

04834580 Software Engineering (Honor Track) 2024-25

# Introduction to Software Engineering

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## Definition (ISO/IEC/IEEE 24765:2017)

The application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software; that is, the application of engineering to software. [1]

## Margaret Hamilton



Developed on-board flight software for NASA's Apollo program.

*When I first started using this phrase, it was considered to be quite amusing. It was an ongoing joke for a long time. They liked to kid me about my radical ideas. Software eventually and necessarily gained the same respect as any other discipline. [2]*

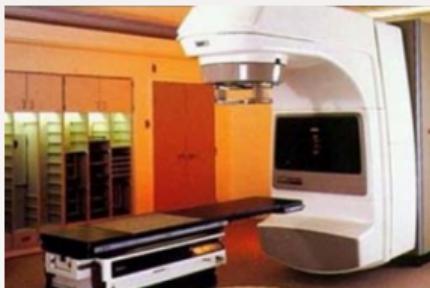
## 1968 NATO Soft. Eng. Conference



1960s saw the emergence “software crisis” — projects were **over budget**, **overdue**, and **unreliable**.

*The phrase software engineering was deliberately chosen as being provocative, implying the need for software manufacture to be based on the types of theoretical foundations and practical disciplines that are traditional in the established branches of engineering. [3]*

Therac-25: Patients Received Overdoses of Radiation in 1985–87 [4]



Heartbleed affected 17% (around half a million) of web servers in 2014 [6]



Ariane flight v88 failure in 1996 resulted in a loss of US\$370 million [5]



Two Boeing 737 MAX crashed in 2018 and 2019 [7]



In 2007, only 30% of government technology-based projects and programmes are successful — Joe Harley, CIO at the UK Department for Work and Pensions. [8]

A 2002–03's survey from 412 experienced (on average, 9 years of experience) project and program managers in the United Kingdom [9]:

- ▶ On average, exceed budget by 13%.
- ▶ On average, overshot schedule by 20%.
- ▶ 9% of projects are abandoned.
- ▶ 23% of projects are budget or schedule challenged.

## Frederick Brooks



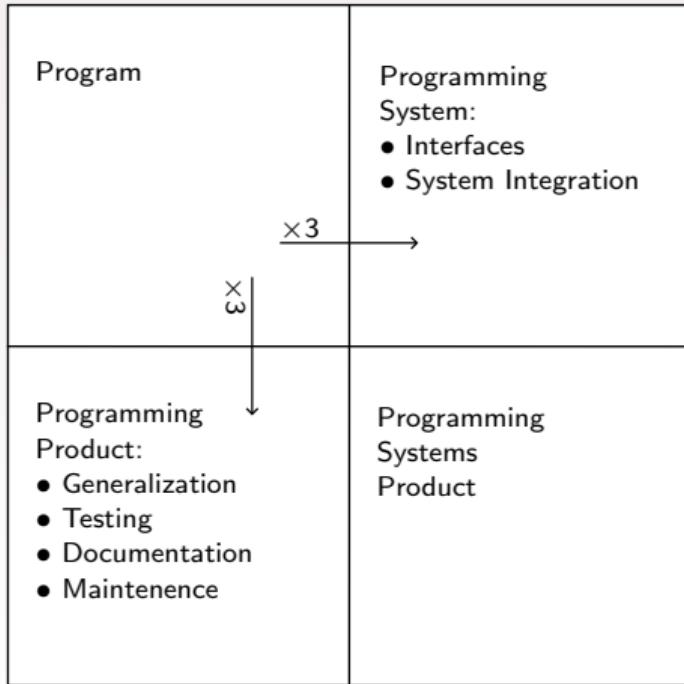
Managed the development of IBM System/360. Turing Award in 1999.

1975 The Mythical Man-Month: Essays on Software Engineering [10]

1989 No Silver Bullet — Essence and Accident in Software Engineering [11]

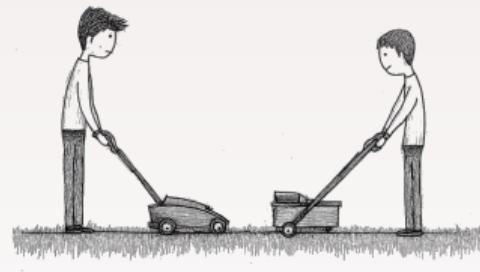
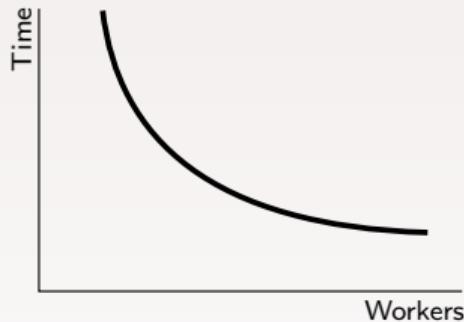
## Key Ideas

