Hidden in Plain Sight: The Secret History of Silicon Valley
The Genesis of Silicon Valley Entrepreneurship

- Defense
- Integrated Circuits
- Personal Computers
- Internet
- Innovation Networks

Steve Jobs
Gordon Moore
Marc Andressen
Hewlett & Packard

Hidden in Plain Sight: The Secret History of Silicon Valley
A few caveats

- Not a professional historian
- Some of this is probably wrong
- All “secrets” are from open-source literature
Six Short Stories
Story 1: WWII  The First Electronic War
Strategic Bombing of Germany
The Combined Bomber Offensive

- British bombed at Night
  - Area Bombing
    - Lancaster's
    - Halifax
    - Flew at 7 - 17 thousand feet

- The American’s by Day
  - Precision Bombing
    - B-17’s
    - B-24’s
    - Flew at 15 - 25 thousand feet
British and American Air War in Europe

28,000 Active Combat Planes

40,000 planes lost or damaged beyond repair:
18,000 American and 22,000 British

79,265 Americans and 79,281 British killed
The German Air Defense System
The Kammhuber Line

- Integrated *Electronic* air defense network
  - Covered France, the Low Countries, and into northern Germany

- Protection from British/US bomber raids
  - Warn and Detect
  - Target and Aim
  - Destroy
Early Warning Radars in Occupied France
Mammoth
Early Warning Radar

- 200 mile range
  - 150 MHz, 200KW, PRF 500hz, PW 3us, accuracy 0.5°
- 100’ wide, 33’ high
- 1st phased-array radar
- Operational 1942
- 20 built
Wasserman
Early Warning Radar

- 175 mile range
  - 150 MHz, 200KW, PRF 500hz, PW 3us, accuracy 0.25°
- Backbone of the German early warning network
- Steerable tower 190’
- Operational 1942
- 150 built
Early Warning Radar Range
Himmelbelt
Local Air Defense Network

- Box ~30 x 20 miles
- Integrated network of radars, flak, fighters, searchlights
Himmelbelt
Radar Order of Battle

• Freya
  – early warning radar
  – detect allied bombers

• Giant Wurzburg
  – Ground Controlled Intercept radar
  – direct fighters to bombers
  – fighters could then intercept with their on-board radar

• Lichtenstein BC & SN2
  – Airborne radar on German fighters
Freya
Early Warning Radar

- 90 mile range
  - 150 MHz, 15KW, PRF 500hz, PW 3us, accuracy 1.5°
- Steerable and mobile
- Over 1000 deployed
Giant Wurzburg
Ground Control Intercept Radar

- 45 mile range
  - 533-566mhz frequency
    agile, 10KW, PRF 1875hz, PW 2us
- GCI radar
- 25’ wide
- over 1,500 deployed
Himmelbett
Air Battle Air Traffic Control

- Radars fed Himmelbett centers
- Operators worked from rows of seats in front of a huge screen
- Fighters would fly orbits around a radio beacon
  - fighter controller talked it to the vicinity of the target
- Fighters would turn on its radar, acquire the target, and attack
Hidden in Plain Sight:
The Secret History of Silicon Valley
Flak - Radar Controlled Anti Aircraft Guns

- 400,000 soldiers in flak batteries
- Radar-directed flak to 30,000’
  - 128mm: 10 shells/minute
  - 105mm: 15 rounds/minute
  - 88mm: 15-20 rounds/minute
- Fused for time
  - Fragmentation rounds
  - No Proximity Fuses
Wurzburg Anti-Aircraft Radar

- Fire control of flak batteries
- 15 mile range
  - 533-566 MHz frequency agile
  - 10KW, PRF 3750hz, PW 2us, Accuracy 25 meters
- 10 feet wide
- Steerable and Mobile
- ~ 5,000 deployed
German Night-Fighters
On-board Radar

