

# Breaking Codes, Designing Jets, and Building Teams

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“History doesn’t repeat itself,  
but it often rhymes.”

-- Mark Twain





Purpose



Organizational Culture



People



Engineering Excellence



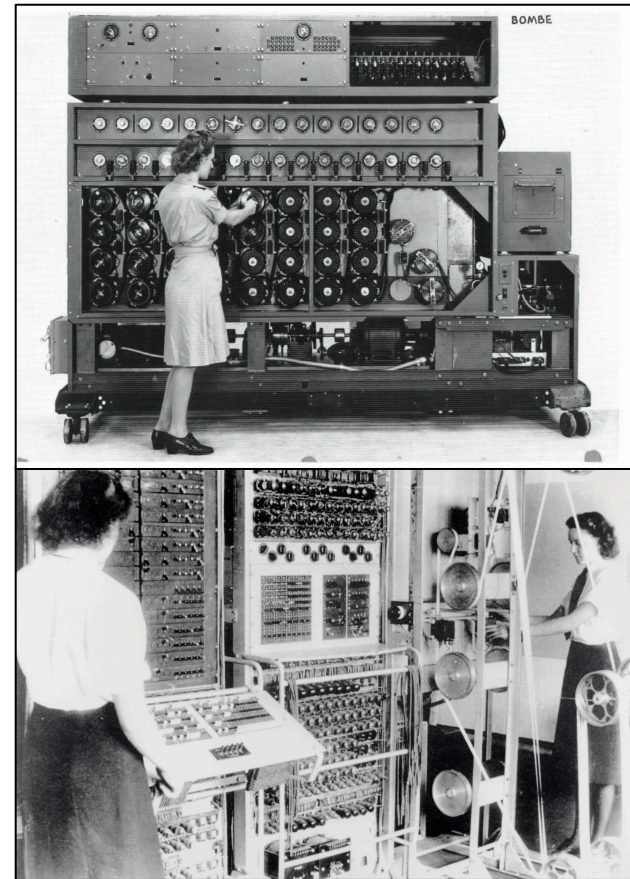
# Bletchley Park

*Broke the German Enigma and Lorenz codes in WWII*

*Built the world's first programmable electronic digital computer in 1943, entirely in secret*

*Information from "Ultra" ended WWII at least 2 years early, saved 14 million lives*

