical business in 1943. As the business climate changed it spun off various operations and acquired other companies. FMC today is a diversified chemical company with headquarters in Philadelphia. Its machinery unit was spun off as FMC Technologies, with headquarters in Houston.

We'll pass by Altivity Packaging, which is a paper mill producing packaging board from recycled paper. It was formed in a leveraged buyout in 2006. The company's roots go back to the 1935 formation of Jefferson Smurfit in Dublin, Ireland. US operations began in 1974 with acquisition of a packaging material manufacturing company.

Near Central Expressway are the offices of Macrovision. They are market leaders in copy protection and digital rights management. Through the techniques they have developed,

movie studios can make it very hard to copy the contents of a DVD or other media. This is a perpetual arms race, as equally clever folks break the latest schemes. The company also acquired the maker of the InstallShield installation software package in 2004, but is in the process of selling their software business for about $200 million. In December, 2007 the company acquired Gemstar-TV Guide in a transaction valued at $2.3 billion. Robert X. Cringley, a Silicon Valley columnist/blogger/PBS TV Star (*Revenge of the Nerds*) predicted that Cisco would buy Macrovision in his 2008 predictions. Lately, he's hit a dismal 60% correct.

As we turn on to Central Expressway, you can see the large circular antenna that is part of the airport's landing and navigational aids. Technically it's a VOR/DME (VHF Omni Range/Distance Measuring Equipment) antenna.

Just past the railroad bridge, on the west side is Hitachi Data Systems headquarters. They now make computer storage systems and related services. The company is part of the large Japanese conglomerate, Hitachi Ltd.

Hitachi's other major local presence is their Global Storage Systems business, which took over IBM's disk business in 2003. The disk drive was initially developed by IBM researchers in a rented lab at 99 Notre Dame in downtown San José in 1956. The resulting drive, about the size of an oil drum held a whopping 5 megabytes. (You can see one of these in a restoration lab at the Computer History Museum later in the trip.) In 1957 IBM established a new campus in South San José. One of the first buildings there, Building 25, was home to a variety of disk technology R&D projects over the years. It ushered in a new style for office buildings, involving open space, and extensive use of glass to integrate the surroundings with the offices and laboratories. In recent years Building 25 was the center of controversy, as Lowe's proposed to demolish it to put up a new store. Alas, in March 2008, Building 25 was destroyed in a suspicious fire, the fourth historic building in San José to be destroyed in the last year or so.

IBM continued to develop disk technologies, including the first floppy disks, and the modern sealed disk found in your PC, iPod, etc. A host of other disk technology companies were formed in the Valley. While on different technology curves from those in the semiconductor industry, "Moore's Law" (discussed below), the growth of disk capacities has been equally impressive.

A little way up Central Expressway, we pass the large Owens Corning Fiberglas™ plant. Originally formed in 1938 as a joint venture between Coring Glass and Owens-Illinois, the company recently (2006) emerged from Chapter 11 stemming from asbestos liability cases. The Santa Clara plant was opened in 1949 and was the first new Fiberglas plant for the company (previous plants were converted from other products). Owens Corning was the first company to trademark a color, Pink, in 1987. The company started adding red dye to its fiberglas products in 1956 as a way to differentiate them from other vendors. They eventually obtained the rights to the cartoon character Pink Panther for use in ads and other promotions for the brand.

We'll pass by lots of small buildings housing a wide variety of companies. Many of them are "tiltups" a style of construction in which the walls are poured concrete laid out on the new building's floor. When the concrete cures, large cranes lift the wall sections into their vertical position. This is very quick and uses much less labor than other techniques. It wouldn't work in places with a less Mediterranean climate.

Most of these buildings originally housed specialized firms in various aspects of the electronics and semiconductor industries. Global and local economic forces have resulted in a dramatic decline in all segments of manufacturing, so many of these have been repurposed. You can also notice a lot of "see through" buildings, empty parking lots and empty offices. The collapse of the dot com bubble and changes in other industries resulted a quite high rate of office/r&d vacancies, at one point there was over 30% vacant office space in the area. Silicon Valley experienced one of the most dramatic and sudden losses of jobs since the Great Depression in the period from 2000 to 2005. Joint Venture Silicon Valley estimates over 200,000 jobs were lost (the total population of their definition of Silicon Valley is about 2.48 million) in that time. 2005 was the first year that there was measurable job growth.

