NBSIR 75-753 (R)

Programmatic Coverage of Computer Science Topics Within the Institute for Computer Sciences and Technology of the National Bureau of Standards

Joseph O. Harrison, Jr.

Institute for Computer Sciences and Technology
National Bureau of Standards
Washington, D. C. 20234

June, 1975

Final Report

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

NBSIR 75–753

PROGRAMMATIC COVERAGE OF COMPUTER SCIENCE TOPICS WITHIN THE INSTITUTE FOR COMPUTER SCIENCES AND TECHNOLOGY OF THE NATIONAL BUREAU OF STANDARDS

Joseph O. Harrison, Jr.

Institute for Computer Sciences and Technology
National Bureau of Standards
Washington, D. C. 20234

June, 1975

Final Report

U.S. DEPARTMENT OF COMMERCE, Rogers C.B. Morton, *Secretary*
John K. Tabor, *Under Secretary*
Dr. Betsy Ancker-Johnson, *Assistant Secretary for Science and Technology*

NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Acting Director*

FOREWORD

The material in this paper is taken from two reports on computer science in ICST submitted to the Director, ICST, Dr. Ruth M. Davis in April 1975. This report will serve to make it available to the NBS staff.

In compiling the material a number of prominent members of the academic community were interviewed regarding their views on a definition of computer science. In particular, discussions were held with the following persons:

Dr. Bruce Arden	Princeton University and Principal Investigator of NSF Study to Classify Computer Science
Dr. William F. Atchison	National Institute of Education Program for Productivity and Technology Former Chairman of the ACM Curriculum Committee That Developed ACM Curriculum 68
Dr. Richard Austing	University of Maryland and Chairman of ACM SIGCSE Under Whose Auspices ACM Curriculum 68 Is Being Revised
Dr. John W. Hamblen	University of Missouri
Dr. Donald E. Knuth	Stanford University
Dr. Jack Minker	University of Maryland Head of Computer Sciences Department
Dr. Steve Yau	Northwestern University and President IEEE

In addition, the definition of computer science was discussed with the following persons within ICST:

J. Albus
J. Berg
R. Butler
J. Evans
E. Fong
M. Fox
M. Henderson
E. Istvan
S. Jeffery
G. Lindamood
T. Lowe
T. Pyke
B. Ramsay
R. Saltman
S. Stewart
R. Stillman
Z. Thornton
J. Walkowicz
J. Wegstein
H. White
J. Wood

The definition finally selected is based largely on the subject classification in ACM Curriculum 68[1] but in addition reflects the author's discussions with these persons.

The ICST programmatic coverage table presented in the report was developed from various NBS program documents. The list of top scientists was compiled largely from nominations of NBS staff members.

The author gratefully acknowledges the assistance of all of the above persons.

The author is particularly indebted to Mr. Edwin J. Istvan, Associate Director for Teleprocessing and Acting Chief, Information Technology Division, ICST, for reviewing the manuscript of this document and making a number of helpful suggestions.

TABLE OF CONTENTS

PROGRAMMATIC COVERAGE OF COMPUTER SCIENCE TOPICS WITHIN THE INSTITUTE FOR COMPUTER SCIENCES AND TECHNOLOGY OF THE NATIONAL BUREAU OF STANDARDS

ABSTRACT

This paper presents three items of information relative to computer science at NBS:

(1) it gives a definition of computer science in terms of topical areas,

(2) it shows by examining past and present ICST project descriptions which topical areas have been or are presently covered by ICST programs, and

(3) it presents a list of some of the top computer scientists in each of the topical areas included in the definition.

Definition of Computer Science

The computer science literature abounds with dictionary-like definitions of computer science, but none of them is precise enough to use as a criterion for determining whether a specific topic in the general area is or is not included. Accordingly, it was decided that for the purpose of this study computer science would be defined in terms of the list of topics of which it consists. The specific list adopted as a definition is based on the subject classification of computer science given in ACM Curriculum 68[1] and is presented in Appendix 1 of this report.

Curriculum 68 was published in March 1968 by the ACM Curriculum Committee on Computer Science after six years of work which included the sponsoring of panel discussions and other sessions at various national committee meetings and the issuing of a preliminary report on undergraduate programs in computer science in September 1965. The committee spent two years in revising the recommendations of the preliminary report and in extending them to graduate programs. Many prominent computer scientists contributed to Curriculum 68. In addition, to the twelve members of the committee, 64 other persons served as consultants or presented written comments or otherwise assisted.

The subject classification of Curriculum 68 is widely recognized throughout the computer community, and is the only such classification used as a basis for instructional programs in a large number of educational institutions.

On the other hand, there have been changes in computer science in the seven years since Curriculum 68 was published, and a number of subjects that are not included in Curriculum 68 are now recognized to be important computer science areas. For this reason, a list of additional computer topics which

appear to have scientific content, at least in part, have for the purpose of this study been appended to the Curriculum 68 list as supplementary computer science topics.

In the definition (Appendix 1) numbered topics I - V together with their subtopics are taken from Curriculum 68 without change. Topics S1 - S6 are the supplementary topics which have been added. The descriptions of the topics from Curriculum 68 are given in Appendix 2, which is reproduced verbatim from Curriculum 68, and the descriptions of the supplementary topics are given in Appendix 3.

