Labor Dynamics of the IT Economy
What IT Planners Need to Know About the Nature of Programming

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General Thesis

In terms of the dynamics of work in the field, computing is different from most engineering domains. Assumptions that hold true in other, more traditional disciplines often turn out to be wrong when applied to computing, particularly when a project requires a significant software-development effort. Understanding these differences is essential to the task of formulating effective technology policy.

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My intent in this session is to provide an overview of those characteristics of computing that policymakers need to comprehend in order to make appropriate decisions.

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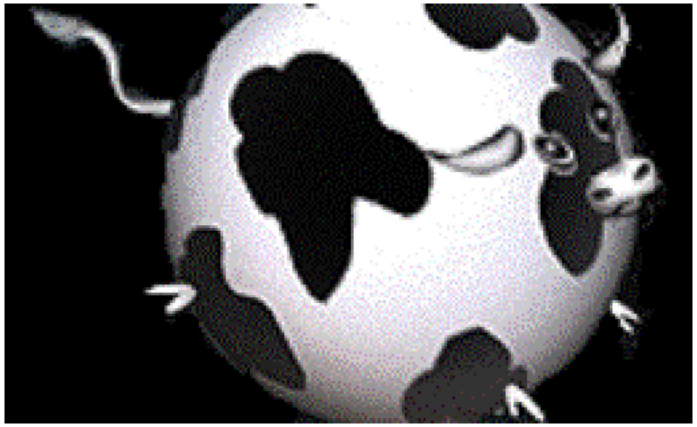

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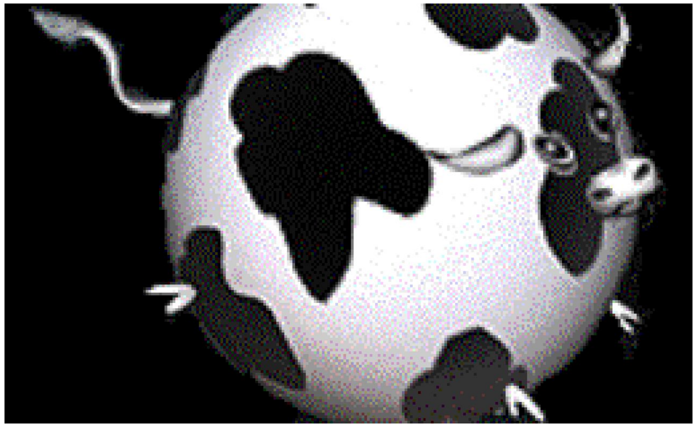

Of course, if a mathematician were to ask farmers for advice, the results might be even more laughable, such as $\pi = 3$.

An Illustrative Example

Because of the preconceptions they have from other disciplines, university administrators often have considerably difficulty understanding the dynamics of faculty recruitment in computer science. If I quote the 1999-2000 ACM finding that

There is one candidate for every three faculty positions.

many listeners hear this statistic backwards. Deans and presidents who are used to having hundreds of applicants for any open job show signs of disbelief and ask:

Are there really only three candidates per position?

The idea that there might be <u>fewer</u> applicants than positions simply does not register.

Critical Observations about Software

1. Software development is an extraordinarily difficult task, exceeding in complexity most other engineering work. That difficulty, moreover, is intrinsic to the discipline and is not likely to change in the foreseeable future.

2. Software development requires people with an unusual combination of skills. Those people are in short supply, but their economic value is huge. Experienced programmers differ in productivity by several orders of magnitude.

3. Economic, social, and political factors are more important than technological progress in determining how computing evolves.

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The Difficulty of Software

People familiar with both software engineering and older engineering disciplines observe that the state of the art in software is significantly behind that in other areas of engineering. When most engineering products have been completed, tested, and sold, it is reasonable to expect that the product design is correct and that it will work reliably. With software products, it is usual to find that the software has major "bugs" and does not work reliably for some users.

— David L. Parnas, *Software Aspects c*
Strategic Defense Systems, 1985

NMD Software Is Particularly Hard

Specifying, generating, testing, and maintaining the software for a battle management system will be a task that far exceeds in complexity and difficulty any that has yet been accomplished in the production of civil or military software systems.

