

Hidden in Plain Sight: The **Secret** History of Silicon Valley

Watch This Talk Online

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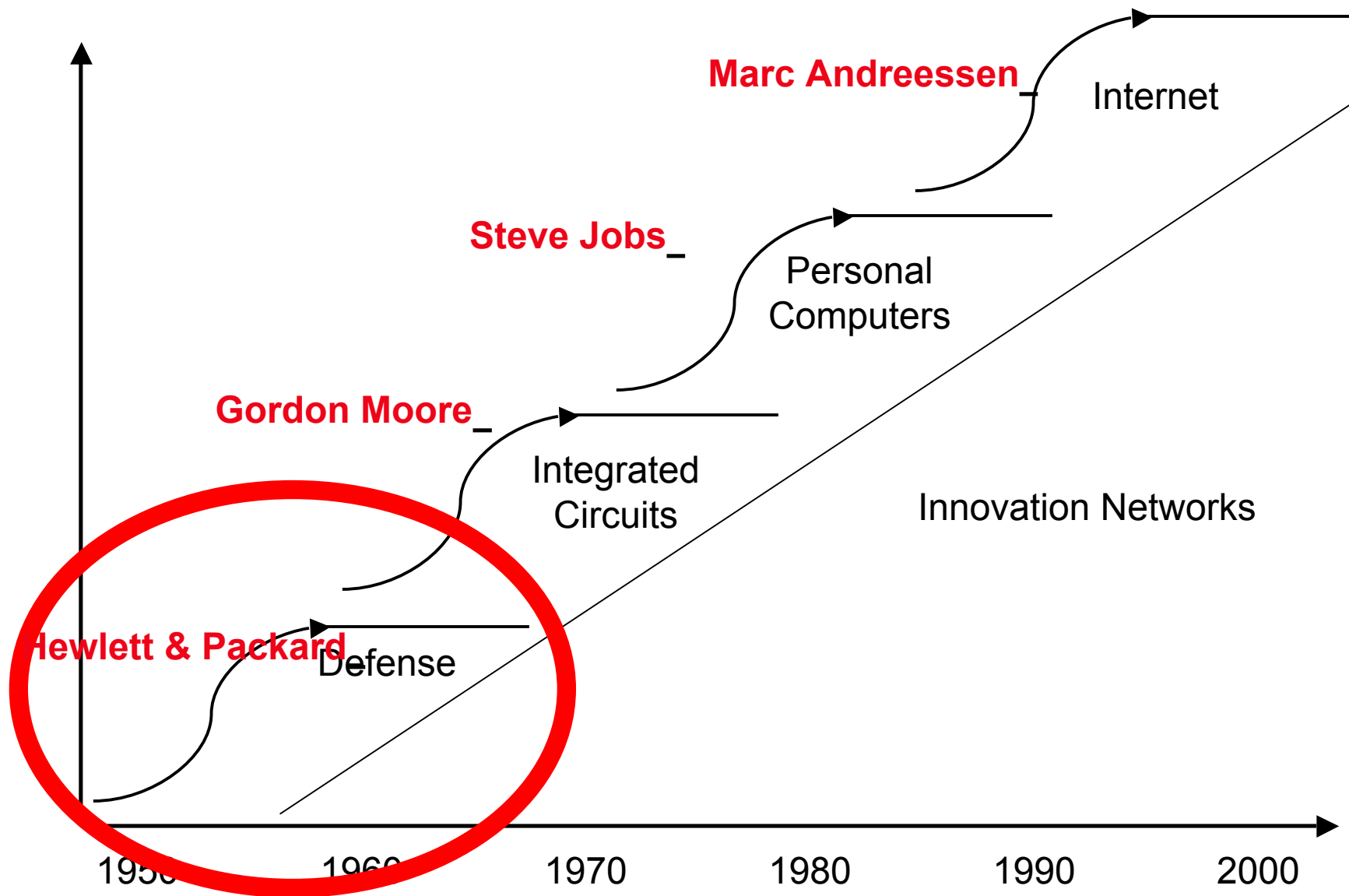
Read the Backstory

<http://bit.ly/SecretStories>

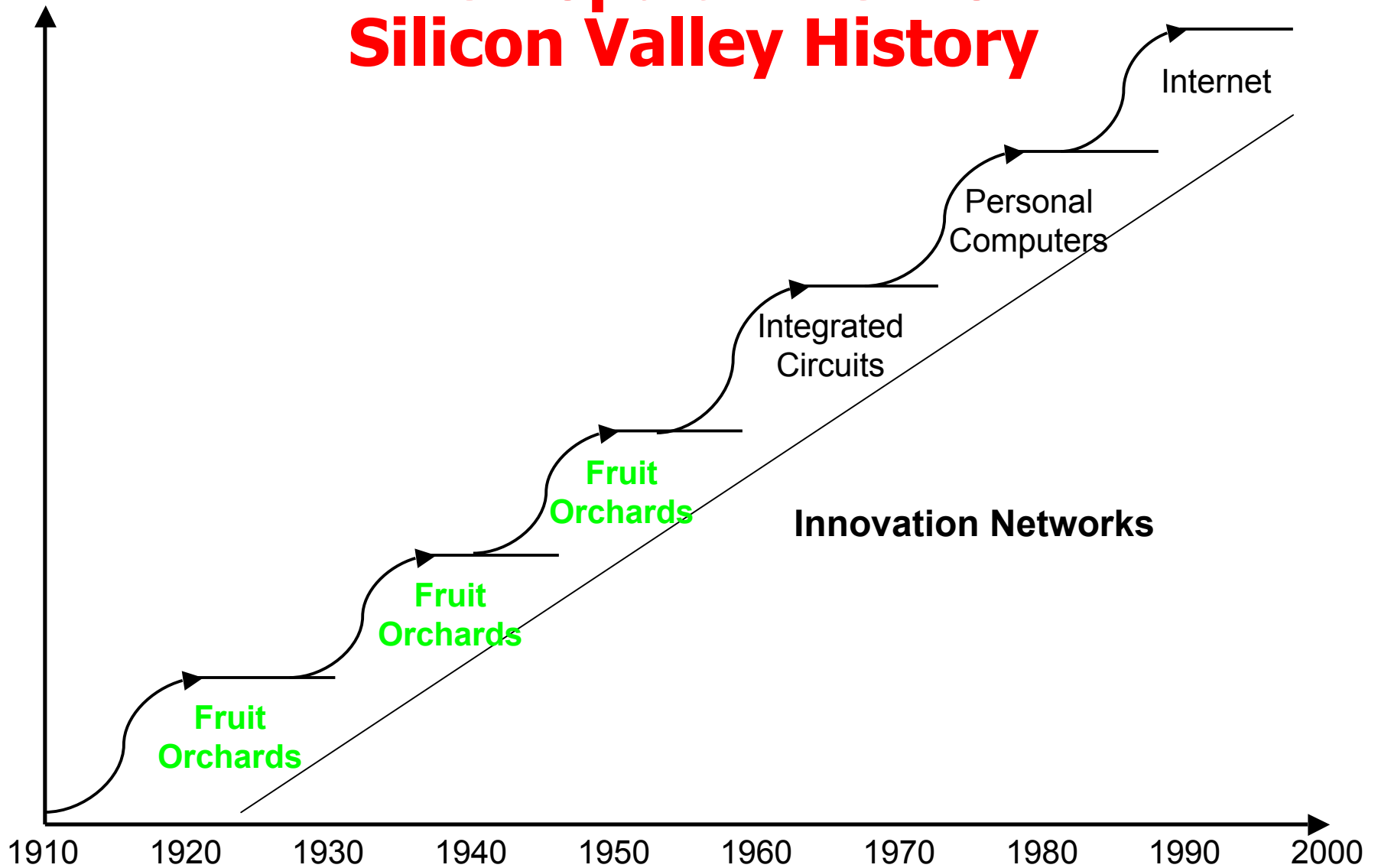
Read the Blog

www.steveblank.com

The Genesis of Silicon Valley Entrepreneurship

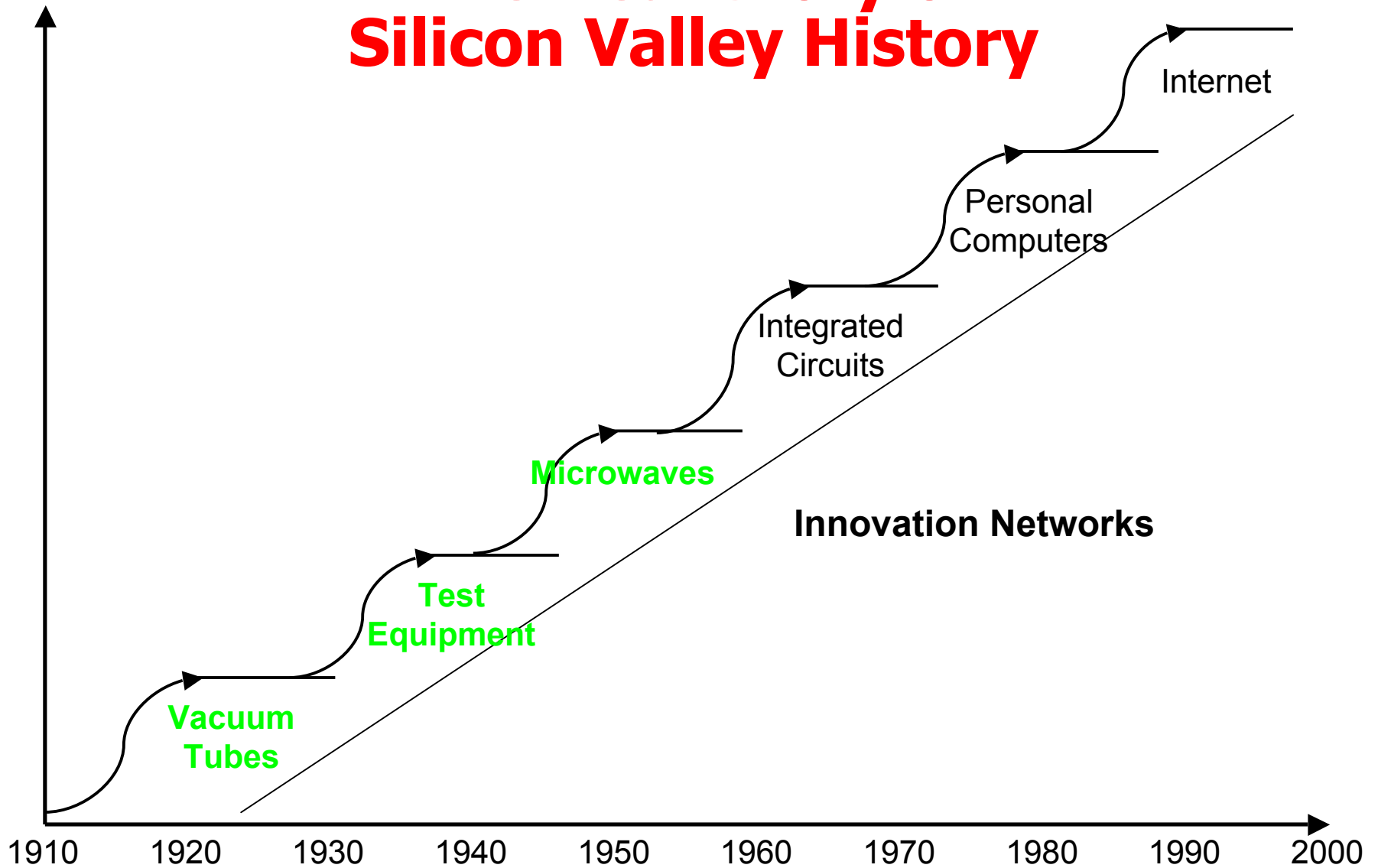


The Popular View of Silicon Valley History



The Secret History of Silicon Valley

The Real Story of Silicon Valley History



The Secret History of Silicon Valley

A few caveats

- Not a professional historian
- WWII story from the western front - lacks Soviet contributions
- Some of this is probably wrong
- Cold War story is U.S.- centric. Other data points welcomed
- All “secrets” are from open-source literature

Seven Short Stories

Story 1: WWII The First Electronic War

Dec 7th 1941: America Enters WWII

- Britain fighting since Sept '39
- Soviets fighting massive land/air battles since June '41
- Allies incapable of landing in Western Europe for 2+ years
- Decide that
 - priority was to win in Europe vs Pacific
 - destroy German war fighting capacity from the air until they can invade



Strategic Bombing of Germany

March 1943: The Combined Bomber Offensive

“Your primary objective will be the progressive destruction and dislocation of the German military, industrial and economic system and the undermining of the morale of the German people to a point where their capacity for armed resistance is fatally weakened.”