Just past Owens Corning is one of the many campuses of Applied Materials Corporation, locally known as AMAT, their NASDAQ ticker symbol. The corporate headquarters is a little farther up Central Expressway at Bowers. AMAT has been in business since 1967. They manufacture equipment used to make semiconductors and similar products. The Tech Museum in downtown San José has an example of some of a "fab" donated by AMAT. (Current fabs are far more automated and work with wafers about the size of dinner plates. On May 4, Intel, Samsung and Taiwan Semiconductor Manufacturing Corporation announced an agreement to upgrade to 450 mm wafers by 2012.) The expertise developed in the semiconductor equipment area has been applied to other products, notably thin film displays (notebook computers, high definition TV's etc.) and photovoltaic cells. Of particular interest is the SunFab Thin Film Line, a complete turnkey manufacturing facility for solar cells as large as 5.7 M (18.7 ft) square. These can be used in large scale solar farms or as architectural elements on buildings. The glass sandwiches can be used as windows as they are transparent.

A contemporary fab (short for semiconductor fabrication) is an almost unbelievably expensive factory, over $4 billion dollars by some estimates. This investment is obsoleted by technology changes after only a few years. Thus, to be economically viable a fab has to produce very large volumes of semiconductors. Semiconductor manufactures like Intel and their vendors like AMAT are on a constant "going out of business" treadmill. Stand still for very long or stumble with a late product or one that isn't competitive and your out of business in a very short time. These firms by necessity must obsolete current product lines with improved technology about every few years. This comes, partly, from "Moore's Law" which holds that semiconductor technology doubles the number of transistors than can be economically produced in a device every 18 to 24 months. Gordon Moore was a co-founder of Intel (and before that, Fairchild Semiconductor), and the company and the rest of the industry have lived by this "law" ever since Moore first

expressed it in 1967. (His actual observation was far milder, it was just some musings on the economics of the nascent semiconductor industry.)

Fabs are so expensive that they have created a new type of semiconductor company, “fabless” semiconductor companies. These companies, such as Qualcom, Broadcom, Xilinx, SanDisk and nVidia design semiconductors then have them manufactured in “silicon foundries”, such as Taiwan Semiconductor Manufacturing Corporation or its arch rival United Microelectronics Company. There are other foundry companies around the world. Both SanDisk and nVidia have a retail presence, most of the other companies are producing components and subsystems.

A little farther north on Central Expressway, at Bowers, is an Intel campus. Their corporate headquarters is a mile or so away and houses the Intel Museum, our last stop in the afternoon. Across the street is the large warehouse for Arrow Electronics, a distributor of electronic parts.

North of Bowers is the campus of Fujitsu Computer Systems. Originally these buildings housed Amdahl Computers, a company founded in 1970 by Gene Amdahl which produced large computers compatible with IBM mainframe computers, System/360 and its successors. Dr. Amdahl was an architect of the original System/360 family. His new company produced machines that were compatible with and less expensive than the then IBM System/370 mainframes. Amdahl was quite entrepeneural, so left the company in 1980 to form a succession of other companies. Fujitsu had been an investor in Amdahl, and took over the company in 1997. Amdahl was a successful competitor to IBM for many years, however IBM developed advanced semiconductor technology and designed a new architecture that was superior to the Fujitsu products, so rather than spend the estimated $1 billion needed to compete with IBM, in 2000 Fujitsu announce it would exit the mainframe computer business.

We’ll pass by the Decathlon Club, an athletic club and restaurant where the deal makers and heavy hitters of the Valley hang out. A little farther up are the offices of Affymetrix, a cross over firm using the microminiature aspects of semiconductor technology in genome analysis.

As we continue north on Central Expressway, at Commercial Street there are two seemingly quite out of place businesses, Lincoln Shoe Polish, founded in 1925, and W.L Hickey and Sons, a regional plumbing contractor founded in 1904.

The large National Semiconductor (locally referred to as “Nasty”, partly from the rather colorful characters who ran very “lean and mean” it in the early days) straddles both sides of Central Expressway. National now focuses on the analog semiconductor marketplace.

We exit Central Expressway at Wolfe and head north to Arques, then north on Arques to Fairoaks, then turn right on California proceeding along the fences of the former Hendy Iron Works, now a part of Northrup-Grumman, to Martin Murphy Jr. Park, where we’ll

get off the bus to take a look at an early Hendy product and talk about this historic company.

Martin Murphy, for whom the park is named, was the founder of what would become Sunnyvale when he and his family migrated from Missouri in 1844. A replica of his wood frame house (that he had shipped from New England) will be the new Sunnyvale History Museum to open in fall 2008.