*Many details declassified in 1974 and in 2000, much still unknown*





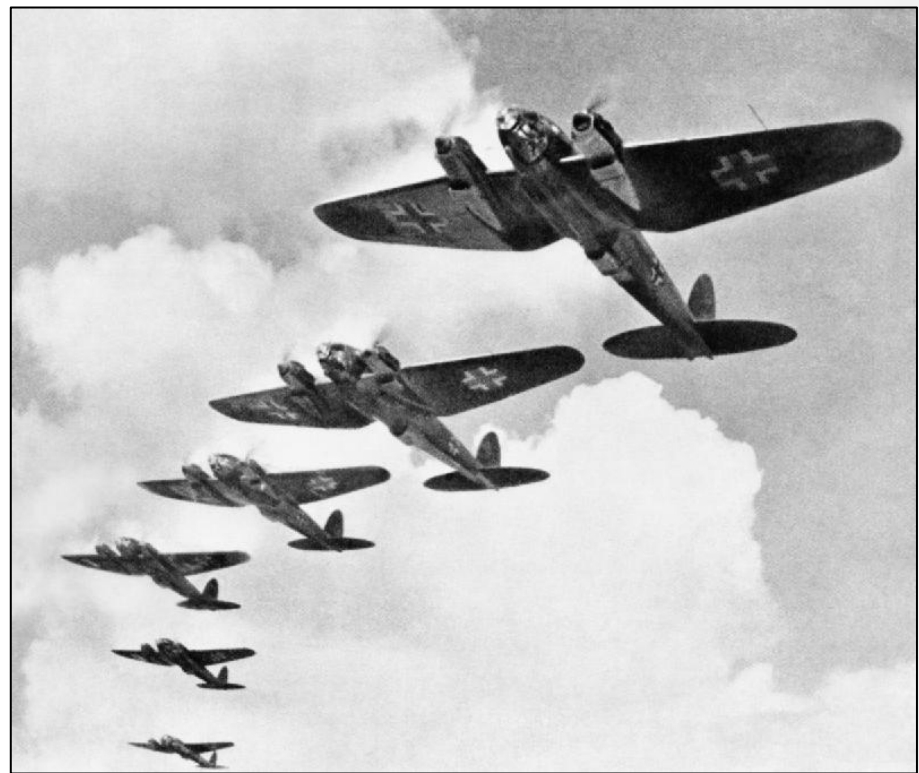
# Battle of Britain, 1940

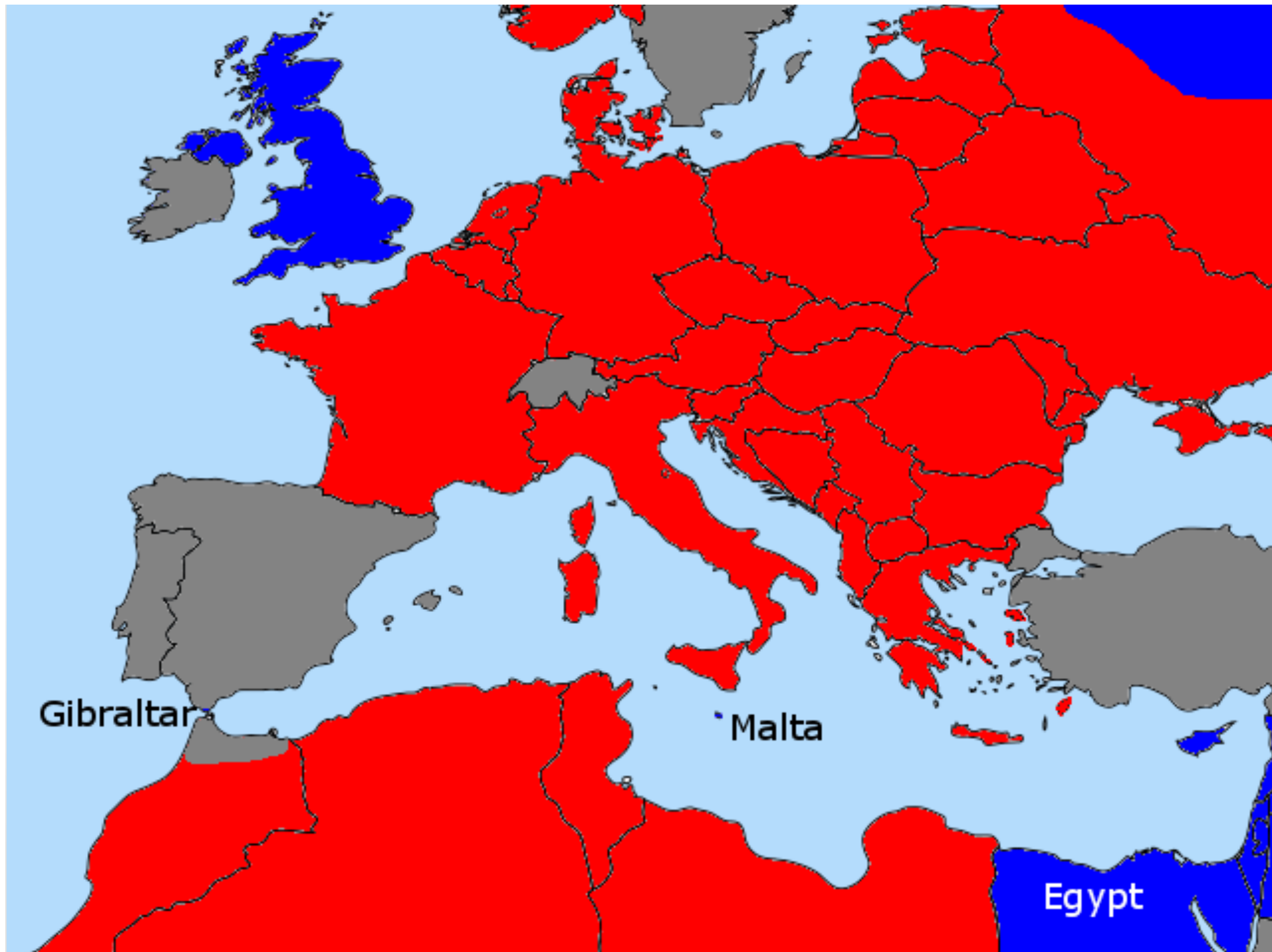
*Battle for air supremacy over Britain, July to October 1940*

*RAF defense prevented German invasion of Britain*

*Ultra intercepts leaked strength and composition of Luftwaffe forces, provided early warnings*

*First major Allied victory in WWII, first turning point in the war*





Gibraltar

Malta

Egypt

# Battle of the Atlantic, 1941

*U-boat attacks on Allied shipping in 1941, sinking hundreds of ships and tens of thousands of seamen*

*Britain was in very real danger of losing the war*

*Starting July 1941, Ultra intercepts of submarine traffic reduced shipping losses by 2/3*



# D-Day, June 6 1944

*Allied invasion of Europe to retake the continent in June 1944*

*“We are putting the whole works on one number” – Eisenhower*

*Ultra revealed strength of forces, reinforced Allied deception about the landing location*

*Landing in Normandy was a complete tactical surprise*





# *Impact of Bletchley Park*

*“The geese that laid the golden eggs – but never cackled”*



# Organizational Culture

*Open management style, very little military hierarchy*

*Pipeline approach: intercept, decryption, cataloguing and analysis, dissemination*

*Each stage performed by a different "Hut"*

*Deep collaboration within a Hut, extreme secrecy between Huts*

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# Organizational Culture

*Constant need for iteration and refinement of techniques to respond to newer Enigma machines and procedures*

*Two-week research sabbaticals to improve methods and procedures*

*Logbook for anyone to propose improvements, discussed every few weeks*

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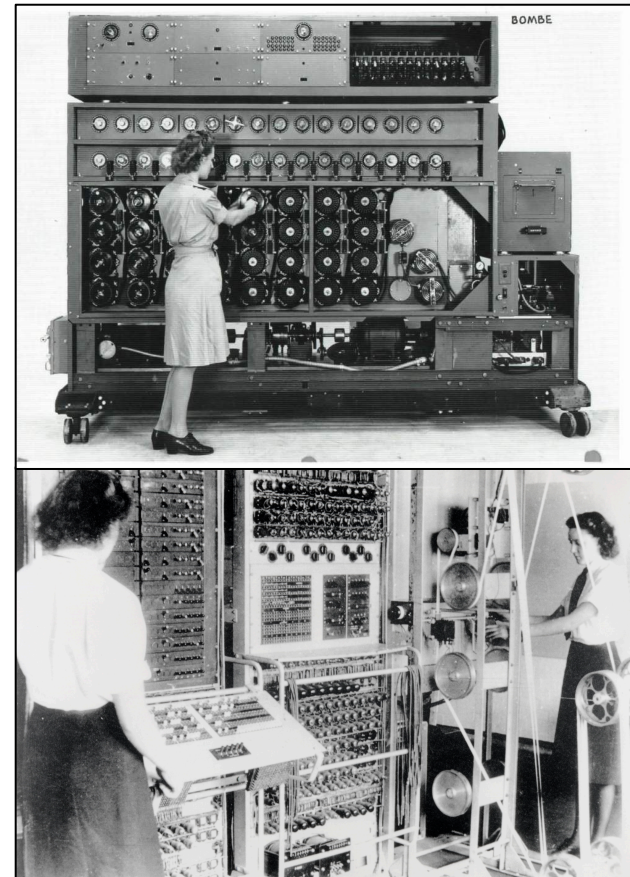
# *“Boffins and Debs”*

