THE SYSTEM BUILDERS

THE STORY OF SDC

CLAUDE BAUM

CLAUDE BAUM **Illustrated**

THE SYSTEM BUILDERS

THE STORY OF SDC

A colorful account of a remarkable company, *The System Builders* unfolds a fast-moving panorama of vivid personalities and dramatic events against a backdrop of the explosive computer revolution.

System Development Corporation (SDC) has indeed led an eventful corporate existence. Builder of the world's first large-scale computer-based systems, whose seven hundred programmers in the mid-1950s outnumbered all rival staffs put together, this proud pioneer saw its dominance and resources erode over the next decade as external bureaucracy and internal upheavals took their toll.

The dramatic turnaround that restored SDC to the front ranks of information system builders in the 1970s is graphically recounted in the strategies, the players, the tough challenges, and the brilliant successes.

The singular experiences that shaped this organization make *The System Builders* more than just a chronicle of a modern company's trials and triumphs.

It is also a case study of the only major corporation ever to succeed in making the difficult transition from a government-sponsored nonprofit organization to an independent profit-making company.

Seasoned with SDC's breakthroughs in forefront research and technology—described here in lay terms—the book portrays a microcosm of the computer age

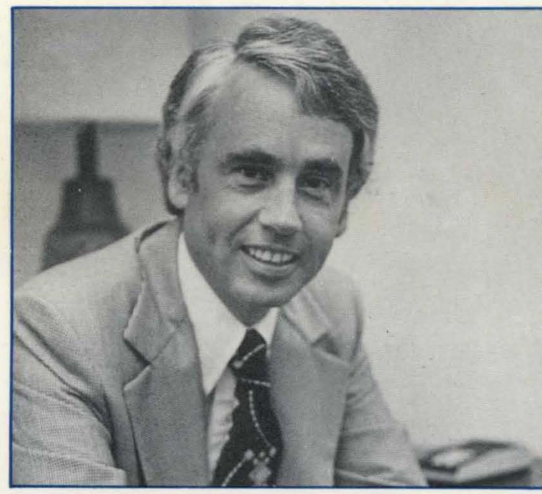
(continued on back flap)

(continued from front flap)

from its dawn a mere quarter century ago to its pervasive role in modern life.

The history of SDC embodies the stories of three remarkable men—corporate presidents Melvin Kappler, Wesley Melahn, and George Mueller—each of whom stamped his personality on the period in SDC's evolution for which his appearance seemed made to order.

Ultimately, *The System Builders* is an account of SDC's people, from the innovators of early systems technology to the builders of our automated society, and the many who span both roles.



Claude Baum has had an intimate vantage point from which to observe the people and events that shaped SDC and the technological revolution in which it was such an important factor. Baum joined SDC in 1958, less than two years after the company was formed. Working in nearly every corporate area, he shared both as participant and observer in much of the history he has chronicled in this compelling book.

Printed in the United States of America
ISBN 0-916368-02-5
System Development Corporation

THE SYSTEM BUILDERS

THE SYSTEM BUILDERS

THE STORY OF SDC

CLAUDE BAUM

System Development Corporation
Santa Monica, California

SDC TRADEMARKS

The following trademarks of System Development Corporation appear throughout this book. In the interest of readability, the superscripts ® and ™ have been omitted in the text. This notice serves to advise the reader that these trademarks are to be used exclusively to refer to products and services of System Development Corporation and are fully protected under law.

CWIC™ Compiler for Writing and Implementing Compilers
DATAVAULT™ Information Management System
DS/3™ Generalized Data Management System
ELECTRONIC MAILDROP™ Information Retrieval Service
NCD™ Network Cryptographic Device
ORBIT® Information Retrieval System
SDC™ Records Manager
SDC® Search Service
SDCSEA™ Image Data Processing System
SPL™ Space Programming Language
STARDYNE® Structural Analysis System
THE SOFTWARE FACTORY™ Management System
TEXT II® Electronic Publishing System
TEXT III™ Automated Document Production System

Library of Congress Cataloging in Publication Data

Baum, Claude, 1928-
The system builders.
Includes index.
1. System Development Corporation—History.
I. Title.
HD9696.C64S83 338.7'610016425'0973 81-5349
ISBN 0-916368-02-5 AACR2

System Development Corporation
Santa Monica, California

Printed and bound in the United States of America

CONTENTS

PREFACE

The System Builders is a collection of uncommon stories comprising the history of an unusual company—System Development Corporation.

It is a chronicle of the builders of America's first large-scale computer-based information systems—groundbreaking achievements that shaped an industry—and of a pioneering company's technological advance into the electronic age.

It is a case study of the only major corporation ever to succeed in making the difficult transition from a government-sponsored nonprofit organization to an independent profit-making company.

It is an ever-shifting scene of stress and adaptation, as SDC and its personnel underwent profound changes: from the sheltered environment of sole-source contracting to the harsher world of technical and financial competition; from a developer of software to a builder of total systems; and from a U.S. Air Force-dedicated resource to a miniconglomerate with an international market.

The history of SDC embodies the stories of three remarkable men—SDC Presidents Melvin O. Kappler, Wesley S. Melahn, and George E. Mueller—each of whom stamped his individual personality on the period in SDC's evolution for which his appearance on the corporate scene seemed made to order.

Ultimately, *The System Builders* is an account of SDC's people, from the innovators of early systems technology to the builders of today's automated society, and the many who span both eras.

Of the 25,000 employees who have passed through SDC's doors, only a few hundred are named in these pages. This necessary abridgement should not suggest that thousands of SDCers past and present—managers, secretaries, technologists, computer operators—have not also left their mark on the corporate archives; they have. Some of those named in this book played major roles in SDC's unfolding story; others represent particular times or points of view.

It has been equally impossible to name the many customers and other friends of SDC who have supported the corporation with their good will and counsel over the years. The company's debt to all of them is expressed in a representative salute to one group of long-term friends: the half hundred officers and men of the 4620th Air Defense Wing (later known as Air Defense Command Computer Programming and System Training Office—APASTO), who resided at SDC for nearly twenty years of close advisory relationships and mutual support on the vital air defense programs entrusted to the corporation.

This book may also be unusual in that its author is a long-term employee of the company and not a writer by profession. Like many SDCers, I have been privileged to work in a number of corporate areas—in my case, nearly all of them: military, civil, commercial, international, research and development, and top management. Having shared in the company's history as both participant and observer, I was often amazed, throughout the many months of research, at how much more there was to the SDC story than I or my co-workers had thought.

Development of this book, like virtually all SDC projects, was a team effort. I am indebted to a trio of veteran SDC personnel—Dr. Gene E. Talbert, Robert A. Freeman, and John F. Luke—for significant portions of research and early drafts. They and others helped to extract and document the contents of some fifty drawers of archives, numerous SDC reports, and other literature. John Luke also performed an inspired job of editing the final manuscript.

Our team conducted more than one hundred taped interviews. Besides thanking the many who were SDC employees when they participated, we wish to express our appreciation to those who were no longer affiliated with the company for enriching this book by giving us their time and cooperation: Charles A. Alders, William C. Biel, Jack R. Goldstein, Melvin O. Kappler, J. Dewey Lederer, John D. Madden, John F. Matousek, Wesley S. Melahn, Joe B. Scatchard, Jules I. Schwartz, and Louis G. Turner.

Without the nimble fingers of Janet A. Harwood flying across the word processor, this book would still be in its first draft. She also sustained our morale with her persistent cheerfulness in the face of endless revisions. Other debts of thanks are due to SDCers Brian F. Goatham for his photographic skills and archives, Raymond L. Bisordi for design of the illustration sections, and Sandra W. Roslof for her thorough reviews of the final text.

When the book neared completion, corporate nature ceased to imitate the biographer's art, as a series of significant changes in executive positions and organization occurred. Rather than extending the book to account for such ongoing developments, I chose to maintain, as the day of looking back, the historic date that forms the setting of Chapter 1 and to summarize subsequent events in an epilogue.

A final word of thanks is sincerely expressed to Dr. George E. Mueller, SDC's Chief Executive, for his abiding interest in having this history of System Development Corporation prepared. Through his supportive counsel, as well as that of SDC's Chief Operating Officer, James B. Skaggs, I have felt the freedom to access all sources, interview any person, and write a balanced account that includes not only the brilliant successes but also the inevitable setbacks.

During the book project's darker days, Dr. Mueller's encouragement was unflagging. In his characteristically quiet and smiling way, he would say: "It's not a question of whether the book can be done, Claude, but—how soon can I have it?"

Claude Baum
Santa Monica, California
July 1981

CHAPTER 1

SDC Today

Monday, January 5, 1981, seemed much like any other day to some four thousand employees of System Development Corporation returning to work after a long year-end holiday. Engrossed in creating new systems—for satellite control, energy production, missile defense, law enforcement, or industrial automation—they noted nothing extraordinary in their environment. Yet, by the time they would leave work at the end of this day, a major new chapter in SDC's future would have been opened.

This veteran corps of system designers, engineers, data processors, and training specialists, augmented by administrators, secretaries, and technicians, collectively brought more than fifty thousand years of experience to their work in SDC's offices and laboratories around the world—from Santa Monica, California, to Washington, D.C.; from Albany, New York, to Denver, Colorado;

from Koblenz, Germany, to Rabat, Morocco—at thirty locations throughout the United States and a dozen more overseas.

Some SDCers recalled that the date marked the inauguration of the company's silver anniversary, a year-long celebration of SDC's leading position as America's first major information systems company. During the quarter century that had begun in 1956, the computer industry, too, had come of age—from its origins in the 1950s, when SDC built the first large automated systems and trained thousands of the nation's first programmers, to its pervasive, indispensable role in modern life.

That morning, SDC's President and Board Chairman, Dr. George E. Mueller, seated in his executive office in SDC's Santa Monica headquarters, talked about the company he has led for the past ten years.

"SDC has come a long way and undergone some amazing transformations. We began in 1956 as an Air Force sponsored nonprofit corporation, chartered to help build the first large-scale command and control system—the SAGE air defense system. SAGE was a remarkable computer programming accomplishment. Features found in the most advanced information systems today—real-time processing, interactive data management, networking—had their origin in SAGE.

"Over the years, SDC evolved, often slowly and arduously, into an independent profit-making company. Today we are a diversified $200 million corporation. We develop not only software but total systems—integrated complexes of hardware, software, and communications, frequently as the lead or prime contractor, supported by the world's major electronics manufacturers. We also provide high-technology services to government and industry, as well as products for office automation."

Mueller was designing systems for Ramo-Wooldridge Corporation when SDC was born in 1956. Yet he speaks of SDC's early days with the same fervor that marks his pride in the company today.

Like their president, most SDC employees reflect proudly on the corporation's long string of accomplishments. SDC was the builder of the first large-scale real-time information system, the world's most widely used system training program, the first general-purpose timesharing system, the first programming language for command-control systems, one of the earliest natural-language query systems, the first interactive user-oriented data management system, the first nationwide bibliographic search service, and a stream of innovations in computer networks, security systems, programming languages, display technology, signal processing, information retrieval, and the efficient production of computer software.

Two pictures on the wall of Mueller's office reveal much about the wiry, energetic, soft-spoken man who has played a decisive role in bringing SDC to this landmark day in corporate history.

One is an autographed picture of Apollo 11 astronauts Armstrong, Aldrin, and Collins, on the occasion of their historic 1969 moon landing, for which Mueller, then NASA's associate director for manned space flight, had prime responsibility.

The other depicts Mueller's forty-six-foot ketch, named "GEM" in no idle coincidence with its owner's initials, which he skippers enthusiastically on pleasure cruises and the annual Newport to Ensenada regatta off the coast of Southern California. His handpicked crew usually includes his wife Darla, the two children, SDC consultant Frank Lehan, corporate colleagues, and other friends.

Today's SDC, a multifaceted electronic information systems company, is many things to many people. To Mueller and management, it is "a modern systems house," "one of the nation's leading suppliers of systems and services for defense, energy, space, government, and industry," or, simply, "the company that manages information for people."

SDC's mobile and versatile professionals understandably equate the company with the assignment currently absorbing them. SDC may mean the ten-story "Towers" building in Oak Ridge, Tennessee, where a hundred engineers and technical specialists support the Department of Energy's Gas Centrifuge Enrichment Program; or the Army's Advanced Research Center in Huntsville, Alabama, for which SDC is designing a microcomputer switching network for ballistic missile defense; or the SDC Medicaid facility in Tallahassee, Florida, where a skilled staff operates the company's computer systems to process a million claims a month for the state's Medicaid participants.

SDC's customers have their own perspectives. For the Los Angeles Police Department, SDC is "the builder of our command, control, and communications system—the nation's largest and most advanced." For Department of Defense communications agencies: "one of the leading prime contractors of computer network security systems." For the Air Force and NASA: "among the select companies experienced in supercomputers, data management, signal processing, image displays, and satellite control qualified to build space and meteorology systems." For a leading bank: "the electronics manufacturer supplying SDC Records Manager electronic filing systems for our front-office staff."

To some of the nation's most advanced research and development centers, SDC means around-the-clock, on-site support in systems engineering, programming, and management of computing facilities. Thirteen hundred SDC specialists work at customer facilities on forefront projects like NASA's Space Shuttle, the Navy's antisubmarine warfare program, the Department of Transportation's fuel economy experiments, the Environmental Protection Agency's pollution models, and other high-technology programs—from the Navy Ocean Systems Center in San Diego, California, to the Command Control Technical Center of the Department of Defense at the Pentagon.

To thousands of end users, seated at terminals hundreds of miles or several continents from the corporation's computer center in Santa Monica, SDC may be the company that "provides SDC Search Service, the on-line electronic library for scientific and management literature," or "built the STARDYNE structural analysis system used by the engineering industry to design complex structures," or "expedites our company's processing of employee insurance transactions with its Claims Administration System."

To the community of nations, SDC is an ambassador of America's advanced technology. The company's system engineers are erecting space and command-control systems in South America, Africa, Europe, and Asia. A team in India is installing an automated weather reporting and analysis system. SDC Search Service provides instant bibliographic information to subscribers in forty countries. SDC Japan, a joint-venture partner, is developing an earthquake warning system. Australia operates the world's largest health claims administration system, installed by SDC. After twenty-five years, the corporation's time-tested System Training Program continues to exercise military personnel, from small teams to global forces, throughout the free world.

"The company is highly diversified," Mueller acknowledges. "But a dominant technological theme unifies both our history and our direction today. I refer to SDC's historic role in developing user-oriented information systems. Typically these systems take in large amounts of data; structure, correlate, and sort these inputs, using sophisticated data management programs; and display the needed information to users swiftly, concisely, and accurately.

"SAGE was the first large user-oriented on-line system. From there, the company developed a billion dollars worth of command and information systems for military, civil, and commercial customers. In the 1960s, SDC pioneered the first large-scale computer timesharing system, coupled with an easy-to-learn data management technology, and placed computing power directly into the hands of nonprogrammers.

"Today the company builds many kinds of information systems tailored to specific users. Our systems are used by Air Force controllers to monitor missile launches on display terminals. Or by welfare workers conducting dialogs with a computer to determine eligible welfare recipients. Or by businessmen retrieving seemingly lost correspondence through the open-ended retrieval logic of the SDC Records Manager."

Mueller's office abounds in information systems hardware. In one corner stands a microcomputer, which the chief executive not only operates but disassembles and reassembles, according to instructions in a thirty-volume manual, "in order to learn more about micros." Near his desk is a Morse-code transmitter, on which he sharpens his technique while thinking through technical problems. Another corner houses a prototype of the SDC Records Manager, the company's first volume-produced product, in which the chief executive staked a major investment in 1978.

"For most of its history, SDC was unable to take full advantage of the innovative software it developed," says Mueller. "Now, however, by coupling our software expertise with our own hardware, we expect to obtain better profit margins. The transformation taking place in the company this day will, if anything, enhance that prospect."

The innovations of which Mueller speaks have been, in large measure, an outpouring of results from the company's research and development program. Regarded by many as the most comprehensive program among SDC's peer companies, the corporate R&D effort has yielded a steady stream of fresh insights and new technology.

In the late 1950s, SDC scientists were breaking fresh ground using the nation's earliest computers to develop working models of human problem solving, English-language processing, classroom learning, space flight, and air traffic control.

SDC's research and development in the 1960s saw the pioneering of timesharing technology, user-oriented data management and display systems, and tools and languages enabling programmers and nonprogrammers to interact readily with computing machines.

Today, SDC's R&D program encompasses the full range of information system operations. One group of SDC technologists is developing techniques for recognizing patterns and meaning in torrents of incoming radar data or other high-volume signals, to enable computers to process them. Another group continues to make life easier for the computer user by imbuing machines with the power to follow human logic and comprehend English speech. The majority of the R&D staff is linking computers and other data devices together in experimental networks, designing tamperproof security controls to protect information systems, developing multicolor image displays, fusing novel data management designs into microcircuitry, and devising techniques to simplify the programming task.

SDC was converted to a profit-seeking corporation in 1969. During the ensuing decade, the company accomplished the transition from a high-quality software developer working almost exclusively for the Department of Defense to a total information systems company with a balanced income from commercial, military, and civilian clients.

The company's maturation began in the early 1970s, when it assumed the prime contractor role for large defense and space programs and provided on-line services and commercial products to new customer sets. In the middle of the decade, SDC expanded its markets to energy programs, medical and welfare benefits processing, and airspace management systems for foreign countries.

In 1981, SDC's contracts are of higher dollar value, greater scope, and longer term than ever before. Culminating the most vigorous marketing campaign in its history, the company has submitted a half billion dollars of proposals for new work, which await award decisions by customers. The 1981 plan projects record revenues for the tenth straight year and record earnings for the third year in a row.

This bright picture of well-distributed growth and solid profitability raises a frequently asked question: Why, for such a long period after changing to a for-profit business in 1969, did SDC remain a privately held corporation, whose stockholders had no ready market for their shares, instead of "going public" through a public offering or merging with another company?

SDC Executive Vice President James B. Skaggs, with whom President Mueller has comfortably divided the responsibility for managing the company, answers the question this way: "Apart from environmental factors, like an uncertain stock market and the fluctuating popularity of our industry, SDC had to establish a consistent reputation as a leading supplier of information systems before we could realize our potential value in the eyes of the public. That was not done overnight. I believe our track record in the past several years, both technical and financial, has made SDC today an infinitely more desirable company from the standpoint of the investor."

Outgoing and articulate, the athletic, youthful-looking Skaggs speaks in a voice charged with energy, laughs easily, and displays a decisive, "let's get on with it" attitude.

"Fortunately, it was SDC's strong background in software that turned the corner for us," he continues. "Throughout its history, SDC's dominant strength has remained the same: the design of the total information system. That system has always been best expressed in the structure of the software, not the hardware.

"Today's sophisticated buyers recognize this. They are no longer preoccupied with the size, capacity, or speed of their computers, terminals, and other gear. They want a complete system that performs the processes and presents the information they need in a timely, useful, and easily assimilated manner.

"Therein lies SDC's advantage in our rapid emergence as a leading systems contractor: our solid roots in software system technology. Today, software, not hardware, demands the greatest expertise, commands the highest revenues, and drives the design of modern information systems."

Skaggs's views are readily corroborated. The federal government alone spent $6 billion on software in 1980 and estimates that by 1985 software will consume 80 percent of its data processing budget. Since the middle 1950s, hardware prices have dropped by a factor of a thousand, while software—still regarded as more an art than a science—costs little less than it did when SDC built SAGE. Meanwhile, the data processing industry bemoans the shortage of skilled programmers.

In anticipation of this "software crunch," SDC streamlined its software production process by developing and implementing The Software Factory management system in the mid-1970s. A blending of R&D results and two decades of experience by the company's software manufacturing divisions, The Software Factory approach is a disciplined technology for producing high-quality software with economies of manpower, time, and cost.

It has become late afternoon. If the drama of this landmark day has left an imprint on George Mueller, he shows no sign. As always, he misses no opportunity to talk about SDC and its people.

"Healthy growth, good profits, and advanced technology are marvelous things for any company. But at SDC we take equal satisfaction in the contributions the company makes to the quality of life. Through the systems we build, we are an active partner of government and industry in finding new sources of energy, monitoring the safety of fuel pipelines, lowering the costs of health care, increasing the effectiveness of law enforcement, building better support systems for space exploration, and strengthening the defense of the United States and its allies. One of our most important contributions is the development of information management technology to improve the productivity of managers and other professionals in industry and government."

Mueller reflects a moment, then continues. "We have been talking a good deal about SDC's technology. But we are really talking about SDC's people. Everything the company accomplishes hinges on their skills, ingenuity, and dedication. To say that SDC is 'people-oriented' is to state the obvious, for people are our major resource. We provide employee benefits as good as any in our industry, conduct internal training classes for about half our employees each year, and maintain a front-rank affirmative-action program. Ultimately, however, professionals in our field are attracted and motivated by new challenges, career growth, and supportive management. I'm pleased that throughout its history SDC has offered an abundance of all three. And beginning today, we will be able to offer even more."

It is 5:00 P.M. in Santa Monica. A fiery sunset rims the ocean two miles west of the corporate offices. As SDC's West Coast personnel prepare to leave, they, and their colleagues in other time zones, are imperceptibly altered.

Tomorrow, and in the foreseeable future, they will continue to do their accustomed work for the organization called System Development Corporation, operating much as usual under its current management.

At the same time, on this January 5, 1981, at the conclusion of the first business day of the new year, SDC and its personnel have become part of the family of Burroughs Corporation, the world's second leading computer manufacturer.

The merger of Burroughs and SDC, effected by Burroughs' purchase of outstanding SDC stock, was overwhelmingly approved by SDC's 630 stockholders on December 8, 1980. Burroughs Chairman and Chief Executive Officer, W. Michael Blumenthal, declared that "SDC's expertise in the systems area . . . will add substantially to our strength in . . . the computer business in the future." Added George Mueller: "Burroughs is the ideal partner to sell and service our automation products." A leading journal called SDC's transition to an independent Burroughs subsidiary, retaining its historic objectivity in total system design, "a match made in heaven."

The merger of January 5, 1981, culminated months of discussions and negotiations. In a more profound sense of SDC history, the occasion provided a logical climax to a twenty-five-year search for corporate identity. The long road had been rarely straight, seldom smooth, and never without obstacles to be surmounted. But SDC had succeeded in a way that no other corporation had or probably would again in transitioning from a government-sponsored nonprofit to an independent profit maker which, at long last, had liquidated the corporate stock.

Herein lies the story of SDC, the system builders—a story that began on another morning in Santa Monica . . . twenty-eight years earlier, in 1953.

CHAPTER 2

Origins

THE BOYS IN THE BACK ROOM

On a brisk spring morning in April 1953, a group of silent and serious men strode intently down Fourth Street in Santa Monica, California. Most carried briefcases; several wore blue uniforms. Crossing Broadway, they turned into an alley and stopped at the side door of the Santa Monica Billiard Room. The leader knocked. Momentarily a security guard opened the door, inspected the visitors' identifications, then led them to a cavernous room at the back.

As the newcomers' eyes adapted to the dim light, they saw a team of men in intense concentration: some seated at consoles watching small blips move across backlit picture scopes, others swiftly plotting tracks on transparent display boards, still others receiving and relaying messages over headphones and intercoms, while the voices of aircraft pilots crackled over loudspeakers. These "boys in the back room" appeared to be directing an air battle raging over the United States and Canada.

The "back room" of this pool hall was, in reality, the Systems Research Laboratory (SRL) of the Rand Corporation, the elite nonprofit "think tank" that had been set up by the U.S. Air Force in 1948 to conduct defense research.

In the SRL, Rand scientists had been conducting research into group behavior and team learning since 1951, using a replica of the Air Force's Tacoma, Washington, air defense center as a laboratory "operations room." The "air battle" was a training exercise simulating conditions expected in an actual air attack. The visitors were members of a study group chartered by the Air Force to evaluate the results of Rand's team-training experiments.

Meanwhile, three thousand miles away at the Lincoln Laboratory branch of the Massachusetts Institute of Technology in Lexington, a very different set of air defense experiments was in progress. Using a large digital computer, designated the "XD-1," linked to radars around Boston which tracked Strategic Air Command bombers in simulated attacks on the United States, experimenters were demonstrating the feasibility of the first large-scale computer-based command-control system.

The West Coast Rand SRL experiments gave rise to the System Training Program—a combination of simulation hardware, computer programs, and training procedures which, commencing in 1955, was implemented throughout the Air Defense Command and eventually throughout much of the free world. The East Coast MIT-Lincoln Laboratory studies culminated in the SAGE (Semi-Automatic Ground Environment) air defense system which, also starting in the mid-1950s, was created with astounding rapidity and then deployed throughout the United States and Canada.

In the convergence of these two landmark programs, which laid the foundations for future information systems, System Development Corporation was born.

THE POSTWAR CHILL

Estimates for the costs of the SAGE system vary—from $4 billion to $12 billion. A commonly used figure for the total development is $8 billion, including construction of twenty-six SAGE sites, purchase of fifty-six computers at $30 million apiece, installation of twenty-five thousand telephone lines, plus the associated equipment and services. SDC's programming for eight versions of SAGE would amount to $150 million, about 2 percent of the total cost of the system.

To understand the reasons behind this most costly of defense systems—in a period when the entire U.S. defense budget totaled $40 billion—one must travel back to the era of intense anticommunist fever that gripped the United States and its Western allies following World War II.

Within a year after that war ended on V-J Day, August 14, 1945, Soviet expansion in Eastern Europe prompted Winston Churchill's 1946 "Iron Curtain" speech. In 1947, the Truman Doctrine formed the first U.S. initiative to contain Soviet expansion, and the term "cold war" was coined on the floor of the U.S. Senate. The next year, 1948, saw such ominous events as the Soviet takeover of Czechoslovakia, the Berlin airlift, and the split between North and South Korea.

By 1949, the Communist Chinese had conquered the mainland and proclaimed the People's Republic, posing a new threat in the Far East, while twelve Western countries bound themselves in the anticommunist North Atlantic Treaty Organization. On June 27, 1950, not five full years after the most costly war in history, the United States found itself engaged in another full-scale conflict, the war in Korea, which would last until 1953.

Internally, anticommunist passions ran high. Former State Department official Alger Hiss was sentenced to a five-year prison term on communist spy charges in 1950. In 1951, Julius and Ethel Rosenberg were sentenced to death for passing atomic secrets to the Soviets. The House Un-American Activities Committee, looking for "subversives" in all facets of American life, toppled the careers of dozens of suspected communists in government, universities, the motion picture industry, and elsewhere. Senator Joseph R. McCarthy wielded awesome power in his investigation of internal communist activities from January 1953 until December 1954, when his conduct during a U.S. Army probe resulted in a vote of censure by the Senate.

Against this backdrop of fear and mistrust loomed a prospect unprecedented in American history: the awesome and abiding danger of an air attack against the continental United States. Powerful post-World War II long-range bombers had shattered the sanctuary of America's geographical isolation and placed its mainland within reach of hostile aircraft based thousands of miles away.

When Russia surprised the world with its first atomic detonation in August 1949, then exploded a hydrogen bomb in 1953, "thinking about the unthinkable," in the words of scientist Herman Kahn, became a national preoccupation.

It was little wonder that the highest priority of the U.S. Department of Defense was to upgrade, at any cost, its manual air defense system, whose vital mission to "detect, identify, intercept, and destroy" hostile aircraft was entrusted to a nationwide patchwork of 150 radar stations, augmented by visual sightings of the Ground Observer Corps, relying on verbal information exchange, and manned by untested air defense crews.

A military staff study appearing in the *Air University Quarterly Review* in 1956 summarized the concerns: "The onslaught will be sudden and all-out. The fact that one minute we would be at peace and the next the target of already-committed enemy intercontinental bombers places immense premium on rapid, positive identification of all continental air traffic.... When the enemy force is detected, its identification as hostile must be swift and unerring. Otherwise near-sonic speed may enable it to penetrate so deep prior to defensive action that it cannot be destroyed before it reaches its bomb-release line."

TRAINING FOR AIR DEFENSE

In this atmosphere of international tension, the Rand Corporation was born. Originating as Project Rand in 1945, and formally incorporated as a nonprofit corporation in Santa Monica in 1948, Rand was created to serve the Air Force with a top-caliber staff of civilian scientists and advisors. Continuing the productive World War II tradition of scientists working closely with the military, Rand's primary mission was to study the problems of intercontinental warfare and to recommend cost-effective programs to the Air Force to attain the greatest security for the United States.

Among the many Rand studies initiated in 1950, one was to have far-reaching effects for the future of automated systems, and for the birth of the first systems company, SDC.

In August of that year, Dr. John L. Kennedy, a psychologist and consultant to Rand, proposed a study of group behavior in man-machine systems—an area of research that had barely been touched. Kennedy was seeking insights into the behavior of organizations under stress, with the eventual goal of improving performance in Air Force weapons and defense systems. The project was shortly joined by two other psychologists, Drs. William C. "Bill" Biel and Robert L. Chapman, and a mathematician, Allen Newell.

With the encouragement of M. O. "Kap" Kappler, then assistant chief of Rand's Electronics Division (and later to become SDC's first president), whose job had familiarized him with Air Force installations, Kennedy, Biel, and Chapman selected an air defense direction center as the embedding environment for this study. By 1951, a near-replica of the Tacoma air defense radar station had been created in Rand's Systems Research Laboratory located, because of severe space limitations, at the back of the Santa Monica Billiard Room. Concurrently, the SRL group developed a mass of simulated input and output materials, representing interactions typical of a direction center, to provide an authentic environment that would elicit spontaneous responses by the crew.

The greatest challenge in this simulation was the realistic representation of flight paths in the form of radar tracks moving across the scopes of the operators. The number of calculations involved was enormous: over one million were required to compute and display the radar data for a two-hour exercise of a small defense center. Fortunately, Rand had several of the nation's earliest computing machines—the "pre-computer" IBM electronic card-programmed calculators—to assist with the job.

In the early experiments, airplane tracks were simulated as patterns of 1s and 8s printed on continuous-form paper that automatically advanced each thirty seconds to simulate a scan of the radar. The paper was housed in a Rand-built rearlit box representing a display scope. For a typical eight-radar exercise, each 100-minute period required 1,600 such computer-produced "displays," as well as eighty time-phased teletype messages and numerous closely coordinated maps, lists, and scripts. Some eight hundred flights were specified for each exercise, resulting in 80,000 punch cards produced in 1,500 hours of manual and computer calculations. From the resulting track library, the actual inputs for each exercise, some 10,000 cards, were machine-produced in twenty-five hours.

The first series of experiments, conducted in June 1952, used twenty-eight college students for the air defense crew. Intended to furnish general insights into organizational behavior, the experiments had a startling side effect: no matter how much the experimenters increased the difficulty of the air defense problem, the student crew was able to handle it. In fact, they surpassed the Air Force professionals the experimenters had observed in the field.

The reason for this surprising performance lay in the innovations the Rand team had introduced into these experiments: realistic simulation of a continuously changing threat, exercising an entire team under pressure, gradually increasing the degree of difficulty, exercising the group frequently, recording pertinent actions for later recall, providing immediate feedback of results, and debriefing the crew on total performance while avoiding individual evaluations or critical comments. By expanding the available technology in simulation and computing to create the most complex simulation vehicle of its time, the researchers had locked onto a powerful new technology for training whole teams to function within man-machine systems.

The next experiment, using Air Force crews, exhibited even more remarkable improvements in team performance. The realism of the battle scenarios produced an intense spirit of involvement and dedication, described by the researchers in the April 1959 issue of *Management Science:*

"Crew members became deeply involved with the organization's goal and its successes and failures. During enemy attacks, the noise level in the station rose, men came to their feet, and the excitement was obvious. Crew members reported restless nights and bad dreams—attackers boring in without an interceptor available. On one occasion, an officer slipped while stepping off a dais and broke his leg. We were not aware of this event for some ten minutes because there was no perturbation in the crew's activity during the attack in progress. He was back the next day, cast and all, because, as he said, they couldn't get along without him."

These reactions were not lost upon a group of Air Force observers led by Major General Frederick H. Smith, Jr., then Vice Commander, Air Defense Command (ADC), on several visits to Rand in February 1953. With the manual air defense system offering marginal protection at best, the new Rand training technology would at least enable the operators of the system to function at peak capacity. In March 1953, General Smith initiated a Joint ADC-Rand Study Group, whose report in May recommended that the Air Force adopt the "System Training Program" with the least practicable delay.

The report was received enthusiastically by ADC and transmitted immediately to Headquarters, USAF. In the letter of transmittal, Major General Jarred V. Crabb, ADC Chief of Staff, emphasized the need "to take all means possible to improve the present system" and concluded that "the Air Defense System Training Program . . . offers the most outstanding improvement of all items being considered."

In August 1953, ADC contracted with Rand to develop a field version of the program and install it in the 27th Air Division, headquartered in San Bernardino, California. If that installation proved successful, Rand would be asked to install the program throughout the U.S. air defense system.

With the prospect that the System Training Program might be conducted at all 150 radar sites, each with unique parameters, the Study Group recognized that paper-tape simulation of tracks, while adequate for a single, small-scale experiment, would have to give way to a more realistic and more portable technology. To fill that need, a Rand engineering team headed by M. O. Kappler shortly originated a design for an electromechanical "problem reproducer."

The problem reproducer automatically transferred computer-generated flight patterns from magnetic tape onto 70-millimeter film for subsequent display, in the form of realistic radar tracks, on the scopes of the consoles normally used by field crews. The invention required modifications to a new IBM digital electronic computer, design of a special cathode-ray tube, adaptation of a 70-millimeter motion picture camera, production of special high-speed film, development of an analog-to-digital converter, and design and manufacture of the problem-reproducing equipment.

This unique device simulated not only hostile and friendly aircraft but also, in tandem with a standard military target generator, the flight paths of interceptors "scrambled" by weapons personnel during the exercise. Its only departure from realism was the inability to "scrub," or erase from the scope, tracks representing aircraft that had been shot down or "splashed."

The modified computer used for this simulation was IBM's first true electronic computer, the 701. With a top government priority, Rand obtained one of the first models in August 1953. This vacuum-tube machine possessed processing capabilities comparable to those of Rand's own Johnniac, then one of the world's most advanced computers.

John Matousek, who led the programming for system training from the beginning, recalls those early times. "There were some grim days. No one had ever undertaken a program of this magnitude within the primitive state of computers. Going from punch cards to the 701 was a two-hundredfold improvement in processing power, but even that advanced machine had an unreliable cathode-ray-tube memory of only 2,048 words. Everything had to be invented. We built the assembler and the programming support tools for the 701, and developed our own techniques for program design, checkout, control, and documentation.

"Each exercise utilized hundreds of planes, which had to be precision-synchronized to appear or disappear consistently on overlapping radar scopes. Eventually, as our computers became more powerful [the project obtained two IBM 704s in 1956 and a 709 in 1958], we developed a programming production system for large-scale real-time simulations that, along with SAGE, was one of the first developments of large coordinated programs. In retrospect, these early systems were remarkable accomplishments."

In August 1954, exactly one year after ADC had requested the prototype version, the Rand team had developed the equipment, programs, and scenarios and was installing the System Training Program at the air control and warning site at Boron, California. Installation at the other sites in the 27th Division followed shortly thereafter.

A large group of Air Force officers, including four generals, observed the System Training Program in action and recognized and praised its importance. In October 1954, the Air Force asked Rand to develop, install, and maintain the program in 150 sites nationwide. The project immediately began hiring and training cadres of psychologists to develop and administer the programs, and data processors to implement them on computers. By March 1955, when the project moved to a rented facility at 1905 Armacost Avenue in West Los Angeles, one hundred people formed its expanding nucleus.

A quarter of a century later, in November 1979, the Human Factors Society would present its prestigious annual "Alexander Williams Award" to William Biel, John Kennedy, and Robert Chapman for their human factors contribution to the nation's air defense system.

Not nearly so belated was the Air Force's recognition, barely a month after the project had inhabited the Armacost facility, that Rand, in developing the System Training Program, had gained an early knowledge of computers, systems programming, and air defense that would be invaluable to the building of a newly conceived, futuristic air defense system, to be known as SAGE.

A SYSTEM FOR COMMAND-CONTROL

The development of the SAGE system in the mid-1950s had a profound and far-reaching influence on the course of world events.

In retrospect, the least durable achievement may have been the one for which SAGE was created—to serve as the nation's first line of defense against the Soviet bomber threat. The mandate to upgrade the inadequate manual system of air defense was imperative in the 1950s, and the nationwide network of SAGE sites provided a renewed degree of military security for the country. But the Soviet launching of the first sputnik in 1957 soon shifted the U.S. defense posture toward a possible missile confrontation, which SAGE was neither equipped nor intended to handle. The more profound question—whether the development of SAGE discouraged an early Soviet military adventure—remains unanswered.

The longer-term fallouts from SAGE were monumental. As the first automated command-control system, SAGE set the pattern for all military and space systems to follow.* In the process, it elevated the military technologist and his command to new positions of eminence and power. Most importantly, the invention of this first computer-based, real-time, on-line, man-machine system revolutionized the information industry by spanning, in one inspired leap, the prehistoric computer era of serial batch processing and the modern world of interactive systems.

SAGE had its origins in an exchange of letters between Dr. George E. Valley, professor of physics at MIT, and other prominent civilian and military personnel on concepts for upgrading America's air defense. In 1950, an eight-man committee headed by Valley recommended an automated air defense system. The proposed system, foreshadowing SAGE, divided the continental United States into air defense "sectors." Each sector was governed by a control center which controlled its radars, communications, and interceptors. Raw radar data would be converted to digital form for quick telephone transmission to the sector control center. There, a computer would extract relevant information from the data and construct tracks of all flights in the sector for display to the air defense crew.

All this would be done in "real time," that is, the computer would process and display radar information within split seconds of its actual receipt by radar antennas. Crew operators, whose

* "Command-control" refers to computer-based information systems, generally operating in real or current time and displaying selective information to commanders and other decision makers for directing and controlling their resources. The term was expanded to "command, control, communications" in the 1960s and "command, control, communications, and intelligence" in the 1970s. For simple consistency, this book uses "command-control" throughout.

pushbutton consoles were "on line," that is, directly linked to the computer without intermediate tape or card processing, could therefore react instantly to the changing air picture. After separating "hostiles" from "friendlies," partly on the basis of prefiled flight plans, the crew, aided by the computer, would choose appropriate interceptors for any hostile aircraft, issue the proper commands for intercept, and, if necessary, "kill."

Dr. Valley and an MIT colleague, Jay W. Forrester, believed that the digital computer, then in its infancy, might be used to handle the massive air defense data processing requirements. Since 1944, Forrester had been developing a large digital computer called "Whirlwind" for the Office of Naval Research. The two scientists concluded that Whirlwind could be adapted for air defense, since it should be able to process data in large amounts and in real time—two main requisites of the proposed system.

The use of computers in military systems, while taken for granted today, was not nearly so obvious in the computing dawn of 1950. Fewer than a hundred machines existed in the United States for even the most rudimentary of calculations. The first modern "computer," the Harvard Mark I, was a mechanical sequence control calculator capable of one scientific computation every 26 seconds. Unveiled in 1944, it was the brainchild of Harvard professor Howard Aiken. As Wesley S. Melahn, an early student in Aiken's master computer class, recollects, the professor once remarked of the proposed SAGE computer, "I won't say it's impossible to get fifty-eight thousand vacuum tubes to work at the same time, but it's a mighty long row to hoe."

The first machine to use some form of electronics was the ENIAC, completed at the University of Pennsylvania in 1946. The EDSAC, developed at England's Cambridge University by 1949, was the first to use an internally stored program to guide its operations. Forrester's Whirlwind, unveiled in December 1950, performed 110 scientific computations per second.

Such was the state of the art when George Valley's bold foresight led him to postulate a computer for SAGE, which would require a capability of 36,000 computations every second, more than three hundred times the power of Whirlwind. Out of this proposal emerged Project Charles, which set forth a definitive concept for a computer-based air defense system. Out of Project Charles grew the MIT Lincoln Laboratory, established in 1951 to perform research and development in air defense, and from which came the design and initial development of SAGE.

In this automated system, the basic air defense tasks would not change. The innovation was the use of a pair of duplexed high-speed digital computers at each sector direction center to receive, process, and display air surveillance, identification, and weapons control information, freeing the human operators to monitor the situation and make the critical decisions.

As a first step, Lincoln Laboratory established the Cape Cod System, in which data from radars on Cape Cod were fed into the laboratory's successor to Whirlwind, the XD-1. As the Cape Cod testbed confirmed the feasibility of automating air defense, the Air Force decided to adopt and develop the resulting system, officially designated the Semi-Automatic Ground Environment or SAGE system, in the summer of 1954.

The dominant challenge was the development of specifications detailing how the XD-1—redesignated the IBM AN/FSQ-7 for its production version—at each SAGE direction center, and the related AN/FSQ-8 computer at each combat center, should be programmed to perform their functions. Lincoln Laboratory, although created as an R&D center, was willing to begin preparing the master computer programs, provided that some other organization would take over their operational development, create the supporting software, adapt the programs to each site, make the numerous updates envisioned, and carry out the massive implementation and installation.

The Air Force did not have far to look to find a logical candidate for SAGE programming. Rand's System Training Program had already established groundbreaking principles for computer-based system design, man-machine interfaces, and simulation. Rand's experience in installing the training program, operational by 1954 in seven divisions, had provided a familiarity with air defense unmatched by any private organization. A trusted member of the "Air Force family," Rand posed no security clearance concerns and could be awarded a contract without competing, as the logical "sole source" for the procurement. Most compellingly, Rand had a corner on the country's programmers.

"It's true that in 1955 Rand owned more than ten percent of the talented programmers in the United States," recalls M. O. Kappler. "But that was about twenty-five people." While one industry bible lists 1,200 programmers in 1955, most of these were working on relatively simple commercial applications, and a consensus of experts confirms about two hundred journeymen data processors in the country in 1955.

At a high-level meeting of SAGE participants in Colorado Springs on April 2, 1955, the Rand representative, M. O. Kappler, by now co-chief (with Bill Biel) of the System Training Project, was asked if Rand would undertake the SAGE programming task. "I thought about two seconds and said, 'Yes, of course!'" he remembers, revealing his characteristic entrepreneurial flair. Subsequent accords between ADC's General Smith and Rand President Frank R. Collbohm confirmed Rand's participation in the development of SAGE. The high national priority of automating air defense overrode any scruples about compromising Rand's research orientation.

On July 5, 1955, a Rand contingent of five programmers arrived at Lincoln Laboratory. Their leader was Wesley Melahn, a Rand "veteran" of seven years who had helped to design the Johnniac computer (and who was to become SDC's second president). Rand's participation in SAGE, which called for a total of seventy programmers to collaborate in the design, was premised on a memorandum from the associate head of Lincoln's SAGE project, John F. Jacobs, to Kappler, indicating that "The two organizations [Rand and Lincoln]... will act essentially as one.... Rand's staff will be integrated... at levels which depend on their background and ability."

"The decision to make it a totally integrated, joint organization was a key to our subsequent success," says SDC department manager John P. "Pat" Haverty, another member of the original Lexington five. "Everybody was completely fascinated with the project. There were three strong motivators: protecting the United States, doing something never tried before, and 'showing' the many skeptics who said that SAGE was an 'impossible objective.'"

Using Lincoln's farsighted initial design as a basis, the Lincoln-Rand team set about developing and implementing the first large-scale information system with capabilities so advanced that a quarter century later they would still be considered the current state of the art. Among the numerous firsts of SAGE are:

- A fully real-time system
- Servicing one hundred simultaneous users
- Acquiring live digital data from many sources
- Routing data to many destinations
- Using interactive graphic displays
- Providing near-instant on-line access to a common data base
- Having fault tolerance and "graceful" degradation
- Incorporating a "hot backup" machine
- Communicating digital data among a dispersed network of computers
- Handling live operations and simulated exercises simultaneously

And incorporating in its computer programs:

- Centralized system data structures and control
- Modular, topdown system organization
- Discrete structured program modules

- Overlapped input/output and data processing
- Simultaneous real-time and computational processing
- Time-sequenced synchronous scheduling and interrupt for ninety subprograms
- Centralized data processing with remote input/output and display devices
- Comprehensive communications pool (compool) defining all global data in the program
- Table-driven software for ease of modification
- Built-in test, recording, and data reduction
- Computer-supported system development and checkout.

To produce this next-generation system, the Air Force drew upon the participation of the country's leading electronics firms. In the colorful language of a contemporary article in *The Saturday Evening Post,* which credited Lincoln as the birthplace of SAGE and IBM for the computers:

"SAGE today is the product of many brains and hands, many of them fiercely competitive in their civilian pursuits. Western Electric took over the job as overall coordinator. RCA, Bendix, and G.E. built the radars. Bell Telephone Laboratories worked out the complicated web of communications that would link together SAGE sectors across the country. Burroughs devised a miraculous machine which would translate raw radar data into mathematical language the computer could understand. System Development Corporation wrote the 7,000 pages of plain English instructions which, reduced to a thousand pages of mathematical formula and transferred to 3,000,000 punch cards, were fed into the computer so that the machine would know what it had to do."

SAGE SPAWNS A CORPORATION

What had started at Rand in 1950 as a small study of group behavior had expanded by 1955 into a capability and commitment to undertake massive projects in the forefront areas of system development, computer programming, and system training. From a half-dozen people working in Rand's Systems Research Laboratory in 1951, a thousand people were working on System Training and SAGE all over the country by 1956—more than the rest of Rand put together—and the end of new hires was not in sight.

Accompanying this growth was a series of organizational changes. In September 1954, the System Training Project had been established under co-directors Kappler and Biel. By September 1955, the organization had grown to three hundred personnel and was made an independent division. Three months later, in December 1955, it had some four hundred and fifty people, of whom seventy-five were developing SAGE in Lexington, and was officially named "System Development Division."

Finding adequate office space to house this population, swelling by fifty employees per month, was a persistent problem. By 1956, the division was spread throughout Santa Monica and adjacent West Los Angeles. In addition to a former manufacturing plant on Armacost Avenue, the elite facilities included a condemned school house, an old garage, a warehouse, and "the space over Vic Tanney's gym."

Recalls the division's administrative assistant, Louis G. Turner, "We couldn't keep track of where everybody was. Any time a Santa Monica office became vacant, the division would gobble it up." There were drawbacks to even the more respectable locations. Betty E. Prior, SDC's manager of Benefits Administration, recalls that SDC's recruitment office in the Broadway Building was colocated with the County Probation Office, resulting in occasional mixups between parolees and programmer applicants reporting for interviews.

Seeking a more settled solution, Rand obtained a long-term lease on several acres of prime land at 2500 Colorado Avenue, twenty-five blocks from the Pacific Ocean, where modern buildings would be erected and leased to house the people and machines of the future SDC. The first shovelful of dirt was hoisted by Kappler and Biel in the groundbreaking ceremony of January 1956.

The decision to split SDC from Rand was not sudden. The developmental role of the division, its overwhelming size, its dedication to one dominant Air Force client—the Air Defense Command—and the prospects of its continuing growth as a system designer and implementer, all conflicted with Rand's charter of selective long-range research for various Air Force agencies. With approval of the Air Force, the Rand Board of Trustees voted at its meeting on October 20, 1956, that a new nonprofit corporation be formed to take over this work. The System Development Division had become the System Development Corporation.

The Articles of Incorporation for the new company were filed with the State of California on November 23, 1956. The SDC incorporators were Frank R. Collbohm, president of Rand; J. Richard Goldstein, Rand vice president; and Edwin E. Huddleson, Jr., of the San Francisco law firm of Cooley, Crowley, Gaither, Godward, Castro, and Huddleson. At their first meeting, on May 1, 1957, they elected an SDC Board of Trustees which, in addition to the incorporators, included John W. Gardner, president of the Carnegie Corporation of New York; William T. Golden, New York financier; and the previous division co-chiefs, "Kap" Kappler and Bill Biel.

Collbohm and Goldstein were elected chairman and vice chairman of the board, respectively. Kappler was elected president of SDC and Biel vice president. Completing the slate of corporate officers, James H. Berkson became treasurer and Louis G. Turner secretary. Arrangements were made to transfer contracts, facilities, and personnel (with no loss of Rand's valued fringe benefits), and to guarantee SDC's line of credit "at the going interest rate of 4.5 percent per annum."

During a lengthy transition period—SDC did not start formal operations until December 1957—and for a time thereafter, Rand and SDC management met to discuss and resolve outstanding issues. As Bill Biel recalls, "Every Tuesday morning, Rand's vice president, Jack Goldstein, and their administrators, King and Jeffries, met with Kappler, Berkson, Turner, and me for breakfast somewhere in town. We would review the happenings of the week, the financial and space problems, and what was being done about them. These meetings were informal; it's hard to get formal when you have seven people around the table eating breakfast. But they were handy because they were so regular, and necessary because Rand's support was vital throughout the formation of SDC."

The establishment of SDC from the Rand System Development Division was gradual, evolutionary, and smooth. As SDC Vice President Dr. Launor F. Carter states, "No one saw any distinct change or difference, except that Kap and Biel were now corporate officers."

The public announcement of SDC on December 10, 1957, contained three revealing passages. The first summarized the basis of the new company: "The Rand Corporation of Santa Monica, California, announced today that negotiations have been successfully completed with the United States Air Force for the transfer from Rand to the newly-formed System Development Corporation of a $20 million contract to provide professional-technical services to the Air Defense Command... utilizing the same facilities and the same personnel."

The second highlighted the novelty of SDC's technology: "The new corporation's second air defense job is that of 'programming' for the computers in the SAGE air defense system. Programming is a comparatively new technical field in which persons with training in logic and mathematics prepare problems for solution by modern computing machines."

The third contained this closing statement by SDC President Kappler: "At present, the energies and talents of the System Development Corporation are devoted exclusively to problems of air defense. However, there is every reason to believe that these same specialized skills—in training and in computer programming—will find equal applicability to other military as well as nonmilitary problems associated with the 'Age of Automation.'"

In that last sentence, which indirectly but clearly expressed the corporate objective of diversification, lay the roots of the ideological conflict over SDC's proper role that was to embroil members of management, the board, the military, and the government for more than a decade of corporate uncertainty.

CHAPTER 3

The Early Years

(1956-1959)

THE BIRTH OF A TECHNOLOGY

"Inside a windowless concrete blockhouse at McGuire Air Force Base, N.J., this week, huge electronic computer elements clattered, clicked, and blinked. Nearby a row of airmen hunched over radarscopes as yellow-white images flickered across the screens.

"Lightning fast and unerringly, the electronic unit of the SAGE air-defense system supplemented the fallible, comparatively slow-reacting mind and hand of man. For the first time, SAGE's electronic brains were tied into the network of early-warning radars, all-weather jet interceptors, missile sites, offshore picket ships, and ground observers protecting some 44 million Americans in the New York Air Defense Sector, all of which covers areas in six states: New York, Pennsylvania, New Jersey, Rhode Island, Connecticut, and Delaware."

Thus *Newsweek* of July 7, 1958, described the unveiling of SAGE. With the opening ceremonies at McGuire the prior June

27, the "impossible objective" of building SAGE, initiated at Lexington three years earlier, had been realized.

In the process, SDC had trained the first cadres of system programmers, built the first real-time computer system, pioneered methods of large-scale program development, and instituted new techniques for simulation, training, and user-oriented data management. With a total staff of 2,100, including 700 programmers, SDC emerged from the early SAGE development as the most experienced organization in the new field of computer-based information systems.

Many information processing managers of the future cut their eyeteeth on SAGE. Lured by SDC ads to "Use your past math background for your future in computer programming," they flocked from the universities, statistical centers, and the early "plugboard" computing installations to Lexington, where, after a basic eight-week training course, they were thrust into the midst of an unprecedented programming project featuring one of the world's largest computing machines.

Paul I. Hicks, who joined the company in August 1955, was assigned to the IBM plant in Kingston, New York, where his job was transferring the SAGE programs from the prototype XD-1 computer at Lincoln to the first "Q-7" machines. "When I walked into the plant the first time, there were five machines side by side and I couldn't see the end of the line. I had just gotten out of programming school and was overwhelmed." Unlike the XD-1 at Lexington, the early Q-7 production machine had no control console, and Hicks had to wire a plugboard to read the toggle switches on the display panels and manually key in the program steps. "We finally got one of the Lexington programs to work," he recalls, "and up on the printer came the words, 'If you got this far, please call me,' signed by the Lexington programmer."

The IBM AN/FSQ-7 computer, the hub of each SAGE direction center, along with its near twin, the SAGE combat center's AN/FSQ-8, was physically imposing. Composed of seventy cabinets filled with fifty-eight thousand vacuum tubes, the Q-7 weighed three hundred tons and occupied twenty thousand square feet of floor space, with another twenty thousand square feet devoted to display consoles and telephone equipment.

"'Where do I find the computer?' were often the first words of a new programmer trainee as he stood in the midst of the AN/FSQ-7 computer frames," wrote Douglas L. Jordan, another SDC project manager, in the January 1970 issue of *Datamation.* He goes on: "Its statistics were almost unbelievable in 1957 and they remain impressive even today: 69K of core memory all directly addressable; 150K of drum storage; 'add' four 16-bit numbers in two memory cycles; 'multiply' in three memory cycles; 'divide' in nine memory cycles; input/output operations proceeding independently of the central processor."*

When the duplexed Q-7 machine arrived at McGuire Air Force Base in June 1956, it took three days to unload the eighteen vans of computer equipment. The initial shipment was followed by thirty-five moving vans packed with display consoles and 7,700 spare parts.

Once programmers got used to this behemoth—with its 170,000 diodes, 7,300 pluggable units, and enough signal wire to stretch from Boston to Los Angeles—an anthropomorphic affection often developed. As expressed by SDC branch manager Joseph W. Thompson, who joined the SAGE project in 1955 after a four-year tour of "feeding Whirlwind" at Lincoln Laboratory, "You could see the wires and tubes of the Q-7 and walk around the guts of the thing. You felt close to it, like a member of the family. Today, computers are small, closed-in, with no personality."

Aaron "Bud" Drutz, fresh out of SDC's programming school in 1956, was assigned to write several SAGE utility and control programs in Lexington. When the 8,000-word memory of the Q-7 was expanded to 69,000 words in 1957, Drutz revised the programs and went to Kingston to test them on the new memory. "I was used to seeing the lights blink on the Q-7, and now the lights just sat there, static. I figured we hadn't adapted the programs correctly, until we realized that the new core had compressed the processing time so much that the machine looked like it wasn't running at all."

Drutz, an SDC division vice president, adds, "SAGE formed the basis of so much later work. We transplanted its utility pro-

* In data processing, "K" stands for thousand (actually 1,024).

grams into SDC's ADEPT timesharing system ten years later. And the current COBOL data dictionary concept was invented in the SAGE compool."

SDC's installation of SAGE followed the so-called Red Book, the SAGE operational plan released in March 1955. Patterned after the manual air defense system, the plan divided the country into air defense divisions, each containing from three to five SAGE sectors. Each SAGE sector collected air surveillance data from radars and other sources and transmitted them to a direction center, where two duplexed Q-7 computers processed them and, with human assessment, developed the definitive air situation for the sector. Each direction center was able to transmit its air picture to adjacent sectors and to the combat center at division headquarters. There, Q-8 computers integrated the sector air pictures into the division air situation. From these, the North American Air Defense Command in Colorado Springs monitored and directed nationwide air defense.

"SAGE represented the first computer network," says SDC department manager Max D. Schleppenbach, another Lexington veteran. "The eventual SAGE configuration contained twenty direction centers, four combat centers, one combined combat/direction center, and one 'remote' combat center—all linked in a computer-to-computer intercommunicating network."

SAGE was also a forerunner of "modular" software development, in which separate functions are implemented in separate, clearly articulated sections of program code. As a result, the direction center and combat center modules were readily integrated into a combined operating system for one sector. The geography, weapons, and other conditions peculiar to each sector were "overlaid" on the master program with simple commands, without the need for reprogramming each installation.

Composed of over one million instructions, SAGE was by far the largest program of its time. The operating programs totaled 230,000 instructions—80,000 for the direction center, 60,000 for the combat center, and 90,000 for the remote combat center. Another 870,000 instructions were distributed over nine utility and support programs, compilers, and training programs.

Erwin Book, who would become an SDC programming-language authority, arrived in Lexington in November 1955 for training class "four." In pretraining, an "old-time programmer" had unnerved Book by claiming to have written a 300-instruction program. "In my experience, large programs were about twenty-five steps. Shortly I was developing the simulation tape input program, one of the five original SAGE programs, which had over eight hundred instructions."

The formidable data management capabilities of SAGE are well summarized in the following excerpt from the 1957 *Proceedings of the Western Computer Conference:* "The computer in the direction center can store over one million bits of information representing weapons and surveillance status of the sector at one time.... Each second, the computer can generate over 100,000 bits of digital information for display to Air Force operator consoles. Each operator receives cathode-ray tube displays tailored to his needs.... Every two and one-half seconds, the computer displays about two hundred different types of displays requiring up to 20,000 characters, 18,000 points, and 5,000 lines."

As the SAGE programming job grew in complexity and magnitude, it became clear that its manpower requirements had been grossly underestimated. Wes Melahn, by 1956 manager of SAGE programming and assistant head of the Programming Department under John D. Madden, recalls that the early estimates for about a hundred programmers were totally unrealistic. "By 1959 we had over eight hundred programmers dedicated to SAGE. Considering the innovative development that had to be done, plus the major tasks of modifications, installation, and maintenance, the number is not surprising."

Among other inventions noted by SAGE developers are use of an assembler with relocatable code, an internal recording capability, digitizing of radar data and their transmission over phone lines, and multiple-radar tracking.

SDC program manager Stuart I. Spratt joined the company in Lexington in December 1955, having answered an ad in a Dallas paper. "It's clear now," he says, "that everything was a new invention: The ability to restart the machine in midcycle without a 'cold start.' The entire backup system of communicating among computers via digital lines. If one machine failed, its backup took over; and if both failed, the surrounding sector direction centers expanded their coverage. It is remarkable that all this was achieved in only eighteen months from system design in early 1955 to the beginning of checkout at McGuire in October 1956, using virtually all brand-new programmers."

The backup features of SAGE provided a phenomenal reliability, a prime requisite of around-the-clock air defense. Pat Haverty, who directed the design of the SAGE switchover programs, recalls that the "uptime" was 98 percent, "something absolutely unheard of in those days."

The theme of "everything was first done in SAGE" has been echoed throughout the industry. Addressing the difficulties of transferring software experience from a landmark development like SAGE to later efforts, one authority commented in *Datamation* of May 1973: "Many of the lessons learned as far back as SAGE are often ignored in today's software developments, although they were published over ten years ago... on the value of milestones, test plans, precise interface specifications, integrated measurement capabilities, formatted debugging aids, early prototypes, and concurrent system development and performance analysis."

In September 1958, three months after the McGuire sector became operational, the SAGE sector at Stewart Air Force Base, Newburgh, New York, went on the air. In rapid succession, additional sectors, averaging one every two months, became operational. This pace continued until 1961, when all SAGE sites had been installed, their personnel trained, and the entire system declared operationally ready.

It had taken one hundred programmers to install SAGE at McGuire; the next site required forty; then fifteen became the standard. Eight programmers plus four training specialists (out of a startup training cadre of twenty) remained on-site as a permanent team to maintain the programs, correct errors, install and test new programs, and provide ongoing training. By 1959, SDC had some four hundred programmers and two hundred trainers in the field.

Being a field programmer offered both opportunities and frustrations. Recalls former field installation supervisor Paul Hicks, "In those days, when you were out in a remote location, you got something to do and you did it. We stepped all over everybody, but we got things done. I was chastised for letting one of my programmers write a program to fix parity errors in the radar returns in one day, after IBM had been given a three-month contract for the same job."

Working inside the massive walls of a SAGE direction center was not the choicest assignment. A typical SAGE center, of which several were still operating in 1981, covered two acres and was housed in a windowless building of blast-resistant concrete with outside walls six feet thick. In a three-story direction center, the first floor housed the communication gear, power units, and computers. The one hundred operator consoles on the second floor were organized by function into several operations rooms—for air surveillance, weapons direction, and other specialties. The command post and offices were located on the third floor.

The dimly lit console rooms had a science-fiction aura. Their deep-blue, shadowless illumination had been designed to provide operators with the best lighting for reading scopes. As the computer received, calculated, and recorded information from radars and compared it with prefiled flight plans of friendly aircraft, the console operators decided whether planes without flight plans were unknowns and whether an interceptor should investigate.

When an unaccounted-for blip, or HUK (for "hostiles, unknowns, and fakers"), flickered on the scope, the operator aimed a lightgun at the image. A photocell in the gun activated a relay in the Q-7. In seconds, the computer displayed the HUK's altitude, speed, and direction, and indicated several possible intercept points if the aircraft proved hostile. Then it helped to select the best defensive weapons and steered the weapon to the enemy.

The diversity among sectors raised interesting problems. As one example, the mathematics in the radar return program assumed an upward or positive angle of the radar. When a radar on a high mountain in the Detroit sector slanted downward, "all hell broke loose in the program," according to site personnel.

"At first it was hard to get some things fixed by Santa Monica," recalls one field programmer. "We'd send in error reports, but the next program tape had the same errors. On top of that, sector boundaries were constantly changing; each sector commander wanted his emergency changes; and the continuing upgrades in weapons, tactics, and operating procedures made for a running stream of changes. Of course, that's what we were there to handle."

If SAGE looked like a running stream from a field sector, it resembled a raging torrent from Santa Monica headquarters where, by 1959, some four hundred programmers were continuously modifying SAGE and attempting to control the orderly implementation of myriad changes.

The list of SAGE variables began with its twenty-six dispersed centers, each with its own environmental peculiarities and unique, on-the-spot field changes. As major innovations were introduced into SAGE—like improved weapons direction, the Bomarc missile, or the remote combat center—they were grouped into versions called "models." Not every sector needed or received every feature of every model. In addition, there were hundreds of small changes, from adding a character to a display to correcting errors and malfunctions, again not necessarily applicable to every center. The implementation of changes had to be carefully phased, so that sectors operating with a new model could still communicate with neighboring sectors yet to be upgraded.

John Matousek, who managed the SAGE Computer Programming Department during these years, recalls the challenges. "The control problem was monumental. Apart from the dynamic nature of SAGE, there was the issue of how to optimally organize a project of eight hundred systems analysts and programmers—four hundred at home and four hundred in the field. Even with today's much smaller staffs, that question is unsolved. We had to invent a whole new technology for building, testing, installing, managing, and controlling a program of that magnitude.

"One significant concept, new at that time, was that modifications and maintenance were never done on the master program operating in the field—but on a parallel version of this program for later controlled implementation. Another was the importance of thorough maintenance—that programs become obsolete, just like hardware. The need for thorough documentation became abundantly clear after several programmers left SDC, having produced key programs with undocumented code."

A programming "production line" was set up in Santa Monica to produce the SAGE models. The programming staff was organized into skill centers corresponding to the major steps in the development process—requirements analysis, operational design, program design and production, testing, and site adaptation.

For each SAGE model, a "model manager" planned, coordinated, and guided the model through the successive skill centers, using techniques for configuration management and documentation control that would become industry standards. SDC produced eight major revisions or models of the SAGE programs between 1957 and 1962.