Joshua Hendy was born in England in 1822, and came to California 1849 in the Gold Rush. He established the first redwood saw mill in California in Benicia, and in 1856 opened a foundry and machine shop in San Francisco to supply the gold mining industry. The object in the park is a stamp mill used to crush gold bearing ore to a fine powder so the gold could be recovered from it. One of the recovery processes used mercury supplied by the mines at New Almaden, another tour. Throughout Gold Country stamp mills like this one worked 24/7 crushing ore. The noise must have been horrific, as a typical mill might have dozens or even more of the stamps. Hendy went on to supply all sorts of mining equipment to customers around the world. Joshua Hendy died in 1891, and the firm was taken over by his nephews, Sam and John. The shop was destroyed by fire after the 1906 earthquake, so the company decided to relocate to roughly the middle of nowhere, what is now Sunnyvale. The company prospered, and during WWI won a contract to supply triple expansion reciprocating steam engines for ships being built under contracts from the U.S. Shipping Board by Western Pipe and Steel. The company faltered during the depression, but hung on. In WWII it produced an amazing 754 steam engines for Liberty ships, about 28% of all engines produced for these ships. It also produce a great deal of ancillary equipment. Our friends visiting the SS Red Oak Victory in Richmond can see Hendy Iron Works equipment in her engine room. The company was acquired by Westinghouse in 1947. It continued to produce marine equipment such as ballistic missile launch systems for submarines. In 1996 it was acquired by Northrup Grumman.

We'll next go across Sunnyvale to the Los Altos History Museum in the Civic Center, for their new exhibit on David and Lucile Packard. Along with his partner Bill Hewlett, David Packard helped create what would become Silicon Valley. Hewlett-Packard is one of the most respected companies in the Valley, and around the world. The exhibition gives some unique insights into the early days of the company and the lives of these two remarkable people. The exhibition recreates aspects of the "garage" on Addison Street in Palo Alto where HP started. It's difficult to get a bus into this residential neighborhood, and the site is closed to the public.

Though nothing remains but a plaque, a few blocks from the Addison St. garage is the site where Dr. Lee DeForest developed the vacuum tube about 30 years (1907) before Hewlett and Packard got together.

We'll next head up Foothill Expressway for a quick drive through of parts of the Stanford Office Park, home to many high tech companies. A strong influence in the formation of Hewlett-Packard was Prof. Fred Terman of Stanford. Terman's vision of collaboration

between academia and industry was revolutionary for the time. He felt that if industries could be brought closer to Stanford this collaboration would be enhanced, so convinced the University to create a large office park on vacant land to the west of campus. Some of the firms located there are household names (well, around here they are…), for example the HP Corporate Headquarters is at 3000 Hanover Street, near the VA Hospital, and Varian Medical Systems Headquarters is just around the corner at 3100 Hansen.

We'll drive by and briefly pause near two remarkable companies, one you've probably never heard of, though it has profoundly influenced the technology most of us use, and another, across the street that is "the next big thing".

The first of these is PARC. In 1970, the Xerox Corporation opened the Palo Alto Research Center with an exceptionally broad mission to "create the architecture of information". The center hired brilliant, innovative staff, and gave them wide latitude to pursue new technology. Much of what we take for granted in current computer systems had its start at PARC. Some of the innovations first developed there include:

- The personal workstation/computer
- WYSIWYG (What You See Is What You Get) "wizzywig" word processing with a rich pallet of type faces, image integration etc.
- Local Area Networking (Ethernet, and later wireless descendents)
- Complex computer networks, leading to today's Internet
- Laser printing

And the list goes on… Alas, the Xerox Corporation for many different reasons wasn't able to capitalize on many of these innovations, but they spawned a very large number of innovations, companies, and entire industries elsewhere. For example, Steve Jobs was so impressed by the Alto workstations he saw on a visit to PARC that he started the development of the disastrous LISA and later, the hugely successful Macintosh computer systems. Xerox did capitalize on laser printing, and by some reports, the royalty stream from the patent portfolio surrounding laser printing, and direct sales of laser printers probably paid for all of the work at PARC. In 2002 PARC was spun off as a wholly owned subsidiary of Xerox, and is a contract R&D organization.

