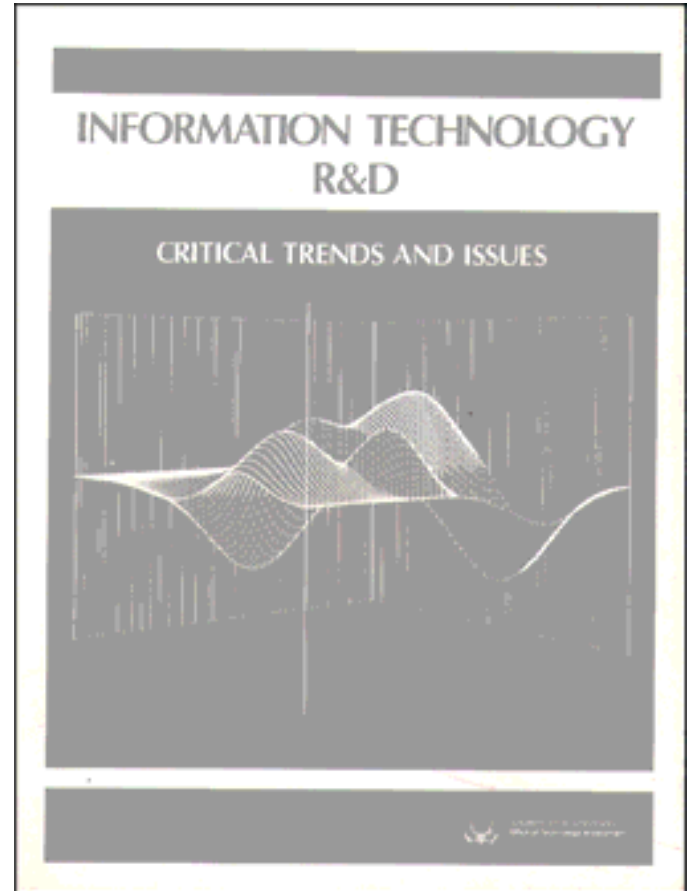


*Information Technology R&D: Critical
Trends and Issues*

February 1985

NTIS order #PB85-245660



Recommended Citation:

Information Technology and R&D: Critical Trends and Issues (Washington, DC: U.S. Congress, Office of Technology Assessment, OTA-CIT-268, February 1985).

Library of Congress Catalog Card Number 84-601150

For sale by the Superintendent of Documents
U.S. Government Printing Office, Washington, DC 20402

Foreword

New computer and communications technologies are obviously transforming American life. They are the basis of many of the changes in our telecommunications system and also a new wave of automation on the farm, in manufacturing and transportation, and in the office. They are changing the form and delivery of government services such as education and the judicial system. Information products and services have become a major and still rapidly growing component of our economy.

A strong U.S. research and development effort has, in the past, been the source of much of this new technology. However, recent events, such as the restructuring of the U.S. telecommunications industry and the emergence of strong foreign competition for some technologies, have changed the environment for R&D. Consequently, the House Committee on Science and Technology, the House Committee on Energy and Commerce, and its Subcommittee on Telecommunications, Consumer Protection, and Finance asked OTA to conduct an assessment of the current state of R&D in these critical areas.

In this report, OTA examines four specific areas of research as case studies: computer architecture, artificial intelligence, fiber optics, and software engineering. It discusses the structure and orientation of some selected foreign programs. Finally, it examines a set of issues that have been raised in the course of the study: manpower, institutional change, the new research organizations that grew out of Bell Laboratories, and implications of trends in overall science and technology policy.

Information technology research and development in the United States is a remarkably adaptable system—important changes may already be taking place in funding patterns, institutional structures, manpower development, and government policies. Hence, the policy issues for Congress are not so much to stimulate change as to remove barriers to productive change, and to monitor and maintain the health of the R&D enterprise in a time of rapid change in an industry so central to our national economy and security.

OTA gratefully acknowledges the contributions of the many experts, within and outside the Government, who served as panelists, consultants, contractors, and reviewers of this document. As with all OTA reports, however, the content is the responsibility of OTA and does not necessarily constitute the consensus or endorsement of the advisory panel or the Technology Assessment Board.