— *The Fletcher Report on Battl*
*Management,*February 1984

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Brooks's Law

"Adding manpower to a late software project makes it later."
— Fred Brooks, *The Mythical Man Month*

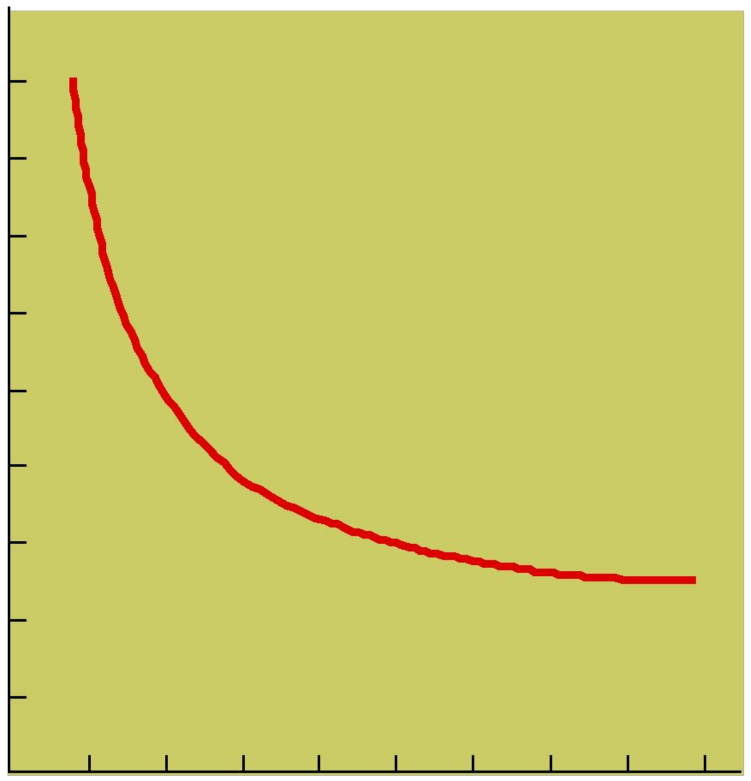

Fig. 2.3 Time versus number of workers—partitionable task requiring communication

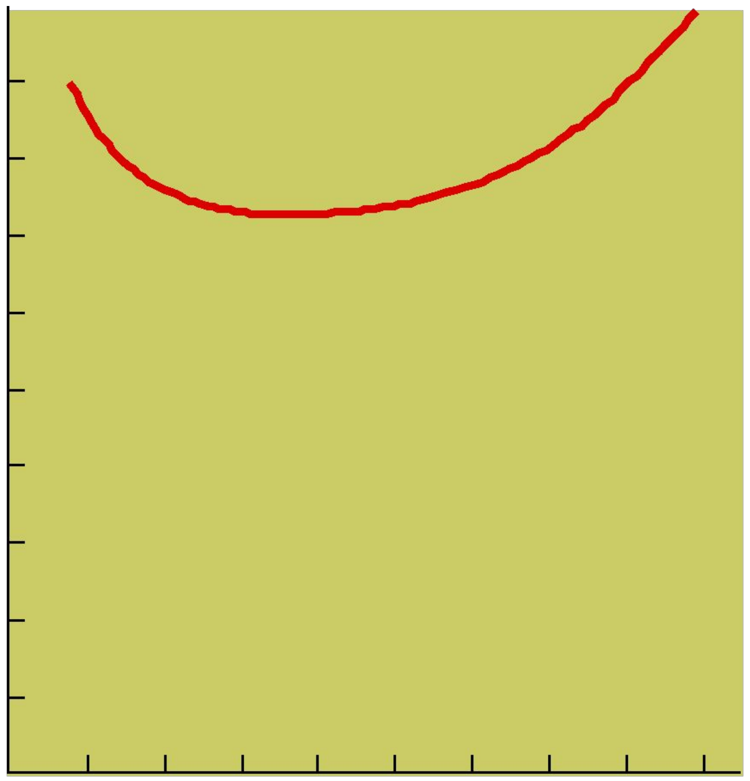

Fig. 2.4 Time versus number of workers—task with complex interrelationships

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The Inevitability of Bugs

Although programming techniques have improved immensely since the early days, the process of finding and correcting errors in programming known graphically—if inelegantly—as debugging still remains a most difficult, confused and unsatisfactory operation. . . . Although we are happy to pay lip-service to the adage that to err is human, most of us like to make a small private reservation about our own performance on special occasions when we really try. It is somewhat deflating to be shown publicly and incontrovertibly by a machine that even when we do try, we in fact make just as many mistakes as other people. If your pride cannot recover from this blow, you will never make a programmer.

— Christopher Strachey, *Scientific American*, 1966

Even in National Missile Defense

Simply because of its inevitable large size, the software capable of performing the battle management task for strategic defense will contain errors. All systems of useful complexity contain software errors.