- Directed to vicinity by ground radar
- Dornier Do 17, Junkers Ju 88, Messerschmitt Bf 110
- “Lichtenstein” B/C then SN2 Radar
  - Range 2.5 miles, 600mhz/80mhz
- Weak link was the ground controller comm channel
German Day Fighters
Vectored by Ground Radar

- Ground Control Intercept radar talked the fighters into visual range of the bombers
- Messerschmitt BF-109, Focke Wolf 190
- Weak link was the controller comm channel
Not many clear days a month in winter over Europe

How did they see the target?
Bombing Through Overcast
Solution: Air to Ground Bombing Radar

- Radar aimed at the ground
- Targets could be seen under clouds and rain
- Outlines of major ground features
  - map overlays
- British in Mid 1943
  - H2S 300mhz
- Americans in late 1943
  - H2X & APS-15 3ghz
- Oops
Math Challenge

For every 100 bombers on a mission
4 - 20% would not return

Crews had to fly 25 missions to go home
Story 2: The Electronic Shield - Electronic Warfare
Harvard Radio Research Lab (RRL)

- Reduce losses to fighters and flak
- Find/understand German Air Defense
  - Electronic and Signals Intelligence
- Jam/confuse German Air Defense
  - Radar Order of Battle
  - Chaff
  - Jammers
- Top Secret 800 person lab
ELINT – Electronic Intelligence
*The Line of Sight Problem*

You got to get close!
ELINT using Ferret’s
Find and understand German Air Defense

- Ferret’s and Crows
- B-24J flights inside Germany to intercept German radar signals
- Fitted with receivers & displays
- Wire and strip recorders
  - Frequency, pulse rate, power, etc.
  - 50 MHz to 3 GHz
Window/Chaff
Jam Wurzburg AAA & GCI Radar

- Strips of aluminum foil 1/2 Wurzburg wavelength
- Disrupted German air defenses by jamming Wurzburg’s
- First used July 1943 - raids on Hamburg
- 46,000 packets manually tossed out
  - Each packet contained 2,000 strips
  - Automatic dispensers came later
- Used 3/4’s of all Aluminum Foil in the US
Blind German Early Warning Radar

*Jam Wassermann, Mammoth and Freya*

- Put Jammers on Airplanes
- Mandrel/APT-3
- DINA/APT-1
  - First on escort fighters
  - Later on bombers
  - 12 watts
Shut down Flak and GCI

Jam Wurzburg’s (AAA & GCI Radar)

• “Carpet” Jammer
  – Confuse Wurzburg radar
  – Shut down flak
  – Shut down GCI
  – 5 Watts

• 24,000 built
  – On all bombers
British Jam German Night Fighter Radar

- **Airborne Grocer**
  - jam Lichtenstein
    Night Fighter radar

- **Airborne Cigar**
  - jam Nightfighter Ground Control Intercept (GCI) communications

- **On all British bombers**

- **Monica**
  - Tail warning system
  - Oops
Electronic Warfare 1944/45

- chaff
- ELINT
- GCI Jamming
- Flak Jamming
Who Ran this Secret Lab and became the Father of Electronic Warfare?

- Harvard Radio Research Lab
  - a spin-off of MIT's Radiation Laboratory
  - Ran all electronic warfare in WWII
  - 800 people
  - 1941-1944
- Director: Fredrick Terman - Stanford
Fredrick Terman
“the Father of Silicon Valley”

- Stanford Professor of engineering 1926
  - encouraged his students, William Hewlett and David Packard to start a company
- Dean of Engineering 1946
- Provost 1955
Story 3: Spook Entrepreneurship
WWII Office of Scientific Research and Development (OSRD)

- $450 million spent on weapons R&D
  - MIT $117 million
  - Caltech $83 million
  - Harvard and Columbia ~ $30 million
- Stanford ~ $50K
Terman’s Postwar Strategy

- Focus on microwaves and electronics
  - Not going to be left out of gov’t $’s this time
- Recruits 11 former members of RRL as faculty
- Set up the Electronics Research Laboratory (ERL)
  - “Basic” and Unclassified Research
- First Office of Naval Research (ONR) contract 1946
- By 1950 Stanford was the MIT of the West
Korean War Changes the Game
Spook Work Comes to Stanford