Strategic Bombing of Germany

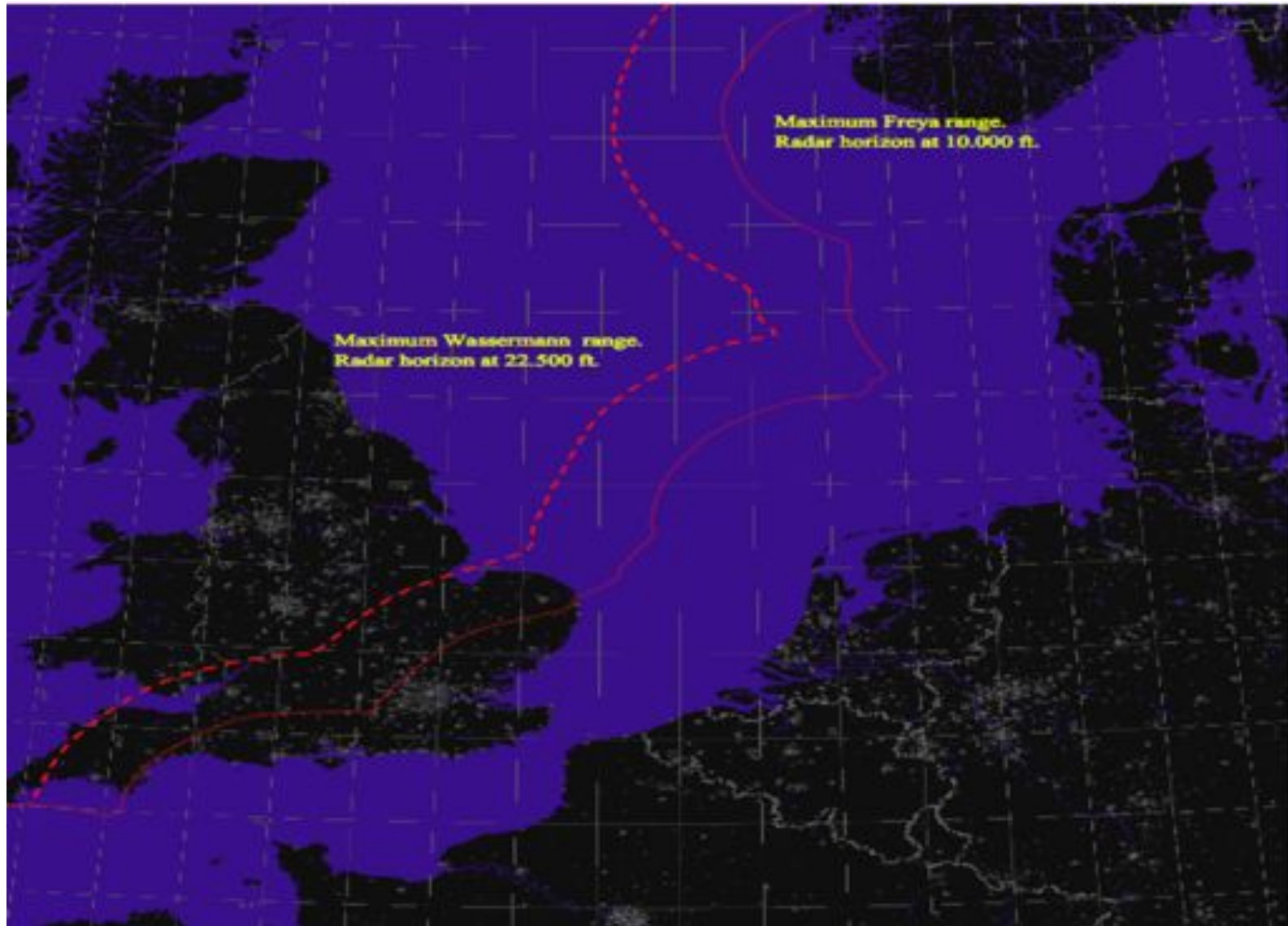
The Combined Bomber Offensive

- 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





Early Warning Radar Range



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



British/American Air War in Western Europe

28,000 Active Combat Planes

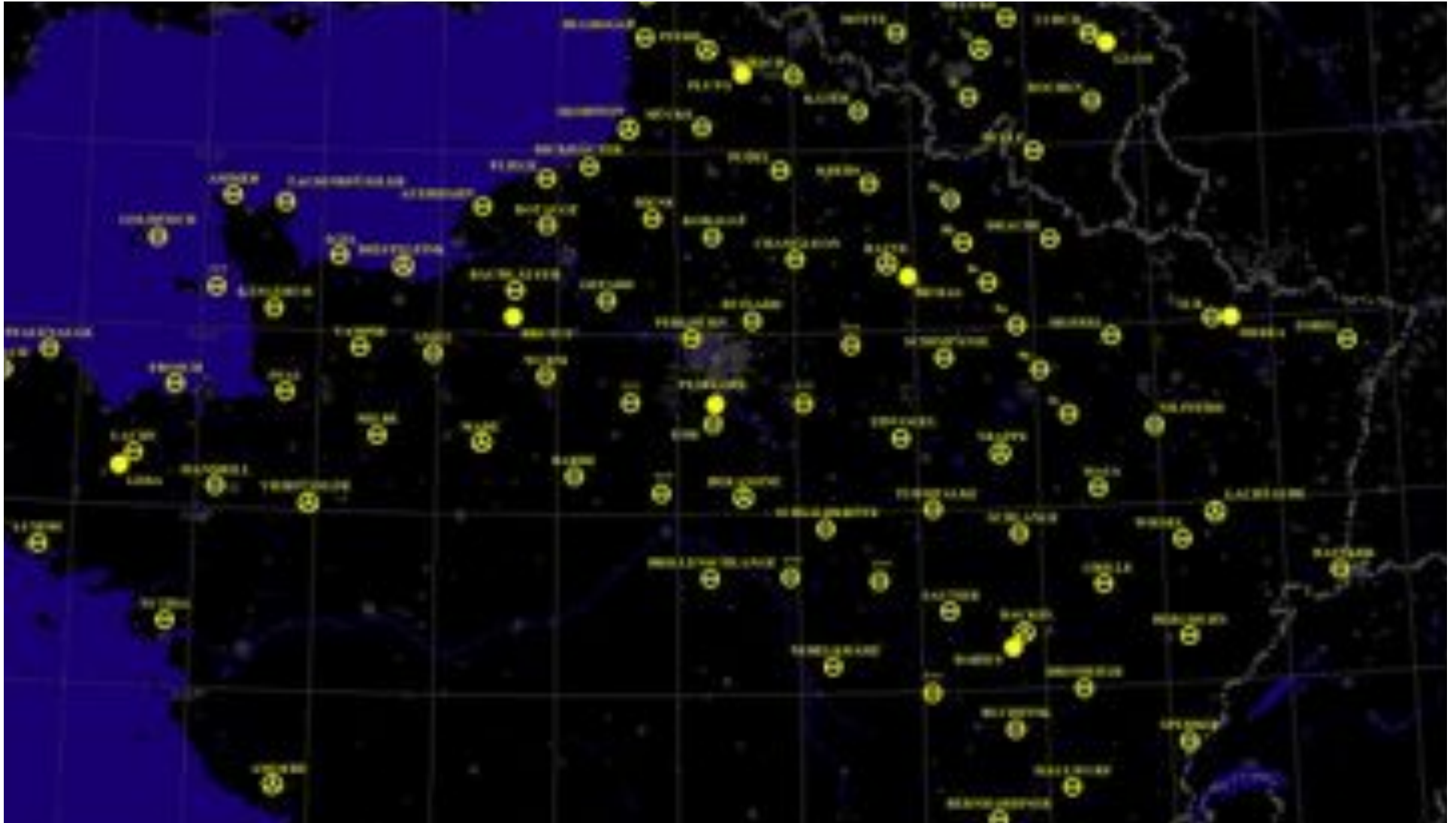
40,000 Allied planes lost or damaged beyond repair:

18,000 American and 22,000 British

(46 000 planes lost by the USSR in the East)

79,265 Americans and 79,281 British killed,
wounded or captured

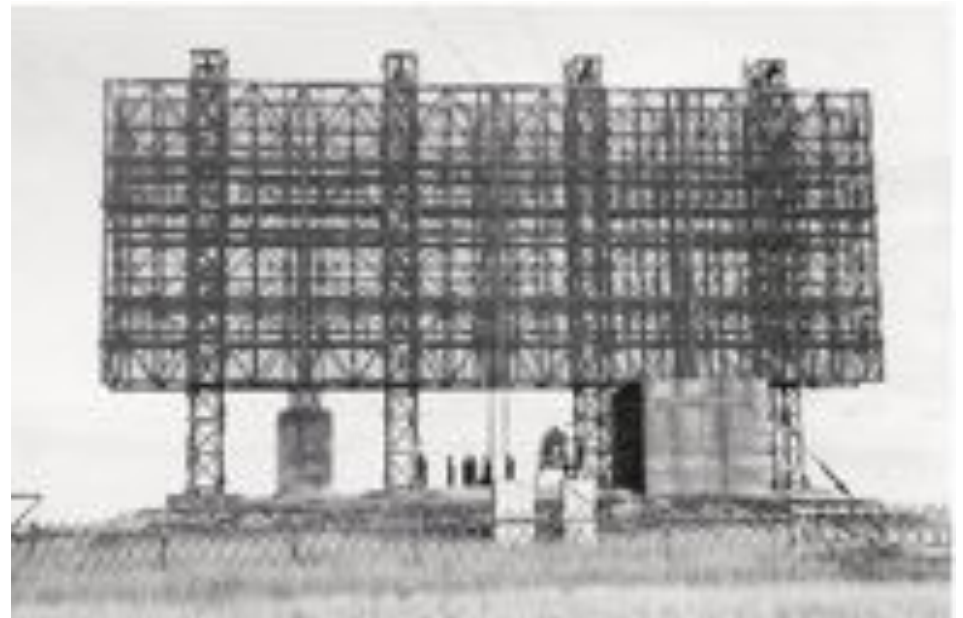
Early Warning Radars in Occupied France



Mammoth

Early Warning Radar

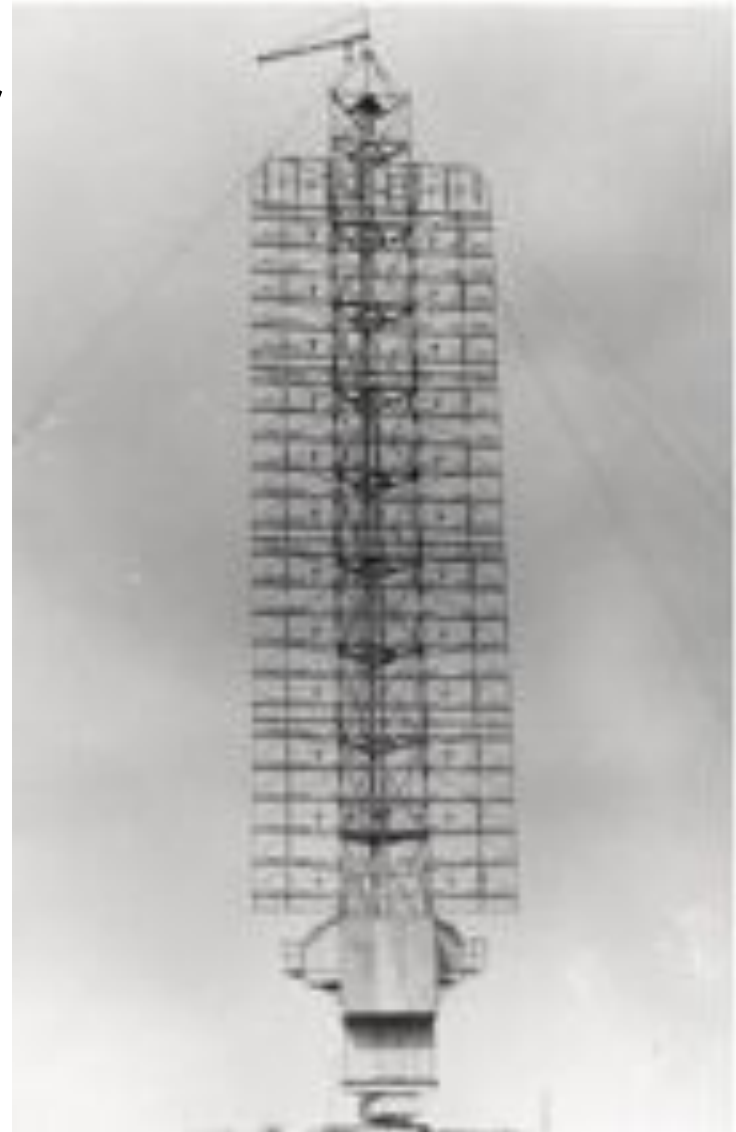
- 200 mile range
 - 150 MHz, 200KW, PRF 500hz, PW $3\mu\text{s}$, accuracy 0.5°
- 100' wide, 33' high
- 1st phased-array radar
- Operational 1942
- **20 built**



Wasserman

Early Warning Radar

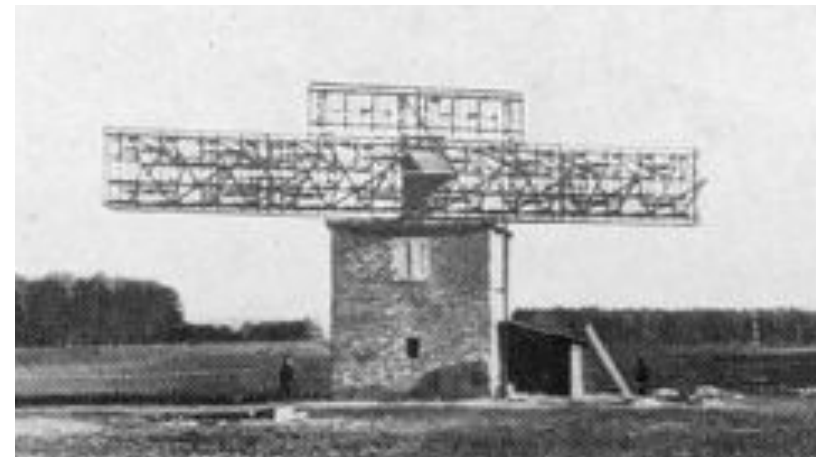
- 150 mile range
 - 150 MHz, 100KW, PRF 500hz, PW 3 μ s, accuracy 0.25°
- Backbone of the German early warning network
- Steerable tower 190'
- Operational 1942
- **150 built**



Jagdschloss

Early Warning Radar

- 180 mile range
 - 120-157 or 156-250 MHz, 300KW, PW 1us, PRF 500hz
- Best early warning radar
- 360° rotation at 4 rpm,
- Remote PPI display via microwave link
- Operational 1944
- **80 built**



Himmelbelt

Local Air Defense Network

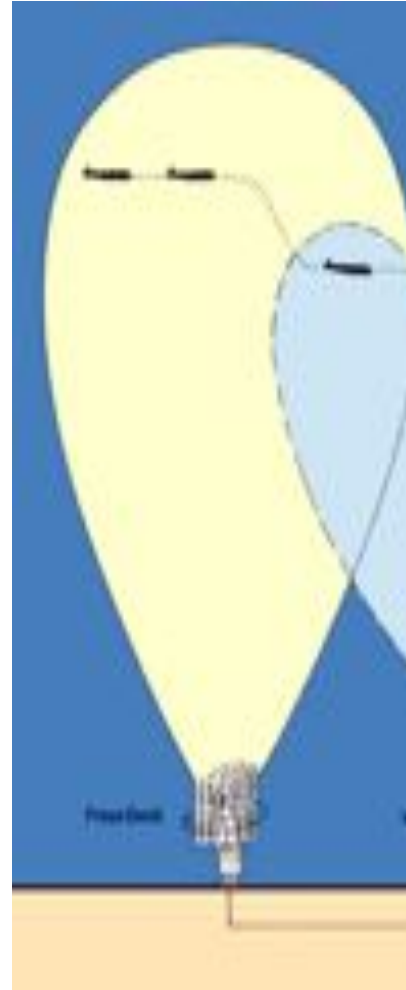
- Box ~30 x 20 miles
- Integrated network of radars, flak, fighters, searchlights



Himmelbelt

Radar Order of Battle

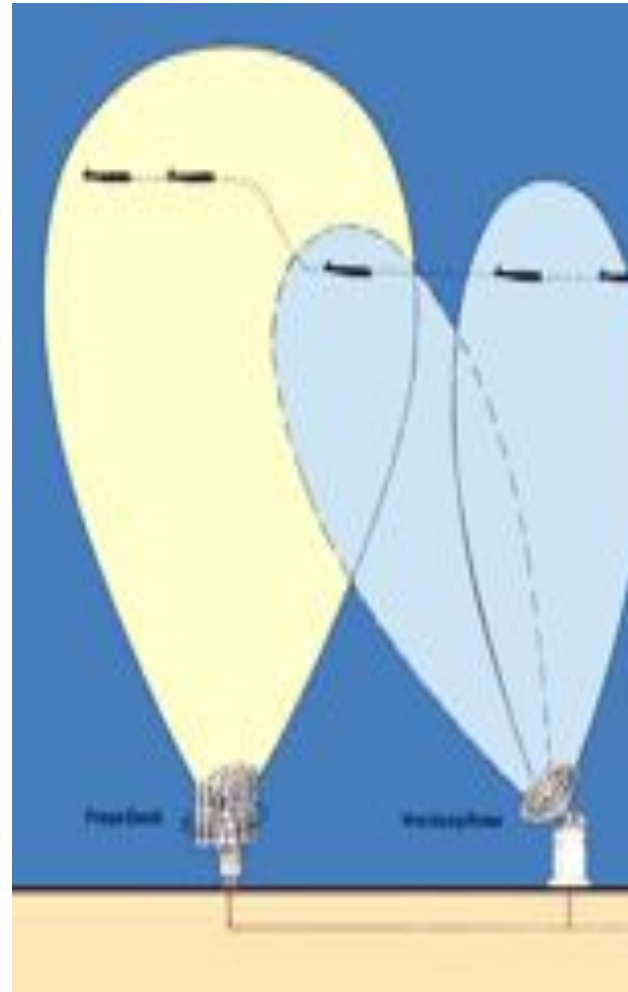
- Freya
 - early warning radar
 - detect allied bombers



Himmelbelt

Radar Order of Battle

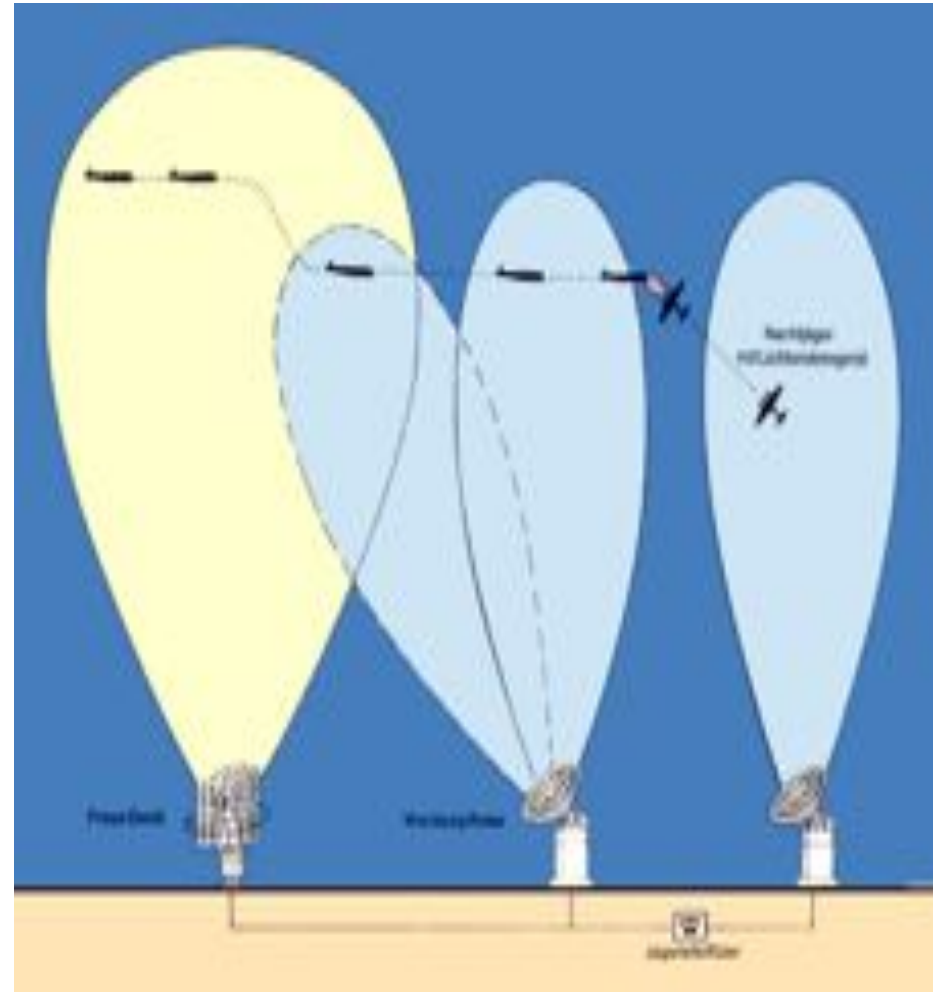
- Freya
 - early warning radar
 - detect allied bombers
- Giant Wurzburg
 - Ground Controlled Intercept radar
 - direct fighters to bombers
 - fighters could then intercept with their on-board radar