Another SAGE builder, senior computer specialist Stanley G. Benson, recalls that after his Lexington training, as he integrated the complex Bomarc missile programs into SAGE, neither he nor his cohorts seemed overly impressed with their contributions. "Most of us didn't know what a programmer was until we came to work at SDC, so we took our assignments for granted. In retrospect, SAGE technology was very similar to what is in use today. Equipment is better and speeds are faster today, but multiprogramming, distributed processing, on-line data management, timesharing—they were all there in SAGE."

LAUNCHING A COMPANY

The SAGE work conducted in Rand's System Development Division was thus expanded and systematized by the new corporation. While the original Rand-SDC master transfer agreement linked the two companies through Rand management services to SDC, the overlapping boards of trustees, and day-to-day management interactions, there was no doubt in anyone's mind who was in charge at SDC. It was M. O. "Kap" Kappler, SDC's first president, supported by William Biel and the other members of the SDC management team.

Associates have described Kap as "an extrovert . . . very selfconfident . . . a good leader . . . a driver . . . very sure of himself . . . a one-man gang!" Launor Carter recalls that "his attitude was always 'By God, we can do it!' and it was a very infectious thing for those around him. And then he pushed to make it happen, to make things go. In some ways he was a visionary. He knew we could not survive forever as a nonprofit, that industry would develop capabilities paralleling ours and we would have to change."

Kappler, an electrical engineer with training in the physical sciences and business administration, had gained broad experience in applying these disciplines in industrial, military, and nonprofit settings. During World War II, he had served with the University of California Division of War Research, conducting sonar equipment research with the U.S. Navy, involving many submarine missions in the Pacific. Joining Rand in 1949, he quickly displayed qualities of leadership that resulted in successive promotions, culminating seven years later in the presidency of a corporation that would grow to 4,300 employees.

Kap's capabilities and attributes were complemented by those of Dr. Biel, SDC's first vice president. Biel was a psychologist with a background in university teaching, military psychological research, and industrial consulting. Having joined Rand in 1951 as a member of the original staff of the Systems Research Laboratory, he had moved from co-leadership of the System Training Project to his new corporate position.

At the operating level, SDC had been organized since 1956 into four skill-oriented departments: Training, Problem Production, Programming, and Engineering. In 1957, the company's Training Department was managed by Dr. Launor F. Carter, a psychologist who, prior to joining Rand in 1955, had been director of the U.S. Army Human Research Unit at Fort Ord. The Problem Production Department was headed by Harry H. Harman, a mathematician-psychologist who had been chief of Statistical Research in the Army Adjutant General's Office before joining Rand in 1953. The Programming Department Manager was John D. "Don" Madden, a mathematician who had joined Project Rand in 1946. The Engineering Department was headed by Thomas R. Parkin, a physicist with a background in computing.

On December 1, 1957, SDC had 1,800 employees. Almost to a person, they had transferred from Rand's System Development Division to form the new corporation's work force. The majority were recent hires for SAGE. But even the longer-term Rand scientists, who valued the elitism of their Rand association, were ready to join SDC to be "in on the ground floor" of a new enterprise in an equally new field of technology. Thus, there was close to 100 percent continuity in performance, job assignments, and worker-supervisor relationships.

By this time, the Santa Monica work force had moved into the three modern buildings built for SDC, which exceeded a quarter million square feet. The first of these, at 2500 Colorado Avenue, was completed and occupied in February 1957; the second, directly behind it, at 2502 Colorado and known as the Q-7 building, in June 1957; and the third, the 2400 Colorado building, in January 1958.

The 2400 and 2500 buildings, housing some 1,300 employees, were built around patios to give all offices outside views with natural light and ventilation. These buildings were constructed without air conditioning because of their proximity to the Pacific's balmy breezes—a livable arrangement for all but a few hundred-degree days per year.

In contrast to these light and airy quarters, the Q-7 building was a windowless, two-story cube of concrete built to house the duplexed Q-7 SAGE computer used by SDC to develop and test SAGE programs. The building also contained a small replica of a SAGE operations room—named the "Blue Room" for its special lighting—where SDC personnel designed displays and developed training scenarios in a realistic air defense environment.

Because it housed a computer, the Q-7 building was, of course, air-conditioned; in fact, it had five hundred tons of air conditioning equipment. SDC division vice president Donald A. Biggar recalls that, when he joined the company in July 1957, the Q-7 building served as the preclearance area for new employees while its air conditioning was being installed and tested. "It was 55 degrees in there. We came to work in sport shirts and then had to put on our winter coats and gloves."

The Q-7 computer began operation at SDC on October 1,

1957. The output of its power supply equaled one-twelfth of the power consumption of the entire city of Santa Monica. Although the big SAGE machines would leave SDC in 1970, the building continued to be known as "Q-7."

A distinctive feature of the new complex was a large blue concrete canopy, in the shape of a hyperbolic paraboloid, which served as entryway to the 2500 building. Planned and installed by the architect as his contribution to the new building, the shape of the canopy became so closely linked with descriptions of SDC as "the place with the 'flying diaper' in front" that it was adopted as the corporate symbol and logo.

To impress upon employees the importance of promoting SDC's symbol consistently, President Kappler insisted on the appearance of a reduced replica of the logo, also called "the bug," at the right bottom corner of every slide presented at corporate briefings. If a luckless presenter failed to include the bug, Kap fined the offender a dollar. He recalls that one day Launor Carter, anticipating some charitable corporate purpose for these levies, asked Kappler what he did with the money. "Why, I keep it, of course," Kap smiled.

Kappler used a variety of approaches to soften his hard-driving image with SDC employees. For one, he encouraged an informal dress code. His own standard attire was slacks and a short-sleeved sport shirt, though he kept a more formal wardrobe in his closet for visitors. It was not unusual to see SDC personnel, inspired by Kappler's example, coming to work in Bermuda shorts, Levi's, or Tyrolean lederhosen. The informal Rand tradition of addressing everyone in the corporate family by first name was encouraged by all managers. At his frequent briefings to the "top 150" at SDC, Kappler recalls planting several "shills" in the audience to ask the toughest questions possible, so that others would be encouraged to do likewise.

Despite these measures, his assertive manner overawed some employees. One senior engineer began a technical briefing to a small management group including Kappler with the words: "This afternoon I'd like to . . . " and promptly fainted.

After several months of operation, management recognized that the corporate organization of four skill-oriented departments was not able to provide the interdisciplinary systems approach espoused in SDC's philosophy and required in its contractual work. The skill-centered organization had originally been intended to promote the various professions separately but equally and to cater to the groups' loyalties to their technical peers. Not surprisingly, this structure widened the separation between the academically motivated human factors Ph.D.s and the applications oriented data processors.

In February 1958, Kappler instituted SDC's first matrix management structure. He retained the skill-oriented departments (human factors, production, engineering, and programming) and overlaid project management offices responsible for managing specific programs, using resources from the departments. The departments were permanent structures, while projects were formed and dissolved as needed.

Three project management offices were established. The SAGE Computer Programming PMO was headed by Benham E. "Ben" Morriss, an engineer and participant in the early SAGE development at Lincoln. The System Training PMO was directed by Dr. Milton G. Holmen, a psychologist who had supervised the installation of the System Training Program. A Special Projects PMO was managed by Dr. Thomas C. Rowan, also a psychologist, who had directed special studies at Rand and SDC.

Conflicts immediately developed as the PMOs and line managers disputed work estimates, budgets, staff selection, and priorities. As the number of projects increased, the conflicts intensified. Lacking the "sovereignty" of the line managers, the PMOs found it difficult to bear responsibility for budgets, schedules, and performance on their projects.

In the spring of 1959, management instituted a bolder organizational change—the first step toward an integrated systems capability. Kappler dissolved the PMOs and vested total responsibility for SDC's two major SAGE programs, system training and computer programming, in two general managers, with the associated departments reporting directly to them. Launor Carter was named general manager for System Training and Wes Melahn for

SAGE Computer Programming. A measure of discipline orientation was retained in four new skill-oriented directorates, responsible for long-range planning, career guidance, and the conduct of research within their disciplines.

Although system design and computer programming for SAGE received a large share of management attention during SDC's early years, the System Training Program remained its equal in importance to both SDC and the Air Force, and its near equal in personnel and funding.

THE DAY NORAD WENT TO WAR

"This is General Lawrence Kuter. . . . The North American Air Defense Command has been ordered to a condition of air defense emergency. . . . High-speed tracks approaching the United States . . . have been positively identified as hostile aircraft. . . . "

These words, coming at midnight on June 8, 1960, brought U.S. and Canadian defense forces to a state of "cocked-pistol" preparedness as the North American Air Defense Command (NORAD) went to simulated war.

A fortnight earlier, the summit conference between the United States and Russia had aborted in Paris when Soviet Premier Khrushchev angrily denounced the United States and President Eisenhower for the U-2 "spy plane" incident. The cold war took on a new and more ominous dimension. Khrushchev warned the world of Soviet prowess and threatened to launch attacks on any U.S. allies permitting Russian overflights from their airbases. Eisenhower reacted by placing U.S. forces on alert around the globe as a "precautionary measure." In early June, the Senate voted to increase military appropriations.

This was the supercharged international atmosphere in which General Kuter, NORAD's Commander in Chief, radioed his midnight message over circuits covering millions of miles. (The exercise is described in detail in *Air Force Magazine* of August 1960.)

Throughout the long night of Exercise Desk Top III, fifteen thousand officers and men along the edges of the free world were involved in this simulation of all-out war. Thousands of personnel from the U.S. Air Force, Army, and Navy and the Royal Canadian Air Force figured in the actions and decisions—from the far reaches of the early-warning radar lines, through the numerous manual radar sites and SAGE direction centers, to the upper levels of the national command structure at NORAD, the Strategic Air Command, and the Joint Chiefs of Staff.

The simulated attack consisted of international ballistic missiles and hundreds of enemy manned bombers. On thousands of radar scopes, a great global air battle took place.

The incoming enemy missiles and planes followed realistic attack routes and appeared on the scopes as real targets. The locations, speeds, and altitudes of the targets were plotted and relayed to NORAD headquarters by local site personnel. Interceptor aircraft were theoretically scrambled, and simulated intercepts were conducted by weapons directors located at air control and warning sites and SAGE direction centers.

When the battle ended, the NORAD air defense system had been taxed to the limit, its equipment and communications lines saturated by data and commands, and its personnel immersed in fighting an air war of worldwide proportions.

Yet during the entire exercise no aircraft actually left the ground, either to defend North America or to play-act as the attackers. The entire exercise was "packaged," a product of SDC. For Desk Top III, the corporation had prepared a monumental arsenal of scripts, 400 separate films stretching 3,000 feet, 10,000 feet of recording tape, and 50,000 computer-generated battle maps.

By the time of this third Desk Top exercise, SDC had installed the System Training Program (STP) in 150 manual radar sites and adapted and implemented its concepts for SAGE. The major innovation in SAGE STP was use of the Q-7 computer to present the exercise materials and record responses. In manual STP, simulated radar data had to be converted from magnetic tape to film for entry into the system via the problem reproducer; in SAGE STP, magnetic tapes could be entered directly into the SAGE computer. Not only was this less expensive than film, it provided greater quality control and enhanced realism—for example, in the capability to suppress radar returns from tracks that had been "splashed."

The nationwide installation of SAGE STP began in March 1958 at the New York air defense sector and concluded with the Sioux City air defense sector in December 1961. During this period, the program was installed in twenty-one sectors and five divisions. In 1963, SAGE STP was also installed at the Northern NORAD Region in Canada.

The very first SAGE system training exercise, featuring a full complement of direction center personnel at McGuire Air Force Base, gained fame as a model of SDC's ingenuity. The simulation went smoothly until the weapons director attempted to scramble interceptors against an unknown aircraft—and absolutely nothing happened. SDC's Dr. Joseph Fink, suspecting a mechanical defect, raced to the communications floor where, after a brief conference with the communications manager, the two found an inoperative relay. Fink wedged a toothpick between the contacts to free the relay—and air defense, albeit simulated, was on its way.

Between July 1957 and July 1960, SDC's human factors staff delivered some nine hundred STP exercise packages, totaling over two thousand hours of exercise material, to the Air Force for use in SAGE, manual, or combined air defense exercises. From its modest beginnings in the Systems Research Laboratory in 1952, where it was used with an IBM electronic calculator to produce simulated radar data on multifold paper, the STP computer complex had grown by 1958 to 125,000 instructions on the IBM 709. With the advent of SAGE STP, BUIC STP, and other variants of system training, the total STP computer program complex would ultimately approach 750,000 machine instructions.

To meet the prodigious needs for system training, SDC had by 1959 become one of the largest private employers of social scientists in the nation. The Human Factors Department's 500 people included 130 Ph.D.s—110 in psychology and 20 in allied fields. Another 30 Ph.D.s served in management and administration throughout the rest of the company, for a total of 160 doctorate-degreed employees, imbuing SDC's systems approach with a uniquely humanistic man-machine orientation.

The pathfinding technology of the System Training Program—with its built-in simulation, recording, training, and exercising—would influence the design of future test and training systems, from aircraft simulators to the Apollo test missions.

Above and beyond STP's training effectiveness was its economy, which saved the government millions of dollars. The cost of operating STP on a continentwide basis for one year was estimated to be less than the cost of conducting one single live exercise involving fifteen aircraft and seven sites.

Over a quarter century, SDC's original contract was to lead to some three hundred training contracts. Not surprisingly, this training expertise would be put to good use inside SDC itself.

TRAINING AN INDUSTRY

"... Rand is far too busy to take on the problems of industry. Besides, its charter forbids it to do so. But it does offer this hopeful thought. Men trained in its System Development Division may become a source of supply for directors of future automation projects.... "

These words, appearing in *Business Week* some eighteen months before SDC started operations, accurately prophesied the role the company was to play in training thousands of programmers, system analysts, and system training experts who would shortly occupy the ground floor of the emerging data processing industry. Questioned on this topic, veteran SDCers are quick to recall:

"We trained this country's first three thousand programmers."

"There were no systems programmers before SDC."

"Whatever company I visit, I meet two or three SDC alumni."

"We trained the industry!"

As validation of the personnel overflow into industry, by the end of 1960, along with 3,500 SDC employees, there were already 4,000 *ex*-SDCers; by 1963, SDC had 4,300 employees while another 6,000 past employees were "feeding the industry."

Beginning with the expanded System Training Program contract, SDC had been recruiting psychologists and other human factors personnel, as well as a small number of programmers for

STP data processing. Human factors candidates were scouted at college campuses, professional conventions, and research laboratories. Recruiting consisted of personal contacts by the company's large doctoral contingent, word of mouth, and individual recommendations, with little need for formal advertising.

But recruitment of programmer trainees—initiated in the fall of 1955 to meet the spiraling needs of SAGE program development and installation—was another matter. Hardly anybody in the country understood what a programmer was or did, and most of the 1,200 programmers who coded for the early machines were doing either batch business processing or scientific calculations, in neither case qualifying them to program systems "from the hardware up."

Indicative of the state of the profession was a 1955 survey which reported, "Most of the companies which will use computers have repeatedly stated: 'It is much easier to teach our personnel to program than to teach outside experienced programmers the details of our business.'"

When Harold Willson was hired in February 1956 to take charge of the recruitment program, he was told that he might be hiring as many as two hundred people. Instead, as both SAGE programming and the System Training Program mushroomed beyond expectations, Willson's staff would be hiring some seven thousand people over the next five years.

Willson, SDC's director of Employee Relations until his retirement in 1981, instituted a nationwide advertising campaign through trade journals, newspapers, and radio; opened an East Coast recruiting office in New York City's Hotel New Weston (moved to the Empire State Building in 1959); and dispatched recruiting teams throughout the country to fill quotas which in some months reached seventy-five programmer trainees.

"We looked for good logical minds and a math or science background," recalls Hal Willson. "We avoided high-pressure tactics—for example, flashy pictures of our new buildings or the palm-lined beaches of Santa Monica, since the large quotas for field personnel subjected everyone to possible relocation."

Interview crews scheduled appointments in the larger cities and usually spent three full days from early morning to midnight screening and selecting applicants. Candidates were first given a battery of psychological tests, Thurstone Primary Mental Abilities and Thurstone Temperament Schedule, which SDC's researchers had validated as reasonable predictors of programming success. The interviewers then briefed those persons who passed the tests on the assignment and probed their interest in the programming field by asking them—in the words of one ex-recruiter—"whether they knew what it was." The most promising candidates received on-the-spot or telex offers.

The campaign was effective: five hundred trainees were hired by May 1957; many times that number had to be contacted and interviewed. Two years later, in the first six months of 1959, SDC's Personnel Department conducted 2,850 interviews for exempt positions, resulting in 700 offers and 500 acceptances. In the same period, SDC received nearly 10,000 inquiries for non-exempt positions, interviewed 4,000 persons, and hired 300.

Starting salaries for programmer trainees were on a par with most entry-level positions in the mid-fifties: $350 per month for inexperienced applicants, $400 for those with applied mathematics backgrounds, and $450 for persons with advanced degrees. Most applicants were satisfied with their salaries; few took cuts to enter the programming field at SDC. Hal Willson recalls one applicant who enthused, "My mother will never believe I'm earning $350 a month in a legitimate business."

Hiring hundreds of persons into a brand-new profession was one challenge met by SDC; converting them to proficient SAGE programmers within the time constraint of two months, without validated training standards or curricula, was another. Here the corporation enjoyed a distinct advantage. For who were the hundreds of professionals working on the System Training Program if not expert trainers?

As early as September 1955, an internal training program for field training specialists had been initiated in Santa Monica. It soon expanded into the alma mater of many early SDCers—"Bogie Tech," named after its founder and indefatigable teacher, Dr. Robert Boguslaw.

But the main training action—between 1955 and 1957—was in the East, in Lexington and in Kingston, New York, where seven hundred employees underwent programmer training before being sent to field sites or remaining to develop the SAGE master programs. The earliest training featured only an eight-week IBM course on programming the Q-7 computer. In January 1957, SDC augmented this offering with another eight weeks of advanced training in the SAGE programs. By mid-1957, the corporation was providing the complete programming course in Lexington and Santa Monica.

The course was intensive: a daily regimen of six hours of lectures, two hours of study with instructors, and generous amounts of homework. By the end of the second week, students were running simple programs on the Q-7. Instructors attributed the subsequent high performance of students to hard work: "Our philosophy is to load students up just beyond their capacities so that thoughts of code and equipment become automatic."

SDC's success in employing troops of novices to produce the difficult SAGE programs on schedule and with few hitches cannot be ascribed solely to fortunate selection and training techniques. The enthusiasm and dedication of those who worked on this landmark project may be unmatched in the history of data processing. Interview after interview of SAGE veterans evokes this spirit: "fantastic morale... totally fascinating project... never been done before... worked all day and studied at night... complete team effort... vital mission to the country... worked with the giants... spirit of inventiveness" and similar inspirational comments.

The large programming contingent was young—89 percent were between ages twenty-two and twenty-nine—and high-spirited. Most felt that the location of the Lexington training classes was singularly appropriate: space limitations at Lincoln consigned them to nearby Murphy Army Hospital—next to the psychiatric ward. In Kingston, SDC commandeered two motels to provide office space for its two hundred programmers, while in Lexington eight large prefabricated "Butler" buildings next to Lincoln Laboratory housed the working population of three hundred and fifty SDCers, plus other major contractors and Air Force personnel—eight hundred people in all.

To relieve the strains of work and study, pranks and horseplay abounded. For a time, when SDCers entered the guarded entryway to the Butler buildings, they announced themselves under the names of comic strip characters whose faces they had pasted over their badges. Without looking up, the guard would dutifully repeat and log the name: "L. Ranger, K. Kong, D. Tracy." After several days of these high-jinks, a stern directive was issued stating that since such people did not exist, they would no longer be allowed in the Butler buildings.

In the fall of 1957, some months after complete responsibility for SAGE programming had been turned over from Lincoln to SDC, the bulk of the eastern contingent, consisting of five hundred families and their household goods, was brought to Santa Monica in special trains chartered by SDC. Some were returning home; most were seeing the land of sunshine and oranges for the first time. They settled in California, forming the core personnel in SAGE programming and augmenting the staff in system training—two vital air defense projects that grew from 125 professional personnel in 1956 to 1,400 at their 1962 peak.

By 1958, hiring to replace attrition had become a serious concern, as termination rates of 20 percent per year for data processors were taking their toll. On the average, four years after their start date, 50 percent of programmer trainees had left the company; after seven years only 30 percent remained. Of the reasons cited for leaving, terminees mentioned money most frequently.

As explained by Dr. Biel, "We would give the trainees good raises every six months but were limited by Air Force salary guidelines. By the end of the second year, many ambitious young people with developing families could go to Northrop or Litton and double their salary." M. O. Kappler adds, "Part of SDC's nonprofit role was to be a university for programmers. Hence, our policy in those days was not to oppose the recruiting of our personnel and not to match higher salary offers with an SDC raise."

The other reason for terminations resided, ironically, in the evolution of SAGE. By 1958, the adventure of creating the archetype man-machine system had been supplanted by the important but less challenging jobs of modification, error correction, and installation. Just as the topdown structure of SAGE systems and subsystems cascaded into a giant pyramid, the hundreds of programmers working on specialized SAGE subfunctions—like the Identification Officer position, or the "forwardtell" program, or the Bomarc module—found themselves encased in specialized blocks of that pyramid with minimal opportunity to move upward or sideways.

As a corporate programmer survey summarized it, "The terminees do not foresee for themselves the opportunities they want for professional growth and development, for increased diversity in their work and consequent broadening of their experience, or for promotion and advancement. At the same time, their training and initial experience in a rapidly expanding field puts them in considerable demand. Changing employers gives them an opportunity to increase their salary, broaden their experience, and, if they are fortunate, find work which is more challenging and satisfying. That they do not always do so is suggested by the substantial proportion of former employees among the experienced personnel hired by SDC."

As the pioneer in programmer training, SDC conducted research to validate and improve its programmer selection process and to contribute to the store of knowledge in the young field. Early findings showed that men and women exhibited no difference in training course performance; majors in mathematics and physical science obtained slightly higher average course grades than others; and trainees without college degrees performed as well in training courses as those with degrees.

Through the years, SDC's programming curriculum was modified to include new languages, techniques, and machines, in keeping with technological advances, the demands of the expanding contractual base, and the changing backgrounds of new generations of trainees.

In July 1954, all the computer manufacturers together provided 2,500 student weeks of programming instruction. Three years later SDC spent more than 10,000 student weeks instructing its own personnel to program.

"We trained the industry. . . "

THE JOVIAL PROGRAMMERS

As the SAGE development was being brought under control early in 1958, SDC found itself with a resource of two thousand uniquely trained and experienced personnel, equipped with an arsenal of forefront technology, all working on a single contract for one customer—the Air Defense Command—and with no clear charter to diversify or compete. The SAGE programming and training work, still going strong, was certain to diminish over time. The burning question "After SAGE—what?" became a paramount concern for SDC management.

Fortuitously, the next major contract walked in the door in March 1958, in the form of a young lieutenant colonel from the Strategic Air Command. According to Kappler, the gist of his message was: "General LeMay has seen SAGE in action and wants something like it, so that SAC commanders will know at any time where their forces are deployed. Would you be willing to undertake a feasibility study for us?" As in an earlier inquiry on willingness to tackle SAGE programming, Kappler assented quickly.

In April 1958, SDC began a six-month study to examine SAC operations and develop preliminary design recommendations for a new SAC command-control system. A five-man team headed by Dr. William R. Goodwin was dispatched to SAC headquarters and various field units to perform the design study. SAC incorporated SDC's recommendations in the specifications of its new system.

By August 1958, SAC had invited some twenty large electronics firms to submit proposals for the job of serving as prime integration contractor for the new SAC Control System, or SACCS. Since SDC was the logical organization to develop the software, some of the contending prime contractors, like IBM, Hughes, and RCA, contacted the corporation for its interest in teaming. Kappler and the SDC Management Committee decided that, as a matter of both business ethics and good strategy, SDC should offer its services to all twenty competitors during the proposal phase. When International Telephone and Telegraph (ITT) won the award, it selected SDC as the software subcontractor after some "encouragement" by the Air Force. SDC's second major contract was signed in February 1959.

SACCS, also known as the 465L system, is a worldwide communication network linked to computers and display systems. Its purpose is to provide SAC planners and decision makers with up-to-the-minute user-oriented displays of weapons status at each SAC base, locations of all SAC bombers, the "enemy's" troop and plane movements, worldwide weather conditions, and other information vital to SAC planning and control.

For the first time, SDC had the exclusive software design responsibility for a major information system. After a rigorous system analysis, SDC designed and wrote the computer programs and devised a system training package. As in SAGE, development of a real-time command-control system of this magnitude and complexity represented a formidable challenge. The SACCS operating system for the large IBM AN/FSQ-31 computer exceeded a million instructions—over four times the size of the SAGE operating system. Another 300,000 instructions were used for the ancillary IBM 709/7090 and 1401 and the AN/FYQ-5, for which SDC built one of the first automated message switching systems.

Many of the design features of SAGE were incorporated in the executive control program for SACCS, along with such innovations as priority program interrupt, permitting the mixture of real-time and "background" processing; dynamic core allocation, facilitating the moment-to-moment loading of programs and data into available blocks of memory; and automatic error recovery, enabling the system to recover from most equipment faults without human intervention.

To accomplish the SACCS mission, a new SDC organization, the SACCS Division, was established in April 1959. Headed by Dr. H. Riley Patton, the division was headquartered in a leased facility in Paramus, New Jersey, close to the SACCS prime contractor, ITT's International Electric Corporation (IEC). The first set of SACCS personnel started trickling eastward to Paramus from Santa Monica in 1959. In June the staff numbered 200; by the end of 1959 it grew to 360; and one year later it was 550.

Clark Weissman, SDC's chief technologist and deputy general manager of the Research and Development Division, joined the SACCS team in April 1959. "Our first assignment," he recalls, "was to write a specification detailing how SACCS would communicate with the other military computer systems then in operation or being developed, including SAGE, the 438L intelligence system, the 433L weather system, and others. This was one of the earliest attempts to deal with diverse, frequently incompatible, communication and security standards—research problems that continue to challenge us today."

One of the most innovative long-term contributions to spring from SACCS was SDC's development of a higher-order language for command-control systems: JOVIAL. Prior to SACCS, programmers coded in machine or assembly language, writing one instruction for each discrete step to be performed by the machine. This procedure, though often resulting in very efficient programs, was expensive, time consuming, error prone, and required detailed understanding of the specific characteristics of each new machine.

Even in the earliest days of programming, the need was recognized for a "higher-order" language that would permit the writing of programs in "near-English," in code that was independent of particular machines, and in statements that were automatically expanded to a number of machine instructions. Several such languages were emerging—FORTRAN for scientific applications and COBOL for business data—but none for the mixture of numbers, data, and real-time processing that characterized command-control systems.

Before the SACCS contract was signed, Kappler recalls, Don Madden, then director of Information Processing, approached him with senior programmer Jules I. Schwartz in tow, saying, "Kap, I want you to hear this!" Schwartz then explained his ambitious plan to develop a new higher-order language for SACCS, concurrently with SDC's design of the system, and in time to program the massive amounts of code in the new language.

Schwartz was uniquely qualified to recommend this approach. Having joined Rand in 1954, he had programmed several of its computers and participated in the conception of an early higher-order language, PACT, under the leadership of Wes Melahn. In the fall of 1955, as a member of the "second five" Rand programmers to go to Lexington on SAGE, Schwartz helped implement the all-important compool program.

On his return to Santa Monica, he spent a year "playing with concepts for language and compiler techniques" based on the recently published International Algebraic Language (IAL). Schwartz worked with a research team including Erwin Book and Harvey Bratman, who were shortly to develop CLIP, the Compiler Language for Information Processing, another source of influence on JOVIAL.

Given his exposure to language development, his familiarity with the compool which would form a major component of the new language, his knowledge of the distinctive language requirements of a command-control system like SAGE, and his conviction that there must be a faster, cheaper, and better way to code such systems, Schwartz put forth a persuasive proposal.

Yet the risks of this approach were high. No major system had ever been coded in other than machine or assembly language. Further, the proposal meant delaying SACCS programming until a yet-to-be-conceived new language, including its translators (called compilers) for the several different SACCS machines, was developed, tested, and documented. After extensive consultations with Madden and the SACCS management team, however, Kap gave his approval.

Schwartz arrived in Paramus in January 1959 and gathered a team of a dozen people to help design the language and develop compilers for the IBM 709 (later replaced by the 7090) and Q-31 computers. The first version of the language was developed in an incredibly short time of four months. Schwartz recalls the hasty creation of the data-definition capability, the original heart of JOVIAL. "When we realized we couldn't postpone it any longer, we developed it in about thirty minutes. Henry Howell and I examined each possible data type and structure and developed the syntax for them immediately."

The language received its distinctive and popular name in February 1959. While Schwartz was on a business trip, his programming staff, along with several SAC and IEC officials, decided that the tentative name, "Our Version of the International Algebraic Language," with its resultant acronym "OVIAL," was not appropriate for the virile SAC system. They placed a "J" for Jules (Schwartz) before it, and let it be known forever as "Jules' Own Version of the International Algebraic Language."

A translator for a small subset of JOVIAL was in use by January 1960. The complete IBM 7090 compiler was delivered in March 1961, and the Q-31 compiler several months later—both in time for the programmers to code 95 percent of SACCS in JOVIAL.

Despite its larger size and greater complexity than SAGE, SACCS—the first major system to be coded in a higher-order language—required less than one-half of the programming labor and cost of the earlier system.

Designed specifically for command-control, JOVIAL was cited in the *Communications of the Association of Computing Machinery* of 1972 as "the first language to include adequate capability for handling scientific computations, input/output, logical manipulation of information, and data storage and handling."

Based on its successful use for SACCS, JOVIAL became the standard language of SDC, which used it on nearly all new programming contracts and retrofitted it to SAGE. JOVIAL would be adopted by the Navy and Air Force as their standard command-control language and used extensively by all services, NASA, and industry.

THE SEEDS OF RESEARCH

Springing from Rand and the Systems Research Laboratory, SDC had an ingrained research orientation. The corporate philosophy on research was summarized by SDC Trustee John W. Gardner, who wrote:

"SDC has one overwhelmingly important short-run objective... to provide the best possible service on our present contracts with the Air Force and other agencies. But we also have an extremely important long-run objective... to exercise the utmost creativity in advancing the technological frontier which we now occupy.... To do that we must select and conduct... research appropriate to such a rapidly advancing field. We must recruit and hold the imaginative research scientists.... And having brought them in, we must support their explorations. All this is necessary if we are to be a national resource in the years ahead. No other aim will satisfy the trustees. And no other aim should satisfy any of our clients."

Like other nonprofit corporations, SDC accumulated earnings for growth and development in the form of fees paid by its clients. In mid-1958, with sufficient funds from fee earnings and with its contracts under control, SDC's management was ready to launch a formal research program centered around the new "systems sciences." A Research Committee, composed of Bill Biel, Launor Carter, Don Madden, and several other line managers, was named to select and monitor the projects. In the fall, the program was announced to all employees with an invitation to submit proposals for research they wished to conduct.

Subsequently, three proposals were funded—projects that applied computer technology to medicine, education, and social systems. A fourth program, in business management control, was added in 1959. A fifth project, a large, modern, computer-based facility for conducting many simultaneous laboratory research projects, was under discussion by the end of that year.

SDC's medical data processing project had two objectives: to collect and organize information on data processing in medical science, and to investigate the potentials of computer-aided medical diagnosis, using cardiovascular disease as a test case.

In October 1959, the Los Angeles Veterans Administration became interested in this research program, renamed Project Medic, particularly in the possibilities of patient data automation—the use of computers to gather, store, summarize, and display patient data. A contract was signed which established a joint effort between SDC and the Veterans Administration to study the patient data system in Wadsworth Hospital Center in

West Los Angeles. SDC management was much encouraged to have one of its first research efforts converted into a socially important contract so quickly.

The original intent of SDC's automated instruction project was to investigate the use of computers and simulation for military training. The principal investigators, Drs. John E. Coulson and Harry F. Silberman, soon focused on the use of automation in programmed instruction—a technique in which an autoinstructional device presents lesson material and related questions to students. If a student answers correctly, the response is reinforced and the student is directed to the next item. If the response is incorrect, the student is routed to remedial material.

The research team quickly recognized that the binary nature of the digital computer—in which circuits are in either the "off" or "on" position—made it an ideal tool for implementing the "right/wrong" schema of programmed instruction. After manual experiments with subjects from Santa Monica City College had validated this premise, SDC's Research Committee approved the building of a computer-controlled teaching machine capable of varying its behavior to meet the differing needs of individual students. SDC engineers selected the Bendix G-15 computer for the teaching machine's control unit and built a random-access slide projector to present instructional materials under computer control.

By the end of 1959, the team had devised a control program that was able to skip forward and backward through the material, "branching" each student according to his or her individual response. In the process of this research, SDC had built one of the nation's first flexible computer-aided instruction systems.

The Leviathan project, conceived and managed by Drs. Sidney C. and Beatrice K. Rome, utilized a computer to model the behavior, interactions, and organization of large social groups. In these experiments, live subjects interacted with large groups of organizational entities simulated by the computer, with the objective of providing insights into social decisions and control processes. At the close of 1959, the Leviathan model represented the activities of two hundred individuals and organizations, both real and simulated, operating under three spans of management control in a military or industrial organization.

An analogous project was the Management Control System, originated by Donald G. Malcolm, who joined SDC in 1959 with a background in industrial engineering. This computer simulation modeled many aspects of a business system—the personnel, the resources, the transactions—and obtained informative results in response to the experimenters' inputs of varying schedules, numeric values, and decisions. The system was featured in the 1960 book, *Management Control Systems* (Wiley & Sons), edited by Malcolm, Alan J. Rowe, and Lorimer F. McConnell. A simulation language called SIMPAC developed for this project influenced the design of later simulation languages at SDC and elsewhere.

The management research project closely matched President Kappler's long-standing interest in management theory and practice. An occasional lecturer on these subjects at universities and graduate seminars for many years, both during and after his SDC tenure, Kappler, from the vantage point of 1981, believes that one of SDC's lasting contributions has been to management science:

"SDC's early management not only had a human factors background, but was nurtured on the system training principles of team performance, positive reinforcement, and prompt feedback. This combination produced a unique spirit of openness, cooperation, and team loyalty in all of us, from top management throughout the echelons. With many SDCers having left to teach in universities or to assume management positions elsewhere, I continually see the pervasive effect of SDC's management principles in management training programs and in practice."

In keeping with the SDC orientation toward large-scale, computer-based, action-oriented research, the board of trustees approved plans for a Systems Simulation Research Laboratory in late 1959. The laboratory was to be a general-purpose, interdisciplinary, computerized facility for systems research. Kappler placed Harry Harman in charge of development and subsequent management of the research laboratory.

These five projects initiated a program of research and development which, within a few years, would become one of the largest and most comprehensive in the information systems industry.

CORPORATE SOUL-SEARCHING

SDC's early years were marked by explosive growth—from 1,270 employees at the start of 1957 to 3,500 at the end of 1959, and from contract revenues of $23 million in fiscal year 1958 to $42 million in fiscal 1960.*

To accommodate its increasing population, SDC acquired two more large buildings in Santa Monica in 1959—the Q-7A, erected adjacent to the Q-7 building, which would house the new Systems Simulation Research Laboratory and the research staff; and the Olympic building, whose 210,000 square feet could accommodate nearly as many employees as the other Santa Monica buildings put together.

In addition to the healthy revenue picture, SDC's cash position was almost always positive, despite lags in government payments. As noted by SDC's former controller, Joe B. Scatchard, this favorable financial situation was due primarily to use of the accrual for vacation and sabbatic (vacation bonus) pay as working capital:

"When SDC split from Rand, the vacation monies owed to the ex-Rand employees were transferred to SDC, providing a cash reserve for working capital. We found that the average employee tended to keep about sixteen days of unused leave in the sabbatic vacation account. This left the company with from half a million to a million dollars, depending on the number of people on board. Consequently, our borrowing during the early years was minimal and short-term."

As the decade of the 1950s drew to a close, SDC could look back on its early years—1956 to 1959—with satisfaction. As a new corporation in a new field of technology, it had surmounted major obstacles and resolved many pressing issues: how to spend its fee earnings—on research; how to remain a vigorous and viable organization—through growth and diversification; how to obtain the programming talent needed to staff its projects—through a massive recruitment and training program; and how to best serve

* SDC's fiscal year runs approximately from the beginning of July of the prior year to the end of June of the designated year.

its customers' needs—through excellent performance backed by a vigorous research program.

Yet there were nagging unresolved issues. So far, SDC had grown on the strength of two major contracts, SAGE and SACCS, awarded on merit but without competition. Now that other companies were beginning to develop similar competencies, often with ex-SDC employees, the corporation could no longer be assured of sustaining itself on sole-source (noncompetitive) awards over the long future. Moreover, SDC's competitive edge was blunted by such public-interest policies as operating a "university for the software industry," widely disseminating its research and contract results, and avoiding hard-sell marketing.

"We very early reached the conclusion that sole-sourcing for SDC would end," states Kappler, speaking of himself and others in management. "The question in our minds was not 'if' but 'how' to compete. Continuing as software subcontractor to large manufacturers was a convoluted way of doing things. Our preference was to become system managers, and we hired qualified engineers to point us in that direction. But in our specialty, air defense, the management role was being assigned to Lincoln Laboratory's spin-off, the Mitre Corporation, with whom we would not compete by policy; and the rest of industry had not made up its mind on the proper status of software houses."

On the other hand, the prospects of competing aggressively or diversifying to nongovernment clients were anathema to the majority of the SDC Board of Trustees, who believed such practices to be inconsistent with the company's nonprofit charter to work in the public interest. The stage was being set for a confrontation between the corporation's president and its board on an overriding issue of corporate policy, with little likelihood that either side would back away from its stated positions.

However, with more than nine hundred data processing personnel on board in 1959, as many as employed by the bulk of potential competitors put together, SDC had no immediate concerns for the future. Not only had the corporation survived its early years, it had performed its task well, made significant scientific and technical contributions, and held bright prospects for even greater achievements in the coming decade.

As President Kappler wrote at the close of 1959, "With the passage of time, a corporation, like an individual, matures and discovers more fully its identity, unique abilities, and the services it is most suited to perform. SDC, like most young organizations, has to do some of this 'corporate soul-searching' to understand more fully the missions we can perform to apply our specialized technology and skills for the public welfare and security of the United States. The new decade—the sixties—will be one of startling achievements in science and technology. To these achievements, SDC will make its unique contributions."

CHAPTER 4

The Maturing Years

(1960-1963)

ROADBLOCKS TO EXPANSION

In his "State of the Corporation" talk before SDC's key personnel in January 1960, Kappler took note of the increasing demand for SDC's system services: "Organizations like ours offer the Department of Defense something it can't get in other ways. That 'something' is an unusual mixture of skills, effectively used, and an advanced technology."

Kap then described what he termed a "permanent theme" for SDC activities: "Rather than being as heavily involved in air defense, we will try to get into other Department of Defense activities. We also want to get into areas outside the Defense Department and feel we can do this now without jeopardizing our work for the Department."

Responding to a question about work for clients outside the government, Kappler cited SDC's nonprofit status as a dominant influence. "Since we are exempt from paying corporate income tax, we must be very careful about the kinds of work we take on for nongovernmental organizations. In the foreseeable future, then, we will not be working for profit-making concerns when such work is not related to government activities."

To inaugurate his "permanent theme" of diversification, Kappler established a succession of marketing organizations, none of which endured long. Between 1958 and 1960, David J. Green headed "Advance Planning," intended as a passive "survey the market and pinpoint opportunities" function. In April 1960, Kappler instituted the Plans and Programs Directorate, under Harold P. Field, with a charter to promote new business aggressively. When Field left a year later, the Directorate was placed under Kappler's new director of Operations, Theodor H. Braun. In July 1963, Kappler established the three TAP Directorates (Technology, Applications, Planning), with a much larger central staff, also under Braun, primarily intended to develop new customers, markets, and applications for SDC.

Despite these elaborate structures, Kappler held the corporate marketing reins closely. "I didn't ever let go of the marketing," he recalls. "I felt the company president should be dealing with the generals. I'd grown up with these fellows and they knew and trusted me. My extensive marketing activities [he averaged a trip every other week] were highly visible to the Air Force and no doubt irritated those who wanted SDC to be a passive Air Force captive. In retrospect, the inability to expand our marketing was a defect. Too much depended on me."

With competitors springing up all around, SDC management knew it would have to compete occasionally. Electronics manufacturers like IBM, General Electric, and Litton were developing their own data processing capabilities, gearing themselves to perform on contracts for "total systems"—hardware and software. Small but aggressive software companies were also contesting SDC's rights to sole-source awards. By 1960, these included Computer Usage Company, Computer Sciences Corporation, and Planning Research Corporation; Computer Applications Inc. appeared in 1961 and Informatics in 1962.

While SDCers welcomed competition on technical grounds, competing on price had never been necessary and seemed a demeaning practice to many. Recalls former controller Joe Scatchard, "It was hard convincing some of the less finance-oriented managers that a relationship existed between their overhead costs for management, marketing, and research and their price-competitiveness. When we first said 'overhead,' people thought we were talking about the ceiling."

In line with a trimmer posture, management began to curtail some of the extra employee perquisites, over and above the already substantial fringe benefits of twenty vacation days per year and ample insurance and retirement plans. For example, the freedom enjoyed by some SDC professionals to establish their own working hours—in deference to which the lights in corporate buildings blazed around the clock—gave way to a more standardized work week. The argument that it would fatigue SDC professionals to fly other than first class was uncompelling to the Air Force, which disallowed the costs, thereby ending that privilege for all but a few exceptions. Some time later, the company dropped sabbatic vacation pay, which had added approximately two-thirds of a day's salary to each paid vacation day as an inducement to take time off, and adjusted salaries to compensate.

None of these deprivations struck with the trauma of Black Friday, July 1, 1960: the day the free coffee ended! Empty were the scores of large coffee urns placed throughout the company's many coffee rooms. The Air Force had advised SDC that it could no longer consider the $75,000 annual coffee bill an allowable contract cost.

Freshly brewed coffee continued to be provided in urns as in the past, but now controlled by a vendor-furnished coin-operated dispenser. In no time, SDC's technologists had analyzed this threat, disarmed it, and were obtaining coffee as "freely" as ever. The vendor revamped the equipment and the coffee filching stopped. Now the employees began removing the cream and sugar for their home-brewed coffee or breakfast cereal. Several months of this, and the vendor asked to be relieved of his contract. Regular vending machines were installed, as were spigots with boiling water to make instant beverages. Twenty years later, long-term SDCers would still be referring to the 1950s at SDC as "the days of the free coffee."

The company more than redeemed itself for these unpopular acts when in 1962 it instituted an annual "SDC Night at Disneyland," an evening every September when the Anaheim amusement park would open its gates only to SDC employees, their families, and friends.

While management was taking economy measures that prepared SDC to diversify and compete, at least selectively, the board of trustees remained opposed to such ambitions. "They saw our role as *pro bono publico,*" says Kappler. "In the early days, when we were the only ones with a systems capability, the view of existing solely for the public good was fine. But the world had changed; SDC's long-term viability was in jeopardy, and we couldn't get that message across to the board convincingly."

As if to dramatize Kappler's worst fears, SDC was caught in the cancellation of a major contract in 1960, resulting in its first layoff. The program: the SAGE Super Combat Center. The potential number of employees affected: three hundred.

Striking at the heart of SDC's major source of business, air defense systems, this setback was doubly stunning. Entering fiscal 1960, some $34 million, or 80 percent of SDC's contractual income, depended on the SAGE and System Training contracts with the Air Defense Command. That foundation began to crack as SAGE came under adverse national scrutiny.

At its conception in the mid-1950s, SAGE had represented the latest in air defense technology. Now, in the early 1960s, before its installation throughout the United States was completed, SAGE was becoming obsolete. A new generation of more powerful and versatile technology in weapons, sensors, and data management was trimming the computing colossus of the fifties down to size. The primary threat to national security had changed—from manned bombers to intercontinental ballistic missiles. As a consequence, the SAGE concept, its cost, and its capabilities had been scrutinized and found wanting. In particular, the SAGE direction centers were considered highly vulnerable to blast damage in the event of a nuclear aircraft or missile strike.

To correct this deficiency, the Air Force proposed to replace the SAGE centers with a series of Super Combat Centers or SCCs. The SCCs were to be hardened (blastproof) sites located underground. Operating with new solid-state computers (the IBM AN/FSQ-7A), the SCCs would combine the SAGE direction center and combat center functions in one centralized system.

Early in 1959, the Air Force designated SDC as the logical software system developer for the SCC. The company hired and trained large numbers of personnel in Santa Monica in preparation for this new opportunity. Then, in February 1960, a presidential commission concluded that the SCCs would be a costly and hardly foolproof solution. Though the SCCs themselves might be invulnerable, their extended communications were susceptible to blast damage, rendering the SCCs virtually useless. In March 1960, SDC's contract was cancelled.

The shock to SDC management was severe. Recalls Launor Carter, "We had hired a lot of people for that particular program. Now, for the first time, SDC was going to have to lay people off. That was a traumatic thing for Kap. I remember meetings in which he gave us hell for not going out and getting new work. In some ways, he never forgot it."

Kappler says, "It certainly was frustrating for the biggest and most capable systems company to have to lay good people off. But since we were not allowed to compete actively for major new business, we were absolutely helpless against such vicissitudes."

The problem of how to deal with the surplus personnel was solved by a unique action, vividly though undeservedly referred to as "the slave market." At the time of the cancellation, new jobs were opening up at remote locations: at various SAGE sites, on the SACCS project in New Jersey, and on new contracts in Lexington and in Washington, D.C. Accordingly, each Santa Monica organization with a surplus made those people available to field organizations needing personnel.

For three days, in the Santa Monica Commons Room, several hundred persons on the availability list trooped from desk to desk to be interviewed for other assignments. Anyone offered a job, no matter where, had only two choices: take it or leave the company.

This ritual succeeded in filling openings throughout SDC's field locations and in limiting the attrition due to forced layoffs to fewer than a hundred employees.

It was fortunate for SDC that a combination of aggressive marketing and new systems opportunities quickly filled the yawning gap in contract coverage. At least during the years 1961 and 1962, SDC would benefit from its efforts to diversify and grow under a policy of limited competition.

DIVERSIFYING FOR DEFENSE

THE AIR FORCE "L" SYSTEMS

In December 1959, the company received an important invitation: fifteen of its senior personnel were asked to participate in the Air Force Winter Study Group in Lexington the following month. The Winter Study Group was to address the future of the "L" systems, electronic command-control systems taking shape on numerous Air Force drawing boards. Designed to accomplish various command-control functions—tactics, intelligence, communications, space tracking—these new systems had one common denominator: like SAGE and SACCS, their nerve center was a computer-based display-oriented information system. The invitation was particularly gratifying since SDC was asked to provide more than 10 percent of the 115 participants selected from government and industry.

As the work of the Winter Study Group crystallized, the Air Force instituted new approaches to command-control systems. To ensure compatibility among "L" systems, their development was concentrated at Hanscom Field in Lexington. In April 1961, the Air Force Systems Command (AFSC) was established under General Bernard Schriever, with broad responsibility for development and procurement of all Air Force systems. Former commander of the Air Research and Development Command, Schriever was a leading proponent of the systems approach to large-scale systems acquisition.

Reporting to AFSC were the Air Force divisions for space systems, ballistic missiles, aeronautical systems, and command-control. The special Air Force nonprofit corporations, like Rand, Aerospace, Mitre, and SDC, worked closely for one or several of these divisions, thereby giving the capping agency, Schriever's AFSC, ultimate customer control over the Air Force's nonprofits.

Also reporting to AFSC was the Electronic Systems Division (ESD), whose responsibility for development and procurement of Air Force "L" systems made it a prime customer for SDC. The System Program Offices, or SPOs, one for each "L" system, were also located at Hanscom, transforming the Boston/Lexington area into the promised land for defense contractors.

SDC had maintained a presence in Lexington after transferring the bulk of its SAGE program development activity to Santa Monica in 1957. The Lexington staff, reduced from 550 people in 1957 to sixty in 1958, continued to work, under Roy B. "Blake" Ireland, to develop programs for the Experimental SAGE Sector at Hanscom Field. SDC's eastern operations were augmented by the SACCS project at Paramus, New Jersey, which had grown to 550 personnel by 1960. Thus the company had a substantial foundation of people, facilities, and work experience in the East on which to build its "L" system participation.

In anticipation of several contracts for the North American Air Defense Command, SDC formed its Command Control Division in Lexington in October 1960. Reporting to Division Manager Riley Patton were the NORAD Department, headed by Dr. James W. Singleton, and the SACCS Department, under Dr. Richard Goodwin. (Goodwin would leave SDC in 1965 and subsequently become president of Johns Manville Corporation.)

SYSTEMS FOR NORAD

NORAD's mission is to survey and evaluate potential threats to the North American continent, give warning of impending aerospace attack, and direct the response of defense forces. Headquartered originally at Ent Air Force Base in Colorado Springs, NORAD moved into a man-made cavern in nearby Cheyenne Mountain in 1965.

In urgent need of automating its critical defense systems in the early 1960s, NORAD turned to SDC. The corporation was awarded contracts in 1960 to design and develop the software subsystems for two NORAD "L" projects—the 425L Combat Operations Center and the 496L Spacetrack System. The first, the NORAD COC, was designed to receive priority defense data from numerous remote sources, including SAGE, the Distant Early Warning (DEW) line, the Ballistic Missile Early Warning System (BMEWS), and SACCS; integrate these into a consolidated status picture; and provide the NORAD battle staff with real-time information displays of the aerospace threat and the status of defense forces and operations.

The mission of Spacetrack, which addressed the need for current space data imposed by the 1957 Soviet sputnik launch, was to detect, track, identify, and catalog all objects in space and, like the COC, display the resultant information to the NORAD command for threat evaluation and defense decisions.

SDC's Lexington staff, working closely with ESD and NORAD, developed an interlocking programming system for a triplex configuration of Philco 2000 computers. One machine operated the COC, the second operated Spacetrack, and the third was a backup for both; the Spacetrack system also provided backup for the BMEWS display processor at NORAD headquarters. Besides integrating these and other machines into a unified system, SDC's software provided interfaces to the other systems reporting into and out of NORAD.

After SDC's Lexington staff had specified and produced the NORAD operating systems, both programmed in JOVIAL, they turned them over to the SDC staff in Colorado Springs for assembly, test, and installation. SDC completed Spacetrack, which became the NORAD Space Defense Center, in 1963, continuing to improve it through 1966; and installed the NORAD COC in the underground mountain in 1965. In the 1970s, SDC would play a large role in an upgrade of the Cheyenne Mountain complex.

As part of the NORAD contract, SDC prepared and conducted programmer training courses for NORAD personnel. The objective was to create a "blue suit" capability that would allow Air Force personnel to operate, maintain, and improve the programs without contractor assistance. The "blue suiting" of 425L foreshadowed similar training programs for other systems whereby SDC, in effect, worked itself out of the job of on-site program maintenance. While this practice reduced the company's contract dollars and follow-on opportunities, it was consistent with the corporate mission of building systems oriented toward easy user operation and maintenance.

THE WASHINGTON DIVISION

The expanding market for SDC's DoD systems led Kappler to announce in October 1960, "For some time now, SDC has been considering opening a corporate facility in the Washington area.... With the award of a contract from the Defense Communications Agency, we can now take steps to put this plan into operation."

Within a few short months, SDC had received several contracts calling for performance in Washington: for the Defense National Communications Control Center, the Department of Defense Damage Assessment Center, and the Naval Command System Support Activity. The first anniversary of the Washington Division, reporting to Ben Morriss, would find 250 people working in SDC's Falls Church facility, just across the Potomac in Virginia.

A compelling urgency marked SDC's work on the Defense National Communications Control Center for the Defense Communications Agency. Established in July 1960 to monitor and control the worldwide military communications network for the Joint Chiefs of Staff, DCA had been directed to have an operating communications control center within nine months. DCA, in turn, tasked SDC with automating the DNCCC's communications monitoring and control functions—from analyzing requirements and designing the software to producing the programs on a new computer, the Philco 2000, and training the DCA staff—in five months!

A DNCCC project staff composed of programmers from Santa Monica, Lexington, and Paramus, and a sprinkling of local hires, was assembled within a small building in nearby Alexandria, Virginia. Early arrivals found empty offices, a few pieces of furniture, one carton of office supplies, two telephones, and a typewriter. The challenge was to build from this base an organization and facility capable of supporting the sixty-person DNCCC software development effort.

The high-pressure schedule was compounded by Washington's severest winter in a hundred years. Despite snowstorms, SDC's team worked around the clock to achieve the deadline. A checked-out system was delivered and installed in five months—and twenty-five days! As noted by the project manager, Dr. Ramon S. "Ray" Rhine, "It was less surprising that the deadline was missed than that it was almost achieved."

In October 1960, SDC's mail contained a "request for proposal" from the Defense Atomic Support Agency, asking for competitive bids to develop the Department of Defense Damage Assessment Center—DODDAC. For the SACCS competition, SDC had offered its services equally to all prime competitors. For DODDAC it went further: it submitted an independent software proposal to the customer and also became a member of six competing industrial teams. In December 1960, contracts were awarded to SDC for software, to Control Data Corporation for computers, and to Thompson-Ramo-Wooldridge for displays, under DASA system management.

The DODDAC mission was to assess damage and fallout from nuclear detonations and relay the data to designated military agencies. SDC provided a utility program system, including a JOVIAL compiler; translated DASA contamination and fallout models from the IBM 709 to the CDC 1604 computer; assisted DASA in establishing a data base of nuclear resources; and trained DASA personnel in programming and operating the system.

By March 1963, SDC had delivered some 375,000 computer program instructions representing ten program systems, and 4,500 pages of formal technical documentation, for the fourteen different computers involved in this contract. In 1963, DODDAC was transferred to the Defense Communications Agency and renamed the National Military Command System Support Center. SDC would continue to support this high-echelon agency with systems and services into the 1980s.

SYSTEMS FOR THE NAVY

In April 1961, the Washington office received a contract from the Naval Weapons Laboratory at Dahlgren, Virginia, to develop the new Naval Space Surveillance System, NAVSPASUR, one of the earliest satellite tracking and status reporting systems.

Working under the direction of project manager Bud Drutz, an initial task force of five quickly grew to forty. The group used a JOVIAL compiler to develop a timeshared system for an IBM 7094, processing real-time orbital data in the foreground and satellite calculations in the background. The NAVSPASUR support activity would continue for five years, until May 1966, with successive contracts calling for ever-improved systems. As Drutz observes, "Completion of one SPASUR model only gave us a chance to take a deep breath and plunge into the next one."

In early 1962, the Navy adopted JOVIAL as a standard for its strategic command-control systems. This unexpected decision meant the Navy had rejected two other command-type languages especially built for Navy use in favor of SDC's product. Capitalizing on this event, the company offered the Naval Command System Support Activity (NAVCOSSACT)—the technology arm for Navy command-control systems—a computer program production system and related services designed to ensure the effective use of JOVIAL. The NAVCOSSACT project marked the Washington Division's fourth major contract and its third contract utilizing JOVIAL. A fifth contract, a study in unconventional warfare for the Office of Naval Research, was soon added.

SATELLITE CONTROL SYSTEMS

SDC entered the space field in a big way in October 1961 when the Air Force Space Systems Division selected the company as the Computer Program Integration Contractor for the Air Force Satellite Control System. The effort would grow in two years from a nucleus of twenty mathematicians, data processing specialists, and engineers to a staff of over two hundred.

SDC's first space activity had commenced in 1959 when a research program, Project Horton, was established within the SAGE Computer Programming Division. Initially directed at a potential "marriage" of SAGE with Midas (a satellite for detecting missile launches) and Nike-Zeus (an antimissile weapon), Horton soon shifted to a general exploration of data processing technology for space defense.

In the summer of 1960, assessing the time to be ripe for an SDC thrust into the space market, President Kappler redesignated Horton the Space Systems Project and assigned it to the new Development Division under Thomas C. Rowan. Among many contacts with potential clients, Rowan's staff submitted an unsolicited proposal to the Air Force Space Systems Division, in neighboring Inglewood, for work on a reconnaissance satellite system. This proposal stimulated the Air Force's interest in the application of SDC's data processing capabilities to satellite systems. The eventual outcome, in October 1961, was an award giving SDC the important role of Computer Program Integration Contractor (CPIC) to the Air Force Satellite Control Facility in Sunnyvale, California. Few would have guessed that this contract in a new area of corporate technology would grow into SDC's longest continuous service to a single customer.

The Satellite Control Facility monitors and controls U.S. military satellites once they are in orbit. As integration contractor, SDC's role has been to integrate the onboard satellite software developed by numerous associate contractors with the SCF's central tracking and control systems, build additional interface programs and software for multisatellite operations, maintain the Air Force satellite program library, and operate a backup computer center in Santa Monica to develop and test programs without interfering with the nerve center of the operation, the Satellite Test Center in Sunnyvale.

One of SDC's early contributions was the development of communication protocols between the satellite control network's worldwide tracking stations and the control center. In order to transmit new instructions to remote outposts, such as the tracking station on the Seychelles islands in the Indian Ocean, SDC would send low-speed transmissions which were received at the other end on paper tape and then pasted together.

Major updates, requiring on-site installation, were an even bigger problem at the Seychelles station. "Our programmers first flew to Kenya," recalls Don Biggar, an early CPIC supervisor. "From there, they rode the remaining 1,200 miles to the island in an antiquated amphibian plane, which flew every two weeks when it flew at all. A round trip to the Seychelles was good for a month."

BACKUP AIR DEFENSE

ADC's continuing concern over the vulnerability of SAGE to nuclear blasts, which had earlier given rise to the aborted Super Combat Center, soon prompted another solution: a decentralized system to back up SAGE. Called BUIC (for Backup Interceptor Control), the new system was based on second-generation, solid-state computer technology. The new transistorized machine, the Burroughs AN/GSA-51, required less than one-tenth the floor space of a duplexed SAGE computer, yet performed the equivalent functions.

BUIC operated like SAGE, except that BUIC centers were colocated with air defense radar stations, whereas SAGE centers were separated from their data sources. Thus, even if the communication lines were disrupted, the BUIC center could still operate using information supplied by its own radar site. SAGE continuously fed current information to the backup system, so that at any given moment BUIC could take over air defense from a disabled SAGE center.

Given SDC's software and air defense experience, it was almost a foregone conclusion that the company would be selected to develop BUIC. In June 1962, SDC was given responsibility for operational design, computer programming, and training program development for the backup system. Coupled with its ongoing involvement in SAGE, the BUIC work let SDC look forward with assurance, for the first time since the SCC cancellation, to a continuing role in developing and maintaining the nation's primary, although rapidly obsolescing, line of defense against air attack.

A DELICATE BALANCE

Kappler's theme of growth through diversification was rapidly transforming SDC from a one-contract operation to a broadly balanced company. From 1960 to 1963, SDC had expanded its contracts from six to forty-five, its customers from five to twenty-eight, its revenues from $42 million to $57 million, and its staff from 3,400 to 4,300. Although the Air Force still accounted for 80 percent of total revenues, the SAGE/NORAD contract, which alone had represented 80 percent of corporate business in 1960, had been balanced to 45 percent by 1963.

Besides its major system developments for the Air Force and Navy, SDC was analyzing a warning system for the Office of Civil Defense; automating patient records for the Veterans Administration; programming for NASA's Orbiting Astronomical Observatory; developing training exercises for the Army Air Defense Command; performing command-control research for the Advanced Research Projects Agency; and applying systems technology to law enforcement, education, and urban information systems for state and local governments.

The flexible organization of four major divisions established by Kappler in November 1960 served the company well during its growth spurt. The Air Defense Division, headed by Wes Melahn, was responsible for SAGE/BUIC system programming and training. Under Tom Rowan, a second Santa Monica division, the Development Division, was developing new business areas, including space, national intelligence, health care, and civil government. The two eastern divisions—Command-Control under Riley Patton and Washington under Ben Morriss—focused on diversification within DoD.

By mid-1963, the corporation was also well balanced geographically to address customer needs at the point of origin, with offices at Lexington, Paramus, Falls Church, Dayton, Omaha, Colorado Springs, Sunnyvale, and Santa Monica.

To maintain communication among his dispersed divisions and the corporate staff, Kappler had instituted, in April 1960, monthly Management Council meetings for reporting progress and problems. Replacing the less formal Management Committee meetings held "as needed" since 1958, the Management Council meetings consumed two days, the first for briefings and the second for decisions.

Kappler explained the council's decision-making process. "If everybody agreed, we had our decision. If there was substantial dissension, I'd hear everybody out and then bring it to closure: 'Okay, I've heard you all. Now this is what we're going to do and why. And if it turns out to be wrong, we'll pick up the pieces and go on.'"

In April 1962, Kappler commissioned a study of the value of these marathon meetings, originally stretched to two days to make the trip worthwhile for the large eastern contingent. Reporting on the most recent meeting, the analyst, noting that twenty-one briefers took eleven hours using sixty-one slides, concluded, "There is too much information to absorb or remember." Kappler tightened the meetings.

Despite the impressive results of diversifying, ominous clouds were forming on the corporate horizon by mid-1963. Two years earlier, recently elected President John F. Kennedy had asked Congress to approve a "major effort to achieve a truly unified nationwide indestructible system to assure high-level command, communications, and control." Such major systems were much more likely to be awarded to large systems contractors than to software houses.

Secretary of Defense McNamara's tightened budget policies not only discouraged the proliferation of command-control systems but introduced new measures of accountability, including payment for contract work based on a single prenegotiated "fixed price," in lieu of the traditional "cost reimbursement" with a predesignated fee. The software industry, still groping for accurate prediction models of program sizes and costs, found fixed-price contracting difficult to accept.

Competition in the burgeoning data processing industry was growing so rapidly that by 1963 SDC, although still the largest, was no longer the only qualified developer of command-control software. General Electric had been selected to develop the 412L Air Weapons Control System. IBM was flexing its muscle in command-control software development. A new system or software procurement was likely to attract anywhere from fifteen to thirty interested and capable bidders.

Closer to home, the impact of these events was growing increasingly evident. Whereas new business—that is, business other than follow-ons to existing contracts—captured by SDC for 1961 and 1962 totaled a respectable $26 million and a win rate of 65 percent of the mostly noncompetitive proposal dollars bid, 1963 brought only $3 million of new business for a 14 percent win ratio. The SACCS contract was facing a possible reduction as the customer contemplated its completion in-house.

SDC management's growing conviction that it must compete to survive could not have come at a worse time. Not only was the board opposed, the Air Force opposed, and the industry opposed, but the role, charter, and very existence of nonprofit corporations like SDC were coming under the spotlight of congressional and other high-level government investigations.

Despite these rumblings, solid accomplishments gave SDC confidence in its future. Not the least of them was a broad program of research and development which, in a few short years, had yielded a fertile array of projects. Kappler paid tribute to SDC's technological stance in his 1962 annual report:

"A program of research to keep the corporation at the leading edge of technology will be continued. It is fair to say that SDC has achieved its corporate purpose: it is at the present time a national resource able to provide specialized services in the public interest. But this achievement is not enough, if it is static. The technology, itself, is dynamic; organizations working in this field must also be dynamic—continuously innovative, endlessly creative."