Programmatic Coverage by ICST

ICST has some activity in virtually all areas of computer science. In many cases, however, this activity is confined to work of a management, administrative support or sponsorship nature. Accordingly, a criterion has been adopted for the use of the term coverage in this study. Specifically, a topic is considered to be covered only if ICST devoted a "major in-house technical effort" in it. The word major is construed to mean a minimum of 1/2 man-year. ICST programmatic coverage of computer science under this criterion is presented in Appendix 4. The appendix consists of a table giving the coverage by fiscal year of each computer science topic and a set of notes describing the rational for each entry in the table on a case-by-case basis. The methodology used in developing the coverage table is given in Appendix 5.

In addition, ICST engages in many important activities not included in the coverage table. They include:

management of NBS and Federal Government computer programs

dissemination of computer related information

compiling computer usage data

conducting computer related economic studies

sponsoring seminars in computer related subjects

producing indices of computer programs

studying legal aspects of computer related problems

Top Computer Scientists

A list of some top scientists in each of the computer science areas included in the definition is presented as Appendix 6. The list is not intended to be complete, nor do the order of the names on it have any significance.

REFERENCE

1. ACM Curriculum 68, Communications of the ACM 11, 3 (March 1968).

APPENDIX 1

DEFINITIONAL LIST OF TOPICS COMPRISING COMPUTER SCIENCE*

COMPUTER SCIENCE

I. INFORMATION STRUCTURES AND PROCESSES

1. Data Structures
2. Programming Languages
3. Models of Computation

II. INFORMATION PROCESSING SYSTEMS

1. Computer Design and Organization
2. Translators and Interpreters
3. Computer and Operating Systems
4. Special Purpose Systems

III. METHODOLOGIES

1. Numerical Mathematics
2. Data Processing and File Management
3. Symbol Manipulation
4. Text Processing
5. Computer Graphics
6. Simulation
7. Information Retrieval
8. Artificial Intelligence
9. Process Control
10. Instructional Systems

S. SUPPLEMENTARY AREAS

1. Computer Security
2. Performance Measurement and Evaluation
3. Computer Networking
4. Data Communications
5. Software Engineering
6. Analysis of Algorithms

RELATED AREAS

IV. MATHEMATICAL SCIENCES

V. PHYSICAL AND ENGINEERING SCIENCES

---

* Numbered topics I, II, III, IV and V together with their subtopics are taken from Curriculum 68 without change. Topics S1 - S6 are supplementary topics which have been added for the purpose of this study.

APPENDIX 2

TOPICAL DESCRIPTIONS FROM CURRICULUM 68

The scope of academic programs and curricula in computer science will necessarily vary from institution to institution as dictated by local needs, resources, and objectives. To provide a basis for discussion, however, it seems desirable to have a reasonably comprehensive system for classifying the subject areas within computer science and related fields. Although any such system is somewhat arbitrary, it is hoped that any substantial aspect of the computer field, unless specifically excluded for stated reasons, may be found within the system presented here. The subject areas within computer science will be classified first; those shared with or wholly within related fields will be discussed later in this section.

Computer Science. The subject areas of computer science are grouped into three major divisions: "information structures and processes," "information processing systems," and "methodologies." The subject areas contained in each of these divisions are given below together with lists of the topics within each subject area.

I. INFORMATION STRUCTURES AND PROCESSES

This subject division is concerned with representations and transformations of information structures and with theoretical models for such representations and transformations.

1. Data Structures: includes the description, representation, and manipulation of numbers, arrays, lists, trees, files, etc.; storage organization, allocation, and access; enumeration, searching and sorting; generation, modification, transformation, and deletion techniques; the static and dynamic properties of structures; algorithms for the manipulation of sets, graphs, and other combinatoric structures.

2. Programming Languages: includes the representation of algorithms; the syntactic and semantic specification of languages; the analysis of expressions, statements, declarations, control structures, and other features of programming languages; dynamic structures which arise during execution; the design, development and evaluation of languages; program efficiency and the simplification of programs; sequential transformations of program structures; special purpose languages; the relation between programming languages, formal languages, and linguistics.

3. Models of Computation: includes the behavioral and structural analysis of switching circuits and sequential machines; the properties and classification of automata; algebraic automata theory and model theory; formal languages and formal grammars; the classification of languages by recognition devices; syntactic analysis; formal

specification of semantics; syntax directed processing; decidability problems for grammars; the treatment of programming languages as automata; other formal theories of programming languages and computation.

II. INFORMATION PROCESSING SYSTEMS

This subject division is concerned with systems having the ability to transform information. Such systems usually involve the interaction of hardware and software.

1. COMPUTER DESIGN AND ORGANIZATION: includes types of computer structure—von Neumann computers, array computers, and look-ahead computers; hierarchies of memory—flip-flop registers, cores, disks, drums, tapes—and their accessing techniques; microprogramming and implementation of control functions; arithmetic circuitry; instruction codes; input-output techniques; multiprocessing and multiprogramming structures.

2. TRANSLATORS AND INTERPRETERS: includes the theory and techniques involved in building assemblers, compilers, interpreters, loaders, and editing or conversion routines (media, format, etc.).