Just across the street is the new complex housing VMware. The stock was a hot IPO in 2007, but has been hammered in the market recently. The building itself is quite interesting, as it's a new, very green building that was designed to fit into the landscape. Inside, talented programmers create virtualization software. This software allows one computer to pretend to be several different computers. Modern computers have so much computational power that typical workloads don't really use all of the machine. There may also be cases where a business critical application only runs on a now nearly obsolete environment, or requires a different software environment, such as Linux. VMware products can dramatically reduce the number of server computers needed by a corporation or institution, and make it easier for the IT staff to run the systems and reducing energy consumption.

We will next journey to the Computer History Museum at 1401 Shoreline Blvd in Mountain View. This is also the site for the Conference banquet on Saturday. The

museum is housed in a building originally constructed for SGI (Silicon Graphics) where it housed the world-wide sales and marketing organization. This building is the largest computer related artifact in the museum's extensive collection. It symbolizes both the boundless optimism that lead to its construction and the harsh realities of the computer industry that lead to its sale only a few years after it opened. The museum is in the planning stage for a large new exhibit space.

The main purpose of the visit is to take a quick look at Innovation 101, a series of displays describing some of the stories of innovation, many of which we have seen or will see on this tour.

Another item to note is Charles Babbage's Difference Engine #2, on loan to the museum. Babbage was mathematician with a wide variety of interests. Much of his work involved the use of mathematical tables. Until the advent of computers, these tables were calculated by hand and manually typeset, leading to errors. After one frustrating session looking for errors in a table book, Babbage exclaimed,
"I wish to God these calculations had been executed by steam!"

Babbage began work on the design of a Difference Engine in 1823 with support from the British government, which was quite unusual. This is the dawn of the industrial revolution, so Babbage and his engineer had to make almost everything they needed. The Difference Engine is a hand cranked mechanical calculator that would generate a table of numbers using a technique called finite differences. The technique requires only addition after an initial setup of the first few entries in a table. It uses a polynomial approximation to an arbitrary function, such as logarithms. The project collapsed in 1833 over a dispute with the engineer, with about 1/3 of the estimated 25,000 parts having been produced. A small demonstration fragment produced in 1832 is all that remains. It still works and is on display at the Science Museum, London.

Babbage started the design of a more sophisticated device, the Analytical Engine. In modern terms, this machine was programmable. Sequences of the machine's operations were to be encoded on punch cards, similar to the techniques used in the Jaccard loom. The Analytical Engine had all the elements of a modern computer, but they were mechanical. He is best known for this work, even though it was never completed.

During the design of the Analytical Engine, Babbage realized that he could build a much simpler difference engine, so in 1848 did the initial design for Difference Engine #2. No attempt was made to build the device during his lifetime.

Science Museum Curator Doron Swade had a lifelong interest in Babbage, and had written articles and a book about this remarkable man. In 1985 the Museum embarked on an ambitious project to build Difference Engine #2 in time for the 200th anniversary of Babbage's birth in 1991. Babbage did only 20 page of drawings for the machine, and did not specify all the details. There were deliberate mistakes in the drawings, probably to hinder the theft of the ideas.

Over the years there had been considerable speculation about whether Babbage could have built a working device with the tools, techniques and tolerances available to him. So the engineering team made a serious effort to produce parts to the tolerances that Babbage would have been able to meet. There was also speculation as to whether such a complex mechanical device would work, whether it could be operated by one person, and whether it would continue to operate.

To the delight of all concerned, the Difference Engine #2 was shown, working, to the public in 1991. The highly sophisticated printing mechanism was completed in 2002. About half the 8,000 parts are in the printing mechanism.

The Difference Engine #2 is about 11 feet long and 7 feet high. It weighs about 11,000 lbs. It is organized as eight digit columns each holding 31 decimal digits. The column farthest from the crank holds the result. The other seven columns hold intermediate results in the finite differences calculation. As the crank is turned the columns engage with their next neighbor and spin around which adds each digit to the neighbor. After the initial spin, digits that have a carry out cause the next higher digit to be incremented in a beautiful, bottom to top sinuous motion on the back of the machine. Every four turns of the crank a new result is produced. The result is also put into the typesetting component that can lay out entire pages of tables in a stereotype mold with a great deal of flexibility in formatting. The result may also be printed on a strip of paper for checking.

The machine's complex series of motions is controlled by an elaborate set of conjugate cams located next to the crank.

Babbage was obsessed with accuracy. The machine is digital. That is, the digit wheels have ten positions and cannot be left in an intermediate position. Locking bars ensure that the digit wheels are in the proper position and do not move inadvertently. If there is an internal error, the machine will lock up and an indicator will show where the problem is.