*Diversity of experience is critical to codebreaking*

*Recruited linguists, mathematicians, bank clerks, crossword experts, national chess champions, department store managers*

*Organized crossword puzzle competition to recruit in 1942*

*Ian Fleming (future creator of James Bond) worked at Bletchley Park*





# *“Boffins and Debs”*

*10,000 people at its peak in 1944,  
75% women*

*Section leaders organized very  
popular talks to explain the  
mathematics of the work*

*Analyzed intercepts, operated  
machines, broke codes*

*One of the few wartime efforts to  
fully utilize women for highly  
demanding intellectual work*



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# *“Boffins and Debs”*

*“I told you to leave no stone unturned to get staff, but I had no idea you would take me so literally.”*



# Mavis Batey

*Studying German at University  
College London in 1939*

*Recruited into intelligence by her  
professor, joined Bletchley in 1940*

*Checked personals columns in The  
Times for spy messages*

*Helped break the Italian Naval  
Enigma in March 1941*

*Helped break the German Abwehr  
Enigma in December 1941*

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# Alan Turing

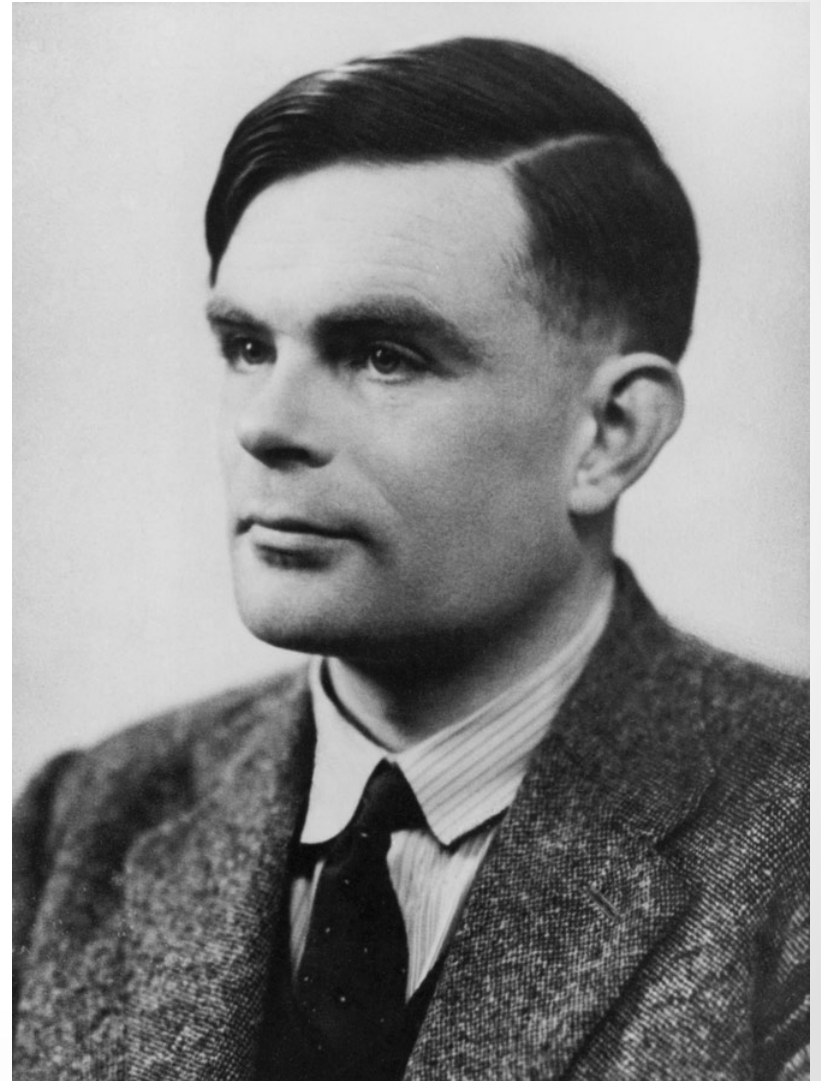
*Described a “universal computing machine” in a seminal 1936 paper*

*Designed and built “The Bombe”, electromechanical machine to find Enigma settings*

*After WWII, designed and built earliest stored-program computers: ACE in 1946, Manchester Baby and Manchester Mark I in 1948*

