The Origins of Silicon Valley: Why and How It Happened Here

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or ... You Are There!

A step back through Santa Clara Valley and SF Bay Area history
Classic Silicon Valley: 1976

- **Homebrew Computer Club**
  - Hobbyists meeting in Menlo Park and at SLAC
  - Steve Wozniak and Steve Jobs
  - The Apple I (to sell to friends)

Classic Silicon Valley: 1976

- Wozniak-Jobs partnership
  - called it “Apple Computer Company”
  - Started in a **garage** in Los Altos
  - Now has largest stock market capitalization
  - Most **valuable brand** in the world

**How could this happen?**
**Why in the SF Bay Area?**
Before 1900 …

The Santa Clara Mission

“Valley of the Heart’s Delight”

Before 1900

This was more typical …
Let’s Go Back …

Federal Telegraph

- Formed in 1909 in Palo Alto (by Cyril Elwell, a Stanford grad)
- Lee de Forest invented the audion oscillator and amplifier in 1907
- Pioneered continuous-wave radio

Federal Telegraph

- Paulsen Arc Transmitter, 1909
  - Demonstrated sending CW and voice
- Raised funds from "angel investors", including David Starr Jordan, Stanford’s president
- Demonstrated communication from S.F. to Honolulu in 1912

- First venture capital
- Stanford’s Involvement
Federal Telegraph
- By 1926, had three high-power stations that covered much of the Pacific Ocean
- In support of maritime shipping companies
- California Historical Plaque in Palo Alto

Let’s Go Back …
- 1st regular commercial radio broadcast
  - Charles “Doc” Herrold
    - Early Stanford EE grad
    - Started a San Jose school near SJSU to teach radio arts (1909)
  - First Commercial broadcast, San Jose, 1909
    - voice and music: “San Jose Calling”
  - FN, then SJN, then KQW, becomes KCBS
    - 740 AM, 106.9 FM (also founded KLIV)
Example: Early Roots of Entrepreneurial Technology

Otis Moorhead
- Early Stanford EE grad
- Radio amateur & vacuum tube entrepreneur
- Established Moorhead Laboratories
  - In San Francisco in 1917
- Moorhead manufactured “bootleg” receiving tubes for radio sets
- A patent-infringement lawsuit put him out of business in the early 1920s.

Defining Events

- Independent private wealth, from gold rush
- Titanic Sinking in 1912
- World War I
  - Importance of technology
- US Navy “push” for ship-to-shore and other communications modes
- Economics: desire to replace expensive telegraph lines, undersea cables with the new “wireless” technology
- Brought frenzy of activity, funds to S.F. Bay Area
We Now Follow Three Pioneers

- William Eitel
- Jack McCullough
- Charles Litton

- Bay Area families with a strong history of entrepreneurship
- Born/raised here

William Eitel

- Took shop classes at Los Gatos High School
- Worked in his father’s quarry
  – ass’t blacksmith, machine operator
- Visited shops of Hall-Scott Motor Car Co.
  – Operation of Complex machinery

William Eitel, W6UF
1908 - 1989

sports cars
aircraft “Liberty engine”
Jack McCullough, Charles Litton

- Attended California School of Mechanical Arts
  Now Lick-Wilmerding High School, San Francisco (private)
- Opened in 1895; free education for boys, girls
- One of the best West Coast technical high schools
  - Rigorous training in the mechanical trades
  - Gained "a realistic 'feel' of materials and processes" [Litton]

Jack McCullough, W6CHE
1908 - 1989

Jack McCullough, Charles Litton

- McCullough continued at a local junior college
- Litton enrolled in Stanford's Mechanical Engineering dept:
  - Small department (3 instructors)
  - Classes with strong practical flavor
  - Got BS-Mechanical Engineering in 1924
  - Grad work in communication engineering
  - Took Stanford's first course on communication engineering fundamentals
Eitel, Litton, and McCullough

- Introduced to amateur “ham” radio through their families and friends in 1910’s, ’20’s
  - Became acquainted with the technology of power tubes through activities in ham radio

Ham Radio in SF Bay Area

- Isolated; maritime orientation; major seaport
- Several military bases; US Navy presence
- Shipping companies needed radio operators
- Over 1,200 licensed amateurs
  - 10 percent of US total (a bubble)

Ham Radio in SF Bay Area

- Active center of radio mfg in the 1910s, ‘20s
- Electronics firms:
  - Remler - made radio sets
  - Magnavox - leading manufacturer of loudspeakers
  - Heintz and Kaufman
    - Designed custom radio equipment
  - Federal Telegraph
    - Produced radio transmitters in the 1910s; up to 1,000,000 watts in 1919.
- Radio parts available to local hobbyists
- Jobs for radio amateurs
Ham Radio Subculture