GROWTH OF SYSTEMS RESEARCH

By 1960, the research program initiated two years earlier had proliferated from a half-dozen to some twenty projects. These were dispersed throughout the corporation in the directorates for human factors, data processing, engineering, and operations research. In May 1960, Kappler decided to make the program more visible, both internally and to SDC's customers, and formed a Research Directorate, under Vice President Launor Carter, to build an integrated R&D program in the systems sciences.

At the beginning, all research had been supported by the fee SDC earned on its contracts. Since many research projects contributed to SDC's federal contracts, Kap and the board deemed it appropriate to ask the government to underwrite a portion of the program. Under long-standing agreements between government and industry, this underwriting takes the form of Independent Research and Development (IRAD) funds that are, upon DoD approval of a company's IRAD program, included in the general and administrative expense of contracts. SDC's first IRAD technical plan, describing twenty-eight projects with a total funding of $2.8 million, was submitted to DoD in the spring of 1961.

In January 1962, Kappler and Carter established an SDC Research Advisory Committee to "provide an independent point of view on the corporate research program." Membership on the committee, which met quarterly to review selected projects, included leaders in science and government. Original members were Dr. C. West Churchman, professor of business administration, University of California, Berkeley; Dr. Harry D. Huskey, professor of mathematics and electrical engineering, University of California, Berkeley; General Earle E. Partridge, USAF (ret.); Dr. George E. Valley, Jr., professor of physics, MIT; Dr. Samuel S. Wilks, professor of statistics, Princeton; and Dr. Dael L. Wolfle, executive officer, American Association for the Advancement of Science.

By 1963, SDC's initial fee investment of $87,000 in a handful of research projects had spawned a major R&D program of $3.6 million, with more than ninety professional researchers, aided by fifty consultants, carrying out sixty projects in the system sciences.

MAN-MACHINE RESEARCH

The hub of this research program was SDC's new Systems Simulation Research Laboratory. Dedicated in September 1961, the SSRL marked a milestone in the evolution of the new technology of system development. Housed in a 20,000-square-foot space in the Q-7A building, the laboratory was custom-engineered for the study of man-machine interaction in computer-based systems.

The main experimental area was a vaulting room 2,200 square feet in area and 20 feet high. On the second story, an encircling observation deck with one-way glass and a special audio system enabled the research staff and visiting scientists to observe experiments without being seen or heard. A false floor provided two feet of underground space for rapid rewiring of the terminal connectors used for different experiments.

The high-speed Philco 2000 computer, the heart of the SSRL, was the first transistorized computer announced by the industry, predating the IBM 7090 by several months. A fast and flexible machine by the standards of the day, it nevertheless could not meet all of the SSRL requirements without special adaptation. SDC's Philco became known not so much for its inherent capabilities as for the modifications made by corporate engineers who designed and built real-time input/output buffers, display systems, and a system clock more precise than any commercially available.

The first large-scale experiment conducted in the SSRL was a simulated Terminal Air Traffic Control System patterned after that in operation at the San Francisco and Oakland airports. Selection of TATC as the prototype vehicle, by Launor Carter and SSRL director Harry Harman, reflected the basic tenets of SDC's research: air traffic control was of public importance; its unclassified nature facilitated the sharing of results; and it exercised many facets of SDC expertise as an on-line, real-time, display-oriented system involving large quantities of data, complex decision making, and tactical and strategic operations.

As in the SAGE System Training Program, a simulated environment, down to facsimiles of air traffic control consoles and realistic airport traffic scenarios, formed the testbed for experimenters and subjects. Continuing until 1963, the TATC project was among the first successful attempts to place a nonmilitary system in a laboratory, operate it under computer simulation with human subjects, and record its performance.

Another group of projects, under Dr. Burton Wolin, illuminated the distinctive roles played by humans and by the computer in decision making within man-machine systems. Wolin himself studied the individual in the system, by analyzing the behavior of subjects asked to predict future patterns based on past sequences, with all data presented and recorded by the Philco 2000 computer.

Drs. Gerald H. Shure and Miles S. Rogers, with Robert J. Meeker, used three-person groups to simulate SAGE sector battle staffs faced with constantly changing conditions that require ongoing attention and action. They found that existing theories of decision making based on static situations were invalid, especially when the decisions emerged dynamically over time and were not clearly delimited from one another. This research led to the group's later experiments in bargaining and negotiation behavior which were to contribute a rich lode of findings to the literature of that domain.

Other research projects quickly lined up to use the SSRL. By the end of 1961, the facility contained an automated classroom and various man-machine simulations. During 1963, users logged more than three thousand hours on the machine, the equivalent of two shifts all year long.

FLEXIBLE TEACHING MACHINES

A combination of the post-world War II baby boom and teacher shortages had, by 1960, produced overcrowded classrooms, accelerating the search for alternative ways to teach more students more subjects. The search soon turned to the computer. At SDC, the Education Research staff, led by John Coulson and Harry Silberman, had built one of the first flexible computer-controlled teaching machines on a Bendix G-15 computer in 1959. By 1960 they had established a research base for advancing the use of such machines in new directions.

Quoting the investigators, "We took issue with the prevailing preference in the educational community for 'single-track' teaching machines that presented students with rigid sequences of presumably 'perfect' items equally suited to the learning needs of all students. Instead, we developed a flexible machine responsiveness, in which learning sequences are automatically modified in midstream to enable both fast and slow learners to move at their own pace."

By 1962, the staff had developed self-instructional programs in logic, geometry, elementary psychology, computer programming, and French. The CLASS facility, a Computer-Based Laboratory for Automated School Systems, had been established in the SSRL; pupils from Santa Monica and Beverly Hills schools were brought into the facility for instruction and testing. There, they interacted with the computer by operating switches on consoles to answer questions displayed on television screens, each working at his or her own pace, with the computer handling twenty individual tracks concurrently. As portrayed by Launor Carter, Robert E. Dear, and Harry Silberman in their book, *Programmed Learning and Computer-Based Instruction* (Wiley & Sons, 1962), automated teaching had reached a new level of sophistication.

INTELLIGENT COMPUTERS

In the spring of 1960, three SDC programming instructors with a novel idea submitted a proposal for a "General Purpose Cognitive Language Processing System." The three—Dr. Robert F. Simmons, Lauren B. Doyle, and Donald P. Estavan—had come to SDC with scientific backgrounds and saw in computer technology more possibilities than suggested by their earlier work on SAGE. Their project, called "Synthex," was the first attempt at SDC to program a computer to do things which, if done by a human, would be regarded as evidence of intelligence.

For Synthex, the task was to create a computer program that accepted questions written in "natural language"—in this case, free-form English—and print out answers from a prestored data base through "intelligent" use of contextual, semantic, and syntactic clues. The system was tested initially on a simple vocabulary from *The Golden Book Encyclopedia* and later on more complex texts. For other SDC projects, the test of a computer's intelligent behavior was the recognition of patterns, the competency to solve intellectual problems in games and puzzles, or the ability to prove theorems in logic.

By the summer of 1962, five projects in artificial intelligence were under way under the leadership of Dr. Frank N. Marzocco, a research psychologist with earlier experience at Rand and TRW. Of these, Synthex provided the richest source of insights and technology—the forerunner of a series of natural-language query systems SDC would be developing over the years.

In a related field, under psychologist Dr. Harold Borko, the Information Retrieval Research staff, including Lauren Doyle, Dr. Robert V. Katter, and other investigators in linguistics, logic, and library science, attempted to understand the concepts underlying retrieval of information from documents, with the goal of automating the process. They studied the statistical distribution of words in text, the strategies employed by humans for abstracting and indexing documents, the conceptual structure of libraries, and the potentials of machine-aided document searching.

Aided by contract support from the National Science Foundation and the Air Force, this research soon advanced to the real-world problems of designing information retrieval systems, emphasizing easy communication between users and the system.

MODELS AND PROBABILITIES

Information Processing Research, under Thomas B. Steel, Jr., was concerned with the abstract underpinnings of computing and data processing. Resolutely theoretical, the projects shared a common theme: the development of abstract models—of machines, of programming languages, and of procedures and algorithms.

"Although the detailed models encountered are disjointed and sometimes mutually contradictory," Steel wrote in 1962, "the employment of a common research technique will lead to a rational attempt to locate integrating principles among the various theories."

Steel himself was one of five national participants in the industry-renowned UNCOL project, an attempt to design a standard Universal Computer Oriented Language to translate between higher-order and machine languages. The studies carried out by Drs. Seymour B. Ginsburg and Eugene F. Rose contributed to a theoretical understanding of the operating principles of information processing systems, which had thus far evolved in the absence of theory. The somewhat later work of Robert Risch on symbolic integration of elementary functions was praised in *Science News* of April 1981 as "the Rosetta Stone of elementary calculus."

The discipline of operations research, with its arsenal of analytic tools for studying complex systems, quite naturally found its way into SDC's R&D program. Dr. Elias H. Porter, a premier writer and thinker of SDC's early days, conceived an often quoted analogy in his book, *Manpower Development* (Harper & Row, 1964), in which he compared the approaches of various system scientists to the multifold problem of serving customers in a busy restaurant—solved in all cases by the ingenious "invention" of the spindle on which orders are placed.

One point of Porter's paper was that in any system involving probabilities rather than certainties, organizing work efficiently poses a problem. The problem is heightened in large information systems like SAGE and SACCS, which require complex strategies for sequencing the order of operations and data, based on the probabilistic occurrence of single or simultaneous events.

Dr. Clinton J. Ancker, Jr., led SDC's Mathematics and Operations Research staff through the early 1960s in the development of mathematical and simulation procedures to further the understanding of the probabilistic and sequence-dependent characteristics of systems. The work of Dr. Antranig V. "Andy" Gafarian in recording and analyzing the flow of vehicular traffic through a diamond freeway interchange was representative: originating with the building of mathematical models of queuing theory, it soon shifted to a real problem of freeway design for the City of Los Angeles. The group's lasting contributions to the literature of statistics included Dr. John E. Walsh's two-volume *Handbook of Nonparametric Statistics* (Van Nostrand, 1962, 1965), and Dr. Charles E. Clark's *Random Numbers* (Chandler, 1966).

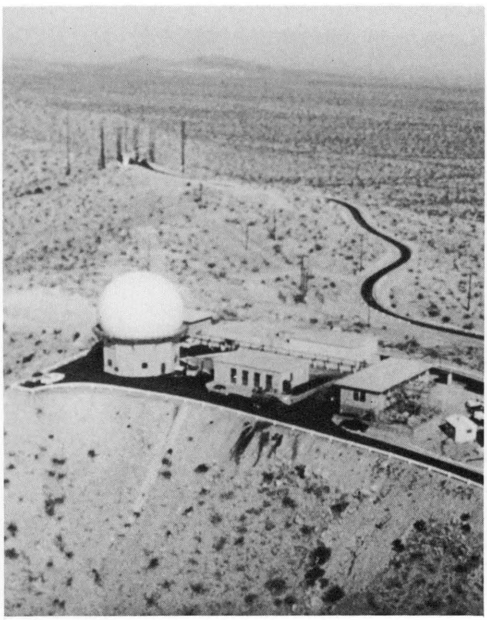
A GENEROUS HARVEST

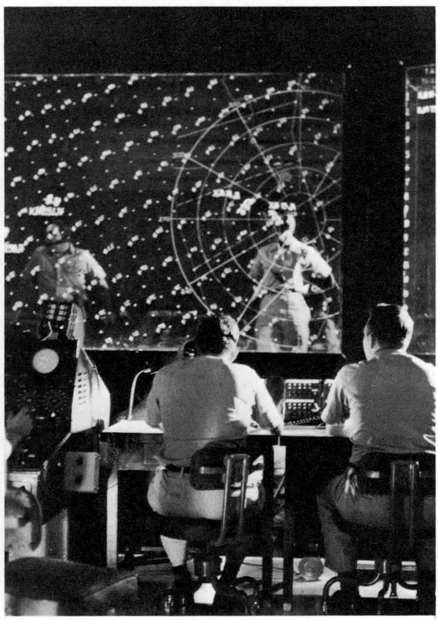
Influenced by its many doctoral research leaders, the research program was oriented toward fundamental research with publishable findings. Its sixty projects attempted to span the range of

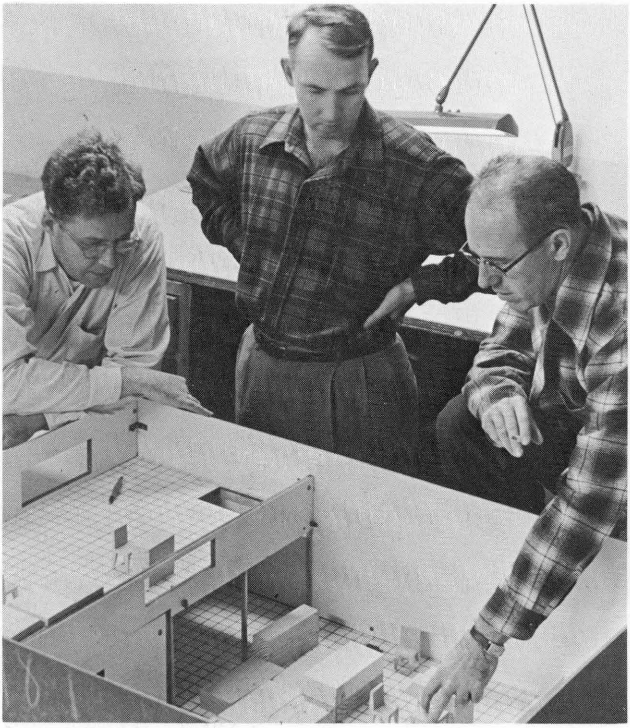
ILLUSTRATIONS

Three sets of photographs, representing three epochs in SDC's history, are placed within their corresponding sections of text.

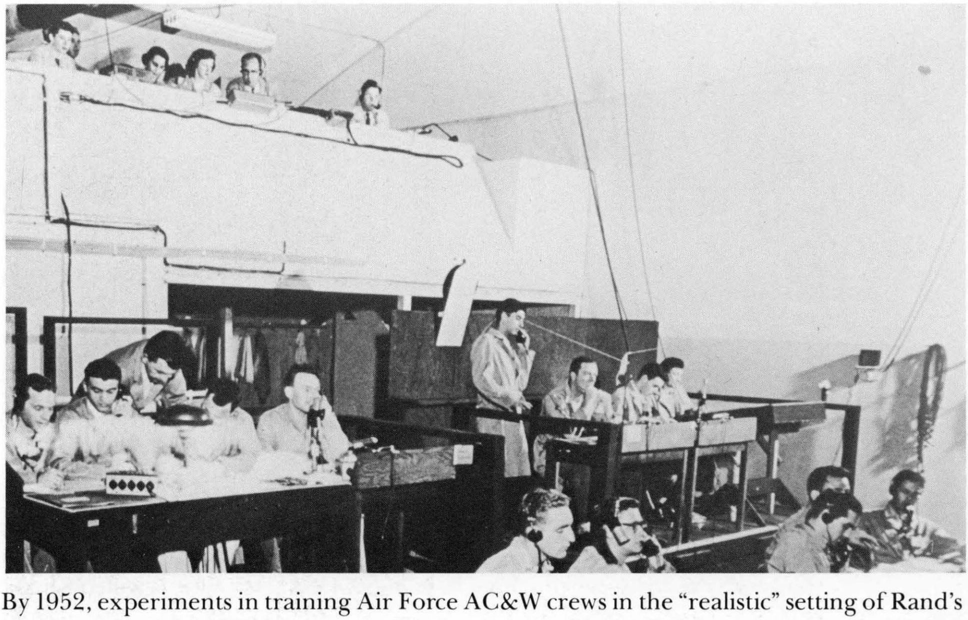
As the world entered the jet age in the 1950s, the vulnerable U.S. air defense system relied on a network of pre-computer air control and warning sites in which radar tracks were plotted manually. SDC was launched during that critical time to apply computer-based systems and training technology to the nation's air defense.







"The start of it all." Pioneering scientists *(l. to r.)* Robert L. Chapman, John L. Kennedy, and William C. Biel examine a model of the Systems Research Laboratory (SRL) in 1951.

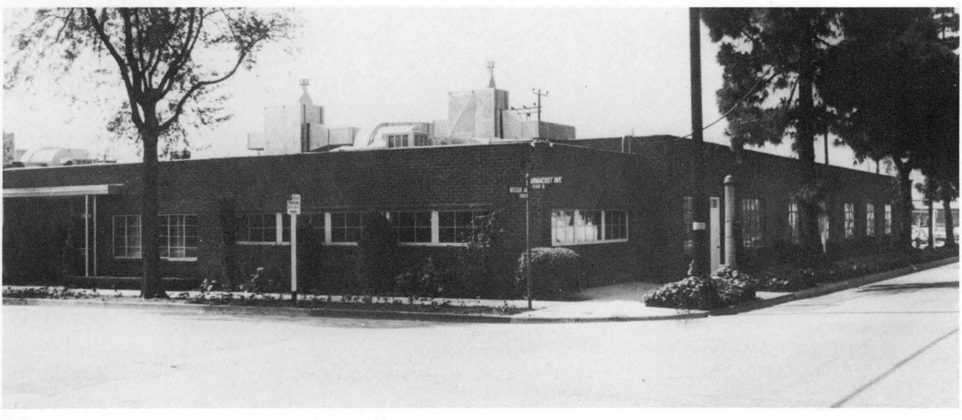


By 1952, experiments in training Air Force AC&W crews in the "realistic" setting of Rand's Systems Research Laboratory were showing measurable performance improvements. Researchers observe from top deck.

Training staff and 40-person Air Force crew of the "Cobra" System Training Program exercise conducted for six weeks in early 1954.

Early locations of the System Training staff in Santa Monica: *(above)* 1505 Fourth Street, where the SRL operated behind the billiard parlor; *(opposite, top to bottom)* another Fourth and Broadway corner, with the third floor "over the gym"; the condemned school building at 1333 Sixth Street; and 1905 Armacost Avenue, home of the Indoctrination Direction Center.

Alka-Seltzer
PRESCRIPTIONS
DRUGS
SANTA MONICA DRUG CO.
SONOTONE
HEARING AIDS
CAL FISH



The Indoctrination Direction Center (IDC) in the System Development Division's Armacost Building replaced the SRL in 1955. Housing a replica of an AC&W direction center, the IDC was used for several years to indoctrinate AC&W crews in the System Training Program (STP).

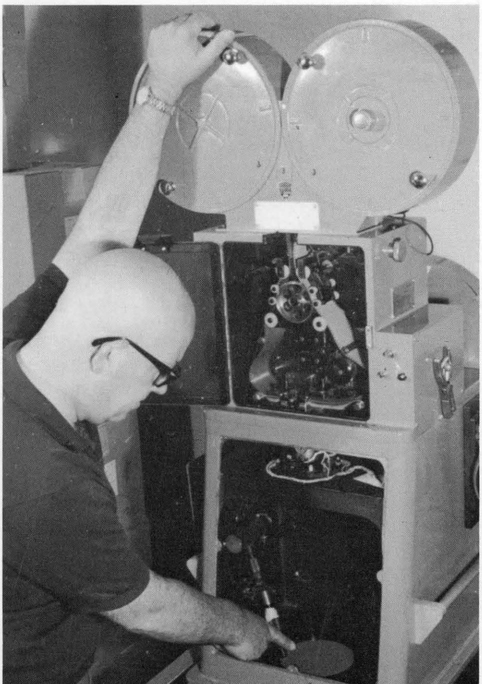
Another view of the IDC. The ground floor contains the air surveillance crew, the second tier the weapons direction personnel, and the third the monitors and observers.

System Development Division co-chiefs William C. Biel *(left)* and M. O. Kappler breaking ground for SDC's 2500 Colorado Avenue building in Santa Monica in January 1956. Looking on are Rand President Frank R. Collbohm and 27th Air Division Commander Brigadier General James W. Andrews.

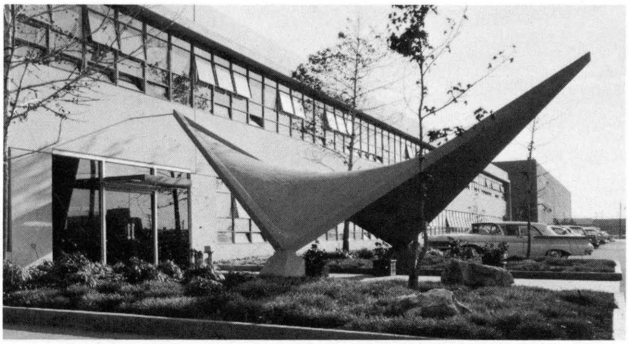
Leaving the 2400 Colorado building after its dedication in January 1958 are *(l. to r.)* Norton F. Kristy, Launor F. Carter, SDC Vice President William C. Biel, SDC President M. O. Kappler, ADC Vice Commander Major General Roy H. Lynn, John D. Madden, H. Riley Patton, and Wesley S. Melahn.

A typical post-exercise debriefing. Participants learn how successfully they "defended" their sector as a crew and individually. Trainers and subjects then consider improvements.

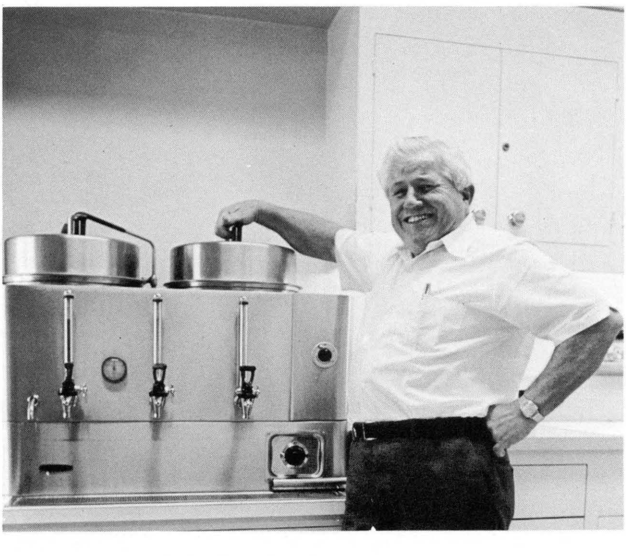
An engineering team headed by M. O. Kappler designed a computer-controlled camera for producing STP problem films. *(Left)* Radar blips were projected onto the face of the cathode-ray tube (pointed at by Elias H. Porter) and photographed by a 70-mm camera mounted above the tube. *(Right)* This component of the "problem reproducer" was used at each radar site to transform the film data into the simulated air picture on the radar scopes of the AC&W crew.



SDC's Santa Monica buildings in 1959: *(clockwise, from right)* 2400 Colorado, 2500 Colorado, Q-7 building, and Q-7A building. The first three were completed by January 1958; Q-7A in March 1959.

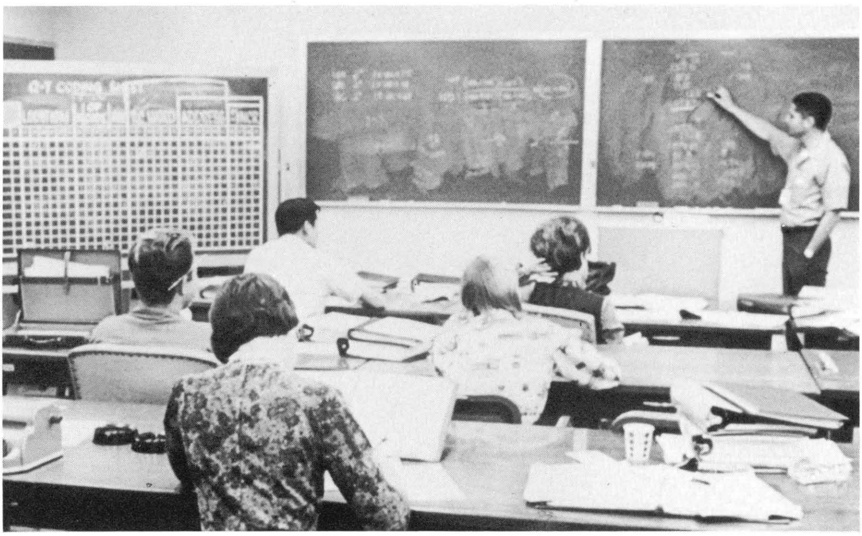


Entrance to the 2500 Colorado building with the "flying diaper" arch, which served as the model for SDC's logo until 1973.



One of the better known faces at SDC was that of John J. Hughes, or "John, the coffee man." From 1955 until his retirement in 1973, John supplied SDCers in Santa Monica with countless gallons of coffee.

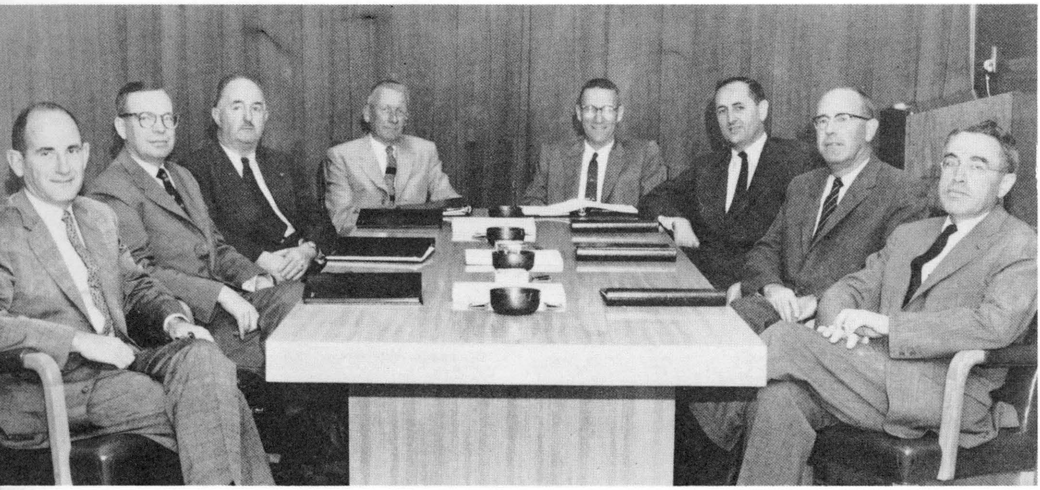
The Butler-type prefab buildings at Hanscom Air Force Base, Lexington, Massachusetts, where 350 Rand/SDC programmers worked from 1955-1957. Another 200 were in Kingston, New York, making SDC the largest employer of system programmers.



A typical session of an early programming class on the AN/FSQ-7 computer and SAGE system.

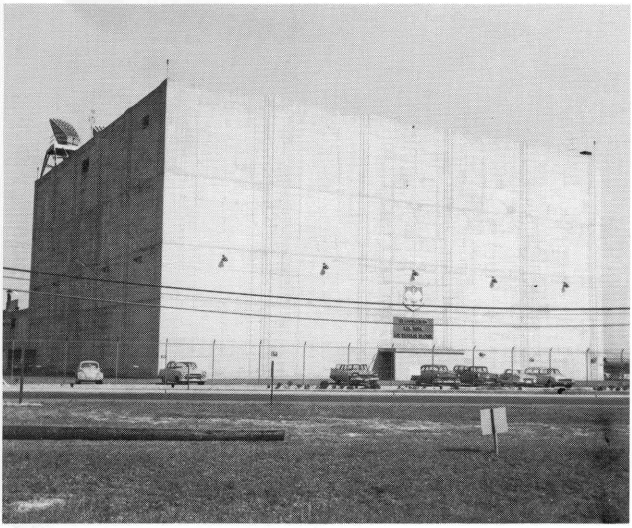
Murphy General Army Hospital in Waltham, Massachusetts, where the earliest SAGE programmer training classes were held in 1955.

Graduates of SAGE programming class no. 13, August 1956, are shown with Programming Department Manager John D. "Don" Madden *(front, third from right).*



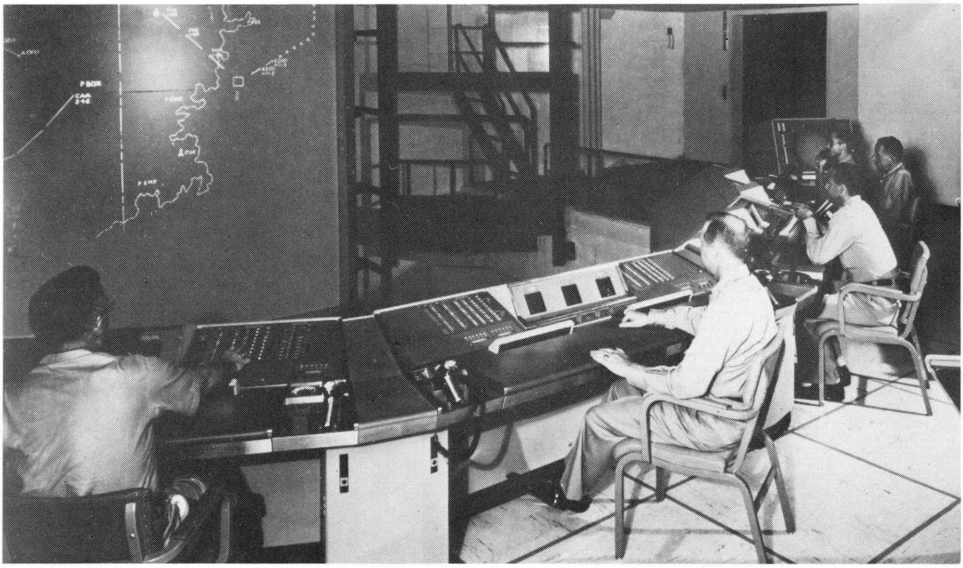
The SDC Board of Trustees in an early meeting in 1958: *(l. to r.)* Vice Chairman J. Richard Goldstein, Edwin E. Huddleson, Jr., H. P. Robertson, Chairman Frank R. Collbohm, SDC President M. O. Kappler, John W. Gardner, SDC Vice President William C. Biel, and William T. Golden.

President Kappler *(left)* in discussion with members of his senior staff in 1958: *(l. to r.)* John K. Herzog, Wesley S. Melahn, and Thomas C. Rowan.



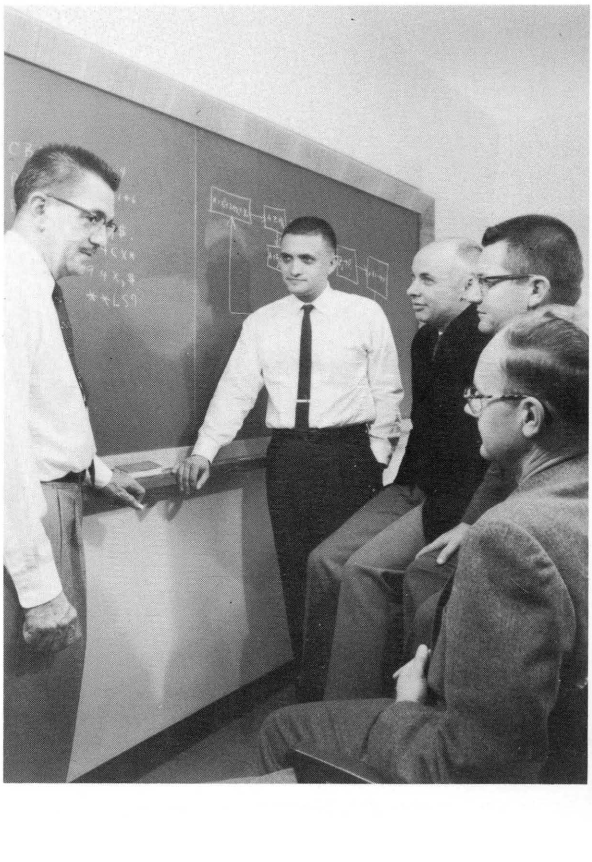
The four-story, concrete-encased, windowless SAGE Direction Center at McGuire Air Force Base, New Jersey, the first operational SAGE sector.

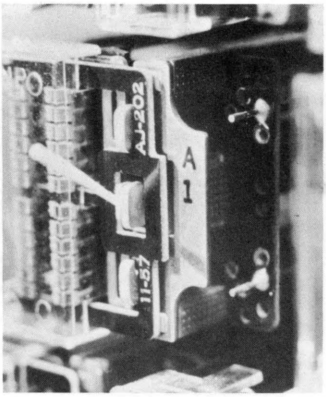
Observing ceremonies marking the opening of the SAGE Center at McGuire Air Force Base, on June 27, 1958: *(l. to r.)* ADC Commander Lieutenant General Joseph H. Atkinson, SDC President Kappler, and NORAD Commander-in-Chief General Earle E. Partridge.



The command post at a SAGE Direction Center. The large-screen display—one of many programmed by SDC—summarizes the area's air defense situation for the sector commander.

Discussing SAGE flowcharting are key managers of SDC's Computer Programming Department in 1958: *(clockwise from left)* V. J. Braun, Richard M. Lintner, Department Manager Don Madden, Herbert T. McGrath, and John F. Matousek.

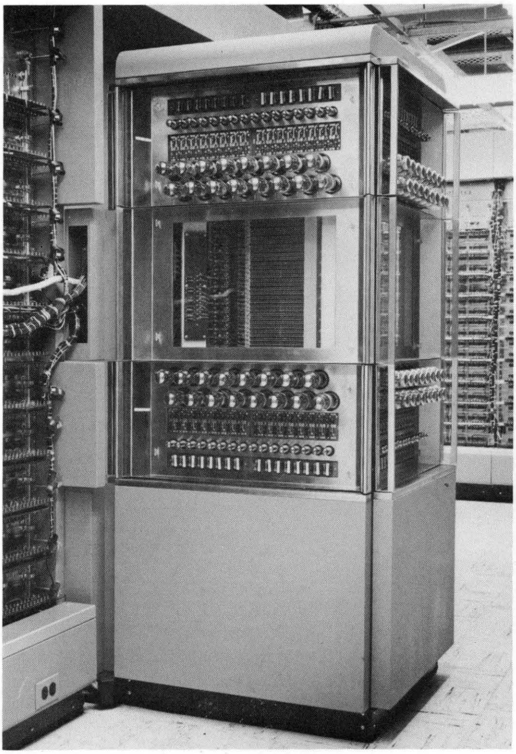


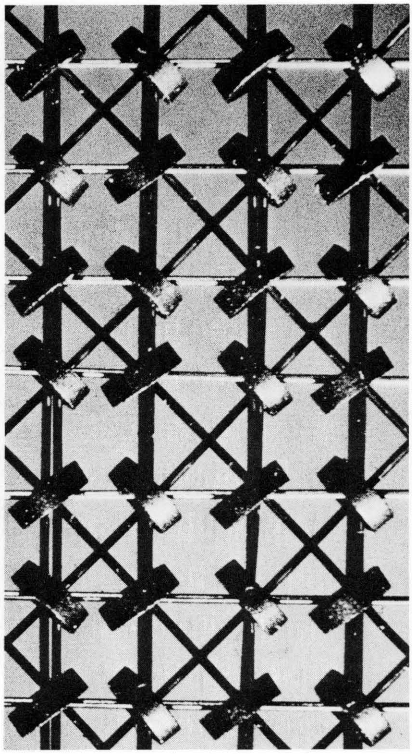


A closeup of the famous toothpick that SDC's Joe Fink used to free an inoperative relay on the Q-7 in March 1958, enabling the first System Training exercise to proceed. A photographer on hand for the event at McGuire Air Force Base captured the shot.

"SDC in the field," at the Syracuse Combat Center in 1958. At top, SDC's on-site training team *(standing, l. to r.)* Romolo L. Raffa, Lorenz P. Schrenk, and Alfred P. Parsell check console action with Colonels William P. McBride (aiming light gun) and William E. Elder, 26th SAGE Air Division; below, on-site programmers *(l. to r.)* Donald D. Berlin, Marla E. Orr, and Mike Weaver check out a new program.

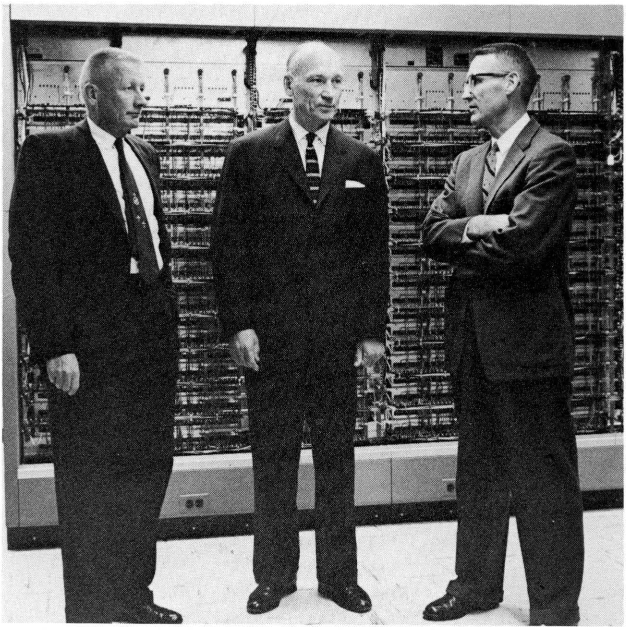
The Blue Room in SDC's Q-7 building was a partial replica of a SAGE Direction Center. Members of the resident ADC Computer Programming and System Training Office (APASTO) supported SDC personnel in operations analysis, development of training scenarios, and program checkout.





The duplex configuration of two mammoth AN/FSQ-7 computers at SDC occupied 25,000 square feet of floor space. Shown are the operating console *(facing page)*, a section of the mainframe *(right)*, a cabinet with the 4,096-word core memory *(top, left)*, and a closeup view of the magnetic cores *(top, right)*.

SDC Board Chairman Frank R. Collbohm *(left),* newly elected Trustee Arnold O. Beckman *(center),* and SDC President Kappler during a 1959 tour of the Q-7 computer at SDC.



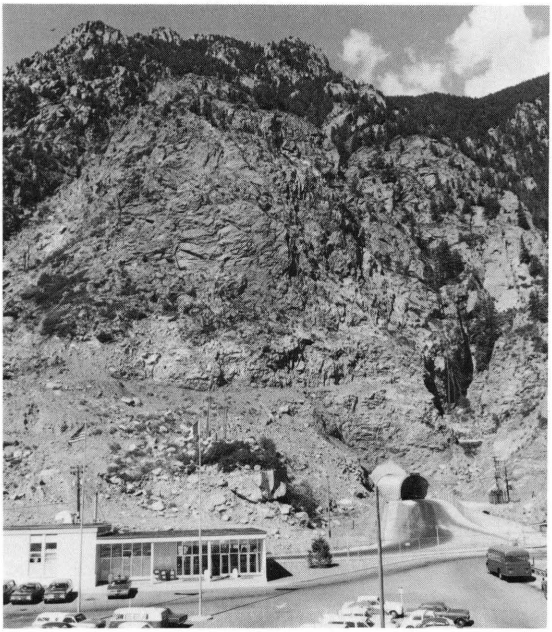
Corporate executives view plans for new Santa Monica building in 1959: *(l. to r.)* James H. Berkson, Launor F. Carter, Donald G. Malcolm *(standing),* Louis G. Turner, Fred G. Suffield, Harry H. Harman *(standing),* John D. Madden, and Wesley S. Melahn.

Attendees at a concurrence meeting on SAGE operational specifications in December 1962: *(at railing, l. to r.)* SDC Division Manager Melahn, Lt. Col. H. G. Christian (NORAD), M. G. Holmen, A. Milbert (Mitre), Lt. Col. G. J. Buer (APASTO), Maj. J. F. Diehl (ADC), Lt. Col. H. J. Mazor (APASTO), D. H. Engel, V. Gillis (Mitre), S. I. Spratt, Maj. D. P. Rehberg (ESD), S. G. Benson. (The SDC symbol—the "bug"—can be seen on the canopy.)

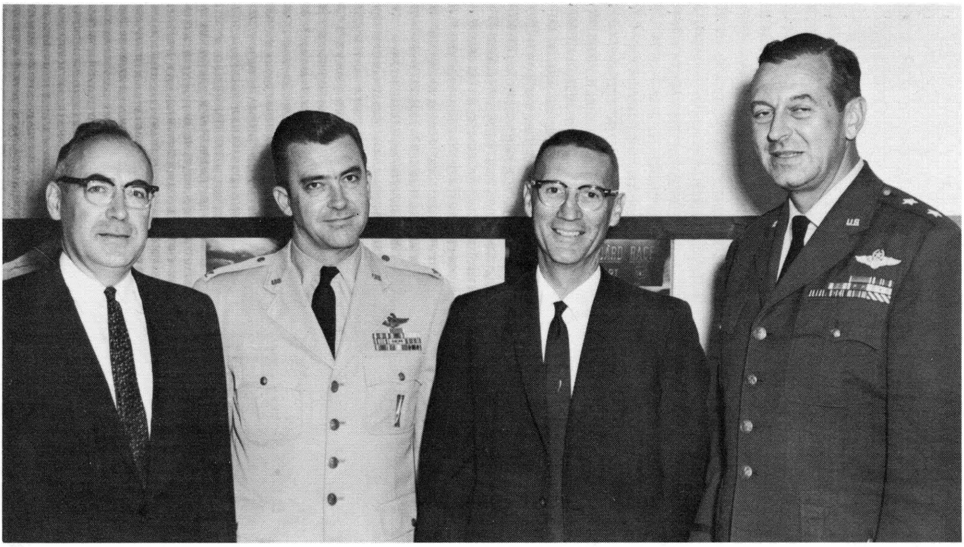
Air Vice Marshal W. R. MacBrien *(right)*, Commander of RCAF's Air Defense Command, visits M. O. Kappler at SDC to discuss implementation of SAGE at the Ottawa sector.

Members of SDC's management team for the SAC command-control system in 1960: *(l. to r.)* James L. Mahoney, Division Manager H. Riley Patton, Harold W. Richmond, Marvin M. Feuers, and Virgil S. Thurlow. After SAGE, SACCS became SDC's second major development contract.

The SAC underground command post, the center of SAC's command-control system, located deep beneath SAC headquarters at Offutt Air Force Base, Nebraska.



In 1960, SDC began work on the programs for NORAD's Combat Operations Center (COC) and Spacetrack systems. Pictured above are the main battle staff positions inside the COC. At left is the entrance to the COC deep under Cheyenne Mountain, where NORAD was moved in 1965.

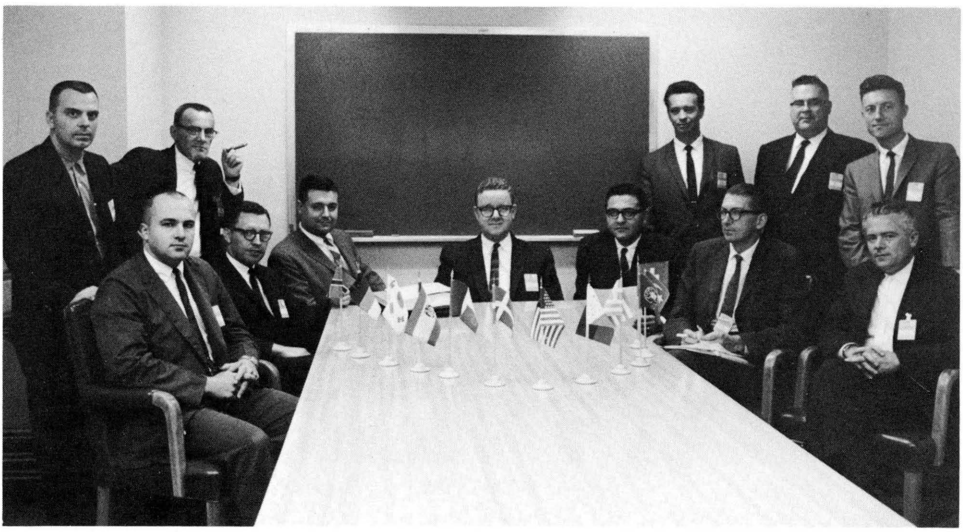


28th Air Division Commander Major General J. D. Stevenson *(right)* visits SDC in July 1960, hosted by *(l. to r.)* SDC Vice President William W. Parsons, APASTO Commander Colonel Sam Galbreath, and SDC President M. O. Kappler.

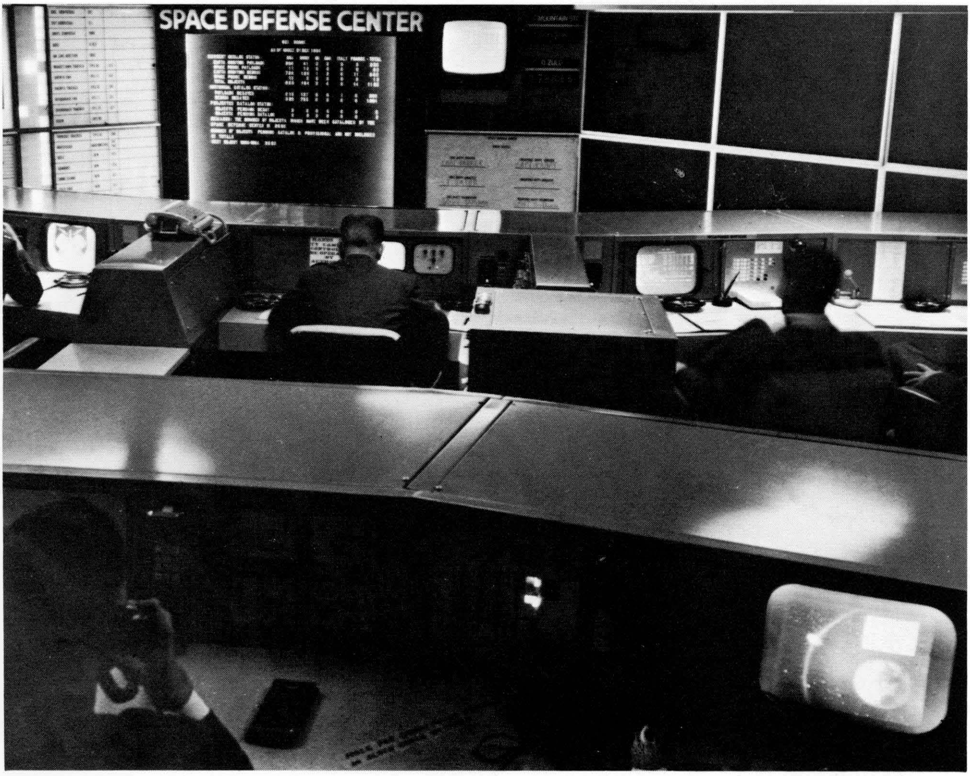
Early diversification. President Kappler *(right)* and Harold P. Field publicize SDC's plans to apply system training in fighting forest fires.

Wesley S. Melahn is made an honorary member of SDC's "Foreign Legion," the company's worldwide System Training Extensions Department, by its manager, Guy G. Besnard.

Global field consultants of System Training Extensions Department meet at SDC in June 1963: *(seated l. to r.)* Neil A. Hofland (Alaska), Donald C. Findlay (European countries), Alfred R. Martin (Spain), Leroy S. Burwen (branch head), Carlos J. Ortegon (Spain), Glenn H. Johnson (Hawaii), and Frank O. Klein (Germany). Standing *(l. to r.)* with Department Manager Guy Besnard *(holding cigar)* are field liaison personnel Daniel A. Fults, Gerald M. Snodgress, William G. Hoyt, and Charles H. Rowan.



Members of the Army Air Defense Command are welcomed to a specification meeting by Air Defense Division Manager Wesley S. Melahn, as SDC extends system training to the Army in 1962.



NORAD's Spacetrack system, for which SDC began software development in 1960, was subsequently designated the Space Defense Center and installed in Cheyenne Mountain in 1965.

A Desk Top concurrence meeting. *(Top)* Conferring on SDC's presentation of the worldwide system training scenario are *(l. to r.)* Colonel Edward C. Gleed, Lieutenant Colonel Stanley A. Rollag, and Lieutenant Colonel Frank Winter (all APASTO), with Wesley Melahn. *(Bottom)* Lieutenant Colonel P. R. Kaufman, NORAD, signing off on the exercise, with personnel from the SDC project team, DoD, and other contractors looking on.

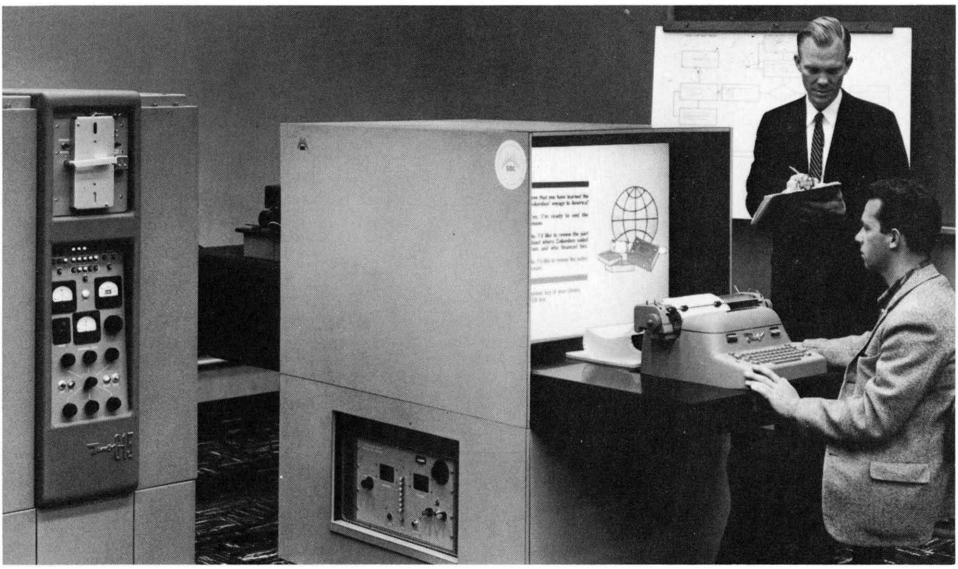
SDC management presents a cake to President Kappler at an informal 1961 luncheon. In foreground *(next to Kappler)* are Wesley Melahn and Herbert D. Benington; Milton G. Holmen is seated opposite.

(Left) SDC President Melvin O. Kappler in a rare pose in formal attire.

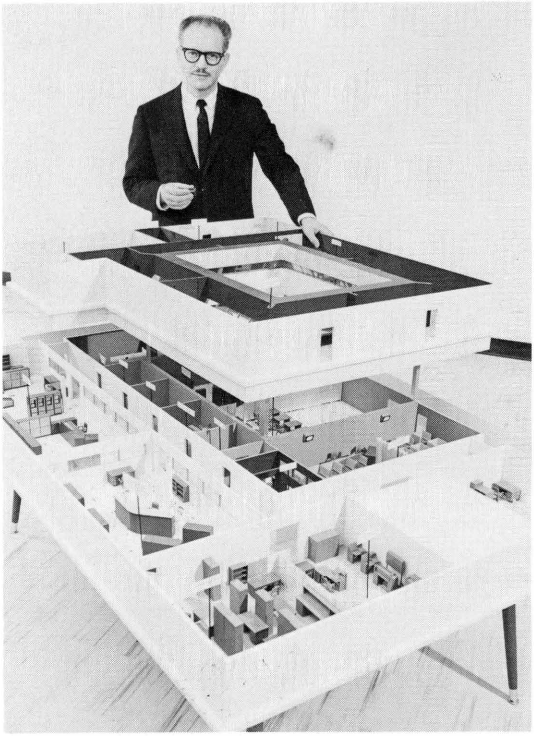
(Left) SDC President Kappler receives his 10-year pin from Rand Vice President J. R. Goldstein. With 13 years of Rand-SDC service, Kappler was one of several retroactive recipients in 1962, the year the service award program was instituted.

(Below) General Curtis LeMay, USAF Chief of Staff, presents the Exceptional Civilian Service Award to SDC's Vice President Launor F. Carter in July 1963 for his contributions as Air Force Chief Scientist during the preceding year.

Veterans Administration officials visit SDC to confer on the company's automation projects for the VA: *(l. to r.)* SDC Department Manager Robert W. Harrington, A. D. Yewell (VA), M. O. Kappler, and General A. T. McAnsh, Deputy Administrator of Veterans Affairs.

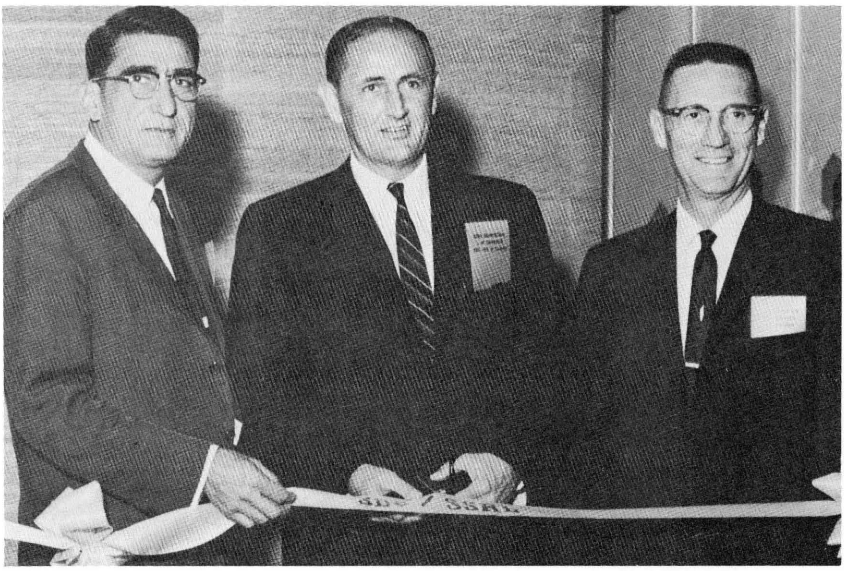


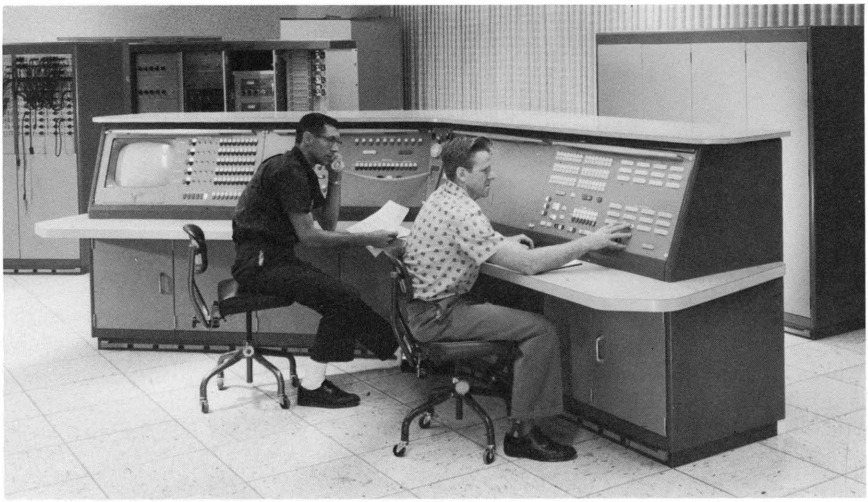
SDC researchers John E. Coulson and Maurice Silber *(seated)* with SDC's first teaching machine in 1959. Linked to the Bendix G-15 computer at left, this device was one of the earliest prototypes of computer-aided instruction.



(Left) Harry H. Harman, developer and manager of the Systems Simulation Research Laboratory, displays a model of the two-story SSRL.

At the ribbon-cutting ceremonies for the SSRL, in September 1961, are *(l. to r.)* Henry F. Argento, Philco Corporation; SDC Trustee John F. Gardner, President of Carnegie Corporation; and President Kappler.





SDC technicians operating special-purpose communication systems built by SDC for the SSRL: the RL-101 (left half), providing real-time communication between the Philco 2000 and many simultaneous experiments; and the RL-102 (right half), enabling participants in an experiment to intercommunicate and observers to hear and record subjects' responses.

Subjects are interacting with SDC's Philco 2000 computer in this 1962 Leviathan research experiment in the SSRL. Photo taken behind one-way glass of observation deck.

Researchers observe an experiment in the SSRL in 1961. From the second-story observation deck *(right)*, researchers *(front to rear)* Lawrence T. Alexander, Milton Ash, and Alvin S. Cooperband monitor operators *(below)* of SDC's experimental Terminal Air Traffic Control system on the main floor.

A highlight for the hundreds of visitors attracted to SDC in the 1960s was the Computer-Based Laboratory for Automated School Systems (CLASS). *(Top)* Planning the facility in the SSRL are senior members of the education research staff: *(l. to r.)* Donald D. Bushnell, John F. Cogswell, John E. Coulson, and Harry F. Silberman. *(Bottom)* Silberman conducts an exercise in CLASS.

the new system sciences: man-machine interaction and simulation, information processing and operations research, artificial intelligence and information retrieval, and automated education and decision making—all embedded in a modern computer-based man-machine facility, the SSRL. Complementing this more fundamental research program was the development of information processing tools, techniques, and languages in Don Madden's Information Processing Directorate.

"The criteria for judging the success of a research program are complex," wrote Launor Carter. "One measure is the number of publications resulting from this work." A bibliography of external publications from 1961 to 1965 shows that the Research and Technology staff published 270 papers in journals, 64 papers in proceedings, 52 chapters in books, and 11 books—a generous harvest from the early seedlings of SDC research.

Besides promoting the writing of technical papers, SDC encouraged its personnel to contribute actively to their professional societies, both to stimulate career growth and to interchange knowledge with other scientists and organizations.

Don Madden, elected chairman of the board of the American Federation of Information Processing Societies (AFIPS) in 1963, recalls, "Not only did SDC purchase corporate memberships in some thirty societies, including the early computing associations, but I had Kap's permission to send about one hundred employees to each Spring and Fall Joint Computer Conference. We were doing our part to assure that these early meetings would be technically and financially successful. It was also a good way of exposing SDC's junior people to the creators of our technology."

The many contributions SDCers made to their peer organizations in the early years are illustrated by a small set of examples.

Eugene H. Jacobs, an early SDC technology manager, served on the governing board of AFIPS and was chairman of the Government Committee of the Association for Computing Machinery. Chairmen of ACM's Special Interest Groups included SDC's Donald V. Black, Erwin Book, Michael R. Lackner, and Tom Steel. Steel was also a charter member of SHARE, the original IBM users group, for which Mort Bernstein and other SDCers later directed long-term projects.

On the human factors side, Dr. Launor Carter was a longstanding member of the board of the American Psychological Association. The Human Factors Society of America, founded in 1957, counted among its initial membership Drs. Lawrence T. Alexander, William Biel, Hudson J. Bond, Robert H. Davis, and Frank Marzocco of SDC. Dr. David G. Ryans, an early SDC research administrator, was elected president of the American Educational Research Association in 1962.

In mathematics and operations research, John Walsh served as president and Kenneth W. Yarnold as treasurer of the Operations Research Society of America (ORSA); Clint Ancker chaired its Military Applications section. Jay B. Heyne was chairman of the College of Management Controls of The Institute of Management Science.

Harold Borko, elected president of the 1,500-member American Documentation Institute (subsequently the American Society for Information Science), was also the author of *Computer Applications in the Behavioral Sciences* (Prentice-Hall, 1962) and *Automated Language Processing* (Wiley & Sons, 1967). Lorry McConnell was one of the founders of the National Classification Management Society in 1964.

Visiting professors for other institutions included Drs. Marvin Adelson, Seymour Ginsburg, Eugene Rose, Harry Silberman, Robert Simmons, and Burt Wolin.

SDCers also wrote and published books intended to make computerized information systems accessible to a wide audience: *Digital Processing: A System Orientation,* by Louise Schultz (Prentice-Hall, 1963); *Introduction To Computer Programming,* by Donald I. Cutler (Prentice-Hall, 1964); *Development of Computer-Based Information Systems,* by Perry E. Rosove (Wiley & Sons, 1967); and *Computers, System Science, and Evolving Society,* by Harold Sackman (Wiley & Sons, 1967). Another forty SDCers served as editors or associate editors for professional journals.

THE ARPA RESEARCH PROGRAM

One of SDC's greatest triumphs, the pioneering of the first large-scale, general-purpose timesharing system, rose like the mythical phoenix from the ashes of one of its earlier disappointments—the cancellation of the Super Combat Center.

In early 1960, in anticipation of the SCC contract, SDC had prepared its Q-7A facility to accept the project's new solid-state computer, the AN/FSQ-7A, subsequently redesignated AN/FSQ-32V. With the SCC cancellation in April 1960, the planned shipment of one of the "Q-32s" in the IBM assembly line went into limbo.

Stimulated by the new "L" system concepts developed in the Air Force Winter Study, research teams at SDC and elsewhere were forming to investigate the potentials of modern command-control systems and to identify new sources of automated support. A team of SDC scientists, including Herbert D. Benington, had been formed in the Development Division under Tom Rowan to formulate SDC's approaches and seek research support from a DoD agency.

After months of discussion with DoD individuals and committees, SDC submitted a draft proposal for command-control research to Rome Air Development Center. At the recommendation of the Assistant Director of Defense Research and Engineering (DDR&E), SDC rewrote the proposal and submitted it in December 1960 to the Advanced Research Projects Agency at the Pentagon.

The proposal described a command-control research program that could advantageously use the Q-32 computer to power a "command research laboratory." DDR&E and the Air Force agreed to have DoD purchase a Q-32 for ARPA and install it at SDC for the performance of command research. The Q-32 arrived in Santa Monica in July 1961 aboard a dozen flatbed trucks; its installation and checkout were to take another nine months.

The ARPA contract, signed in September 1961, brought together a remarkable group of computer scientists, engineers, and programmers, a unique computer, and the determination of a persuasive technical monitor to produce a breakthrough in computer timesharing, resulting in what participants remember as a time of rarely equaled research creativity and cooperation.

The project did not begin on a high note. For the first year, lacking a technical monitor at ARPA and faced with the task of defining a research program with little precedent, the new Command Systems Department, operating under Dr. Paul D. Greenberg, with Herb Benington as technical advisor, worked painstakingly to formulate research activities that capitalized on SDC's resources and would serve the command-control community.

Initially, the staff concentrated on high-level war gaming—commanding and controlling strategic strike forces through simulated conflicts between the United States and the Soviet Union, negotiating strategies, and formulating command decisions. Envisioned was a laboratory that would enable researchers to simulate and analyze the military, political, and economic elements of conflict situations. Until the Q-32 became operational in March 1962, however, little could be done.

In the spring of 1962, the command research staff learned that the ARPA technical monitor was to be Dr. J. C. R. Licklider of MIT, well-known for his strong advocacy of the concept of computer "timesharing." Novel and forward-looking at that time, true general-purpose timesharing was conceived as a system that would enable many users, each possibly located at a different place and operating with a different program, to have simultaneous on-line access to one large central computer, programmed to share its resources so efficiently and rapidly that each user is unaware of the others.

In the meantime, the Command Research Laboratory (CRL) had come into being. Like the adjacent Systems Simulation Research Laboratory, the CRL occupied two floors of the Q-7A building. Here researchers from SDC, ARPA, and other ARPA contractors created information-processing and decision-making environments to represent existing or proposed command centers, including an alternate command post, used to simulate takeover by a backup center during nuclear attack.

The initial projects conducted in the CRL stressed the decision-making and organizational aspects of military command. In the HEMP (Heuristic Economic Military and Political) studies, experiments were conducted in inferring an enemy's intentions from tactical intelligence data. In the related Probabilistic Information Processing (PIP) studies, Bayesian decision theory was used to evaluate alternative hypotheses about enemy intent.

Another project tested subjects' use of computer aids in allocating forces. The results gave the researchers pause: rather than use computer aids to explore complex situations, the subjects used their intuition to simplify problems at the outset, making aids unnecessary.