*Led to the world’s first commercially available general purpose computer*

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# Alan Turing

*Lifelong marathon runner*

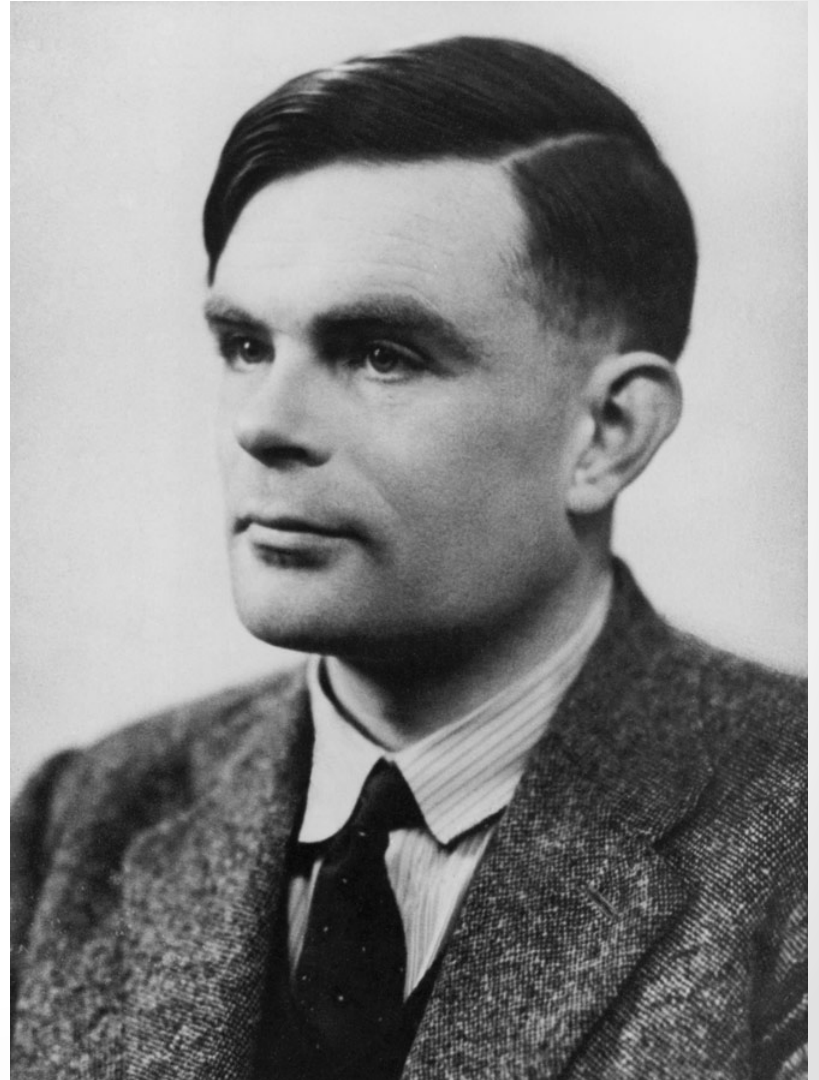
*Openly gay throughout  
adulthood*

*Prosecuted for homosexual  
acts in 1952, sentenced to  
chemical castration*

*Committed suicide in 1954*

*Posthumously pardoned by  
Queen Elizabeth II in 2013*

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**Alan Mathison Turing**  
**1912-1954**

**Father of Computer Science**  
**Mathematician, Logician**  
**Wartime Codebreaker**  
**Victim of Prejudice**

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*“Mathematics, rightly viewed, possesses not only truth  
but supreme beauty, a beauty cold and austere  
like that of sculpture.” - Bertrand Russell*

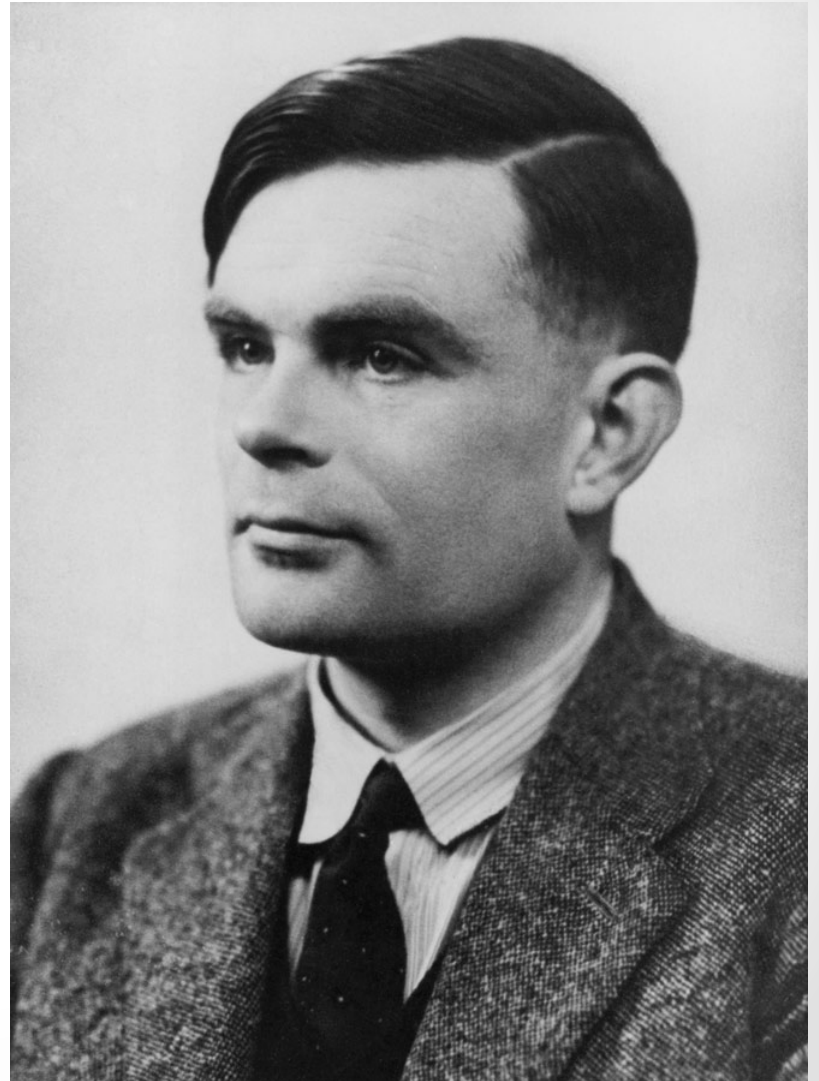






# Turing's Letter to Churchill, 1941

*"This work is being held up, and in some cases is not being done at all, principally because we cannot get sufficient staff to deal with it ... We despair of any early improvement without your intervention."*





# *“An Electric Effect”*

**ACTION  
THIS DAY**

*“Make sure they have all they want on extreme priority and report to me that this has been done”*



# Tommy Flowers

*Pioneered use of large-scale electronics with vacuum tubes at the UK Post Office Research Station*

*Designed and built world's first programmable electronic computer ("Colossus") to crack Lorenz in 1943*

*Post-war secrecy prevented him from commercializing his computing work after WWII*

*Largely unknown for his pioneering computing work*





"It was a terrific human experience and I've never matched it since...Nothing gave the total personal satisfaction that Hut 6 did, because this was a totally dedicated group working together in absolutely remarkable teamwork."