- **Camaraderie** and intense sociability
  - A way to make friends
  - Communicating "over the air" and face to face

- **Egalitarianism** and a democratic ideology
  - Little heed to **distinctions of class**, education
  - Santa Clara County radio club, which Eitel chaired in the mid 1920s, had “**farm boys, Stanford students, Federal Telegraph technicians, and retired executives**”

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Ham Radio Subculture

- Representatives of the citizenry
  - In contrast to large companies, monopolies

- **Interest in extending radio technology**
  - Built personal reputations: innovating new circuitry; devising clever transmitters; contacts with faraway lands

- Mix of competitiveness and collaboration

**A lot like Home Brew Computer Club, and today’s Silicon Valley …**
Following our Entrepreneurs …

- Eitel, Litton, McCullough, ham friends
  - Learned about vacuum tubes
  - Built their own parts, equipment
- Made notable contributions
  - 1924: Litton and Stanford radio club made first radio contact with Australia, New Zealand
  - 1928: Eitel pioneered 10-meter waves (30 MHz)
    - transcontinental communication

The Tube Business

- General Electric, Westinghouse, AT&T
  - All East Coast companies
  - Developed hi-power transmitting tubes in early 1920s
  - Difficulties in producing consistent, reliable ones
  - Required precise machining, glass blowing (Pyrex)
  - Exotic materials, sophisticated sealing techniques
Following our Entrepreneurs …

- **Litton** got local job through a ham friend:
  - Research at **Federal Telegraph**
  - Built up to 60 engineers
  - Became sole supplier of radios to IT&T

- **Eitel** got local job through ham friend:
  - Mechanic at **Heintz and Kaufman Inc**
    - Heintz was a ham
    - Focus on HF radio equipment
  - Recruited **McCullough** a year later

The Tube Business in the ’20s

- Could not buy transmitting tubes on open market
  - Navy and GE set up **RCA** to ensure US dominance
    - Took over non-US companies: Telefunken, Marconi …
  - RCA, GE, Western Electric, and Westinghouse
    - **Exclusive cross-licensing** of 2000 radio patents
  - Sole producers/distributors of power-grid tubes
    - Refused sale to Bay Area firms
    - Threats to RCA’s domination

- So both companies developed triodes
  - Litton, Eitel headed their tube shops
Tube Shops’ Challenge

- Design around ~250 RCA patents
  - Enormously difficult task

- Hired locally (many were hams)
  - Eitel, Litton collaborated with each other (novel!)
  - Based on friendships over the years

- Worked closely with patent attorneys

Tube Shops’ Challenges

- Heintz, Eitel, and McCullough engineered a rugged new power tube:
  - New materials, manufacturing methods
  - Tube’s plates of tantalum (avoid patents)
  - New shock-resistant seals
  - Create high vacuums (better reliability)

- More reliable, longer life than RCA’s tubes
- Didn’t infringe RCA’s patents
The US Depression

- Formed Eitel-McCullough Inc (Eimac)
  - To build high-power, high-frequency tubes
- Financing:
  - Harrison: real-estate agent in San Bruno
  - Preddey: ran movie theaters in San Francisco
  - Eitel and McCullough brought their know-how
  - Ownership, profits to be shared

Precursor to today’s Menlo Park Venture-Capital Firms

Tube Shops’ Challenge

- Litton invented the glass lathe
  - For assembly, glass blowing, and sealing
  - Make complex tubes in large quantities
  - Allowed high repeatability, precision
- Built tube shop on parents' property
The US Depression

Litton, Eitel, McCullough cooperated closely

- Litton helped set up Eimac vacuum tube shop
- Gave castings, engineering blueprints for lathe
- Freely exchanged technical, commercial information
- Reduced risks, for the two small tube-related businesses

Like Jobs & Wozniak, Homebrew Computer Club

The US Depression

1936: Frederick Terman* asked Litton to join Stanford EE department as lecturer

- Shared knowledge with staff, students
- Sperry $1000 Litton klystron grant: let Terman bring Packard to campus for grad studies
- with Litton, Hewlett, others

Formed Hewlett-Packard

Demonstrates University/Industry cooperation

* Built his first radio receiver at 13; 6XH with HH Jr; turned this hobby into a career.
Threats to Peace

- Growing threats from Japan and Germany
  - President Roosevelt rebuilt the Army, Navy
  - New electronic system: radio detection and ranging (radar)

- Needed high-voltage high-frequency transmitting tubes
  - Only Eimac’s best tubes worked at the high voltages and frequencies needed

The Klystron

- Russell and Sigurd Varian
- They worried about Germany
  - Hoped to use microwaves to detect planes
  - 1937: Moved to Stanford’s labs to work with Hansen
  - developed the klystron in 1937
    - Used Litton’s free advice
    - Used Hansen’s theoretical assistance
The Klystron – PA Times, Jan. 30, 1939