In September 1962, Licklider's desires prevailed as ARPA reshaped SDC's contract to focus on developing a timesharing system and concurrently ordered cutbacks in other command research projects, freeing sixteen researchers for new opportunities.

Although the ARPA contract had not been granted to implement timesharing, Licklider's insistence, backed by the ARPA high command, settled the issue. An SDC timesharing project was formed, and in December 1962 Herb Benington asked Jules Schwartz, who had established his credentials on SAGE, JOVIAL, and the Q-32's cousin, the Q-31 SACCS machine, to head it. This took persuasion, since Schwartz had just given notice "to join a new data processing company with ground-floor opportunities." Benington's description of the challenge of timesharing proved irresistible. "In retrospect, I'm glad I stayed to be a part of those exciting developments of timesharing and data base systems at SDC," Schwartz reminisced. "I was, however, surprised when Herb left the company the following week."

Licklider told SDC that he wanted a timesharing system running in six months, by the middle of 1963. ("Everything was 'six months' in those days," comments Schwartz dryly.) Not only did the team design and develop an operational system within that time, but a paper describing the Q-32 timesharing system (TSS), presented by Jules Schwartz, Clark Weissman, and Edward G. Coffman, Jr., won the coveted American Federation of Information Processing Societies prize at the 1964 Spring Joint Computer Conference, one year after the project began.

That a design could be completed so quickly and be judged so highly was due to what Weissman calls "an exceptional group of extremely bright and dedicated people who happened to have precisely the right experience for the job."

To make TSS an easy and convenient vehicle for what Licklider called "man-computer symbiosis," SDC developed a variety of tutorial and conversational programs. Sally C. Bowman, who led the development of the General-Purpose Display System for TSS, remembers Q-32 TSS as the "friendliest system I've ever used. Everything was right about that machine: it had a big 48-bit word of eight 6-bit bytes, which meant it worked very nicely in a binary sense. But the most remarkable thing was the timesharing operating system: it had so many features that we still don't have eighteen years later in 1981."

According to *Business Week* of August 26, 1967, "Timesharing is SDC's showcase development: it was the first general-purpose system that could serve a variety of customers from remote terminal devices." The first remote demonstration of TSS, involving a teletype linked to the Q-32 from MIT, was held in October 1963. One year later, TSS demonstrated the first international use of timesharing—from SDC Santa Monica to Copenhagen, Denmark.

In February 1963, Dr. Donald L. Drukey, a physicist with broad experience in command-control, joined SDC to assume directorship of the ARPA program. In the next four years, Drukey and Schwartz were to oversee the fruition of the TSS effort and its expansion into networking, security, and data management, culminating in the pace-setting Advanced Development Prototype system for DoD.

Besides SDC's two large research computers—the Philco 2000 for the SSRL and the Q-32 for the CRL—its Santa Monica facilities housed two SAGE Q-7s, a CDC 1604, an IBM 7090, and several 1401s, prompting President Kappler to state in 1961, "These machines unquestionably make SDC's in-house facilities the largest computer complex in the world."

The value and capability of SDC's scientific and technical personnel had not gone unnoticed by the outside world. Upon invitation, and with management's concurrence, a number of the staff left during 1962 and 1963 to serve in various governmental and other agencies. These included Dr. Jack L. Maatsch, to serve as a member of the DoD Weapons Systems Evaluation Group; Ben Morriss, to accept a position as technical deputy to the commanding general of the Defense Communications Agency; Herb Benington, to work with the DoD Joint Command and Control Requirements Group; Alan R. Marshall, to become technical director of the Naval Command System Support Activity; Robert Bosak, to serve as a member of the Institute for Defense Analyses; Dr. Marvin Adelson, to work with the National Research Council of the Academy of Sciences; John H. Fisher, to become air defense technical advisor to the United States mission to NATO; Donald Madden, to accept the executive directorship of the Association for Computing Machinery; and Dr. Launor Carter, to serve as Air Force Chief Scientist. Some of these, like Fisher, Adelson, and Carter, returned to the corporation when their tour of duty was completed; others did not.

By spending its money on a wide-ranging R&D program attuned to national defense and the public interest, and disseminating the findings therefrom widely and openly, SDC was carrying out its charter to conduct scientific research in man-machine systems. Yet even this premise, as self-evident as it seemed to President Kappler, the board, and the employees, was to be challenged as governmental scrutiny of SDC's corporate life intensified.

TO PROFIT OR NOT TO PROFIT

Following World War II, the Department of Defense established a number of government-sponsored nonprofit corporations (or "NPs") to perform special missions that DoD could not or did not wish to handle internally and that were not appropriate for universities or industry. Despite contemporary references to "hundreds" of such organizations, fewer than a dozen were of any consequence.

The first, Rand, formed in 1948 to provide the Air Force with analytical research and long-range planning, became the model for this new institutional form, the "special-purpose, government-sponsored nonprofit corporation," supplying the military with scientific advice and engineering services.

MIT's Lincoln Laboratory was formed in 1951 for research and development on computer-based air defense. SDC, spun off from Rand in 1956, developed command-control and information management systems primarily for the Air Force. Mitre, formed in 1958, continued Lincoln Laboratory's systems engineering and management for the Air Force. Several universities established the Institute for Defense Analyses to aid the Weapons Systems Evaluation Group of the Joint Chiefs of Staff.

In 1960, Aerospace Corporation was conceived as an outgrowth of TRW Corporation's Space Technology Laboratories to provide the Air Force with system engineering and technical direction for space programs. The Research Analysis Corporation was chartered the following year to continue the work of Johns Hopkins University in weapons evaluation for the Army.

Along the way, several other special-purpose NPs were spawned in a similar manner to perform similar functions. As General Schriever remarked in 1963, "Fundamentally, nonprofit corporations have been created to provide the Air Force (and other government agencies) with an elite and unique technical competence that would not otherwise have been available."

The special-purpose NPs shared many characteristics. Each was created with government participation to meet a particular need. Fees, earned in place of profits, were spent in the public interest, usually for research. NPs generally did not engage in manufacturing. Since there were no stockholders, management was financially and technically responsible to a board of trustees and indirectly to the military sponsor.

At first, industry viewed the proliferation of NPs with tolerance. After all, the big money was in the follow-on hardware production, from which the NPs were excluded. But by 1960, as the NPs continued to grow in size, number, and influence, industry began to take notice. They noticed that the federal R&D budget had grown from $1 billion in 1950 to $10 billion and that the NPs were getting an increasing share. They further noticed that the NPs were attracting some of the best scientific talent from academia and industry. Even more worrisome was the belief that NPs influenced not only the shaping of billion-dollar defense and space programs but also the selection of their contractors.

Industry reacted with a litany of complaints to Congress: many jobs done by NPs could be done cheaper and better by government or industry; the NPs were pirating the best scientific talent with generous compensation packages; the alleged high life style adopted by NPs was a misuse of public funds; the no-risk posture of NPs did not justify the fees they received; NPs could abuse their privileged position by compromising proprietary information from defense contractors. One aggrieved executive lamented in *Business Week* of December 16, 1961, "If something isn't done about the nonprofits and done soon, industry will be nothing more than a hardware maker in the U.S. space effort."

Government responded by launching a series of investigations into the role and conduct of the NPs. The Brooks Subcommittee of the House Committee on Science and Astronautics, headed by Rep. Overton Brooks, commenced its investigation into operations of the NPs in early 1961. The Bell Committee, headed by David Bell, director of the Bureau of the Budget, was initiated in mid-1961, at the request of President Kennedy, to examine government contracting for research and development. This investigation culminated in the Bell Report in April 1962, which led to further hearings by Rep. Chet Holifield's Military Operations Subcommittee of the House Committee on Government Operations.

The NPs were invited to these hearings to respond to questions on their operations. Appearing before the Holifield Subcommittee on August 9, 1962, M. O. Kappler delivered sixteen pages of testimony, including a justification of SDC's compensation package. An SDC salary survey, starting from 1960, showed the average monthly salary of SDC's 3,570 employees to be $554, with 5 percent earning over $1000 and 51 percent earning under $500. The subcommittee found little evidence of excessive compensation or luxuries at SDC.

Collectively and individually, the NPs received a clean bill of health. The Bell Report concluded that it was in the national interest for the government to rely on the NPs; that the choice among alternative suppliers—NPs, industry, academia, government—should be made on the basis of efficiency in accomplishing the work; and that NP salaries and benefits should not be regulated but be comparable to those for industry.

Nevertheless, the NP boat had been rocked and would never find the waters quite as smooth again. And while these broad investigations posed no particular threat to SDC, a more formidable authority, the U.S. Air Force, was laying a weightier hand on the oars of special nonprofits in general and SDC in particular.

A serious setback to SDC's plans for greater independence was a policy statement by Air Force Secretary Zuckert, in September 1961, advocating tight control over all Air Force NPs, including SDC, and requiring coördination with the Air Force before NPs undertook assignments for other government agencies or industry.

This policy highlighted SDC's basic dilemma. On the one hand, the Air Force was genuinely concerned about the dilution of NP resources for its own programs if the NPs worked for other clients. On the other, the Air Force was unwilling, and perhaps unable, to guarantee a steady income for SDC as it did for its other special NPs.

In fact, SDC was very different from the other special-purpose NPs. Corporations like Rand, Aerospace, and Mitre were tied to a single sponsoring command which assured them a prespecified level of income—so-called line-item funding—as annual compensation for the NP's total work effort on a variety of support projects. SDC, on the other hand, was in fact a manufacturing organization—of software systems—paid, by its clients, for delivering specific end products on a contract-by-contract basis. By working for many clients rather than a single major one, SDC enjoyed greater freedom, a situation that the Air Force, which deemed SDC less responsive to its policies and guidance, was eager to correct.

An example of the squabbles that ensued was the refusal of Rome Air Materiel Area, SDC's assigned procurement agency, to approve SDC's $28 million Air Force budget for fiscal year 1962 unless SDC agreed to some fundamental changes. These included: prior Air Force approval of all corporate research to ensure its conformance to DoD needs, reversion of all SDC assets to the U.S. government in case of company dissolution, and a reduction in overall fee.

SDC refused. "We were an independent corporation," states M. O. Kappler, "and very proud of our diversified research program. In no way were we going to restrict it." The impasse dragged on through the last six months of 1961, during which SDC had to borrow money and curtail recruiting while the Air Force withheld partial reimbursements. Ultimately, SDC agreed to a slightly reduced fee but not to the other revisions.

Not until April 1963 were the festering differences between the Air Force and SDC formally addressed in the "Kappler-Terhune Agreement," between SDC's president and the general in charge of the Electronic Systems Division. Shunning specificity, the agreement pledged the Air Force to "provide continuity of effort to assure availability of SDC's resources for Air Force tasks," while SDC would "avoid actions that jeopardize its usefulness to the Air Force" and would "consult with the Air Force before planning programs for the Air Force and others." A tangible concession was Air Force recognition that SDC could conduct a research program in its own interest as well as that of the Air Force.

This solution was short-lived. The opposing forces were gathering momentum, the pace of events quickened, and the last six months of 1963 were dotted with a series of dramatic confrontations involving Kappler, the trustees, and the Air Force, whose outcome would hold lasting consequences for SDC.

SHOWDOWN AT FORT HUACHUCA

On the morning of March 4, 1963, SDC department manager Richard M. Lintner carried a large parcel onto an airplane bound from Los Angeles to Tucson, Arizona. In Tucson, he rented a car and drove some two hours to Ft. Huachuca. There he delivered, by the required deadline, to the Electronics Research and Development Agency of the U.S. Army, an SDC proposal for a five-year development program, to result in a Command Control Information System for the 1970s, also known as CCIS 70, in a highly competitive procurement, at a price of approximately $30 million.

In the early stages of this proposal, Kappler and others in management had informally mentioned SDC's intention to bid to senior Air Force personnel and to the trustees, though it is uncertain that anyone understood the magnitude of the work and price at that time. When all proposals had been submitted, half a dozen companies complained about the "unfair competition" from nonprofit SDC. One competitor contacted its senator, who notified the Holifield Subcommittee and the Air Force. Seriously annoyed by SDC's action, General Schriever warned that if the corporation intended to compete openly with industry, it could no longer expect sole-source Air Force awards.

Reviewing the rationale behind SDC's competing for a major non-Air Force program at what was clearly a politically sensitive time, Kappler recalls, "We were ideally suited for this job, and the Army knew it and encouraged us. It was in the national interest to make SDC's capabilities and experience in command-control available to other government agencies. Moreover, we were facing a staff reduction in SACCS, so the new work would dovetail smoothly without disturbing the manning on existing Air Force contracts."

Concurrently with submitting CCIS 70, SDC was asked by the Army to submit a proposal on the Interim Satellite Communications Control Center (ISACCC). ISACCC resembled the Defense National Communications Control Center, a system which SDC had developed for DCA. Once again, the corporation felt singularly qualified to handle this job and submitted a proposal.

The Air Force did not share this enthusiasm. It had been on the verge of asking help from SDC in preparing a brief to DoD, objecting to the Army's inroads into satellite communications, when it learned that the corporation had bid on ISACCC—the very embodiment of the Air Force's objections.

As related by a senior member of SDC's staff, a high-ranking U.S. Air Force officer called one of SDC's trustees and exploded, "What in the world are you people in Santa Monica doing? You're a nonprofit sitting in a protected environment! Why do you have to compete with commercial industry? You are putting the whole nonprofit concept in jeopardy!" The board was not insensitive to pressures of this sort and quickly made it known to SDC management that a serious reconsideration of SDC's diversification and competitive bidding policies was in order.

Compounding everyone's embarrassment was the strong likelihood that SDC would win the Ft. Huachuca contract. Joe Scatchard and SDC contracts manager Erwin F. Czichos, Jr., attended the preliminary negotiations on April 19, 1963. "We went there several times," recalls Scatchard. "We were led to believe our chances were excellent and that we were in a serious final negotiation."

Finally, on June 27, the long-awaited word came from Ft. Huachuca. SDC had won! SDC manager Robert J. McGill recalls: "We were all jubilant. I was slated to be one of the branch heads, and my family had been set to move for weeks. That same night I signed the papers selling my house."

The next day, however, June 28, 1963, SDC was informed officially that TRW, not SDC, had won the Ft. Huachuca procurement. Although many SDCers detected in this stunning reversal some blue-sleeved twisting of brown-sleeved arms, such suspicions were neither pursued nor corroborated.

The pace of activity grew hectic as SDC's managers met with each trustee to explain their position prior to a planned meeting between the trustees and General Schriever. They pointed out that these Army bids were not unique—that in the past five years, SDC had submitted an astonishing total of seventy-two competitive proposals, of which seven had been awarded. Admittedly, none were on the scale of CCIS 70.

Joe Scatchard recalls his own position: "We maintained, quite accurately, I believe, that it was a one-way street. The Air Force wouldn't guarantee us any funding but wanted us as a captive Air Force supplier. We couldn't survive." And Kappler told the Management Council in June, "If the chips were down, we might be forced to make a choice between continuing to bid competitively and maintaining our sole-source position with the Air Force."

The SDC board itself was in an unenviable position. Most members were by temperament and background attuned to SDC's public-service charter and the needs of the Air Force, but none were unmindful of the need for corporate stability. By 1963, the original composition of the board had changed radically. Frank

R. Collbohm, J. Richard Goldstein, and John W. Gardner had retired at the end of their terms. William T. Golden had been elected chairman in 1961; Dr. Arnold O. Beckman, president of Beckman Instruments, who joined in 1959, became vice chairman. Other recently elected trustees were Charles A. Coolidge, partner in the Boston law firm of Ropes and Gray; Dr. Gaylord P. Harnwell, president of the University of Pennsylvania; Dr. Augustus B. Kinzel, vice president of research at Union Carbide; David Packard, co-founder and partner of Hewlett-Packard; and retired Lt. Gen. Donald L. Putt, vice president of United Aircraft. Physics professor Howard P. Robertson, of the California Institute of Technology, served from 1957 until his death in 1961. The other board members in 1963 were Edwin E. Huddleson, M. O. Kappler, and William Biel.

To provide a cooling-off period and an opportunity for further conferences with Air Force officials, the board in late June placed a 90-day moratorium on all competitive proposals. This decision brought SDC's diversification actions to an abrupt halt, at least temporarily—and possibly, depending on the outcomes of these "further conferences," for all time.

SDC President Kappler remained undaunted and equally firm in his belief that diversification was not only desirable in the national interest but essential to SDC's survival. To test this position, he initiated a series of meetings with senior officials in the Department of Defense, the Air Force, other NP corporations, and members of the SDC board.

Kappler's message reached at least one pair of responsive ears: those of Under Secretary of the Air Force Brockway McMillan. The secretary's memorandum dated August 14, 1963, recognized SDC's distinctiveness among NPs both in size and product orientation and stated the case as follows:

"Whatever the original justification for SDC's special status, there are clear indications that it has been overtaken by events. One significant development has been the growth of industrial competence within fields of SDC interest. This suggests that, realistically, SDC may no longer be the sole source for at least some of the services it now performs."

Recommending that by 1965 SDC be "realigned" and treated like any other contractor, McMillan asked the Air Force Chief of Staff, in conjunction with the Air Force Systems Command, to reexamine Air Force relations with SDC.

During the stormy fall months of 1963, SDC's Management Council debated a multitude of alternatives. In September they split on the issue of remaining nonprofit versus becoming a profit maker as one possible solution to corporate independence, while a third option—dividing the company into profit and nonprofit halves—received few votes. Other alternatives concerned mixed modes of limited and unlimited competition. One serious proposal advocated an interservice review board, under whose guidance SDC would work for all military services, with a guaranteed funding level and without competing.

Kappler submitted several such alternatives to the board, urging their acceptance, and stressing the criticality of the issue: "Some SDC contract work has been cancelled, and our current forecasts are the worst in the history of the company. They call for new contract coverage for six hundred people by July 1964. Vigorous action will be required or else..."

Kappler's entreaties went unheeded. In October, General Schriever responded to the McMillan memo on future realignment of SDC. He remained opposed and reaffirmed his original reasons. He cited a recent meeting with William Golden, in which the SDC board chairman had summarized the board's position as one of wanting to support the Air Force and national security and not desiring to compete with private industry. The ground had disappeared from under those who had somehow not heard this message clearly before.

While the SDC board was convening in an extraordinary closed session in New York City on November 22, 1963, Kappler was realistic enough to read the final signs: although he himself, many of his managers, and probably a majority of the employees favored diversity and growth, SDC had few other champions to promote this "permanent theme," either among the board, in the Air Force, in DoD, among NPs, or in industry. Under the circumstances, he was compelled to resign.

The same afternoon, the board appointed Wesley Melahn, vice president and general manager of the Air Defense Division, as acting president of SDC. By the time rumors of these changes filtered through SDC's Santa Monica hallways about 3:00 P.M., few employees were still on the premises. Starting at noon, many had left for home to join their families in listening to news bulletins of the shooting of President Kennedy in Dallas.

The maturing years under Kappler had been dynamic and exciting, filled with a sense of national urgency and contribution, of new and unique challenges, of expanding horizons and involvement. Kappler would reappear from time to time in SDC's later history, sometimes as advocate, sometimes as competitor, but always with an aura of dedication and energy that inspired admiration. He pursued a successful career as executive officer in the electronics industry until he retired in 1976.

In the years since his resignation as president, M. O. Kappler has not changed his stand on the proper course for SDC in the 1960s. "We should have stood firm," he maintains. "I don't fault the board; everybody was under a lot of heat and pressure. But we should have said, 'We're an independent corporation, and this is what we're going to do!' They couldn't cancel our contracts. Nobody else could do the work. We were the biggest then. And we might have become as big as IBM is today."

CHAPTER 5

The Normalization Years

(1964-1969)

THE ROAD TO INDEPENDENCE

After years of soul-searching, it took the corporation only thirty days after M. O. Kappler's departure to enunciate the results of "some deep and serious re-examination of SDC's purposes and goals," in the form of Wes Melahn's year-end message for 1963:

"SDC has the quality, competence, and uniqueness of capability to justify being selected for tasks on a sole-source basis, and therefore does not enter into competitive bidding." Further, SDC will turn down work "that impairs our ability to serve the Air Force." Finally, the company will limit other sole-source tasks to "new frontiers of technology" which it will promptly vacate "when private organizations demonstrate their capability to undertake such tasks."

Crippling as this policy seemed to most SDCers, it symbolized the reaction, or overreaction, to the company's competitive transgressions. Upon Kappler's resignation, the trustees, with advice from the Air Force, charted unambiguous guidance for SDC's new management: limit future business acquisition to sole-source contract awards; do not compete in any way against anyone, with the exception of other nonprofits (this would be an unlikely occurrence); continue to treat the Air Force as a preferred customer; and defer all matters of policy to the board. Recalls Melahn, who officially became president of SDC in January 1964, "I was primarily concerned with day-to-day operations, while the board addressed the broader policy issues. And there was no shortage of issues in those days."

THE PRESIDENT AND HIS MEN

In their selection of Wesley Melahn as the second president of SDC, the trustees had chosen a man of patience and restraint, well suited to riding out the storms. Having joined Rand in 1948, with one of the first master's degrees in what has become known as computer science, Melahn was thoroughly familiar with SDC's key people, technologies, and customers. After heading the company's early SAGE programming in Lexington, he had become general manager of SAGE Computer Programming and subsequently vice president and general manager of the Air Defense Division.

Melahn's style of management was in marked contrast to Kappler's. Whereas Kappler was regarded as dynamic, extroverted, and sometimes impulsive, Melahn is described by contemporaries as calm, reflective, and deliberate. Kappler liked to maintain centralized control of operations, whereas Melahn moved to a highly decentralized mode. "The division managers frequently made their own decisions," recalls one vice president. Another puts it, "He gave his vice presidents as much headway, incentive, and sweeping aside of the roadblocks as he could. He was, in that sense, a superb manager."

Both presidents were strong advocates of equal-rights programs for employees and applicants. Under Kappler, SDC became one of the nation's first equal-opportunity employers, being named "Employer of the Year" by the local chapter of the National Urban League in 1962. Two years later, in April 1964, Melahn met with President Johnson at the White House for the signing of SDC's Plans for Progress charter, continuing the corporate commitment to equal opportunity.

Kappler's departure was followed by the resignation of several other members of senior management. Three vice presidents left—Ted Braun and Bill Biel in 1964, and William W. Parsons, who had been vice president for Administration since 1960, several years later. Biel, a founding father of System Development Corporation, became an assistant vice president at the University of Southern California and would later serve on SDC's Research Advisory Committee.

To fill these and other vacancies, Melahn's policy, with few exceptions, was to promote from within. In doing so, he assembled a proven technical and management team, having a common background and versed in dealing with the corporation's main customer, the Air Force. However, as he was to comment later, "A weakness may have been that it was too much of an internal group, not adept in the competitive methods and entrepreneurial practices of our competitors as the business changed from a nonprofit mode. But considering our early constraints, an aggressive profit-making attitude might have gotten us in trouble a lot faster."

The first new appointment was that of Richard Lintner to take Melahn's place as head of the Air Defense Division. Having joined Rand in 1954, Lintner had organized and managed the first computing facility of the System Development Division. A popular and respected manager, Lintner elicited strong loyalties in his personnel. Quoting a middle manager, "He was the greatest guy in the world to work for. He was succinct, expected his people to be responsible, and didn't interfere with them." Lintner held a succession of key positions at SDC until his untimely death in November 1967.

Other early appointments included those of Launor Carter as senior vice president and of Charles A. Alders as assistant to the president. Very shortly Melahn simplified his line structure into three divisions: Defense Systems under Dick Lintner, Advanced Systems under Tom Rowan, and Research & Technology under Don Drukey.

RULE BY COMMITTEES

As Melahn and Board Chairman Bill Golden made a fence-mending tour of military commands in January 1964, they found a disturbing number of them preoccupied with drafting policies to restrain SDC.

At the Electronic Systems Division, a group was drafting an "Air Force Management Plan for Utilization of SDC." A restatement of prior policy, the plan reaffirmed SDC's "special status" as an Air Force nonprofit, except that SDC was not eligible for line-item funding; complimented the new management for showing "every indication ... [of] full cooperation in the implementation of a management plan for USAF relations"; and emphasized no competition. The only surprise was a plan of deliberate attrition for SDC, calling for a gradual reduction in the current $47 million of revenues to "a more stable level on the order of $35 million" and, given Air Force success in blue-suit programming, a volume that "could drop to about $20 million."

At the Air Force Systems Command, General Schriever had ordered the drafting of a new regulation to establish an SDC Planning Group, to be composed of representatives of the major Air Force commands, under the chairmanship of the AFSC commander—at the time, Schriever himself. This multicommand group would coordinate, control, approve, and evaluate all SDC activities, while assigning to SDC "only those selected tasks and functions which cannot be accomplished ... by industrial contractors and/or by in-house Air Force resources."

This directive never came into being. As stated by Melahn, "There was no way to define a particular segment of work for SDC that was distinctive from what could be done by the other nonprofits and in-house military staffs on the one hand or by industry on the other. It was a stark reality we had to face."

The next probe was to affect SDC more severely. At Air Force headquarters, Secretary Zuckert had established yet another committee of eight prominent military and private individuals, including ex-SDC Trustee John Gardner, to review relations between SDC and the Air Force. After five months of interviews throughout the military commands and industry, the Goodwin Committee, named after its chairman, Air Force special counsel

Bert Z. Goodwin, presented its findings in June 1964.

The report cited SDC's "unique capabilities... in computer applications as complex and difficult as any ever attempted," with few organizations matching its "competence in the design, development, and production of large-scale real-time computer software, and none its special skills in air defense and system training automation... underscored by the first-of-a-kind challenge of much of its work."

Nevertheless, concluded the committee, it did not follow that just because SDC had special capabilities it should also have special Air Force status. Quite the contrary, argued the report; because SDC lacked a single Air Force mission, sponsor, and line-item budget, its classification as a special nonprofit was "inexact and should not be retained."

Any hope that this opinion would lead to the so-called normalization of SDC into an independent nonprofit was quickly dimmed. The report also stipulated that, in order to maintain the Air Force's confidence in its continued ability to perform on sole-source procurements, SDC should not compete, diversify, or grow.

Instead of loosening the Gordian knot tying SDC to the Air Force, as Melahn and his managers had hoped, the outcome had a more subtle twist. Within six months of the Goodwin Report, in December 1964, the Air Force finally deleted SDC from its list of special nonprofits. Although that action restricted the Air Force's legal basis for regulating SDC's affairs, the guidance of the trustees, matching the restrictive caveat of the Goodwin Report, continued to resist corporate competition, diversification, and growth. More than ever dependent on its new "special relationship" to the Air Force for obtaining sole-source contracts, while still denied the freedom to control its destiny in a competitive environment, SDC appeared to have achieved the worst of both worlds.

For two years, from 1964 to 1966, the company languished in this bridled state, while all around the data processing industry was booming. During the decade of the 1960s, the number of computers in operation grew from 2,500 to 50,000; the amount of available computing power increased five hundredfold; a dozen higher-order languages had swelled to one hundred; and a handful of software companies in 1960 had grown to two thousand by decade's end. Even the smaller of these companies were luring employees with offers of bonuses and equity participation, while investors began casting greedy eyes at the fast-growing electronics market.

Meanwhile, SDC struggled to survive under its self-imposed no-growth or attrition ceiling which, recalls Melahn wryly, "just happened to coincide with what the government people wanted." With SAC's decision to finish 465L in-house, corporate revenues dropped from $58 million in 1963 to $50 million in 1965, remaining in the low $50 million range through 1968. Considering inflation, this flat volume translated to an actual erosion of revenues, confirmed by a drop in personnel from 4,300 in 1963 to 3,000 in 1968—30 percent of the work force.

In mid-1965, a year after issuance of the Goodwin Report, SDC received a boost from an unexpected source. While Melahn was trying to convince the new ESD commander, Major General John W. O'Neill, to relax SDC's constraints, General Schriever initiated a new committee—the AFSC Board of Visitors Ad Hoc Group on AF Relations With the Nonprofit Corporations, focusing on Aerospace, Mitre, and SDC. In December 1965, the committee released its findings in the Johnson Report, named after its chairman, Dean Howard W. Johnson of the Sloan School of Management.

Acknowledging the irony that SDC, by its contributions to the data processing field, had worked itself out of a job, the report stated: "The increased national capability in computer programming and the fact that much of it has been derived from personnel with SDC training and experience, makes it increasingly difficult to justify sole-sourcing of new business to SDC, including new air defense programs."

The Johnson report concluded that the Air Force should "normalize" its relations with SDC, that is, treat the company like any arm's-length contractor. Concurrently, Air Force Secretary Harold Brown, who had replaced Zuckert in October 1965, wrote to General Schriever that he saw no reason why SDC should not compete as it moved to independent status.

"I do not believe that such competition . . . can be considered any more 'unfair' than other situations in which a contractor, profit or nonprofit, is in a favorable position... because of experience acquired from prior contracts.... A far more serious issue, in my view, would be the retention of SDC in a special relationship with the Air Force after the need has been overtaken by events."

It took another six months for the Air Force to issue the paperwork clarifying SDC's new status to all commands. On July 7, 1966, the corporation celebrated its own independence day, as the so-called normalization from Air Force special nonprofit to an independent, competing nonprofit company was officially completed. Thus came to pass an amicable resolution, dictated primarily by the sweep of events rather than by the will of men, of a festering issue that only thirty months earlier had deposed SDC's first president.

In one of his frequent briefings to key personnel, Melahn lauded the decision: "A major milestone—a good event for SDC. There are now no policy roadblocks, no artificial constraints, to limit our ability to make a future for SDC and ourselves. I want all of you to share my optimism, which I believe is completely justified. I have no doubt that great things are ahead for SDC."

As often in SDC's history, the celebration was short-lived. Two months later, in September 1966, the Air Force notified SDC that, given the company's new status, renewal of the ADC contract—the SAGE and BUIC work which accounted for one-half of corporate sales—could no longer be sole-sourced to SDC but would be awarded in open competition. Not only would SDC have an opportunity to compete, but its first major contest would be a fight for its corporate life.

COMPETING IN THE MILITARY MARKET

THE ADC COMPETITION

The Air Force decision to compete the SAGE/BUIC contract for fiscal 1968—i.e., commencing July 1, 1967—posed a make-or-break situation for SDC. At a $25 million value in the prior year, this contract had provided the core of corporate revenues since the beginning of SDC. Additionally, it served as the first real test of SDC's ability to compete in the open marketplace.

In its favor, the corporation was the incumbent contractor—the weathered veteran of SAGE design, programming, and training for over ten years, intimately familiar with the job, the technology, and the customer. Yet this familiar terrain had its pitfalls. In the words of Melahn, "We were oriented to having the customer ask SDC to implement what *we* thought he needed, and then doing the best job that we possibly could. Now the big risk was that we would continue to propose what we thought ADC *ought* to have, rather than proposing the minimum tasks that just met the Air Force's stated requirements."

Moreover, SDC did not have a corner on familiarity with the ADC contract. Many ex-SDCers with SAGE and BUIC experience were now working for the competition. At the Information Systems Company, a subsidiary of Lear-Siegler, the ADC proposal activity was headed by a familiar figure—SDC's ex-president M. O. Kappler—assisted by several senior SDC alumni. Computer Sciences Corporation had ex-SDC department manager Dr. Stewart E. Fliege and other SDC SAGE experts. Other competitors counted among their staffs persons with similar SDC/ADC experience, who understood not only the technical content of the program but also SDC's bidding and pricing practices.

The competition commenced with a bidders' conference on January 24, 1967. Sixteen companies attended: Autonetics, Bendix, Burroughs, Computer Sciences Corporation, Computer Applications Inc., Conductron Missouri of Pomona, Hughes, IBM, Informatics, Information Systems Company, International Telephone and Telegraph, Melpar, Planning Research Corporation, RCA, SDC, and United Research Services.

The competition was scheduled in two phases: a technical proposal followed by a price proposal. The proposals would be evaluated on the basis of 100 points, with the technical proposal counting 70 percent and the cost proposal 30 percent of the final score.

SDC's proposal team was led by Dr. John R. Ottina, assistant manager of the Defense Systems Division under Lintner. Ottina had joined SDC's SAGE computer programming group in 1958 and had advanced through a number of key positions, including that of head of the Data Processing Department, prior to his present appointment. The price negotiations were led by Bernard Fried, who had joined SDC in 1965 as corporate contracts manager.

Under the watchful eyes of Melahn and Lintner, Ottina's team developed the proposal. A Red Team critiqued the draft, deleting any features which, however indispensable they seemed to their inventive designers, were not required in the customer's specification and therefore added unnecessary costs. With the contemporary publicity given to industrial espionage, the company invoked special security measures to protect the proposal and developed it behind locked doors.

On March 6, 1967, four firms submitted their technical proposals: Computer Sciences Corporation, Information Systems Company, Planning Research Corporation, and SDC. The technical evaluation was completed in early April. SDC and CSC were judged qualified and were requested to submit price proposals by May 1.

SDC's price proposal was developed with equal care. Any unwarranted expense was pared. Unlike previous open sharing of cost and price data among nearly all SDC personnel involved in a proposal, the ADC price was known to only five: the controller, Scatchard; the negotiator, Fried; the line managers, Ottina and Lintner; and President Melahn.

In the closest of competitions, with SDC holding a small technical edge, the company won with a price lower by 1.5 percent. As Fried recalls, "Our bid was only $200,000 under CSC's and technically very close. Nevertheless, we were delighted that we had won on both price and technical considerations. It proved that we could meet a well-established profit company head-on and win fair and square. It was a singular achievement we were all proud of."

The negotiated contract value was $14.4 million for the first year, with unpriced options for two additional years, a decided reduction from the $25 million figure of prior years. SDC had succeeded in its determination to bid a barebones program that just met ADC's specified minimum requirements. By competing a minimum-capability system, ADC had also succeeded in trimming its annual cost for SAGE and BUIC software and training by $10 million.

Whether this close win for SDC, which had held the advantages of a ten-year incumbent, signaled a permanent change in corporate posture from sleeping giant to aroused competitor remained an open question. In the glow of victory, those in management who knew the narrowness of the margin must have winced to think that but for a small technical and price differential, one-half of SDC could have disappeared. "We knew we had to diversify from one major contract," says Melahn. "And we did."

THE TRIALS OF COMPETING

By mid-1966, when SDC was at last permitted to compete, there were few new military systems to compete for. The sun had set on the heyday of early "L" systems. Escalating U.S. involvement in the Vietnam War, which the country had entered militarily in 1964, placed increasing demands on conventional weapons, leaving a smaller budget for R&D and new systems. Aerospace marketing and planning had become more uncertain under Secretary of Defense McNamara's policy of tradeoff analyses in a cost-cutting approach to military procurements. Civil unrest, from war protests to urban riots, shifted the spotlight from the military arena to domestic problems and their solution.

Competition for SDC was coming from all sides, including the five inner walls of the Pentagon. A DoD directive of March 1965 asserted the policy of providing programming support personnel for command-control systems from in-service resources, and directed each service to submit a five-year plan for mustering the necessary programming talent internally.

Since SDC's business consisted not only of the front-end development of new systems but also of their ongoing improvement and maintenance—if anything, a recent preponderance of the latter, exemplified by long-term support to NORAD COC, SPASUR, DODDAC, NAVCOSSACT, SAGE, and BUIC—the new policy meant a phasedown of the mainstream business that had kept the company rolling in the early 1960s. It was minimal consolation for SDC to be asked by the Air Force to help develop the curriculum for training blue-suit programmers.

On its own ground, SDC faced more insidious obstacles to marketing success. Virtually no one in senior line management had an industrial or aerospace background, much less one in competitive marketing. One exception, contracts director Bernie Fried, whose work history included Bendix, Bunker-Ramo, and Martin-Marietta, recalls conducting marketing seminars for SDC executives after his arrival in 1965. "I lectured on strategies for making 'bid/no bid' decisions on proposal requests, proper conduct at a bidders' conference, negotiating a 'best-and-final' offer, and so on. Many of our managers had not been exposed to these situations."

Former controller Joe Scatchard states of the 1960s, "Our marketing was spotty. A series of individuals kept shuttling in and out of corporate marketing, so that we never mounted a respectable and consistent marketing effort."

Corporate marketing was a problem that would plague SDC for fifteen years, from 1956 to 1971. The dilemma was expressed by another ex-SDC executive: "When the marketing manager was an SDCer, he didn't know about competing. If he was a professional outsider, he didn't understand software or else wasn't accepted by the other managers. Usually both." With rare exceptions, executives brought in by Kappler or Melahn did not survive long within the close-knit SDC management family.

If management was ill prepared to compete, the typical professional was simply uninterested. "Competing meant a total change in SDC behavior," says Melahn. "Our people had historically obtained their job satisfaction from doing the best possible job for the customer and inventing new features to improve a system. Competitive procurements with price ceilings meant just about the opposite: bidding and performing only as much as would satisfy the customer's minimum requirements without adding uncalled-for improvements."

The spiritless attitude toward competing is vividly recalled by division vice president Frank S. Morris who, shortly after his arrival at SDC in 1967, turned back a draft proposal that began, "The authors wish to make clear that they are not professional proposal writers. . . . "

In this climate, the company won few large competitions for military work during the late 1960s. Instead, it continued to sustain itself on sole-source business, which DoD routinely awarded to many companies for procurements such as add-ons to existing contracts, small contracts not worth competing, and tasks calling for unique contractor competence.

President Melahn's year-end highlights for 1967—eighteen months after the company was permitted to compete—featured primarily old and familiar programs. Besides the competitive SAGE/BUIC win, he cited "deepening involvement with the Army; ongoing projects for the Navy, including an additional antisubmarine warfare study; continuing efforts for civil emergency operations; and work on resource management systems and national space programs."

New military and space contracts during these years included design support for the Air Force Tactical Air Control System—407L; analysis of the ground station for NASA's Orbiting Astronomical Observatory; design of an airlift information system for the Military Airlift Command; development of a JOVIAL-based Space Programming Language for the Air Force (an outgrowth of a 1967 Air Force decision to make JOVIAL its standard language); and development of an automated document handling system for the Joint Chiefs of Staff.

While SDC was struggling to maintain its leadership in military software, the System Training Program kept rolling along. Although SDC's normalization plan stated that STP contracts be competed "wherever possible," the company's leadership in this domain was never seriously challenged.

By 1966, SDC had contracts with the Pacific Air Forces, Alaskan Air Command, United States Air Forces Europe, Army Air Defense Command, Germany, and Spain. The USAF Military Assistance Program called on SDC for system training of air defense forces in the NATO nations of Denmark, Greece, Italy, Norway, Portugal, and Turkey. By 1968, the list included Japan, the

Republic of China, South Vietnam, and Iran. Including SAGE and BUIC, STP sales during the 1960s averaged $10 million annually, or 20 percent of corporate sales.

In the absence of winning any major new program in the five years from 1964 to 1968, compounded by a sharp reduction in ADC work after the competition of 1967, the ability to keep revenues constant was a heroic achievement by Melahn and his management. The feat was accomplished by pursuing and accepting a larger number of smaller contracts. From a corporate base of 100 contracts totaling $50 million in 1965, SDC worked on 185 the next year, 288 the following year, and 387 totaling $53 million in 1968.

Apart from the "bread and butter" ADC and Satellite Control Facility contracts, which accounted for about half of corporate revenues, the average contract shrank from $250,000 in 1965 to $65,000 in 1968. Considering that a number of such "smaller contracts" reached $1 million or more, an even greater quantity yielded $20,000 or less. While a lot of small contracts meant temporary survival, they could not sustain the ambitions for growth of the company or of its employees.

THE SHAPE OF NEW TECHNOLOGY

During the 1960s, SDC broke ground for several technologies that would become prerequisites for systems of the future. One was a new approach to more flexible and user-responsive data management, embodied in the ADEPT system, developed by the Research & Technology Division. Another was a digital communications technology that enabled various commands, operating under different communication standards, to intercommunicate. The latter formed the backbone for SDC's thrust in tactical systems, both for the Vietnam conflict and afterward.

FROM RESEARCH TO TECHNOLOGY

As the corporation made the transition from sole-source to competitive contractor, its R&D program made a corresponding shift from basic research to technology development—in particular, development of user-oriented data management systems. Basic research in computing theory, artificial intelligence, and decision theory gradually gave way to applied research in timesharing, data management, and programming tools. In its early years, SDC's R&D program had yielded publications and prestige; now it was turning out advanced products for use by the corporation's customers.

In February 1964, the Research and Technology Directorates were merged to form the Research & Technology Division under Launor Carter. Supporting Carter were Dr. Frank N. Marzocco as director of Research and Dr. Donald L. Drukey as director of Technology. The ARPA program, managed by Drukey, was folded into the Technology Directorate.

In 1965, President Melahn asked Carter to devote full time to his position as senior vice president and appointed Don Drukey to head the R&D Division. Drukey named Jules Schwartz as director of Technology; Kenneth W. Yarnold replaced the departed Frank Marzocco as director of Research. The two computer laboratories—the Systems Simulation Research Laboratory and the Command Research Laboratory—were merged into a new Computer Center Department under Guy H. Dobbs.

THE GROWTH OF DATA MANAGEMENT

By 1964, system designers were viewing command-control systems in terms of their underlying data management technology. Drukey was a strong advocate for the building of improved systems for user-oriented data management.

"In military applications, the use of the computer is dominated by the data base problem," he declared in a December 1964 briefing. "To the best of my knowledge, the problem is being treated only at SDC." The three key SDC developments in this area were timesharing, LUCID (Language Used to Communicate Information-system Design), and GPDS (General Purpose Display System), which laid the foundation for a new standard in interactive systems: the Advanced Development Prototype.

LUCID, an interactive data management system, impressed observers by its speed and flexibility. In contemporary military systems, such as SAGE or SACCS, the man-machine interaction was rigidly preprogrammed. Changing the format or content of a computer response involved weeks or months of reprogramming. By contrast, the LUCID user could conduct a flexible, instantaneous dialog with a complex data base, browse through data at random, and derive new comparisons and unanticipated relationships.

"Ultimately it is the data themselves that suggest the answers that managers are looking for. They often do not know in advance what they need," said Drukey at the Second Symposium on Computer-Centered Data Base Systems sponsored by SDC, ARPA, and ESD.

Along with this flexible capacity to construct data bases went a need to select—even design—the formats in which the information is presented. "Display is a very personal thing," Drukey declared. "The format that displays a great deal of information to me may be ineffective at conveying information to someone else."

SDC's General Purpose Display System, begun by Alfred H. Vorhaus in the ARPA Command Research Laboratory, used a technique of on-line display building to allow the user—programmer or nonprogrammer—to construct formats for interacting with data bases. As in LUCID, the user addressed GPDS in English-like terms, communicating instructions through a combination of teletype, light pen, switches on the display console, or graphic input tablet.

GPDS and LUCID were reprogrammed in 1965 to operate in tandem under the Q-32 Timesharing System. Sally Bowman was responsible for GPDS, and Robert E. Bleier headed the LUCID effort. By the fall of that year, the unified systems were being used for experiments in design tradeoffs in on-line operations.

SDC's efforts to develop user-oriented methods for communicating with computers were expanded when Morton I. Bernstein, a long-time Rand researcher, arrived to develop a prototype online graphic input/output system. Intended to enable humans to write or draw directly on a graphic input tablet connected to the Q-32 computer, the system could recognize a large number of handprinted characters, including uppercase and lowercase Roman and Greek letters, digits, and special marks and symbols.

Meanwhile, SDC had decided to phase out the two research laboratory computers—the Q-32 and the Philco 2000—and convert existing programs to new, third-generation IBM 360 series machines, which were becoming generally available to DoD agencies. For the data management component of the new 360 architecture, the Technology staff planned a new system incorporating features of LUCID but having larger storage and more efficient data structures—the Timeshared Data Management System, TDMS.

ADEPT: THE ADVANCED DEVELOPMENT PROTOTYPE

Eager to move timeshared data management technology out of the laboratory and into operational settings, ARPA issued SDC a two-year contract in January 1967 to design, program, and install a new general-purpose timesharing system for IBM 360 computers. Called the Advanced Development Prototype and soon known widely as ADEPT, this system was to demonstrate to command-control managers the usefulness and feasibility of having rapid, direct, on-line access to large stores of data from their own terminals, without programmer intermediaries.

Under Technology Director Jules Schwartz, a team led by Clark Weissman, Al Vorhaus, Eugene Jacobs, and Clayton E. Fox set about to implement ADEPT. Five months after programming began in June 1967, ADEPT Release 1 was operating on a newly available IBM 360/50, and soon was being transferred to a more powerful IBM 360/67. By March 1968, the basic ADEPT timesharing operating system and its data management component, TDMS, were complete.

ADEPT also featured tamperproof security safeguards to comply with rigid military security requirements. A paper entitled "Security Controls in the ADEPT-50 Timesharing System," by Clark Weissman, was voted best paper of 1969 by the American Federation of Information Processing Societies.

SDC symposia on ADEPT in April and July of 1968 were attended by nearly a thousand representatives of the Department of Defense and other government agencies. Demonstrations showing a nonprogrammer querying an on-line data base on the status of

Vietnam forces aroused wide interest in ADEPT's capabilities.

Before long, ADEPT was installed in the National Command Center at the Pentagon where, on a trial basis, it furnished timely status information for the Chiefs of Staff. The system was also installed at the Air Force Command Post in 1968 and at two other government agencies in 1969. Together, these four installations provided some 400 hours per month of timeshared service to their users.

The Air Force contracted with SDC to convert ADEPT from IBM computers to its General Electric 635 machines. SDC's design of a Nuclear Weapons Status System for the Defense Atomic Support Agency was founded on ADEPT architecture, as was the Movements Requirements Generator, a strategic mobility model SDC developed for the Pentagon in 1968.

SAC contracted with SDC to have the data management segment of ADEPT—TDMS—adapted to its need for around-the-clock information on the status of its global forces. Eventually, the SAC Command System took over the entire Q-32 computer at Santa Monica and moved it to the SAC base at Omaha in 1971. Meanwhile, SDC's ADEPT installation in Santa Monica became the testbed for new advances in computer-aided command, computer networking, and computer security under a new ARPA contract that began in September 1968.

LANGUAGES FOR DESCRIBING LANGUAGES

A component of ADEPT was the "professional programmer's package," a set of tools for use by programmers in maintaining and modifying ADEPT. Among the tools was a new type of language called "metalanguage," capable of describing the syntax and properties of other programming languages. At SDC, Erwin Book, D. Val Schorre, Marvin Schaefer, and their associates had devised several such metalanguages, which were then used to program other software tools such as compilers, interpreters, and syntax analyzers, with greatly increased efficiency.

One important outcome of this work was META—a system for building compilers. Since compilers were considered the most complicated element in system development, the more able programmers were assigned to building them. With META came the possibility of automating the compiler-production process, freeing senior programmers for other critical system tasks.

By 1968, the technology had advanced sufficiently for SDC to invest in building a proprietary version of META for IBM 360 computers. CWIC (Compiler for Writing and Implementing Compilers), as the new SDC product was christened, was subsequently used by SDC in the development of compilers for many system contracts.

SDC also did innovative work in another emerging language field, called "list processing." Clark Weissman, who directed this research and who wrote the *LISP 1.5 Primer* (Dickinson, 1967), notes, "These languages, particularly LISP, freed programmers from arbitrary constraints on how they formulated problems. Where a JOVIAL or FORTRAN program had to include instructions for managing machine resources, LISP programs focused on a problem's structure and information content, prefiguring the powerful data management systems of the future. Under our ARPA contract, the first interactive compilers for LISP were perfected on the Q-32 and ADEPT timesharing systems."

TACTICAL INFORMATION SYSTEMS

While ADEPT was being readied in the Technology Directorate, a new technology for tactical systems was taking shape in the Defense Systems Division. ADEPT became the underpinning for one such system—the Tactical Information Processing and Interpretation or TIPI system—a development that was to play a pivotal role in SDC's future.

TIPI was a tactical information system in the form of an electronically equipped mobile trailer that could be airlifted to forward battle areas. Inside the trailer, twenty-four analysts would monitor and digest continuous streams of information and feed the results to battle commanders. In July 1968, the Air Force contracted with SDC to develop the prototype TIPI software, using ADEPT and TDMS as core programs for the design. Some years later, SDC's development contract for the final TIPI system was to provide the corporation's first experience as a major prime contractor.

The Vietnam combat emphasized the need for tactical information systems such as TIPI. In contrast to strategic systems, which address global aspects of defense and retaliation, tactical systems deal with the immediate picture of a changing battle front. The lifeline of a tactical command post is a communications network that monitors and transmits information on operations, intelligence, logistics, weather, and status of forces.

SDC's work on computer-based tactical information systems gave rise to a new eight-syllable technology: "interoperability." Interoperability refers to communication among disparate military commands joined together in a single information complex. For example, TIPI called for intercommunication among Air Force, Marine Corps, and Army units. Since each service typically uses its own computers, languages, and protocols for communication—often several different ones at the command levels—a methodology for cross-communication had to be invented.

SDC's first interoperability design was produced for use in Vietnam. In January 1967, the Air Force asked the company to adapt the BUIC programs for a classified air control system—Seek Dawn—in Southeast Asia. Within eighteen months a team under Stuart Spratt had redesigned the BUIC system to handle both offensive and defensive air missions in Vietnam.

DoD quickly recognized the need for integrating the Air Force's Seek Dawn with the tactical data systems of the Navy, Marine Corps, and Army to form a unified strike force. The unsolved technical problem was that of getting the computers of these disparate systems to "talk to each other" in a common language. SDC's "white paper" outlining the concept of a computer-based digital interface was well received by the Director of Defense Research & Engineering, and SDC was authorized to develop and test this approach as quickly as possible.

Under contract to ESD, SDC built a test facility in Santa Monica for the CONUS interface. (CONUS, an acronym for Continental United States, distinguished the testbed from the operational version for Southeast Asia.) Housed in SDC's Q-7 building, the CONUS laboratory contained computers, cryptographic devices, digital and voice communication systems, SDC-designed intercom systems, a closed-circuit TV, and a complex of telephones, radios, and other special hardware. Using both simulated data and live inputs—from the Navy and Army in San Diego, the Marine Corps at Santa Ana, and nearby Air Force radars—an SDC team under William H. Brinkmeyer developed programs to interface the various systems and test their combined operations. In 1969, a live demonstration using Air Force fighter planes validated SDC's interoperability design.

Brinkmeyer recalls, "Among the tougher CONUS challenges were synchronizing the timing among the four tactical systems and avoiding duplicate displays of tracks from aircraft picked up by several systems at once. Fortunately, we had solved the identical problems in SAGE in its abilities to 'crosstell' tracks from one sector to another and 'forwardtell' them from direction center to combat center."

SDC also interfaced Seek Dawn with the College Eye reconnaissance aircraft, using a hundred-foot-high troposcatter radio tower erected in SDC's parking lot to test the information exchange between air and ground before installing the aerial communication system in the Vietnam combat zone.

Other SDC contingents worked in Vietnam developing information systems for the Agency for International Development and the Military Assistance Command. SDC's training cadres indoctrinated users of all these systems. At peak, SDC had some one hundred analysts, programmers, and trainers in Vietnam.

TOWARD A NEW FUTURE FOR R&D

In a corporate reorganization of January 1968, Launor Carter incorporated parts of the R&D program into his newly formed Public Systems Division. These included projects in automated education, library information systems, vehicular flow analysis, and computerized health systems. The bulk of effort remaining in the Research & Technology Division, under the direction of Bill O. Barancik, continued to focus on developmental applications of timesharing, data management, and advanced programming languages and tools.

In January 1968, "in view of the impending changes both in our corporate form and in our organization," President Melahn, anticipating SDC's approaching effort to become a profit-making corporation, wrote to the members of the Research Advisory Committee to advise them that the RAC would cease its function as of June 30, 1968.

At the time of its dissolution, the RAC included: Dr. William C. Biel, assistant vice president for Academic Affairs, University of Southern California; Dr. C. West Churchman, professor of business administration, University of California, Berkeley; Dr. Harry D. Huskey, professor, Computer Center, University of California, Santa Cruz; Dr. John L. Kennedy, Department of Psychology, Princeton University; Dr. Anthony G. Oettinger, professor of mathematics and linguistics, Harvard University; and General Earle E. Partridge, USAF, Retired. Dr. Paul M. Fitts, professor of psychology, University of Michigan, served on the RAC from 1963 until his death in 1965. Dr. Merrill M. Flood, formerly of the University of Michigan, who had served as RAC chairman through mid-1967, was head of the Special Projects staff of the Research Directorate.

Throughout the 1960s, SDC's R&D program had grown from a handful of unrelated projects to a well-rounded $7.5 million program, supported by Independent Research and Development funds, ARPA, and twenty-five other agencies. The program had resulted in over five hundred technical and scholarly articles and papers, some two thousand SDC documents, and the training of many personnel from SDC's line divisions through a one-year R&D internship program. Most importantly, the R&D program had spawned a new business area—timeshared data management—and, in ADEPT, a new system architecture for the government.

THE ERA OF CIVIL SYSTEMS

If military systems were on the decline, public or civil programs appeared to offer a burgeoning new market for a company like SDC. President Johnson's election in 1964 refocused attention on the civil sector: the promise of a "Great Society," with equal rights, ample economic opportunity, urban renewal, and improved services in health care, welfare, and education. Four years later, President Nixon added crime prevention, transportation, and pollution control to the list of civil priorities.

Many public figures were intrigued by the promise that computer technology and the systems approach held for solving the baffling problems of the public sector. In the words of a government keynoter at SDC's 1964 Symposium on EDP Systems for State and Local Government: "No single advance in recent times has contributed more to effectiveness and economy in government than the computer."

Focus on the civil arena was part of Melahn's early game plan. "The issue facing us in 1964 was how to build a viable organization given all of SDC's constraints," he states. "Until we were allowed to compete, our strategy was to maintain an outstanding reputation, seek sole-source awards from DoD, continue to invest in a forefront R&D program, and use our knowledge for other public-serving organizations. In our civil programs, we believed we had something to offer to a set of clearly appropriate customers, while broadening our skills and base."

SDC had worked on civil programs since its earliest days. In medicine, the company had provided automation support to the Los Angeles Veterans Administration in 1961, designed an information processing system for the Puerto Rico Medical Center in 1962, analyzed medical practices of New York's Health Research Council in 1965, and developed a centralized information system for the New Jersey Hospital Association in 1966.

In education, from the earliest experiments on teaching machines through development of the CLASS laboratory for computer-based instruction, SDC continued throughout the 1960s to develop new systems and languages for automated counseling, scheduling, and instruction.

The company's research on using computers for retrieval of documents and their contents had secured it a national reputation in documentation science. In 1965, the Federal Council for Science and Technology had turned to SDC to analyze the system of handling all U.S. scientific and technical information. An SDC team headed by Launor Carter developed the plan for evolution of a national technical information system. The analysis was published in book form by John Wiley & Sons in 1967.

In 1964, the National Science Foundation funded SDC's information retrieval staff to develop the *Annual Review of Information Science and Technology.* This comprehensive international review was put together by Dr. Carlos A. Cuadra, who would be its editor from 1966 to 1976.

Complementing these central thrusts, SDC's field offices, hoping to augment their declining military business, were offering their services to state and local government agencies. In 1966, SDC's Paramus, New Jersey, office, established seven years earlier for the long-completed SACCS contract, was busy developing the New York Identification and Intelligence system for sharing data among the state's 3,600 criminal justice agencies, installing a cost system for Hackensack Hospital, and advising New York Mayor-Elect John Lindsay on systems solutions to urban problems.

SDC's Washington Department was developing a computer-based information system for the Washington, D.C., public schools. Washington's civilian agencies were beginning to use SDC: the Department of Housing and Urban Development commissioned an information system; the Office of Economic Opportunity asked SDC to forecast occupational trends; and the U.S. Department of Transportation supported mathematical analyses of vehicular traffic flow.

At the home office, systems analysts were conducting a feasibility study of Skylounge, a novel scheme to expedite passenger travel between Los Angeles International Airport and citywide destinations via helicopter-transported mobile lounges. Others were developing a transportation information system for the San Francisco Bay Area, recommending action programs for the Los Angeles Youth Opportunities Board, and developing an information system for the Los Angeles Police Department.

In January 1968, President Melahn decided to consolidate these disparate civil programs in a Public Systems Division under Launor Carter. This move was part of a corporate reorganization intended to aim the services of a competitive SDC at specific classes of customers. In addition to Public Systems, Melahn formed a Military Systems Division under John Ottina, who had managed this domain since Dick Lintner's death in November 1967; and a new Commercial Systems Division under John Matousek, focusing SDC's technologies at business and industry.

Within Public Systems, Carter established six departments, each of which addressed a different civil application: education, information retrieval, public safety, health, transportation, and government information and manpower systems. Over the next seven years, until its amalgamation into the Systems Division in 1975, the division was to perform some five hundred contracts for federal, state, and local governments. Most of these contracts were small by SDC's 1980 standards, averaging $50,000, although a handful in the early 1970s were to run into the millions.

Of the medium-sized contracts, several were notable. In education, the company made a lasting contribution to computer-aided instruction (CAI) with the PLANIT language, developed by Samuel L. Feingold and Charles H. Frye. By the mid-1960s it was apparent that a major drawback to CAI was the prohibitive time and cost involved in lesson creation. Even a short lesson required detailed programmer flowcharts and computer instructions, followed by trial usage with a class and more revisions. PLANIT, on the other hand, enabled a nonprogrammer teacher to develop a lesson interactively on a terminal, change the lesson on line until it passed muster, and then monitor student responses to the lessons in real time. This newest in a family of user-oriented SDC systems sharply cut the time and cost for lesson development.

The National Science Foundation, wishing to promote utilization of PLANIT in the academic community, funded SDC in 1968 to embed PLANIT in a portable software system for easy transfer to various computers. Subsequently, PLANIT would be used by universities in America and Europe, and by SDC to fulfill some twenty-five military training contracts.

Another widely publicized education project was a five-year program, sponsored by the Ford Foundation, to develop a peer tutoring program—older students helping younger ones—as an instructional aid in minority schools. Reaching beyond the instructional system to the entire faculty, parent, and community infrastructure, a version of the "Tutorial Community" was implemented in a Los Angeles area elementary school. The program resulted in significant learning and behavorial gains for the participating students. The principal investigators, Drs. Ralph J.

Melaragno and Gerald Newmark, received commendations from President Nixon in 1970 for their "active commitment to quality education for children of all racial and social backgrounds."

Despite its innovative systems for automated instruction, counseling, and administration, SDC could not translate these education aids into a going business. As Launor Carter points out, the marketing of these tools was hampered by the wide dispersion and low budgets of the country's 27,000 school districts. Wes Melahn adds, "We were one of the first companies to recognize that machine teaching, other than for military training, was not a good business to be in. The costs of hardware and materials were an order of magnitude above standard school texts."

In the domain of automated document abstracting, indexing, and retrieval systems developed by Carlos Cuadra's library systems staff, the most important development, both for the user community and for the company's own future, was the ORBIT information retrieval system. Originally conceived in 1963 for rapid on-line screening of foreign literature, the ORBIT system was refined, by Robert C. Burket and other systems programmers, into a powerful bibliographic search tool.

The marriage of timesharing and user orientation in the ORBIT system enabled researchers, scientists, and information specialists to have a million-document library electronically placed at their fingertips. Working in an on-line mode from video terminals, ORBIT system users reached into the automated document repository by subject, author, title, keywords, publication date, or a combination of these, until they homed in on the target of their search and retrieved the relevant entries. Searches that took days manually were being accomplished in minutes.

In 1968, the National Library of Medicine purchased the ORBIT programs to expedite access to the millions of documents stored at the Lister Hill National Center for Biomedical Communications by its thousands of nationwide medical subscribers. In June 1970, NLM contracted for on-line search of its *Index Medicus* on SDC's IBM 360/67 computer. These events would lead to a major development contract for NLM in 1971 and to the genesis of SDC Search Service.

In the realm of public safety, SDC's work under Ralph R.

Bledsoe and, later, Herbert Saxon had two components: civil defense and administration of justice. The company's best-known project for the Office of Civil Defense was the Emergency Operations Research Center (EORC), an electronically equipped laboratory featuring "packaged disasters." Based on the System Training Program, the EORC contained all features of that vehicle—simulated crisis scenarios, decision making under stress, and instant feedback of results. Instead of an air attack, the simulated threat in the EORC was a civil disaster—flood, fire, hurricane, earthquake, or nuclear fallout.

So real were the simulated disasters to the participating municipal, county, and state officials that their complete immersion in an exercise produced shouting matches and elbowing for control of the command post. Such problems were addressed head-on in the subsequent debriefings and were usually absent from the next exercise. During operation of the EORC from 1964 through 1970, under Terry R. Haney and John J. Mecozzi, SDC prepared thousands of public officials in communications, decision making, and teamwork during crisis situations.

In a new role, SDC became a participant in the nation's manpower training programs. Prompted in part by the unemployment frustrations expressed in the Los Angeles and Detroit riots of the mid-1960s, manpower training had become a prime commitment of the administration. Programs such as JOBS (Job Opportunities in the Business Sector), WIN (Work Incentive), and CEP (Concentrated Employment Program) were generously funded through the U.S. Department of Labor and the Office of Economic Opportunity. In a new application of its systems analysis and human factors experience, SDC evaluated the success of such programs and recommended improvements.

In performing these contracts, SDCers worked directly in the inner cities of most large U.S. metropolitan centers. Evaluating the impact of an "antipoverty" program was a long step from flowcharting the functions of a command post, but SDC's analysts accepted the challenge enthusiastically. In the words of one: "Gaining the trust of the ghetto residents and contributing to their employability was one of the most rewarding things I've done at SDC." The company won six competitive manpower evaluation contracts in 1968 and was to continue its support in training the nation's disadvantaged throughout the early 1970s.

A pioneering approach to providing new skills to the disadvantaged has been SDC's own program for training the visually handicapped in computer programming. In April 1966, during programmer training class 88, a blind programmer, Richard Sakamoto, using only standard devices for aiding the blind, mastered SDC's curriculum and outperformed many of his peers. Shortly thereafter, he accepted a job offer from a large data processing company.

Later that year, under sponsorship of the California Department of Rehabilitation, SDC initiated a series of programmer training courses for the blind. The curriculum and training were basically the same as for the sighted; only the tools of learning differed. Blind students would take notes with tape recorders, construct flowcharts with a stylus that creates impressions on acetate, compose and read programs in Braille, and read printouts and video displays with a standard Optacon electronic scanner.

By the 1970s, SDC would have trained 150 visually impaired programmers and helped to place them in jobs with the corporation and elsewhere. SDC received several awards for this program, including that of "1970 Employer of the Year" from the Governor of California's Committee for Employment of the Handicapped.

SDC's other civil work in transportation, criminal justice, and government information systems would be reaching fruition in another several years.

GOING PROFIT: THE DECISION

"Once we had become competitive, we could not stay nonprofit," recalls Wes Melahn of his own attitude after SDC's normalization in 1966. "Three motivations made that choice inevitable: the ability to offer incentives and equity participation to attract and retain high-caliber professionals, the desire to access capital markets and explore acquisitions, and the need to adopt more aggressive business practices to win contracts—practices that are typical of the commercial world but not of nonprofits."