JOHN H. GIBBONS

Director

OTA Information Technology Research and Development Project Staff

John Andelin, Assistant Director, OTA
Science, *Information and Natural Resources Division*

Fred W. Weingarten, *Communication and Information Technologies Program Manager*

Project Staff

Donna L. Valtri, *Project Director*¹
Fred W. Weingarten, *Project Director*²
Chuck Wilk, *Senior Analyst*
Linda G. Roberts, *Senior Analyst*
Linda Garcia, *Analyst*
M. Karen Gamble, *Analyst*
Prudence S. Adler, *Analyst*
Jim Dray, *Research Analyst*
Earl Dowdy, *Research Analyst*
Lauren Ackerman, *Research Analyst*
John Williams³
Peg Kay⁴

Administrative Staff

Elizabeth A. Emanuel, *Administrative Assistant*
Shirley Gayheart, *Secretary*
Jennifer Nelson, *Secretary*
Marsha Williams, *Secretary*
Renee S. Lloyd, *Secretary*

Contractors

Myles Boylan	J. F. Coates, Inc.	Barbara Davies
Russell Drew	Sidney Fernbach	Michael Goetz
Stan Liebowitz	Abbe Mowshowitz	Larry Olson
Bruce Owen	John Young	

¹Project Director from November 1982 to December 1983.

²Acting Project Director from December 1983.

³Detailee from the Federal Communications Commission from October 1982 to October 1983.

⁴Detailee from the National Bureau of Standards, May 1984.

Information Technology Research and Development Advisory Panel

Roger G. Noll *Chairman*
Professor of Economics, Stanford University

Geneva Belford
Department of Computer Science
University of Illinois

Steven Bisset
President
Megatest, Inc.

John E. Bryson
Morrison & Foerster

Nandi Kishore M. Chitre
Director
Systems Planning Division
INTELSAT

Ralph E. Gomory
Vice President and Director of Research
IBM Corp.
Thomas J. Watson Research Center

John V. Barrington
Director
COMSAT Laboratories

William C. Hittinger
Executive Vice President
RCA/David Sarnoff Research Center

Bruce Lusignan
Director
Communication Satellite Planning Center
Stanford University

Donald McCoy
Vice President and General Manager
CBS Technology Center

Ithiel de Sola Pool*
Professor of Political Science
Massachusetts Institute of Technology

Paul E. Ritt, Jr.
Vice President and Director of Research
GTE Laboratories, Inc.

Larry W. Sumney
Executive Director
Semiconductor Research Corp.

Victor Vyssotsky
Executive Director
Research, Information Sciences
AT&T Bell Laboratories

Robert E. Wesslund
Vice President for Technology Exchange
Control Data Corp.

George R. White
Senior Research Fellow
The Harvard Business School

Advanced Computer Architecture Workshop

Duane Adams
Consultant
Defense Advanced Research Project Agency

James C. Browne
Department of Computer Science
University of Texas

Alan Charlesworth
Senior Staff Engineer
Floating Point Systems, Inc.

Kent K. Curtis
Section Head, Computer Science
Division of Mathematical and Computer
Sciences
National Science Foundation

Sidney Fernbach
Consultant
Control Data Corp.

Dennis Gannon
Assistant Professor
Department of Computer Science
Purdue University

Robert G. Gillespie
Vice Provost for Computing
University of Washington

David Kuck
Department of Computer Sciences
University of Illinois

*Deceased Mar. 11, 1984

Neil Lincoln
Vice President and Chief Architect
ETA Systems, Inc.

Roger G. Nell
Professor of Economics
Stanford University

Paul Ritt, Jr.
Vice President and Director of Research
GTE Laboratories, Inc.

Paul Schneck
Leader, Information Sciences Division
Office of Naval Research

Jacob Schwartz
Director
Division of Computer Sciences
Courant Institute of Mathematical Sciences

Burton J. Smith
Vice President
Research and Development Department
Denelcor, Inc.

Harold Stone
Professor
Department of Electrical and Computer
Engineering
University of Massachusetts

Jim Thornton
Chief Executive Officer
Network System Corp.