The Klystron

- Sperry (NY) invested, got exclusive rights
  - Bought lathes, welders, pumps from Litton
- Litton made klystrons for IT&T, for France
  - Needed for war effort, French radar
  - Transformed klystron from lab to production
  - Litton became IT&T’s de facto VHF and microwave design arm
  - Continuous-wave klystrons, VHF/radar triodes

SF Bay Area/Stanford was microwave hotbed
Wartime Expansion

- Progressive Approach to business
  - Egalitarian relations among engineers, between companies

- Managerial techniques to thwart unions, keep employees happy, productive
  - Profit-sharing, cafeteria, medical clinics

Similar to Hewlett-Packard, Fairchild, Intel, Tandem ...

Post-War Realignment

- RCA, others focused on TV, broadcast (NBC)

- Eimac developed new line of better tubes
  - Power tetrodes for high frequencies

- FCC’s surprise shift of FM radio to VHF (88-108 MHz)
  - RCA, others’ tubes wouldn’t work at VHF
  - RCA copied Eimac’s tubes, which did work
Reversal of Fortunes

- In 1947, Eimac sued RCA and GE
  - alleging patent infringement
  - GE, RCA lost lawsuit, halted production
  - Eimac transformed them into its own sales force and distribution network
  - Let them buy Eimac products and resell them under their own names

The “Big Dog” was now Silicon Valley!

Charles Litton After the War

- Focus on higher-power klystrons
  - For physics research, linear accelerators
  - Scaled from 30 kilowatts to 30 megawatts
  - Transformed Stanford into a major player
    - 2-mile-long linear accelerator: physics research
  - Developed “Recipe” to build a firm:
    little initial capital; R&D contracts or a new idea;
    engineering teams and a product line;
    move to production
Varian Associates

- 1948: Sold microwave measurement instrument plans to H-P for $20,000
- Enabled Hewlett-Packard to enlarge its product line, increase revenues in 1950s
- Santa Clara division became Agilent (largest IPO in history), now Keysight

David Packard and Bill Hewlett
The Mural in Palo Alto

Fast Forward to 1950’s

- William Shockley invented transistor while at Bell Labs
  Raised in Palo Alto; CalTech, MIT
- Point-contact Germanium device
- Developed to replace vacuum tubes

Fast Forward to 1950’s

- William Shockley left the East Coast, returned to CalTech
  - His mother, graduate of Stanford, lived here
  - Funded by Beckman
  - 1955: Shockley Semiconductor in Mt View
  - “Traitorous 8” left him in 1957 to form Fairchild, with first real venture capital funding
    (Sherman Fairchild)

The Planar Process

- Developed by Dr. Jean Hoerni at Fairchild Semiconductor in 1959
- Required a special infrastructure:
  - High-vacuum technology;
    precise furnaces
  - Glass/quartz capability and machinists
  - Ultra-pure gasses/water
- Process control; continuous improvement

Built on top of all of the capabilities developed here during the ’20’s, 30’s, ’40’s
The Planar Process

It all happened here …

Isaac Asimov said this was "the most important moment since man emerged as a life form"
… perhaps with a bit of exaggeration.
At the end … (1960’s)

- Situation had changed dramatically
- Peninsula was a major electronics center
- The main center for development and production of tubes, semiconductors, ICs
  - Half of the microwave tubes
  - In every advanced weapons, space system
  - In a wide range of industrial goods (broadcast, TV, microwave ovens)
- SV was central to the US defense effort and to the US manufacturing economy

Why?

Silicon Valley Business Climate

- **East’s** large, vertically integrated firms
  - Focus on protecting current products
  - Slow to adjust to technology, market changes

- **SV**: highly fragmented, decentralized structure
  - **Specialized** firms, nimble/flexible, **engineering-driven**
  - Dense regional network of small & medium-size firms that support each other; draw from common work force
  - **California** (since 1870s) doesn’t enforce employment contracts
  - Adapt more rapidly to change
  - Thrived in the new environment
Silicon Valley Uniqueness

Practices, skills, and competencies:
- Developed over 100+ years
- Communities of hobbyists; collaboration
- Analog ➔ digital ➔ SW ➔ biotech ➔ mobile ➔ Big Data ➔ Deep Learning ➔ VR
- Large number of cutting-edge entrepreneurs
- Engineers and venture capitalists
- Local universities, research, development
- Supporting industries
- Role models, expectations
- Special Culture of Innovation

The ’40’s and ’50’s
The ’60’s

- Intel
- AMD
- National Semiconductor
- Memorex
- Intersil
- Applied Materials
- Frog Design