— Eastport report on Computing in Support of Battle Management, December 1985

The Space Shuttle Laser Test

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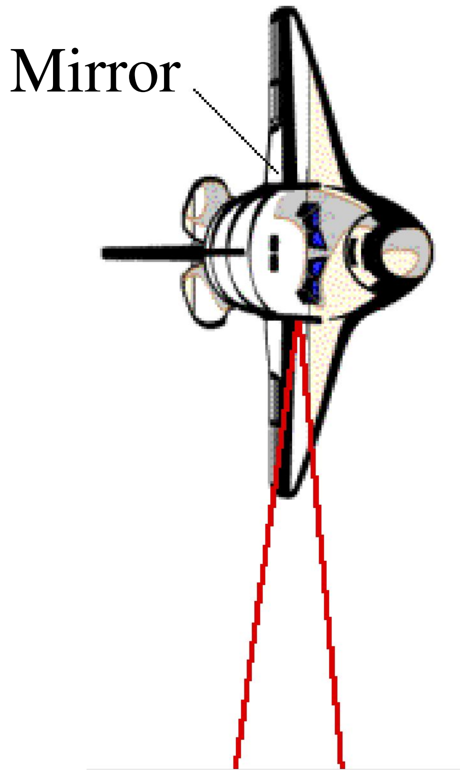

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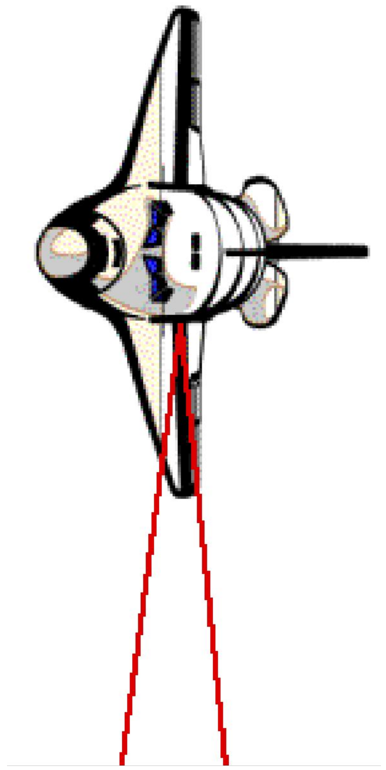

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Computing Is a New Discipline

We find it a bit troublesome to be discussing whether radical advancements in software technology would enhance the quality of a new defense system, when we are aware that many of the DoD's biggest software development contractors are presently literally decades behind the state of the art—an art that is only a few decades old.

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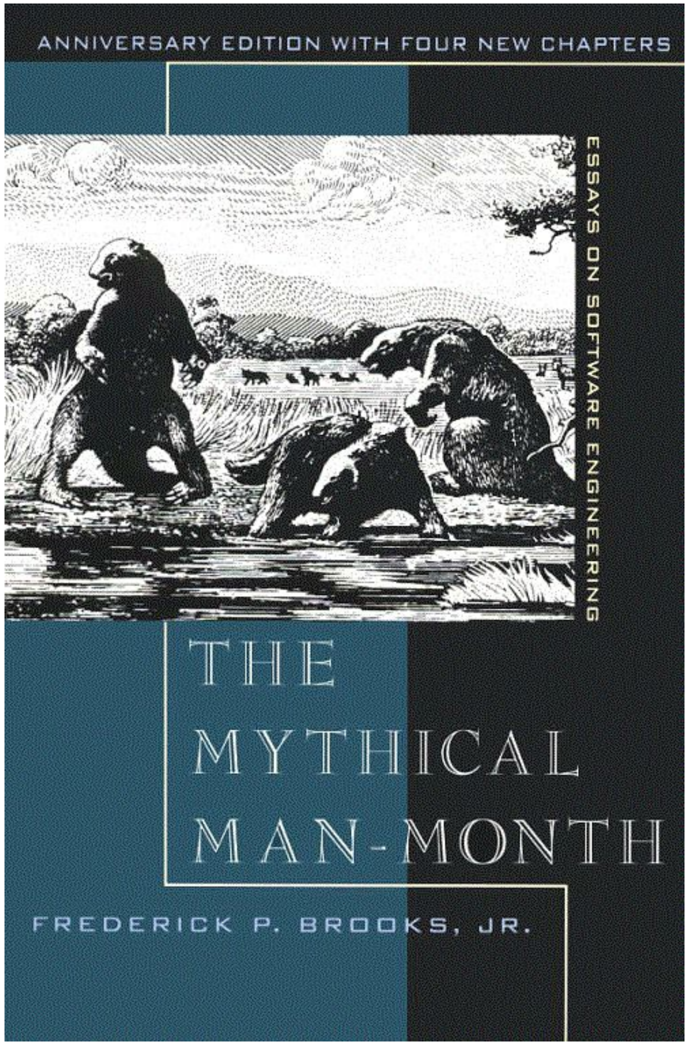
The Mythical Man-Month


ANNIVERSARY EDITION WITH FOUR NEW CHAPTERS
ESSAYS ON SOFTWARE ENGINEERING
THE MYTHICAL MAN-MONTH
FREDERICK P. BROOKS, JR.