3. COMPUTER AND OPERATING SYSTEMS: includes program monitoring and data management; accounting and utility routines; data and program libraries; modular organization of systems programs; interfaces and communication between modules; requirements of multiaccess, multiprogram and multiprocess environments; large scale systems description and documentation; diagnostic and debugging techniques; measurement of performance.

4. SPECIAL PURPOSE SYSTEMS: includes analog and hybrid computers; special terminals for data transmission and display; peripheral and interface units for particular applications; special software to support these.

III. METHODOLOGIES

Methodologies are derived from broad areas of applications of computing which have common structures, processes, and techniques.

1. NUMERICAL MATHEMATICS: includes numerical algorithms and their theoretical and computational properties; computational error analysis (for rounding and truncation errors); automatic error estimates and convergence properties.

2. DATA PROCESSING AND FILE MANAGEMENT: includes techniques applicable to library, biomedical, and management information systems; file processing languages.

3. SYMBOL MANIPULATION: includes formula operations such as simplification and formal differentiation; symbol manipulation languages.

4. TEXT PROCESSING: includes text editing, correcting, and justification; the design of concordances; applied linguistic analysis; text processing languages.

5. COMPUTER GRAPHICS: includes digitizing and digital storage; display equipment and generation; picture compression and image enhancement; picture geometry and topology; perspective and rotation; picture analysis; graphics languages.

6. SIMULATION: includes natural and operational models; discrete simulation models; continuous change models; simulation languages.

7. INFORMATION RETRIEVAL: includes indexing and classification; statistical techniques; automatic classification; matching and search strategies; secondary outputs such as abstracts and indexes; selective dissemination systems; automatic question answering systems.

8. ARTIFICIAL INTELLIGENCE: includes heuristics; brain models; pattern recognition; theorem proving; problem solving; game playing; adaptive and cognitive systems; man-machine systems.

9. PROCESS CONTROL: includes machine tool control; experiment control; command and control systems.

10. INSTRUCTIONAL SYSTEMS: includes computer aided instruction.

Related Areas. In addition to the areas of computer science listed under the three divisions above, there are many related areas of mathematics, statistics, electrical engineering, philosophy, linguistics, and industrial engineering or management which are essential to balanced computer science programs. Suitable courses in these areas should be developed cooperatively with the appropriate departments, although it may occasionally be desirable to develop some of these courses within the computer science program.

Since it is not feasible in this report to list all of the areas which might be related to a computer science program, let alone indicate where courses in these areas should be taught, the following listing is somewhat restricted. It is grouped into two major divisions: "mathematical sciences" and "physical and engineering sciences."

IV. MATHEMATICAL SCIENCES

1. ELEMENTARY ANALYSIS
2. LINEAR ALGEBRA
3. DIFFERENTIAL EQUATIONS
4. ALGEBRAIC STRUCTURES
5. THEORETICAL NUMERICAL ANALYSIS
6. METHODS OF APPLIED MATHEMATICS
7. OPTIMIZATION THEORY
8. COMBINATORIAL MATHEMATICS
9. MATHEMATICAL LOGIC
10. NUMBER THEORY
11. PROBABILITY AND STATISTICS
12. OPERATIONS ANALYSIS

V. PHYSICAL AND ENGINEERING SCIENCES

1. GENERAL PHYSICS
2. BASIC ELECTRONICS
3. CIRCUIT ANALYSIS AND DESIGN
4. THERMODYNAMICS AND STATISTICAL MECHANICS
5. FIELD THEORY
6. DIGITAL AND PULSE CIRCUITS
7. CODING AND INFORMATION THEORY
8. COMMUNICATION AND CONTROL THEORY
9. QUANTUM MECHANICS

No attempt has been made to include within this classification system all the subject areas which make use of computer techniques, such as chemistry and economics; indeed, to list these would require inclusion of a major portion of the typical university catalog. Furthermore, the sociological, economic, and educational implications of developments in computer science are not discussed in this report. These issues are undoubtedly important, but they are not the exclusive nor even the major responsibility of computer science. Indeed, other departments such as philosophy and sociology should be urged to cooperate with computer scientists in the development of courses or seminars covering these topics, and computer science students should be encouraged to take these courses.

APPENDIX 3

DESCRIPTIONS OF SUPPLEMENTARY TOPICS

1. COMPUTER SECURITY: Refers to the technological safeguards and managerial procedures which can be applied to computer hardware, programs and data to assure that organizational assets and individual privacy are protected.

2. PERFORMANCE MEASUREMENT AND EVALUATION: A technology for improving the efficiency of computer systems and facilities. It is most often defined as the application of accounting systems, hardware monitors, software monitors, benchmarks, resource drivers, simulators and various other tools to the information gathering process that enables the ADP management to make rational choices between the practical alternatives that confront him through the life cycle of a computer system.

3. COMPUTER NETWORKING: The interconnection of two or more computers and/or terminals by means of data communications links; includes hardware, software, rules and policies to permit operation and interaction of network components.

4. DATA COMMUNICATIONS: Electronic transmission of digitally encoded data; includes encoding, decoding, modulation, demodulation, multiplexing, formats, procedures, protocols, reliability, checking and correction.

5. SOFTWARE ENGINEERING: Includes program quality, modular and top-down design, structured programming, proofs of correctness, testing and checkout.