The ’70’s

- PARC
- Tandem
- Apple
- Selectron
- Oracle
- 3Com
- Amdahl
- Cypress
- Western Digital
- ATARI
- Genentech
- Convergent Technologies
- KPCB
- ComputerLand
The '80’s

Adobe
Altera
LSI
Sanmina-SCI
RSA
Cisco
EA
Electronic Arts
Symantec
Sun
Next
Logitech
Silicon Graphics
MIPS
Fry’s

The ’90’s and beyond

Yahoo!
VMware
Palantir
Intuit
Surgical
Google
Facebook
Juniper
Informatica
PayPal
Netflix
BROCADE
Dropbox
NVIDIA
Salesforce
Pandora
Major companies moving here …

Streaming Media and Biotech …
Stanford alumni and faculty created 39,900+ companies between the 1930s and 2011

"Stanford University’s Economic Impact via Innovation and Entrepreneurship”, published in 2011:

- a large-scale, systematic survey of Stanford alumni and faculty
- by Charles Eesley, Stanford School of Engineering, and William F. Miller, Stanford Graduate School of Business
- created 5.4 million jobs since the 1930’s
- $3 trillion in economic impact each year
- 39,900+ companies (18,000 in CA), plus 30,000 non-profits
- not just in Silicon Valley and California but across the globe
- Tesla Motors, Charles Schwab, Gap, Nike, Netflix, Trader Joe’s…
- 39% of all alumni founding firms located within 60 miles of Stanford
- if an independent nation, would constitute the world's 10th largest economy

Where is “Silicon Valley”?

"A map of Silicon Valley in 2013, which originally just included the Santa Clara Valley from Gilroy to Palo Alto. Today it is a metaphysical space stretching from San Jose to San Francisco and Berkeley."

A History of Silicon Valley, p. 264
Other Technology Centers

- Silicon Roundabout (London)
- Silicon Forest (Oregon)
- Silicon Allee (Berlin)
- Silicon Cape (S. Africa)
- Silicon Alley (New York City)
- Silicon Prairie (Omaha; DFW)
- Silicon Valley-India (Bangalore)
- Silicon Valley-Taiwan (Hsinchu)
- Silicon Oasis (Dubai)
- Silicon Wadi (Israel)
- Silicon Hills (Austin)

Where is VC funding? (Spring 2014)

- Bay Area: $7.1 billion (55%)
- Northwest: $411 million (3%)
- Southern California: $761 million (6%)
- All others: $253 million (2%)

Map showing VC funding distribution across the United States.
### Where is Innovation Today?

- **Hackathons**
- **TechShop**
- **Maker Faire**
- **Incubators**
- **Open Source** software projects
  - Egalitarian use of jointly-developed software
- **Android, iOS Apps**

... and dozens of other collaborative spaces

**Like Ham Radio, Homebrew Computer Club**

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### How Different are We?

- “In Silicon Valley, great ‘collaborators’ are prized; in Washington, DC, they are hanged. When they say ‘collaborator’, they mean ‘traitor’; here [SV], they mean ‘colleague’.”
  
  Thomas Friedman, *NY Times*, Jan 13, 2013

- It’s our attitude in Silicon Valley: “**Failure is a feature**, not a bug.” 100:1 (in SV: 100:5)
Get the book!

Learn MUCH more about those early days …

More about that period …

Fred Terman at Stanford: Building a Discipline, a University, and Silicon Valley
by Stewart Gillmor

2004,
ISBN 978-0804749145
Another fun book

Norm Pond was president of Varian Associates (Sigurd and Russell’s company), then formed Intevac and is CEO.

www.russcochran.com

To explore the invention of the integrated circuit:
To understand how H-P was a product of Silicon Valley, and shaped its culture through a number of re-inventions (1930s, up through 2009)

I also recommend Leslie Berlin’s recent book on Bob Noyce
For another view of Silicon Valley

For a view of another Innovation Environment
On Netflix Streaming:

2011 video, 85 minutes
(SXSW Best Documentary)
Covers funding and startup of Apple, Intel, Genentech, Tandem, Cisco, with views from the key funders (Rock, Perkins …) and entrepreneurs (Moore, Treybig …)

On PBS’s American Adventure:

“Silicon Valley: Where the Future was Born”
video, 85 minutes, $20
(Broadcast on Feb. 5, 2013)
Can be streamed online

“The creativity of the founders of Fairchild Semiconductor, including physicist Robert Noyce, helps transform Santa Clara County into Silicon Valley …. the story of the pioneering scientists.”
Reviewing the Good Ol’ Days
… to understand how Silicon Valley became the hub of technology development … and STILL is …

Download the slides (3 MB) and suggestions for further reading at: learn.e-grid.net/docs/1608-wesling.pdf

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