• Applied Electronics Laboratory (AEL)
  – “Applied” and Classified Military programs
  – Doubles the size of the electronics program
  – Separate from the unclassified Electronics Research Laboratory
  – Made the university, for the first time, a full partner in the military-industrial complex
The Cold War and the “Black” Valley

- The Cold War battlefield moves 500 miles east
- Fear of a “nuclear Pearl Harbor”
- Countermeasures, Elint and Sigint, become critical
- Stanford becomes a center of excellence for the NSA, CIA, Navy, Air Force
The Cold War is an Electronic War

• Russian air defense modeled after Germans
  – add surface to air missiles, fighter radar, IFF
  – Understand and defeat

• Soviet strategic missile and bomber threat
  – Monitor telemetry (sigint) to understand performance
  – Photo reconnaissance to find silo’s and bombers

• Soviet Naval threat
  – Monitor and track soviet submarines

• Soviet Nuclear threat
  – Identify and understand production facilities
Stanford Helps Understand the Electronic Order of Battle (EOB)

- Where are the Soviet radars?
  - Consumers; SAC, CIA.
- Details of the radars
  - NSA/CIA to contractors
- Periphery of Soviet Union known
- Interior terra incognito

Hidden in Plain Sight: The Secret History of Silicon Valley
Hidden in Plain Sight: The Secret History of Silicon Valley
Problem: Understand the Soviet Radar Order of Battle

Solution: A Fleet of ELINT Planes

- PB4Y2, P2V, C-97, RB-47, EC-121, C-130, EA-3B and RC-135’s
  - Navy Special Electronic Search Project (SESP)
- Flew around periphery of Soviet bloc
- Joint NSA/CIA/Air Force
- Measured Soviet Air Defense
- Revealed low-altitude coverage was good
  - Changed SAC SIOP plan to go even lower
ELINT – *The Line of Sight Problem*

You got to get close!