Frederick P. Brooks, Jr., *The Mythical Man-Month: Essays on Software Engineering,* second edition, Reading, MA: Addison-Wesley, 1995.

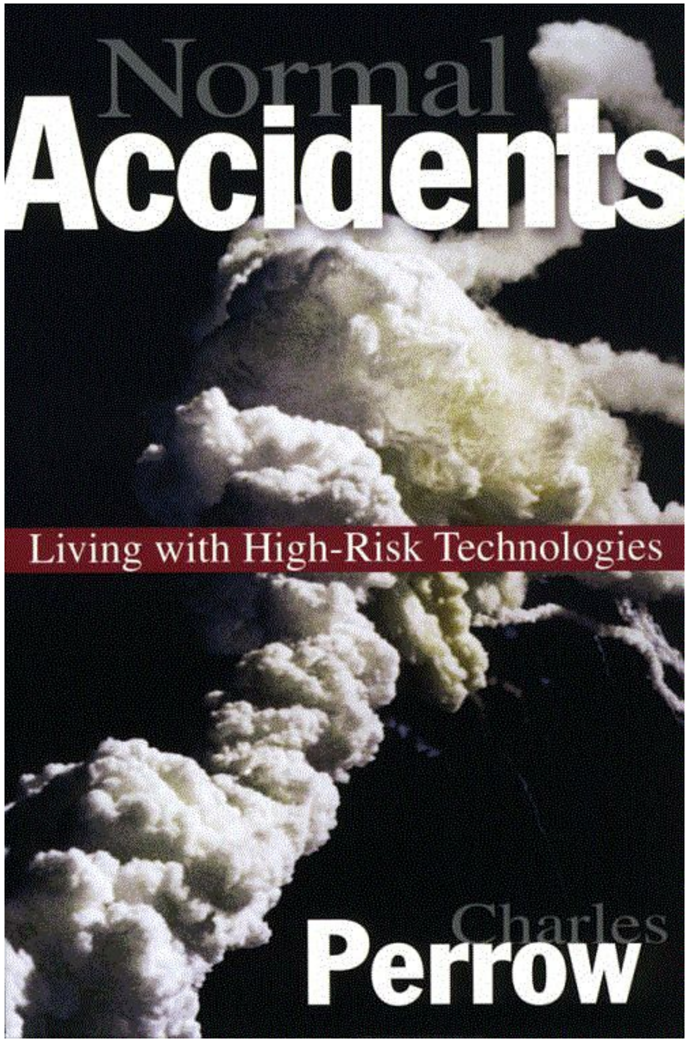
Originally published in 1975, *The Mythical Man-Month* remains the classic text on software engineering and its importance. Despite the fact that Brooks is an expert programmer with a background in both industry and academia, this book is easily accessible to a popular audience.

The Sachertorte Algorithm

John Shore, *The Sachertorte Algorithm and Other Antidotes to Computer Anxiety,* New York: Penguin Books, 1985.

This book is a highly accessible introduction to the complexities and pitfalls of software development.