All evidence supported Melahn's position. During fiscal 1967, the year following normalization, the company's competitive efforts for new business—as opposed to follow-ons to prior contracts—yielded only $3 million. While SDC's revenues had been holding steady at slightly above $50 million, the rest of the software industry had been enjoying an annual growth rate of 26 percent over the preceding five years. The revenues of SDC's major software competitors—Computer Usage, Computer Applications Inc., Computer Sciences Corporation, and Planning Research Corporation—had been zooming upward at a combined annual rate of 50 percent over the same period, with a hefty share of the growth attributable to acquisitions.

A more worrisome statistic was the gradual exodus of SDC's key personnel to more verdant pastures. Recalls Joe Scatchard, "This was the heyday of go-go stocks, with the market paying fantastic multiples of earnings for software companies. It was demoralizing to our managers to see their counterparts in industry becoming wealthy overnight. This was the underlying issue that forced us to become a profit-seeking company."

As Melahn and management were painfully aware, between 1963 and 1967 some eighty high-level managerial and technical personnel had voluntarily left the company. In the next two years, another seventy would join their ranks. Among the illustrious SDC alumni were many early builders of the company: Guy Besnard, James Berkson, Ralph Canter, Don Drukey, Charles Durieux, Harry Harman, Milt Holmen, Frank Marzocco, Riley Patton, Ray Rhine, and James Singleton. Not all terminees left for more lucrative positions in industry. A goodly number departed for the opposite reason: SDC was becoming too commercial for their taste, and they sought refuge in academia or other nonprofits.

When Melahn broached the issue of reassessing SDC's status at the board meeting of April 1967, he met a receptive audience. Ever since SDC had become an independent nonprofit, the trustees had aligned themselves solidly behind sustaining a viable and growing corporation. A number of recently elected trustees did not share the concerns that shaped the thinking of the 1963 board, having accepted their trusteeship in full knowledge of SDC's evolving status.

By 1967, the composition of the SDC board had changed significantly from the one with which Kappler contended in 1963. Retiring trustees included Chairman William Golden, who had served two terms; Charles Coolidge, made an honorary trustee; and Gaylord Harnwell, David Packard, Bill Biel, and, of course, Kappler.

The board of which Melahn was now a member was chaired by Arnold Beckman. Its new members were Lloyd N. Morrisett, vice president of the Carnegie Corporation of New York and the Carnegie Foundation; David A. Shepard, executive vice president and director of Standard Oil Company; Dr. Horton Guyford Stever, president of the Carnegie Institute of Technology; Dr. Ralph W. Tyler, director of the Center for Advanced Study in the Behavorial Sciences; and Bethuel M. Webster, partner, Webster Sheffield Fleischmann Hitchcock and Chrystie. Holdovers from the 1963 board (besides Beckman) were Edwin Huddleson, reelected after a brief absence; Augustus Kinzel, who had become president of the Salk Institute in 1965; and Donald Putt.

Once stirred, the board acted swiftly. Ordering "further study" of the alternatives confronting SDC was not a euphemism for tabling the issue. Two months later, at the June 1967 board meeting, the trustees stated "for the record" that SDC's resources and capability could best be preserved and employed in a truly competitive environment and that the Air Force should be informed of the trustees' views.

Going further at its October 1967 meeting, the board authorized an independent study of the fundamental issues relevant to SDC's future. The study, commissioned to Lehman Brothers, one of the country's leading investment bankers, was to determine "whether the future of the company lies in continuing as a not-for-profit entity or whether the conditions under which it presently operates make desirable, or even necessary, a change to a for-profit status."

Two months later, Lehman Brothers presented its recommendations: realign SDC to a profit-making operation as soon as possible. The report stressed, "Only this alternative appears to offer the possibility of perpetuating the vitality and level of excellence which has characterized the corporation in the past. . . . The alternative, doing nothing, could very well lead to erosion of the organization's capabilities" and "would jeopardize the corporation's control over its chief asset, its key technical and managerial personnel."

The Lehman report included a plan for accomplishing the proposed realignment. Basically, SDC would convert to a profit-seeking company under its existing management. To compensate the government and people of the United States for SDC's nonprofit origins, the new profit-seeking company would assign the corporate equity—almost $8 million—to the board, which would disburse these funds in the public interest, in accord with SDC's charter. A large number of SDC employees would be eligible to purchase stock in the new for-profit company at a fair market value over a period of five years.

In February 1968, the board unanimously adopted this plan and set an ambitious deadline of June 1968 for completing the realignment. The first priority was a meeting with the Air Force to ensure that the plan was understood and accepted, so that current Air Force contracts, which comprised 80 percent of SDC's revenues, would be novated—that is, transferred—to the new for-profit company without a hitch.

One week later, when Arnold Beckman, with board members Huddleson, Melahn, and Stever, briefed Harold Brown and his senior staff on the realignment plan, the Air Force Secretary had mixed reactions. He was disappointed that no alternatives were presented to going profit—for example, dissolving the business. Staying nonprofit also had appeal, particularly since things seemed to be going well—"much better with SDC than with other nonprofits."

At the same time, the Secretary recognized the rationale behind a realignment, particularly in holding SDC's strong personnel capability intact. Therefore, he would not oppose the concept, provided certain aspects of the plan were changed, particularly the $8 million value put on SDC, which seemed to him very low and certain to be criticized on Capitol Hill as a giveaway.

"The big stumbling block with the Air Force was price," recalls Melahn. "Software was the darling of the marketplace, and stock was selling at ridiculous price-earnings ratios. Comparing us to CSC, we would have been a $300 million company." (Computer Sciences Corporation stock was listed at $67 a share on December 15, 1967; its 4.3 million shares yielded a market equity of $290 million.) "But SDC was a service business," continues Melahn, "inexperienced at competing, and no one would pay anything like that."

As discussions with the Air Force continued, SDC was rocked by an event that forcefully dramatized its dilemma. On February 23, 1968, corporate Vice President Tom Rowan, along with a marketing executive, three long-time department managers, and eighteen key technical personnel, announced their resignations to form a new company, called EDP Technology. Prior departures of senior personnel, occurring in small numbers, had not been noticed by most employees as a pattern of spiraling resignations. The Rowan group, by contrast, brought to the forefront the issue of employees' future prospects in nonprofit SDC, stirring uneasy questions: "Who's next?" "What about you?" "What about me?"

Difficult as the sudden loss of twenty-three key personnel was to absorb, the event provided fresh evidence for SDC and the Air Force that the for-profit realignment should move ahead. When several calculations of SDC's "real value" proved unacceptable to either the Air Force or SDC, Secretary Brown suggested that a fair price for the corporation could be established only through an arm's-length sale to another company. At a special board meeting on March 6, 1968, the trustees accepted the Air Force's recommendation, and authorized SDC management to work with Lehman Brothers to find a suitable buyer.

By the end of March, a list of prospective companies was compiled. In the fourteen months between April 1968 and June 1969, SDC and Lehman made contact with sixty-eight organizations, a tremendous drain on the time of management just for introductory meetings and briefings. Ultimately, SDC identified eight organizations sufficiently interested to carry these discussions to definitive proposals.

Joe Scatchard, who helped Melahn in the subsequent negotiations, recalls this period as his most interesting at SDC. "We met some fabulous characters. I recall an executive of Leasco flying in from Chicago, whipping out his checkbook, and asking 'How much do you want for this company?' Another flamboyant guy was John King, owner of King Resources, an oil prospecting company. His grandiose office suite on the top floor of his Denver building featured the world's biggest desk, and telephones in the executive restrooms."

Negotiations with these two companies did not pan out, nor did those with other leading prospects, including American Research and Development Corporation, Arcata National Corporation, Gulf Oil Company, and Rockefeller Associates. Either SDC deemed the transaction too speculative or the price too low, or the potential buyer backed away.

Of the offers, which ranged between ten and fifty million dollars, one of the more generous came from RCA, which proposed to make SDC a separate division within one of its groups. SDC management typically voted on each offer. In the RCA case (as in most others), the executive office was split, with a number of key managers asserting that their technical personnel were opposed to the merger. These employees were concerned that working for a large computer manufacturer would compromise their technical independence, confine their professional growth to one product line, and lead to a dismantling of SDC over time.

As Melahn recalls, "A lot of people said they didn't want to work for a large company—that SDC was small and proud. I had to tell the buyer that I couldn't guarantee how many people would come along or how long they would stay." With a smile he adds, "Whatever the reason, we made the right decision. Three years later, RCA got out of the computer business."

Meanwhile, other events threatened to impact the realignment. The U.S. House of Representatives Committee on Government Operations asked the Government Accounting Office to investigate SDC's impending for-profit conversion and ensure that the government's interests were protected. The newly formed Association of Independent Software Companies lobbied against SDC's continued existence in *any* form, for-profit or otherwise.

SDC's population was growing more restive with the rumors of each passing day. After a year of failing to consummate the realignment, management was losing the confidence of the employees that it would ever complete this long-sought event. These factors made the closing of an acceptable agreement most pressing.

The final and most promising prospect was Wells Fargo & Co., the San Francisco-based bankers. Under the recently enacted "one bank holding company" law, a bank was permitted, as a holding company, to acquire other businesses. From contacts between Lehman Brothers and Wells Fargo's president, a mutual interest between SDC and Wells Fargo rapidly developed.

During April and May 1969, an agreement for the bank to acquire SDC was hammered out to the satisfaction of all involved. Enthusiastically approved by SDC's board of trustees and by Wells Fargo's management, the transaction was subject only to the formalities of endorsement by the Wells Fargo executive committee on May 26 and the Wells Fargo board on June 2. So close to realization was the merger that Wells Fargo's president had already addressed SDC's two hundred key employees, outlining their future under the bank's umbrella.

As SDC President Melahn walked into his office on Friday, May 16, 1969, he had abundant reasons to be satisfied. The company's sales volume for the fiscal year ending in June was a vigorous $61 million, $10 million over the prior four-year average, thanks to the success of diversifying to some 150 customers in the military, civil, and commercial sectors. Employee strength stood at 3,200, after having dipped below 3,000 for the past two years. A healthy balance sheet showed a two-to-one ratio of assets to liabilities, and a retained income, or equity, of $8 million.

Best of all, the long trail from noncompetitive nonprofit in 1964, to competitive nonprofit in 1966, and finally to a normal for-profit company in 1969 seemed at an end. In ten days, the Wells Fargo executive committee would, from every indication, endorse the recommendations of its management. Following the expected approval of the Wells Fargo board, SDC would become an independent profit-oriented corporation owned by a prosperous and prestigious bank.

It was reportedly about 9:00 A.M. when several senior SDC personnel asked to speak to Melahn. Within an hour, six key executives had announced their resignations. They intended to accept offers from John King, one of the prior potential buyers, to found a data processing organization for King Resources. The group included John Ottina, vice president over the Military Systems Division; Jules Schwartz, director of Technology; and four executives in management, marketing, and planning. Several other key technical people were to join them shortly. "The group that left SDC was very strong," recalls Melahn. "And King knew it."

Evidence of its strength could be found all too readily in the corporate prospectus SDC had given to potential buyers, including Wells Fargo. The section entitled "Management Biographies" contained twenty-one resumes and photographs of executive personnel. Five of the faces matched those of the terminees.

Melahn quickly reorganized the company over the weekend, creating a three-headed structure out of the Military Systems Division: Air Operations under John Matousek; Space and Range under George C. Clement, who had recently joined the company from Rand; and Command Support Operations, primarily Washington-based, under veteran manager Raymond P. Barrett. The new organization was announced the following Monday morning, May 19.

The Wells Fargo executive committee met on May 26. They understood SDC's explanations of the circumstances surrounding the recent terminations and commended management's prompt actions. They had decided to go forward to their board with the proposal to acquire SDC. However, their dampened enthusiasm was evident in several new reservations of record. The primary one indicated that "the loss of key employees on Friday, May 16, 1969, would be of grave concern if it was the start of a wave of resignations."

On Monday, June 2, after several hours of deliberation, the Wells Fargo board's decision was announced to the waiting SDC contingent: the merger had been rejected.

"The last-minute departure of key employees was definitely a factor in the deal coming apart," believes Melahn. "It underscored vividly to Wells Fargo that there was no way to tie people to an organization in the volatile information processing industry, and that made the acquisition too risky."

According to one of the SDC participants, that afternoon in San Francisco a last-ditch alternative strategy took form. Included within the SDC contingent were Melahn, Huddleson, Alders, and representatives from Lehman Brothers and SDC's legal counsel. There was little need to speculate what the recent executive departures, coupled with the collapse of the Wells Fargo deal, would mean to corporate morale. Another such defection could trigger a wholesale exodus. The outcome of six years of patient and conciliatory negotiations to become a normal company hung in the balance.

The notion of a syndicate buying SDC, instead of merger with a single company, had surfaced as a possible alternative in recent months. Now, representatives of SDC management asked Lehman Brothers if they would form a syndicate of investors to buy into a new for-profit SDC. The price offered by the syndicate would be consistent with the range of serious prior offers. A new business-oriented board of directors would manage the new company. The present board would become trustees over the proceeds of the sale and administer the funds in the public interest.

All paperwork for the proposed realignment would be prepared immediately, to accomplish the conversion within 30 days, by the start of SDC's new fiscal year beginning July 1, 1969. Government agencies with an interest in the conversion would also be informed directly. Upon careful reflection, Lehman Brothers agreed to help SDC by trying to form a syndicate within the pressing deadline. At a special board meeting of June 5, 1969, the trustees approved this plan. SDC had run out of alternatives.

In reflecting back on these far from normal "normalization years," and on the laborious transition from a special nonprofit to profit maker, Wes Melahn would later observe, "I'm told that in Rand's original deliberations establishing SDC, they considered and then rejected the idea of setting up a for-profit company. It sure would have saved a lot of us a lot of trouble if they had done that back in 1956."

CHAPTER 6

The Lean Years

(1969-1971)

GOING PROFIT: THE ACHIEVEMENT

Monday, July 21, 1969, was a special and buoyant holiday for Americans. On the previous day, millions of people around the world had witnessed the epochal sight of two earthmen, U.S. astronauts Armstrong and Aldrin, setting foot on another celestial body. As the swirling moon dust settled firmly beneath the astronauts' boots, America's pride and confidence in its technological supremacy, clouded by Soviet sputniks since 1957, were being firmly and solidly restored.

SDCers had special reason to celebrate "moon day." Since 1966, their software had supported the U.S. space program, from the early Apollo missions through the presently feted Apollo 11 moon walk. An SDC team of thirty programmers had been working for the MIT Instrumentation Laboratory in Lexington, Massachusetts, to develop critical portions of the onboard guidance and navigation system—in particular, the all-important navigation program for the rendezvous between the lunar landing vehicle and the orbiting command module.

A GROUP OF INVESTORS

SDC management had another reason to celebrate. After wearying months of trying to change SDC's nonprofit stripes, it had found a solution that appeared to satisfy the government, the Air Force, and the employees. Upon collapse of the Wells Fargo purchase of SDC on June 2, 1969, Lehman Brothers had mounted an eleventh-hour rescue mission by spearheading a syndicate of prestigious investment firms willing to buy part of for-profit SDC. With the financing hurdle apparently overcome, SDC had finally made the official transition to the ranks of profit-making corporations on July 1, 1969.

The conversion plan had two aspects: the mechanics of transition and the sale of stock to the investor group. Of the two, the administrative mechanics were to prove far simpler. Nonprofit SDC changed its name to System Development Foundation and exchanged its assets, liabilities, and business for the stock of a new for-profit company called—not surprisingly—System Development Corporation. The not-for-profit foundation essentially owned the new for-profit SDC, holding all of its outstanding stock in trust until the stock could be liquidated and disbursed in the public interest. Additional unissued shares were reserved for SDC employees under a long-term, wide-distribution stock option plan. If all such options were issued and exercised, employees would own 20 percent of the corporation. The current SDC trustees became the officers of the foundation, while a new board of directors was to manage new SDC.

Prior agreement among all parties ordained that the ultimate beneficiary of this transaction was to be the U.S. public and not any private individual or organization. The foundation therefore pledged the following: a voluntary payment to the U.S. Treasury of $4 million (half of SDC's equity); distribution of all remaining proceeds, as realized, for scientific, educational, and charitable purposes; and nonparticipation by any trustee in SDC stock ownership.

To discharge its obligations promptly, the foundation intended to realize an immediate liquidation of a block of SDC stock through its sale to the Lehman consortium. Under an agreement of July 23, 1969, the group offered to buy 25 percent of SDC's stock for $6.25 million, with a future option on another 20 percent for $8 million. These prices established a range of values from $25 million to $40 million for 100 percent of the company, higher than the average price that had been offered for SDC by prior interested purchasers.

A CHANGE IN PLANS

By August, SDC still had a number of administrative and political hurdles to clear to complete the realignment. The major customer, the Air Force, had yet to novate its contracts to new SDC. Officials in the Air Force, the Government Accounting Office, and Congress had to be assured that the conversion safeguarded national interests and would not result in windfall profits to anyone. The State of California had yet to approve the conversion, including the purchase of shares by the Lehman group.

None of these events would come to pass if some of SDC's competitors had a vote. A group of fifteen, calling themselves the Association of Independent Software Companies, continued its intensive lobbying to block the conversion and the Lehman deal. Led by Informatics, Planning Research Corporation, and Applied Data Research, they contended that the unleashing of a nonprofit built up from sole-source government contracts was unfair competition. More specifically, they claimed that the value placed on the firm by the Lehman group was "materially inadequate," citing $250 million as the market value for comparable Computer Sciences Corporation (number of shares times current stock price).

SDC reaffirmed its views: preserving the company in a viable for-profit form was in the nation's best interest; the value established for SDC was fair, notwithstanding an inflated market for comparable issues. (The latter point was borne out within six months with the giddy downslide of computer stocks.)

In the end, SDC's position was upheld in every quarter but one. The views of the Air Force, Congress, and the Executive Branch were reflected by the U.S. Comptroller General, Elmer Staats, who cited the actions of SDC's Board of Trustees as "extraordinarily responsible." After the corporation agreed to place in the public domain its major findings, research results, and computer programs from the nonprofit years, thereby opening its archives to all competitors, the Air Force novated SDC's contracts.

The sticking point was the State of California. Although the corporations commissioner had approved the for-profit transition, the attorney general raised questions about the dual role of Lehman Brothers: first, as SDC consultants, recommending a for-profit conversion in December 1967; now, as investors, possibly benefiting from the results of their own recommendations. Without suggesting any improprieties in the transaction, the attorney general reserved the right to review its outcome in perpetuity. This Damoclean sword was uncomfortable to SDC, the foundation, and the investor group, and the agreement of July 23 was called off by consent of all parties at the end of 1969.

Undaunted by this setback, the trustees continued on the for-profit course with an announced intention to bring SDC's stock to the public market by the end of 1970. To most SDC employees, the setback seemed more like a boon. The irony of circumstances had finally backed SDC into the position recommended exactly two years earlier in the Lehman study, and endorsed by most of management and the employees—namely, an independent for-profit corporation, unfettered by outside ownership, free to grow and prosper to its potential in the burgeoning world of information processing.

All signals pointed to success. In the fiscal year that had just ended on June 30, 1969, SDC had enjoyed the highest revenues in its history, $61 million. Net income had been only $250,000 (untaxed since SDC was then still nonprofit), but that was after a sizable investment in a promising new business called Datacenter. Military revenues had been up 13 percent. SDC's public and commercial lines of business, fresh off their starting blocks, had recorded even higher percentage gains in sales. Small wonder that *Business Week* had headlined industry shock waves over SDC's realignment with "Software Giant Goes Commercial."

An overlooked statistic was the lack of new business captured by SDC, particularly competitive awards, during the same fiscal 1969 time span. Out of $58 million in orders, only $14 million came from new programs while $44 million was for follow-on work in SDC's traditional but declining military programs. More alarmingly, competitive wins totaled but $2.6 million, of which 70 percent came from nonmilitary sources. In the three years since SDC had gained the freedom to compete, it had won less than nine million dollars worth of competitive proposals. These facts offered no comfort to a company that depended on competitive awards, primarily in the military arena, for survival.

Since the for-profit realignment, SDC's trustees had been serving in a dual role: primarily representing the interests of the nonprofit foundation, they had also acted as interim directors of SDC until a new board, originally intended to be formed with the investor group, took its place. Once the Lehman deal was called off, the trustees selected a new board of directors, which held its first meeting in April 1970.

Reflecting a broad cross-section of leadership in industry and science, the six-person board was chaired by William E. Zisch, former president and vice chairman of Aerojet General Corporation. Other members were John F. Bishop, president of Dana Laboratories; John J. Burke, former chairman, Howmet Corporation; Brooks Walker, Jr., chairman of U.S. Leasing Corporation; Dr. Owen Meredith Wilson, director of the Center for Advanced Study in the Behavioral Sciences; and SDC President Wesley Melahn.

With establishment of the new board of directors, the trustees relinquished their long-standing role of directly guiding SDC's affairs. Except for David Shepard, who had resigned in 1968, the new trustees were the same group that charted the for-profit course in 1967: Beckman, Huddleson, Kinzel, Morrisett, Putt, Stever, Tyler, and Webster.

Throughout the years of SDC's search for identity, these public-spirited men had successfully guided the company from a narrow government-dependent operation to a diversified national resource and industry leader. Now their sole remaining mission was to redeem the SDC shares they held in trust and distribute the proceeds in the public interest. All that would be required was a public offering of SDC stock after the company had established a track record of profitability—a matter, it seemed, of at most one or two years. Few realized how long and arduous that mission was to be.

THE AIR DEFENSE BASE ERODES

In May 1969, the Military Systems Division had been reorganized into three separate divisions to address specific defense technologies: Air Operations under John Matousek, Space and Range under George Clement, and Command Support Operations under Ray Barrett.

This organizational partitioning occurred against a backdrop of cutbacks in military spending. President Nixon's announced intention to disengage the nation from Vietnam, coupled with growing disillusionment in Congress over that war, slashed $4 billion from the U.S. defense budget in fiscal 1970 and another $5 billion in 1971. One consequence was a continuing lack of new large-scale military programs geared to SDC's capabilities.

At the same time, the company was delivering the remaining SAGE/BUIC programming tasks into the hands of military programmers. Once accounting for $40 million of SDC's annual revenues, the ADC work stood at $15 million in 1969 and shrank to a $5 million residue for the System Training Program in 1971. Symbolic of this decline, SDC's AN/FSQ-7 computer, once a proud forerunner of large modern computers and the nerve center of SAGE, found itself sitting forlornly in SDC's parking lot in September 1970, waiting to be picked up for scrap.

FROM BOMBER TO MISSILE DEFENSE

Even as the earliest SAGE sectors were becoming operational back in 1958, their primary mission—defense against manned bombers—was rapidly being overshadowed by the threat of missile attack. The growth of Russia's space program since the launching of Sputnik I in 1957 confirmed the Soviet capability of producing intercontinental ballistic missiles with the potential of devastating the United States.

The primary U.S. strategy became one of counterforce, that is, the buildup of a deterrent missile capability. In the background was the more difficult creation of a defensive anti-ICBM shield. The Nike-Zeus system, under development since 1955, had not been deployed because it depended on an uncertain missile intercept beyond the earth's atmosphere. Nike-Zeus was replaced by Nike-X in 1962, by Sentinel in 1967, and by Safeguard in 1969, systems capable of making intercepts nearer ground level by using more reliable atmospheric data for pinpointing targets.

The responsibility for maintaining the Sentinel and Safeguard ICBM shields resided with the Army's Advanced Ballistic Missile Defense Agency (ABMDA) at Redstone Arsenal near Huntsville, Alabama. Faced with the virtual cessation of SAGE/BUIC activities, SDC sought to apply its systems experience to the Army's program of ICBM defense.

In the 1967-1971 time frame, SDC won six such contracts, each in a different area of corporate capability. The first called for design of a computerized management information system for Sentinel. ABMDA endorsed SDC's design and used it as the basis of a 1969 competition for the subsequent development of the software. It came as an unpleasant surprise when SDC did not win the contract.

The company drew upon its human factors and evaluation skills to win the competitive Task and Skills Analysis for Safeguard in 1969. Safeguard contemplated an anti-ICBM blanket of twenty-five U.S. sites, each containing some five hundred personnel and a massive complement of radars, computers, communications, and intercept missiles. SDC's recommendations for the best balance of Safeguard personnel and equipment were estimated to have saved the government millions of dollars, even though Safeguard was ultimately deployed in only two sites.

Using its air defense expertise to advantage, SDC modified the BUIC programs to provide an air surveillance system for the

Army's White Sands Missile Range in New Mexico. This $850,000 award in 1970 was the largest fixed-price contract held by SDC up to that time.

In April 1971, SDC won a facility management contract for Bell Telephone Laboratories' Safeguard computer center in Madison, New Jersey. Providing programmers and operators to manage a customer's computer complex was a departure for the corporation but one with decided advantages. Facility management contracts are generally of long duration, employ large numbers of people with diverse skills, and provide a steady stream of moderate but low-risk income. This contract would expand and be renewed many times until its phaseout in 1980.

Bell Laboratories' desire for gradual withdrawal from the Safeguard program led to SDC's fifth missile defense contract, ultimately one of the most successful in corporate history. The initial contract called for the design and prototype development of a new type of computer, called a Parallel Element Processing Ensemble or PEPE, which would draw upon SDC's most experienced resources in advanced software and hardware design.

PEPE (pronounced "peppy") was developed because the real-time computation problem facing ABMDA in its Safeguard mission eclipsed all current data processing capabilities. During a possible missile attack, Safeguard computers would be required to pinpoint hundreds of objects in space, distinguish nuclear-armed missiles from decoys, and guide interceptor missiles to their real targets—all within thirty seconds.

The major hardware manufacturers were offering their most advanced machines to ABMDA. But the average processing capacity of these computers was fifteen "mips" (million computer instructions per second), one-tenth the requirement. One feasible solution, proposed by Bell engineers, was a string of many high-speed processors operating in parallel—a Parallel Element Processing Ensemble. In August 1970, SDC was selected to build a feasibility model of PEPE, with the hardware design assigned to its subcontractor, Honeywell.

Six months later, in February 1971, an SDC-developed prototype of PEPE tackled the challenging benchmark test, developed by ABMDA, of processing all required data during a simulated missile raid. The last of many contractors (primarily computer manufacturers) to have joined the quest for a demonstrable computing capability to be developed for Safeguard, SDC was the first to succeed in meeting the demanding test of real-time ballistic missile defense.

In 1972, the PEPE program moved from Bell Laboratories in Whippany, New Jersey, to SDC facilities in Huntsville. The PEPE prototype was to lead to the pioneering achievement—by SDC and Burroughs Corporation—of an operational version in 1976. This event and SDC's successful entry into a sixth area—providing an advanced computation facility for the ABMDA Advanced Research Center—are described in the next chapter.

THE ONES THAT GOT AWAY

SDC obtained other military contracts in the 1969-1971 time period: design of an Ocean Surveillance Information System for the Navy, which would lead to one of SDC's largest awards ten years later; support to the West German Defense Ministry in command-control; design of an undergraduate training program for Air Force pilots; and several smaller programs. In addition, SDC continued to perform as software integration contractor for the Air Force Satellite Control Facility and to support the Army Air Defense Command with training in tactical operations.

The corporation's interoperability programs continued to expand. In July 1970, SDC captured a procurement to design the software for the Air Force Tactical Data System Development Testbed. Later that year, the company received the complex design and programming job of interfacing the Air Force Tactical Air Control System with Army, Navy, and Marine Corps tactical systems. By mid-1971, the Marine Corps also had contracted with SDC to integrate its Air Command and Control System into the Joint Service System.

Although technologically challenging, the new contracts were not large enough to offset the decline in the historic air defense business. A trickle of layoffs was gaining momentum. The government's 1969 decision to cancel the Manned Orbiting Laboratory, for which SDC had been selected to develop the software, compounded the problems of deteriorating job security and employee morale.

Amid this downturn in military business, two prospects loomed large on the horizon. The first was the Airborne Warning and Control System. AWACS was conceived as a highly mobile command post, in the form of a jet aircraft, directing air operations in theaters of battle. The aircraft would be equipped with sophisticated radar and communications equipment, enabling it to monitor and direct reconnaissance, attack, air cover, and other operations.

A multibillion dollar program, AWACS was not just the largest air operations systems "buy" in 1969; it was virtually the only one. SDC had been closely involved with AWACS since 1966, when it developed a computer simulation of an airborne command post for the Air Force. The computer model displayed air battles on a radar scope; simulated the behavior of aircraft, weapons, and radars; and enabled prospective AWACS commanders to participate in the simulated air battle, providing new insights for designing the final AWACS man-machine system.

In 1967, SDC became a member of one of two major aerospace consortia competing for the AWACS procurement—the McDonnell Douglas team, which was competing against a team headed by Boeing Aircraft. SDC was responsible for the computer-controlled information system that formed the hub of AWACS. The potential value of the software subsystem was $50 million over five years, offering a source of long-term stability to SDC.

In July 1970, exactly one year after submission of final proposals, the Air Force announced its selection. There was no jubilation in Santa Monica for either McDonnell Douglas or SDC. The Boeing team had won.

Three months prior to the AWACS loss, SDC had embarked on its first major foreign proposal: delivery of a total air defense capability, both hardware and software, to Israel. Again the competition narrowed to two: SDC and its hardware subcontractors, and Hughes Aircraft. Welcome news that SDC had won proved premature. A reprocurement by Israel, including a request for license to manufacture the contractor's hardware in Israel, effectively ended prospects for nonmanufacturing SDC.

Coming among SDC's earliest large competitive efforts, the AWACS and Israel losses were bitter pills. Yet they had their consoling aspects. SDC had proven that it had the resources to design and build very large systems, that it could team with the aerospace giants both as subcontractor and prime contractor, and—most significantly—that it could credibly bid as total integration contractor responsible for developing all aspects of a computer-based system. These lessons would strongly influence the plan for SDC's future.

A SHOW OF PUBLIC STRENGTH

Within a span of fifteen months, from April 1970 through July 1971, Launor Carter's Public Systems Division won six major contracts for a combined value exceeding $10 million. These were substantial programs not only in dollar volume but also in technical scope and public benefit. Unlike many small civil studies, these awards called upon SDC's forte in building total systems.

The first and largest was the development of a computerized communication system for the Los Angeles County Sheriff's Department—the nation's largest. Requiring a capability for communicating more than thirteen million emergency radio transmissions annually, the Sheriff's system was SDC's first full-scale transfer of military command-control technology to the civil sector.

The corporation won this keenly contested award with an innovative use of computers in automated dispatching, in competition with larger and more experienced electronics manufacturers. SDC proposed a dual automation approach: a highly centralized command-control system operating out of the Sheriff's downtown center, augmented by sixteen decentralized substations using minicomputers to perform automatic load-balancing among dispatchers in addition to other expediting functions. The county was sufficiently impressed with SDC's novel approach that it asked the corporation to redesign the entire communication system.

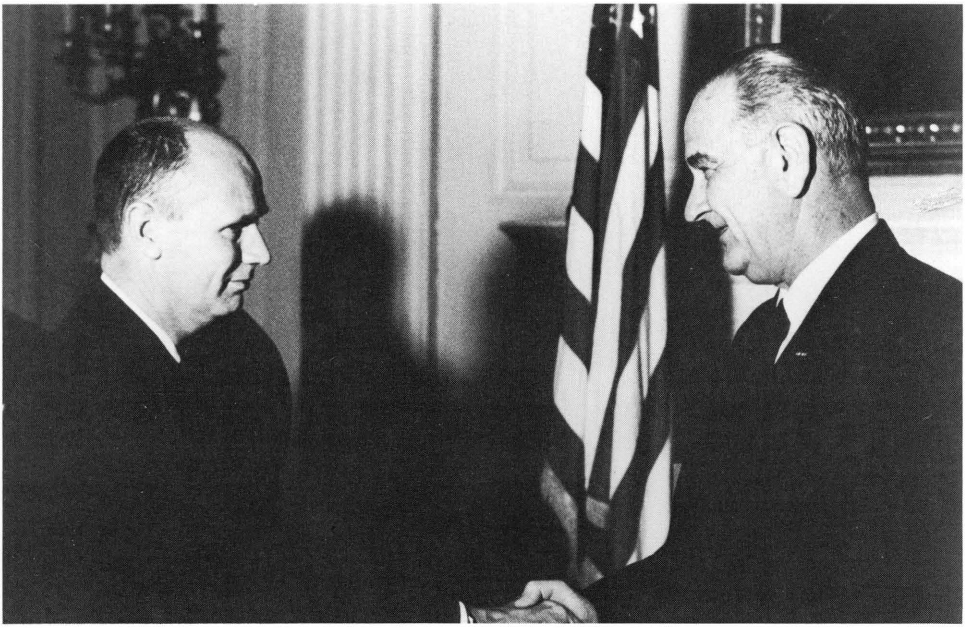
Project manager Jack C. Campbell recalls the many months of requirements analysis that went far beyond SDC's usual degree of customer involvement. "By day, the Sheriff's people were at SDC, learning about computer-based communications. At night, our people rode in their patrol cars—observing crises like the East L.A. riots, the Malibu fire, and the 1971 Sylmar earthquake. At the end, they knew what our technology could do and we understood what their problems were."

At a negotiated value of $3.5 million, the Sheriff's contract was SDC's largest public systems award and largest fixed-price contract to that time. As the total systems contractor, responsible for all communications hardware and software, SDC simultaneously entered the worlds of production engineering and manufacturing. Corporate engineers designed the switching system with subcontractor support, bought thousands of components, and assembled many of the consoles and special-purpose equipment in new corporate laboratories. Considering that SDC had little experience in high-volume, fixed-price hardware development, the L.A. Sheriff's contract was a bold and, to some minds, risky departure for a software house.

An equally prestigious award in that April of 1970 was a multimillion-dollar contract to develop an Integrated Municipal Information System for the Department of Housing and Urban Development, using Charlotte, North Carolina, as a testbed. This system, which over the next several years would automate the city's functions of finance, public safety, transportation, sanitation, and other services into a single integrated information system, was one of only two such government-funded prototypes, which HUD intended for later transfer to other U.S. cities. Indicative of the widespread interest in municipal automation, over 130 consortia of companies, cities, and universities had submitted proposals for this landmark procurement.

Public transportation was the focus of two large contracts. In one, the U.S. Department of Transportation funded SDC to develop an experimental computerized traffic control system to expedite vehicle flow through a freeway diamond interchange in Los Angeles. In the other, as subcontractor on the winning team led by Boeing Aircraft, SDC developed the vehicle control

SDC Board of Trustees elects Wesley S. Melahn president on January 24, 1964: *(seated, l. to r.)* Vice Chairman Arnold O. Beckman, Chairman William T. Golden, and Melahn; *(standing, l. to r.)* Augustus B. Kinzel, Gaylord P. Harnwell, E. E. Huddleson, Jr., Donald L. Putt, SDC Vice President William C. Biel, and Charles A. Coolidge.



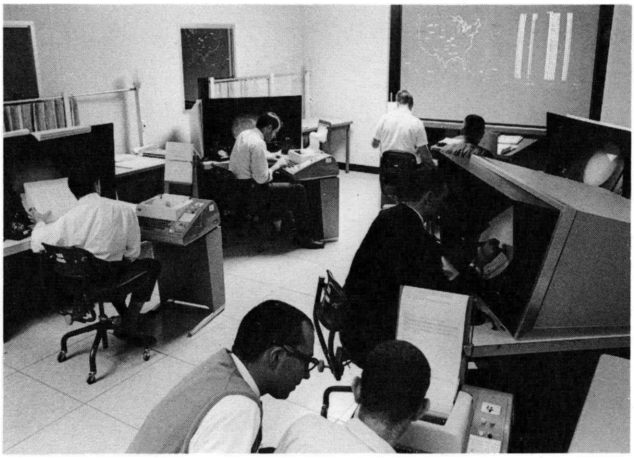
SDC President Melahn is greeted by President Johnson at the White House during the April 1964 signing of SDC's Plans for Progress Charter.

Celebrating a ten-year service award luncheon in January 1965 are *(l. to r.)* President Wesley Melahn, Jack C. Campbell, Vice President William W. Parsons *(partially hidden),* Marvin R. Jones, Betty E. Prior, and Vice President Richard M. Lintner.

(Above) Since 1960, SDC's headquarters complex in Santa Monica included this large building at 3000 Olympic Boulevard, a few blocks from the Colorado buildings. The Olympic building became western headquarters of SDC's Systems Group.

(Above) An SDC patio, during a summer student orientation. Patios in Santa Monica buildings were used during lunchtime as well as for briefings, exhibits, and open houses.

(Right) A bridge, completed in 1961, connects the Q-7 building *(foreground)* and the Q-7A building, immediately adjacent, with SDC's 2500 Colorado Building *(not shown)* in Santa Monica.

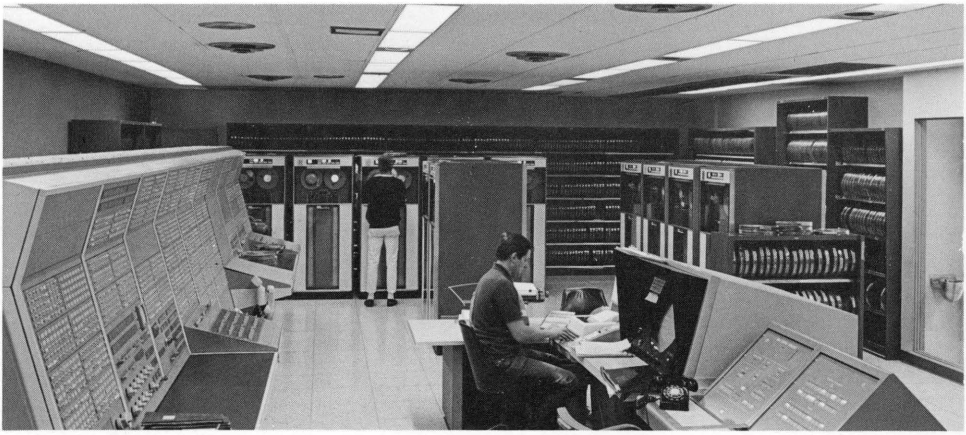


An early research project in the Command Research Laboratory was this experiment on the use of group displays in support of damage assessment and restrike planning.

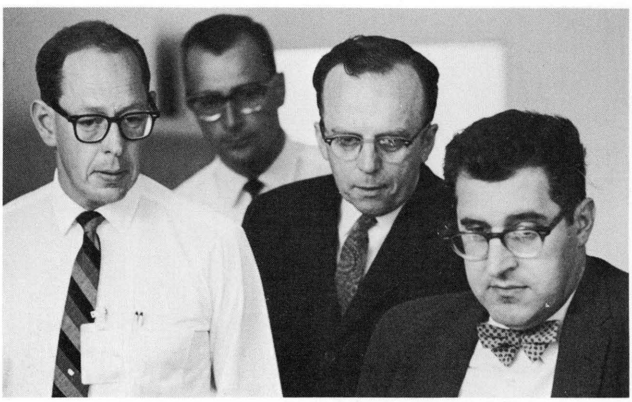
ARPA-SDC conference on timesharing held at SDC in December 1962. At head of table are co-chairmen J. C. R. Licklider, ARPA *(left)*, and SDC's Herbert Benington. SDC's timesharing project leader, Jules I. Schwartz, is seated at right rear.

Winners of the American Federation of Information Processing Societies (AFIPS) prize for the best paper presented at the 1964 Spring Joint Computer Conference: *(l. to r.)* Jules Schwartz, Edward Coffman, and Clark Weissman for "A General-Purpose Timesharing System."

The senior staff of SDC's ARPA-sponsored command-control and timesharing research program in 1964: *(bottom row)* Department Manager Paul D. Greenberg *(left)* and Command Research Project Director Donald L. Drukey; *(middle row, l. to r.)* Leland F. Page, Jules I. Schwartz, and Robert F. von Buelow; *(top row)* Bobette Jones, Bill O. Barancik, Robert M. Peterson, and Guy H. Dobbs.

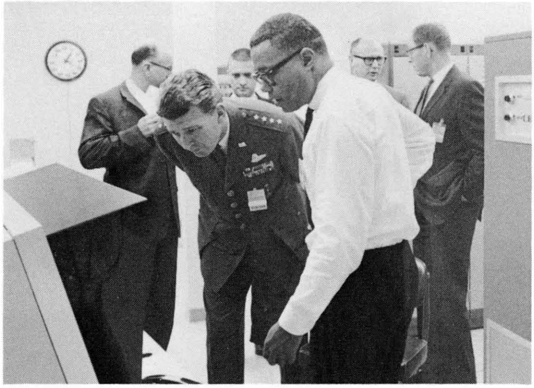


The $7 million IBM AN/FSQ-32 computer in SDC's Command Research Laboratory, originally intended to support command-control experiments, became the vehicle for SDC's pioneering general-purpose timesharing system in 1963. Operator sitting at the "I Spy" console is able to monitor and communicate with all users.

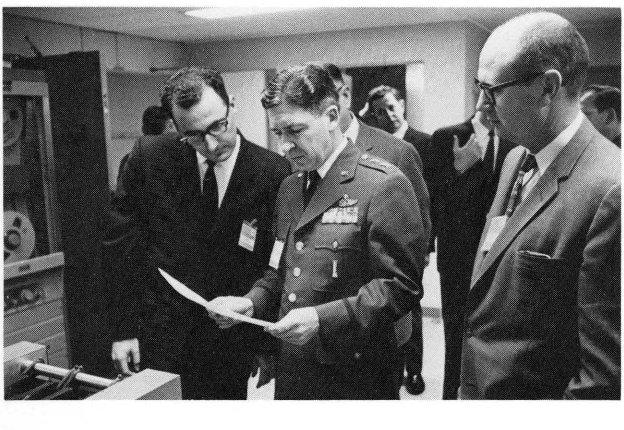


Observing a demonstration of the SDC timesharing system in 1964: *(l. to r.)* Donald L. Drukey, Bill O. Barancik, ARPA Project Director J. C. R. Licklider, and ARPA Deputy Director Charles Herzfeld.

AFSC Commander General Bernard A. Schriever views a display console in the Command Research Laboratory in October 1964, as Assistant Technology Director Guy Dobbs explains the operation. In background: *(l. to r.)* Launor Carter, Richard Lintner, Wesley Melahn, and Donald Drukey.



Major General John B. Bestic (Deputy Director, NMCS) visits the Command Research Laboratory in November 1964. Standing *(l. to r.)* are Guy Dobbs, General Bestic, Wesley Melahn, William Parsons, and Howard Manelowitz; Charles A. Kribs *(left)* and Jules Farell are operating timesharing consoles.

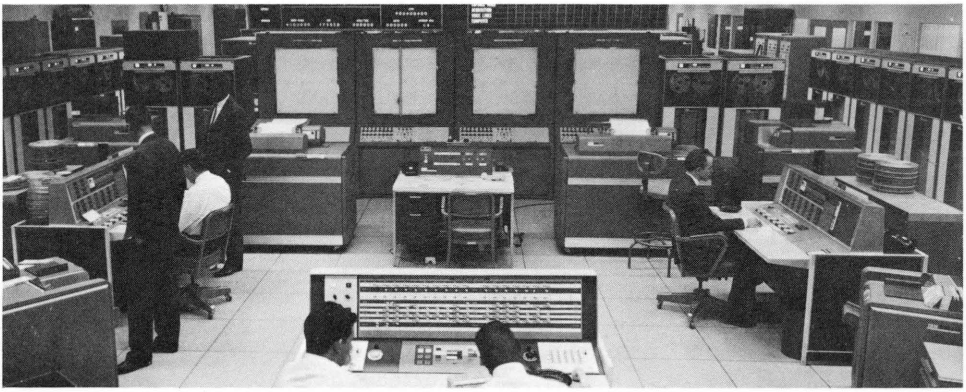


Inspecting a SAGE computer printout in a 1965 visit to SDC is ESD Commander Major General John W. O'Neill, flanked by John R. Ottina *(left)* and President Melahn.

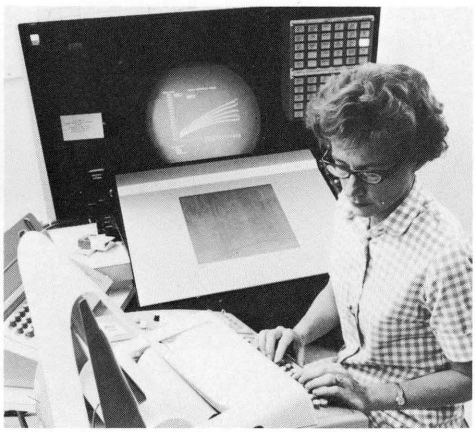
The BUIC III development computer at SDC—a duplicate of an operational military computer, the Burroughs AN/GSA-51. BUIC was designed to conduct air defense if SAGE became inoperative.

(Left) SDC integrated a computer-aided instruction system into the operational BUIC air defense consoles. This student is using lightpen in response to the lesson frame on the scope.

(Below) In 1965 NASA asked SDC to analyze the operations of its computer complex at Goddard Space Flight Center.

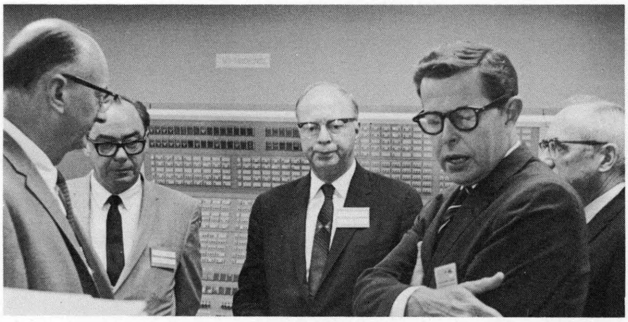


Donald L. Drukey addresses the Second Symposium on Computer-Centered Data Base Systems, sponsored by SDC, ARPA, and ESD, and hosted by SDC at the Santa Monica Civic Auditorium in September 1965.



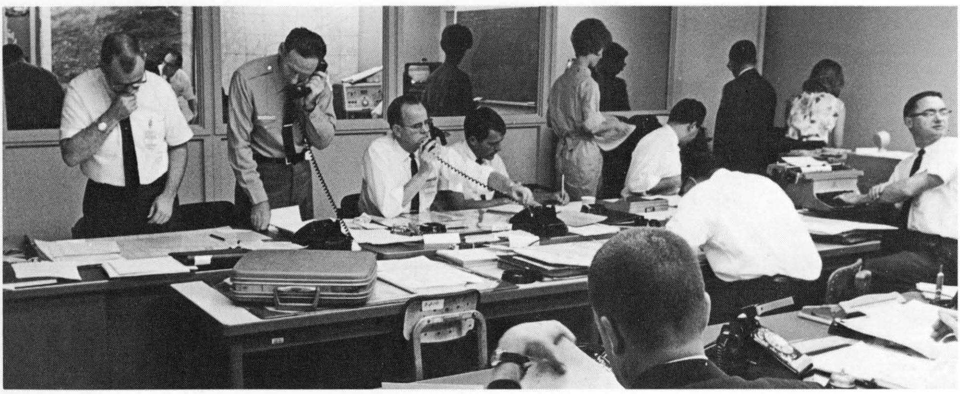
Research leader Sally C. Bowman demonstrates SDC's General Purpose Display System at the Second Data Base Symposium. The system *(also shown at right)* accepted input from teletype, graphic input tablet, lightpen, and console buttons in allowing users to construct personalized displays.

Navy visitors view SDC's data management technology in a February 1966 visit: *(l. to r.)* Vice President Thomas C. Rowan, Caleb B. Laning, President Melahn, Vice President William Parsons, Vice Admiral Charles B. Martell (Director, Antisubmarine Warfare Programs), Rear Admiral Ernest W. Dobie, Jr. (Director, ASW R&D Programs), Vice President Donald Drukey, Robert E. Bleier *(at console)*, and Rear Admiral Eugene P. Wilkinson (Director, Submarine Warfare Division).

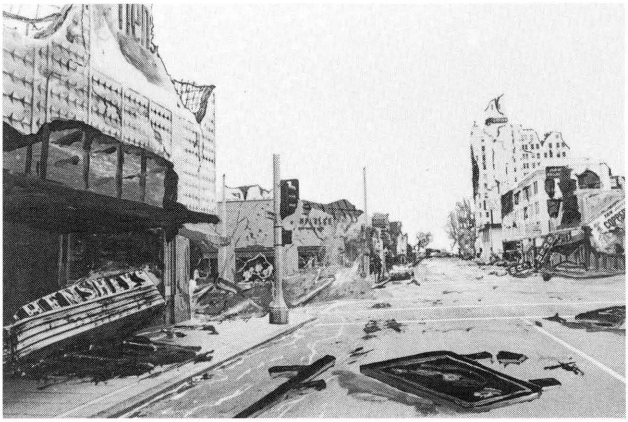


U.S. Comptroller General Elmer Staats was an SDC guest in September 1968. Shown with Staats *(center)* are *(l. to r.)* Vice President Launor Carter, visitor Richard Gannon, and Vice Presidents Charles A. Alders and William Parsons *(partially hidden)*.

Enjoying a demonstration of on-line data management during a 1967 tour of SDC is Air Force Logistics Commander General Thomas Gerrity, accompanied by *(seated, l. to r.)* Charles Moor, Major General Donald Jackson, and Colonel Joe Drach *(at Gerrity's left)*. Standing: *(l. to r.)* John Ottina, Richard Lintner, Aaron "Bud" Drutz, and Robert W. Hamer.

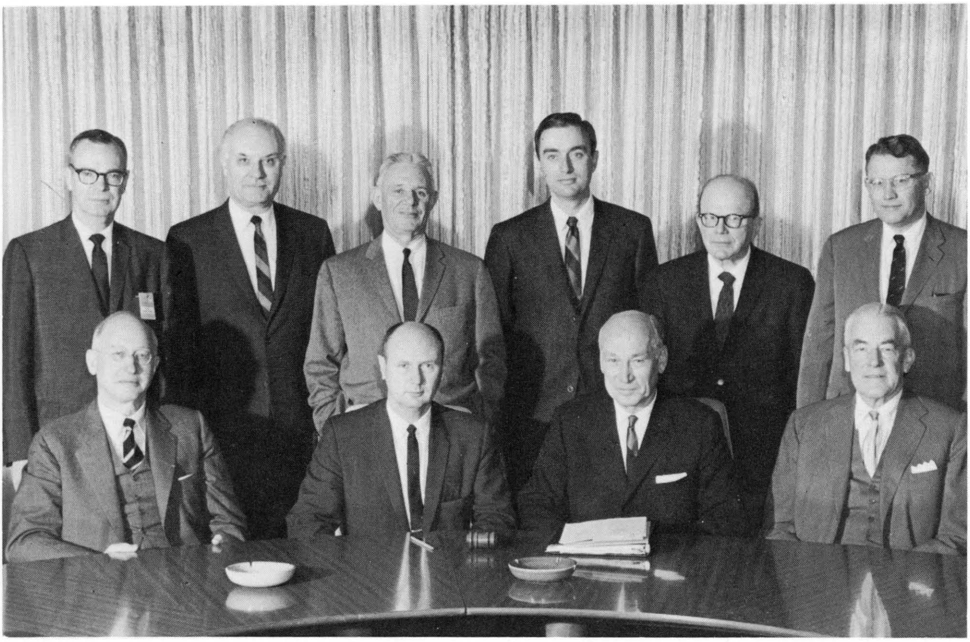


From 1964 to 1970, SDC trained hundreds of state and municipal officials in coping with civil emergencies through simulated exercises in its Emergency Operations Research Center (EORC). *(Top)* Indoctrination in a civil defense exercise is presented by Terence P. Haney. *(Middle)* A shirt-sleeved group takes to the operating stations as realistic stimuli on an earthquake are presented. *(Bottom)* The exercise is in full swing.



"Before" and "after" photos of simulated disasters (such as this one of downtown Santa Monica) were used to test participants' skills at observation, reporting, and damage assessment.

(Below) The EORC was a popular attraction for visitors. SDC Trustees are observing a simulated hurricane disaster exercise in 1966: *(standing, l. to r.)* Department Manager Ralph C. Bledsoe, with Trustees A. B. Kinzel, C. A. Coolidge, W. T. Golden, L. N. Morrisett *(partially hidden),* E. E. Huddleson, A. O. Beckman, and D. L. Putt.



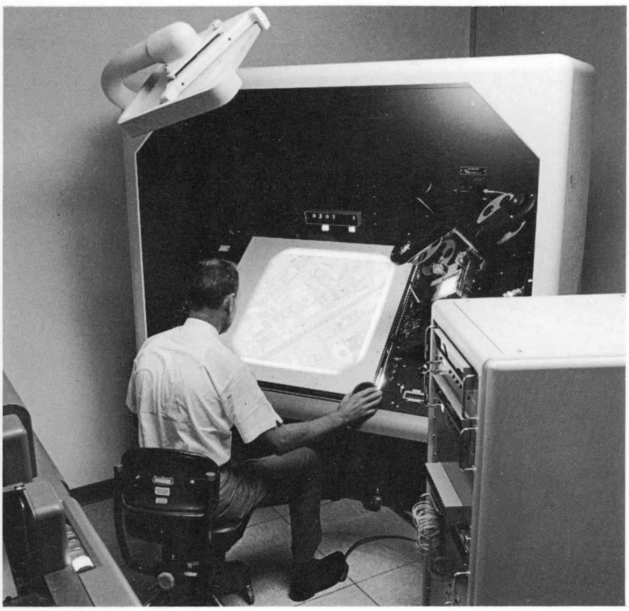
Attending the 36th meeting of the SDC Board of Trustees in January 1967 are: *(seated, l. to r.)* Bethuel M. Webster, President Wesley S. Melahn, Chairman Arnold O. Beckman, and Vice Chairman David A. Shepard; *(standing, l. to r.)* Edwin E. Huddleson, Jr., Donald L. Putt, Augustus B. Kinzel, Lloyd N. Morrisett, Ralph W. Tyler, and H. Guyford Stever.

President Melahn seated at his desk. Subjects in the vivid photographs of SDC activities on rear wall appear to be observing the executive office.

Three of SDC's administrative executives in a 1967 discussion: *(l. to r.)* Controller Joe B. Scatchard, Corporate Secretary Louis G. Turner, and Director of Administrative Services Julius D. "Dewey" Lederer.

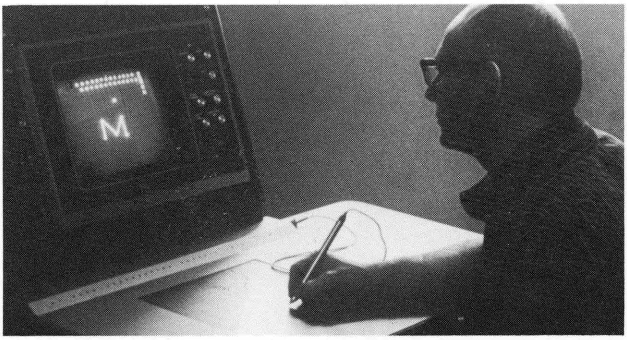
SDC trained over 150 visually handicapped persons to become proficient computer programmers, using a variety of special teaching aids. Shown with this 1968 class is project head Constance Walker.

Five hundred representatives of DoD and other agencies attend a symposium on SDC's ADEPT-50 at Andrews Air Force Base in July 1968. Sharing the panel are *(l. to r.)* Colonel Alfred R. Novak, Hq. USAF; Don McLagen, Office of Assistant Secretary of Defense; SDCers Jules Schwartz and Bud Drutz *(speaking);* and Charles West, DCA.



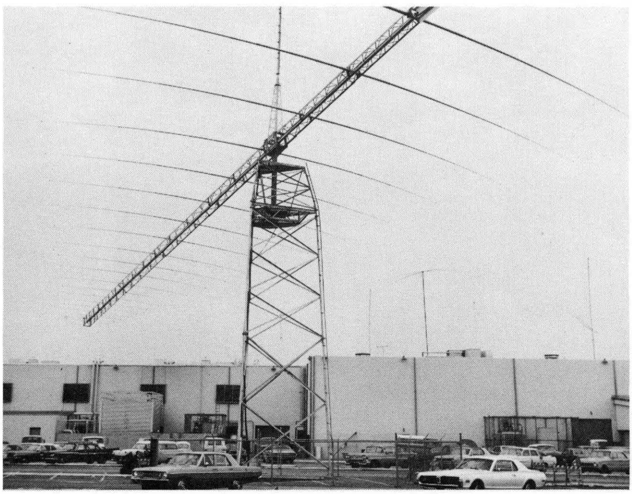
Research in vehicle flow led SDC to design of automated signal control systems. Principal investigator Antranig "Andy" Gafarian is seated at the SDC-developed automated traffic analyzer.

Computer-mediated studies in bargaining and negotiation behavior are being demonstrated by SDC's principal investigator Gerald H. Shure *(standing)* to members of an Indian Management Study Team.



(Left) SDC's handwritten-character analysis program indicates that it recognizes the letter "M" written on the graphic input tablet by Morton I. Bernstein, developer of the system.

(Right) A 100-foot-high troposcatter radio tower was erected in SDC's parking lot in the early 1970s to test the interface between the Seek Dawn tactical system and airborne radar planes, prior to installation of this communication system in Vietnam.



ESD Commander Major General John B. Bestic awards a plaque to SDC Vice President Launor F. Carter in token of Carter's service on ESD's Advisory Group. Observers are *(l. to r.)* William Parsons, Colonel C. Laustrup, Emmett Gosnell, Wesley Melahn, William R. Warren, and Emil Gaynor.

The new Board of Directors of for-profit SDC at its first meeting in April 1970: *(seated, l. to r.)* John F. Bishop, Owen Meredith Wilson, and Chairman William E. Zisch; *(standing)* Brooks Walker, Jr. *(left),* and John J. Burke. (Not shown is board member Wesley Melahn.)

software and displays for a novel mass transit system—the People Mover in Morgantown, West Virginia. This personal rapid transit system was designed to carry passengers in small automated cars over dedicated guideways at speeds up to twenty-five miles an hour.

SDC's support to the National Library of Medicine took on major proportions when NLM asked the company to develop its huge new Medical Literature Analysis and Retrieval System. When completed, the MEDLARS II system would store millions of citations, from every medical publication in the world, in machine-readable form for on-line retrieval and analysis by medical researchers.

The sixth major contract, like the Sheriff's system, was a justice application—development of a computerized information system to help Los Angeles Police Department detectives connect related crimes and spot developing crime patterns. Called PATRIC, this system used SDC's timeshared data management technology to correlate information about crimes in order to identify suspects based on their modes of operation. Described by Los Angeles Police Chief Edward Davis in 1971 as "a significant step beyond computerized law enforcement systems now in use," PATRIC would still be pinpointing offenders for the LAPD at the beginning of the 1980s.

All six contracts were completed successfully. But they were not the harbinger of great waves of civil systems work. Over time, SDC became increasingly selective, waited for exceptional opportunities to build large civil systems, and then went all out to win them.

THE RISE AND FALL OF DATACENTER

DATA FOR THE MANAGER

SDC's most spectacular financial failure coincided, unhappily, with its first year of attempting a track record of profitability. The venture, called SDC Datacenter, operated for 172 days, from September 8, 1969, to February 2, 1970—and cost the company $3 million.

Datacenter attempted to parlay SDC's forefront capabilities in timeshared data management into a new commercial business—a network of service centers offering on-line use of the world's most sophisticated information management tools to executives and managers with no knowledge of programming.

The events leading to Datacenter had begun in 1966, when SDC's development of a timeshared data management capability branched in three directions. The first was the continued refinement of the timesharing system on the Q-32 computer, where it served clients in government and universities from 1963 until its phaseout in 1969. The second was ADEPT—the ARPA-sponsored Advanced Development Prototype—installed on the IBM 360/50 and other machines for a number of military commands.

The third development was an adaptation of the ADEPT timesharing system to the new corporate IBM 360/67 computer, along with the conversion of its data management component, TDMS, into the Commercial Data Management System or CDMS.

When the Commercial Systems Division was formed under John Matousek in January 1968, along with the Military and Public Systems Divisions, a prototype version of CDMS was already operational on the 360/67. The main thrust of SDC's commercial activity became the translation of this data management technology into a viable line of business.

According to Matousek, "The Datacenter decision was based in part on unloading SDC's excess computer power. We had the Q-32, a 360/50, and a 360/67, giving us more capacity than we needed or wanted. CDMS was supposed to solve that problem along with offering our unique technology to the commercial market."

In its open-ended search capabilities and ease of use, CDMS was unique for its time. Its guiding principle was to enable an on-line user to ask any logical question of a complex data base, in fairly natural English, without having to tell the machine where to find the answer, and without waiting overly long while the program searched serially through the entire data base. To avoid these drawbacks, which plagued most existing data management systems, the innovative CDMS architecture shaped a data base into a fully indexed and inverted file structure, in which every data item could be used as a retrieval key, thereby expediting the search process significantly. This pioneering approach would influence the design of a generation of future retrieval systems.

Considering the enthusiastic response to ADEPT by government, its commercial counterpart was expected to appeal widely to industry. The emerging Datacenter business plan, developed throughout 1968, contained the following mandates: Improve CDMS, particularly the data entry and update features, since data retrieval, display, and reporting were already in good shape. Plan to offer the service over a nationwide network of timeshared Datacenters, starting with Santa Monica and Washington, D.C. Feature CDMS as the main attraction, offering other systems and languages as well. Hire a sales force and begin advertising. Expect a sizable front-end investment in 1970, breakeven in 1971, and good profits by 1972.

A DATA BANK OF PROBLEMS

In March 1969, Santa Monica's Datacenter opened on a trial basis for a six-month shakedown period with a select group of subscribers. The versatility of CDMS became quickly evident: Atlantic Richfield used the system to analyze customer sales, Gulf & Western Industries to maintain personnel files, Continental Can Corporation to develop a container index, and Texas Instruments to manage financial and personnel data.

These and about twenty other users tried Datacenter in order to find the best match between its computerized power and their individual needs. Based on their generally favorable responses, SDC initiated full operations, opening the doors for all-day Datacenter service in Santa Monica and Washington in September 1969. The following month, multiplexers extended the service to Dallas and New York.

During this period, there was a change in leadership of Commercial Systems. In the wake of the King Resources defection in May 1969, President Melahn needed John Matousek's air defense experience back in the military area and named him to manage the Air Operations Division. Robert W. Hamer, then assistant manager of Commercial Systems Division, was promoted to be its manager. Hamer had joined SDC in 1957 as a mathematician and had progressed through various management positions on the military side, including management of the 800-person Operational Systems Department.

After its September launching, Datacenter was beset by a welter of problems. One was marketing: new customers and revenues quickly trailed behind plan. Paying $30 per hour to use the system, the average Datacenter customer was spending about $3,000 per month, or $36,000 per year, for the service. With SDC's breakeven point projected at $4 million, that would require 110 clients, more than three times the 35 currently on board. Moreover, the technical difficulties of getting new customers operational on Datacenter, particularly in converting their existing files to CDMS, set unforeseen limits to the number of new subscribers that could be accommodated at one time.

An attractive alternative was to increase usage by current clients. A Fortune 500 customer, with half a dozen Datacenter terminals in its executive suite, each used for only half the working day, would bring in $15,000 of monthly revenue, requiring only twenty-two subscribers at $180,000 per year to break even.

Here the Datacenter concept hit new snags. Despite the undeniable user orientation of CDMS, the business executive for whom it was intended showed a marked disinterest in personally punching a keyboard. Moreover, he was unsure how best to utilize CDMS. The highly advertised general-purpose nature of the system became at once its major virtue and its bane: CDMS was a general solution in search of specific problems.