You got to get them turned on!!
The Cost: 23 ELINT Planes

<table>
<thead>
<tr>
<th>Date</th>
<th>Victim</th>
<th>Service</th>
<th>Aircraft</th>
<th>Pilot</th>
<th>Weapon</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 Apr 50</td>
<td>PB4Y-2</td>
<td>USN</td>
<td>La-11</td>
<td>B.Dokin</td>
<td>23/37mm</td>
</tr>
<tr>
<td>24 Apr 50</td>
<td>F-82</td>
<td>USAF</td>
<td>MiG-15</td>
<td>Keleinikov</td>
<td>23/37mm</td>
</tr>
<tr>
<td>Apr 50</td>
<td>F-51D</td>
<td>USAF</td>
<td>MiG-15</td>
<td>N.Guzhov</td>
<td>23/37mm</td>
</tr>
<tr>
<td>May 50</td>
<td>F-51D</td>
<td>USAF</td>
<td>La-11</td>
<td>Yefremov</td>
<td>20mm</td>
</tr>
<tr>
<td>11 May 50</td>
<td>B-24</td>
<td>USAF</td>
<td>MiG-15</td>
<td>I.Shinkarenko</td>
<td>23/37mm</td>
</tr>
<tr>
<td>26 Dec 50</td>
<td>RB-29</td>
<td>USAF</td>
<td>MiG-15</td>
<td>S.Bhakaev</td>
<td>23/37mm</td>
</tr>
<tr>
<td>6 Nov 51</td>
<td>P2V-2</td>
<td>USN</td>
<td>MiG-15</td>
<td>M.Schukin</td>
<td>23/37mm</td>
</tr>
<tr>
<td>13 Jun 52</td>
<td>RB-29</td>
<td>USAF</td>
<td>MiG-15</td>
<td>O.Fedotov</td>
<td>23/37mm</td>
</tr>
<tr>
<td>7 Oct 52</td>
<td>RB-29</td>
<td>USAF</td>
<td>MiG-15</td>
<td>Zheryakov</td>
<td>23/37mm</td>
</tr>
<tr>
<td>7 Oct 52</td>
<td>RB-29</td>
<td>USAF</td>
<td>MiG-15</td>
<td>Lesnov</td>
<td>23/37mm</td>
</tr>
<tr>
<td>29 Jul 53</td>
<td>RB-50</td>
<td>USAF</td>
<td>MiG-15</td>
<td>A.Rybakov</td>
<td>23/37mm</td>
</tr>
<tr>
<td>4 Sep 54</td>
<td>P2V-5</td>
<td>USN</td>
<td>MiG-15</td>
<td>?</td>
<td>23/37mm</td>
</tr>
<tr>
<td>7 Nov 54</td>
<td>RB-29</td>
<td>USAF</td>
<td>MiG-15</td>
<td>Kostin</td>
<td>23/37mm</td>
</tr>
<tr>
<td>17 Apr 55</td>
<td>RB-47H</td>
<td>USAF</td>
<td>MiG-15</td>
<td>Korotkov</td>
<td>23/37mm</td>
</tr>
<tr>
<td>22 Jun 55</td>
<td>P2V-5</td>
<td>USN</td>
<td>MiG-15</td>
<td>?</td>
<td>23/37mm</td>
</tr>
<tr>
<td>10 Sep 56</td>
<td>RB-50</td>
<td>USAF</td>
<td>MiG-15</td>
<td>?</td>
<td>23/37mm</td>
</tr>
<tr>
<td>27 Jun 58</td>
<td>C-118</td>
<td>USAF</td>
<td>MiG-17 P</td>
<td>Sevetlichenkov</td>
<td>23/37mm</td>
</tr>
<tr>
<td>2 Sep 58</td>
<td>C-130A</td>
<td>USAF</td>
<td>MiG-17</td>
<td>H.Gavrilov</td>
<td>23/37mm</td>
</tr>
<tr>
<td>1 Jul 60</td>
<td>RB-47</td>
<td>USAF</td>
<td>MiG-17 F</td>
<td>V.Polyakov</td>
<td>23/37mm</td>
</tr>
<tr>
<td>1963</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>30mm</td>
</tr>
<tr>
<td>1963</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>30mm</td>
</tr>
<tr>
<td>10 Mar 64</td>
<td>RB-66C</td>
<td>USAF</td>
<td>MiG-21 F-13</td>
<td>Zinovlev</td>
<td>30mm</td>
</tr>
<tr>
<td>14 Dec 65</td>
<td>RB-57F</td>
<td>USAF</td>
<td>MiG-17 F</td>
<td>?</td>
<td>23/37mm</td>
</tr>
</tbody>
</table>
Elint - Is There a Better Way?
The U-2
U-2 as an Elint Platform
Courtesy of Stanford and Silicon Valley

- System IV
  - 150 - 40,000 MHz
  - Stanford Electronics Laboratories
- U2 E/F Band Jammer
  - Granger Associates
- Watkins Johnson
  - Traveling Wave Tubes QRC -192
    Elint receiver
  - 50 -14,000 MHz
- Communications receiver
  - 100-150 MHz
  - 3 channel tape recorder
Stanford Joins the “Black” World

- Electronics Research Laboratory
  - “Basic” and Unclassified Research
- Applied Electronics Laboratory (AEL)
  - “Applied” and Classified Military programs
- Merge and become the Systems Engineering Lab (SEL) in 1955
  - Same year Terman becomes Provost
Terman Changes the Startup/University Rules

- Graduate students encouraged to start companies
- Professors encouraged to consult for companies
- Terman and other professors take board seats
- Technology transfer/IP licensing easy
- Getting out in the real world was good for your academic career
Story 4: Spook Innovation
Project: Melody  ~1960

• First noticed at Cape Canaveral
  – The signals from one of our ground radars bounced off a Thor missile on a test launch
  – Was received by a second radar
  – Hmm…