Normal Accidents



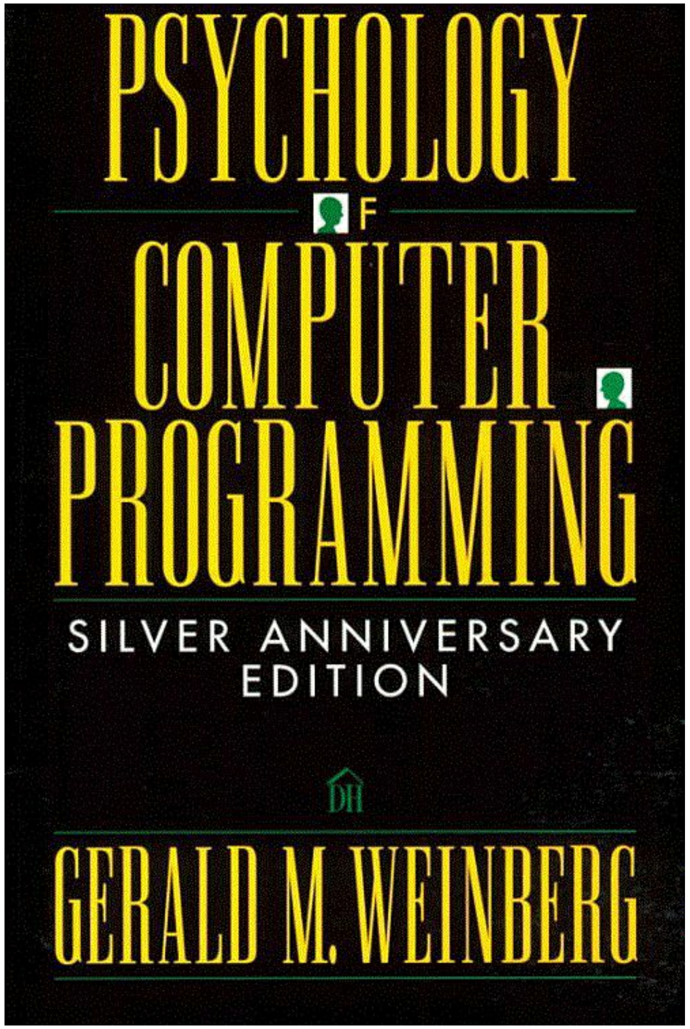
Charles Perrow, *Normal Accidents: Living with High-Risk Technologies*, New York: Basic Books, 1984.

Although this book does not focus specifically on programming—and indeed does not include software or programming in its index—the issues that it raises are critical to an understanding of why complex technological systems fail.

Psychology of Computer Programming

Gerald M. Weinberg, *Psychology of Computer Programming,* New York: Dorset House, 1998.

From the time it first appeared in 1971, this book has offered the best popular description of the mental working processes of programmers. The 1998 edition includes reflections on how well each chapter has held up over time.


PSYCHOLOGY OF COMPUTER PROGRAMMING
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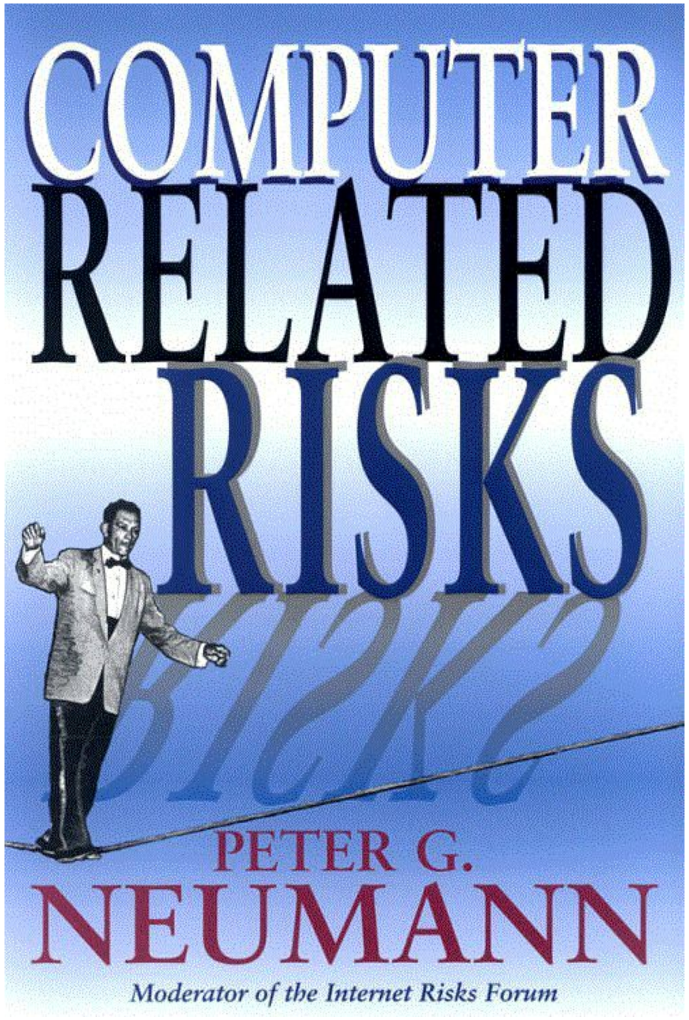
Computer Related Risks



Peter G. Neumann, *Computer Related Risks*, Reading, MA: Addison-Wesley, 1995.

This book presents a summary of the most compelling computer-related failures. Peter Neumann is best known as the moderator of the Internet Risks Forum available at

`http://catless.ncl.ac.uk/Risks/`