Himmelbelt

Radar Order of Battle

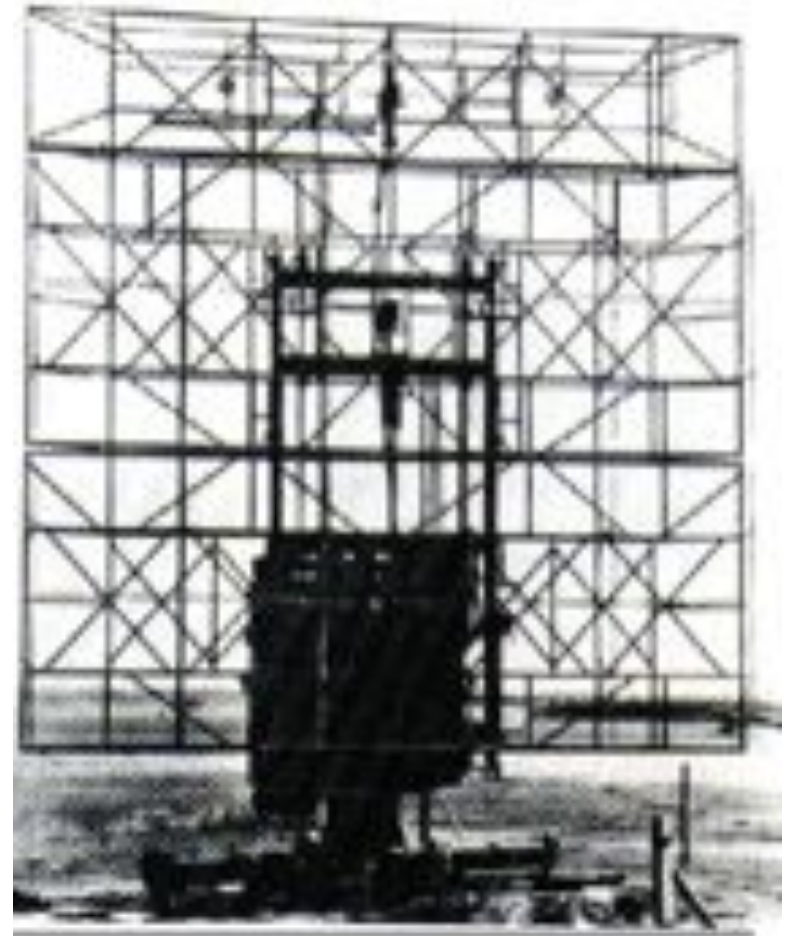
- Freya
 - early warning radar
 - detect allied bombers
- Giant Wurzburg
 - Ground Controlled Intercept radar
 - direct fighters to bombers
 - fighters could then intercept with their on-board radar
- Lichtenstein BC & SN2
 - Airborne radar on German nightfighters



Freya

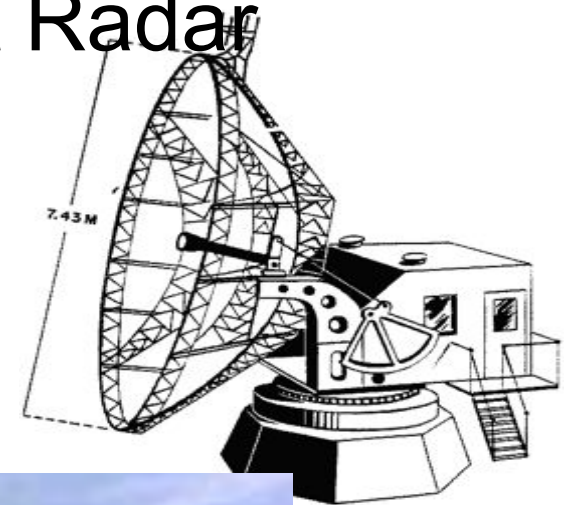
Early Warning Radar

- 60-120 mile range
 - 120-144 MHz, 15KW, PRF 500hz, PW 3 μ s, accuracy 1.5°
- Steerable and mobile
- **Over 1000 deployed**



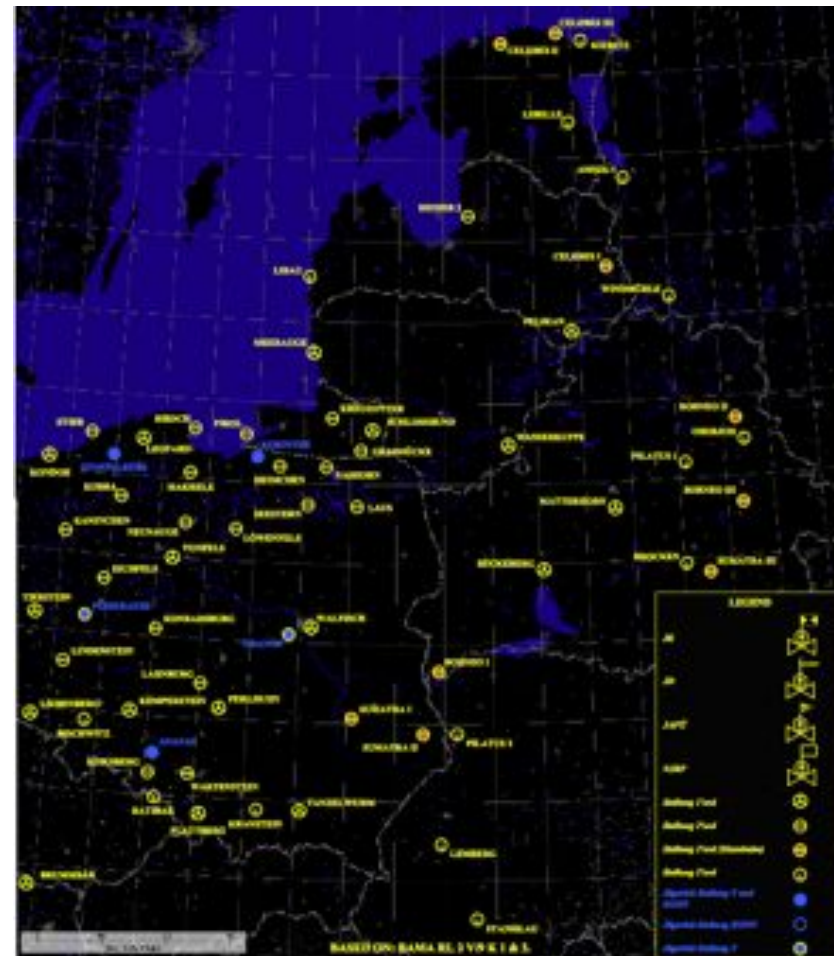
Giant Wurzburg Ground Control Intercept Radar

- 45 mile range
 - 533-566mhz frequency
agile, 10KW, PRF 1875hz,
PW 2 μ s
- GCI radar
- 25' wide
- **over 1,500 deployed**



Luftwaffe Signals Intelligence Service

- Network of *passive* intercept stations
- Picked up allied radio and bombing-radar signals
- Plotted location of bomber streams



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





Flak - Radar Controlled Anti Aircraft Guns

- **15,000** Flak 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



105 mm flak

Flak: an abbreviation for Fliegerabwehrkanonen, german for anti-aircraft guns

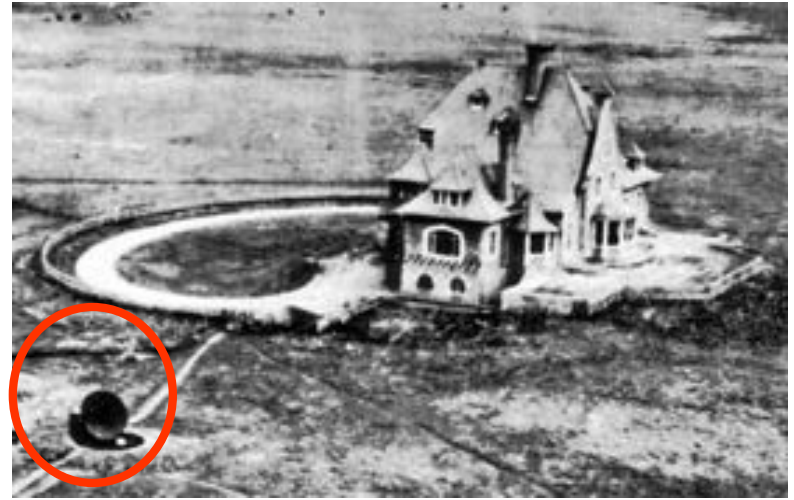
Wurzburg Anti-Aircraft Radar

- 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**



Operation Biting - Raid on Bruneval

- Commando raid to *steal* a Wurzburg
- 27 February 1942
- Captured all the radar electronics and technicians
- Used it to test countermeasures



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, 400mhz then 90mhz





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





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
 - B-24 & P-38 Pathfinders
- Oops - Naxos



Math Challenge

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

Crews had to fly 25 mission to go home

Story 2: The Electronic Shield - Electronic Warfare

Harvard Radio Research Lab (RRL)

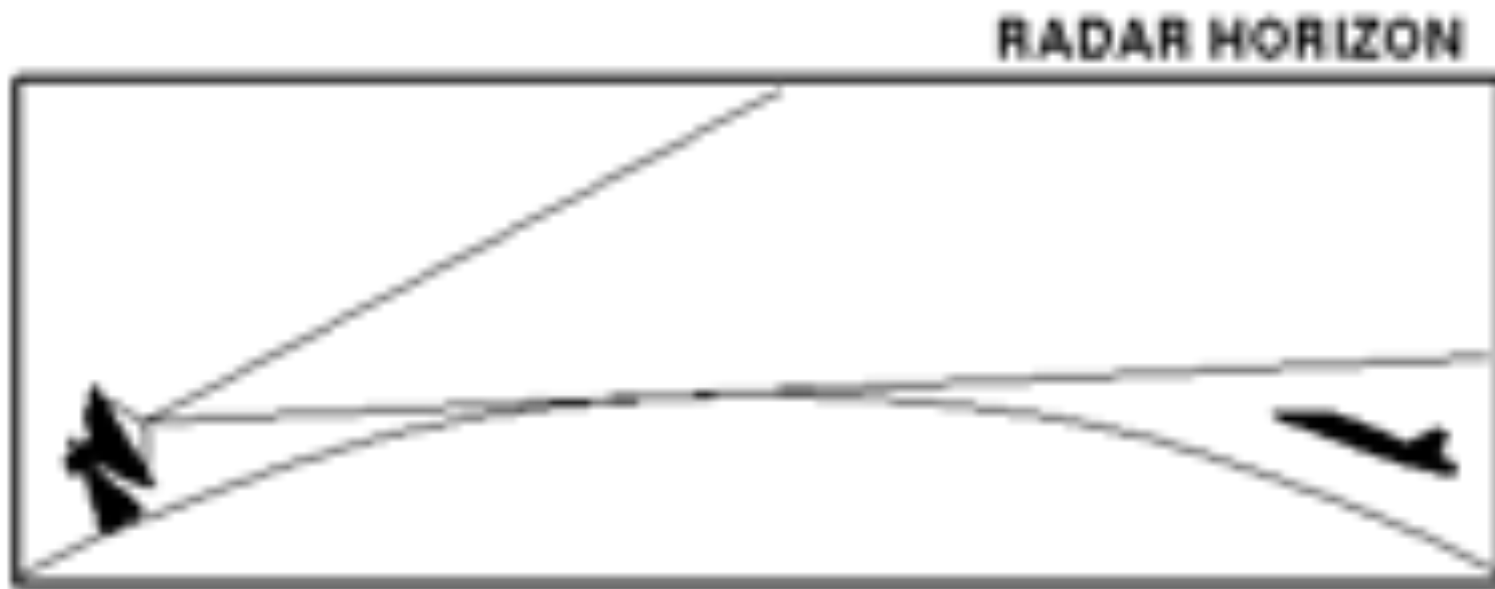
Signals Intelligence and Electronic Warfare

- 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 – **E**lectronic **I**ntelligence

The Line of Sight Problem



You got to get close!

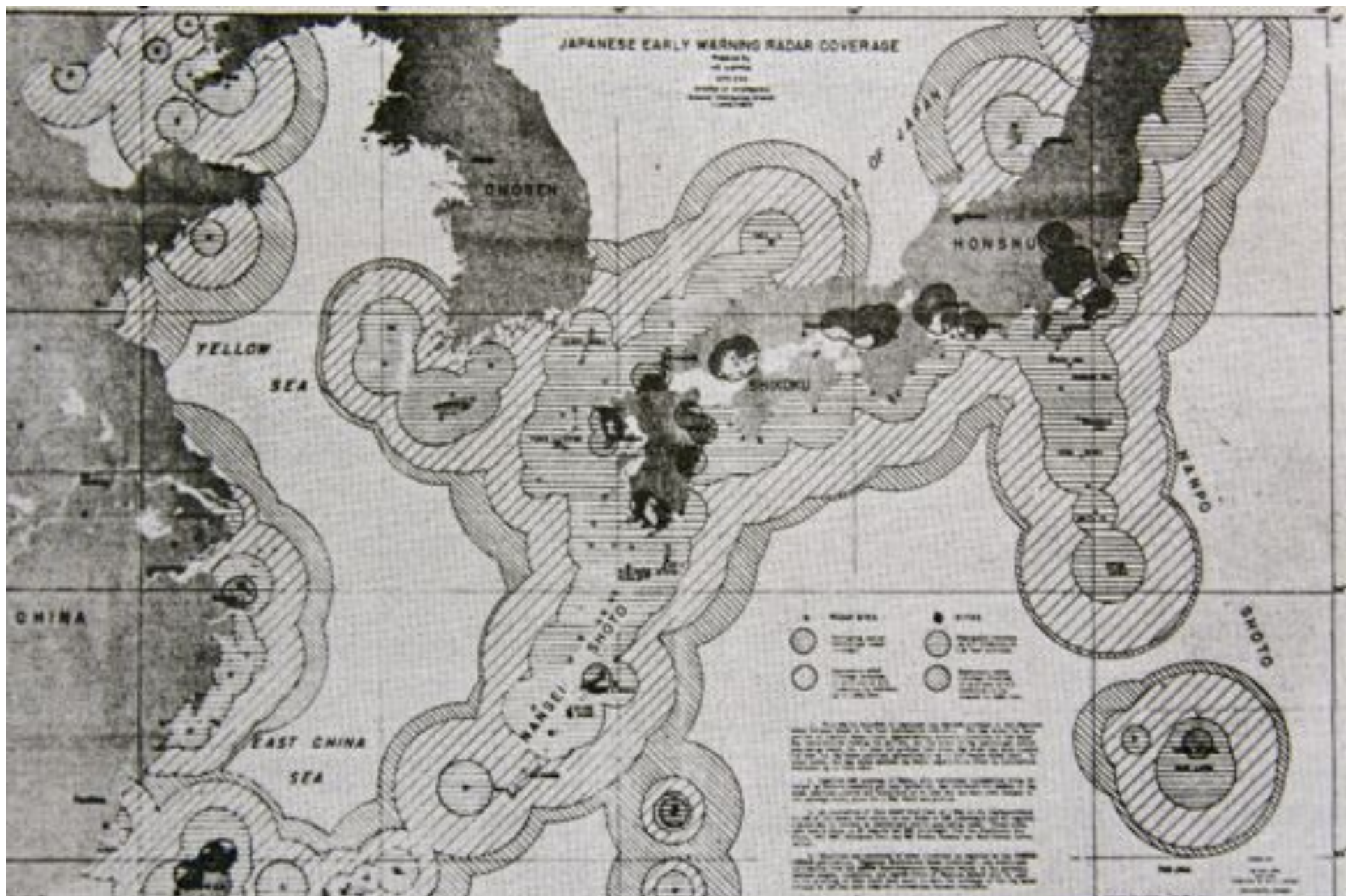
ELINT using Ferret's

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



Using ELINT to Map Radar Coverage



Window/Chaff

Jam Wurzburg AAA & GCI Radar

- Strips of aluminum foil
 - 1/2 Wurzburg frequency
- 46,000 packets tossed out by hand
 - Each packet contained 2,000 strips
 - Automatic dispensers came later
- First used July 1943
 - Raid on Hamburg
 - Shut down German air defense
- Used 3/4's of 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



MANDREL
Jammer



DINA
Jammer

Shut down Flak & Ground Control Radar

Jam the Wurzburg's

- “Carpet” AN/APT-2 Jammer
 - Confuse Wurzburg radar
 - Shut down flak
 - Shut down GCI
 - 5 Watts
- **24,000 built**
 - On all bombers



Carpet Jammer

Shut down and Spoof Fighter Ground Control

Jam Fighter/Ground VHF Radio Links

- "Tinsel"
 - Microphones in the engine nacelles of a bomber broadcast noise
- "Corona"
 - German-speaking RAF personnel, broadcast fake controller instructions
- "Airborne Cigar"
 - Jammed VHF Nightfighter Ground Control Intercept comm
 - Flew in special ops Lancasters
- "Jostle IV"
 - Jammed VHF Ground Control Intercept comm
 - Took up the entire bomb bay of a B-17