American Capt. Bil Bundy, member of U.S. Army Special Branch at Arlington Hall, assigned to Bletchley Park later served as Assistant Secretary of State; From the book, *Station X*.



Purpose



Organizational Culture



People



Engineering Excellence



# Lockheed "Skunk Works"

*Lockheed's secret Advanced Development Projects group, founded 1943*

*Generation after generation of the world's fastest, highest-flying, stealthiest aircraft*

*Design, development, and manufacturing in a single facility*



# *P-38 Lightning*



1 Million

*Over 10,000 manufactured, in continuous production throughout WWII*

*Inspired generations of propeller aircraft*



# *P-80 Shooting Star*



Million

*First operational American jet fighter*

*Skunk Works produced the airframe in 143 days, from start of the design process to combat-ready*





# *U-2 Dragon Lady*



*High-altitude aerial reconnaissance aircraft, up to 70,000 feet*

*In continuous service since 1955*

*Used in Suez Crisis, Cuban Missile Crisis, Middle East conflicts*

illion





# *SR-71 Blackbird*

*Long-range strategic reconnaissance aircraft, 1964-98*

*World's fastest and highest-flying operational manned aircraft (Mach 3+, 85,000 feet)*

*Built from titanium and polymer composites*

*Never shot down*



# *F-117 Nighthawk*



*First operational aircraft designed around stealth technology,  
1983-2008*

*Radar cross-section of 0.001 m<sup>2</sup>, size of "an eagle's eye"*



# Developing Stealth

*“The most significant advance in military aviation since jet engines”*

*Co-located teams, with stealth expert always available on site*

*Tested extensively with models, computational simulation, wooden mockups*

*Intense collaboration with test pilots*





# Engineering Excellence

*Huge engineering challenges reconciling aerodynamics with minimizing radar cross-section*

*Extremely difficult engineering problems with exhaust system, pitot tube, canopy, etc.*



# Organizational Culture

*Rapid iteration, flexibility,  
collective ownership*

*Never put an engineer more  
than 50 feet from the assembly  
area*

*"I wanted a direct relationship  
between design engineer and  
mechanic and manufacturing"*



# Organizational Culture

*"We created a practical and open work environment for engineers and shop workers, forcing the guys behind the drawing boards onto the shop floor to see how their ideas were being translated into actual parts and to make any necessary changes on the spot."*



# Organizational Culture

*“We made every shop worker who designed or handled a part responsible for quality control. Any worker – not just a supervisor or a manager – could send back a part that didn’t meet his or her standards.”*

*“Our inspectors stayed right on the floor with the machinists and fabricators.”*





# Kelly's 14 Rules

- ① *The Skunk Works manager must be delegated practically complete control of his program in all aspects.*
- ② *Strong but small project offices must be provided by both the military and industry.*
- ③ *Use a small number of good people (10% to 25% of normal).*
- ④ *A very simple drawing and release system with great flexibility for making changes must be provided.*
- ⑤ *There must be a minimum number of reports required, but important work must be recorded thoroughly.*

Million





# Kelly's 14 Rules

- ⑥ There must be a monthly cost review (spent, committed, projected)
- ⑦ Get good vendor bids for subcontractors
- ⑧ Push more basic inspection responsibility back to subcontractors and vendors.
- ⑨ The contractor must be delegated the authority to test his final product in flight. He can and must test it in initial stages. If he doesn't, he rapidly loses his competency to design other vehicles.

# Kelly's 14 Rules

- ⑩ State clearly which military specification items will not knowingly be complied with and the reasons therefore.
- 11 Funding a project must be timely.
- 12 Mutual trust between the military organization and the contractor with very close cooperation and liaison on a day-to-day basis. This cuts down misunderstanding and correspondence to an absolute minimum.
- 13 Access by outsiders to the project and its personnel must be strictly controlled by appropriate security measures.
- 14 Ways must be provided to reward good performance by pay not based on the number of personnel supervised.

Million

# Clarence "Kelly" Johnson

*Joined Lockheed as a tool designer in 1933, later promoted to aeronautical engineer*

*First team leader of Lockheed's "Skunk Works", 1938-75*

*Led teams that built the P-38 Lightning, P-80 Shooting Star, and the SR-71 Blackbird*

*Initiated construction of Area 51 for flight-testing the U-2*





# Ben Rich

*British Jew, WWII war refugee*

*Raised in the Philippines,  
escaped weeks before Pearl  
Harbor*

*Second director of Skunk  
Works, 1975-91*

*Directed experimental  
prototypes of stealth  
technology, led development  
of stealth fighter*



# Mary G. Ross

*First Native American female engineer, from the Cherokee Nation*

*Part of the founding team of 40 Skunk Works engineers*

*Contributed to the P-38 Lightning, Agena rocket, ballistic missiles, satellites*

*Most of her work is still classified*



# Mary G. Ross

*"A Cherokee woman from Park Hill, Oklahoma, helped put a man on the moon" – Mary Ross*

*"I had the privilege of studying with three Nobel prize winners, and I have to say I hold Mary at that same level" – Lockheed colleague*

*Featured on What's My Line in 1958 ("Designs Rocket Missiles and Satellites")*







Purpose



Organizational Culture



People



Engineering Excellence

# Xerox PARC

*Palo Alto Research Center,  
founded in 1970*

- *Graphical user interface with overlapping windows*
- *Object-oriented programming with Smalltalk*
- *WYSIWYG text editing with Bravo*
- *Networking with Ethernet*
- *Printing via the laser printer*
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# Xerox PARC

*“Every time you click a mouse on an icon or open overlapping windows on your computer screen*

...