• Bistatic intercept receiver
Project: Melody ~1960

- Pick up Soviet radars *bounced off their own ICBM’s* during test flights
  - Used existing CIA “Tacksman” intercept sites in Iran
  - Use the missiles’ telemetry beacon to steer our antennas
- Produced intercepts of all ground-based Soviet missile tracking radars
  - Including all ABM radars
  - At a 1000 mile range
OXCART / A-12
U-2 Successor
CIA: Directorate of Science & Technology

• Concerned about OXCART* vulnerability
  – First aircraft designed for Stealth (tail was plastic)
  – High speed (Mach 3.3), high altitude (90K feet)
• Facing evolved Soviet air defense system
• ELINT Staff Office (ESO) asked:
  – What’s the radar environment like inside the Soviet Union?

* A-12/OXCART was the CIA version of the plane which was kept secret (15 built). SR-71 was the 2 seat Air Force reconnaissance version which was made public (31 built.) The YF-12 was an Air Force fighter interceptor (3 built.)
Problem: Find “Tall King”

• Primary Soviet Air Defense Radar
  – Long Range, 375 miles
    • 150mhz, PRF 100/200hz, 800Kw
  – 100’ wide, 30’ high
• Where were they located?
• How many are there?
  – B52 bombers needed to know
  – OXCART needed to know
Solution: Project “Flower Garden”
Shoot the Moon

- Point dishes at the moon
- Use the moon as a bistatic reflector
- Listen for TALL KING signals
  - As earth and moon revolved and rotated all TALL KING’s came into view, one at a time
  - Plot their precise location
Radio Dishes Get Funded at Universities

• Attach ELINT receivers to Bell Labs 60’ radar antenna in New Jersey
  – Use “matched filter” techniques
  – Developed at Stanford
• Pay for and build Stanford “Dish”
  – Hide relationships via “cover agencies”
• Build steerable antenna at Sugar Grove Virginia
• Use Jodrell Bank 250’ disk in UK
Project Grab

• Put Elint into space  
  – 1960-1962
• Collect radar emissions from Soviet air defense radars
• Built by the Naval Research Laboratory
• Used by SAC for EOB then given to the NRO
Project POPPY

- Elint in space for the Navy
- Collect radar emissions from Soviet naval vessels
- Clusters of satellites
  - 1962-1971
- Triangulate and direction find
Stanford Alum’s: Sylvania Electronics Defense Laboratory (EDL)

- Focus was to understand/counter Soviet threat
  - Army Signal Corps funded
  - Countermeasures, search receivers, converters
  - Hired faculty as consultants, including Terman
  - 1,300 employees and $18 million in contracts

- 1964, EDL director William Perry + 6 of his top lieutenants leave to found Electronic Systems Laboratories (ESL)
Terman and the Cold War
Silicon Valley’s 1st Engine of Entrepreneurship

Entrepreneurs

Military Finance

Crisis

Profit

Cooperative Culture

Entrepreneurial Culture

Outward-Facing Tech Universities

Risk Capital

Free flow of People/Information

24/7 Utilities

Predictable Economic System

Stable Legal System

Technical Labs/Universities

Motivation

Culture

Infrastructure

Steve Blank 23 Sept 2008
Story 5: Why It’s *Silicon* Valley
Meanwhile, on the Other Side of Town…

The Head of Radar Bombing training for Air Force starts a Company
William Shockley
“The Other Father of Silicon Valley”

- Director of Navy anti-submarine warfare operations group at Columbia (1942-1943)
- Head of Radar Bombing training for Air Force (1943-1945)
- Deputy Director and Research Director of the Weapons System Evaluation Group in the Defense Department (1954-1955)
- Co-inventor of the transistor
  - Nobel Prize in 1956
- Founded Shockley Semiconductor 1955
  - First semiconductor company in California
William Shockley
“Great Researcher, Awesome Talent Spotter, Horrible Manager”

• Unintended consequences:
  “The traitorous 8” leave Shockley
  – found Fairchild Semiconductor
    • First VC Investment (Venrock)
  – Noyce & Moore leave Fairchild to start Intel
  – Fairchild spinouts: AMD, National, et al