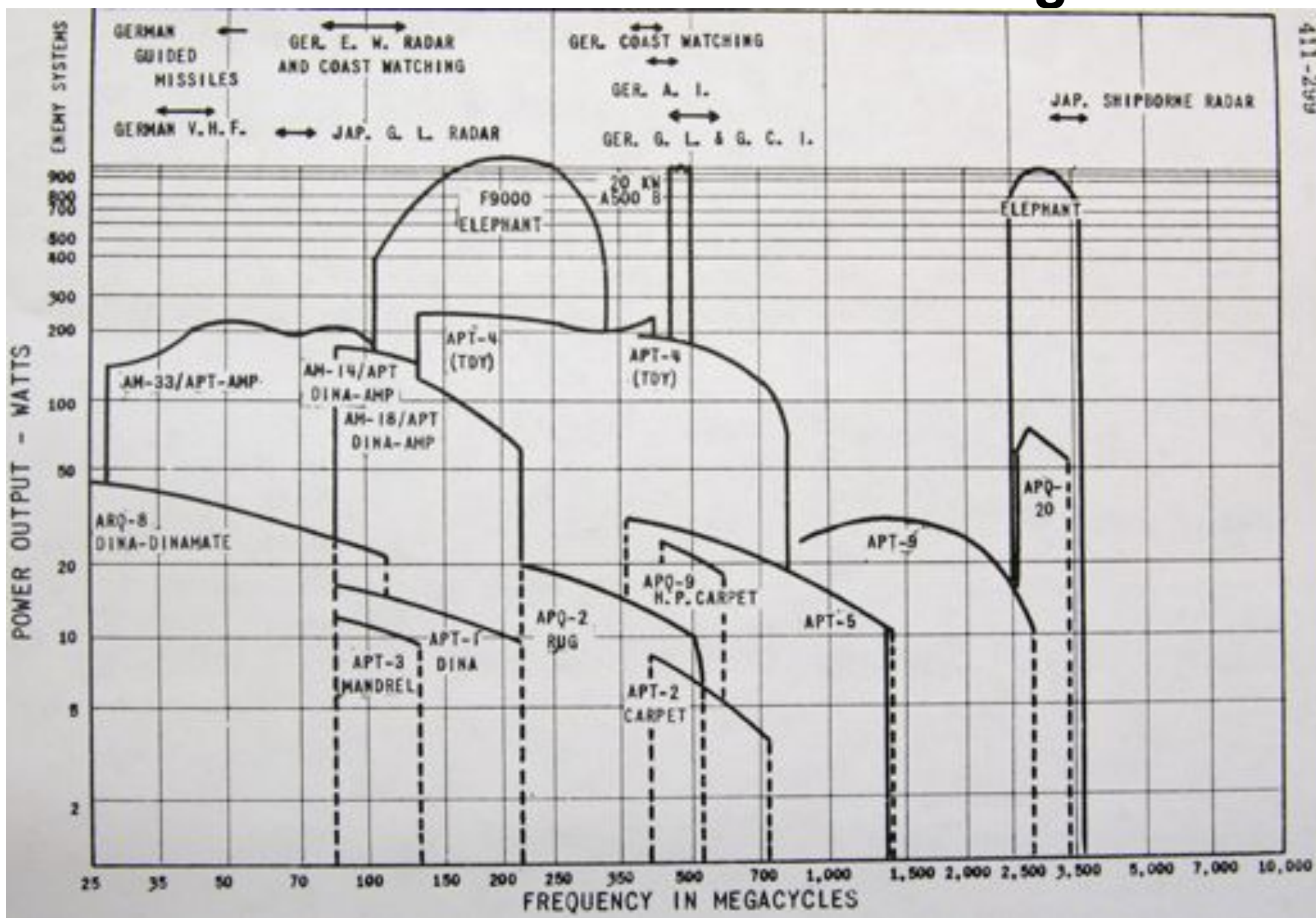


British Jam German Night Fighter Radar

- Airborne Grocer
 - Jam Lichtenstein Night Fighter radar
- On all British bombers
- Monica
 - Tail warning system
 - Oops, German Flensburg

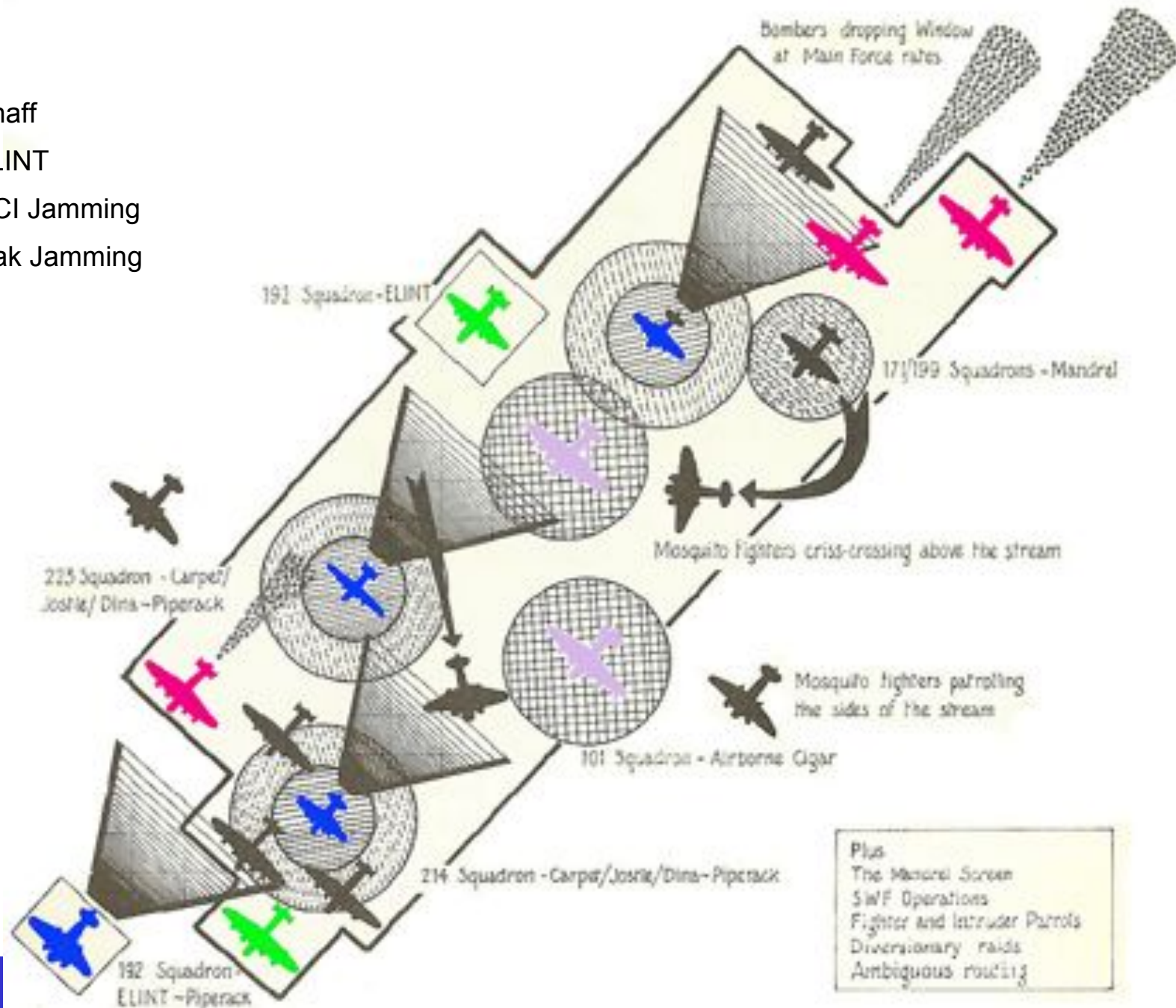


Jammer Versus Radar Coverage



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
 - Separate from 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

Problem: Jammers Need:

More Power and Frequency Agility

- *More Power*
 - WWII: low power jammers X 100's of planes
 - Now each bomber needed to protect itself
- *Frequency Agility*
 - WWII radars xmitted on a single frequency
 - Jammers needed to be manual tuned
 - Soviet radars used multiple frequencies

Solution: Electronically Tunable Microwave Power Tubes

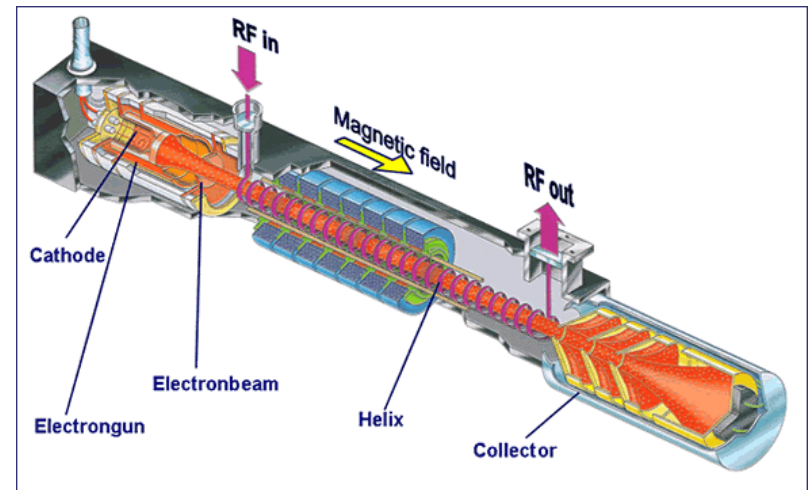
- Magnetron - limited scale, fixed/unstable freq
- Klystron - scale to extremely high power
 - Drawback: narrow frequency range
- Backward wave oscillator (BWO)/Carcinotron
 - Electronically tunable
 - Can sweep 1000/mhz per second
 - High Power ~1,000 watts

Problem: ELINT Receivers Need: *Higher Bandwidth & Frequency Agility*

- *High Bandwidth*
 - Need to cover 300mhz to 40ghz w/one receiver
- *Frequency Agility*
 - Soviet radars used multiple frequencies
 - Manual tuning would miss signals
 - Needed high probability of intercept single pulses

Solution: Electronically Tunable Wideband Amplifiers

- Traveling Wave Tubes
 - High gain $>40\text{db}$,
 - low noise,
 - high bandwidth >1 octave
 - 300mhz - 50ghz
 - Tune at 1000mhz/sec



Microwave Valley - Components

Klystrons, Carcinotrons, & Traveling Wave Tubes

- Eitel-McCullough (1934)
- Varian Associates (1948)
- Litton Industries (1946)
- Huggins Laboratories (1948)
- Stewart Engineering (1952)
- Watkins-Johnson (1957)
- Microwave Electronics Co. (1959)





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 (ELINT)
- 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 Technical Advisory Meetings

- Air Force, Navy, Army, CIA and NSA
- Sylvania, and other contractors
- Review of projects and new concepts

PROGRAM			
THURSDAY, August 18, 1955			
9:00-9:30	Registration		ERL Lobby
9:40-12:00	SESSION I	Geology Bldg., Rm. 320	
	(Chairmen: F. E. Terman, D. B. Harris, K. R. Spangenberg)		
	Introduction	F. E. Terman	
	Program of the Meeting	D. B. Harris	
	Operation of the Laboratories	K. R. Spangenberg	
	The Research Program		
	1. Radio Propagation	O. G. Villard	
	2. Transistors; Circuits and Devices	J. M. Pettit	
10:30-10:55	Recess		
	3. High-Power Tubes and Accelerators	E. L. Ginzton	
	4. Backward-Wave Tubes and TW Tubes	D. A. Watkins	
	5. Systems Techniques	W. R. Rambo	
	Announcements	D. B. Harris	
12:00-1:30	Recess		
1:30-2:50	SESSION II-A Systems Techniques I	Geology Bldg., Rm. 320	
	SESSION II-B Klystrons	ERL, Rm. 126	
2:50-3:10	Recess		
3:10-4:30	SESSION III-A Radio Propagation and	Geology Bldg., Rm. 320	
	Ionospheric Research		
	SESSION III-B Traveling-Wave Tubes	ERL, Rm. 126	
FRIDAY, August 19, 1955			
9:30-10:40	SESSION IV-A Transistors and In-	Geology Bldg., Rm. 320	
	formation Theory		
	SESSION IV-B Backward-Wave Tubes	ERL, Rm. 126	
10:40-11:00	Recess		
11:00-12:10	SESSION V-A Systems Techniques II	Geology Bldg., Rm. 320	
	SESSION V-B High-Power TW Tubes	ERL, Rm. 126	
12:10-1:30	Recess		
1:30-2:00	SESSION VI General Discussion	Geology Bldg., Rm. 320	
2:00-	SESSION VII Tour of the Laboratories		

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

Top Secret//SI//TK//Q3

Stanford Systems Engineering Lab

- Immediate, practical application of real world intelligence problems for CIA, NSA, NRO, Air Force
- Combined ERL components with advanced theory into complete ELINT and Jamming *systems*
 - Usually prototypes turned over to contractors
 - At times, built one-off systems
 - Digital filtering, OTH, etc.
- Use PhD students and staff
 - classified thesis!
- Ultimately 800 person lab

Problem: Understand the Soviet Radar Order of Battle

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





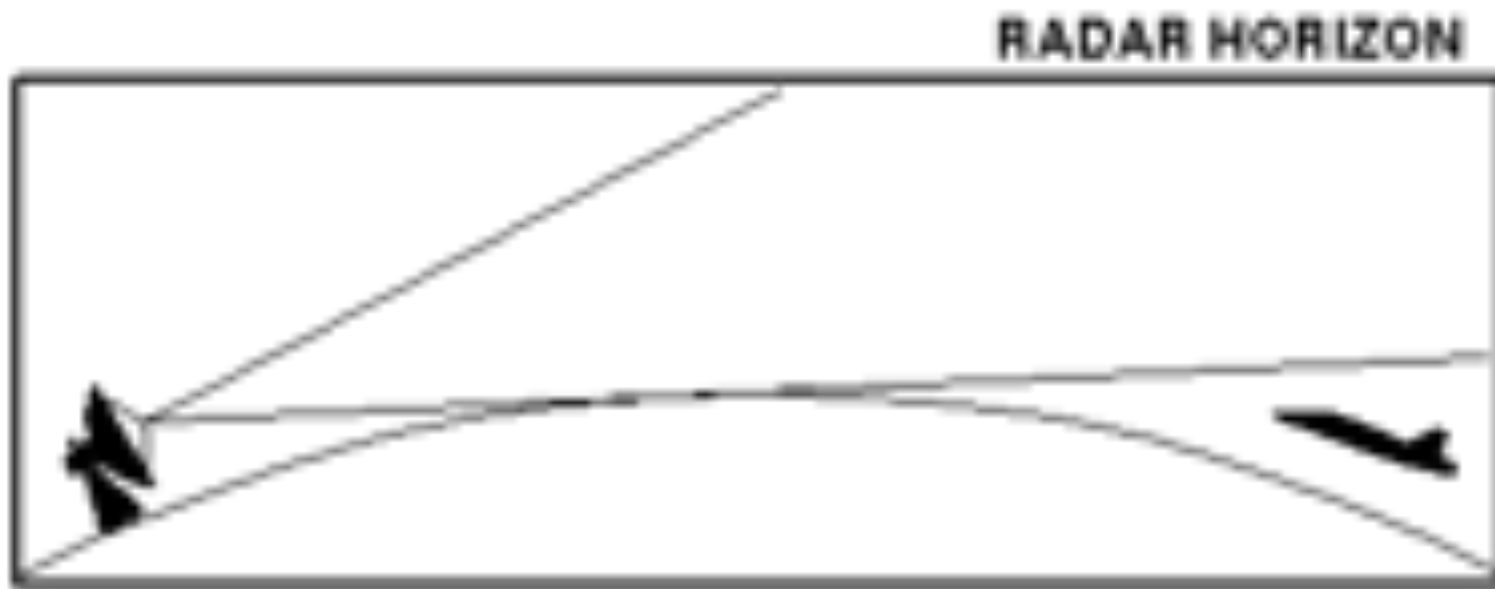
Solution: A Fleet of ELINT Planes

- Joint NSA/CIA/Air Force/Navy
- Flew periphery of Soviet bloc 24/7
 - PB4Y2, P2V, C-97, RB-47, EC-121, C-130, EA-3B, RC-135
- Measured Soviet Air Defense
 - Revealed low-altitude coverage was good
- Continuous Comint



ELINT – *The Line of Sight Problem*

You got to get close!



You got to get them turned on!!

The Cost: 23 ELINT Planes

Date	Victim	Service	Aircraft	Pilot	Weapon
8Apr50	PB4Y-2	USN	La-11	B.Dokin	23/37mm
24Apr50	F-82	USA F	MiG-15	Keleinikov	23/37mm
Apr50	F-51D	USA F	MiG-15	N.Guzhov	23/37mm
May50	F-51D	USA F	La-11	Yefremov	20mm
11May50	B-24	USA F	MiG-15	I.Shinkarenko	23/37mm
26Dec50	RB-29	USA F	MiG-15	S.Bhakaev	23/37mm
6Nov51	P2V-2	USN	MiG-15	M.Schukin	23/37mm
13Jun52	RB-29	USA F	MiG-15	O.Fedotov	23/37mm
7Oct52	RB-29	USA F	MiG-15	Zheryakov	23/37mm
7Oct52	RB-29	USA F	MiG-15	Lesnov	23/37mm
29Jul53	RB-50	USA F	MiG-15	A.Rybakov	23/37mm
4Sep54	P2V-5	USN	MiG-15	?	23/37mm
7Nov54	RB-29	USA F	MiG-15	Kostin	23/37mm
17Apr55	RB-47H	USA F	MiG-15	Korotkov	23/37mm
22Jun55	P2V-5	USN	MiG-15	?	23/37mm
10Sep56	RB-50	USA F	MiG-15	?	23/37mm
27Jun58	C-118	USA F	MiG-17 P	Sevetlichnikov	23/37mm
2Sep58	C-130A	USA F	MiG-17	H.Gavrilo v	23/37mm
1Jul60	RB-47	USA F	MiG-17 F	V.Polyakov	23/37mm
1963	RB-47	USA F	MiG-19 S	?	30mm
1963	T-39	USA F	MiG-19 S	?	30mm
10Mar64	RB-66C	USA F	MiG-21 F-13	Zinowlj ev	30mm
14Dec65	RB-57F	USA F	MiG-17 F	?	23/37mm

Elint - Is There a Better Way?