Hamer says, a decade later, "Had we been astute commercial marketers, we would have packaged CDMS so it appeared tailor-made for different sets of users—an inventory control system, a manufacturing system, a distribution system—instead of playing up its general-purpose features."

In the few instances where both management interest and a practical use for CDMS were evident, the customer often preferred to build an internal capability before spending tens of thousands of dollars a year for a service over which he had limited control. Although the CDMS software was also for sale, there were no takers. The explanation, according to Bud Drutz, who was responsible for ADEPT and CDMS in Washington, was simple: "While all the world was going with IBM's OS/360 operating system, we had built our own operating system for TDMS and CDMS. That meant the user had to shut down everything else and swap executive programs before running our data management systems. And we, in turn, couldn't run anybody else's programs in our Datacenter."

These difficult marketing problems aside, the times themselves conspired against Datacenter. The promise of timesharing had given rise to a sprawling—and often brawling—service industry which had seen competition cut the price for a timesharing hour from $12 to $4 within six months. In 1969, only one out of some 120 timesharing companies made money, with the industry leader, General Electric, losing $20 million.

Although SDC was selling sophisticated data management and not mere timesharing, the distinction was often not obvious to a prospect besieged by hordes of salesmen advertising their "data centers." Thus, SDC also fell victim to the overall profit squeeze.

Internally, the timing for Datacenter could not have been worse, coming more by coincidence than by design on the heels of the for-profit announcement in July 1969. SDC management had been prepared to risk a first-year investment of $2 million, which would still have left some corporate profits to show for the year's efforts. Three months into Datacenter, by December 1969, it faced the alarming prospect that the venture's growing deficit was likely to swallow all corporate profits. This was unwelcome news in the year of setting the stage for a public stock offering.

Additionally, the Datacenter story played out during the troubled on-again, off-again negotiation with the Lehman investor group—a half year when ownership of SDC was unclear, fresh capital hard to raise, and companies that might otherwise have become financial partners in a long-term Datacenter association looked vainly for a clear sense of direction for the future SDC.

The Commercial Systems Division's own doubts about Datacenter were confirmed by a national consulting firm whose 130-page report of January 1970 may be synopsized as: "Deemphasize

Datacenter." On February 27, SDC did just that, shutting down all installations. Users who depended on CDMS for day-to-day operations were helped in making the transition to other systems.

A COSTLY LESSON

During its brief tenure, Datacenter had filled the working lives of some one hundred employees, taxed the time and energies of an already beleaguered management, and in its $3 million loss turned a profitable year into a losing one for the new SDC.

What went wrong? In the view of a senior manager: "We asked the scientists to invent a marvelous new tool. They did. Then we asked these selfsame scientists to package it for industry. They tried. Then we asked them to market it. They didn't."

Lack of financial experience in commercial products was another factor. Says Hamer: "As the system engineers, we did not fully appreciate cash flow, amortization, and breakeven analyses—things that commercial businessmen learn in kindergarten." Echoes John Matousek: "The financial plan was unrealistic. We didn't have the capital or staying power to make it work."

Wes Melahn sums it up: "We made the incorrect assumption that if you have the technology, the rest will take care of itself. What we made available wasn't necessarily what the customer wanted or needed. We had an inexperienced sales force and not much capital. It was probably an unwise choice."

The lessons of Datacenter impressed themselves on the corporate memory. A decade later, in its venture on a far more ambitious development program, of a unique data-handling system called the SDC Records Manager, the company would recruit a small army of seasoned commercial products specialists to bring the product to the marketplace.

OTHER COMMERCIAL BUSINESS

The charter of the Commercial Systems Division went beyond Datacenter to marketing all of SDC's capabilities—in system development, data processing, and training—to industry.

This mission proved no easier than selling Datacenter. In the commercial software area, several factors militated against SDC. Businesses either bought small off-the-shelf systems or applications packages (for accounting, inventory control, or the like) or, if a company's size warranted a major new system, it generally owned the staff to develop it internally. Moreover, SDC's expertise lay in scientific programming using such languages as JOVIAL and FORTRAN, an order apart from COBOL-oriented business programming. Rarely did a company need or buy a system analysis or design, and its training needs were met either internally or by a commercial training institute.

In short, there was a clear mismatch between SDC's general, scientific, systems-oriented capabilities and industry's specific, commercial, applications-oriented needs.

Given this dilemma, SDC did well to dent the commercial market at all. Using its programming language experience, SDC built a special-purpose compiler for a minicomputer for Bendix Corporation. Several leading banks used SDC to assess their automation needs. The company designed a nationwide information network for a large insurance carrier, which then elected to develop the system in-house. In a short-lived venture, SDC co-managed a computer service bureau with Republic Corporation. Longer-term facility management contracts were won for several hospitals in New York City.

SDC's most successful commercial contract in this time period was support to Bell Laboratories in its groundbreaking efforts to automate the production of telephone directories. From 1969 to 1975, an SDC team of designers and programmers, reaching levels of thirty professionals, would work with Bell to convert the cumbersome hot-metal printing of white-page directories to a streamlined computer-based technology which automatically composes the final pages from magnetic tape. The results of these efforts are estimated to have saved many millions of dollars for the operating companies of the AT&T family.

Despite successes, SDC's commercial business during 1969 and 1970, including Datacenter, accounted for only 5 percent of corporate revenues. Nor did this business show signs of growth. With the demise of Datacenter, the company had no other credible, attractive service or package to offer industry.

Among SDC's combined intelligence, few brain cells had grayed in the dusty back rooms of business. Having matured in the building of sophisticated, large-scale systems for the nation's defense, corporate personnel could hardly be expected to invent automated, cost-saving miracles for a commercial world few had known.

It would take a more business-oriented management team to breathe life into SDC's commercial endeavors. Within a few years, a concerted program of acquisitions, product development, and transaction services would provide SDC with a focused and successful reentry into the commercial marketplace.

A TIME OF CRISIS

A PROFIT PREDICAMENT

When SDC's new board of directors took office in April 1970, its chairman, William Zisch, was asked to operate in that capacity on a full-time resident basis. This decision created an anomalous management situation. SDC now had a full-time board chairman in Zisch, and a full-time president in Melahn, neither of whom was chief executive officer. Although the two men saw eye to eye on many issues confronting SDC, they also differed on others.

With neither man clearly in charge, an atmosphere of confusion began to permeate the executive halls. As one veteran manager recalls, "I got so much conflicting direction, I often wound up doing nothing."

Among the serious problems facing management in June 1970 were the financial results of the year just ended. In this, its initial profit-seeking year, SDC for the first time in corporate history registered a loss—of $550,000. Contributing to the loss were the Datacenter deficit, a decline in military revenues, and a writeoff of a joint venture in the urban systems domain.

This venture, called Doxiadis-SDC, had been formed in February 1969 to combine the urban planning expertise of Doxiadis Associates with the systems and data management skills of SDC for an integrated approach to a wide array of urban problems. The operation did not thrive and was dissolved by mutual consent in June 1970.

In experiencing the misery of unprofitability, SDC did not lack company. If anything, it had gotten off lightly compared to a host of competitors who had staked large sums in proprietary services, akin to Datacenter, with disappointing results. During 1970, Computer Applications discontinued a grocery inventory system and registered a $10 million loss; Informatics invested in data centers and lost $4.2 million; Computer Usage set up service bureaus and lost $1.5 million; and Computer Sciences wrote off a $13 million dollar investment in a computerized ticket system.

Times were hard for the entire industry. From a handful of software houses in 1960, some two thousand companies had sprung up within a decade. No one could blame these entrepreneurs of electronics for forming a spate of new companies each week. Since 1966, the stock market's enchantment with any new listing including the word "computer" had skyrocketed those companies' stock prices and made the owners overnight millionaires. One new "computer services" company saw its stock soar from $10 a share to $80, until the discovery that it installed acoustic tiles in computer rooms sent it down to $2. But by mid-1969 the number of software suppliers exceeded demand; red ink began to flow; and the stock market phenomenon of go-go electronics stocks was starting to short-circuit.

These financial realities were small comfort to the many SDC employees who now owned a piece of the company. Throughout the years of SDC's painful struggle toward for-profit status, many had waited hopefully for the opportunity of equity participation in the company they helped to build. In 1970 their patience was rewarded with the granting of stock options to 992 employees, about one-half of the professional population, an almost unprecedented percentage of grantees.

Despite legal and practical objections to this wide stock distribution, SDC management had held firm in rewarding as many employees as feasible. The breadth of distribution also served to dampen the number of options granted to any one individual, conforming to the "no windfall" policy set by the trustees.

However, at the close of fiscal 1970, with profit at a minus 17 cents per share and no foreseeable public market for the stock, many SDCers must have scratched their heads and wondered, "Was it really worth going profit?"

The following year's business picture was not much brighter.

Even without the albatross of Datacenter, the company could not reduce overhead fast enough to keep pace with plummeting sales. Over the two-year period from July 1969 to June 1971, the company could claim a 50 percent gain in commercial and public sector business against a 40 percent decline in military sales. Unfortunately, the financial starting points for these calculations were not in SDC's favor. While public and commercial revenues climbed from $8 million to $12 million, military sales nosedived from $53 million to $33 million, for a net revenue loss of $16 million. Profits for fiscal year 1971 were only $130,000, helped by a $55,000 tax-loss-carryforward.

One casualty of the economy drive was the prize-winning *SDC Magazine*, published monthly since 1957 and mailed gratis to 30,000 recipients. A holdover from SDC's nonprofit days, the *SDC Magazine* was one of the few publications to make the complexities of modern technology understandable to a broad and appreciative readership. June 1970 marked its last issue.

SIX DAYS IN FEBRUARY

Three events highlighted the period of February 5-10, 1971. On February 5, SDC personnel formed part of an MIT team that won a race against time to save the Apollo 14 lunar mission. While preparations were under way for the descent to the surface of the moon, telemetry data indicated that the Lunar Module's "abort" switch was generating spurious signals, apparently caused by a speck of dirt on a contact. Since the program logic would abort a landing under these conditions, immediate action was necessary for the mission to proceed.

The MIT/SDC team was assembled a scant three hours before start of the landing phase. Under intensive time pressure, the team worked out a program patch to prevent the unintentional abort of the landing. After the solution was double checked by Mission Control in Houston, it was relayed to Captain Alan Shepard aboard the Lunar Module. The operation was completed only ten minutes before the scheduled start of the descent.

On February 9, at 6:01 A.M., many Los Angeles residents were jolted out of bed by a major earthquake. Although registering only a "moderate" 6.5 magnitude on the Richter scale, the quake killed 58 people, injured some 4,500, and demolished 800 buildings. Corporate headquarters in Santa Monica escaped with a few broken windows and a temporary power outage, but many employees living near the earthquake's epicenter in the San Fernando Valley sustained more severe damage to their homes. For the first time, SDC's public address system was used for emergency broadcasts, notifying employees of available water supplies and closed roads.

The following day, Wednesday, February 10, was to have a profound and lasting impact on the company. SDC's Board of Directors met in emergency session in Santa Monica to resolve a pressing concern: the need for a single chief executive to operate the company. The board concluded that, in the best interests of SDC's uncertain future, the new executive should be of recognized national stature with strong credentials in both technology and profit-making industry.

A NEW CHIEF EXECUTIVE

After a nationwide search, the board believed they had found an ideal candidate in Dr. George E. Mueller. Mueller was known as the man behind America's successful program of lunar exploration. Additionally, in a distinguished thirty-year career, Mueller had combined a strong engineering background with an innate flair for management to hold key executive positions in industry. At Space Technology Laboratories he had been vice president for Research and Development. Most recently, as senior vice president of General Dynamics, his plans for cost reductions, technology development, and marketing had been instrumental in stabilizing that company during a period of declining aerospace business.

The most persuasive qualification for SDC's purposes was Mueller's reputation for accepting and conquering challenges that deterred others. As NASA's associate administrator for Manned Space Flight, from the beginnings of the Gemini flights in 1963 to the second Apollo moon landing in 1969, Mueller had successfully directed one of the largest, most challenging, and most complex peacetime efforts in U.S. history—coordinating a team of thousands of contractors and resource personnel, while maintaining an accelerated schedule and meeting cost targets.

Before accepting NASA's most difficult job, Mueller had laid down one condition: If he was to redeem President Kennedy's pledge of a lunar landing by 1970, he needed authority to reorganize the whole manned space flight program. He got the authority—and put man on the moon by 1969.

Mueller willingly accepted the new challenge of redirecting the fortunes of SDC. "At NASA I learned first hand that SDC's reputation for excellence was well deserved," he recalls. "But it was also known for having a nonprofit attitude. Changing that attitude 180 degrees, and SDC's profit trend along with it, was an exciting prospect."

On May 3, 1971, near the end of the 1971 fiscal year, the board elected Mueller chairman, chief executive officer, and president of SDC. William Zisch, relinquishing the post of full-time board chairman, would remain a member of SDC's board until 1976. Wes Melahn helped to assure a smooth transition, then left the corporation to continue a distinguished career in public service.

During his presidency, from 1964 through 1971, Melahn had steered the company safely through the shallows and crosscurrents of persistent government probes, various strategies for going public, many attempts to sell SDC, a continuing erosion of key personnel, and the determined efforts of competitors to scuttle the company. None of it had been easy; all of it drained the time and energy of management—energy that could have been deployed in planning for future growth. Yet the company had ridden out the storm, supported by Melahn's calm and reflective leadership.

The trustees paid tribute to Melahn with an inscription which read, in part: "Wesley S. Melahn has contributed significantly to giving SDC life, substance, and continuity. At a critical moment in the corporation's history, the board called upon him to become president. He led the organization through the impact of a profoundly and rapidly changing environment. His leadership was a vital part of the process of evolving the for-profit organization. All this has been effected by his integrity, loyalty, stability, and leadership."

A CRITICAL QUESTION

Within two years, SDC had traversed an unexpected orbit: from supporting the first manned moon landing in July 1969 to gaining the director of U.S. manned spaced flight for its corporate chief executive. In his NASA role, Mueller had been credited by many with performing miracles. In the words of Wernher von Braun, "Without George Mueller, we could not have landed a man on the moon as soon as we did." Within SDC, many were hoping for a touch of the same wizardry to restore the sagging corporate fortunes.

For these had reached their nadir. Fiscal 1971 revenues of $45 million were the lowest in ten years. Retained income after two years of profit seeking was a minus $420,000. Awards for new business to replace the completed SAGE/BUIC work had averaged $20 million over the past three years, implying in time a $20 million company. At the end of June 1971, the backlog of contracts yet to be completed amounted to less than six months of assured work for SDC personnel. Datacenter had become closely identified with SDC's for-profit future; to many, the failure of one implied the absence of the other.

These concerns, as well as low morale and a host of internal problems, were cited by a management firm employed by SDC in December 1970, whose report concluded: "A critical question is whether the company has the inherent strength to survive and be viable in a fast-moving, competitive, for-profit environment."

Discouraging as losses in prestige, contracts, and revenues may have been, they seemed small compared to the far more damaging loss of SDC's most valuable resource—its skilled people. In two years, SDC's work force had dwindled alarmingly, from 3,200 to 2,000. In round terms, for every ten employees on board in July 1969, there were only six in 1971. This severe drop came at the tail of an eight-year personnel downslide, which had reduced SDC's talent pool of 4,300 people in 1963 by more than half.

With SDC primarily in the business of offering high-technology services in which people make the difference, this loss would be one of many obstacles on any road leading to recovery.

CHAPTER 7

The Turnaround Years

(1972-1974)

STARTING OVER

In his first SDC talk, before two hundred management employees on May 12, 1971, President Mueller set the stage for his turnaround program: "We must capitalize on the military and public market areas where SDC is already strong, while selectively diversifying into growing commercial markets and developing new product lines."

In response to a question on his foremost objective, Mueller surprised the assembly. "I intend to have fun at SDC. I'd like you to share in that feeling. And I think you will."

Assembling his senior staff, Mueller asked for their ideas on improving operations and trimming costs. He was pleased by the number of good suggestions but disturbed at the barriers cited to getting them implemented.

With a friendly smile, he told the group, "I don't need experts to tell me all the ways things cannot be done. I'd like to know how they can be done and how soon we can have them." Work began on the suggestions later that day.

After receiving the National Medal of Science from President Nixon at the White House for his contributions to the design and planning of Apollo, Mueller began to chart a new course for the corporation.

INFUSION FROM INDUSTRY

A foremost priority was the development of a profit-oriented management team. "We knew we had a solid technical management," says Mueller. "Now all we needed were people who knew how to make a profit. It was essential to attract such people to complement our technical strength and weld a new team."

Within a year of his arrival, Mueller had recruited experienced industry executives with strong aerospace or commercial backgrounds for key slots around the company.

The first to arrive—originally as assistant to the president—was James B. Skaggs, a young and rising executive known to Mueller from NASA and General Dynamics. At NASA, Skaggs had been director of Apollo Program Control for the Apollo program director, General Samuel C. Phillips, and director of Plans Integration for Wernher von Braun.

Complementing Mueller's visionary talents, Skaggs's abilities to translate long-term objectives into action soon earned him the reputation at SDC of Mueller's alter ego. Whether or not that label fits, Skaggs has been near or at the center of corporate power throughout his SDC career.

"Some think of Mueller as the thinker and Skaggs as the doer, but that's a gross oversimplification," says a close associate. "Both men are thoughtful and action-oriented. They make an extraordinary team."

When Dr. Mueller reorganized the company in March 1972—ten months into his tenure—he liberally seeded its management with fresh talent. Jim Skaggs became senior vice president and deputy to Mueller. Gordon M. Binder, from Ford Motor Company, was named vice president of Finance. Military operations were consolidated in a single Defense and Space Division under Dr. Donald A. Dooley, from General Dynamics. Another General Dynamics graduate, Jack C. Cannady, was named vice president of Business Operations for Dooley's new division. Edward J. Doyle, from RCA, became vice president for Marketing of Defense and Space Programs.

A new commercial Product Planning and Development organization was placed under Marvin J. Franklin, from Computer Sciences Corporation, with Roger W. Sadler, formerly with Singer Company, as deputy. Robert E. Carroll, from Rockwell International, joined SDC as corporate controller and became deputy manager of Public Systems Division a year later.

Except for Dooley, who left SDC in 1974, the new slate of vice presidents would remain in key executive positions throughout the 1970s.

A corps of veteran SDC managers continued to occupy more than sixty top and middle management positions. They included organization managers Launor Carter (Public Systems Division), Bernard Fried (Contracts), Harold Willson (Industrial Relations), and J. Dewey Lederer (Administration). Long-term manager John B. "Jack" Munson was promoted to deputy general manager of the Defense and Space Division. Bobette Jones, with SDC from its inception, was promoted to corporate secretary, and Clark Weissman to chief technologist.

In this reshuffling, some long-time executives felt displaced. Recalls one, "I had looked forward to a new management and was committed to making it work. But I soon felt that those on top regarded the old-timers with suspicion, thought we were not adaptable, and lacked confidence in us."

Jim Skaggs recalls the situation. "I can believe that some perceptions of management's actions were different from what we really intended. It was never a question of 'old is bad, new is good.' SDC was in serious trouble and we tried to place everyone in the jobs they fit best. We were building a team in which all members could play a significant role."

Within a short period, several veteran executives left SDC.

They included line managers Ray Barrett, George Clement, and John Matousek. Controller Joe Scatchard and secretary-treasurer Lou Turner had left earlier. The preponderance of managers remained to take part in SDC's new growth plans.

A THREE-PRONGED STRATEGY

In the ten months between Mueller's arrival in May 1971 and the reorganization of 1972, a new corporate strategy had been shaped and initiated.

According to Mueller, "The problem facing SDC in 1971 was that we were building custom software on a 'one-by-each' basis, in a fast-maturing industry where SDC's competitive edge had all but eroded, predominantly for a single customer—the Department of Defense—with unpredictable demand for our services, and at a price that covered our labor plus a small government-allowed markup. The answer to growth in revenues and profits was clearly not in doing more of the same."

From management deliberations on ways of "leveraging" SDC's software strength—that is, using the core of software experience to extend the company in new directions—came a threefold strategy for growth.

"First we needed to restructure our approach to system development," says Mueller. "SDC had proven in SAGE, SACCS, and other programs that it had great talent for developing real-time software systems with sophisticated data handling and display capabilities. But software, as a separate commodity, was no longer in great demand. Customers wanted to buy total systems in which software was an ingredient. SDC, therefore, had to become a total systems contractor—responsible for hardware, communications, and software, from system design through installation—if we were to have control over our destiny."

Jim Skaggs echoes this view and amplifies the notion of leverage. "The large aerospace companies had developed their own software staffs to enable them to bid and build whole systems. Occasionally they would subcontract the software to a company like SDC on their terms. We felt it shortsighted to limit ourselves to building software on someone else's team, when for an added investment in capability we could be the prime integration contractor for the entire system. Our software background provided the needed systems orientation, which was often lacking in the large manufacturers."

The strategy was to pay off handsomely for SDC. Beginning with the $23 million TIPI award in 1972, and stretching through a classified intelligence system of an estimated $90 million eight years later, a string of prime-contract awards would place the company in a leading technical and financial position.

The other two thrusts in corporate strategy addressed the commercial market. Here President Mueller was looking for services or products that the company could sell more than once. "SDC did not have a continuing business," he explains. "Without some kind of repeat sales, we could easily have worked our way down to a $10 million semi-consulting firm." The idea was to develop a unique, commercially attractive system one time only, then parlay it into repeat sales and profits by offering it as a proprietary service or product.

Recognizing the pitfalls of commercial software developments, including SDC's own recent Datacenter debacle, management nevertheless felt compelled to diversify away from its nearly exclusive reliance on the Department of Defense, which accounted for 85 percent of sales. "With all its eggs in the DoD basket, SDC had no hedge against the inevitable slumps in orders, work force, and morale witnessed in the 1960s," says Mueller. "Although the commercial world also has swings, these generally alternate with government cycles. Diversification was imperative to a healthy SDC. Our goal was to achieve 50 percent non-DoD business in five years."

UNUSUAL INCENTIVES

The Mueller administration did not limit itself to planning. Members of the management team reviewed the company's several hundred contractual efforts to separate the viable strands of technology from the dead ends; consolidated and streamlined the functional organizations of finance, administration, and personnel; introduced new standards for control and reporting of costs; and decentralized responsibility for financial performance to individual profit centers.

Dr. Mueller took personal charge of the R&D program and pointed it toward obtaining usable results in the company's growth areas. He emphasized SDC's historic work in data management and man-machine interaction and initiated new programs in areas he viewed as important to the company's future: initiation of a corporate hardware capability, a methodical "factory" approach to developing software, and extension of SDC's experience in computer security to the broader domain of networks.

Mueller also regimented the informal corporate planning process into a rigorous annual operating plan and five-year long-range plan which would be updated annually. One version of the first long-range plan was entrusted to "the young Turks," a group of SDC managers below thirty years of age, to provide a freewheeling input to SDC's future.

A newly formed Operations Planning Board of top managers, chaired by President Mueller, began to scrutinize all new programs and proposals. Objective risk analyses and cash flow projections were required to justify major proposals. Mueller was not supportive of the occasional "lowball" bid designed to get SDC's foot in the door of a new customer or line of business. "SDC already had too many such feet in too many doors," he says. "Our goal was to get it to stand on its own."

To maintain the whirlwind momentum of restructuring SDC, the chief executive put all senior managers on a six-day work week, culminating in a planning seminar each Saturday. "Considering his ambitious goals for the company," recalls one veteran SDCer, "none of us minded that much." "I thought his plan to double sales in three years was plain crazy," says another. "But just in case it wasn't, I wanted to see how he did it."

Mueller convinced his senior and middle management that the company was serious about meeting sales and profit targets by instituting an unusual incentive plan. The plan lopped 20 percent off a manager's normal salary, then enabled him to earn it back for "expected performance" by meeting assigned sales and profit targets. Exceeding targets resulted in significantly higher payouts.

"When we first reduced salaries, some managers shrugged and said it's only money," recalls Mueller. "But when their spouses saw the lower paychecks, we knew we had everyone's attention."

Management also took steps to bolster company spirit. A well-publicized achievement award program paid employees for exceptional contributions. A new employee promotion and retention policy eased the lingering fear of layoff. Several hundred senior employees joined the newly formed SDC management club. Mueller initiated "Speak Up" sessions during which he exchanged views informally with small groups of employees in his office.

Continuing the SDC tradition of supporting equal opportunity initiatives, management revitalized the corporation's ten-year-old program and created three committees to stimulate and monitor affirmative action: one comprising employees, one from top management, and one representing the board of directors.

BUILDING THE WHOLE SYSTEM

A MOBILE DATA MANAGEMENT SYSTEM

Even the most forward-looking management practices of the Mueller team might prove short-lived unless some major new business came in the door, and soon. The most critical procurement was TIPI—the Tactical Intelligence Processing and Interpretation system for the Air Force and Marine Corps—with an initial value of $23 million for its computerized display, control, storage, and retrieval segment.

SDC had designed the prototype of this mobile tactical information system around its ADEPT timeshared data management technology back in 1968. The 1971 procurement for the operational version was competitive and strongly hardware oriented. The customer, the Air Force Systems Command, had specified Univac computers, whereas SDC's ADEPT was tailored to IBM machines. Moreover, despite some limited exposure as a systems integrator, mainly on the Los Angeles Sheriff's Communication System, SDC was not recognized as an experienced prime contractor in the defense community.

As Joseph W. Lathrop, a veteran SDC manager, recalls, "When we first presented the idea of priming TIPI to management back in 1970, most of the vice presidents felt we should stick to the software—that no major manufacturer would consent to be a subcontractor to us on this complex systems job." Nevertheless, an SDC team briefed five of the nation's largest aerospace corporations on the merits of becoming subcontractors to SDC on TIPI, received commitments from four, and eventually selected RCA as its hardware integration teammate.

After months of proposal development, including Mueller's fine-tuning of the bid, SDC was the announced winner of its largest competitive award in September 1971.

"The win of TIPI was key to SDC's stability," says Finance Vice President Gordon Binder. "Coming at a time when backlog was at an all-time low, TIPI halted personnel attrition and provided a contractual base to support an already barebones overhead structure."

Equally important, TIPI was the stepping stone that would elevate SDC from a software system developer to a complete systems integrator. Over the four years of building TIPI, SDC acquired and sharpened an array of systems capabilities—in engineering, logistics, subcontract management, procurement, systems integration, and inventory control—and the skilled personnel to go with them.

Prime contracting the TIPI display, control, storage, and retrieval system was a baptism of fire for SDC. Intended to provide tactical commanders with "finished intelligence," the system called for computerized fusion of multiple intelligence data streams, including photographic and electronic. TIPI had to be mobile, containerized, and militarized—able to withstand radiation and electronic countermeasures. Hundreds of components from multiple vendors had to be acquired and integrated, many of them new and untested. To accommodate the software to the Univac AN/UYK-7 computer, SDC had to build a special JOVIAL compiler and a new timeshared operating system before work could begin on the intelligence processing programs.

Geographically and administratively, the large project was far from tidy. Assigned managerially to SDC's Washington, D.C., operation, the corporate work force of more than one hundred personnel was located at Hampton, Virginia, near the user organization, the Tactical Air Command at Langley Air Force Base. The official government buyer, the Air Force Electronic Systems Division, and SDC's major subcontractor, RCA's Aerospace Systems Division, were located in Massachusetts.

SDC was required to build two versions of TIPI: one for the Air Force and one for the Marine Corps, each with its own requirements. After SDC had embarked on a system to meet the contractual specifications for an operational field version, the Air Force decided to switch to an experimental prototype system with new features. Under a fixed-price contract, this midstream change was hard to accommodate.

The TIPI stepping stone to total system development was steep and often slippery. As one manager recalls, "At the outset we presented management with a lengthy analysis of risks, and darned if every one of them didn't happen."

To solve the problems that emerged, many SDC Santa Monica personnel, both managerial and technical, became deeply involved. At contract's end, the SDC team delivered what it had promised: an advanced tactical intelligence system that performed to all specifications. Although DoD added funds to cover changes and additions, SDC hardly broke even on TIPI. What it gained was worth more than money: a large resource of personnel experienced in all phases of building total systems.

A SUPERCOMPUTER

One of the most successful systems built by SDC in the first half of the 1970s was the PEPE supercomputer for the Advanced Ballistic Missile Defense Agency (ABMDA). The development of this Parallel Element Processing Ensemble, winner of national awards for engineering excellence, resulted from a team effort of SDC and Burroughs Corporation.

PEPE was an outgrowth of the Army's search for a real-time processor to handle the millions of calculations per second anticipated during a missile attack. Having joined the PEPE effort in

September 1970, SDC had demonstrated the concept with a prototype that passed the Army's exacting benchmark tests during the spring and summer of 1971. In September 1971, nearly coincidently with the TIPI award, SDC won the competition as prime contractor for building the complete PEPE system. Although PEPE was largely hardware based, the selection of SDC over several hardware manufacturers confirmed a growing awareness that the complex software component had become the most critical factor to total system success.

Three months after the PEPE award, SDC won the closely related contract for development and operation of ABMDA's Advanced Research Center (ARC) in Huntsville, Alabama. Among the most advanced data processing research centers in the United States, the ARC has the mission of developing and evaluating future hardware and software for ballistic missile defense.

As ARC support contractor, SDC was responsible for recommending the center's main computer. Since this machine would be doing double duty as the large serial computer for PEPE, SDC's pivotal role on the two contracts—both to be performed in Huntsville—helped ensure the smooth integration of diverse technologies. After some study, SDC selected the CDC 7600 for the ARC and PEPE interface.

The final specifications for PEPE hardware and software were completed at the end of 1972, and competition was opened for the hardware development contractor. From those bidding, SDC chose Burroughs. "Burroughs came in with an outstanding proposal, reflecting its ILLIAC IV supercomputer experience, especially in power and signal distribution," recalls former Huntsville department manager Gerald J. Hansen.

The Army renewed SDC's prime contract to build the parallel processor in March 1973. Three and a half years later, in December 1976, an operational PEPE was accepted by the customer.

During that time, SDC and Burroughs invented a new real-time processing technology, including a first-of-its-kind control logic that orchestrated hundreds of individual processors operating in parallel, while interfacing with a large conventional serial computer. PEPE also featured large-scale integration of electronic circuits, a forefront technology at that time. Although funding constraints had limited the delivered version to eleven processing elements (rather than the thirty-six originally envisioned), these handled more than a hundred million instructions per second, compared with twenty million for the largest conventional computers of the day.

"There never was a better managed program," says William Brinkmeyer, another former Huntsville manager. "Burroughs had to invent new approaches to signal distribution, thermal design, and high-capacity power supplies. Remarkably, Burroughs' hardware and SDC's software, developed in separate locations, operated smoothly together after only two weeks of integration."

The delivery of PEPE triggered a series of accolades. *Business Week* of December 1976 highlighted PEPE's potential to handle eight hundred million instructions per second, compared with an industry maximum of one million instructions ten years before. *Aviation Week and Space Technology* heralded the PEPE concept of parallel associative architecture.

Among other distinctions, SDC received an Outstanding Achievement Award from the Ballistic Missile Defense Advanced Technology Center (the new designation for ABMDA), and the Engineering '77 Project Achievement Award from the Institute for the Advancement of Engineering, which acknowledged PEPE as potentially the world's most powerful computer.

Equally gratifying to SDC management was the delivery of this complex system on schedule, within budget, while meeting or exceeding its technical goals.

THE UPGRADE OF THE MOUNTAIN

Thirteen hundred feet within Colorado's Cheyenne Mountain, the North American Air Defense Command had been performing the vital around-the-clock mission of defending the American continent against aerospace attack.

For over a decade, SDC had been closely involved with NORAD, beginning with design of the Combat Operations Center and Space Defense Center in 1960 through completion of their computer programs exceeding several million instructions.

By 1970, the Air Force recognized that new developments in hardware and software, coupled with ever-mounting processing loads, mandated an upgrade in the NORAD computer, communications, and display facilities. The subsequent Cheyenne Mountain Upgrade, or 427M program, was divided into three segments. SDC bid as prime contractor on the Space Computation Center (SCC) segment—responsible for real-time processing of data on all objects in space—and won this $16 million procurement in December 1972 in competition against TRW and Bendix.

As prime integration contractor, SDC was supported by Raytheon on displays, Philco-Ford on the astrodynamic software, as well as Data General, General Electric, and other vendors.

SDC's relationship with Philco-Ford illustrates the intertwining of "primes" and "subs" in aerospace. Two months earlier, Philco had been awarded the communications segment of 427M with SDC as *its* software subcontractor. Philco also served as the overall 427M system integration contractor, presenting a third facet of coordination between the two companies.

Such problems as developed—and they were serious—were not among the contractor team, but reportedly in philosophical differences within DoD about the nature of the upgrade. "The official buyer, that is, the Electronic Systems Division, wanted an upgrade pure and simple," says an SDC program manager, "while the NORAD users wanted a whole new capability—a replacement of their obsolescing systems. Throughout the contract there was a technical tug of war between these two groups and we couldn't get the specs frozen."

The Air Force finally resolved the issue in May 1975 by restructuring the 427M program. Funds were added and schedules revised to cover program changes on all segments. Software technical direction was shifted from ESD at Lexington to the Aerospace Defense Command at Colorado Springs. With this redirection, the program moved ahead to successful completion.

SDC met formidable technical challenges in its 427M segment. The Air Force had mandated that the main computer be a WWMCCS ("wimmix") machine—that is, a Honeywell-6080 like those used for the World Wide Military Command Control System. In the opinion of SDC personnel, this machine lacked the capacity and scientific orientation to process and maintain data covering some five thousand space objects being tracked by more than two hundred sensors.

To adapt to the WWMCCS computer, SDC had to modify the code in the manufacturer's operating system—often a delicate operation both technically and politically—before producing new executive and systems software as well as some hundred application programs for real-time monitoring of objects in space.

SDC's successful installation of the Space Computation Center segment of 427M would develop into a continuing corporate presence at Cheyenne Mountain in support of NORAD's mission of national defense.

Over their four-year life span, these three major system contracts—TIPI, PEPE, and 427M—contributed $80 million to corporate revenues, provided jobs for several hundred professionals, and built a reservoir of system development expertise for SDC's future. Beyond that, they changed the company's image from software developer to total systems contractor, endowing the name "System Development Corporation" with a deeper and richer meaning.

ACQUIRING NEW CAPABILITIES

Mueller soon recognized that the rapid diversification and growth he had targeted for SDC could not spring solely from within—that the corporate body required infusions of new capabilities to accomplish its turnaround.

Without a profit record or the lure of a publicly traded stock, SDC lacked the conventional option of using its equity to buy other companies. Fortunately, SDC's conservative accounting practices had provided a good cash position and high bank credit rating, traditions that the new management had taken pains to maintain. Using primarily cash, as well as common stock and warrants, the company made four acquisitions from 1972 to 1974 which would become forceful catalysts for diversification and growth.

AN ENGINEERING COMPANY

At a time when SDC's plans for building systems and products called for a broad augmentation of hardware and engineering skills, a high-technology engineering company called Mechanics Research, Inc., located ten miles from corporate headquarters, near Los Angeles International Airport, was seeking to be acquired. This proved a providential combination, particularly since the MRI principals were known to George Mueller and Frank Lehan, a scientist-engineer who had recently joined SDC's board of directors. The experience of MRI's 120 engineers in nuclear power, oceanography, and environmental science matched Mueller's long-standing interests in the energy field. In April 1972, SDC bought the company for approximately $1.8 million plus warrants.

Besides bolstering SDC's engineering talents, the MRI acquisition paid two added bonuses. One was a capability in environmental technology, which, coupled with SDC's systems know-how, was to lead the company to a prominent role in the nation's energy program. The other was a proprietary computer program called STARDYNE—an on-line engineering tool for structural analysis. Widely used by engineering companies over commercial computer networks, the STARDYNE system was to become one of the world's more profitable computer programs.

FINANCIAL TRANSACTION SERVICES

The remaining acquisitions were designed to diversify SDC into commercial markets. The next purchase, in September 1972, was Investment Data Corporation for $600,000 and stock. Founded four years earlier, IDC had developed an impressive array of computerized financial services for banks, insurance companies, and corporations. Most intriguing to SDC management was the "transaction-based" nature of IDC's computerized services, which fit Mueller's objective of getting SDC into the transaction services business.

Computer transaction services are akin to services of a public utility. Just as a telephone user pays fixed rates for each call as determined by distance and duration, the subscriber to a proprietary computer service pays fixed rates for the type and length of each transaction conducted.

The IDC service with widest potential appeal was the automated investment program. Aimed at the small investor, this service enabled him to invest moderate sums in preselected stocks at his local bank and have the dividends automatically reinvested in additional stock. SDC cleared the hurdle of having this novel stock plan approved by the Securities and Exchange Commission, translated the IDC programs to operate on its Santa Monica computer, and signed up banks with a respectable 5 percent of the nation's checking accounts. Unfortunately, the 170-point Dow Jones slide in 1973 chased small investors out of the market, and the automatic investment service fell short of the sales projected for it.

Like the other acquisitions, IDC brought a cadre of new people with new skills to SDC—in this case, experts in the per-transaction business which was to become a growing source of SDC revenues.

THE CORDURA UNITS

In September 1973, George Mueller received a call from a colleague of his Space Technology Laboratories days—Cordura Corporation's President Norman Friedman. Cordura was thinking of disposing of its software companies. Would SDC be interested? The more President Mueller heard, the clearer it seemed that the Cordura package was tailored to SDC's long-range plan. In February 1974, six Cordura units with annual sales of $20 million entered the SDC fold at a price tag of $7 million.

The acquired units offered something to every SDC business area. Bolstering SDC's commercial thrusts were two prestigious Chicago-based firms: Applied Information Development (AID), providing computer-oriented management consulting, and May & Speh, one of the nation's oldest data service bureaus. Another commercial company, Aquila BST of Canada, dovetailed with SDC's expanding international role. The computer graphics division of this Quebec-based company brought the phototypesetting expertise that would be needed in a new corporate product line for the newspaper industry.

In civil systems, SDC had acquired Cordura's manpower training contracts and an automated "job bank system" which it would operate for governmental departments of employment for many years.

The most enduring contribution came in the form of the Cordura's Data Systems Division, holder of several facility management and support contracts for NASA and the Army. Prior to the acquisition, SDC's own efforts to build a support services division brought contracts with $4 million in annual revenue, an inadequate base to sustain the low overhead required in this price-competitive domain. The Cordura contracts tripled the sales volume overnight, providing the critical mass to spur the growth of SDC's support services to over $60 million by 1981.

A BETTER BALANCE

The last purchase was another transaction service: an automated Claims Administration System for computer processing of employee health insurance claims, purchased for $300,000 in June 1974. After a period of slow growth devoted to resolving critical software and marketing problems, the acquisition would become a profitable mainstay of SDC's computer services.

Within a relatively brief period, from April 1972 to June 1974, SDC had spent close to $10 million, most of it borrowed capital, in four acquisitions that strengthened the company in important ways. MRI brought the systems engineering to solidify SDC's roles in prime contracting and energy systems. Well-established companies like AID and May & Speh, together with the growing STARDYNE system royalties, offered a dependable cushion of profit to buffer the startup costs of new opportunities such as transaction services and product development. "These acquisitions provided the balance and diversity that enabled us to make more meaningful choices about our future," says Jim Skaggs. The company made several more acquisitions in subsequent years, but none had the impact of this early set.

SYSTEM PRODUCTS AND ON-LINE SERVICES

Simultaneously with launching SDC on the prime contractor path, President Mueller opened his drive for commercial repeat sales. This objective would lead SDC along two main avenues—hardware products and transaction services. A third road common to many data processing firms, namely, the sale of proprietary software packages, brought a modest effort to market an SDC data management program called DS, with equally modest results.

Mueller's product orientation was strictly toward hardware. "I believe a key weakness of SDC's early days is that it lacked the hardware to implement its concepts," he says. "The hardware manufacturers were incorporating SDC innovations in timesharing, compilers, and data handling in their equipment. It was time for SDC to benefit directly from its own developments."

THE ELECTRONIC NEWSPAPER

The principal product SDC developed in the early 1970s was a newspaper automation system called the Text II electronic publishing system. Built around minicomputers tied to data entry stations—as many as several hundred terminals throughout a newspaper's offices—the Text II system automated the production of reporter copy, wire service copy, and classified and display advertising. Working at keyboards with video terminals, reporters and other newspaper personnel could type in their copy, edit it on line, and, at a touch of a button, instruct the Text II system to typeset the approved text via a computer-controlled photocomposition machine. The electronic process had replaced the traditional but uneconomic hot-type and linecasting operations.

A feature distinguishing SDC's product from competing ones was the automation of classified advertising. With the Text II system, ad takers could type ads directly into their terminals as requesters called them in, then have the computer typeset the ads, calculate the prices, and bill the customers.

After validating the market for newspaper automation in the summer of 1971, SDC's management gave its go-ahead for the development and marketing of an automated composition system, known initially as Text 71, and then as Text II, a trademark that would become well known in publishing.

The Text II system satisfied many of management's objectives. It was built around SDC's mainstream technologies of online, display-oriented systems, with a man-machine interface sensitized to a new set of users—newspaper people. The product adhered to the "total system" yardstick, was hardware-based and intended for repeat sales, and diversified SDC into the commercial publishing market. While the company would not manufacture its own Text II system hardware but use available minicomputers and peripherals, it would build, buy, and integrate the components and include the hardware in the total price.

SDC sold its first Text II system to Tucson Newspapers, Inc., publisher of two local dailies, in February 1972. Installed twelve months after contract award, the Tucson system represented a remarkable accomplishment: the design, building, and testing, literally from the ground up, of a new and complex system, with rigid constraints on data loads and response times, requiring the interleaving of major subsystems by a new executive program—all achieved within one year. Recalls the Tucson project leader, "Every day we learned something new about the newspaper business and every night we'd change the computer code."

Budgeted at a quarter million dollars, the Tucson contract cost SDC several times that amount. "The extra costs were a corporate investment—the same as any front-end product development costs," says an SDC executive. "Now we had a turnkey electronic publishing system we could sell to the world."

SDC SEARCH SERVICE

For the company's introduction of per-transaction services, Mueller selected three entries. Two were obtained externally: IDC's financial transaction services and the Claims Administration System. The third, which would become one of the world's most widely known and used computer services, was a fortuitous adaptation of an existing SDC capability to the commercial market.

Among SDC's contracts in support of the National Library of

Medicine, one called for providing a nationwide on-line retrieval service called MEDLINE. The large MEDLINE data base of medical articles was made available by NLM to some three hundred research centers, all linked to SDC's timesharing computer in Santa Monica. At the heart of the system, the medium for fast and efficient retrieval, lay SDC's ORBIT information retrieval system.

By mid-1972, several project personnel saw in MEDLINE the basis of a broader commercial retrieval service and advocated its startup to SDC management. Coincidently, NLM decided to confine its service to nonprofit organizations—universities and libraries—thereby cutting off the pharmaceutical firms that had relied on MEDLINE. When the Pharmaceutical Manufacturers Association asked SDC to provide the service to its members, the corporation went one step further. It expanded the ORBIT program and system procedures to support a high-volume transaction business and opened the doors to the first nationwide commercial retrieval service.

SDC Search Service was launched in January 1973 with fifty customers and three data bases—MEDLINE, an educational file called ERIC, and the CHEMCON data base of chemical articles. The service was to grow steadily over the years. By 1981, it would be providing more than eighty data bases to thousands of subscribers in some forty countries.

A representative user of the system might be a research biologist working in Madison, Wisconsin, whose interest this day is in a literature search on the relationship between vitamin intake and weight control. After logging onto SDC Search Service from a desk-top terminal connected over telephone lines to SDC's Santa Monica computer, she types the key words—"vitamin intake" and "weight control"—and scans the data base index.

The computer shows her how many citations relevant to her inquiry—out of some fifty million contained in chemical and biological journals, government-sponsored research papers, doctoral dissertations, conference papers, and newspaper articles—reside in each data base. After searching specific data bases for abstracts of interest, she may select some to be printed out on her terminal immediately while requesting that others be airmailed to her.

Like the Text II product, SDC Search Service fit George Mueller's model for corporate diversification. At once an on-line, real-time, user-oriented system with a strong data management bias, it also represented a one-time system development leading to repeat sales.

Before initiating SDC's transaction services, Mueller ordered the upgrade of the Santa Monica computer center, replacing its IBM 360/67 with a more powerful IBM 370/145 and 370/155 combination in March 1972. Financial transaction services were initiated the same year, SDC Search Service a year later in 1973, and the Claims Administration System in 1974. With three proprietary services pouring from the spigots of the Santa Monica computers, SDC was well launched into the transaction services business.

FOREIGN VENTURES

As if the challenge of growth and diversification in the United States were not sufficient, Mueller decided to move the company into the international market. In the early 1970s, the United States had a clear lead over most other countries in data processing technology. Mueller sought to capitalize on that lead, particularly SDC's strengths in on-line applications, by creating a string of "mini-SDCs" throughout the world.

The corporation was no stranger to the international scene. Through its defense and training programs, SDC had been placing people in other parts of the world since 1960—in Germany, Japan, Iran, Spain, and elsewhere. In nearly all cases, even when the end user was a foreign power, the buyer was the U.S. government under DoD procurements known as foreign military sales.

By 1970, the balance of foreign military procurements was shifting—away from U.S. influence and dominance to selection and even purchase by local governments. Foreign civil and commercial systems—in banking, insurance, social services—were also ripening for automation. The establishment of overseas companies infused with U.S. technology should, it appeared, enable SDC to benefit from the anticipated boom in international automation.

The corporation's strategy for expanding outside the United States departed from the conventional establishment of wholly-owned foreign branches or subsidiaries. Instead, SDC opted for joint-venture companies. In these ventures, the foreign partners supplied the operating capital and local management and staff in return for two-thirds ownership, while SDC provided its know-how, training, and technology for a one-third equity.

This arrangement appeared to provide the best of all worlds: a predominantly foreign company, managed and staffed by its own nationals, enjoying the marketing advantages of a domestic supplier, while strengthened by SDC's advanced technology and training. With minimal risk, SDC would gain important footholds abroad, providing growth for both SDC and the joint-venture partner.

After months of painstaking negotiations, three international ventures were formed within a five-month span. The first, in September 1972, was dSE, an existing German company of seventy people and sales of $2 million. With a subsidiary in Switzerland, dSE provided a potential outlet for SDC's capabilities in central Europe. Two prominent banks provided the capital for the German partners.

One month later, System Development Corporation of Japan was born. Announced by Mueller as "the first instance of American participation in a Japanese software company," SDC Japan culminated months of high-level negotiations with the Japanese government to pierce that country's protective industrial barriers. SDC's prestigious partners in this fifty-person company included the Long-Term Credit Bank of Japan and the *Japan Economic Journal*.

The third foreign venture, ERIA Systems, was created in February 1973 in preparation for a specific procurement—the automation of the Spanish air defense system known as Combat Grande. Combat Grande was another instance of SDC's bidding as prime contractor on a major procurement—this one for some $45 million, the equivalent of over $100 million at 1981 prices. At a cost of $750,000 for the proposal, Combat Grande was the largest system SDC had proposed to that time. With IBM as its teammate, SDC lost the bid to Hughes on price. So great was the differential that the SDC proposal leader reflected, "We could have given away the computers and still lost."

Despite the Combat Grande setback, ERIA Systems was maintained as a joint venture for other Spanish business. Its in-country sponsors were another Spanish software company and the Spanish Institute for National Industry.

In February 1974, SDC acquired its fourth and last major foreign holding, the Canadian Aquila BST, included in the Cordura package. Headquartered in Montreal, this three-hundred-person data processing company specialized in computer services, system design and programming, proprietary software, and the new technology of automated photocomposition—the use of electronics to produce camera-ready text pages of typeset quality. Having acquired 100 percent ownership of Aquila through the Cordura purchase, SDC intended to sell a two-thirds interest to Canadian owners to maintain its joint-venture pattern.

THE JINX OF GOING PUBLIC

One of Mueller's near-term goals was to take the company public as early as possible. Besides lending luster to SDC's for-profit status, a stock offering would provide a public market for SDC's six hundred shareholders and, most importantly, would enable the System Development Foundation to convert some of its stock into cash to meet its pledge to contribute $4 million to the U.S. Treasury and distribute any excess in the public interest.

Confident of achieving a strong first year, Mueller did not even wait for the official results before heading to market. In March 1972, in rightful expectation of closing the fiscal year profitably in June, SDC embarked upon its first public offering.

The initial step, finding an investment banker, proved trickier than expected. Given SDC's sheltered nonprofit background, the company's name was hardly a household word within the financial community. Several of the more prestigious investment bankers were surprised to find SDC making a sales pitch on their doorstep. Normally, bankers seek market-ready clients, not vice versa. As the bankers listened, they found more to SDC than they had surmised, and several investment firms bid for the opportunity to take the company public. Ultimately, SDC selected the well-known firm of Smith, Barney & Co.

In Mueller's first full year at SDC—that is, fiscal 1972—the company registered earnings of $1.15 million, a record since the benign untaxed-income days of 1960. An increase in sales from $45 to $51 million, coupled with a $600,000 trimming of overhead expense, contributed to SDC's first seven-figure earnings since becoming a profit maker in 1969.

As the company continued to meet all subsequent financial milestones, the climate for a public offering waxed optimistic. By the fall of 1972, the paperwork required by the Securities and Exchange Commission and the State of California for going to market was completed. SDC had already been filing most of these forms, since its many shareholders qualified it as a public company in the eyes of the SEC.

If ever the market seemed ripe for an SDC offering, the end of 1972 was that time. From a low of 675 in June 1970, the Dow-Jones index had broken the magic 1,000 barrier in November 1972—the first time in six years. The only recent downturn had been a 40-point slide in May 1972, when President Nixon had resumed bombing of North Vietnam after a three-year pause.

By October 1972, the war appeared all but over as Henry Kissinger announced the start of cease-fire negotiations. An optimistic nation reelected Nixon in November, giving him a record forty-nine states. Few Americans were concerned about stories regarding a break-in at Democratic Committee headquarters in Washington's Watergate complex five months earlier.

As the Dow reached 1,036 on December 11, 1972, the timing seemed perfect to put the final touches on SDC's stock offering. The offering would consist of 400,000 shares owned by the System Development Foundation. SDC would not sell new shares, because its strong internal cash flow was providing adequate capital for expansion. Smith, Barney had assembled a willing syndicate of underwriters. The stock appeared assured of being fully subscribed at a potential selling price—according to an educated consensus—near $15 per share. The magic day was to be Tuesday, December 19, 1972.

On December 18, President Nixon announced the resumption of the bombing of Hanoi. Prompted by an impasse in peace negotiations, the bombing "would be continued until a settlement is reached." The market slid 20 points in two days. Although the syndicate was prepared to go forward, its leading members advised SDC to postpone the offer. Hindsight shows this to have been sound counsel. Not even the cease-fire accord of January 27, 1973, ending nearly twenty years of U.S. involvement in Vietnam, had an uplifting effect on the sluggish market. The Dow sank to 850 in the next twelve months. Most new issues faltered, and SDC cancelled its offering. As Mueller was to remark during the ensuing years of market doldrums, "Most companies I know that have gone public wish they'd stayed private."

SDC was to initiate attempts for public offerings twice more, in 1973 and 1976. Both times, a discouraging stock market aborted the efforts before they reached fruition.

A DIFFERENT COMPANY

DIVERSITY AND GROWTH

The company quickly rebounded from the momentary deflation of the ill-fated stock sale. As one manager put it, "There was too much going on to worry about stock." Indeed, the diversity of SDC's activities in the years following Mueller's arrival was prodigious. In addition to the areas already cited—systems contracts, acquisitions, foreign ventures, products, and services—SDC undertook numerous other projects and contracts. "We were growing in many directions at once," says Jim Skaggs. "Certainly there were risks, but we had the safeguards—an action-oriented and decisive management and an outstanding technical team."

In the military arena, SDC consolidated its leadership in tactical communications systems with important new contracts. Other technical challenges surfaced: development of real-time software to monitor pilots being trained in live dogfights on the Navy's

Air Combat Maneuvering Range; integration of computer programs for the Air Force Defense Support Program, a classified satellite system with overseas and U.S. ground stations; and design and delivery of software for a new over-the-horizon radar system, called Cobra Dane, to monitor Soviet missile tests near the Pacific Ocean.

Renewal in 1972 of SDC's $10 million-per-year contract for support of the Air Force Satellite Control Facility was accompanied by a broad marketing thrust into space programs. The result would be a round of awards in satellite and meteorology systems.

In the civil area, the company's experience in developing a computer-controlled traffic flow system for a freeway interchange propelled it into a new market: automated traffic signal control systems for municipalities. These systems called for an optimized pattern of signal control geared to the city's changing traffic flow. The flow was continuously sensed by electronic detectors embedded in the pavement and transmitted in real time to a central computer over telephone lines. There, the computer processed the inputs and transmitted responsive instructions to the city's traffic signals. The successful signal control contractor, determined by the sole criterion of low price, was responsible for the total system, from designing the logic to pouring the concrete.

With many competitors eager to enter this wide-open field and each newcomer "buying in" to get the experience of that first contract, automated signal control quickly turned into the "lowball of the month club," according to Robert Carroll, then deputy manager of Civil Systems. SDC won the Oklahoma City system for 33 intersections in 1972, and the Charlotte, North Carolina, system for 185 intersections in 1973, and lost money on each.

"We were lucky to win only two," says Mueller. "With three we might have gone bankrupt." He is only partly in jest. After SDC lost its next bid for the Baltimore system, on which the "successful" bidder reportedly lost between $5 million and $10 million, Mueller switched off the green light on signal control.

The company developed a unique product for the airline industry. Called Crew Ops, this complex software system optimized the assignment of airline personnel to flights based on a mass of interacting legal, safety, and financial factors. Crew Ops enjoyed wide interest but slim sales, partly because a national recession was hurting the air carriers financially.

SDC was also growing a vigorous support capability in facility management and technical services. With five hundred personnel working at Army, Navy, and NASA facilities—managing data centers, writing programs, analyzing results—the corporation had a viable $12 million service operation by 1974.

Research and development were taking on new dimensions. As acting manager of R&D, Dr. Mueller established departments for improved software engineering, computer security, and natural-language communication with machines, including automated speech understanding.

From a predominantly single-customer software service organization in 1971, SDC had been transformed into a multinational miniconglomerate by 1974. The Department of Defense still accounted for the lion's share of business, but the remainder had grown to a better balanced 30 percent. Within DoD, the company had established its credentials as a prime systems contractor. A multimillion-dollar award for support on the Alaskan oil pipeline would be fueling a new energy capability. A broad space automation program was taking shape. Two subsidiaries—AID and May & Speh—were thriving in Chicago, while a third, MRI, was making inroads into the classified intelligence market. A new product line, the Text II electronic publishing system, had been launched. Computerized transaction services were handling data for clients across the continent. Companies in Japan, Germany, Spain, and Canada were flooding the international circuits with a stream of marketing leads.

The exceptional diversity and expansion accomplished in only three years, while reducing corporate overhead, exemplified Mueller's abilities to extract the most and best from people. His favorite question, "How soon can I have it?" was serving two purposes. In the short run, it was getting the job done. More lastingly, Mueller's quiet exhortations were instilling in others an attitude that they, like their boss, could overcome personal and environmental limitations to achieve greater things.

As Jane Long, who advanced from the position of Dr. Mueller's secretary to corporate director of Public Affairs, summed it up, "When I used to complain that a particular assignment was too difficult, Mueller wouldn't hear of it. After a while, all such problems became challenges to me. He built a realization in me that I could accomplish things I had thought would never be possible."

NEW FACES

To help manage this dynamically expanding organization, Mueller reshuffled some slots and recruited more industry managers, with emphasis on finance and administration. J. Stanley Crum, financial executive at Rockwell International, became corporate controller; Leroy A. Keuler, formerly with NASA, was made assistant treasurer. Robert K. Floyd, from General Dynamics, headed the increasingly sophisticated business operations of the Government Systems group, while Fred Tschopp, Jr., veteran contracts manager from TRW, was brought in to manage that group's contracts function. James C. Riviere, an industrial engineer from Boeing, assumed a series of increasingly responsible positions in logistics and operations.

Another addition was Benjamin G. Walker, whose background in hardware-oriented electronics engineering ideally suited Mueller's notion of SDC's chief of Research and Development. Reportedly, Mueller relinquished the role of acting R&D manager with some reluctance; inventing new technology has always been a driving passion for him.

By this time, SDC managers, both old and new, operated as a smoothly functioning team. One practice that served Mueller well in promoting teamwork was the conduct of off-site meetings for his managers, away from the pressures of the office, at least twice a year. Typically convened over a Friday and Saturday at a guest lodge somewhere in the Southern California environs, the "off-sites" spanned a two-day program of structured meetings and unstructured free or recreation time, in about equal parts, for some thirty SDC executives.

"These gatherings provide virtually the only opportunity for managers who typically don't interact, or who may occasionally meet in a crisis or conflict situation, to get to know each other in a relaxed setting," says Mueller, a career-long believer in the cohesive value of management off-sites. "That kind of familiarity solidifies a management group."

These executive conferences would become a tradition at SDC. Each year, the May meeting has been devoted to presentations and discussions of the annual operating plan; the November meeting has served a similar purpose for the long-range plan. A high point has been the presentation of mock awards by permanent entertainment chairman Bob Carroll, including the inevitable bucket of tears for the most sympathy-provoking pitch on the toils of meeting next year's targets.

By February 1974, SDC's president had decided it was time to loosen the tight corporate reins with which he had governed during the years of corporate recovery and to decentralize management. This abrupt change reflected Mueller's philosophy on organizational structure, as reported in *Nation's Business* of August 1977: "It is a great mistake to believe that once you have an organization that works, you have to stick to it forever. No organization works that effectively over a long period. At least this is true of an industry as subject to change as ours."

The reorganization divided management responsibility into five major operating units, each under a president. Commercial operations were placed under Daniel L. Dudas, an executive from Litton Industries. Civil programs reported to Robert Carroll, and International operations to veteran manager Charles Alders. Mechanics Research, Inc., remained a subsidiary under the leadership of its president, Dr. Robert H. Anderson.

To revitalize SDC's crucial military business, whose growing pains were starting to show in performance and marketing problems, Mueller selected his top man—James Skaggs—as president of Government Systems.

ON THE UPWARD TRAIL

Over its first fifteen years, SDC's revenues had hovered around $50 million, with few dramatic upward or downward swings. Now, after three years of hard-paced initiative, the lid was finally off. Uncannily on Mueller's target, almost to the dollar, revenues had doubled from $45 million in fiscal 1971 to $90 million in fiscal 1974. Acquisitions accounted for a third of the $45 million sales increase, while the majority stemmed from internal growth.

Earnings also followed this upward trend. From $130,000 in 1971, the new management team recorded $1.2 million in 1972 and $1.5 million in 1973. But in 1974 a few seams of the swelling enterprise were showing the strains of fast growth. Several fixed-price contracts were experiencing performance delays, indicating that SDC might exceed the available contract funds. In accord with conservative accounting practices, SDC recorded the associated potential loss during 1974—the year a possible cost growth was recognized. Interest expense went up by $600,000, the result of bank loans to buy the Cordura units and to provide operating capital during a delay in government payments on TIPI deliverables. Several international operations—in Canada and in Germany —were experiencing significant startup costs. Withal, the company still posted earnings of $800,000—an unwelcome dip in the earnings curve but also proof of newfound strength to absorb setbacks.

Another indicator of growth—new orders—was spiraling upward, breaking the $100 million mark in 1973 and again in 1974. With sole-source awards becoming rarer for profit-making SDC, the company was competing for two-thirds of its business. Moreover, it was winning 50 percent of all dollars proposed, including 20 percent of the competitive dollars—good returns for the supercompetitive information systems industry. Contract backlog in

1974 exceeded $80 million in committed future work, a fourfold increase over 1971, providing a welcome foundation of stability.

Diversification into new roles, markets, and products—coupled with growth in sales, orders, and profits—gave evidence of a successful corporate turnaround. But for a people-oriented and skill-dependent company, the most reassuring measure of progress lay in the near-vertical slope of the personnel growth curve. Including its wholly owned subsidiaries, SDC had almost doubled its staff, from 2,000 to 3,900, in three short years. With a professional population exceeded only in its peak SAGE years of 1961-1962, the company in 1974 was once again fully staffed to undertake the high-technology challenges of the future.

Consistent with a new SDC image, use of the old corporate logo, the hyperbolic paraboloid or "flying diaper," was discontinued in August 1973. The original inspiration for the symbol, the massive canopy near SDC's main entrance, was scheduled for leveling. Like many efforts to change the old SDC, smashing this icon was not easy. Recalls corporate secretary Bobette Jones, "The demolition contractor had bid only a couple of hundred dollars, thinking the arch was made out of wire and plaster. When he attacked it with pickaxes, they just bounced off the reinforced concrete. After some weeks, he found the right power tools to undo the diaper."

Mueller also changed the corporate color, from powder blue to his favorite gold. But he did not substitute a new symbol for SDC, partly out of respect for the company's tradition and partly to leave the future as wide open as imagination and enterprise could make it.

CHAPTER 8

The Expanding Years

(1975-1978)

VIGOROUS STIRRING

The four years from fiscal 1975 through fiscal 1978 marked a period of continued growth for the company, with all key indicators—sales, profits, orders, and personnel—rising steadily. On the national scene, the period began with Richard Nixon's resignation on August 4, 1974, while the new President, Gerald R. Ford, Jr., pledged an "uninterrupted search for peace and national tranquility."

At SDC, too, there was a calming after three years of spirited initiative. Several new ventures were started, but not on the mass scale of the early Mueller days. Management focused on nurturing SDC's many embryonic enterprises, assessing each for its growth potential, strengthening those of promise, and eliminating the rest.

Below the calm surface of this period, a vigorous stirring continued. Mueller's driving energies would not have it otherwise. In the words of a senior administrator of the American Institute of

Aeronautics and Astronautics, a 30,000-member professional society which elected Mueller president in 1978 and which he promptly set out to remold, "I've served under twenty pretty demanding AIAA presidents, but there's never been anyone like George!"

Strong crosscurrents swirled through the corporation as it passed into its twentieth year. Large new markets were penetrated in space systems, energy, and health care, all of high national priority. The business of supporting the government's advanced-development centers grew thirtyfold during the decade. The sales curve for Text II newspaper automation systems shot upward, but the profit curve failed to follow suit. A new civil business—evaluation of federal aid-to-education programs—succeeded brilliantly, while several other civil contracts were forced to surmount temporary problems. Many commercial enterprises thrived, but an entry into financial services proved to be mistimed.

Overseas, SDC Japan won a large space systems contract, while economic and political conditions dimmed prospects for SDC's German and Canadian operations. Mueller's vision of a methodical approach to producing software more efficiently and economically became a reality with establishment of the process trademarked as "The Software Factory." The R&D Division laid the groundwork for SDC's entry into the products market. The period ended with a head-on competition over a $27 million police command-control system, culminating in an emotionally charged session of the Los Angeles City Council, which overruled an earlier recommendation by awarding the contract to SDC. In all, the years were eventful ones for the corporation.