6. ANALYSIS OF ALGORITHMS: Includes the study of time and space requirements for algorithms, efficient algorithms, trade-off characteristics, proofs of correctness, and testing.

APPENDIX 4

ICST PROGRAMMATIC COVERAGE OF COMPUTER SCIENCE TOPICS

TOPIC	FISCAL YEAR					
COMPUTER SCIENCE	70	71	72	73	74	75
I. INFORMATION STRUCTURES AND PROCESSES						
1. Data Structures						x
2. Programming Languages	x	x	x	x	x	x
3. Models of Computation						
II. INFORMATION PROCESSING SYSTEMS						
1. Computer Design and Organization						
2. Translators and Interpreters	x	x	x	x	x	x
3. Computer and Operating Systems	x	x	x	x	x	x
4. Special Purpose Systems	x	x	x	x	x	x
III. METHODOLOGIES						
1. Numerical Mathematics						
2. Data Processing and File Management	x	x	x	x	x	x
3. Symbol Manipulation	x	x				
4. Text Processing				x	x	
5. Computer Graphics	x	x	x	x	x	x
6. Simulation						
7. Information Retrieval	x	x	x	x		
8. Artificial Intelligence	x	x	x	x	x	x
9. Process Control						
10. Instructional Systems						
S. SUPPLEMENTARY AREAS						
1. Computer Security					x	x
2. Performance Measurement and Evaluation		x	x	x	x	x
3. Computer Networking			x	x	x	x
4. Data Communications	x	x	x	x	x	x
5. Software Engineering					x	x
6. Analysis of Algorithms						
RELATED AREAS						
IV. MATHEMATICAL SCIENCES						
V. PHYSICAL AND ENGINEERING SCIENCES	x	x	x	x	x	x

NOTES ON TABLE OF ICST PROGRAMMATIC COVERAGE OF COMPUTER SCIENCE TOPICS

I. 1. Data Structures

Except for a brief excursion in FY 70, 71, this subject was recognized explicitly in the ICST Program for the first time in FY 74 with the introduction of a cost center to support the data descriptive language committee of CODASYL, and in FY 75 in addition by a study of the properties of data bases independent of particular hardware or software. These cost centers together amount to about 1/2 man year of effort and are considered to be marginally suitable for inclusion in the ICST coverage table for FY 75. The development of data elements and their coded representations, upon which ICST has done much work, is not included under this topic since it is not in general concerned with the structural properties of data nor are the technical aspects of data elements and codes carried out in-house.

I. 2. Programming Languages

This topic has received a high level of coverage in the ICST Program since FY 70. The bulk of the effort has been on the development and standardization of FORTRAN and COBOL although other languages have also been included from time to time (ALGOL, BASIC and special purpose languages), and other language oriented activities, such as the development of static and dynamic analyzers have been undertaken. Most of the work has been on the applied level with little or no effort expended on that portion of the topic concerned with the relation between programming languages, formal languages and linguistics.

I. 3. Models of Computation

This subject has received no formal recognition in the ICST Program.

II. 1. Computer Design and Organization

Although NBS' original entry into the computer field was based on expertise in this area, there has been little attention paid to it during the span of time covered by this report. Work on peripheral interface standards has been in the program since 1970; however, this work has not generally involved broad studies of computer design and organization, although it might have. Also, a study of man-machine organization was conducted in 1970-71, and some work on advanced system functions is currently underway in the Computer Services Division. In addition, much of the current work on computer networking might be considered to fall in this area. The fact remains, however, that there is not now, and there has not since FY 70 been any comprehensive work in computer design and organization as such. Therefore, the topic is not included in the coverage table.

II. 2. Translators and Interpreters

Some work on compilers has been done over the years in conjunction with the standardization of programming languages. This includes, work on both FORTRAN and COBOL compiler validation routines. The FORTRAN compiler validation routines were successfully completed in 1974 as an NBS in-house technical effort. The COBOL compiler validation routines were completed several years earlier but not as an NBS in-house technical effort. Also, some of the systems programming work in the Computer Services Division and much of ICST's ADP standards work supports that part of the topic concerned with media, code and format conversion routines. The topic is considered to be qualified for inclusion in the coverage table.

II. 3. Computer and Operating Systems

This area includes a miscellany of diverse topics, but ICST has had most of them covered, particularly since 1972. The Computer Services Division has maintained

a hands-on technical capability covering program monitoring for both batch and time sharing systems, data base management and utility routines. In addition, the Systems and Software Division has work completed and underway in program testing aids, documentation and software quality, and the Computer Systems Engineering Division has worked and is working with operating systems for experimental computers. Work on the magnetic tape label-standard and source data automation might also be considered to fall within this area. This area also includes certain types of utility routines, particularly those involved in the conversion of character codes and the transferability of data. This sub-area has been emphasized in the Computer Services Division systems programming effort, and has been the subject of many standardization studies. The area is considered to be qualified for inclusion in the coverage table.

II. 4. Special Purpose Systems

Although there has been essentially no work on analog and hybrid computers, the coverage of special terminals for data transmission and display, peripheral and interface units for particular applications and special software to support them has been extensive since FY 70. Examples include the entire output of the Office of Automation and Control Technology, and many other agency problems such as the IRS Remittance Processing System in the Computer Systems Engineering Division, and AUTOCAL in the Systems and Software Division. The area is considered to be qualified for inclusion in the coverage table.