The U-2



Stanford/Military/Industry Ecosystem

- Stanford did basic research in electronics
- Stanford and SRI do applied research
- Microwave and systems companies in Silicon Valley produce equipment for the military

Example: U-2 as an Sigint Platform (1956)

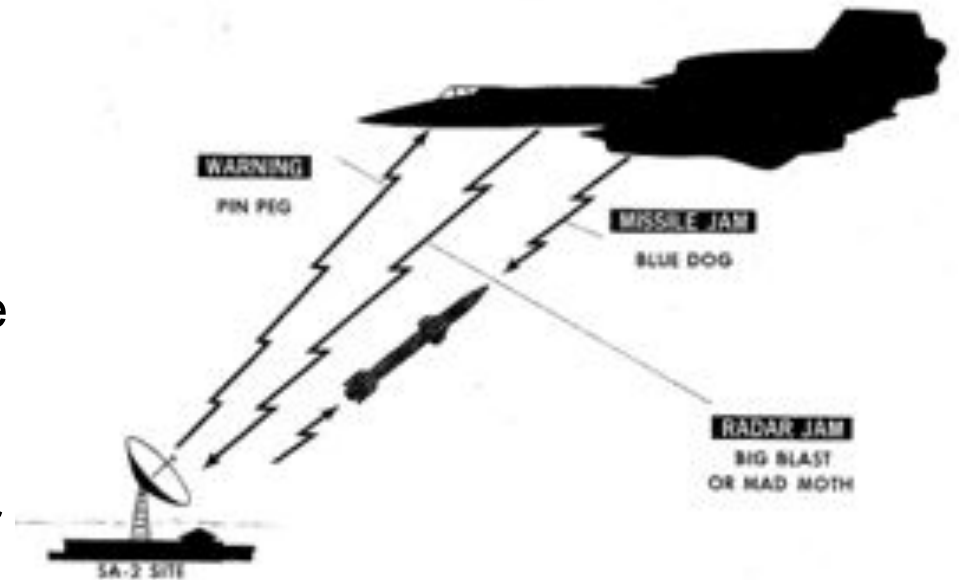
Courtesy of Stanford and Silicon Valley

- System IV
 - 150 - 40,000 MHz
 - Stanford Electronics Laboratories
 - Ramo Woolridge
- E/F Band ELINT recorder (1956)
- A Band ELINT recorder (1959)
- E/F Band Jammer (1959)
 - Granger Associates
- Watkins Johnson
 - QRC -192 Elint receiver
 - 50 -14,000 MHz
- Communications receiver
 - 100-150 MHz/3 channel tape recorder



Example: A-12 ELINT/EWS Suite (1965)

- System VI ELINT analog recorder
 - 50 - 8,000 MHz -45 dbm
 - TRW
- Bluedog SA-2 L-band guidance jammer
 - Sylvania
- Pinpeg SA-2 warning receiver
 - 2.8-3.2 & 4.8 -5.2 ghz -40 dbm
- Big Blast SA-2 Noise Jammer
- Mad Moth SA-2 Jammer



Microwave Valley - Systems

Some Stanford Alum's

- Sylvania Electronics Defense Laboratory (1953)
 - Countermeasures, search receivers, converters
 - Hired faculty as consultants, including Terman
- GE Microwave Laboratory (1956)
- Granger Associates (1956) Bill Granger
- Applied Technology (1959) Bill Granger
- Electronic Systems Laboratories (ESL) (1964)
 - William Perry + 6 other's from Sylvania EDL
- Argo Systems (1969) James de Broekert
- Advent Systems (1972) James de Broekert

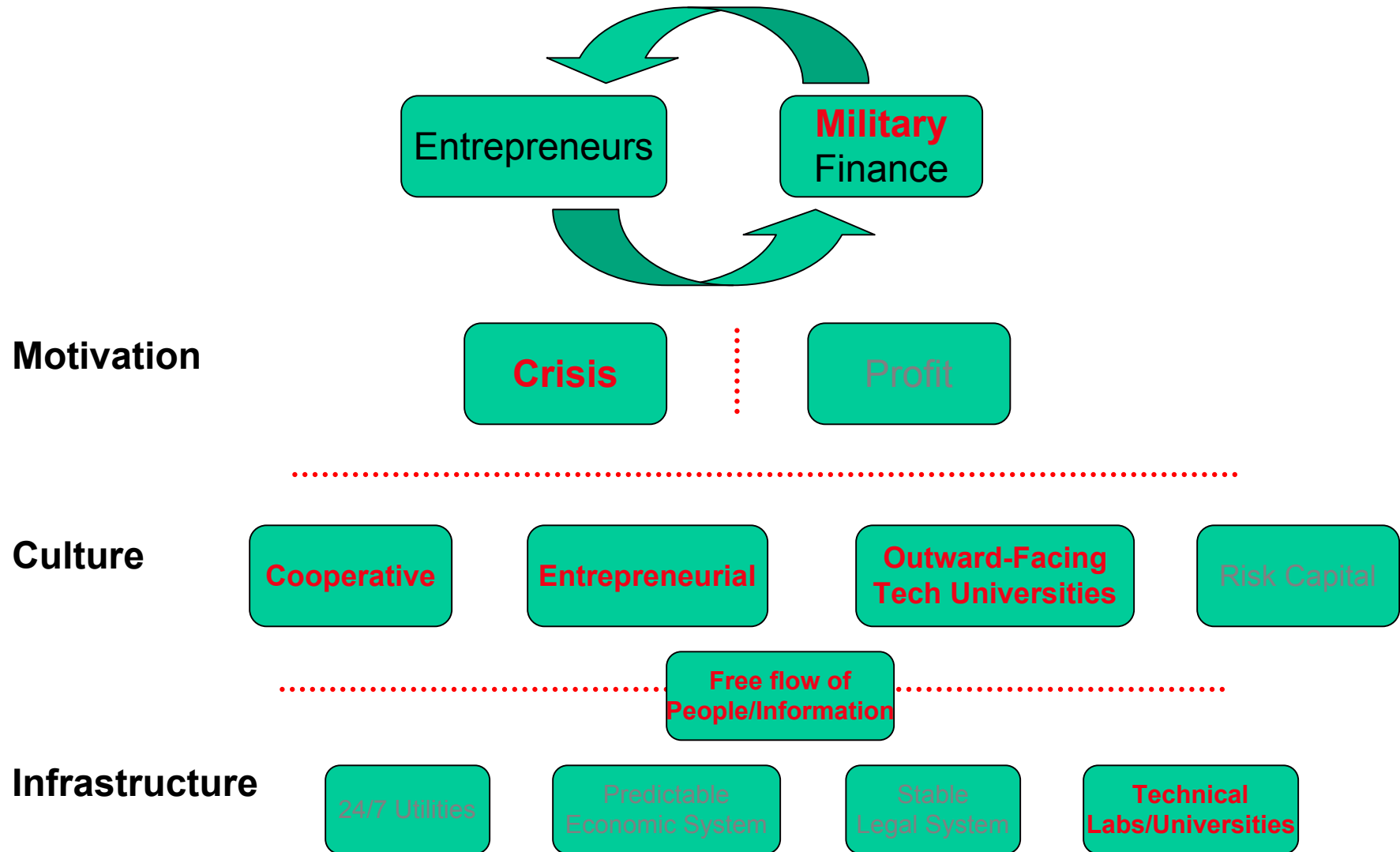
Terman Changes the Startup/University Rules

Silicon Valley as We Know it Starts Here

- 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

Terman and the Cold War

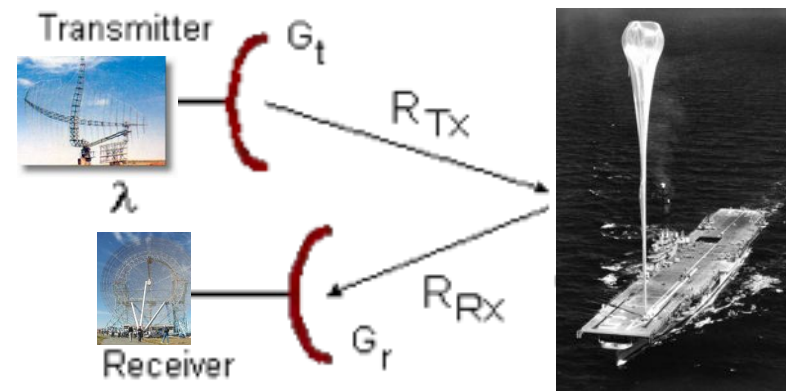
Silicon Valley's 1st Engine of Entrepreneurship



Story 4: Spook Innovation

Project: Melody ~1960

- First noticed in Project Genetrix
 - Soviet P-20 Token radar bounced off our high altitude spy balloons
 - Was received by our radars
 - Hmm...
- Bistatic intercept receiver



Irony Alert: In WWII Germans used their Klein-Heidelberg Bistatic radar using the British “Chain Home” radar to track allied bombers

Project: Melody ~1960

- Pick up Soviet radars *bounced off their own ICBM's* during test flights
 - Used CIA “Tacksman” intercept sites in Beshahr/Kabkan Iran
 - Use the missiles’ telemetry beacon to steer our radars
- Produced intercepts of all ground-based Soviet missile tracking radars
 - Including all ABM radars
 - At a 1000 mile range
- Later used ionized cloud of Soviets nuclear tests

OX CART / 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”

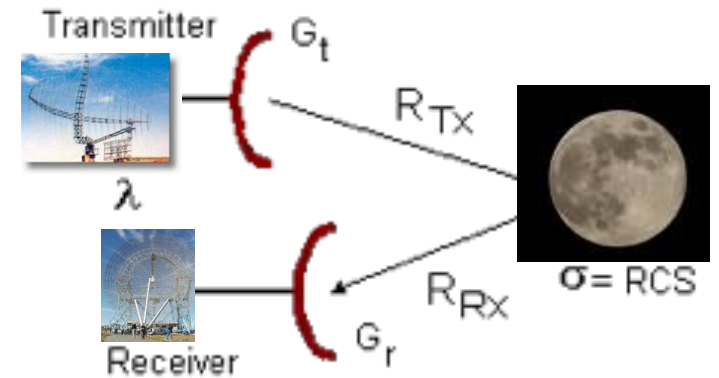
- Primary Soviet Air Defense Radar
 - Long Range, 375 miles
 - 150mhz, PRF 100/200hz, 800Kw
 - 100' wide, 30' high
- Where were they located?
- How many are there?
 - B52 bombers needed to know
 - OXCART needed to know



Solution: Project “Flower Garden”

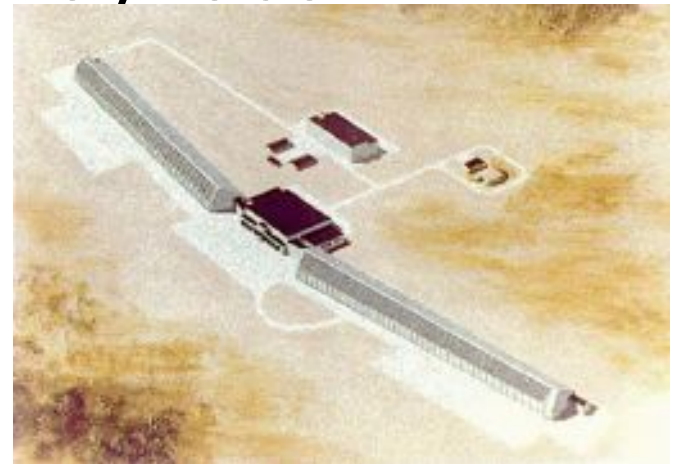
Shoot the Moon

- 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



HENHOUSE Radar

- Soviet HENHOUSE phased-array radar
 - 850' long, 25MW
 - Missile Warning/ABM system
 - Space surveillance
- Identified via satellite photos and ELINT
- But what were its capabilities?



Radio Dishes Get Funded

- Attach ELINT receivers to Bell Labs 60' antenna in New Jersey
 - Use Stanford “matched filter” techniques
- Use antennas at Sugar Grove, Chesapeake Bay, Aricebo, Jodelle Bank
- Pay for and build Stanford “Dish”
 - Hide relationships via “cover agencies”
 - Air Force Cambridge Research Center and Office of Naval Research
 - Discovers “Hen House” radar



PPMS: Power & Pattern Measurement Systems ~1962

- Now we know where Tall King & Spoon Rest radars are but
- Now we need to know:
 - Spatial Coverage
 - Radiated Power
 - RF Coherence
 - Polarization
- For Jamming and Stealth

Project: Palladium

- Ok, now we know spatial coverage, etc. we need to know:
 - Sensitivity of Soviet radar receivers
 - How good were their operators
- Hence, Project Palladium
- Build a system that electronically generated and injected false targets into Soviet radars
 - They saw ghost aircraft
 - We could simulate any aircraft, any speed
 - Trick was to know what they were seeing

Project: PALLADIUM

- Teamed with NSA and used SIGINT intercepts
 - Listened to their communication channels and could decrypt them *in real time*
 - Watch when they turned on their SA-2 target tracking radar
- We used ground bases, naval ships, submarines

Project Echo 1960

ELINT Balloons in Space

- 100' aluminized mylar balloon
- Cover was “radio relay” tests
- Originally to be launched from Vandenberg
- Launched in Aug 1960
- By this time something else was in space



Story 5: **1956** - The Year It All Changes

Lockheed Comes to Town

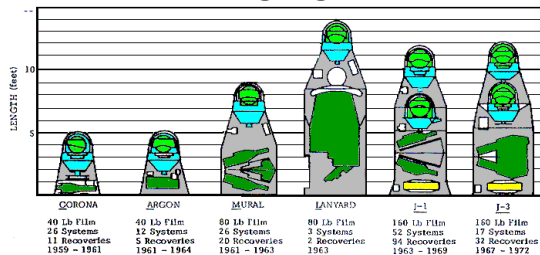
- Polaris missile SLBM
- Built in by Lockheed Missiles Division in Sunnyvale
 - Westinghouse Electric launch tube subcontractor
- *20,000* employees by 1960
 - From 0 in 4 years
 - HP: 3,000 employees 1960



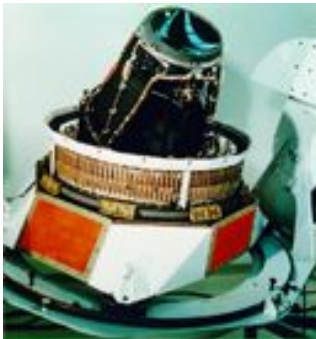
Lockheed and WS-117L

NRO - Move Reconnaissance to Space

CORONA



MIDAS - Program 461



IR - Launch Detection

SAMOS/SENTRY



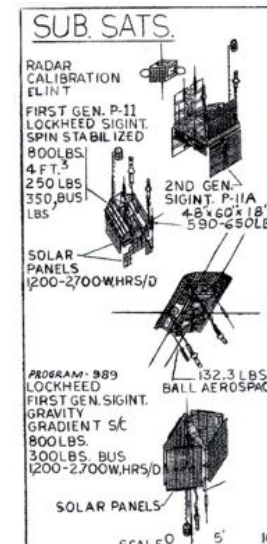
Imaging

VELA



Nuclear Detection

Program P-11/ 989 SAMOS F-1/2/3



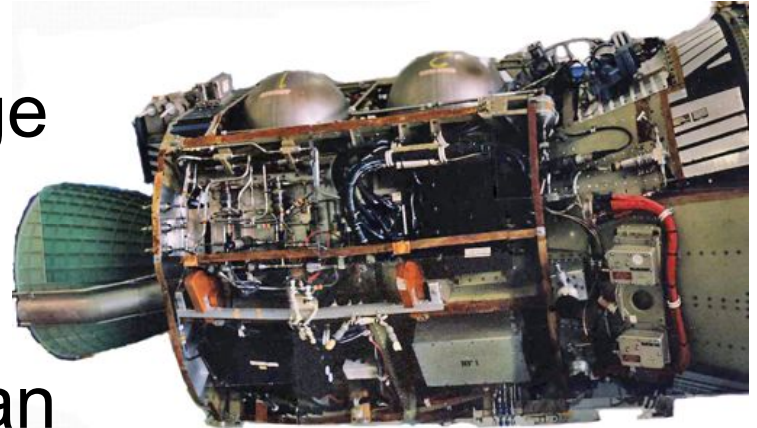
ELINT/SIGINT

Program A: Air Force - imaging and sigint
Program B: CIA - Imaging electrooptical and sigint
Program C: Navy sigint
Program D: U-2, A-12/Oxcart, D-21/Tagboard