REBUILDING "GOVERNMENT SYSTEMS"

SDC's "bread and butter" division, Government Systems, was showing marketing and performance strains when Jim Skaggs took it over in February 1974. The durability of its $50 million sales base in command-control and space systems was by no means assured. Forty percent of those revenues came from three big contracts—TIPI, PEPE, and 427M—whose completion dates were drawing near. New orders in fiscal 1974 had skidded to $35 million from $65 million in 1973. Long-term backlog was nonexistent.

At the same time, performance problems were plaguing several large developments like TIPI and Cobra Dane, fixed-price contracts with little margin for error. Delivery schedules were stretching out. Customers were growing restless. Profits were depressed. Quick and effective solutions were imperative.

Skaggs's personal, "hands-on" style of management seemed made to order for the ailing division. No respecter of arbitrary chains of command, Skaggs likes to deal directly with people at all levels. In Government Systems, he formed an "office of the president," including two vice presidents, Jack Munson for Technology Operations and Jack Cannady for Management and Operations. All three moved freely throughout the organization, setting policy at the top and solving problems at all levels.

Skaggs took personal charge of marketing. He identified the targets, assembled the capture teams, and developed the win strategies. As Jack Cannady, who routinely puts in a sixty-hour work week, recalls, "When I arrived in the morning and when I left at night, Jim was there. He didn't just review proposals, he rewrote them. And if someone said SDC had lost a bid, he'd restrategize and go after it again."

The bookings curve sloped up again in 1975. Later that year, Skaggs promoted Frank Morris, then a ten-year SDC veteran in marketing and management, to vice president of division marketing. The entire Government Systems management team concentrated on bringing in new business. By 1978, orders for the division topped $100 million.

At the same time, Skaggs knew he must restore SDC's image within DoD, marred by delays on the TIPI and Cheyenne Mountain programs through circumstances often beyond the company's control. Depending on the situation, SDC did what was necessary to fulfill its contracts: add more technical specialists, replace personnel, negotiate constructive contract changes, and deliver the product.

Two improvements in SDC's operations during this period are noteworthy. Many project managers were learning the hard way that dealing as a prime contractor with more experienced profit-motivated subcontractors was different from negotiating in the old nonprofit days of mutual trust. "Our people were still doing some incredible things," recalls Gordon Binder. "Like promising a subcontractor a price increase without passing it on to the customer." Subcontracts management was revamped into a skillful, self-standing support organization.

A more revolutionary change came in 1975 with the trial use of The Software Factory approach. Fully implemented in 1976, the new process invoked a set of procedural disciplines that yielded measurable improvements in SDC's production of software.

As SDC's Government Systems personnel gained a new team spirit and sense of confidence, contractual demands, however taxing, were met and SDC's image resumed its luster. Each succeeding year saw an increase in sales and a decrease in problems. By 1978, the division was earning twice as much profit on every dollar of sales as it had four years earlier.

While the trim look of a revitalized Government Systems Division had been shaped by new leadership and creative approaches to marketing and performance, its fabric was woven of the solid technical achievements of its 1,500 personnel. Beyond advancing the technologies in command-control and training, they secured major footholds in the high-growth areas of space and energy.

THE ASCENT OF SPACE AND METEOROLOGY

To assert that SDC had only moderate space systems capabilities in 1974 may, at first view, seem to understate the facts. For thirteen years, three hundred SDC personnel had been supporting the Air Force Satellite Control Facility in Sunnyvale with program development and integration. Another 250 were upgrading the Space Computation Center in Cheyenne Mountain, where SDC had been involved for nearly as long. The company had built numerous space-related systems: a computerized satellite scheduler for NASA, a real-time control system for the Manned Orbiting Laboratory, and onboard software for Apollo.

Yet, in the words of a veteran department manager, Ronald D. Knight, "SDC was not recognized as a serious system developer in the space field. Our contracts had given us a good secondary background in space—in how to process telemetry and radar data—but not the primary familiarity with the content of space programs required of a total system designer."

At the same time, the market was declining for SDC's strongest capability, the building of command-control systems for air defense and air traffic control, while that for space technology, both military and civil, was expanding rapidly. Responding to this projection, the Government Systems team rebuilt its marketing plan for the space field and followed it despite several early disappointments. The years between 1974 and 1978 would see SDC rise from ground zero to become a leading space systems contractor and possibly the most versatile company in the domain of meteorology.

Following unsuccessful proposals for work on NASA's Space Shuttle and the Air Force Attack Assessment System, SDC obtained a sole-source award to evaluate the Air Force Defense Support Program. The in-depth analysis of this sophisticated multicontinent satellite system gave SDCers invaluable insights into the tactics and logistics of space defense.

At the end of 1973, SDC was awarded the software portion of the Air Force's vital Cobra Dane program, as subcontractor to Raytheon Company. Cobra Dane called for a new high-precision radar technology—a phased array—in which segments in space are continuously sampled by multiple electronic sensors. The intricate timing required to control the radar, coupled with the problem of extracting meaningful signals from relentless streams of radar data, provided SDC with one of its most severe technical challenges of the decade.

In 1976, SDC helped to install an operational Cobra Dane system on Alaska's Shemya Island, where it has served as the Air Force's watchdog over the Pacific, and where SDC has continued to maintain and improve it. Winner of the Air Force Organizational Excellence Award, the landmark Cobra Dane program provided SDC a liberal education in modern radar technology.

In the spring of 1975, an SDC team paid a visit to DoD's weather information agency, the Air Force Global Weather Central facility in Omaha, with an offer to build a PEPE-like supercomputer for the center's immense weather data loads. The Air Force declined but, as a return courtesy, placed SDC on its list of potential bidders to design the Global Weather Central data processing architecture for the 1980s. In competition against what may have seemed more logical contenders for a hardware-based system—IBM, TRW, General Electric, CDC, and Ford—SDC won this important contract and entered the world of satellite weather data processing.

On the heels of this key award came another design procurement, this one for the ground support system of the TIROS-N polar-orbiting weather satellite. Gaining confidence with every win, SDC again challenged several industry giants—IBM and General Electric. In a three-way competition, the company captured one of the two design contracts awarded by the National Oceanic and Atmospheric Administration. One year later, in May 1976, SDC bested GE in the runoff competition to build the $7 million TIROS-N data processing and services system. When the first TIROS-N satellite was launched in October 1978, SDC's ground data processing system supported the launch to perfection.

Government Systems President James Skaggs was more than pleased to present the SDC achievement award for the month of September 1975 to project manager Allen J. Hansen, leader of the winning proposal teams for Air Force Global Weather Central and TIROS-N.

Concurrently with these developments, a technology from an unexpected source was beginning to open new vistas in weather data processing for SDC. In 1974, NASA had asked the company to develop an interactive display system for analyzing some fifty thousand pictures of the sun taken from Skylab. In short order, an SDC team at Huntsville had built an image data processing system called IDAPS.

IDAPS was designed to convert pictures to digital form through a laser scanner, then enable scientists working at display terminals to analyze the digitized pictures by sharpening, expanding, and otherwise intensifying their parameters. A novel feature of IDAPS is pseudocolor, valuable in highlighting subtle changes in image intensities not obvious in black and white.

IDAPS scored an immediate success with NASA, which would use the system for many years.

SDC quickly recognized an ideal application of IDAPS in the analysis of weather imagery—cloud formations, wind patterns, temperature spectra—routinely collected by weather satellites like TIROS-N. When an SDC technical team showed a dozen mock weather analyses from IDAPS to Air Force Global Weather Central officials, an evidently impressed Air Force contingent flew to Huntsville the following day to see the system in operation. SDC shortly had its second IDAPS order.

Over the ensuing years, SDC would continuously enhance IDAPS through new contracts and the R&D staff. More than fifty computer programs were added: weather analysis programs for wind vectors, cloud motions, and other meteorological phenomena; programs for analyzing land and sea satellite data, used for crop evaluation, ocean mining, and pollution control; and improvements to IDAPS itself, particularly in real-time input of sensor data through direct linkage of IDAPS with satellite antennas.

The result was an integrated software-hardware product called the SDCSEA Image Processing System, which has been installed for customers in the United States and overseas.

In 1976, SDC took another large stride into space defense with the capture of TIPS, a $19 million program for the Telemetry Integrated Processing System of the Space and Missile Test Center at Vandenberg Air Force Base. TIPS was designed to monitor up to six simultaneous Air Force and NASA missile launches from the Western Test Range at Vandenberg. Two years on SDC's drawing boards before contract award, TIPS illustrates the complexity of modern high-technology systems.

The TIPS data processing architecture is imposing. Seventeen minicomputers receive multiple on-line streams of billions of bits of telemetry data from simultaneous satellite missions at rates of one million bits per second. The machines then sort out the meaningful signals from a mass of data, compress the wideband space data loads to limited ground bandwidths, and display real-time status data to Air Force ground controllers over neon-glow plasma displays against a microfiche background map of the terrain, while recording other data streams on printer-plotters operating at speeds of one page per second. The entire operation is orchestrated by a distributed-processor control program operating in a large CDC Cyber-173 computer.

SDC drew on an arsenal of experience to build TIPS. The systems management techniques gained from earlier prime contracts were now mature. Hardware and telemetry expertise came from years of working at the Satellite Control Facility and the Navy's launch facilities at Point Mugu, California. The 180,000-instruction TIPS program embodied a telemetry compiler based on Apollo programming and on the SDC-designed Space Programming Language which, in turn, owed a debt to JOVIAL.

Displays for TIPS were influenced by an electric power management system the company had developed for a Canadian utility. Signal processing experience derived from other space contracts and the R&D program. As for the on-line, real-time, user-oriented management of complex data—that came from SAGE and nearly everything SDC had done since. During its third year of development, TIPS was able to support missile launches.

SDC also found an ideal opportunity to extend its space experience overseas by helping to build the ground control system for Japan's satellite program. Working with its venture partner, SDC Japan, which served as prime contractor, the SDC team supported the launches of various Japanese satellites, including the Kiku test satellite in 1977 and the Sakura communication satellite in 1978, whose poetic names translate to "chrysanthemum" and "cherry," respectively.

In 1977, the company put all its space know-how together to win a procurement that opened the gateway to one of the largest and most challenging of future programs—the multibillion-dollar Space Defense Command and Control System.

The initial study contract—to identify the functions and capabilities of the space command-control system of tomorrow—brought out the toughest competitors SDC had faced. Six aerospace consortia, each composed of three or four major contractors—large corporations including IBM, TRW, McDonnell Douglas, General Electric, Litton, and Rockwell—bid on this pivotal study leading to the futuristic Space Defense Operations Center. By far the smallest of the competing firms, including all prime contractors and subcontractors, SDC as the prime bidder led its team of GTE/Sylvania, Lockheed, and Teledyne-Brown to one of the two contracts awarded. "SDC will be working on the follow-on from this award through the year 2000," predicts Systems Group division vice president Frank Morris.

By 1978, SDC had become a credentialed integration contractor in the space field, much as it had established itself as a total systems developer in the aerospace command-control domain a half decade earlier.

COMMAND-CONTROL AND TRAINING

GETTING THE MESSAGE ACROSS

In addition to exploring the potentials of space, SDC found or made new opportunities in its support of national defense. Having coined its approach to interoperability in early programs like Seek Dawn and the CONUS Testbed, SDC minted a series of ever-improving approaches to integrating the tactical systems of the Air Force, Army, Navy, and Marine Corps.

Among a string of new contracts was the integration of the Tactical Air Control System within the joint services (so-called TACS/TADS) interface. Next, SDC system-engineered communication links among six Army tactical systems, the first of a series of tasks for the Army Tactical Data System. For the Marine Air Command and Control System, SDC provided six years of planning, systems, and software support. In 1974 the company won a $3 million award for GAMO—Ground and Amphibious Military Operations—a broad-scale establishment of interfaces among major-service command-control systems. By that time, SDC had become a national leader in interoperability.

In 1976, Skaggs shifted responsibility for interoperability programs to the Washington Division, close to the center of the tactical command structure. Expanding its contract base under the leadership of Dr. Edward G. Ries, SDC integrated digital voice networks for the Joint Tactical Information Distribution System; developed the system architecture for the successor to GAMO, the Joint Interoperability of Tactical Command and Control Systems, or JINTACCS; and helped to engineer a Tactical Systems Interoperability and Support Center.

In April 1979, a twelve-person SDC team won high government praise for its initiative in reconciling the conflicting message protocols, or standards, of the Navy and Air Force. Within nine hours of assessing the problem, the SDC team had developed a compromise interoperability design acceptable to both services.

Measured in terms of payoff in future business, no award rivaled a $1 million contract in 1976 for preliminary design of an improved automated information capability for the Naval Intelligence Command. SDC's system design would lead to an implementation contract in 1980 whose estimated value far exceeded any previous competitive award.

MANAGING AIRSPACE

As countries began to integrate their air defense and air traffic control systems, a new technology known as airspace management emerged. In Spain, a corporate team, working with SDC's partner, ERIA Systems, performed a requirements study of the Spanish airspace system of the future. In Japan, SDC and SDC Japan helped to configure that country's BADGE-X air defense shield. SDC bid on airspace systems for Libya and Kuwait but failed to win them. The reason for the shift to the foreign market was simple: the U.S. demand for airspace management systems had largely been satisfied.

In the summer of 1976, SDC received a fortuitous phone call from a long-time associate, Burroughs Corporation. Burroughs wondered if SDC would like to join them on a Westinghouse team competing for an airspace system for Morocco. SDC agreed, and after a tense, year-long international competition, the Westinghouse group won. SDC's share for system engineering, software development, and training was $12 million.

Based on the design of SAGE and BUIC, the Morocco Air Defense System (MADS) posed new technical challenges for SDC. It represented the first airspace system to use a standard commercial computer (the Burroughs B7700) and to be implemented in a standard higher-order language (ALGOL), in lieu of the more costly special-purpose resources typically used for command-control. With all SDC deliverables accepted on schedule, MADS represented a model of optimum software development.

KEEPING MAN IN THE SYSTEM

In its 1960 heyday, SDC's human factors staff had numbered four hundred—psychologists, sociologists, and educators, most with advanced degrees. As the Air Defense Command training programs dwindled over the next decade, this prodigious social science resource—unique for a systems company—diverged in three directions.

One obvious direction was out of the company, and a contingent chose that route, returning to universities or joining government or other industry. A second group stayed to make the successful transition from human factors to programming and engineering. By so doing, they created a rare breed of technologists whose data engineering skills complement a human factors background. "If SDC is unique among systems corporations," says veteran department manager Dr. D. Brian Murphy, "it's because of the heavy influence of human factors in all areas of corporate technology. SDC put the 'man' in 'man-machine' systems."

The third human factors group continued to push SDC into new directions in human engineering—resulting in new contracts for new customers. During the 1970s, this staff's analyses and recommendations produced improvements to the all-volunteer Army, the Navy human goals programs, the Air Force career ladder, and the DoD alcohol abuse prevention program. A large contingent managed the National Drug Abuse Training Center in Washington, D.C. Others were developing self-paced training courses for military personnel in telecommunications, helicopter maintenance, and tactical data processing.

The System Training Program thrived in sizable contracts for the Tactical Air Command, as SDC continued to build worldwide simulation exercises for U.S. and allied forces in eighty locations throughout the world. Continuously modernized, the program featured a self-contained portable simulator, dubbed "the electronic suitcase," providing realistic battle training for air controllers at the front lines.

PUTTING MAN IN THE LOOP

SDC also won a number of special projects that represented advance waves of the technology of the future.

The Defense Advanced Research Projects Agency selected the company to provide system engineering and network programming support to the Acoustic Research Center in Sunnyvale, California, one of the nation's most advanced facilities for research in acoustic signal processing. SDC's mission included experiments in ocean science, testbed development for advanced undersea surveillance concepts, and real-time directed search and tracking.

On a visit to this facility, Secretary of Defense Harold Brown praised the work: "By virtue of our computer and data processing resources, we now have a very considerable capability and expect this to improve in the future." Along with SDC's research program in signal processing, this contract helped to maintain the corporation at the forefront of an important new technology.

For the Aerospace Medical Research Laboratory in Dayton, a team of SDC scientists participated in a series of novel man-machine experiments. In the so-called man-in-the-loop weapons system, SDC put together a sophisticated simulation in which a weapons officer homes in on a target by directing the in-flight course of a glide bomb while he observes the target via images transmitted from a TV sensor built into the bomb. The SDC team also contributed to experiments with remotely piloted vehicles, laser-guided missile simulation, and jamming-resistant imagery transmission.

Another significant award was that for OASIS (Operational Application of Special Intelligence Systems), a forefront Air Force program for tactical data fusion in which SDC supported Martin Marietta. The concept of "fusion" or integration of real-time military reconnaissance data from many sources—from infrared sensors and phased-array radars to aerial photos and telephone reports, in a way that makes the results readily understandable by a commander—has become the sine qua non of modern command-control. OASIS is a multi-year program concerned with enhanced fusion of intelligence data and the interface between the Tactical Fusion Center in Europe and its U.S. and NATO users.

THE SURGE OF ENERGY

As Americans contended with the unaccustomed problems triggered by fuel shortages, engineers and scientists at SDC were helping to develop solutions.

The acquisition of MRI in 1972 had brought a talented group of mechanical and electrical engineers to SDC. Their prior experience focused on classical engineering mechanics, primarily the design verification of structures ranging from offshore oil rigs to tomato crushers. The group had also designed advanced hardware, such as the shock isolation system on Apollo crew seats. For many years it had been building the rocket test sleds that run at supersonic speeds on tracks at Holloman Air Force Base in New Mexico, testing components under simulated rocket flight conditions.

MRI engineers had also built and installed special test equipment for energy producers, a capability they expanded at SDC. This equipment, consisting of sensors, minicomputers, and other electronics, performs stress tests on structures used for offshore oil drilling and deep ocean mineral mining. Typically, such structures function under heavy strain. One example is the buildup of pressure in ocean oil drilling pipes as the drilling mud shoots downward and the excavated oil and debris shoot up. SDC-MRI personnel have monitored these tests in such inhospitable regions as the North Sea and the Arctic Ocean.

Shortly after SDC acquired MRI, the U.S. government announced plans to build the Trans-Alaska pipeline to convey oil over eight hundred miles of rugged Alaskan terrain for shipment to the western United States. Of immediate interest to SDC, the

U.S. Department of Interior required a quality assurance contractor to protect the six hundred miles of federally owned wilderness traversed by the pipeline. MRI's experience in building and monitoring sensor-test equipment for pipelines in the ocean, combined with SDC's computerized systems to manage the large volumes of environmental data to be collected, garnered an $18 million competitive award in January 1974.

The job of SDC's eighty-person team was to review the pipeline design, recommend improvements, and then monitor the construction in Alaska. The design constraints ranged from seismic safety and spill containment to protection of caribou migration paths and revegetation of construction sites. SDC issued numerous recommendations and cautions, including those pertaining to the risk potential of pipeline welding, which surfaced as a major problem during the project.

One year after their impressive contract victory, members of the same SDC-MRI team confidently entered another competition, only to finish in seventeenth place! The sorry event: the world championship dog sled races, high point of the annual Fur Rendezvous Festival in Anchorage, Alaska. The lame excuse: one of the eight Alaskan Malamutes suffered stiff joints in the icy footing. So reported the April 10, 1975, issue of the *SDC Bulletin,* the biweekly employee newspaper edited by Mary Lou Buer, who would later become director of Corporate Relations.

The pipeline contract was a strong revenue producer. Delays in construction were to extend SDC's performance to 1978 and increase funds to $24 million. But its one-of-a-kind nature offered no bridge to other opportunities. Eager to get into a repeatable business in the growing energy field, President Mueller created an SDC energy task force in April 1975 with a mandate to move the company into new, expanding, long-term energy markets.

The crystal ball for the future of the U.S. energy program looked fairly clear to the task force. Its members foresaw multibillion-dollar projects for fuel development sponsored by government and industry—projects that in size and complexity rivaled the largest programs of DoD and NASA. The team reasoned that the system engineering and system management techniques that had served the aerospace community so well—project planning and control, technical direction and contractor coordination, automated budgeting and scheduling, configuration and documentation management—would become equally vital to the success of these ambitious energy programs. Not only did SDC have such skills in depth, but the MRI contingent added the engineering and energy know-how to translate the capability from DoD to DoE, the newly formed Department of Energy.

The first opportunity to test this strategy came in late 1975 as SDC won the role of cost and schedule integration contractor for the Clinch River Reactor project, the country's largest civilian breeder-reactor program. For this project, which had been troubled with cost, schedule, and coordination problems, SDC established a technical and financial baseline, monitored the program to the baseline, and shortly instituted a high degree of program control.

During 1976 the energy task force worked with both SDC-MRI and Government Systems to identify similar targets—but of a value to SDC one hundred times that of the $400,000 Clinch River Reactor contract. One such project was the government's multibillion-dollar Gas Centrifuge Enrichment Program. This program would implement a new technique for developing enriched uranium that consumed only 10 percent of the energy input of the more conventional gaseous diffusion techniques. A new plant was being constructed in Portsmouth, Ohio, and the project would be monitored by the DoE office in Oak Ridge, Tennessee. One of DoE's many procurements on this large program—for a system support contractor—validated the market assumptions of the company's energy task force.

To take SDC's best shot at this golden opportunity, George Mueller and Jim Skaggs made several key decisions. First, MRI's West Coast staff, which for the five years since acquisition had remained in its crosstown facilities, was consolidated in SDC's Santa Monica building complex. In July 1977, the MRI subsidiary was merged into Skaggs's Government Systems organization, which was renamed SDC Systems. Skaggs then recalled Robert Carroll to Santa Monica from his Washington management assignment and designated him corporate energy capture manager.

Carroll assembled a select crew of technologists and marketers to penetrate what amounted to a new world for SDC. He tells what happened next. "First, we learned all we could about centrifuge technology. At the outset, we knew few of the players and they didn't know SDC. Over the summer of 1977 we traveled some fifty thousand miles, visiting everybody connected with the program—customers, contractors, and competitors. We soon became the trusted cross-communicators between all these groups, who seldom talked to each other. By the end of the summer, we had become respected colleagues in the energy business."

For the Gas Centrifuge Enrichment Program bid, SDC teamed with the highly respected architect and engineering (A&E) firm of Daniel, Mann, Johnson & Mendenhall (DMJM). The joint venture proposed an integrated management, with SDC to perform about 70 percent of the work.

The procurement followed the so-called A&E solicitation technique, a genteel form of competition for SDC. In this instance, twenty-two bidders (including large systems houses like Boeing and TRW as well as many A&E firms) submitted qualification statements; these were narrowed to seven, which were then asked to provide additional data. From these, DoE culled a "short list" of three finalists. Final orals were held at the sites of these three, with SDC/DMJM the last to be visited.

When every gate had been cleared, the SDC/DMJM team was announced the winner, in June 1978, of a ten-year contract for $45 million. Vice President Jack Cannady still marvels at the feat. "It's remarkable that Carroll and his team, competing in a relatively new market, on a new technology for SDC, and for a quite recent customer, were able to prevail."

One of the corporation's competitors on the Gas Centrifuge Program, Universal Oil Products, subsequently a member of the Signal companies, was sufficiently impressed by SDC's system capabilities to invite the company to co-venture on the large Fossil Fuel Processes Program it had been tracking. Another DoE multibillion-dollar project, this one set its sights on the conversion of coal to gaseous or liquid fuels. System management would be complex because many contractors with varying approaches to coal conversion were to be monitored and evaluated.

The happy history of the centrifuge award was repeated. DoE issued its request for proposal for a technical evaluation and program control contractor. In another competition using the A&E solicitation technique, the SDC-UOP team was the winner of a two-year, $16 million contract with two one-year options for another $16 million.

By the end of 1978, SDC had 160 staff members working on the fossil fuel program in McLean, Virginia, and on the centrifuge project in Oak Ridge, Tennessee. Jointly with their venture partners, the teams were performing the complete range of system engineering and management support activities to make both programs a success.

"Whether we're analyzing an experiment in peat gasification or monitoring plant and equipment, our teams supply the project control and system engineering glue that holds thousands of program elements together," is how Energy Division vice president Roger Sadler explains the corporation's broad support role. On the centrifuge project, the customer indicated that SDC/DMJM had saved the government $40 million in the first two years.

Two other capabilities rounded out SDC's energy and engineering program. One of these was a disciplined approach to improving the productivity of U.S. power plants. "This work may prove as valuable to the nation's energy needs as anything else the company has done," says Energy Division vice president Fredric A. Cohan. "When you realize that large nuclear and coal-fired electric power plants in the United States operate at about sixty percent of maximum capacity, it's clear that achieving the other forty percent would solve much of our energy crisis."

Beginning with a 1976 award from the Federal Energy Administration to improve plant productivity, SDC amassed its experience quickly on a dozen power stations under $10 million of contracts. Applying rigorous systems analysis to pinpoint the causes of power plant inefficiencies, SDC personnel then worked with plant managers to improve productivity and train the operators in new procedures.

Perhaps best known of SDC's engineering tools continued to be the proprietary STARDYNE program for structural analysis. Created in 1968 and continuously improved over time, a decade later the STARDYNE system was being accessed by the design engineers of 350 companies in twenty countries through commercial service bureaus. The program accepts a mathematical model of any structure—from an automobile frame to the shell of a power plant. Then, drawing on a prestored data base of the properties of virtually nearly all existing materials, it calculates the load factors and determines the safety of the structure. If allowable tolerances are exceeded, the engineer goes back to the electronic drawing board, his terminal, with a new approach.

By the late 1970s, structural analysis had become the highest revenue producer of any scientific capability in the service bureau repertoire, and the STARDYNE system led all competitors. Its annual contribution to SDC's bottom line has been equivalent to a profitable $10 million contract.

At the end of 1978, the 250-member energy staff was consolidated in an Energy and Engineering Division under Bob Carroll, with Fred Cohan and Roger Sadler as managing vice presidents.

THE CIVIL ROLLER COASTER

CONSOLIDATION AND CONFLICT

In the early 1970s, SDC had achieved an $8 million annual revenue base in civil contracts: several large contracts amounting to $3 million, and another fifty contracts averaging $100,000 each. Bob Carroll, in charge of civil programs prior to his energy assignment, remarked, "We were a mile long and an inch deep."

The smaller contracts were often a form of high-grade consulting, culminating in a report on the characteristics of railroad crossings, or federal libraries, or adult education. A 1971 book called *Think Tanks* (Atheneum), featuring SDC as "one of the world's leading software and systems firms," devoted a third of its description of the company's work to an esoteric study of the health care needs of the Papago Indians. For a government-funded analysis of the "Mellonby Phenomenon," which related behavioral impairment to alcohol intake, SDC offered subjects $1.65 an hour to ingest vodka in sessions advertised "to last anywhere from twelve to twenty hours."

"These studies were more appropriate for a university or research institute," says Jim Skaggs. "They required a year-round marketing effort to sustain funding and would never lead to the systems business in our long-range plan."

Management began a restructuring of civil programs in 1972, completing the job by 1974. After finishing its traffic-signal-control and people-mover contracts, SDC deemphasized the transportation business, except for singular opportunities. Work in library automation was consolidated into the new business of SDC Search Service. As smaller projects in education ended, they were replaced by a new capability: the evaluation of large federal aid-to-education programs. In public safety, the L.A. County Sheriff's communication system was being completed, and a core capability for similar justice systems was kept together. Attempts to market SDC's technology to state and local governments gave way to more substantial data processing developments for agencies in Washington—Housing and Urban Development, General Services Administration, Social Security Administration, and Farmers Home Administration.

SDC's deemphasis of municipal automation stemmed from the difficulties of trying to contact states and cities all over the country. Even the Charlotte (North Carolina) Municipal Information System, a landmark automation project whose twenty-five computerized modules for public safety, human resources, financial management, and physical planning were completed by SDC in 1975 as a national prototype, experienced limited transferability to other cities.

Recalls program manager John D. Barry, "Sharing our products wasn't easy. Every city had a different requirement, a different computer, and its own, usually slow, procurement cycle. A city-by-city marketing effort was too expensive to justify the results." Even so, several Charlotte modules, particularly vehicle status and geographic reference, were adopted by other municipalities.

Into this murky picture, rain began to fall in the form of cost growths on three fixed-price civil contracts. The first and largest emerged in the Sheriff's Communication System. Under way since 1970, this $4.3 million contract to build a computer-based telecommunications system integrating sixteen sheriff stations and covering Los Angeles County's four thousand square miles had run into unexpected delays. Responsibility for county management of the program was split between two departments—Sheriff's and Communications—which had frequently pulled in different directions. Construction of the underground facility to house the system was delayed by nearly a year, stretching the schedule inordinately. As SDC's costs pushed through the budget, the company could hardly get the smallest change negotiated, since any amount over $5,000 had to be approved by the five-person Board of Supervisors of Los Angeles County.

In 1974, SDC assembled a cost claim against the county for over $2 million. SDC's contracts director, Bernard Fried, persuaded the Board of Supervisors to submit the matter to binding arbitration by the American Arbitration Association, the first time that Los Angeles County agreed to have a financial dispute decided by outsiders. The county's sense of fair play was no doubt influenced by SDC's unflagging performance on the project, culminating in a grandstand ribbon-cutting for a fully operational facility in early 1975. After three months of hearings, the three-person arbitration board reached its conclusion in July 1975—an award of $1.2 million to SDC.

About the same time, similar problems on a smaller scale cropped up on the contract for the Charlotte, North Carolina, traffic-signal-control system (unrelated to the Charlotte Municipal Information System). SDC cited customer redirection, additional work, and time delays. Again, a legal confrontation was avoided and a financial settlement reached.

The third dispute concerned a 1971 contract for the General Services Administration, which had selected SDC to automate the Public Building Service's records covering one billion dollars worth of federal buildings. Satisfied with SDC's performance, GSA added new tasks and funds in 1972 and again in 1973; but by 1974, SDC was forced to seek compensation for extensive customer redirection on this fixed-price contract. Although a financial settlement was reached agreeably, the contract monitor terminated SDC's contract at the government's convenience. At the same time, another arm of GSA was complimenting SDC's quick results on a second, closely related contract for the Public Building Service—automation of its accounting system, which became operational one year after award.

Even on disputed contracts, where SDC was permitted to continue, the results were exemplary. The Los Angeles Sheriff's Communication System had not once failed through its first six years of operation. Both it and the Charlotte traffic system became national showpieces. Quoting Dr. Mueller, "Although these contracts cost us money, SDC has never walked away from a commitment. We always did what we said we were going to do."

EVALUATING EDUCATION

In 1971, the company's Education Systems Department performed a contract to amalgamate, into a single data base, hundreds of data tapes collected on various Head Start remedial learning programs and to analyze their combined content. This project, which utilized SDC's computers, statistical library, and analytic techniques, was carried out by Dr. John E. Coulson, one of the corporation's earliest research workers in education. The U.S. Office of Child Development was impressed and changed some Head Start policies based on SDC's results.

In 1973, SDC entered the competition for evaluation of the pilot program of the Emergency School Aid Act. This bid included the nationwide collection of data, in addition to the data analysis. Again spearheaded by Coulson, the SDC team of psychologists and statisticians, augmented by a blue-ribbon consultant panel of renowned educators, secured this $5 million award.

When a $25 million procurement was announced by the U.S. Office of Education in 1975, SDC's management recognized that evaluating compensatory education programs had become a major source of federal funding. Under Title I of the Elementary and Secondary Education Act, some $3 billion a year was disbursed to public schools for compensatory education—to improve learning for disadvantaged and minority students. To ensure the effectiveness of these programs, an independent evaluation was built into the funding of each. President Mueller asked Launor Carter, then on SDC's Executive Planning Board, to consider managing the proposal effort and, if SDC were to win, the total SDC evaluation program. Attracted to the education field and the R&D challenge, Carter agreed.

Replicating the successful approach of the 1973 win, a team of SDC professionals and nationally known educators wrote a superior proposal and won over highly regarded organizations within the educational establishment, including the potent combine of Rand and Educational Testing Service.

SDC's Title I evaluation followed some eighty thousand students throughout the fifty states for three years to determine the "sustaining effects," or long-term impact, of various forms of compensatory education on cognitive skills. The data flow was immense: two million forms and questionnaires containing an average of fifty items, or one hundred million pieces of data altogether, were added annually to the already information-rich data base. The heavy emphasis on computerized data management, coupled with SDC's system design and human factors skills, had added the evaluation of large programs to the list of corporate specialties.

In short order, SDC became the leading evaluation contractor for the U.S. Office of Education (later the Department of Education). Other corporate evaluations concerned delinquent students, parental involvement, and human relations in schools. At the end of the 1970s, a staff of sixty experienced analysts was working on contracts totaling $40 million.

Addressing the often asked question of whether these evaluation expenditures are worthwhile, Launor Carter responds, "These funds are but a small fraction of the billions spent on social programs. Our results are presented to Congress and used for future legislation. You can't imagine an expensive weapons system without test and evaluation. Social programs should be the same."

"X" MARKS A HIGH SPOT

On February 14, 1978, SDC won what was then its largest fixed-price contract: the $28.5 million Emergency Command Control Communication System (ECCCS—pronounced "X") for the Los Angeles Police Department. After nearly two years of intense competition between SDC and the team of Motorola/IBM, the award was finally decided by a ten-to-three vote in favor of SDC by the Los Angeles City Council. According to the *Los Angeles Times* of the following day: "The selection was made in the face of virtually solid opposition from key members of the City Hall 'establishment' who favored Motorola."

The story began in 1975, when the City of Los Angeles decided to procure a new, modern police communication system to handle its three million calls a year, or one call every four seconds during peak loads, over a territory stretching 450 square miles. The largest and most complex police command-control system ever conceived, the ECCCS capability called for more sophisticated communications to relieve congested radio frequencies, improved efficiency for 1.2 million vehicle dispatches per year, faster system response times, and increased officer safety.

Three major subsystems of ECCCS played key roles in the procurement: computer-aided dispatch (CAD), mobile digital communications (MDC), and master radio plan (MRP).

In June 1976, SDC elected to bid on the first two subsystems and their integration, the so-called CAD/MDC/I segment, whereas the Motorola/IBM team—long-standing incumbent suppliers for LAPD—bid the entire system. After a lengthy evaluation, the City Technical Steering Committee recommended two awards in January 1977: one to SDC for the CAD/MDC/I segment and one to Motorola for the MRP segment. Next followed eight months of contract discussions and negotiations. In September 1977, both bidders were redirected to their respective drawing boards as the city decided that a single contractor for the total system was in its best interests.

Since SDC had not previously bid the sophisticated master radio plan, its ECCCS team worked feverishly in the two months available to develop the MRP bid, together with its subcontractor, E-Systems, and the major supplier, General Electric—then integrated the MRP segment into a revamped proposal. Motorola also prepared a revised bid.

At first the many departments involved in the City's Technical Steering Committee favored SDC; then they leaned toward Motorola. The final confrontation came before the city council, where SDC was represented by Jim Skaggs, in charge of civil programs since their merger into Government Systems in July 1975.

With the two bids virtually equal in price, the issue narrowed to SDC's systems management and software engineering expertise against Motorola's superior radio communications credentials. Hammering hard on the need for an integrated systems capability on a job of this magnitude, Skaggs won his point. In the words of one council member favoring SDC, "It's like choosing a surgeon—you want someone who can look at the whole system, not the manufacturer of a piece of surgical equipment."

When Skaggs declared afterward, "This successful effort was due to the superb marketing strategy of Frank Morris and the perseverance and dedication of Herbert Saxon and the entire ECCCS team," he intended more than obligatory compliments.

For six months, while the final proposals were being prepared and analyzed, the city had requested daily briefings on various facets of the system, together with reams of backup data. Subsequently named ECCCS program manager, Saxon recalls, "For that half year, I literally lived at a hotel in downtown L.A., near City Hall. Every day the SDC proposal team, including our subs, E-Systems and Comcenter, worked till one in the morning preparing materials at SDC, after which I'd head for the hotel and be ready with new briefings the next day."

Requiring twenty thousand pages of design specifications and an equal number of engineering drawings to describe it, ECCCS represented an array of high-technology developments never before integrated on that magnitude. Some of the firsts were: largest centralized computer-aided command center, with four PDP 11/70 computers and sixty multifunction dispatch consoles; largest number of mobile digital terminals (850) in patrol cars; largest voice simulcast system for public safety, with 90 transmitters and 350 receivers; integration of 5,000 new portable ROVER two-way communication devices; optimum balance of UHF, VHF, microwave, and telephone communications; and an intricate software system linking all components under rigid on-line time constraints in one of the largest DEC computer configurations.

SDC supported the building of ECCCS technology with a host of support tasks that made this contract fully live up to SDC's "total systems" reputation. The project team selected and leased the transmitter sites, installed thousands of components in fixed and mobile stations, designed the facility in City Hall East's underground communications center, trained hundreds of LAPD personnel in the operation and maintenance of ECCCS, coordinated numerous special licenses and permits with state and federal agencies, validated the quality of radio coverage with simulations and live tests—in short, ensured that nothing was overlooked in building the largest public safety system in the world.

SDC SOFTWARE: DIRECT FROM THE FACTORY

Profound events in the 1970s shaped SDC's industry-leading approach to management of the software development process.

The transformation of SDC into a total systems company had brought several early awards: TIPI, Cheyenne Mountain Upgrade (427M), and Cobra Dane—the first two prime-contracted by SDC, the last a complex software development under subcontract to Raytheon.

While the software SDC was developing for each system was unique, the contracts had disturbing commonalities. All were pushing the state of the art in real-time command-control information systems. All had fixed prices or cost ceilings. All called for major software developments to be performed away from

SDC's Santa Monica headquarters, near the customer. And all suffered from early schedule and, consequently, cost difficulties.

The ultimate success of these systems was due, in equal parts, to the dedication of SDC's on-site professional teams, the infusion of high-powered technical aid from other geographic locations, and a corporate commitment to make these landmark programs testaments to SDC's professionalism.

Apart from the specific technical challenges posed by each system, two generic issues lay at the root of their problems: a lack of software development standards, and a requirement to perform these one-of-a-kind projects away from the cognizance of SDC headquarters. In the words of Jim Skaggs: "We were engaged in creating a 'one-time miracle' in three places at once."

Unlikely as it may seem, SDC, the pioneer in system management, had no standard policy or engineering procedure for company-wide software development. For that matter, neither had anyone else. True, the corporation had established exemplary standards for SAGE, for SACCS, and for scores of other major developments. But until SDC crafted its standardized software development approach in the mid-1970s, each programming project was thought to be so unique as to defy a common policy.

The entire domain of software development was deemed more an art than a science by its practitioners. Even more discouragingly, the decade of the 1970s saw little improvement within the industry, to judge by a sample of typical opinions.

"It is unfortunate that... computer science is still not on a firm path toward becoming a science.... All too few people are even trying to make it into a science...." (*Datamation,* 1970)

"The study showed that for almost all applications, software, as opposed to computer hardware, was the... major source of difficult future problems and operational performance penalties." (*Datamation,* 1973)

"There does not seem to be anything coming down the pike which gives any hope in the near future for significant improvement in the system designer's or programmer's performance." (*Datamation,* 1976)

"The computer revolution is running into a bottleneck. The stumbling block is software.... " (*Business Week,* 1980)

SDC's vice president for Software Engineering, Jack Munson, highlights the issues. "For SDC's large development contracts in the early 1970s, the diversity of computers—Honeywell 6080 for 427M, CDC Cybers on Cobra Dane, and Univac AN/UYK-7 for TIPI—made it impractical to apply common development tools. With no common body of procedure or support capability tying these disparate activities together, each team had to develop these skills for itself.

"Staffing these contracts was another trying experience. Specialists in operating systems, compilers, man-machine interfaces, telecommunications, and astrodynamics are always in short supply. To find these skills in people who would also relocate their families to Colorado Springs, Boston, or Hampton was a formidable and expensive task.

"Even when we had enticed the key people, staffing the remaining team with local hires was difficult. Each project spent much time and money hiring talented personnel and training them on the job. Today, some of our most qualified software specialists grew up in this crucible of challenge. Needless to say, it's hardly the way to run a business or perform on tightly scheduled, cost-constrained contracts."

As a plague of similar software crises spread through the industry, SDC was fortunate in having made some preparations for this contingency. Dr. Mueller had recognized that the first company to develop custom software more scientifically, economically, and reliably would be helping itself and could lead a major industry toward greater productivity. In 1972, he had initiated an R&D program aimed at achieving a methodical, standardized engineering approach to software development—a concept he called "The Software Factory."

For three years, Terry D. Court and his group within the R&D Division had been developing experimental procedures and automated tools for software development. When major software problems on SDC contracts surfaced in 1975, Mueller asked Jack Munson to form a task force to accelerate the transfer of the technology from R&D to the line.

The Munson team first developed an action plan that addressed, in detail, software control and pricing during the proposal phase, a disciplined engineering approach, modern production methodology, economies of scale (or the advantages of combining many small resources into one large one), personnel specialization, improved project visibility and control, an upgraded technical approach, and a people-sensitive work environment.

During the next eight months, the task force refined and implemented a set of standards for software development that could be applied to all projects. The foundation for those standards was a "model" software development life cycle, specifying the major activities, events, and products inherent in all projects. The next layer was a set of procedures called "modern programming practices," specified for each discrete unit of activity. Overlying the process was a management control system that integrated planning, project control, review and evaluation, and quality assurance.

Based on work originated in the R&D division, amplified and field-tested by the task force, and widely reviewed, these standards were embodied in an SDC Software Development Manual. As the final review authority, President Mueller authorized publication in January 1976, together with the directive that "all line organizations will commence the application of these standards to all internal projects immediately as well as to all future proposals and contracts."

SDC had accomplished one of the first efforts to create a standard engineering discipline for software development. The Electronic Systems Division, the Air Force's principal manager for the acquisition of computer-based systems, contracted with the corporation to develop similar standards for DoD. Over the next two years, SDC, with Air Force and Mitre help, published a sixteen-volume set of guidebooks for military managers on software acquisition and management. DoD placed the documents in the open literature, where they have become "best sellers."

Yet this important breakthrough addressed only part of the problem. SDC still had a large number of autonomous software efforts scattered throughout the company, some reporting to software managers and some to engineers or other technical specialists, who carefully shielded their specialized and often scarce programming resources from use by others. Many projects were located at remote sites, away from central cognizance and control. It became very difficult to apply the new software development process consistently within this heterogeneous environment.

The U.S. government's all too frequent insistence that a contractor's programming staff work on the customer's premises had long been one of Mueller's favorite targets for reform. Addressing the American Institute of Industrial Engineers, he said, "With today's technologies of emulation, intelligent terminals, and remote job entry, there is no need to have a mass of programmers swarming around the end-item computer. Apparently the government thinks that each software firm has a fully qualified staff of experts willing to traipse around the country like traveling gypsies. No one seriously entertains the idea of a traveling hardware factory."

The drawbacks to "traveling gypsies" are confirmed by SDC's project manager on the TIPS program. "We lost a lot of time due to having to move or recruit a hundred people to Lompoc [California] so they could work under the customer's eye at Vandenberg. Besides the move costs and the inflexibility of swapping people at a remote site, day-to-day contact with the customer produces a creeping elegance in the system that escalates into cost and schedule growths."

After further study, the Munson task force recommended a single, centralized software development organization that would build all software for SDC, either in Santa Monica or under close Santa Monica management control. New procedures enabled a single set of personnel to monitor and control a large number of software projects concurrently, taking advantage of economies of scale and providing for cross-utilization of scarce skills.

Every major software project would flow through an "assembly line" of three suborganizations of The Software Factory—Requirements and Analysis, Software Production, and Independent Test and Operations—to ensure optimal division of skills, provide better management visibility, and guarantee objective quality assurance.

On December 1, 1976, Jim Skaggs announced the official establishment of the pioneering Software Engineering Organization in the SDC Systems division, with Jack Munson as its leader and another long-time SDC manager, Robert W. Hamer, as deputy. The factory had opened its doors.

If SDC's journeymen programmers resented the "factory" label, they expressed it with good-natured humor. Some came to work wearing overalls and baseball caps and toting lunch pails. One wag blew a concentration-shattering whistle every two hours. Cartoons abounded, including one in Hamer's office showing The Software Factory assembly belt, with its workers frantically designing programs on blueprints, knocking them out with hammer and chisel, and checking them under a microscope.

Within a short time, amused tolerance gave way to a new spirit of camaraderie, teamwork, and pride in a more closely knit Software Engineering Organization, as results began to justify the novel but clearly efficient methodology.

One of Systems Group's division vice presidents, Donald Biggar, recalls, "The first of my projects to use The Software Factory approach was TIROS-N—and the software produced was accurate, timely, and on budget." Shortly, The Software Factory methodology was at full steam, developing the Mobile Sea Range program, the fixed-price MADS software, and the ECCCS communication system. The results exceeded expectations, as schedules and budgets were met with greater precision than ever before.

In the spring of 1978, Mueller and Skaggs extended the discipline throughout the company. Munson was promoted to corporate vice president responsible for all software development in the corporation, while Hamer performed a similar function as a division vice president for the Systems Group. A commercial factory was formed under Judith H. Hamilton. The next challenge was to break the programming logjam in the Text II newspaper automation project, caused by many large orders coming in at once. Within six months, the situation was stabilized and Text II software was being produced on schedule.

The Software Factory structure was in place when SDC began the building of one of its most important products—the SDC Records Manager—a major software challenge that would be met successfully under the auspices of The Software Factory approach to doing business.

SDC SERVICES: FROM NAVAL AID TO MEDICAID

MISSION SUPPORT

"People make the difference" had become the slogan of the SDC Services Group, reporting to Edward J. Doyle. On the assumption that more people make an even bigger difference, the Services Group grew from 200 employees in 1971 to over 1,500 ten years later.

In explaining the group's role, Larry D. Campbell, manager of SDC's 200-person mission support staff to the Environmental Protection Agency at Research Triangle Park, North Carolina, relates one extraordinary incident: "On Sunday morning, April 1, 1979, our operations manager, Ronald Courtney, was awakened by an urgent phone call from our customer. Ron was to rush a crew of local SDCers to EPA's National Computer Center. The Three Mile Island nuclear plant had just blown, and the government needed a quick computer readout of the contamination levels recorded by water and air sensors in the vicinity, hooked up on line to the center. Within four hours the data was on a helicopter to Washington."

Although this anecdote does not typify the average workday of every Services Group member, most have found themselves in challenging roles in the forefront of technology. Depending on the customer installation to which they were permanently assigned in the 1970s, they may have been programming the computer for a U.S. Navy antisubmarine-warfare aircraft, developing security controls for the World Wide Military Command Control System, building a computerized model of pollution in the Great Lakes for the Environmental Protection Agency, writing data analysis programs to test NASA's space shuttle, or conducting computer-based fuel analyses for the U.S. Department of Transportation.

For these agencies and others, SDC personnel worked on the premises of the customers' advanced computing centers, programming and operating third-generation computers, minicomputers, and microprocessors; developing computer executive systems and new software for technical applications; providing customer support and training; and augmenting the agency's engineering and systems analysis staffs.

SDC was a latecomer to the support service business spawned by a prolific data processing industry in the early 1960s. Under the designation "facility management," large computer users, particularly in government, were turning the management of their data centers over to professional organizations. At reasonable rates, software houses undertook the chores of providing and managing the on-site computer personnel, arming them with the latest industry standards, and guaranteeing a measure of quality control.

Originally, management of a facility meant operating the computer and keypunching; it then extended to development of the computer system software; and ultimately it embraced highly technical program planning, systems analysis, and applications programming. Hence, the broader term "mission support services" has been more appropriately applied to this billion-dollar industry.

When SDC decided to enter the market in 1970, a number of competitors were well ensconced in the field—CSC, PRC, Univac, and some dozen others. Because of the keen price competition and the minimal overhead required on the customer's premises, each company typically formed a special "field services" subsidiary with a lower overhead rate than the parent. SDC formed Integrated Systems Support, Inc. (ISSI), later changed to ISI, and subsequently to SDC Services Group. The organization was managed successively by Raymond Barrett, Gorden N. Selby, and Jackson Maxey. Edward Doyle became its president in 1974.

SDC's first big effort to secure a foothold in support services came in a competition for the Navy's Fleet Computer Programming Center Atlantic at Dam Neck, Virginia. For this critical procurement, SDC assembled a proposal team, in October 1970, including Leonard "Bill" Maley, recently hired ex-naval officer and former director of the command and control department at Informatics; SDC department manager Bud Drutz; and Dr. Joseph G. Robertson from corporate marketing.

In a spirited procurement, aptly dubbed "the Dam Neck donnybrook," which lasted nearly half a year through an almost unprecedented three rounds of bidding prompted by an ongoing legal fracas involving another competitor, the incumbent contractor, and the Navy, SDC emerged as the winner in the third round—the first one, ironically, in which it had been the lowest-priced bidder. Maley recalls, "We were jubilant when we learned that we had won a three-year, $7.8 million contract. We were notified on Good Friday, 1971, and we were on the job by Easter Sunday."

Of the initial 175 contract personnel, SDC provided four top managers: project manager Thomas F. Marks, Jr., John A. Crowley, Rowlet "Lew" Lewallen, and Robert R. Marshall. Ten years later, Crowley and Lewallen would still be on the project.

This contract provided an unexpected opportunity for SDC personnel to show their skill and dedication under perilous conditions. In March 1972, two SDC program analysts, David F. Stone and Noah D. "Bud" Steele, were assigned to a U.S. Navy ship operating in the Gulf of Tonkin, to test and implement a new set of programs for the Navy Tactical Data System. On April 16, the ship suddenly came under attack by North Vietnamese air and surface craft. After the initial shock, during which, according to Steele, "we closed our listings and ran over and hugged the computers," both men assumed their own battle stations under fire, providing peak operation of the critical tactical data system. Their heroic efforts contributed directly to the ship's ability to defend itself. The two were commended by the Navy and, most deservedly, received SDC achievement awards.

In 1972, Tom Marks, a respected, long-time SDC manager, died unexpectedly. Frank M. Irons, who had earlier left SDC for a seven-year tour as manager of Navy programs for CSC, returned to take charge of Navy support programs.

In the two and a half years following the award of the Navy contract at Dam Neck, SDC received several small contracts from the Navy and Army; but despite other major bids, the company could not repeat its early success. The main problem was the small support services labor base, which limited SDC's ability to bid current employees for large new opportunities and, more seriously, prevented achievement of a competitive overhead. In a Catch-22 situation, SDC needed more business volume to get more business volume.

With perfect timing, the remedy came in February 1974 in the form of four mission support contracts from the Cordura purchase. Two large contracts at NASA facilities in Langley, Virginia, and Slidell, Louisiana, accounted for 300 people and $8 million in annual revenues. Overnight, SDC had a 500-person support operation with annual sales exceeding $12 million.

At SDC, the NASA work continued to be important and stimulating. The Langley complex of seven large CDC computers, including a Star supercomputer performing 40 million operations per second, was serving 1,500 scientists in aerospace research ranging from trajectory calculations to computer-aided design of space vehicles. A flight simulator facility handled six simultaneous simulations of every type of aircraft. SDC's staff provided a range of mission support services, from writing programs for analysis of vibrating structures to supporting experiments in aircraft mechanics and deriving the results. In 1975, an SDC team worked around the clock to provide the telemetry analyses for the Viking launch, helping to ensure its successful mission to Mars.

The NASA operation at Slidell, Louisiana, built around three Univac 1108 computers, proved no less challenging. The center provides analytic computer services for the Marshall Space Flight Center. In the 1970s, SDC supported tests of space shuttle components to ensure their return to earth after launch. The center also served other agencies, for example, the National Weather Service in predicting flood levels of the Mississippi river. In its role of complete facility support contractor, SDC has literally done everything from designing complex computer simulations to cutting the grass and operating the cafeteria. Says a senior site manager, only partly facetiously, "Some days the cafeteria gave us more static than the shuttle."

From the time of the acquisition of the Cordura mission support business, which also included smaller contracts at White

Sands Missile Range and Edwards Air Force Base, SDC recorded a string of successful procurements, removing all doubt that the company had achieved the "critical mass" of personnel to be one of the industry leaders. The next one came from the Environmental Protection Agency at Research Triangle Park, North Carolina. The two NASA contracts played a decisive role in SDC's win: the project managers for the EPA job came from Langley, and the requisite Univac experience came from Slidell.

From its eighteen-person beginning in 1974, the EPA contract would expand to two hundred SDCers six years later. "Our philosophy is to grow existing contracts into a total mission support service for the customer," says Services Group President Ed Doyle. At EPA, SDC was working with a massive computer configuration composed of the Univac 1100/44 and 1100/82, IBM 370/168, and two DEC PDP 10 machines, linked to 1,700 terminals across the nation. Using EPA's telecommunications network, thousands of scientists and state and local officials accessed the center's programs and models to monitor and control air and water pollution, toxic substances, and hazardous waste.

At the apex of DoD's communication net stood the National Military Command System Support Center, supporting the Secretary of Defense, the Joint Chiefs of Staff, the World Wide Military Command Control System, and NATO. From 1961 to 1972, IBM had furnished high-level mission support to the center, under contracts administered by the Defense Communications Agency.

When SDC challenged IBM in 1972 and appeared to have won this prize contract on both technical evaluation and price, the customer's decision to stay with the incumbent stunned SDC into its first official protest. The General Accounting Office took nine months to review the issue, ultimately upholding the award to IBM. The decision prompted SDC's vice president of Contracts, Bernie Fried, to lament, "A new procurement law has been written: being first technically and lower in price does not guarantee you'll win."

At the next opportunity to compete for this coveted award, three years later, SDC tried again. This time the corporation was the announced winner of a five-year, $10 million contract for the redesignated Command Control Technical Center. In addition to mathematicians, analysts, and programmers, SDC's staff included foreign-language translators, psychologists, and "our man in Brussels," who monitored the status of European forces data bases.

Meanwhile the company expanded its Navy mission support work under Frank Irons. The initial Dam Neck contract grew to five contracts, providing hundreds of Services Group professionals with experience in adapting the Navy's computer programs to the World Wide Military Command Control System, designing early-warning systems, testing trajectory programs for the Puerto Rico weapons range, and building software for an airborne antisubmarine-warfare system. SDC won other major support contracts for the Naval Air Development Center in Pennsylvania, the Naval Surface Weapons Center in Virginia, and the Navy Ocean Systems Center in California.

IT'S A LONG WAY TO TALLAHASSEE

In January 1976, following a Monday morning executive staff meeting, George Mueller asked Ed Doyle to step into his office.

"Ed, your sales are growing marvelously," said Mueller. There was a pause while Doyle digested this unexpected accolade. "But your pre-tax profits always manage to stay under a million," Mueller added.

"You know it's a very competitive game, George," Doyle responded. "Our division's return on assets is the best in the company. The profit margins in this business just aren't very high."

"Then please find us a business where they are," requested Mueller good-humoredly.

Doyle had already been examining other lines of business and had satisfied himself, through his Washington contacts, that launching the Services organization into the benefits processing market should increase the business base and provide Mueller with the profits he was looking for.

After assessing various alternatives, Doyle selected the federal- and state-chartered Medicaid program as a logical extension of SDC's support services into a new, potentially rewarding realm. Under Medicaid, nearly all states were hiring a "fiscal agent" to process the millions of medical claims for eligible recipients and to pay the providers of the services—doctors, pharmacists, and hospitals.

The commonalities between the role of Medicaid fiscal agent and SDC's mission support work included a computer-centered facility; a large support staff furnishing programming, data entry, and customer liaison; and long-term contracts like services procurements. Other pluses were: SDC's experience of analyzing Medicaid alternatives for New York back in 1966; the company's background in per-transaction services, relevant because the fiscal agent is paid per claim processed; and familiarity with health systems through hospital support contracts in New York City and the company's Claims Administration System.

Yet there were also important differences and risks. Unlike the cost-type government support contracts, Medicaid contracts paid a fixed price per transaction, leaving the contractor to his own devices to stay financially healthy. Secondly, despite some exposure to Medicaid, SDC had few experts on the subject. Finally, the field was dominated by a few strong contractors, notably Electronic Data Systems (EDS) and "the Blues"—Blue Cross and Blue Shield.

With the national budget projecting a $500 million annual market in fiscal data processing for Medicaid and Medicare, Doyle's strategic plan to penetrate the Medicaid market was approved by Mueller and the Operations Planning Board of senior executives in February 1976 and went into effect immediately.

The capture plan was entrusted to William M. "Maury" Mineart, a strong manager in several senses: twenty-five years of SDC managerial experience, and mention in "Ripley's Believe It Or Not" for his weightlifting feats. The plan had SDC "homework teams" swarming over states with already installed Medicaid systems—Michigan, Ohio, Texas, Oklahoma—sponging up knowledge, gathering software in the public domain, and getting crash courses in the technical and political basics of medical claims processing.

In July 1976, SDC lost its first bid, for the Massachusetts system, but reached the technical finals. In the next competition, for New York, the SDC team was one of two finalists but eventually lost by a narrow margin. The company then bid on the Kansas system and lost. It bid Wisconsin, came close, but lost.

Fifteen months into this consuming marketing effort, which was beginning to raise some skeptical eyebrows, both Mueller and Doyle remained steadfast in their commitment to the benefits market. At a corporate planning meeting, someone asked Mueller just how many bids would be allowed before the venture was abandoned. "Oh, I guess I'll let them bid about eight," he replied with a twinkle.

Meanwhile, Doyle, tired of well-wishers counseling patience, found the ideal slogan for rallying his troops. It came from a cartoon showing one hungry buzzard saying to another: "Patience my foot! I'm goin' out and attack something!"

In October 1977, eighteen months after the bidding started, patience combined with aggressiveness paid off, as SDC won a big one: a three-year award for $13 million in Florida. Facing the incumbent, EDS, SDC outscored its competitor technically and, in the closest of price competitions, beat the EDS price by a hairline four-tenths of a cent per claim.

Initial jubilation over the award soon gave way to concern, as SDC began to experience a benign form of the Medicaid startup problems that were making unpleasant headlines for other contractors in states from California to Massachusetts. The acquired baseline software did not work smoothly; the plan to use the computer in SDC's Chicago data center proved inefficient; a shortage of local keyboarders required their importation from as far away as Canada; and the work load greatly exceeded the estimated seven million annual claims.

Out of the West came the corporate troubleshooter, Jack Canady. In the East, Doyle promoted Bud Drutz to vice president of the newly created Social Services Division and charged him with getting the technical performance back on track. Cannady, Drutz, and other key people took up semipermanent residence in Tallahassee. The team restructured the organization, replaced project personnel, revised procedures, had the software rebuilt, corrected the hardware bottleneck, and cemented relations with the medical providers. It took some months to turn things around but, once again, SDC had successfully stepped up to its commitments.

Soon the company was processing more than twelve million claims and disbursing 400 million dollars annually to providers. From the customer's standpoint, the contract was more than paying for itself: in 1978 alone, SDC's system denied payment of $26 million in incorrect claims, prompting a senior HEW administrator to report, "The system is working and working well in the state of Florida."

Shortly afterward, Mueller and Skaggs appointed Jack Cannady corporate vice president for Management Operations, chartered to provide a new corporate check-and-balance function by conducting operational audits, or in-depth analyses, of major contracts and proposals, with emphasis on minimizing potential risks. Cannady would be assembling a select staff of experienced SDC managers, whose program reviews, including recommended solutions to perceived problems, would be provided to the responsible line organization for action, to corporate management for information, to the board of directors as an independent status report, and to the external auditors as an input to their own audits.

Almost as gratifying to Cannady as his new corporate role was a personally delivered award from Ed Doyle of his organization's highest distinction for meritorious service—"The Order of the Buzzard."

THE COMMERCIAL LEARNING CURVE

By the mid-1970s, the seeds of commercial business sown in prior years had sprung to full growth. While a few early bloomers would require special cultivation, the bulk of the harvest had sprouted into hardy perennials on the corporate landscape.

A CROP OF WINNERS

Among the successful enterprises were the two Chicago-based subsidiaries, AID and May & Speh. Respected businesses of long standing and solid reputation, their sales and income continued to grow after their acquisition by SDC in 1974. The only disappointment was a failure to achieve a synergy between their operations and SDC's. For the most part, they remained self-standing entities, neither contributing to nor benefiting from the parent's mainstream technologies.

Mueller's assessment that on-line transaction services would become a popular business was paying off for SDC. SDC Search Service had added new bibliographic data bases for almost every letter of the alphabet: in agriculture, business, commodities, data processing, education, foods, geology—on through petroleum, transportation, and zoology. In 1974, the Electronic Maildrop service was added, enabling a growing clientele to mail-order entire articles of interest with a simple computer command.

The following year, 1975, was one of breakthrough as SDC Search Service obtained exclusive rights to Derwent's World Patent Index, a very popular data base. That year the service became international, providing on-line access from Canada and Western Europe, followed by South Africa, Australia, and Singapore. The Information Industry Association honored SDC Search Service with its 1975 Product of the Year Award "for its usefulness, innovation, and responsiveness to the information needs of a changing society."

With the departure of Carlos Cuadra, an early proponent and first manager of SDC Search Service, Thomas F. Collins was named its director in 1978.

The Claims Administration System (CAS), under the management of Arthur L. Slotkin, likewise achieved a marketing momentum that had attracted more than twenty clients by 1978, typically large employers like Safeway Stores, Security Pacific Bank, General Tire Corporation, and Weyerhaeuser Company. These and other organizations chose to automate the processing of medical claims for their employees by subscribing to SDC's on-line service or purchasing or leasing CAS for internal use. In either case, CAS work stations—video terminals permitting rapid input and verification of claims as well as computerized printing of checks and transaction records—became a familiar sight in the personnel offices of many U.S. organizations. Advertised as "the most versatile claims administration system," CAS was processing medical and dental insurance claims for more than two million employees and dependents nationwide.

Another consistent revenue producer was SDC's Santa Monica Computer Center. In October 1977, to accommodate a growing volume of internal and external users, SDC replaced the center's IBM 370/158 computer with one of the first Amdahl 470V/5 machines of several times the processing power, and periodically upgraded that computer with more powerful models. In the 1977 machine swap, the corporation disposed of its two-year-old IBM machine at an $800,000 profit. As recalled by Nicholas J. Corritori, then computer center manager, "We watched the market for the 370/158 carefully and sold at the high point. Two weeks later, IBM announced a new series and the price of the machine dropped by half a million."

While these and other commercial operations registered excellent growth, two enterprises followed less clearcut paths. In both electronic banking and newspaper automation, SDC found itself embarked on ventures that appeared to be ahead of their time, enjoyed early marketing success followed by production problems, and required concentrated rescue efforts before the problems were overcome.

AHEAD OF THE CHECKLESS SOCIETY

SDC's announcement in 1976 of a contract to "develop the most sophisticated electronic funds transfer system (EFTS) ever undertaken in the United States" climaxed a two-year R&D investment in electronic banking. The contract, with a consortium of California savings and loan institutions, called for a sophisticated electronic funds switching network. Comprising a statewide complex of computer and banking hardware and a distributed software network, SDC-EFTS would enable thousands of Californians to become the vanguard of the "checkless society," paying for purchases through terminals in stores and handling most other financial transactions by placing plastic cards in automatic teller machines located throughout metropolitan centers.

In the middle 1970s, EFTS was hailed as the wave of the future by a financial community fearful that the rolling snowball of paper would shortly bury bank operations under an avalanche. The load of twenty-seven billion checks written in 1976 was projected to swell to forty-two billion by 1980. Electronic funds transfer was widely supported as a viable, perhaps the only, alternative to fast-obsolescing manual or semi-automated operations. EFTS could save clerical time and costs for financial institutions, protect merchants through automatic credit verification, and expedite the general ebb and flow of the public's cash.