- ▶ The cost and effort to move from a program to a system product grow exponentially.
- ▶ Adding manpower to a late software project makes it later.
- ▶ Larger teams require more channels for communication, which exponentially increases complexity.
- ▶ There is no single development, in either technology or management, which by itself promises even one order-of-magnitude improvement.

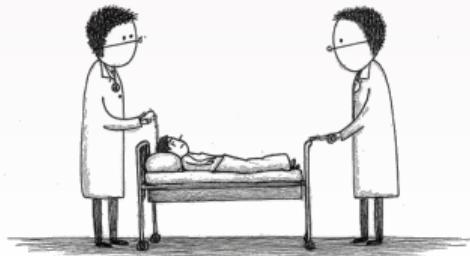
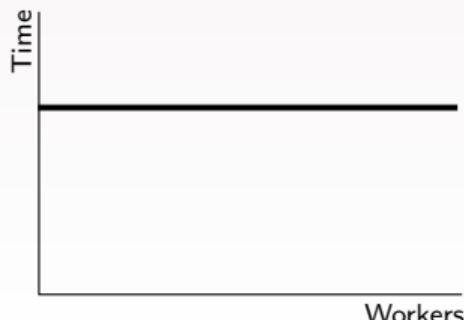


- ▶ **Program:** “it works on my machine...”
- ▶ **Programming product:** usable in many environments, with various input formats/data, thoroughly tested and documented.
- ▶ **Programming system:** interacting components, well-defined interfaces, uses a budget of resources (memory, CPU time), integration testing.
- ▶ **Programming systems product:** all of the above.

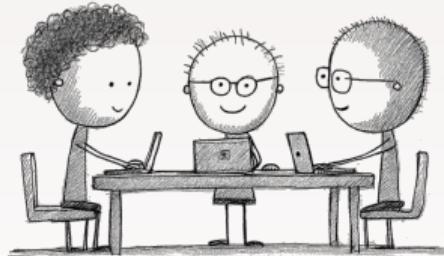
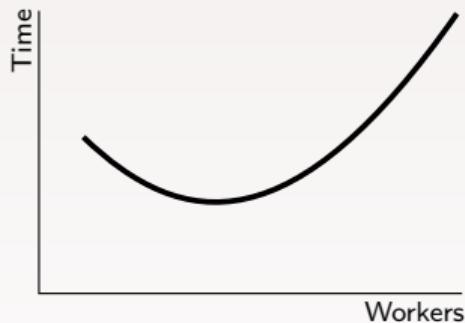
Perfectly partitionable task:



Unpartitionable task:

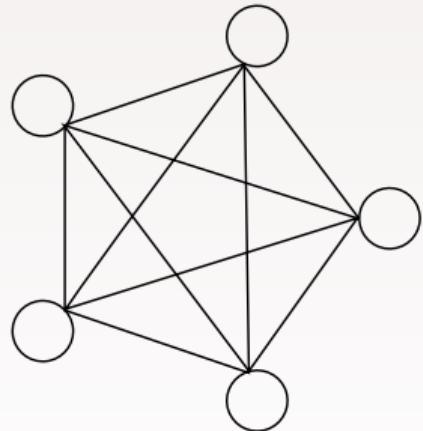


Task with complex interrelationships:

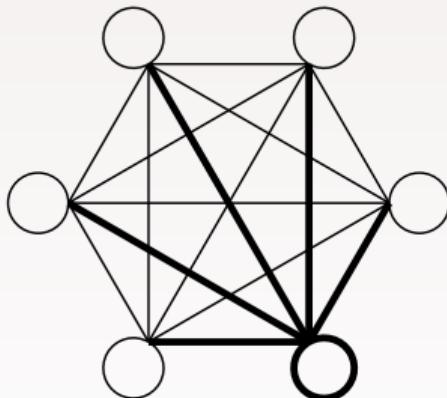


*Since software construction is inherently a systems effort — and exercise in complex interrelationships — communication effort is great, [...]. Adding more men then lengthens, not shortens, the schedule.*

If there are  $n$  workers on a project, there are  $\frac{n^2-n}{2}$  interfaces across which there may be communication.