III. 1. Numerical Mathematics

There has been little work in this area in ICST, but considerable in the NBS Applied Mathematics Division which is not a part of ICST. Recently, a cost center has been set up to cover computer related numerical mathematics in addition to other topics, but the level is still below the threshold of the coverage chart.

III. 2. Data Processing and File Management

ICST has a long history of practical experience in setting up and employing computerized files both for other agencies and for carrying out its own mission. In addition, there have been many theoretical studies of file management. The area is considered to be covered.

III. 3. Symbol Manipulation

Considerable work in this area was undertaken before the beginning of the period of this report. It centered mostly around the analysis of chinese characters and chemical diagrams and tapered off around 1971. The topic is considered to be covered through fiscal year 71 only.

III. 4. Text Processing

This area consists of two rather distinct sub-areas. The first, linguistics, treats the syntactic and semantic aspects of language and was a subject of inquiry in ICST before the period of this report. Work in this sub-area tapered off in 1969. It was in part related to the chinese character studies. The second, text editing, including correcting and justification, treats the mechanical aspects of text processing. This latter sub-area was actively pursued in ICST until 1974. Many of the outstanding problems in it have already been solved and considerable practical use is being made of computerized composition and type setting. The area is considered to have been covered in FY 73, 74.

III. 5. Computer Graphics

This subject has received coverage in the ICST Program over the entire period, much of it under the classification of Computer Aided Design. A large portion of the work was, and still is sponsored by the Army. This topic includes display equipment, and another aspect of ICST work is the standardization of display format functions and symbols.

III. 6. Simulation

There was considerable activity in simulation before the period of this report. It consisted of simulation as a fundamental methodology and of several applications to the simulation of communications nets. The only activity in simulation included in the ICST Program between FY 70 and FY 75 has been the simulation of one computer system by another which is considered to be a technique of computer system performance measurement. Activity in this area is considered to be below the threshold required for inclusion on the coverage chart.

III. 7. Information Retrieval

ICST has had practical experience in information retrieval over many years through the activities of the Computer Information Section of the Information Technology Division and its predecessors. In addition, there were NSF sponsored studies in information retrieval related to chemical information. A study on selective associative recall was in the program in FY 70, 71 and computer assisted indexing in FY 73. There appears to have been no theoretical work in information retrieval since that time. The topic is considered to be covered through FY 73.

III. 8. Artificial Intelligence

The subject of automated fingerprint classification sponsored by the FBI began in 1968 and has continued uninterrupted since that time. This subject is concerned for the most part with visual pattern recognition. Other aspects of artificial intelligence (heuristics, cognitive systems, man-machine systems) are beginning to be studied seriously in the automation technology program. Other aspects of artificial intelligence such as game playing, theorem proving, problem solving and brain models are not now and never have been in the ICST Program. The

extensive ICST work in standardizing OCR fonts is not considered as artificial intelligence. Artificial intelligence is considered to marginally qualify for inclusion on the ICST coverage chart since the initiation of the fingerprint classification work, and to fully qualify with the initiation of the automation technology work in addition, in 1974.

III. 9. Process Control

The only continuing identifiable work in process control is that associated with NBS laboratory automation. This has gone on intermittently over the years. There has been no work in machine tool control other than the standardization of the APT Programming Language and a brief inquiry into methods for converting machine tool programs from the U. S. Customary to the metric system of measurement. Nor has there been work in command control systems in recent years. The coverage of this topic is considered to be below the threshold for inclusion in the ICST coverage chart.

III. 10. Instructional Systems

There has been no identifiable work in this area in the ICST Program.

S. 1. Computer Security

Work in this area began in FY 72 with a controlled accessibility study. It was expanded to a high level in FY 74 and 75. The topic is considered to be covered in FY 74, 75.

S. 2. Performance Measurement and Evaluation

Although it was mentioned in the ICST Program before that time, work on performance measurement and evaluation began seriously in FY 71 and was expanded to a high level in FY 73, 74, 75. It is considered to have been covered from FY 71 on.

S. 3. Computer Networking

There has been some work on remote computing and ADP time sharing since before the period of this report. However, large scale work in computer networking started with the dialog monitor, ARPA network participation, teleprocessing support facilities and other studies in FY 72. The topic is considered to have been covered since that time.

S. 4. Data Communications

Unlike some of the other standards efforts, data communications standards have been pursued vigorously and in considerable technical depth from the beginning of the period. In addition, there have been many other agency studies involving terminal to computer and terminal to terminal data links. The effort in data communications was emphasized further in 1972 by the emphasis on computer networking studies. The topic is considered to have been covered throughout the entire period of this report.

S. 5. Software Engineering

This area was recognized as a separate topic in the ICST Program only in the last two years. However, it is now emphasized and is considered to qualify for coverage in FY 74, 75.

S. 6. Analysis of Algorithms

There has been no work on the analysis of algorithms identified as such in the ICST Program.

IV. Mathematical Sciences

This area is not covered by ICST for the same reason that Numerical Mathematics, area III. 1., is not covered -- namely that the bulk of the work in this area at NBS is in the Applied Mathematics Division.