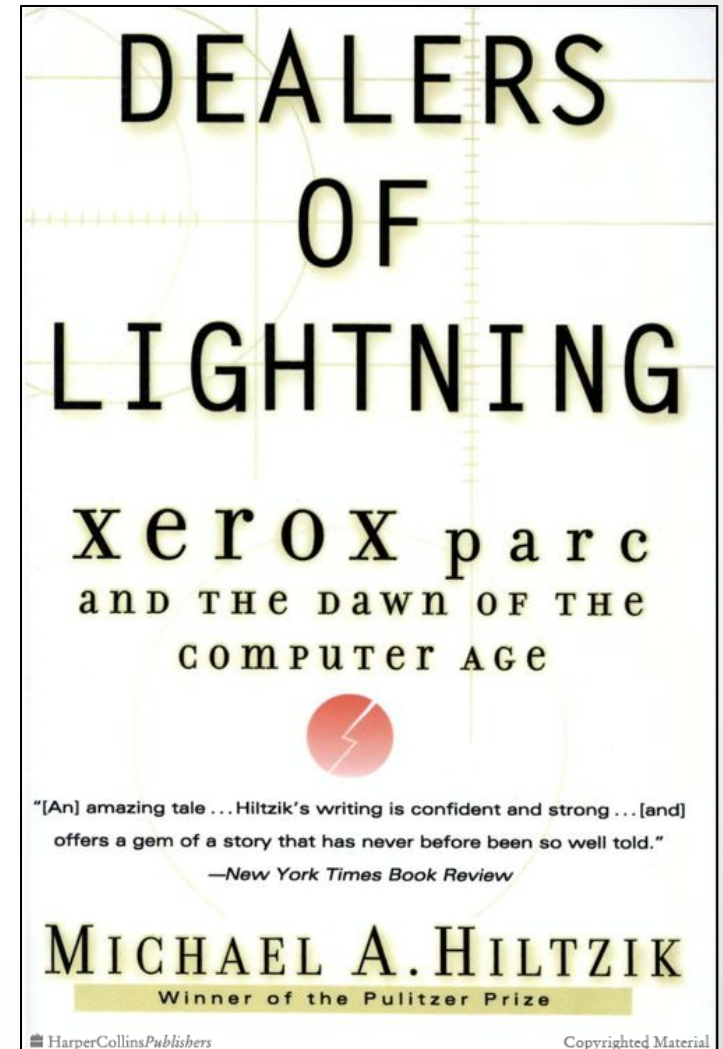
*Compose a document by word processor*

...

*Make the print larger or smaller, replace ordinary typewriter letters with a Braggadocio or Gothic typeface*

...

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# Xerox PARC

*"Surf the internet*

*...*

*Send email to a workmate*

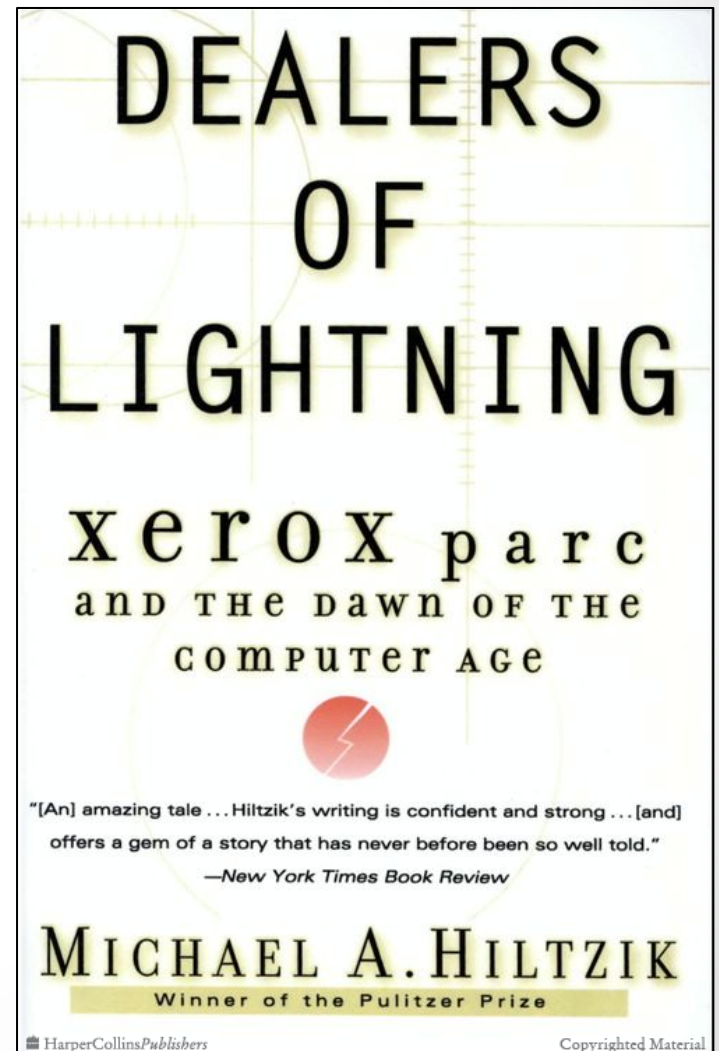
*...*

*Check your bank account at an  
ATM with a touch screen*

*...*

*Watch the three-dimensional  
computer graphics that give life to  
the dinosaurs of Jurassic Park and  
the inspired playthings of Toy  
Story."*