Kenneth G. Wilson
James A. Weeks Professor of Physical
Science
Newman Laboratory
Cornell University

Fiber Optics Workshop

Thomas Giallorenzi, *Chairman*
Superintendent, Optical Sciences Division
Naval Research Laboratory

Michael Barnoski
Consultant
Pacific Palisades, CA

Melvin Cohen
Director, Interconnection Technology
Laboratory
AT&T Bell Laboratories

Anthony J. DeMaria
Assistant Director of Research for Electrical
and Electrooptics Technology
United Technology Research Center

Charles W. Deneka
Director, Optical Waveguide Technology
Corning Glass Works

Charles Kao
ITT Executive Scientist
ITT Corp.

Herwig Kogelnick
Director
Electronics Research Laboratory
AT&T Bell Laboratories

Henry Kressel
Senior Vice President
E. M. Warburg, Pincus & Co.

William Streifer
Senior Research Fellow
Xerox Corp.

John Whinnery
Department of Electrical Engineering and
Computer Science
University of California, Berkeley

Amnon Yariv
Professor of Electrical Engineering and
Applied Physics
California Institute of Technology

Software Engineering Workshop

Richard A. DeMillo
Professor of Information and Computer
Science
Georgia Institute of Technology

George Dodd
Department Head
Computer Science Department
General Motors Research Laboratories

Capers Jones
Manager of Programming Technology
Analysis
ITT Corp.

Brian Kernighan
Head, Computing Structures Research
AT&T Bell Laboratories

Ann Marmor-Squires
Chief Technologist
TRW Defense Systems Group

Robert Mathis
Director
Ada Joint Program Office
Department of Defense

Harlan Mills
IBM Fellow
IBM Corp.

Leon J. Osterwell
Chairman
Computer Science Department
University of Colorado

C. V. Ramamoorthy
Professor of Electrical Engineering and
Computer Science
University of California, Berkeley

Paul Schneck
Leader, Information Sciences Division
Office of Naval Research

Ben Shneiderman
Professor of Computer Science
University of Maryland

Steve Squires
Software Technology Programming Manager
Defense Advanced Research Projects Agency

Terry A. Straeter
Vice President and Program Director
General Dynamics Electronics

Raymond Yeh
Professor of Computer Science
University of Maryland

Artificial Intelligence Workshop

Bruce Bullock
Vice President
Teknowledge Federal Systems

Marvin Denicoff
Executive
Thinking Machines Corp.

Ewald Heer
Program Manager
Autonomous Systems and Space Mechanics
Jet Propulsion Laboratory

Thomas F. Knight
Assistant Professor of Electrical Engineering
and Computer Science
Artificial Intelligence Laboratory
Massachusetts Institute of Technology

Mitchell Marcus
Member of the Technical Staff
Linguistics and Artificial Intelligence
Research Department
AT&T Bell Laboratories

Ronald Ohlander
Program Manager
Defense Advanced Research Projects Agency

Kamron Parsaye
President
Silogic, Inc.

Stephen Polit
Manager of Advanced Development
Artificial Intelligence Group
Digital Equipment Co.

Azriel Rosenfeld
Director
Center for Automation Research
Computer Science Center
University of Maryland

David Waltz
Professor of Electrical Engineering and
Research Professor
Coordinated Science Laboratory
University of Illinois

Patrick H. Winston
Professor of Computer Science and Electrical
Engineering and Director
Artificial Intelligence Laboratory
Massachusetts Institute of Technology

Information Technology Research and Development Federal Workshop

Charles Brownstein
Head
Information Science Division
National Science Foundation

Douglas Crombie
Chief Scientist
National Telecommunications and
Information Administration

John A. Daly
Special Assistant
Agency for International Development

Craig Fields
Assistant Director for Systems Services
Defense Advanced Research Projects Agency

Clinton W. Kelly, III
Assistant Director, Systems Science Division
Defense Advanced Research Projects Agency

Robert Lovell
Director of Communications
National Aeronautics and Space
Administration

Robert Powers
Chief Scientist
Office of Science and Technology
Federal Communications Commission

John Riganati
Division Chief
System Components Division
National Bureau of Standards

Paul Schneck
Leader, Information Science Division
Office of Naval Research

Elias Schutzman
Program Director
Electrical Optical Communications Program
National Science Foundation

Reviewers and Other Contributors

Robert Ayres
Carnegie-Mellon University

Richard Baxter
British Embassy

Donald S. Beilman
Microelectronics Center of North
Carolina

John Biddle
Computer and Communications
Industry Association

Marlan Blissett
University of Texas

Erich Bloch
Semiconductor Research Corp.
IBM Corp.