V. Physical and Engineering Sciences

This area is so broad that no organization the size of ICST could do it justice. However, considerable work has been done in the computer related physical sciences. Projects that fall into this category include magnetic tapes, cassettes and disks; experimental OCR devices, some of them for the Post Office Department; optical character font evaluation; fingerprint readers, and much of the work of the Office of Automation Technology.

APPENDIX 5

METHODOLOGY FOR DEVELOPMENT OF PROGRAMMATIC COVERAGE TABLE

For the past 6 fiscal years, FY 70 - 75, ICST has had approximately 100 cost centers each year. For all practical purposes cost centers had to be treated as independent projects since records are kept not by project but by cost center. The following information on cost centers was available for the study:

(a) A list of the numbers, titles, and in some cases the sponsors, of each cost center for each fiscal year, FY 70 - 75.

(b) NBS-228 project reports for each cost center, almost complete for FY 73, 74, 75 and partially complete for FY 72.

(c) Quarterly project reports for most cost centers for FY 72, 73, 74, 75.

The problem was to derive from this data a historical record of the ICST coverage of computer science topics by fiscal year from FY 70 through FY 75.

The numbers and titles only of cost centers for the FY 66 - FY 69 period were also available. This information was not analyzed as was the data for the FY 70 - FY 75 period but it is referred to several times for historical perspective in the notes to the coverage table in Appendix 4.

The following procedure was employed:

(a) Cost centers for fiscal years 70 - 75 were listed on a single multipage work sheet in numerical order. For each cost center, the title and the fiscal years in which it was active were listed. This resulted in a table of 312 line items reduced from about 600 (approximately 100 cost centers per year for each of 6 years) since the average duration of a cost center is slightly less than 2 fiscal years.

(b) The topics of computer science were then superposed on the work sheet as columns.

(c) Each cost center was then examined in turn by title and a judgment made as to which of the topics of computer science, if any, it related to. Checks were made in the appropriate columns of the work sheet. In connection with this judgment, the NBS-228's, where available, and frequently the quarterly progress reports as well, were examined.

(d) The work sheet was then inverted so as to make computer science topic the primary entry, and to list under each computer science topic the cost centers associated with it, together with the fiscal years in which they were active.

(e) For each computer science topic a judgment was then made as to whether the work done under the cost centers associated with it qualified it by fiscal year for coverage under the "major in-house technical effort" criterion. If so an appropriate mark was put on the ICST coverage chart in Appendix 4. The NBS-228's and the quarterly progress reports, where available, were consulted extensively in connection with this process, but even so it is recognized to be quite subjective.

APPENDIX 6

SOME TOP COMPUTER SCIENTISTS

Name	Affiliation
I. INFORMATION STRUCTURES AND PROCESSES	
1. Data Structures	
Charles W. Bachman	Honeywell
James P. Fry	University of Michigan
Calvin C. Gotlieb	University of Toronto
Malcomb C. Harrison	New York University, Courant Institute
Donald E. Knuth	Stanford University
Jim Luching	ICL, UK
Jean Sammet	IBM, Cambridge
M. E. Senko	IBM Research Labs, Palo Alto
Edgar H. Sibley	University of Maryland
Robert E. Tarjan	Cornell University
Robert W. Taylor	University of Michigan
2. Programming Languages	
John W. Backus	IBM
Victor R. Basili	University of Maryland
F. L. Bauer	Munich
Edgar W. Dijkstra	Burroughs in Holland
Robert W. Floyd	Stanford University
Ivan Flores	New York
Susan L. Graham	University of California, Berkeley
David J. Gries	Cornell University
Kenneth E. Iverson	IBM
C. H. Lindsey	Manchester University (ALGOL) UK
Dan McCracken	Consultant
Peter Naur	Denmark (ALGOL)
Alan J. Perlis	Yale University
Terrence W. Pratt	University of Texas
Val W. Pratt	University Western Ontario
John Reynolds	Harvard University
Jeffry D. Ullman	Princeton University
Joseph Wegstein	ICST
A. Van Wijngaarden	Holland
Niklaus E. Wirth	Zurich, Switzerland
William A. Wulf	Carnegie Mellon University

3. Models of Computation

Alfred V. Aho	Bell Laboratories
Robert Ashenhurst	University of Chicago
Taylor L. Booth	University of Connecticut
Patrick C. Fischer	Penn State University
Symour Ginsburg	University of Southern California
Shelia Greibach	UCLA
Michael A. Harrison	University of California, Berkeley
John E. Hopcroft	Cornell University
Richard M. Karp	University of California, Berkeley
E. D. Ritchie	Washington State University
Jeffry D. Ullman	Princeton University

II. INFORMATION PROCESSING SYSTEMS

1. Computer Design and Organization

Gene M. Amdahl	System 360
Robert Barton	Burroughs
C. G. Bell	Carnegie Mellon University
Frederick P. Brooks, Jr.	University of North Carolina
Yaohan Chu	University of Maryland
Seymour Cray	Cray Associates
Gerald Estrin	UCLA
Michael J. Flynn	Stanford University
Harry Huskey	University of California, Santa Cruz
David Kuch	University of Illinois
E. J. McClusky	Stanford University
Allen Newell	Carnegie Mellon University
Chittoor Ramamoorthy	University of California, Berkeley
Saul Rosen	SUNY, Buffalo
Robert F. Rosin	New York State University