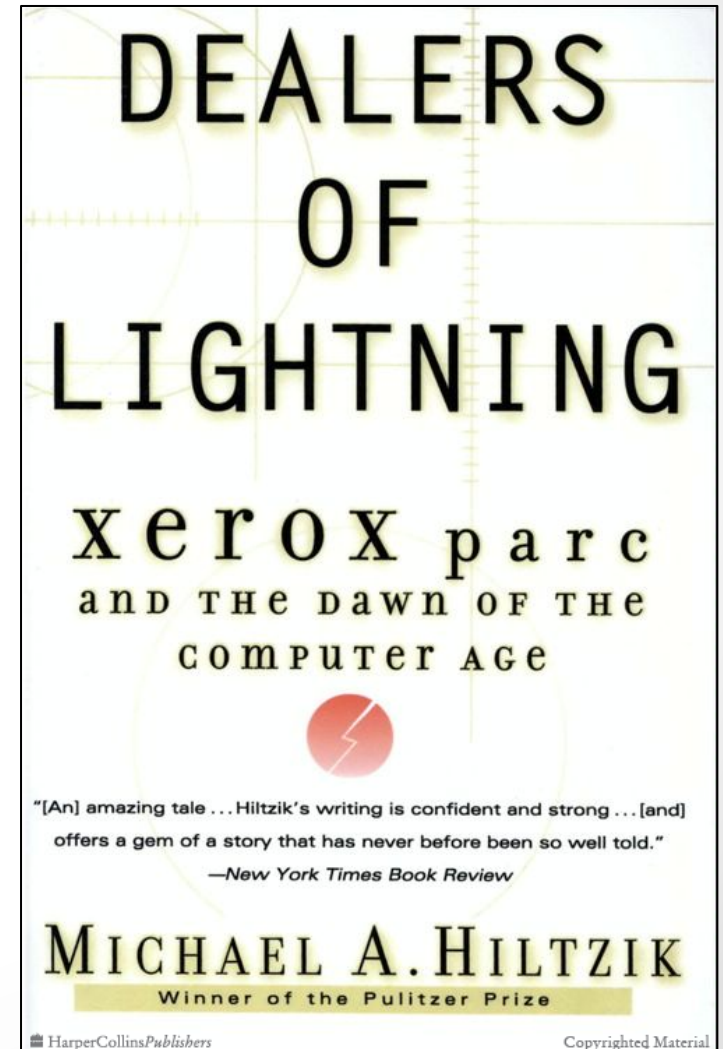
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# Xerox PARC

*“When Apple sued Microsoft in 1988 for stealing the ‘look and feel’ of its Macintosh graphical display, Bill Gates’s defense was essentially that both companies had stolen it from Xerox.”*

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# Xerox Alto

First “personal computer”, in 1973

- ① *Placed computing power in individual hands*
- ② *Interacted with user via a high-performance display*
- ③ *Linked several computers together on a high-speed network*





*“The Alto  
is a time  
machine”*



# Alto Engineering

*Original design completed by  
Chuck Thacker and Ed McCreight  
in 3 months*

*Display consumed 2/3 of CPU  
cycles and 3/4 of memory*

*Microparallel processing – CPU  
prioritizes and executes  
computation for peripherals*

*Bitmap representation of display in  
main memory*





# PARC's Legacy

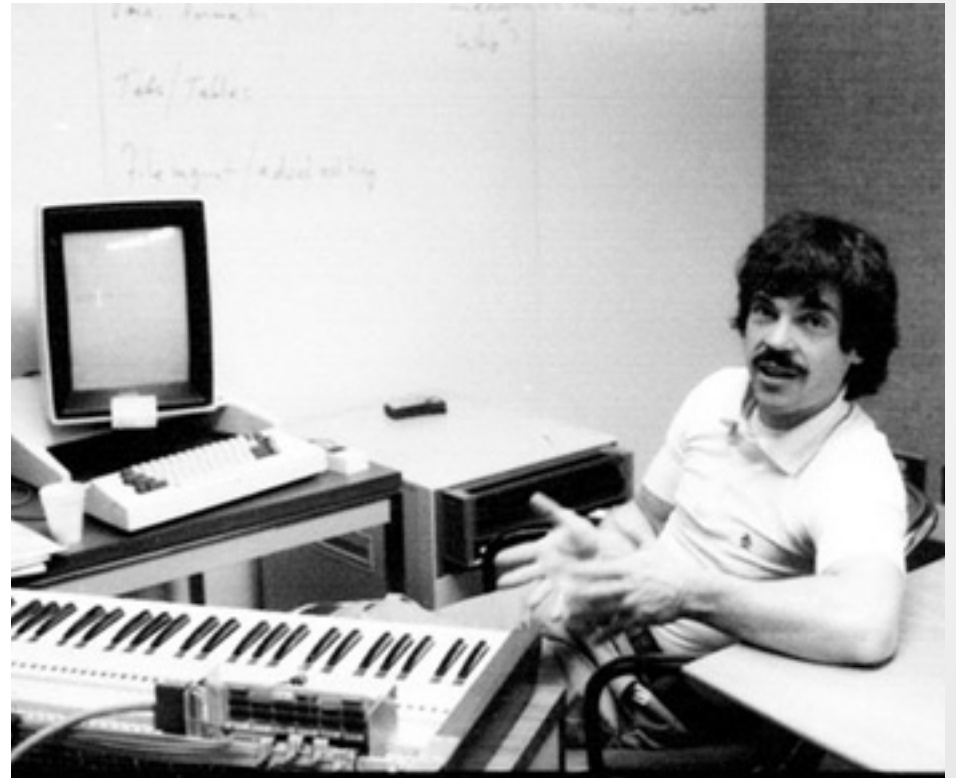
*Inspired Macintosh user interface after 1979 demo to Steve Jobs and the Macintosh team*