Lockheed - Agena

Space Bus for Spy Satellites

- First restartable second stage
 - Boost and maneuvering
 - 3-axis stabilized
- Used on Thor, Atlas and Titan
- Controlled all 1960's spy satellites
- 365 built on an assembly line in secret in Sunnyvale





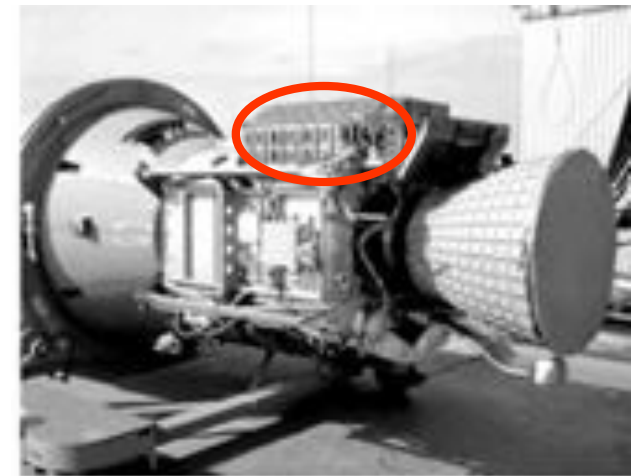
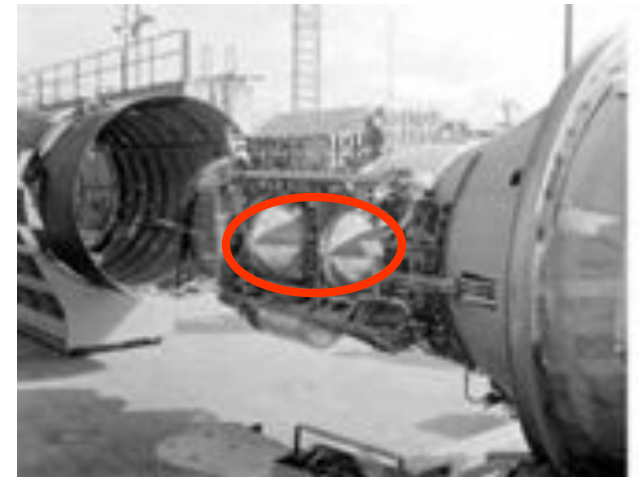
Stanford AEL/STL and Rambo

- William Rambo
 - Designed “Carpet” Jammer at RRL
 - Went to AIL after WWII, Stanford - 1951
 - Headed AEL then STL - 1958
 - NSA/CIA consultant
- Stanford STL leads the space ELINT effort
 - Works with Lockheed on ferret subsatellites



STL/Lockheed and de Broekert

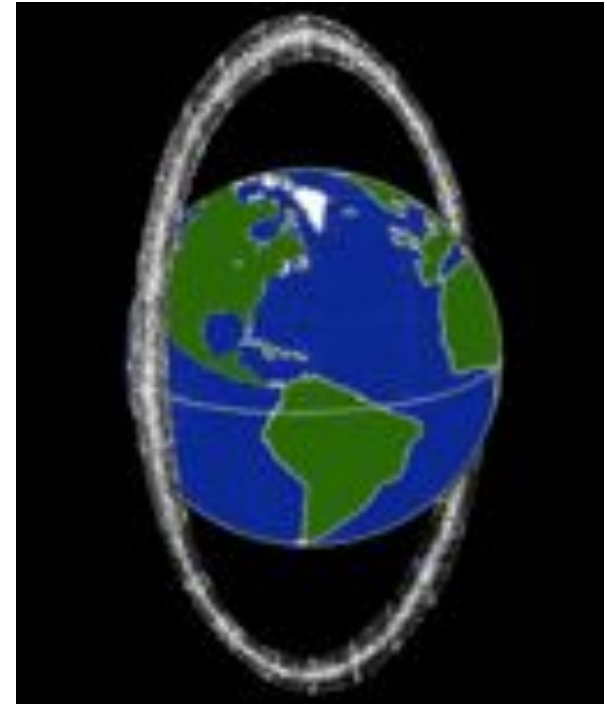
- James de Broekert of Stanford STL
- STL & Lockheed built P-11 Ferret sub-satellites carried on Corona photo satellites
 - 7 launched between Mar 1963-Oct 1964
- 1962: Samos F-2/3 Elint satellites
 - redesignated as Program 102
- Founded Argo, Signal Science, Advent Systems



Project West Ford 1963

A Ring of Chaff in Space

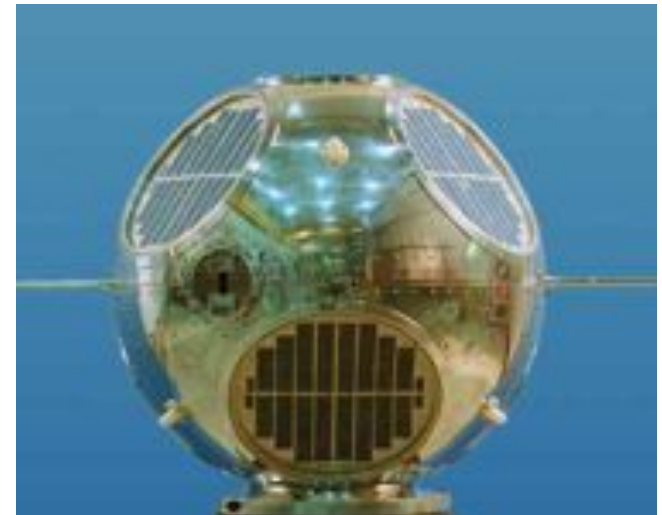
- 400 million copper dipoles
- 3/4's of an inch long
- 2000 mile altitude, 5 miles wide, 25 miles thick
- Cover was “radio relay” tests
- Launched as part of MIDAS



Project Grab 1960-1962

ELINT in Space

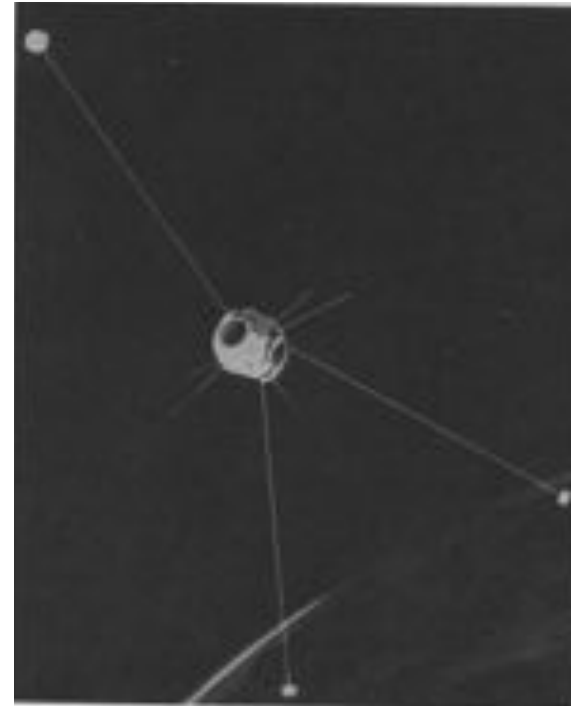
- No more overflights or balloons
- Collect radar emissions from Soviet air defense radars
- Record, Store and Dump
- Built by the Naval Research Laboratory
- Used by SAC for EOB then given to the NRO



Project POPPY 1962-1971

Navy ELINT in Space

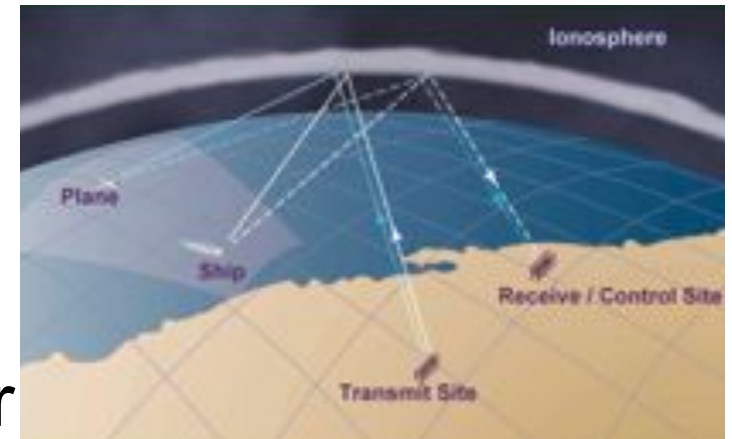
- Ships can no longer hide
- Collect radar emissions from Soviet naval vessels
- Clusters of satellites
- Triangulate and direction find





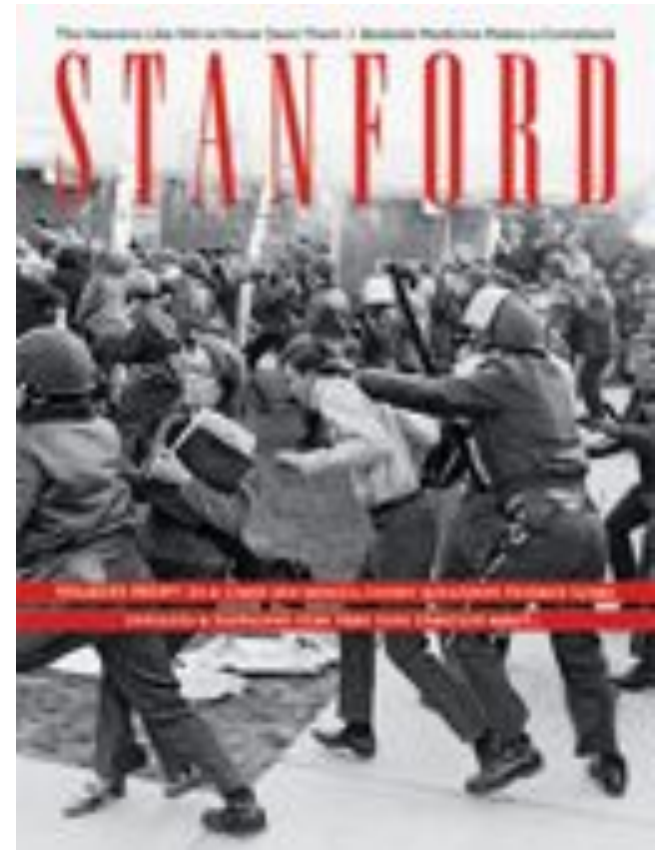
Villard and Over the Horizon Radar

- Meteor trails
 - burst comm and ELINT receiver
- Nuclear tests
- OTH - Over The Horizon Radar
 - Monitor missile launches
 - EARTHLING in Pakistan in 1961
 - CHECKROTE in Taiwan in 1966
 - Aircraft tracking
- Stealth - 1969 at SRI



The End of Classified Work at Stanford

- In 1968, 35 percent of Stanford research funding in electronics was for classified work
- 50% of SRI's work was from DOD
- April 9, 1969 400 students occupy AEL



Story 6: **1956** 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”

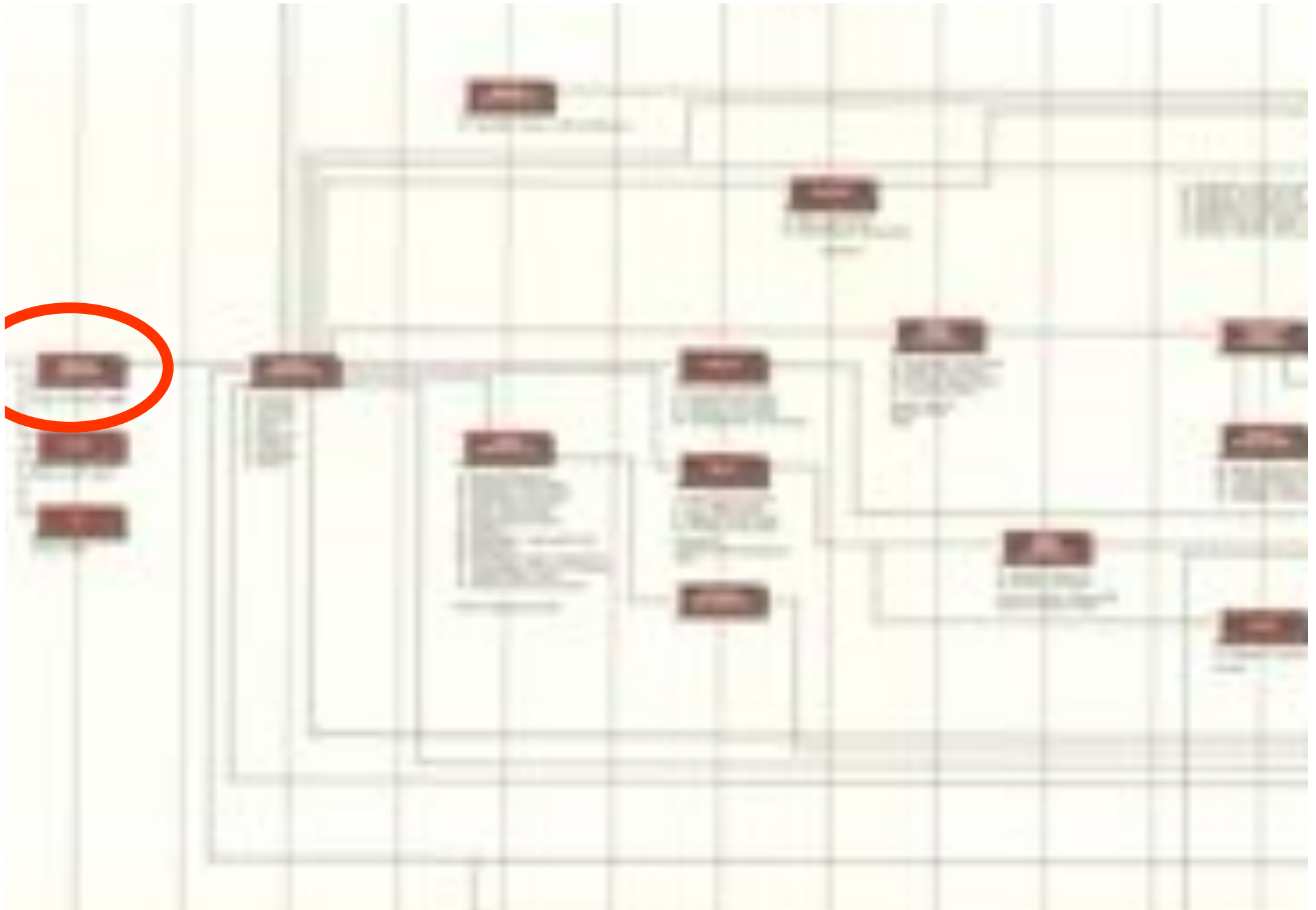
- Director of Navy anti-submarine warfare operations group at Columbia (1942-1943)
- Head of Radar Bombing training for Air Force (1943-1945)
- Deputy Director and Research Director of the Weapons System Evaluation Group in the Defense Department (1954-1955)
- Co-inventor of the transistor
 - Nobel Prize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

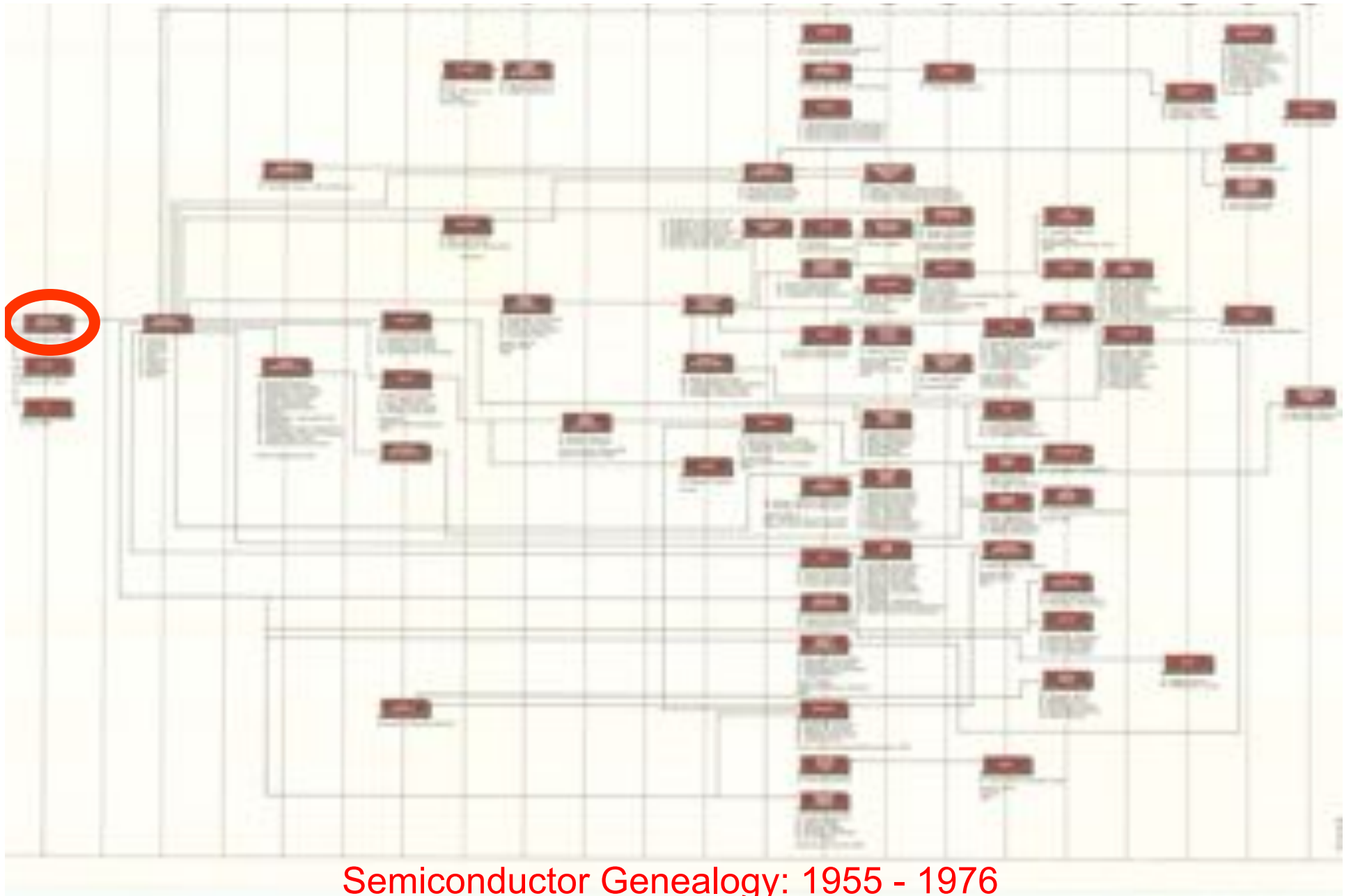
William Shockley



“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
 - 65 other chip companies in the next 20 years
- Eugenics beliefs end his career 1963