This instance of the Difference Engine #2 was commissioned by former Microsoft CTO Nathan Myhrvold. He funded the completion of the printing mechanism for the first machine, also.

Another option at CHM is the *Fairchild at Fifty* overlay in Visible Storage. Our speaker for Saturday's banquet is David Laws, a semiconductor industry veteran who curated a series of events and exhibits about Fairchild Semiconductor for their 50th anniversary in 2006. Fairchild Semiconductor is another company of constant change. The company was founded in 1957 by eight visionaries who had been recruited by Nobel Lauriate William Shockley for his Shockley Transistor Company in Mountain View. (Shockley later referred to them as "the Traitorous Eight".) They disagreed with his plans and chafed under his management style. Art Rock was working for an East Coast bank looking for investments here. He felt that this group of scientists and engineers had enormous potential, but couldn't convince his management (or anyone else) to fund them. Finally, he convinced Sherman Fairchild (I recently learned the Sherman Fairchild was the son of George Fairchild, the first CEO of IBM!) to invest in this startup, the first

venture capital investment. In 1958 Robert Noyce invented the integrated circuit in a Fairchild laboratory in Palo Alto. Noyce, Gordon Moore and others left Fairchild in 1968 to found Intel, which Rock also backed. After many product transitions and corporate owners, Fairchild Semiconductor became an independent company again in 1997, and specializes in analog and power semiconductors.

There has been a large aerospace industry presence in the Valley for many years, though since much of the work has been highly classified, it's not well known. The roots can be traced to the next stop, Moffett Field. In 1931 the Navy constructed the base to house the dirigible USS Macon (ZRS-5) in the massive Hanger 1. The Macon was a flying aircraft carrier. It could launch and recover small Curtis F9C Sparrowhawk biplanes, extending its search range in its role in fleet defense. The Macon was lost in a storm off Big Sur in 1935. During WWII, the base housed a fleet of blimps, semi-rigid airships, used in anti-submarine warfare and costal surveillance. Hangers 2 & 3 across the runway were constructed for this purpose. Due to wartime shortages of steel, their frames are made of wood. We'll do a bit of driving around the lovely main campus, a Registered Historic District, before stopping at the Moffett Field Museum for a brief visit. They have an excellent collection of artifacts and images relating to the history of the base and the Navy's lighter than air program.

In 1939, the NACA (predecessor to NASA) established a research center adjacent to NAS Moffett and named it after long time administrator Joseph Ames. The Ames Research Center was an influence in the development of the aerospace industry in the Valley. Over the years the center has conducted research and development in a wide variety of areas. One of its most visible features is the massive wind tunnel, capable of holding a full sized aircraft. The wind tunnel is one of many facilities for testing new aircraft and spacecraft designs. It is now operated by the US Air Force. Most of NASAs aerodynamic research is now conducted in computer simulations using large supercomputers. NASA no longer offers tours, but is planning to have a speaker for us at their visitor facility outside the main gate. NASA Ames contributed to the growth of the aerospace and defense industries in the Valley. One of the largest of these is Lockheed's Sunnyvale operations.

We'll take a ride through the Moffett Park area south of the field. The largest firm there is Lockheed. This facility developed submarine launched ballistic missiles for the Navy, and a wide range of other defense and intelligence programs. The area now is home to a variety of high tech companies. It is also the home to a Silicon Valley institution, Weird Stuff Warehouse, a surplus electronics store beloved by geeks.

Our final stop will be the Intel Museum located in the Robert Noyce Building. Dr. Noyce was the inventor of the integrated circuit (at just about the same time Jack Kilby of Texas Instruments also invented the integrated circuit independently) while working at Fairchild Semiconductor. Noyce, Gordon Moore and others left Fairchild to found Intel in 1968. In its 40 year life, the company has constantly reinvented itself. For example, in a "bet the company" decision Intel left the RAM business in 1983, a business that it had helped create and which was the dominate revenue source for the company in the early days. In

January 2008, Intel announced the planned closure of the D2 fab, the large building next to the Noyce Building. This was the last major production fab in the Valley. (There are still some smaller, specialized fabs in operation.) “Increasingly, Silicon Valley is less about silicon and more about technology development. It’s something that has been happening in Silicon Valley for the last two decades.” (Intel spokeman Chuck Mulloy, quoted in the San José Mercury News, Jan 19, 2008)

As we head back to The Sainte Claire, we pass by a large number of office buildings along US 101 and CA 87. Who knows which of them house a brilliant entrepreneurial team coming up with the next big thing!