Justin Bloom
Technology International, Inc.

Bill Boesman
Congressional Research Service

Jane Bortnick
Congressional Research Service

Paul Bortz
Brown, Bortz & Covington

Martha Branstad
National Bureau of Standards

Kenneth Brown
American Enterprise Institute for
Public Policy Research

Glen Chancy
AT&T Bell Laboratories

Gary Coleman
Department of Education

Arthur Cordell
Science Council of Canada

Matthew Crugnale
Gnostic Concepts, Inc.

Beverly Daniel
General Accounting Office

George Dummer
Massachusetts Institute of
Technology

Lauren Erling
ADAPSO

Frank Fisher
Urban Institute

Penny Foster
National Science Foundation

Donald R. Fowler
California Institute of Technology

Peter Fuchs
Harvard University
Osmund Fundingsland
General Accounting Office

Robert Gallawa
National Bureau of Standards

Howard Gobstein
General Accounting Office

Robert A. Gross
Columbia University

Walter Hahn
George Washington University

Glen Hansen
Department of Commerce

Richard Hersh
University of Oregon

Christopher Hill
Congressional Research Service

Joseph Hull
Department of Commerce

B. R. Inman
Microelectronics & Computer
Technology Corp.

Charles L. Jackson
Shooshan & Jackson, Inc.
Don Kash
University of Oklahoma
Todd LaPorte
University of California-Berkeley
Christopher LeMaistre
Rensselaer Polytechnic Institute
Jean-Pierre Letouzey
French Embassy
Thomas Linney
Council of Graduate Schools
Harold Linstone
Portland State University
John G. Linvill
Stanford University
John Logsdon
George Washington University
Albert Lumbroso
French Embassy
Enrique Marcatili
AT&T Bell Laboratories
Michael Marcus
Federal Communications
Commission
Nick Metropolis
Los Alamos National Laboratory
Charles H. Miller
AT&T
Robert Miller
University of Houston
Robert Morgan
Washington University

Joel Moses
Massachusetts Institute of
Technology
Jane Myers
Patent and Trademark Office
Tom Nardone
Bureau of Labor Statistics
Dorothy Nelkin
Cornell University
William F. Nelson
GTE Laboratories, Inc.
Arnie Packer
Manpower Economist
Paul Penfield
Massachusetts Institute of
Technology
Robert Pepper
Department of Commerce
Paul Polishuk
Information Gatekeepers, Inc.
John M. Richardson
National Research Council
Michel Robin
French Embassy
Martha G. Russell
University of Minnesota
Grant Saveers
Digital Equipment Corp.
Wendy Schacht
Congressional Research Service
Jurgen Schmandt
University of Texas

Dan Slotnick
University of Illinois
Ollie Smoot
Computer and Business
Equipment Manufacturers
Association
Bill Stotesbery
Microelectronics & Computer
Technology Corp.
Gregory Tassej
National Bureau of Standards
Henry Taylor
Naval Research Laboratory
Al Teich
American Association for
Advancement of Science
William Wells
George Washington University
Irwin White
New York State Energy R&D
Agency
Robert Willard
Information Industries
Association
John G. Williams
Carruthers, Deutsch, Garrison &
Williams
Paul Wilson
AT&T
Paul Zurkowski
Information Industries
Association

In-House Reviewers

Audrey Buyrn, *Program Manager*
Martha Harris, *Project Director*
Paul Phelps, *Project Director*
Henry Kelly, *Project Director*
John Alic, *Project Director*
Barry Holt, *Analyst*
Eric Bazques, *Analyst*