Semiconductor Genealogy: 1955 - 1976



Shockley's Legacy

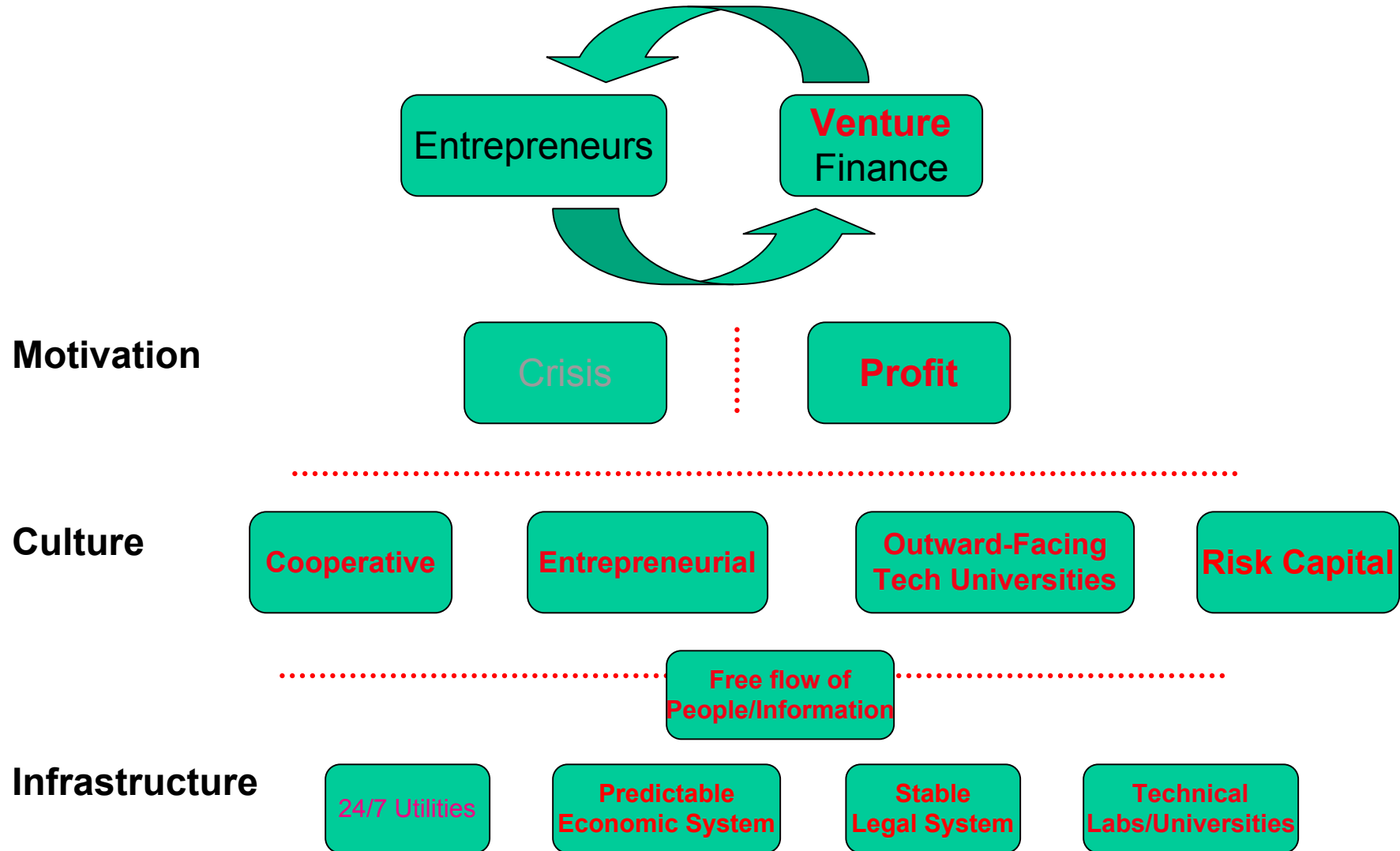
- It's *Silicon* Valley

Story 7: Why We All Don't Work for the Government

The Rise of *Private* Capital

Venture Capital

Silicon Valley's 2nd Engine of Entrepreneurship



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”

Soviet Union Launches Sputnik and the U.S. Venture Capital Industry

- Soviet satellite shocked the U.S.
- Galvanized congress
- New agencies/programs
 - NASA
 - ARPA
 - National Defense Education Act
 - **SBA SBIC Act**

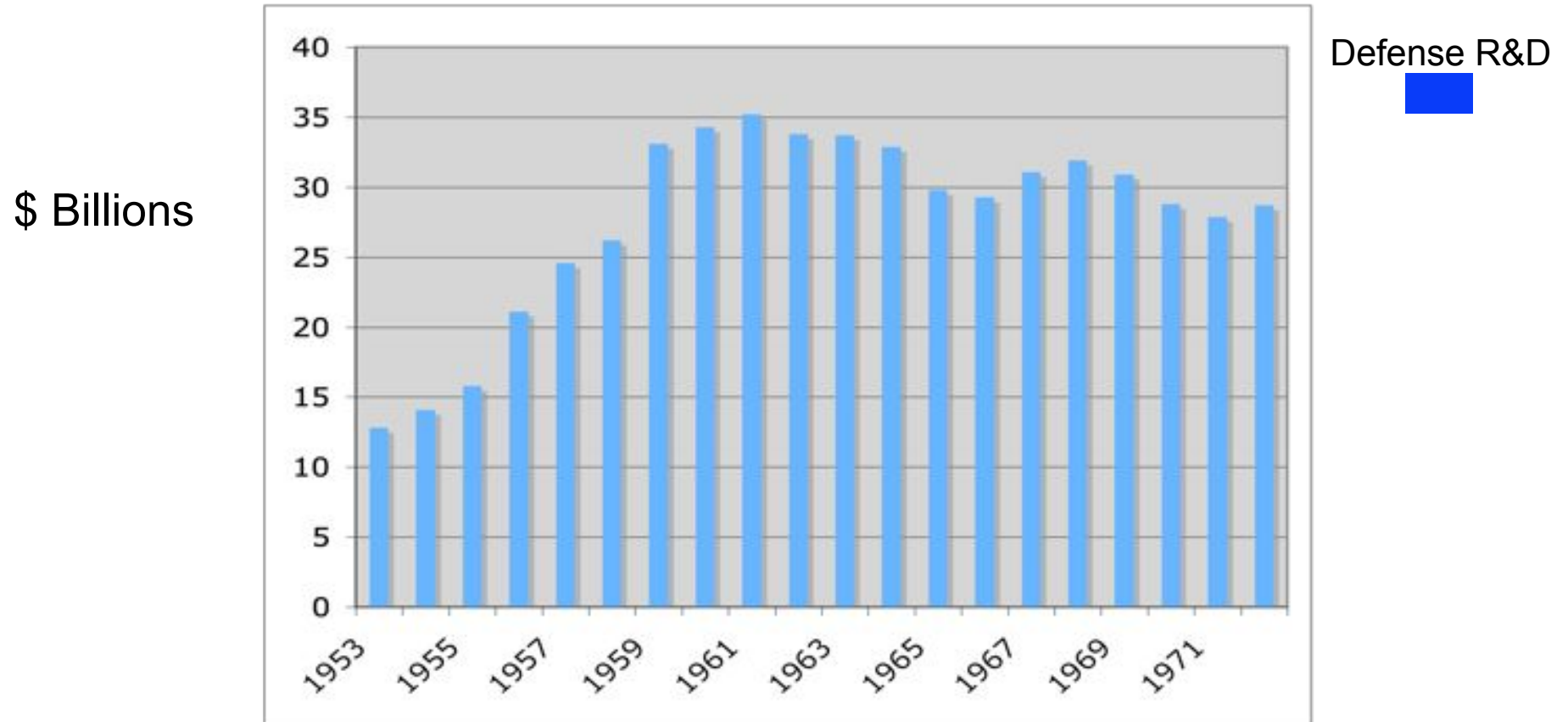


The Rise of Risk Capital

 SBIC Act of 1958

- Gov't match of private investments **3:1**
- 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

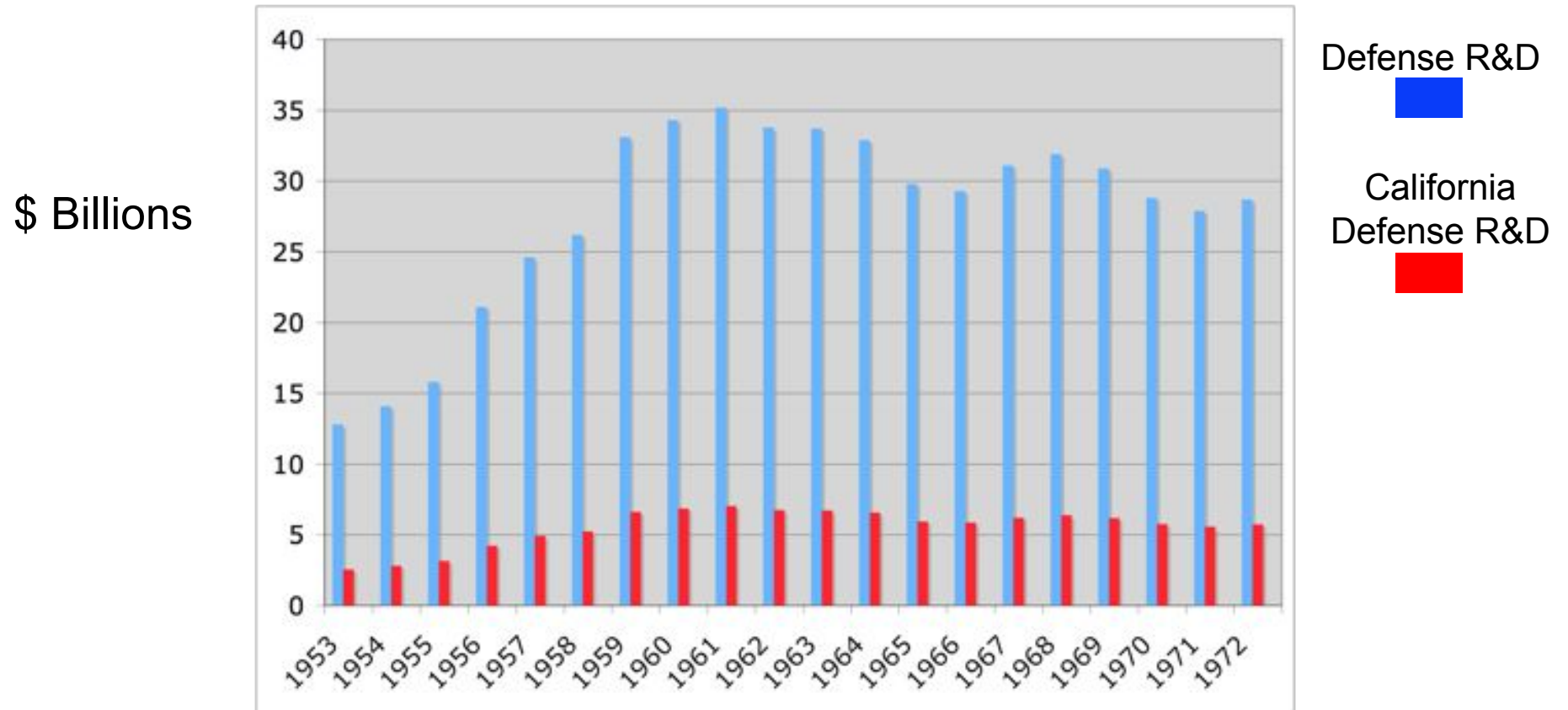
Defense R&D Budget



Sources: United States National Science Foundation Science and Engineering Indicators 2006, 2006, <http://www.nsf.gov/statistics/seind06/append/c4/at04-03.pdf>; United States Government, Budget for FY 05, Historical Tables, 2004, Table 9.7, <http://www.gpoaccess.gov/usbudget/fy05/hist.html>

Defense R&D Budget

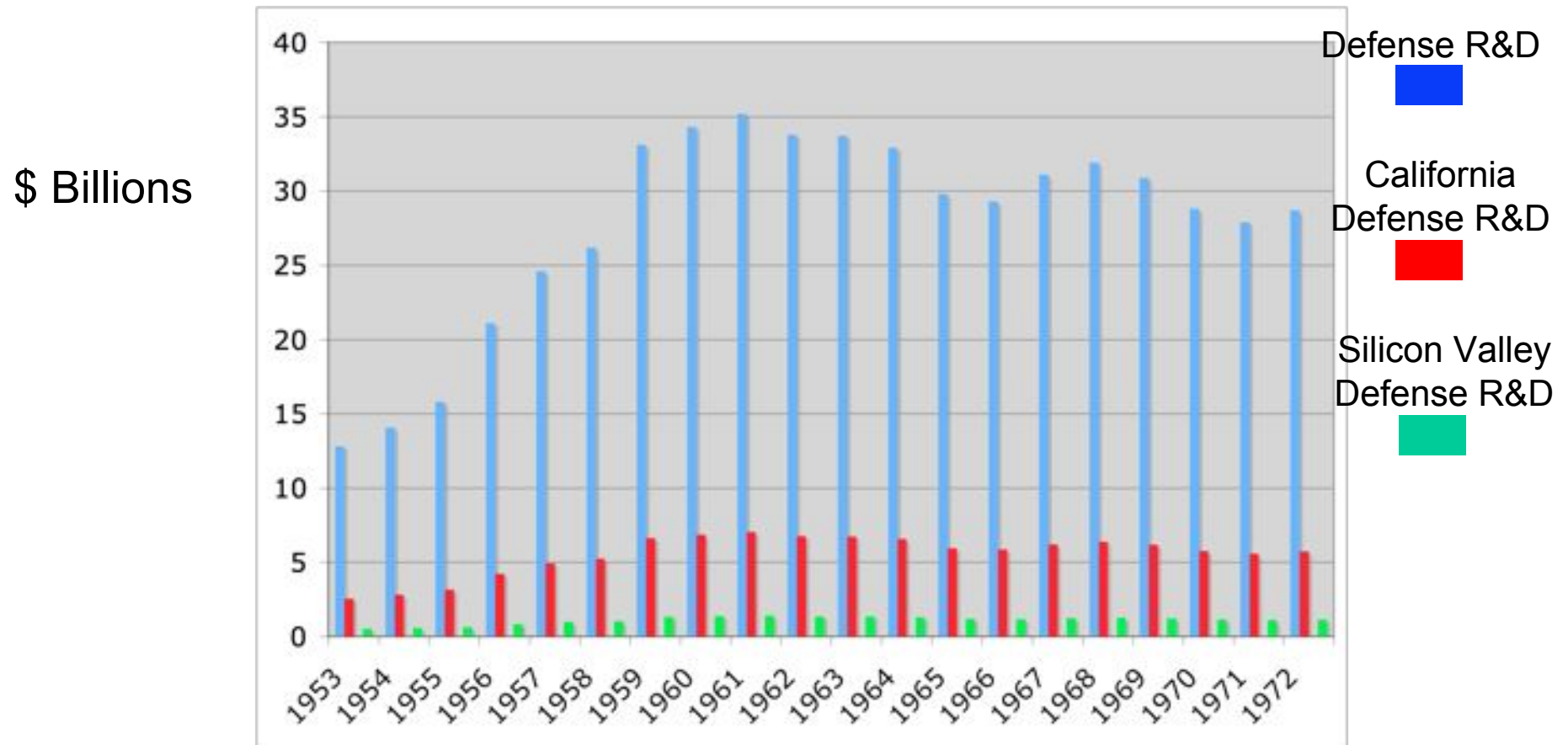
California



Sources: United States National Science Foundation Science and Engineering Indicators 2006, 2006, <http://www.nsf.gov/statistics/seind06/append/c4/at04-03.pdf>; United States Government, Budget for FY 05, Historical Tables, 2004, Table 9.7, <http://www.gpoaccess.gov/usbudget/fy05/hist.html>