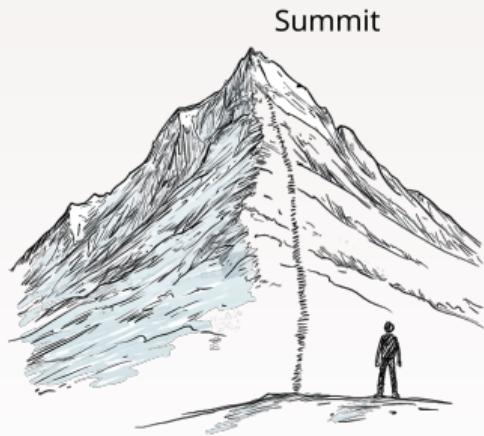
5 workers, 10 connections.



+1 worker, +5 connections.

**Essential complexity** — the difficulties inherent in the nature of the software:

- ▶ Software is complex.
- ▶ The complexity is arbitrary (forced without rhyme or reason).
- ▶ Software is constantly changing.
- ▶ Software is invisible.



**Accidental complexity** — the difficulties of today's production, but not inherent.

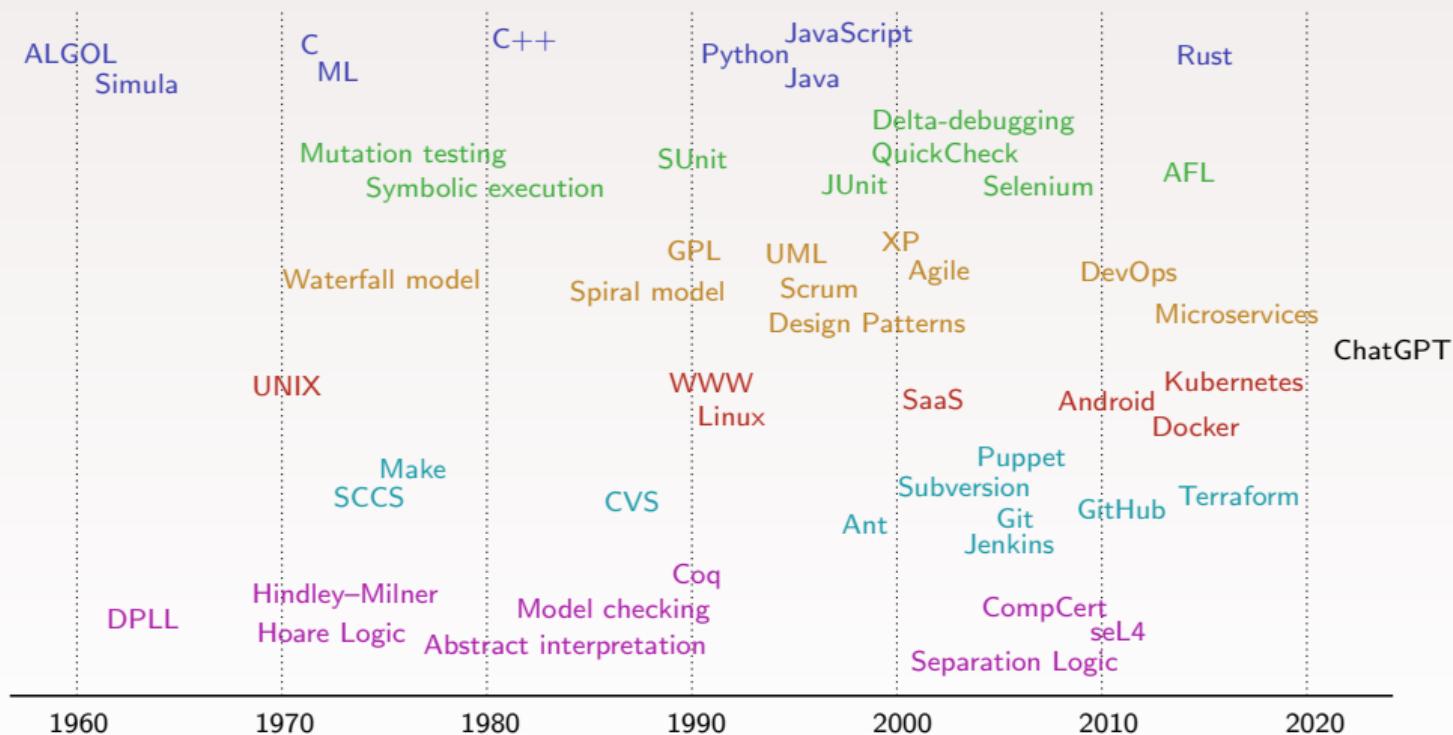
- ▶ Complexity of hardware — addressed by high-level languages.
- ▶ Executing multiple programs — addressed by time-sharing, virtualisation.
- ▶ Information exchange — addressed by the Internet.