• Eugenics beliefs end his career 1963
Shockley’s Legacy

• It’s Silicon Valley
Story 6: The Rise of *Private* Capital
Venture Capital
Silicon Valley’s 2nd Engine of Entrepreneurship

Motivation
- Crisis
- Profit

Culture
- Cooperative
- Entrepreneurial
- Outward-Facing Tech Universities
- Risk Capital

Infrastructure
- 24/7 Utilities
- Predictable Economic System
- Stable Legal System
- Technical Labs/Universities

Free flow of People/Information

Steve Blank 23 Sept 2008
The Valley Attracts Financial Attention
The 1st West Coast IPO’s

- 1956 Varian
- 1957 Hewlett Packard
- 1958 Ampex
The Rise of Risk Capital
Family Money 1940’s - 1960’s

- J.H. Whitney
  - 1st family office 1946
- Laurance Rockefeller
  - Draper Gaither & Anderson (1st limited Partnership) 1958
  - Spun out as Venrock in 1969
- Bessemer
- East Coast focus
- Wide variety of industries
The Rise of Risk Capital
East Coast VC Experiments

• 1946 American Research & Development
  – George Doriot
  – Right idea, wrong model
    (public VC firm)

• 1963 Boston Capital
The Rise of Risk Capital
“The Group”  1950’s

• First Bay Area “Angels”
  – Reid Dennis
  – William Bryan
  – William Edwards
  – William K. Bowes
  – Daniel McGanney

~ 10 deals $75 -$300K
Reid Dennis Remembers

• “The first 25 electronics companies required total capital of $300k each and private individuals formed the basis of the early syndicates”

• “....in 1975, prior to the relaxation of ERISA laws, the entire VC industry raised $10m”
The Rise of Risk Capital
SBIC’s 1958 - 1988

• SBIC Act of 1958
  – 700 SBIC funds by 1965
  – 75% of all VC funding in 1968, 7% in 1988

• Corporate
  – Bank of America - George Quist, Tom Clauson
  – Firemans Fund/American Express - Reid Dennis

• Private
  – 1959 Continental Capital - Frank Chambers
  – The Group; Bryan Edwards, McGanney
  – 1962 Pitch Johnson & Bill Draper
  – 1962 Sutter Hill
Defense R&D Budget

$ Billions

Defense R&D Budget

California

Hidden in Plain Sight: The Secret History of Silicon Valley

Defence R&D Budget
Silicon Valley

Defense R&D Budget
Versus Venture Capital

$ Billions

Defense R&D Budget
Versus Venture Capital

The Rise of Risk Capital
Venture Capital - The Limited Partnership

• DGA (Draper Gaither & Anderson) 1958
• Rock and Davis 1961
• Sutter Hill 1964
• TA Associates 1968
• Mayfield Fund 1969
• Patricof & Co. 1969
• Kleiner Perkins 1972
• Capital Mgmt Services (Sequoia) 1972

• Capital gains 49.5% to 28% 1978
• ERISA allows Pension funds to invest 1979
  – Employee Retirement Income Security Act

Hidden in Plain Sight: The Secret History of Silicon Valley
Venture Capital
Silicon Valley’s 2nd Engine of Entrepreneurship

Motivation
Crisis | Profit

Culture
Cooperative | Entrepreneurial | Outward-Facing Tech Universities | Risk Capital

Infrastructure
24/7 Utilities | Predictable Economic System | Stable Legal System | Technical Labs/Universities

Free flow of People/Information

Steve Blank 23 Sept 2008
Summary

• Terman/Stanford responsible for entrepreneurial culture of Silicon Valley
• Military primed the pump as a *customer* for key technologies
  – Semiconductors, computers, Internet
  – But very little tech cross pollination
• Venture Capital turned the valley to volume corporate/consumer applications
This Presentation is on YouTube

Search for:

“The Secret History of Silicon Valley”