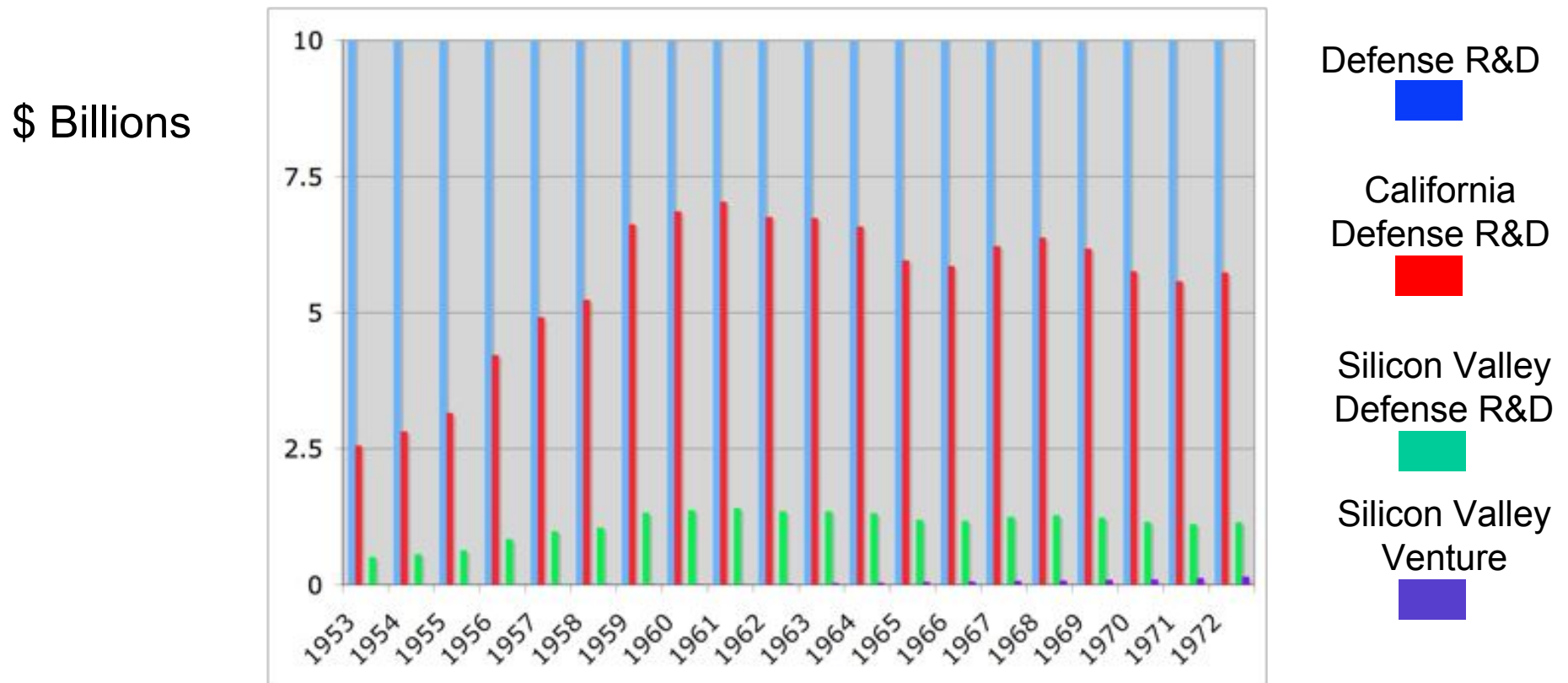
Defense R&D Budget

Silicon Valley



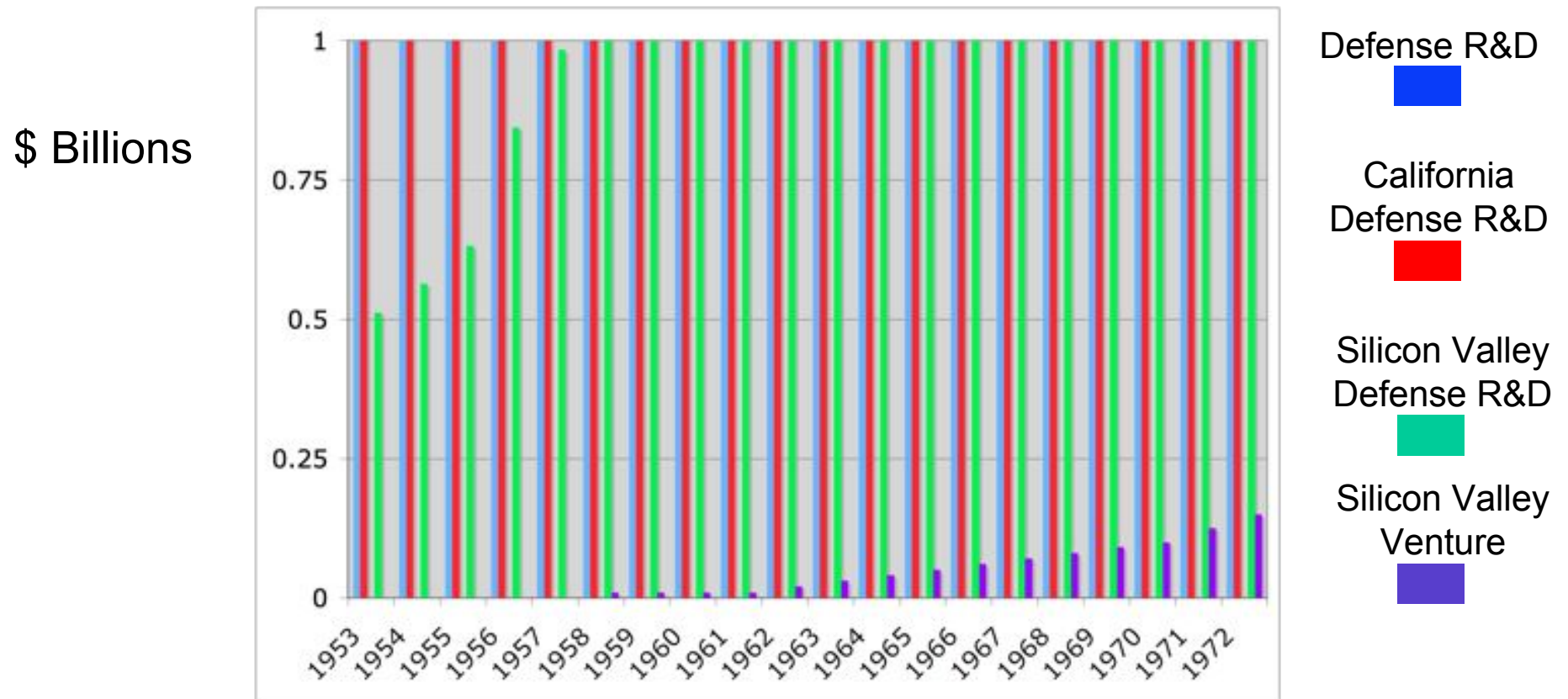
Sources: United States National Science Foundation Science and Engineering Indicators 2006, 2006, <http://www.nsf.gov/statistics/seind06/append/c4/at04-03.pdf>; United States Government, Budget for FY 05, Historical Tables, 2004, Table 9.7, <http://www.gpoaccess.gov/usbudget/fy05/hist.html>

Defense R&D Budget *Versus Venture Capital*



Sources: United States National Science Foundation Science and Engineering Indicators 2006, 2006, <http://www.nsf.gov/statistics/seind06/append/c4/at04-03.pdf>; United States Government, Budget for FY 05, Historical Tables, 2004, Table 9.7, <http://www.gpoaccess.gov/usbudget/fy05/hist.html>

Defense R&D Budget *Versus Venture Capital*



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The Rise of Risk 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

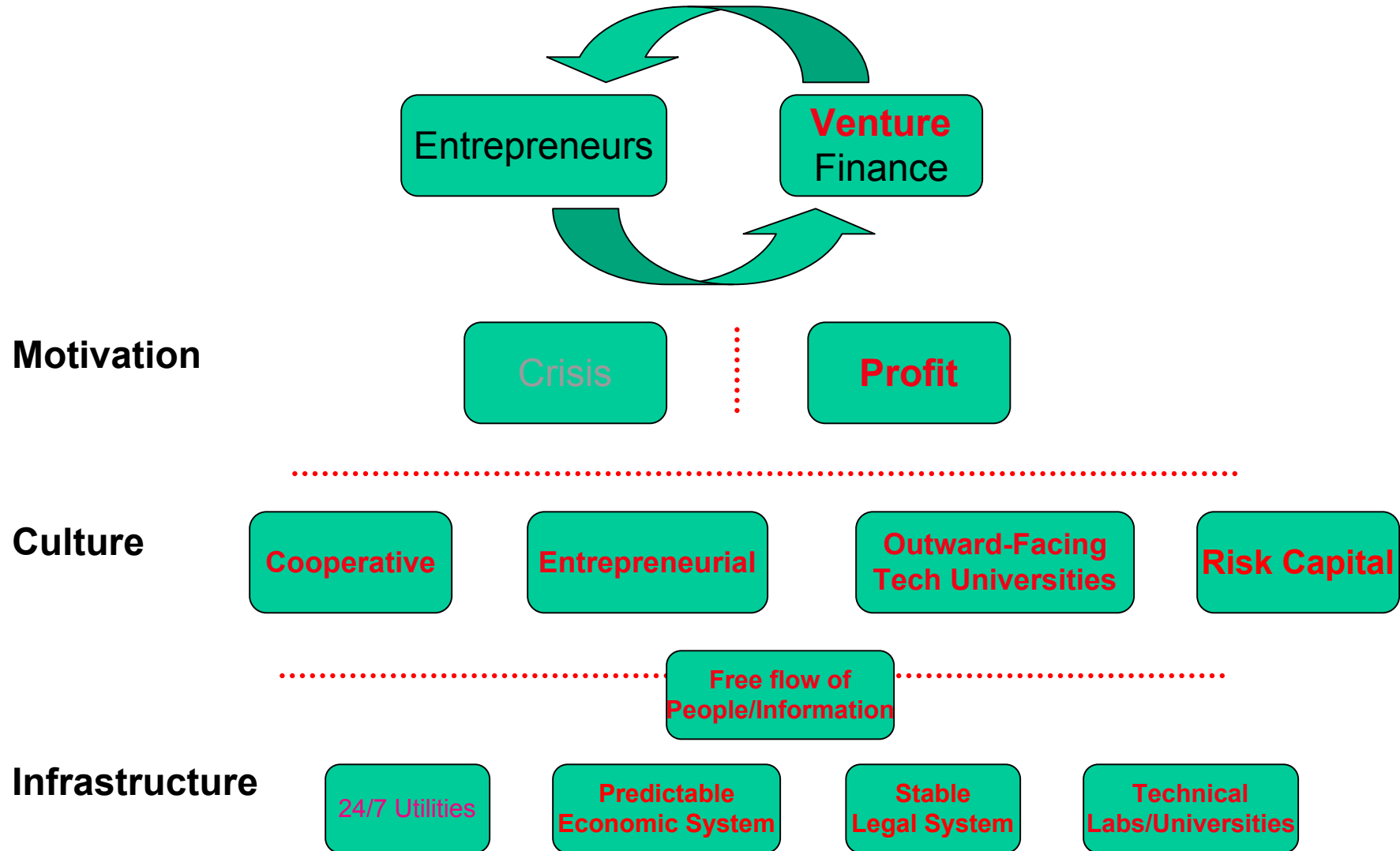
The Rise of Risk Capital

1978/1979 - A Watershed

- Capital gains slashed (1978)
 - 49.5% to 28%
- Employee Retirement Income Security Act (1979)
 - Pension funds can invest

Venture Capital

Silicon Valley's 2nd Engine of Entrepreneurship



Summary

- Terman/Stanford/Government responsible for entrepreneurial culture of Silicon Valley
- Military primed the pump *as a customer* for key technologies
 - Semiconductors, computers, Internet
 - But very little technical cross pollination
- Venture Capital turned the valley to volume corporate and consumer applications

Is there another “crisis” that will restart the valley’s cycle of innovation?

Or will we continue to be profit driven?

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<http://bit.ly/SecretVideo>

Read the Backstory

<http://bit.ly/SecretStories>

Read the Blog

www.steveblank.com

WWII Sources - Books

- WWII
 - A Radar History of WWII - Louis Brown
 - Confound and Destroy - Martin Streetly
 - Echoes of War, the Story of H2S Radar - Sir Bernard Lovell
 - The Invention that Changed the World - Robert Buder
 - Wizard War, British Scientific Intelligence - R.V. Jones
 - History of Air Intercept Radar and British Nightfighter - Ian White
 - The Luftwaffe Over Germany: Defense of the Reich - Donald Caldwell
 - Instruments of Darkness: The History of Electronic Warfare - Alfred Price
 - Volume I: The History of US. Electronic Warfare to 1946 - Alfred Price

Cold War Sources - Books

- Cold War
 - Volume II: The History of US. Electronic Warfare: Renaissance Years- Alfred Price
 - The Wizards of Langley - Jeffrey T. Richelson
 - Body of Secrets: Anatomy of the Ultra-Secret National Security Agency - James Bamford
 - The Puzzle Palace: Inside the NSA, - James Bamford
 - Secrets of Signals Intelligence During the Cold War and Beyond - Matthew M. Aid, Cees Wiebes
 - Eternal Vigilance? - Jeffreys-Jones, Rhodri Jeffreys-Jones, Christopher M. Andrew
 - High-Cold-War-Strategic Air Reconnaissance and the Electronic Intelligence War - Robert Jackson
 - By Any Means Necessary: America's Secret Air War in the Cold War - William E. Burrows
 - Shadow Flights: America's Secret Airwar Against the Soviet Union: A Cold War History - C. Peebles
 - Spyplane - Norman Polmar
 - Radar Handbook, - Merrill I. Skolnik
 - Out From Behind the Eight Ball: A History of Project Echo by Doanld C. Elder

Silicon Valley Sources - Books

- Terman/Shockley/Intel
 - Fred Terman at Stanford - Stewart Gilmore
 - Broken Genius: The Rise and Fall of William Shockley- Joel Shurkin
 - The Man Behind the Microchip: Robert Noyce - Leslie Berlin
- Silicon Valley History
 - Electronics in the West: the First Fifty Years - Jane Morgan
 - The Origins of the Electronics Industry on the Pacific Coast- Arthur Norberg
 - Creating the Cold War University: The Transformation of Stanford - Rebecca S. Lowen
 - The Cold War and American Science: The Military-Industrial-Academic Complex at MIT and Stanford - Stuart W. Leslie
 - Making Silicon Valley: Innovation & the Growth of High Tech - C. Lecuyer
 - Regional Advantage: Culture and Competition in Silicon Valley and Route 128 - Annalee Saxenian
- Venture Capital
 - Creative Capital: Georges Doriot and the Birth of Venture Capital - Spencer E. Ante
- Semiconductor Timeline to 1976: Semi and Don C. Hoefler

ELINT Sources - Web

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 - <http://www.tbp.org/pages/Publications/Bent/Features/F99Poteat.pdf>
 - <http://www.gwu.edu/~nsarchiv/NSAEBB/NSAEBB54/>
 - <http://www.gwu.edu/~nsarchiv/NSAEBB/NSAEBB54/st06.pdf>
 - <http://www.gwu.edu/~nsarchiv/NSAEBB/NSAEBB54/st08.pdf>
 - <http://www.gwu.edu/~nsarchiv/NSAEBB/NSAEBB60/abm022.pdf>
 - <https://www.cia.gov/library/center-for-the-study-of-intelligence/kent-csi/pdf/v11i2a05p.pdf>
 - <https://www.cia.gov/library/center-for-the-study-of-intelligence/kent-csi/pdf/v12i2a02p.pdf>
 - <https://www.cia.gov/library/center-for-the-study-of-intelligence/csi-publications/books-and-monographs/a-12/hiding-oxcart-in-plain-sight.html>
 - <http://jya.com/nsa-elint.htm>
 - <http://fas.org/irp/program/list.htm>
- ELINT Aircraft Losses
 - <http://www.rb-29.net/HTML/77ColdWarStory/08.01apndxC.htm>
 - <http://www.history.navy.mil/avh-1910/APP34.PDF>

Photo and Movie Sources - Web

- B-24 Ferret ELINT equipment photos
 - <http://aafradio.org/>
- WWII Radar History/Photos/Radar Order of Battle
 - www.gyges.dk
 - <http://www.luftarchiv.de/>
 - <http://www.vectorsite.net/ttwiz.html> The Wizard War
 - http://www.museumwaalsdorp.nl/en/german_radar.html
 - <http://www.baermann.biz/pauke/index.php?catid=9&blogid=1>
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