*There is no single development, in either technology or management technique, which by itself promises even one order of magnitude improvement within a decade in productivity, in reliability, in simplicity.*

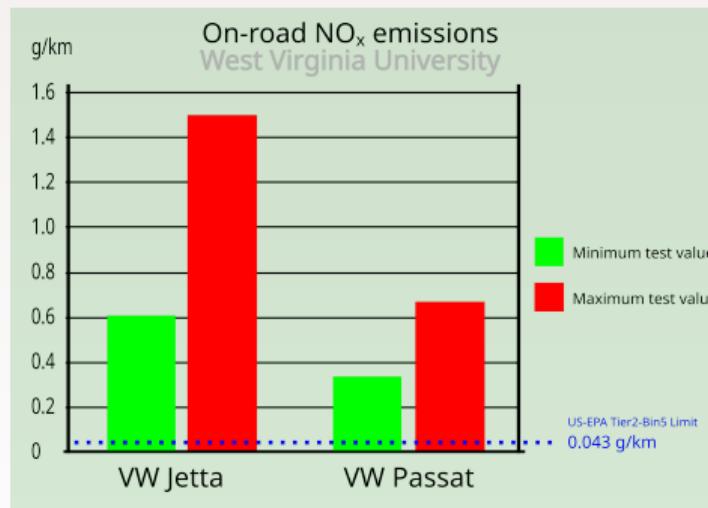
# A Partial Software Engineering Timeline

北京大学



*Each of us as individual software engineers has an opportunity to make a significant positive impact on society, simply by becoming more sensitive to the long-range human relations implications of our work, and by incorporating this sensitivity into our software designs and products. — Barry Boehm [12]*

In September 2015, the US Environmental Protection Agency charged Volkswagen with installing software in their diesel-powered cars that allowed the vehicles to cheat on EPA emissions tests.



Outcome: over \$30 billion in fines and damages — the largest scandal in the history of the automotive industry.

87 million individuals' data were harvested without their consent to create psychographically tailored advertisements to influence people's voting preferences in the 2016 US presidential election.



Outcome: Facebook lost more than \$60 billion in market capitalization.

## Definition (Fairness in Decision-Making [15])

The absence of any prejudice or favoritism toward an individual or group based on their inherent or acquired characteristics.

Correctional Offender Management Profiling for Alternative Sanctions (COMPAS) measures the risk of a person to recommit another crime.



## High Risk (10)

Prior Offense: 1 resisting arrest without violence  
Subsequent Offenses: None

## Low Risk (3)

Prior Offense: 1 attempted burglary  
Subsequent Offenses: 3 drug possessions

Nikon Coolpix S630 featured “blink warning”.



When Asian faces were photographed, a message would pop up on the camera screen asking, “Did someone blink?”

Proof-of-work blockchains such as Bitcoin are secured and verified by virtual miners. A reward provides an incentive to participate in this type of network. The more computational power one has, the bigger the share of all distributed rewards that go to that miner.



In 2018, Bitcoin's energy consumption is comparable to the one of Ireland [18].

**PUBLIC** Software engineers shall act consistently with the public interest.

**CLIENT AND EMPLOYER** Software engineers shall act in a manner that is in the best interests of their client and employer consistent with the public interest.

**PRODUCT** Software engineers shall ensure that their products and related modifications meet the highest professional standards possible.

**JUDGMENT** Software engineers shall maintain integrity and independence in their professional judgment.

**MANAGEMENT** Software engineering managers and leaders shall subscribe to and promote an ethical approach to the management of software development and maintenance.

**PROFESSION** Software engineers shall advance the integrity and reputation of the profession consistent with the public interest.

**COLLEAGUES** Software engineers shall be fair to and supportive of their colleagues.

**SELF** Software engineers shall participate in lifelong learning regarding the practice of their profession and shall promote an ethical approach to the practice of the profession.

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