*Led directly to Microsoft Word, 3Com, Adobe, etc.*





*“The best way  
to predict the  
future is to  
invent it”*



# Organizational Culture

*Flat organization, no hierarchy*

*Hybrid of academia and industry*

*“There was a lot more teamwork than in academia. It was about getting things done, not about publishing papers”*

*Regularly scheduled “Dealer” meetings*

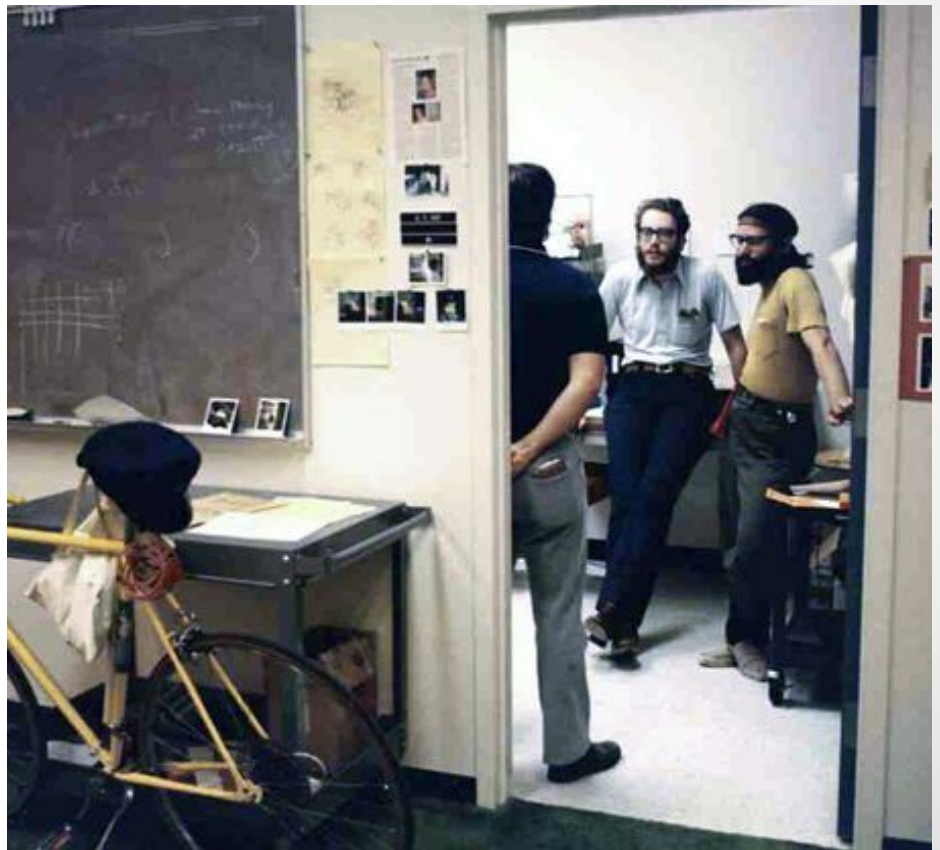


# *“Tom Sawyering”*

*Informal collaboration across groups and projects, everyone pitches in*

*“A continuous form of peer review .. Quality work flourished, less interesting work tended to wither”*

*The “Bose Conspiracy”*





# *“Computer Bums”*

*“By far the best I know of as far as talent and creativity. The people here are all used to dealing lightning with both hands.”*



# *Alan Kay and Smalltalk*

*Intuitive and  
simple enough  
for children to  
use*



# Alan Kay and Smalltalk

*Challenged his team to create world's most powerful language in a single page of code*

*Simple things should be simple*

*"Hiding the details"*

*Object-oriented programming – combine data and procedures, manipulate through messages*





# Adele Goldberg

*Began as a research assistant,  
eventually manager of Systems  
Concepts Laboratory at PARC*

*Co-developer of Smalltalk-80*

*Co-introduced "design  
templates"*

*Delivered (under great protest)  
1979 demo to Steve Jobs*

*President of the ACM, 1984-6*

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# Richard Shoup and SuperPaint

*World's first digital videographics system, parent of all modern paint programs*

*Graphical interface with separate palette and canvas; one of the earliest uses of anti-aliasing*

*Collaborated with and inspired Pixar co-founder Alvy Ray Smith*

*Earned Emmy Award in 1983 and Academy Award in 1998*



- [https://en.wikipedia.org/wiki/Richard\\_Shoup\\_\(programmer\)](https://en.wikipedia.org/wiki/Richard_Shoup_(programmer))



Purpose



Organizational Culture



People



Engineering Excellence





- Think \*Big\*
- Important and motivating goal for the entire organization
- Laser focus on meeting that goal



# Organizational Culture

- Cross-functional, “full stack” teams
- Maximize autonomy, minimize bureaucracy and central control
- Collaboration and camaraderie
- Learning culture



- Hire the best people for the job, regardless of background
- Diversity of experience and perspective
- Treat them well





# Engineering Excellence

- Systems-thinking, holistic solution to the problem
- Pragmatic focus on delivering
- Constant iteration and feedback

# Thank you!



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