2. Translators and Interpreters

Alfred V. Aho	Bell Labs
Thomas E. Cheatham, Jr.	Harvard University
Robert W. Floyd	Stanford University
David J. Gries	Cornell University
John McCarthy	Stanford University
William McKeenan	University of California, Irvine
Roy Nutt	Computer Sciences Corporation
Elliott I. Organick	University of Utah
Jeffry D. Ullman	Princeton University

3. Computer and Operating Systems

Bruce Arden	Princeton University
Thomas E. Cheatham, Jr.	Harvard University
Yaohan Chu	University of Maryland
Edward G. Coffman, Jr.	Penn State
Fernando J. Corbato	MIT (MULTICS)
Peter J. Denning	Pennington, NJ
Edgar W. Dijkstra	Burroughs in Holland
David J. Farber	University of California, Irvine
Samuel H. Fuller	Carnegie Mellon University
Bernard A. Galler	University of Michigan
Durbridge Hansen	UCLA Denmark
Leonard Kleinrock	LA, California
Butler Lampson	Xerox
Elliot I. Organick	University of Utah
Dave Parnas	University of Pittsburgh
Alan J. Perlis	Yale University
Tad Pinkerton	University of Wisconsin
Saul Rosen	Purdue University
Harold Stone	University of Massachusetts
Peter Wegner	Brown University
William A. Wulf	Carnegie Mellon University

4. Special Purpose Systems

Robert B. Collender	Lockheed (Displays)
Henry Hoffman	Goddard Space Flight Center (Analog Computers)
G. A. Korn	Analog Computers
Carl Machover	Information Displays, Inc. (Displays)
Nils Nilsson	SRI (Analogue Computers)
Alfred Pletz, Jr.	Kaiser Aerospace (Displays)
Stephen P. Robinson	Teledyne Camera Systems (TV Displays)

III. METHODOLOGIES

1. Numerical Mathematics

Samuel D. Conte	Purdue University
Gene H. Golub	Stanford University
Saul Gorn	University of Pennsylvania
Richard W. Hamming	Bell Labs
Alston S. Householder	University of Tennessee
Thomas E. Hull	University of Toronto
Velvel Kahan	University of California, Berkeley
Cleve B. Moler	New Mexico University
James M. Ortega	University of California, La Jolla
Anthony Ralston	SUNY, Buffalo
Werner C. Rheinboldt	University of Maryland
John R. Rice	Purdue University

Joseph F. Traub	Carnegie Mellon University
James S. Vandergraft	University of Maryland
J. H. Wilkinson	UK, National Physical Laboratories
David M. Young, Jr.	University of Texas

2. Data Processing and File Management

Charles W. Bachman	Honeywell
Alfonso F. Cardenas	UCLA
Vincent Y. Lum	IBM, San Jose
Charles T. Meadow	AEC
Jack Minker	University of Maryland
Ivan B. Schneiderman	London, England
Daniel Teichroew	University of Michigan

3. Symbol Manipulation

Daniel G. Bobrow	Bolt, Beranek & Newman
Terry J. Frederick	Purdue University (PLANIT)
W. M. Gentleman	University of Waterloo
John B. Goodenough	Boston
John McCarthy	Stanford University (LISP)
Anthony Ralston	SUNY, Buffalo
Jean E. Sammet	IBM, Cambridge

4. Text Processing

T. Bar-Hillel	Israel
Harold Borko	UCLA
Blanton C. Duncan	Washington, D. C.
D. C. Engelbart	SRI
Charles Irby	SRI
Calvin Mooers	Cambridge, Massachusetts (TRAC)
David E. Rice	Brown University
Gerald A. Salton	Cornell University
Ralph W. Swanson	University of Chicago
Andries Van Dam	Brown University

5. Computer Graphics

Stephen Coons	Syracuse University
George Dodd	GM Research Institute
J. Encarnacao	Saar University
W. K. Giloi	Saar University
Thomas S. Huang	MIT
Lawrence G. Roberts	formerly ARPA
Ivan E. Sutherland	University of Utah
Andries Van Dam	Brown University

6. Simulation

O. J. Dahl	Oslo, Norway (SIMULA)
Geoffrey Gordon	IBM, New York
Philip J. Kiviat	FEDSIM
M. H. MacDougall	Control Data
Harry M. Markowitz	SIMSCRIPT
Thomas H. Naylor	Duke University
K. Nygaard	Oslo, Norway (SIMULA)
Thomas J. Schriber	University of Michigan (GPSS)
K. D. Tocher	Princeton University

7. Information Retrieval

Harold Borko	UCLA
Michael E. Lesk	Bell Labs
Jack Minker	University of Maryland
Noah Prywes	University of Pennsylvania
Gerald A. Salton	Cornell University
Vladimir Slamecka	Georgia Tech
Marshall C. Yovits	Ohio State University

8. Artificial Intelligence

Daniel G. Babrow	Xerox
Thomas Binford	Stanford University
Woodrow W. Bledsoe	University of Texas
Richard O. Duda	SRI
Edward A. Feigenbaum	Stanford University
Jerome A. Feldman	University of Rochester
Cordell Green	Cornell University
Russell A. Kirsch	NBS
Ralph L. London	Stanford University
Jack Minker	University of Maryland
Marvin Minsky	MIT
John McCarthy	Stanford University
Allen Newell	University of Pittsburgh
Nils J. Nilsson	SRI
Seymour A. Papert	MIT
Bertram Raphael	SRI
J. Allen Robinson	Syracuse University
Herbert A. Simon	Carnegie Mellon University
Terry Winograd	MIT
Arthur Samual	Stanford University
Joseph Wegstein	ICST

9. Process Control

K. J. Astrom	Lund Inst, Sweden (Automatic Control)
M. Athans	MIT
Ruth M. Davis	ICST, Command Control Systems
I. D. Landau	Goenoble Polytech, France
Jack C. Lozier	IFAC
A. Nomoto	Tokyo, Automatic Control
Jules I. Schwartz	Computer Sciences Corporation Command Control Systems
Cecil L. Smith	Louisiana State University
Theodor J. Williams	Purdue University

10. Instructional Systems

Donald Bitzer	University of Illinois (PLATO)
C. Victor Bunderson	Brigham Young University (TICCIT)
Adele J. Goldberg	Stanford University
Seymour A. Papert	MIT
Karl L. Zinn	University of Michigan

S. SUPPLEMENTARY AREAS

1. Computer Security

Robert P. Abbott	Lawrence Livermore Laboratories
J. P. Anderson	J. P. Anderson Company
Peter S. Browne	General Electric Company
Robert H. Courtney, Jr.	International Business Machines
Daniel J. Edwards	National Security Agency
Hilda C. Faust	National Security Agency
Lance J. Hoffman	University of California, Berkeley
Robert V. Jacobson	Chemical Bank of New York
Arthur J. Levenson	National Security Agency
Steven B. Lipner	MITRE Corporation
Jerry Loebel	Honeywell Information Systems
Eldred C. Nelson	TRW, Inc.
Donn B. Parker	Stanford Research Institute
Roger R. Schell	United States Air Force
Richard Seymour	International Business Machines
Gerald E. Short	TRW, Inc.
Walter L. Tuchman	International Business Machines
Rein Turn	RAND Corporation
Stephen T. Walker	Advanced Research Projects Agency
Willis Ware	RAND Corporation
Clark Weissman	System Development Corporation

2. Performance Measurement and Evaluation

Thomas Bell	TRW, Inc.
James Brown	University of Texas
Gary Carlson	Brigham Young University
M. E. Drummond	International Business Machines
Stephen Kimbleton	University of Southern California
Kenneth Kolence	Palo Alto, California
H. C. Lucas	Stanford University
Dudley Warner	Los Gatos, California

6. Analysis of Algorithms

Alfred V. Aho	Bell Laboratories
John E. Hopcroft	Cornell University
Donald E. Knuth	Stanford University

USCOMM-NBS-DC

NBS-114A (REV. 7-73)

U.S. DEPT. OF COMM. BIBLIOGRAPHIC DATA SHEET	1. PUBLICATION OR REPORT NO. NBSIR 75-753	2. Gov't Accession No.	3. Recipient's Accession No.

4. TITLE AND SUBTITLE

PROGRAMMATIC COVERAGE OF COMPUTER SCIENCE TOPICS WITHIN THE INSTITUTE FOR COMPUTER SCIENCES AND TECHNOLOGY OF THE NATIONAL BUREAU OF STANDARDS

5. Publication Date: June 1975

6. Performing Organization Code

7. AUTHOR(S)

Joseph O. Harrison, Jr.

8. Performing Organ. Report No.

9. PERFORMING ORGANIZATION NAME AND ADDRESS

NATIONAL BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
WASHINGTON, D.C. 20234

10. Project/Task/Work Unit No. 6004222

11. Contract/Grant No.

12. Sponsoring Organization Name and Complete Address (*Street, City, State, ZIP*)

Same

13. Type of Report & Period Covered: Final

14. Sponsoring Agency Code

15. SUPPLEMENTARY NOTES

16. ABSTRACT (*A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.*)

This paper presents three items of information relative to computer science at NBS:

(1) it gives a definition of computer science in terms of topical areas,

(2) it shows by examining past and present ICST project descriptions which topical areas have been or are presently covered by ICST programs, and

(3) it presents a list of some of the top computer scientists in each of the topical areas included in the definition.

17. KEY WORDS (*six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons*) Computer science; Curriculum 68; ICST program; information structures and processes; information processing systems; information processing methodologies

18. AVAILABILITY

☐ Unlimited

☒ For Official Distribution. Do Not Release to NTIS

☐ Order From Sup. of Doc., U.S. Government Printing Office Washington, D.C. 20402, SD Cat. No. C13

☐ Order From National Technical Information Service (NTIS) Springfield, Virginia 22151

19. SECURITY CLASS (THIS REPORT)	21. NO. OF PAGES
UNCLASSIFIED	
20. SECURITY CLASS (THIS PAGE)	22. Price
UNCLASSIFIED	


AMERICAN REVOLUTION BICENTENNIAL
1776-1976