In conjunction with the EFTS contract, SDC had sought to expand its market in financial systems through closer relationships with commercial banks and thrift institutions (savings banks and S&Ls). Some twenty-five banks were already subscribing to SDC's financial investment services acquired with the IDC purchase. Also, SDC was marketing a multibank teller system that combined several teller functions into a minicomputer-based network of on-line terminals.

In February 1976, as the EFTS work got under way, SDC found an opportunity to extend its bank services to the East Coast with the purchase of Moll Associates, a financial data processing firm of eighty employees. Moll operated data centers in Boston and Cape Cod, Massachusetts, and on Long Island, New York, processing the financial paperwork of twenty-six banks and thrift institutions.

An anticipated lag in Moll's business volume dictated a lean operation until more substantial prospects materialized. That turning point appeared to come in late 1976 when the Cape Cod Network of thrift institutions selected SDC-Moll to implement a large system for automated cash dispensing. An award for an even more sophisticated thrift service network for major New York banks followed in 1977.

It swiftly became apparent that the vendor software that Moll had obtained as the major building block of the new on-line thrift services required massive retailoring affecting eleven hundred application programs. An additional computer was acquired to support the army of programmers attacking the software.

In the meantime, EFTS in general, and SDC's project in particular, had encountered three kinds of obstacles: legal, attitudinal, and technical. The legislation required to authorize full-scale electronic banking was stalled in various state and federal committees. Several trial EFTS installations were failing because of slow public acceptance of plastic-card banking. These setbacks caused SDC's current and potential customers to lose confidence and interest in EFTS as a near-term solution.

Technically, SDC's EFTS provided a battery of tough design problems. The system required the integration of advanced computer and financial system hardware with state-of-the-art software that would perform complex message switching, system-wide settlement of transactions, verification of audit trails, teller-machine support, around-the-clock "hot backup," and cryptographic protection of sensitive data. The schedule began to slip.

In September 1977, Robert K. Floyd, vice president for Business Operations in SDC Systems, was brought in to smooth the troubled waters of Financial Services. It took nearly two years to stabilize operations and meet SDC commitments. By 1979, the New York and Boston data centers of SDC-Moll were closed, the Long Island center was sold, and the company's EFTS was acquired by a commercial service bureau for future use by S&Ls.

Floyd, who would later become vice president for Commercial Services, reflected on the experience. "What at first seemed a cohesive grouping of financial services turned out to be a variety of businesses, each with a different market. Around this time, the big banks were getting into financial data processing, giving the service away to smaller banks in return for quid pro quos, thereby squeezing commercial suppliers like Moll. EFTS was simply ahead of its time, with a high fixed cost and no ready market."

THE NEWSPAPER TIGER

By 1978, more than ten million people were reading daily newspapers produced with SDC's Text II electronic publishing system. In six years of Text II system usage by over thirty newspapers, not one had ever missed an edition because of a failure of SDC's automated newspaper system. Therefore, when some international papers alleged that SDC was to blame for shutting down the venerable 197-year-old London *Times* on November 30, 1978, their uninformed interpretation of events added insult to an already injurious situation.

The facts were that a lengthy history of labor disputes and work stoppages had prompted *Times* management to suspend publication indefinitely. The future automation of the *Times'* production, in the form of a Text II system ordered some eighteen months earlier, was only one of many disputed issues. Nor were the system's qualifications in question. Quoting a November 1978 issue of the *Times* itself: "The system will in many ways be one of the best in the world."

Following its introduction back in 1972, the Text II product had registered an almost immediate sale to Tucson Newspapers, followed by an order from the *San Gabriel Valley Tribune.* SDC confidently foresaw a wide-open market for its comprehensive automated publishing system. However, the close-knit and conservative newspaper community took a "wait-and-see" approach. Not until the two installed systems had proven themselves in long-term operation marked by efficient and dependable production, positive employee acceptance, and sufficient cost savings to have repaid their costs within a short period, did other newspapers step up to the counter.

The next contract, for two Salt Lake City papers in January 1975, came a full two years after the San Gabriel order. Six months afterward, SDC won a contract to automate the *Des Moines Register and Tribune.* Then came the deluge!

In the eighteen months from December 1975 to June 1977, SDC received fifteen orders for Text II systems. "For a long time, despite intense competition, we could not seem to lose a proposal," states senior staff member Carl R. "Dick" Blancett.

The new customers were far from homogeneous in size, requirements, or geographic location. They ranged from smaller papers, like Florida's *Gainesville Sun* with 35,000 subscribers, to the nation's largest, like the *Philadelphia Inquirer* and *Daily News*, with a circulation of 650,000. Their requirements varied from the 48-terminal system of California's *Modesto Bee* to the 250 terminals needed for the *St. Louis Post-Dispatch* and *Globe-Democrat*.

Geographically, they represented the heartland of America, from the *Detroit News* to the *Pasadena Star;* the expanses of Canada in the *Toronto Globe and Mail, Hamilton Spectator, Windsor Star,* and *Calgary Herald;* and the capitals of Europe, from Helsinki's *Sanomat* to the prestigious *Times* of London with its two million readers.

Had the diversity been limited to the size and terminal requirements of each newspaper, production could have proceeded according to plan. Unfortunately, a variety of special features had been promised to each customer, yielding fifteen separate customized systems. "We thought we were selling a standard product," says Mueller. "By the time we recognized we weren't, the damage was done."

Some customization was anticipated. The papers owned various optical character readers for text input, and various electronic phototypesetters for printed output, with which the Text II system was prepared to interface. Beyond these expected variations, SDC's customer representatives had also accepted many requests for new and different features that each paper simply "had to have": special ways of pricing and displaying ads, of keying text, of designing the printed page. Each change was relatively small; each could be justified as an attractive feature for future customers; each required only moderate redesign. But in their totality they produced a welter of dissimilar systems. Says Jim Skaggs, "By having to build separate systems, we were unable to take advantage of the learning curve on a standard product."

This, then, was the situation facing SDC in 1976 and 1977: an inundation of new orders for fifteen customized systems, the need to rapidly train large numbers of additional designers and programmers in the sophisticated Text II technology, and the pressure to meet contractual commitments that individually appeared reasonable but collectively proved difficult. Despite a work force that rapidly built up to 160 people, the project could not untangle itself from a mass of competing obligations. As deliveries lagged, a Text II user group of customers, formed in 1976, began to grow concerned.

When the situation became critical in June 1977, Mueller and Skaggs brought in Elijah V. "Trip" Triplett, a veteran Cordura and SDC manager, to take over SDC's Electronic Publishing Systems Department, with Gregory J. Peel, previously the assistant treasurer, assigned to manage its finances. To prevent any further deterioration in deliveries, Triplett stopped all marketing for additional systems. Each current system was analyzed in depth, and contracts were renegotiated to get customers operational as quickly as possible with a basic capability that excluded frills.

"We did our utmost to maintain customer goodwill," says Triplett. "In April 1978, the publisher of the *Sacramento Bee* called to say that a labor problem threatened the next day's production of classified advertising. I had an SDC team fly up with an untested classified ads module, which they installed and checked out overnight. The next day the paper was producing computerized classified ads."

The SDC Software Factory techniques, refined on major defense and space programs, were extended to the Text II system in 1978. Eighteen different executive programs were standardized to two. All systems were delivered within their revised schedules. All but one were operational, producing some thirty newspapers throughout the world.

The exception was the *Times* of London, which resumed publication in November 1979. A checked-out Text II system had been accepted and paid for but remained unused because of labor unrest. Eleven months later, in October 1980, the *Times* announced that continuing losses and strikes had forced a decision to sell the newspaper or shut it down. Discussions with the eventual buyer of the *Times* indicated a positive interest in using the Text II system.

AFTERMATH

In the drama inherent in such uphill struggles as SDC faced in electronic banking and newspaper automation, it is possible to overlook the mass of solid successes in scores of equally challenging programs—completed according to plans and budgets—in command-control, space, meteorology, energy, mission support services, civil systems, transaction services, and research and development. Whatever technical or managerial problems arose, they were eventually overcome. SDC was fortunate among its peer organizations in not having experienced the major technical disaster of being unable to deliver a capability to which it had committed itself.

In recognition of the growing complexity of SDC's operations, George Mueller promoted Jim Skaggs to executive vice president "responsible for the day-to-day operations of the corporation" in June 1977. Skaggs would also continue as president of SDC Systems until a replacement was found. Having decentralized SDC Systems into five operating divisions, all tracking an upward course, Skaggs dove into corporate problems, working closely with Mueller toward their resolution.

GLOBAL INVOLVEMENTS

The formation of three international joint venture companies, followed by the acquisition of a large Canadian subsidiary, profoundly changed SDC's foreign operations in the middle 1970s.

The three foreign ventures in which SDC held a one-third minority interest had been formed within a five-month span in the winter of 1972-1973. By 1976, their fortunes had diverged into separate destinies.

At their formation, dSE had seventy employees, SDC Japan fifty, and ERIA Systems only two—a Spanish manager and an SDC marketer. The two larger companies employed their personnel in conventional data processing assignments for in-country clients. The overriding goal for each partnership was the injection of systems business into this milieu, thereby developing an indigenous work force trained in advanced systems and capable of conducting high-technology projects in the future.

The model worked to perfection in Japan. After a series of small defense and industry awards on which SDC worked closely with its partner, the team won a multimillion-dollar contract from the National Space Development Agency to furnish integration and software support for the ground system of Japan's new space program.

This contract, pivotal to the successful growth of SDC Japan, exemplified SDC's emphasis on technology transfer. "At first there were thirty Americans and five Japanese working in Japan for NASDA," says Donald Biggar. "Over time, we methodically phased in more and more SDC Japan people, to the point where only one SDC professional worked on the contract in 1980."

Under the leadership of Mikito Kono, who became its president in 1979, a profitable SDC Japan won other system procurements from government and industry and became an in-country partner for SDC Search Service.

Considering its small initial size, ERIA Systems' success in capturing a half-million-dollar air traffic design study for the Spanish Air Ministry in 1975 was a notable feat. However, a series of technical and political considerations kept delaying the government's decision to implement the SDC-ERIA Systems air-space design. After completing a difficult automation project for a Spanish automobile manufacturer, ERIA Systems, lacking the critical mass of personnel to bid on large programs, slowed to a low level of activity.

As a wave of economic recession engulfed Europe in 1973, the commercial clients of SDC's German partnership, dSE, shelved their software projects or completed them internally, idling nearly half of dSE's seventy employees. Laying these people off, even temporarily, was no simple matter, as German law mandated termination pay of anywhere from three to twelve months of salary, depending on length of service.

The major determinant of dSE's future was a large procurement for design of a German air traffic control system, which the SDC-dSE team appeared to have captured in late 1973. Subsequent contract negotiations dragged on over a year, as the customer's procurement office, in its first exposure to expatriate compensation, could find nothing in German procurement regulations to justify reimbursing SDC for the sizable costs of relocating its employees and their families to Germany. When these overseas allowances, which were standard for SDC and American industry in general, were finally negotiated, a new complication arose. The project manager originally proposed by SDC, and highly regarded by the German customer, was now—some eighteen months later— unavailable for overriding personal reasons. Despite SDC's offers of other well qualified managers, the customer was unappeasable and broke off negotiations. Some months later, dSE closed its doors for the last time.

Aquila BST (1974) Ltd., the Canadian subsidiary acquired in the Cordura purchase of 1974, presented yet another story. This 300-person data processing company in Montreal had been incurring small losses, owing in part to its earlier entry into the already saturated Canadian market of computerized typesetting. SDC's objective of selling a two-thirds interest in Aquila to Canadian partners—thereby recasting the company into SDC's foreign joint venture mold—would also be frustrated by unexpected political and economic developments.

When the Parti Québécois, with its uncompromising charter of divorcing Quebec Province from the rest of Canada, scored a dramatic electoral upset in 1976, ensuing legislation favoring French-Canadian interests, and the spectre of a referendum on separation from the rest of Canada, created a climate of uncertainty and "Anglo flight" from Quebec. The city of Montreal was hurting financially from huge deficits on the 1976 Olympics. Aquila's computer center, despite having loyal customers in the Justice Ministry and the Montreal Stock Exchange, began to suffer as competitors acquired an overabundance of hardware and began underpricing to fill idle machine capacity. Finally, with no arm of the Canadian government funding large-scale systems, the opportunities for transfer of SDC technology were sparse.

Given these conditions, and despite many exploratory discussions, finding local partners for Aquila proved infeasible, leaving SDC with the burden of managing a problematic foreign operation alone.

Aquila also brought its share of welcome news: sales of the

Text II system to four Canadian newspapers, a long-term development contract for a display system for the Ontario Hydro Power Commission, a moderately thriving Canadian SDC Search Service venture, and development of a much-acclaimed automated sports results system used at the Montreal Olympics and subsequently resold by Aquila for the 1980 Olympics in Moscow.

When SDC sold the Canadian subsidiary in 1979, the resultant capital loss offset other corporate capital gains, so that the saving of corporate income taxes compensated for the major share of Aquila's deficit.

As some of SDC's overseas holdings phased down, others of different form sprang up. Like many U.S. companies, SDC had mounted an Iranian marketing campaign in 1974 that came within a hair's breadth of capturing a long-term award. The target was a $60 million command-control system for the Imperial Iranian Gendarmerie or state police. As described by the SDC marketer, "Within a half hour before signing the procurement, all the key officials left Iran for their lunar holidays. When they returned, the requirements had changed completely, and our team was recalled to Santa Monica." Considering the substantial losses of other American companies in revolutionized Iran, SDC's near miss was a veiled blessing.

The company's long-standing role in training and command-control in support of America's allies was continuing to place SDCers all around the globe. Several had to beat a hasty retreat, however, as overheated world conditions threatened their safety. SDC's advisor to South Vietnam's Air Force, Donald D. Newhouse, fled Saigon just ahead of a Viet Cong invasion in April 1975. In January 1979, SDC's training consultant to the Imperial Iranian Air Force, Charles H. Rowan, caught the last plane out of Teheran after the Shah's regime had fallen.

On the European continent, after the shutdown of dSE, the corporation entered into a series of sizable contracts directly with the German government and with major German companies working for the government. SDC personnel helped to develop the German Air Defense Ground Environment, Army Artillery Experimental, Air Force Command and Control, and Army Command and Control systems.

The successful Morocco Air Defense System, for which SDC had supported Westinghouse, became a model for proposals and contracts for similar international systems. Rounding out the company's foreign interests through 1978 were SDC Search Service and the STARDYNE system, which between them carried SDC technology to forty countries.

Learning from both its overseas successes and its misadventures, SDC would expand its international business in the following years, and foreign contracts would contribute increasingly to corporate sales and profits.

RESEARCH & DEVELOPMENT IN THE SEVENTIES

Under the stimulus of Dr. Mueller's restless search for technological leverage in solving the major problems facing the information systems industry and its customers, SDC's research and development programs shifted, consolidated, and grew in the 1970s.

Mueller's original vision for R&D had four cornerstones. First, as an advocate of disciplined engineering, he believed there must be a better way to produce software than the individual artisan approach he saw within the industry. Second, he was convinced that SDC must become proficient in hardware technology if it was to succeed in the systems and products markets. Third, he deemed it essential for the company to expand its proven strengths by continuing research in security, networks, and user-oriented man-machine interfaces. Finally, he maintained that current approaches to data management were needlessly constrained by the underlying computer architecture and that someone—preferably SDC—must crack the current mold.

"The truth is," said Mueller in an address to the American Institute of Industrial Engineers in 1976, "today's computers are wonderfully efficient at performing complex mathematical calculations—but they are woefully deficient at all those storing, sorting, and fetching operations that are involved in data base management. However, these mundane tasks constitute ninety percent of what we ask computers to do today. In other words, the computer industry has gone through three generations of development to perfect machines optimized for ten percent of the workload."

In December 1973, Benjamin G. Walker, whom Mueller had known as vice president of Space General Corporation and who had more than twenty years of experience in electronic systems engineering, was named SDC vice president and general manager of the Research and Development Division. In short order, Walker was overseeing a number of key technology areas in the division's research program: software engineering, information and data management, system security—an area in which SDC was becoming a national leader—and its outgrowth, network design. By the mid-1970s, several hardware development programs were in place, in the form of an encryption device and a sophisticated information management system.

ENGINEERED SOFTWARE

Over the years, SDC had amassed a storehouse of technology to simplify and optimize the job of programming large systems. However, these tools, developed individually over time, could not be readily integrated to embody Mueller's concept of a streamlined approach to the manufacture of software.

In the fall of 1972, Mueller established a Software Development Department in the R&D Division. Terry D. Court, a senior project manager experienced in compilers and operating systems, was transferred from Government Systems as manager for software development. Court would lead a handpicked team of programming specialists in an R&D effort to build The Software Factory system for use throughout the corporation.

"Many of the tools that had been developed," Court says, "useful as they had been for specific tasks, could not be upgraded to serve as general-purpose tools. Even CWIC, one of our most ambitious tools at that time, was limited to producing compilers for IBM 360 computers. But where the specific tools could not be generally applied, the technology and discipline that had produced them could."

Court points out that most of the tools that had been developed, at SDC and elsewhere, focused on program coding and checkout—essential tasks, but consuming at most 25 percent of the total cost of a software system. Few tools supported the remaining 75 percent of the job—requirements analysis, design specification and verification, project management, and documentation. "The best promise for containing software costs," Court adds, "lay in a methodology that would bring the entire development process under control."

Throughout 1973 and 1974, the Software Development group implemented, in a prototype system, a set of programs for cost estimation, project control, program documentation, and program code testing. In May 1975, an article describing The Software Factory management system, co-authored by Court and his research leader, Harvey Bratman, was published in *Computer,* an international journal for computer system designers and managers.

This public notice of SDC's commitment to establish a discipline of orderly software development attracted wide attention, and the Software Development team was soon briefing potential customers and teammates on the factory concept. In 1976, when SDC management determined that the time had come to implement the factory in the SDC Systems organization, these R&D products contributed to its successful installation.

FRIENDLY MACHINES

By the early 1970s, SDC's growing family of user-interface technologies included the English-like commands in the ADEPT system, an electronic tablet that recognized and parsed printed mathematical equations, and the emerging CONVERSE system, which used sentence parsing and logical inference rules to understand and respond to queries phrased in ordinary English.

An even more ambitious effort was under way on speech understanding by computers. ARPA's five-year speech research program, begun in 1971, brought linguists, computer scientists, and communications engineers together in a well-funded effort to build automated capabilities for understanding continuous speech from more than one speaker. As one of five participating contractors, SDC survived a midprogram evaluation in 1973. However, none of the final systems met the criteria for success by the deadline of September 1976.

States R&D director Benjamin Walker, "At that stage of hardware and software development, the problem was simply too big. We learned that it would take an impractically large computer to solve the problem. Since then, we've been applying speech technology to simpler systems. In the long run, it is paying off."

Walker refers to SDC's automated speech recognition program under Dr. Beatrice T. Oshika, which emphasized recognition of discrete speech, with deliberate short pauses between words, as well as of more difficult continuous speech.

In 1977, Mort Bernstein, who had directed the early natural-interface research, and Jeffrey A. Barnett, a leader of the speech understanding program, were funded by DoD to prepare a comprehensive survey report on "knowledge-based systems."

"These systems draw upon programmed facts and rules—analogous to human knowledge—to function as intelligent assistants to the on-line user," explains Bernstein. "SDC's working models in speech recognition and natural-language processing will form an essential part of knowledge-based systems, serving as the user's means for drawing on the logic and information stored in the computer."

The company's research in computer linguistics spawned new and simpler approaches to natural-language communication with computers. Charles H. Kellogg, the originator of CONVERSE, and John H. Burger, its chief program architect, began to address, separately, two major problems this early language processor had tried to attack simultaneously: getting computers to answer questions based on forming logical conclusions from data, and automatically translating English questions into data management query statements.

By 1978, Kellogg had developed a new system, DADM (Deductively Augmented Data Management), enabling computer programs to employ reason in data management. Under the leadership of Iris M. Kameny, a team including Burger participated in developing EUFID (End User Friendly Interface to Data Management), which enabled on-line users to communicate with the computer in a generous subset of natural English.

These prototypes formed the core of SDC's research program in optimizing man-machine communication. According to R&D department manager Harvey I. Gold, "There are two ways to bring the human and the computer into a closer, more productive partnership. One fairly common approach is to have people imitate machines and learn their languages. SDC's approach is to program the machine to model the human's thought, speech, and language."

SECURE NETWORKS

The security of classified data in a timesharing system was a built-in feature of the Advanced Development Prototype (ADEPT), designed and built by SDC for ARPA in 1968. Before ADEPT, users with different security classifications could not share a computer. To change classifications, a computer facility had to undergo the cumbersome process of being shut down, "sanitized," and then restarted under the new classification.

In 1973, a Security Systems Department was established in the R&D Division, with Clark Weissman as manager. The following year, IBM contracted with SDC to study the security properties of its VM/370 operating system, the first to permit the interposition of barriers between user programs. The study confirmed the operating system's suitability for housing a security kernel—an enforcing mechanism in the operating-system software to deny unauthorized access. Design and development of kernelized operating systems, together with formal methods for verifying their trustworthiness, became the underpinning of SDC's security research.

The corporation's growing competence in security drew the attention of government agencies planning to link computers into networks for processing classified defense and intelligence data. As in the development of secure operating systems, network designers faced the problem of verification—of formally proving that the software controlling communications over a network cannot be violated. SDC had devised a methodology for writing the specifications of a program and then proving mathematically that they are correct. By 1979, the staff had completed proofs of some two thousand lines of formal design specifications for a major computer network—one of the largest verification efforts ever attempted.

SDC had been an innovator in network technology as early as 1965, when it participated in the Lincoln TX2/SDC Q-32 network experiments that led to the creation of ARPANET, the first major experimental computer network. Between 1970 and 1974, the R&D staff designed and implemented communications protocols for ARPANET—the procedures, implemented in software, by which two or more not necessarily similar computer systems exchange information over a shared communication facility.

During the mid-1970s, SDC had a hand in the study and development of the U.S. government's major networks. These included the Prototype WWMCCS Intercomputer Network, the Automatic Data Interchange Network (Autodin), the SATIN IV upgrade to Autodin, and others in command-control, intelligence, and logistics. The R&D staff also supported security and network contracts of SDC's Washington Division, in particular the Information Sciences Department managed by Billie Rhae Pruett.

During 1974 and 1975, the network security research staff, led by David J. Kaufman, developed a hardware interface—the NCD network cryptographic device—as a safeguard to be interposed between each user and the network's nodes or terminals. The NCD device protected data by automatically coding and decoding all messages in the network, using an encryption key that was continuously changing to protect the code from unauthorized use. SDC employed the device in several network contracts, including its electronic funds transfer system.

When the government announced a competition to build a prototype communications network for highly classified data, an R&D proposal team, under Charles A. Savant, director of SDC's networking program, and Dr. Gerald D. Cole, won the contract in early 1978. SDC embarked on a three-year project to design, implement, test, and deliver a secure computer network of unprecedented sophistication.

"SDC's entry into the actual design of networks may have seemed unaccountable to some," says Savant. The point is that we believed we knew how to *secure* a network. We bridged into networks from computer system security. Developing the new class of communication protocols needed for network security was—and to an extent still remains—a black art. But in developing solutions to the problems of program verification and proof of correctness, we had already tackled problems of a similar nature and succeeded."

R&D director Walker believes that SDC's strong entry into computer networks and distributed processing is an indispensable asset to building the systems of the 1980s.

"It is estimated," Walker wrote, "that the amount of processing power in use increased a thousandfold between 1968 and 1980 and that we will see another thousandfold increase by 1990. This growth carries with it significant problems—the distribution and control of data, transition from present-day systems into the distributed systems of the near future, development of the necessary interconnection technology, and the associated interface standards and communications protocols. We have matured greatly in this area in the last five years; we will mature a great deal more in the next five."

AN OPTIMIZED DATA MACHINE

One of SDC's largest R&D efforts was a project that originated at a midwestern university, was transitioned to SDC after a chance meeting between the investigators and George Mueller, and resulted, among other outcomes, in one of the most voluminous patent applications ever approved by the U.S. Patent Office. This was the DATAVAULT information management system.

The DATAVAULT system story began in 1975 when President Mueller was chairing an advisory committee for DoD. Among its members was Edward L. "Ted" Glaser, then chairman of the Computing and Information Science Department at Case Western Reserve University in Cleveland, Ohio. Glaser, his associate Paul Pitt, and two other researchers at Case had developed techniques for an unusual information storage and retrieval system which they believed could be implemented in a combination of software and hardware to provide highly condensed and secure data storage for military, intelligence, and other sensitive information. The Glaser-Pitt team had implemented a prototype version, called "Holotropic Logic System," to which they held the technical rights jointly with the university.

Mueller, ever alert to a possible breakthrough in data management system architecture, persuaded Glaser and Pitt to come to SDC to develop their invention using SDC's resources. SDC, in turn, would purchase exclusive rights to the technology and employ the principal investigators. An agreement was reached, and Glaser and Pitt joined SDC in December 1975.

The holotropic system, renamed the DATAVAULT information system for its SDC incarnation, came with Glaser's considerable credentials. Holder of nine patents for computer hardware and software systems, he had been a long-time adviser to the artificial-intelligence and cryptographic communities. Blind since the age of eight, he had become an accomplished pianist and was renowned for feats of mental calculation that others were helpless to perform without paper and pencil.

The concept underlying the DATAVAULT system was that of a set of sophisticated algorithms, or program steps, for storing information in a highly compacted format, then retrieving it in response to free-form queries. Predicated on a unique pattern-matching approach, rather than more conventional brute-force data management technology, the system was designed to retrieve data by approximate as well as exact matches to a query. At the time of the project's inception at SDC, the algorithms were still being developed. Glaser's first task, as manager of a new Product Development Department in the R&D Division, was to build a feasibility model of the system.

The new department, secreted behind combination-lock doors to protect the proprietary technology, began operations in February 1976. During the next two years, Glaser, Pitt, and a team of computer engineers worked arduously to refine the algorithms to the point where they could be translated into electronic circuits and embedded in semiconductor chips.

At the same time, the corporate legal counsel was putting together what came to be called the "jumbo patent," a document containing over 450 pages of technical description—among the largest applications ever approved.

Pressure to commit the algorithms to hardware mounted on the R&D Division from other SDC organizations eager to assess the technology. After an independent R&D team had performed tests to verify that the techniques were logically compatible, this unique retrieval system was moved from R&D to the line structure, where its potential for SDC's business would be evaluated.

SIGNAL PROCESSING

SDC's assumption of the prime contractor role in large-scale system procurements called for expertise in the demanding new technology of processing and interpreting the signal and sensor data on which defense, intelligence, and space systems depend. Indicative of the challenge was the awesome growth in capabilities to transmit sensor data: from an average 250 characters per second in the mid-1960s to twenty million characters per second by 1981.

William B. Green, who heads the company's signal processing research, says, "Signal processing technology is crucial to the analysis of radar data, signals in missile detection and guidance systems, images from satellites, acoustic signals from undersea activities, and numerous other sources. The basic research issues we address are how best to detect and process signals embedded in noise and interference, extract useful content from incomplete and uncertain data, and discover and identify meaningful information within high-speed, high-volume data streams."

The company's need for a sophisticated approach to signal processing was met in part as early as 1972, with the acquisition of MRI, whose engineering staff infused SDC's R&D program with modern capabilities in the analysis and processing of complex waveforms. Combined with concepts in image processing, computer graphics, and speech signal analysis, these capabilities were shaped into a new R&D program in signal processing.

"The Cobra Dane system is a classic example of the role of signal processing software in large real-time systems," explains Charles Savant, who earlier directed the signal-processing program. "The system's phased-array radar and computer constantly scan particular areas of the world, looking for something to turn up in the return signals. When something does appear, the signal processing subsystem applies a series of elaborate hypotheses to the incoming signals, eliminating unpromising ones and pursuing promising ones, until it pinpoints what it is seeing. Meanwhile, new signals are constantly coming in. The amount and complexity of software required to control all of this, and at the same time communicate with other worldwide sensor-based intelligence systems, is enormous."

In 1978, based on the pioneering research of SDC Board member Frank Lehan, the R&D Division embarked on a new approach to signal processing. Called BAMPS, for Bayes and Markov Processing System, this program applies statistical estimation techniques to particularly difficult signal processing problems—in target acquisition, tracking, and communications.

"BAMPS treats all inputs as probabilities," explains Ben Walker. "This allows the system to reserve judgment as it processes ambiguous signals, waiting until enough information emerges on which to base a firm processing strategy. The BAMPS approach thus gives the system far more generality and freedom." Adds Bill Green, "Systems of the 1980s will require the demonstration of innovative signal processing capabilities. BAMPS is one example of such innovation."

A CLARITY OF PURPOSE

In the seven years from fiscal 1972 through 1978, SDC had become a different company. At the beginning of this period, a new management team had initiated a diversified action program that broke the company out of the mold of a software supplier with a dwindling market. In the following years, SDC strengthened and solidified a broad and growing business base.

Several changes in upper management took place during this period. Daniel Dudas left the company in 1977, and Robert Anderson left the following year. The latter's position as manager of the Washington Division was filled by Julian Davidson, previously deputy manager of the U.S. Ballistic Missile Defense Program and two-time winner of the Exceptional Civilian Service Award, who had joined SDC in 1976 to manage the Huntsville operation.

A prominent change came in March 1978, when Grant L. Hansen accepted the reins of the SDC Systems organization. With an executive background in industry as corporate vice president and manager of the Convair division of General Dynamics, as well as in government as assistant secretary of the Air Force for R&D, Hansen brought new dimensions of experience to the Systems Group presidency. The appointment enabled Jim Skaggs to relinquish his management of SDC's largest line organization and devote more time to corporate affairs as executive vice president.

Three SDCers were promoted to vice presidencies at the corporate level: Jack Cannady for Management Operations, Jack Munson for Software Engineering, and Jerry C. Zinser for Corporate Planning. The remaining executive staff included Gordon Binder, Finance; Marvin Franklin, Personnel; Bernard Fried, General Counsel; James Riviere, Operations; and Bobette Jones, Secretary. The executive staff was an equal mixture of the old and the new: Fried, Jones, Munson, and Zinser predated Mueller's arrival at SDC, while the other four came afterward.

The line managers were Grant Hansen for Systems Group, Ed Doyle for Services Group, Charles Alders for SDC International, and Ben Walker for R&D. A still unformed Products Group was slowly metamorphosing from a gleam in Mueller's eye to a luminous corporate glow.

In 1978, SDC's board of directors consisted of chairman George Mueller; three original 1970 members—John F. Bishop, Brooks Walker, Jr., and O. Meredith Wilson; Frank Lehan, elected in 1971; and, for a brief time, well-known industrial and government executive Roy L. Ash.

Of the two other founding directors, William Zisch, who had chaired the board until Mueller's arrival in 1971, left it in 1976 to devote full time to other interests; John Burke, also important to the early days of "new SDC," died in 1978. The corporation's long-time friend, retired Lt. General John W. O'Neill, served on the board from 1976 until his death the following year.

In terms of the vital numbers in financial reports, the years had been good. Comparing fiscal 1974 with 1978, sales had grown from $90 million to $145 million, contract awards from $100 million to $175 million, and contract backlog from $80 million to $165 million. The company was consistently improving its percentage of dollars won to dollars bid—a key indicator of marketing maturity—achieving an overall win ratio of 66 percent and a remarkable 44 percent on competitive bids, ratios that had been 50 percent and 20 percent, respectively, five years earlier. The personnel count of 4,200 was the highest since 1963.

The company's debt of $12 million in 1974, stemming from borrowings for acquisitions, was reduced to $2 million in 1977, rebounded temporarily to $10 million in 1978—a combination of interest expense, growth in receivables, and a cash payout for stock—and was completely eliminated the following year, placing SDC in a positive cash position.

On the all-important bottom line, SDC's moderate after-tax earnings curve appeared to understate the company's vitality. Another upward trend had started to build from $800,000 in 1974 to $2.7 million in 1977. But, as in the 1974 downturn, the 1978 profit dipped—to $1.6 million—as cost growths in several domestic and foreign ventures took their toll. It seemed to most SDCers and financial observers that once specific problem areas, such as the Canadian subsidiary, were cured, the company's real and much greater profit potential would be realized. That optimistic view would be borne out by strong profit growth in the following years.

Throughout this period, as stock market conditions continued to argue against a public offering, the System Development Foundation grew increasingly concerned about discharging its financial commitments. To provide some liquidity, primarily for the foundation but also for other stockholders, SDC issued a tender offer in February 1977, under which the company agreed to buy a limited number of shares at a price of $9.20. The foundation tendered some 264,000 shares, other stockholders 56,000, for a total of 320,000 shares or nearly $3 million out of the company's coffers. The foundation promptly contributed $2 million, one half of its original pledge, to the U.S. Treasury.

Dr. Mueller continued to steer the company in new hardware directions. Confident that the engineering staff had grown amply proficient in hardware integration for prime contracts like TIPI and for products like the Text II system, he shifted the R&D effort to design and test of the microcircuitry required for the new DATAVAULT technology. In another hardware move in 1976, SDC obtained exclusive rights to market Ampex Corporation's TBM II computer mass-storage system, an on-line mass-storage device based on videotape technology with a remarkable storage capacity equivalent to 150,000 computer tapes. Although a big market did not materialize, SDC's firsthand exposure to advanced mass-storage media contributed to winning several large awards.

In 1977, SDC purchased an interest in Computer Transmission Corporation (TRAN), a high-technology developer of electronic communications equipment. TRAN had manufactured the SDC-designed cryptographic device for safeguarding data in computer networks, and the two companies began working closely together. Several years later, SDC's growing in-house hardware capability would enable the company to sell its TRAN holdings at a gain.

By 1976, the corporation had achieved one of Mueller's original five-year goals: a fifty-fifty mix between DoD and non-DoD business. Apart from reducing its reliance on defense contracts, which had represented 85 percent of sales in 1971, the company had attracted important new clients in other market segments whose steady growth was to outpace DoD contract volume in subsequent years.

The recent years had been decisive in shaping SDC's future technologies and markets. The clear successes were command-control, also extended to non-DoD customers through the ECCCS police system; the nation's high-priority areas of energy, space, and meteorology; mission support services and proprietary transaction services; an arsenal of advanced capabilities in secure networks, interoperability, and signal processing; the evaluation of federal compensatory programs; Medicaid, which, after a front-end investment, became a moneymaker and harbinger of related contracts; even the Text II product line, which became profitable at lower sales volume; and The Software Factory discipline, an acknowledged contributor to many of these accomplishments.

Assured of a stable and profitable systems and services business base, President Mueller was about to rekindle his vision of a hardware-based product line for SDC, as the DATAVAULT technology was emerging from the shelter of SDC's laboratories to face the scrutiny of managerial, technical, and marketing analyses.

CHAPTER 9

The Recent Years

(1979-1981)

A NEW BLUEPRINT FOR THE FUTURE

When SDC President George Mueller was able to inform stockholders that fiscal 1979 had been the company's most successful year in sales, profits, and orders—pointing to the effective resolution of problems in Medicaid, electronic newspaper systems, and Canadian operations—and one year later announce another set of records for 1980, it was evident that SDC's virtually trouble-free contract base of $165 million in revenues was approaching the company's earnings potential. After-tax profit climbed from $1.6 million in 1978 to $3.8 million in 1979 and $7 million in 1980, a more than fourfold increase in two years. Although the profit included a capital gain from divestitures, it was achieved while substantial funds were being invested in a new product line.

By 1979, the company was once again moving in new directions. Throughout the growth years of the late 1970s, a revised strategy had emerged which formed the backbone of the long-range plan of 1978. The plan encompassed three broad objectives. In the systems area, the goal was to obtain increasingly larger prime contracts in SDC's established competencies of command-control, space, and energy. In services, the variety of enterprises would be pared to three mainstream lines of business—mission support services, transaction services, and benefits processing services—implying disengagement from a number of smaller, more diverse activities. A new products plan, for the third objective of bringing a volume-produced product line to the marketplace, formed a logical extension of SDC's systems and services traditions.

Other corporate goals were continuation of a vigorous R&D program, strengthening of the training and evaluation capabilities, companywide emphasis on asset and cash management, and continued decentralization into autonomous profit centers.

In keeping with the tripartite business plan, management had consolidated operations into three major profit centers in 1978: a Systems Group under President Grant Hansen; a Services Group under President Ed Doyle; and a newly formed Products Group under President Roger W. Johnson, who had come to SDC with a broad background as a products executive in the electronics industry. The R&D Division under Vice President Benjamin Walker rounded out the major line organizations.

Another step in the decentralization process came in June 1980, with the transfer of functional organizations, such as accounting, recruiting, and materiel, from the corporate staff to the three profit centers. This move toward greater group autonomy, directed by Executive Vice President Jim Skaggs "in order to provide the operating groups with responsibility for resources to meet the growth projected in our long-range plan," took into account the distinctive needs of each group.

To accomplish its revamped business plan, the company could not simply mandate that a spate of new large system contracts flow through its doors, nor could it will a new product line into existence overnight. Both would take vigorous spadework. But management could start disposing of some of its diverse holdings, in preparation for a focused approach to its main objectives.

Several reasons underlay the divestiture plan. First, a small operation appeared to demand as much management time as a large one (more if there were problems, as often there were)—time that had to be diverted from primary objectives such as building a products business. Secondly, while some of these operations had been profitable, their potential for contributing significantly to the growth of SDC's mainstream business was limited. Finally, the proceeds from the sale of units could be utilized to finance new initiatives, in preference to borrowing during times of fluctuating interest rates.

SDC's divestiture program was remarkably successful. In the twelve months between March 1978 and March 1979, SDC sold its two Chicago subsidiaries, May & Speh and AID, as well as the Canadian-based Aquila—all acquired from Cordura in 1974—at a price exceeding what SDC had originally paid for all six Cordura units. SDC also divested a specialized Washington, D.C., department that had come with the MRI purchase. All four operations were sold to their managements. The combined selling price for these units represented 80 percent of SDC's original investment in its entire acquisition program, of which key elements, including the MRI energy and engineering staff, the NASA mission support contracts, and the Claims Administration System, remained at SDC to provide continuing synergy for corporate growth.

SDC also sold or shut down its Financial Services activity, an automated photocomposition service which had earlier been transferred to California from Canada, an electronic circuit testing service, and several other small operations. A lean and pared-down Commercial Services Division, under Vice President and General Manager Bob Floyd, was free to concentrate on developing the on-line transaction business in Claims Administration, SDC Search Service, and Automated Reinvestment Service, supported by a profitable computer facility.

VOLUME PRODUCING THE MIRACLE

"We've mastered a new kind of machine that is optimized for efficient, easy-to-use storing, sorting, and fetching of information in a data base. By hanging our software expertise on our own hardware, we'll find some real margins." Thus *Business Week* quoted George Mueller in its November 26, 1979, issue featuring SDC in "A Bold Step Into Hardware."

Mueller's pronouncement denoted that SDC had come a long way in a short time, from entertaining aspirations to enter the products market with an undefined commodity to having built a hardware prototype of a promising new product. Yet, only eighteen months earlier, in the summer of 1978, the corporate path of higher profits through volume products had been stalled at the crossroads.

First, a number of embryonic prototypes were vying for product recognition. They included a cryptographic device for safeguarding data in secure computer networks; a word processing system adapted from Text II technology and already in experimental use; and the DATAVAULT system technology with its seemingly limitless potential. The challenge of harnessing the DATAVAULT architecture for information storage and retrieval was twofold: to narrow the focus of its many suggested applications and to translate the technology from laboratory concepts to operational reality.

Ideas for "productizing" the DATAVAULT system ranged from an automated spelling correction feature on electronic typewriters to a mass-storage system for automating a library. Recognizing the need for professional advice in the specialized electronic products market, the company engaged a market research firm to appraise this wealth of opportunities. At the same time, Mueller commissioned an experienced industry executive to develop a long-range product plan for SDC.

The consultant was Roger Johnson, whose twenty-year background as electronic products executive at Memorex, Singer, and General Electric had gained him a command of all phases of product development. Working independently, the market research firm and Johnson each saw many possibilities in SDC's new information retrieval technology. Significantly, their recommendations converged in one domain—its application to the rapidly growing field of office automation.

Johnson developed the requested product plan and handed it

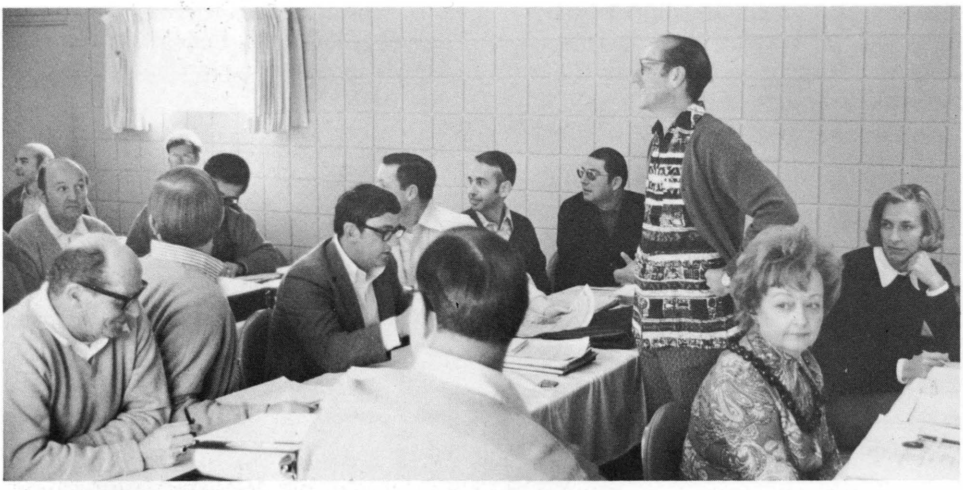
(Above) May 10, 1971: SDC Director William E. Zisch *(at microphone)* introduces SDC's new Board Chairman and President Dr. George E. Mueller *(front row, right)* to the corporation's senior personnel.

"We must expand on SDC's proven capabilities and begin to diversify," says President Mueller in his first message outlining his growth plans for SDC.

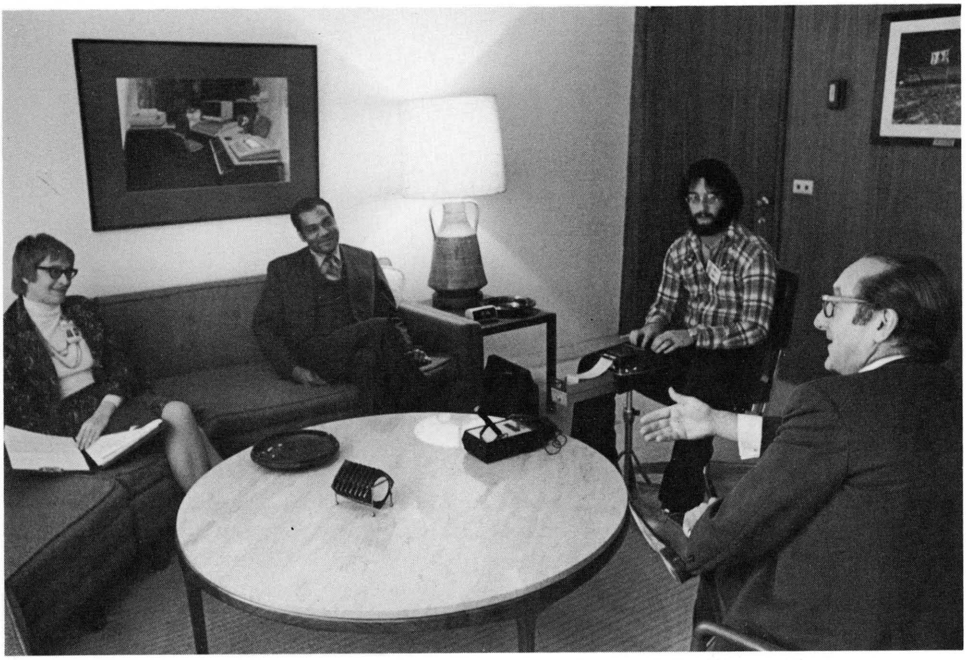
President Richard Nixon confers the National Medal of Science on SDC President George E. Mueller in June 1971 for his contributions to the success of the Apollo program.

During the 1972 SDC Open House, Dr. Mueller, assisted by Jane Long, "converses" with the computerized psychiatrist, Dr. Otto Matic, as Robert "Pete" Cooper and Dean A. Thie, Jr., observe.

President George Mueller *(left)* meets with employee-officers of SDC's Management Association to discuss corporate salary and benefit policies: *(l. to r., clockwise from Mueller)* Lorimer F. McConnell, Marlene H. Judd, J. Walter Lambertson, and Arthur L. Slotkin; *(l. to r., foreground)* Gloria Lee and Harvey Eisenberg.

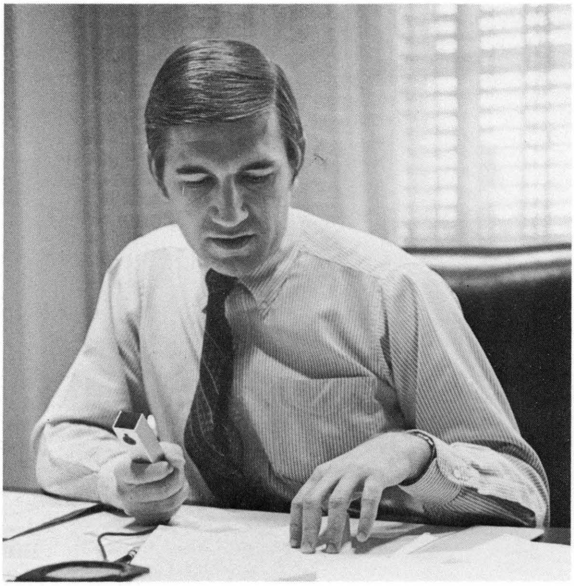


A management "offsite" meeting in 1972: George E. Mueller *(standing)*; *(front row, l. to r.)* Robert W. Hamer *(back turned)*, Anne B. Summerfield, Jane Long; *(second row, l. to r.)* Harold Willson, James B. Skaggs *(back turned)*, Roger W. Sadler, Marvin J. Franklin *(partly hidden)*, author Claude Baum, Peter W. Melitz; *(at back, clockwise from lower left)* Louis H. Gresh, George B. "Bernie" Dant, Lewis B. Barnes, and Frank S. Morris *(partly hidden)*.



SDC employees Elene B. Maginnis and Raymond B. Stewart, Jr. *(seated on couch)* exchange views with Dr. Mueller *(right)* in a "Speak Up" session recorded by stenographer for the employee newspaper. (Background picture shows SDC's prototype intelligent terminal, System/One.)

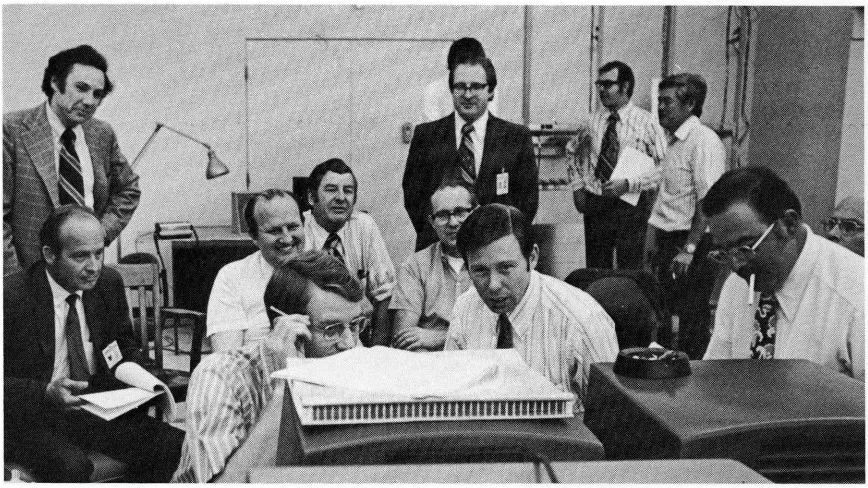
President Mueller *(left)* presents SDC's monthly achievement awards for June 1972 to Dorothy M. Johnson (for improvements in accounts receivable) and to Clarence L. Starkey (for contributions to corporate planning).



Senior Vice President James B. Skaggs broadcasts win of the NORAD Space Computational Center segment of the Cheyenne Mountain Upgrade (427M) program in December 1972.

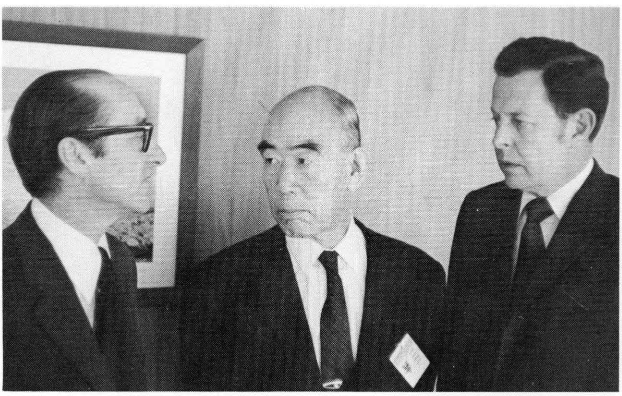
(Below) SDC delivers first display consoles on 427M in October 1974. Around console *(l. to r.)* are Space Defense Center Director Colonel T. C. Brandt, and SDC managers Paul G. Galentine and Aaron "Bud" Drutz, with other SDC and contractor personnel.

SDC built its first hardware laboratories in the early 1970s for the Los Angeles Sheriff's Communication System. *(Above)* Assemblers build wiring harnesses for the switching subsystem. Production line of communication consoles is seen below.

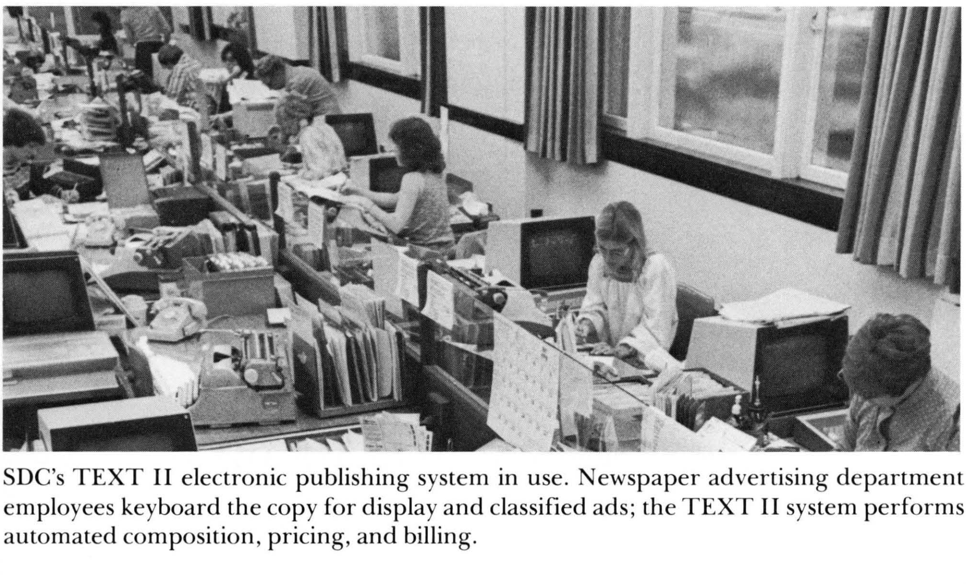


The Los Angeles Sheriff's Communication System passes a software acceptance test in May 1973 as members of the L.A. Sheriff's and Communications Departments and SDC's project team watch results on the console. Among the observers are SDC managers Fred M. Zimmerman *(standing, extreme left)* and James C. Riviere *(standing, rear center).*

Discussing their joint venture company in 1973 are SDC Japan Chairman Dr. Shigenori Hamada, distinguished scientist and chairman of Japan's Electronic Council, SDC President George Mueller *(left),* and SDC International Vice President Charles A. Alders *(right).*

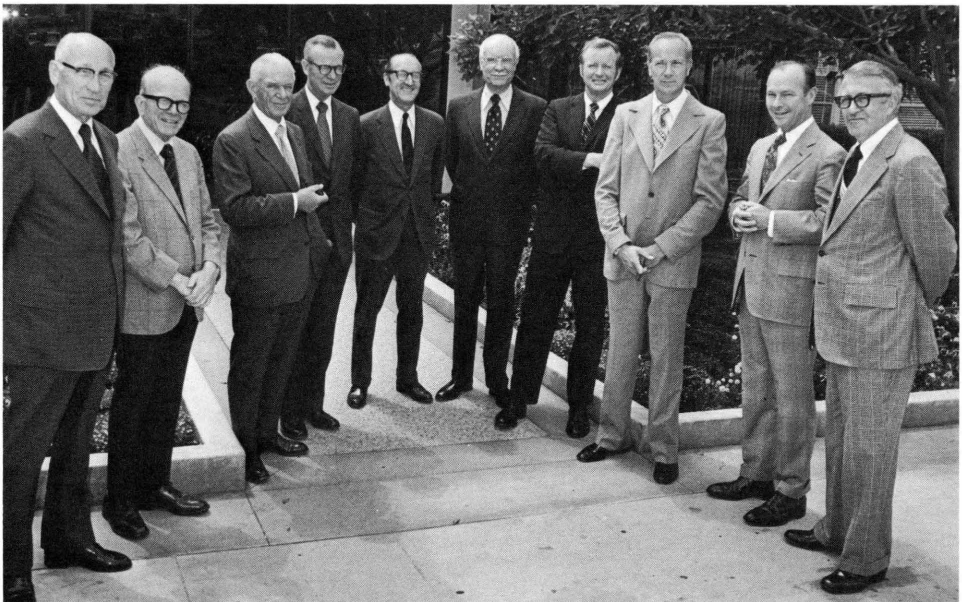


A TEXT II system demonstration, conducted by *(l. to r.)* Helen G. Simmons, Shirley A. McFerran, and Charles D. Hunter *(foreground)* is observed by *(seated, l. to r.)* Trustee Edwin Huddleson, SDC Director O. Meredith Wilson, and Trustee Arnold Beckman; *(standing, l. to r.)* Vice President Gordon M. Binder, Secretary Bobette Jones, SDC Directors William Zisch and John Bishop; *(far background)* author Baum and Albert F. Hartung.



SDC's TEXT II electronic publishing system in use. Newspaper advertising department employees keyboard the copy for display and classified ads; the TEXT II system performs automated composition, pricing, and billing.

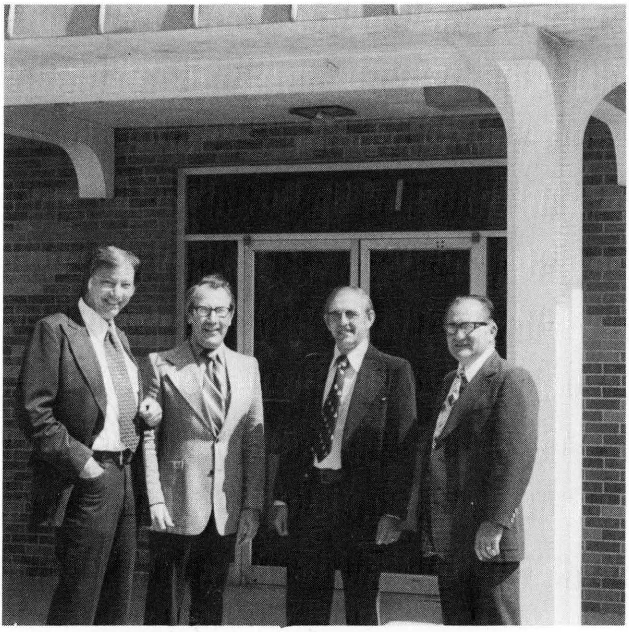
George Mueller *(left)* presents diamond-studded twenty-year service emblems in 1974 to *(l. to r.)* Patrick F. Carnes, Betty E. Prior, John P. Haverty, Robert F. Montavon, Donald B. Manning, and James P. Wong, Jr.



A joint meeting of the SDC Board of Directors and the System Development Foundation Trustees in 1974 brought together *(l. to r.):* Trustees Arnold O. Beckman, Ralph W. Tyler, Augustus B. Kinzel, Edwin E. Huddleson, Jr.; SDC Chairman and President George E. Mueller; Trustee Donald L. Putt; and Directors Brooks Walker, Jr., John J. Burke, John F. Bishop, and William E. Zisch.

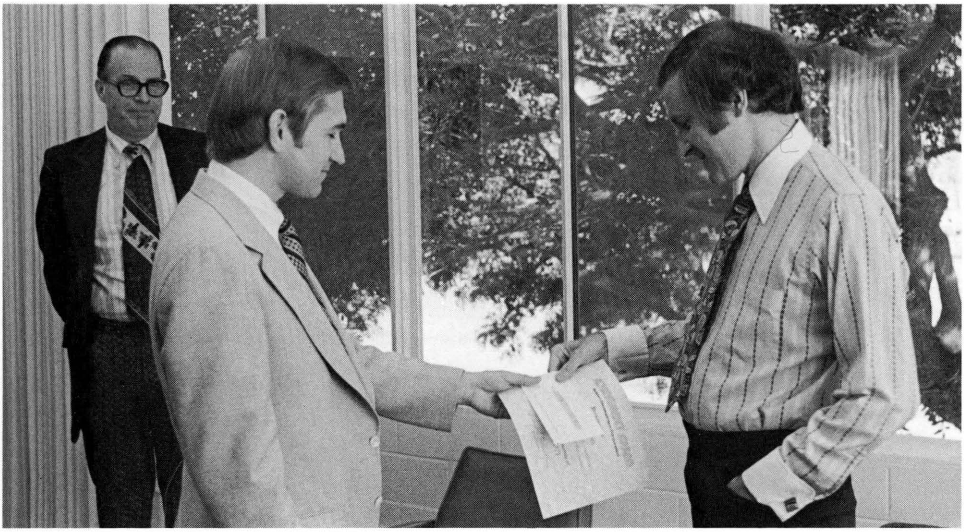
William Wilson *(right, front),* director of SDC's 80-person staff on the Alaska Pipeline Program, monitors construction of the 800-mile oil pipeline with team members.

SDC "pipeline" team gets ready to enter the World Championship Dog Sled Races at the Fur Rendezvous Festival, Anchorage, Alaska, in February 1975.



Dedicating the new SDC Services Group office in Warminster, Pennsylvania, in May 1976: *(l. to r.)* Division Vice President Frank M. Irons and senior managers John A. Crowley, Lee R. Ellis, and Joseph A. Palermo.

SDC Services Group in McLean, Virginia, welcomes its 1,000th employee in December 1977: *(l. to r.)* Daniel P. Guzowski, Fred C. Aaron, SDC Services Group President Edward J. Doyle, John A. Meehan (#1,000), and Division Vice President Bud Drutz.



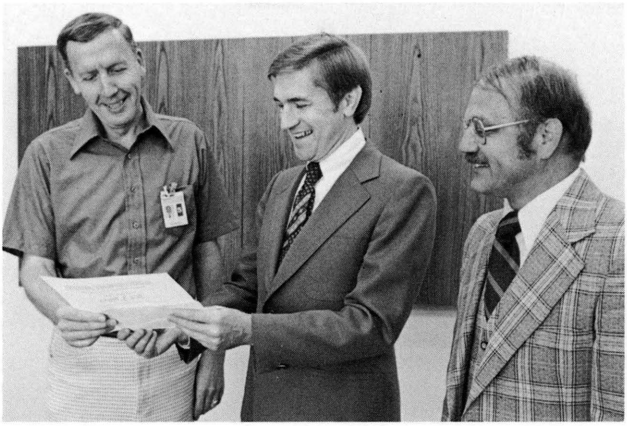
(Top) James B. Skaggs, SDC Government Systems President in 1975, presents achievement award to Allen J. Hansen *(right)* for his contribution to establishing SDC in meteorological data processing, as Ronald D. Knight offers congratulations. *(Bottom)* Celebrating the contract award for the TIROS-N satellite ground data processing system in May 1976 is the management team of *(l. to r.)* David J. Deaver, Donald A. Biggar, Robert L. McGarity, Lewis T. Zilly, Robert J. McGill, Richard E. Johnson, and Allen J. Hansen.

One-third of the more than 150 SDC participants in the winning marketing effort for TIPS (Telemetry Integrated Processing System) pose with one copy of the proposal in July 1976.

Inside the TIPS Development Center, SDC analysts and operators are working on the Cyber 173 computer and the "Quick Look Display."

"It is fitting that fiscal 1976—SDC's 20th anniversary as the oldest major systems company in America—was our best year in profits, sales, new orders, and backlog." G. E. Mueller, Chairman and President, September, 1976.

(Below) Two PEPE program managers—SDC's John A. Cornell *(left)* and Burroughs' Richard Stotler *(right, rear)*—watch a third, Joe McKay of the Army's Ballistic Missile Defense Advanced Technology Center, accept the system in December 1976, as SDC manager Julian Davidson observes at right.



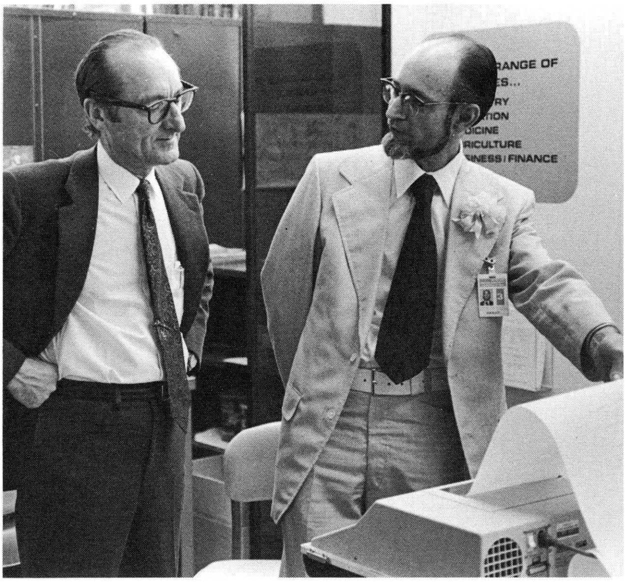
Jack A. Bendar *(left)* receives the July 1977 achievement award from Jim Skaggs for his technical contributions to SDC's airspace management programs, while Robert C. Smith shares in the occasion.

Discussing the seventeenth year of SDC support to the Air Force Satellite Control Program in 1976 are branch heads *(l. to r.)* Robert J. McGill, S. Ray Ericksen, J. Lee Tillman, program manager Gerald J. Hansen, Howard H. Kaiser, and Milton E. Winsor.

A 1978 project "kickoff" meeting on the Emergency Command Control Communications System (ECCCS) for the L.A. Police: *(clockwise, from bottom left)* SDC Systems Group President Grant L. Hansen, ECCCS project manager Herbert Saxon, ECCCS engineers Jack C. Campbell, Jack E. Wimberley, Walter J. Wiseman, and George S. Beckwith, and Division Vice President Donald A. Biggar.

SDC Systems Group senior staff share a lighter moment in summer of 1978: *(l. to r.)* Robert C. Smith, Jack C. Cannady, Robert T. Shultz, Fred Tschopp, Jr., Robert W. Hamer, and Frank S. Morris.

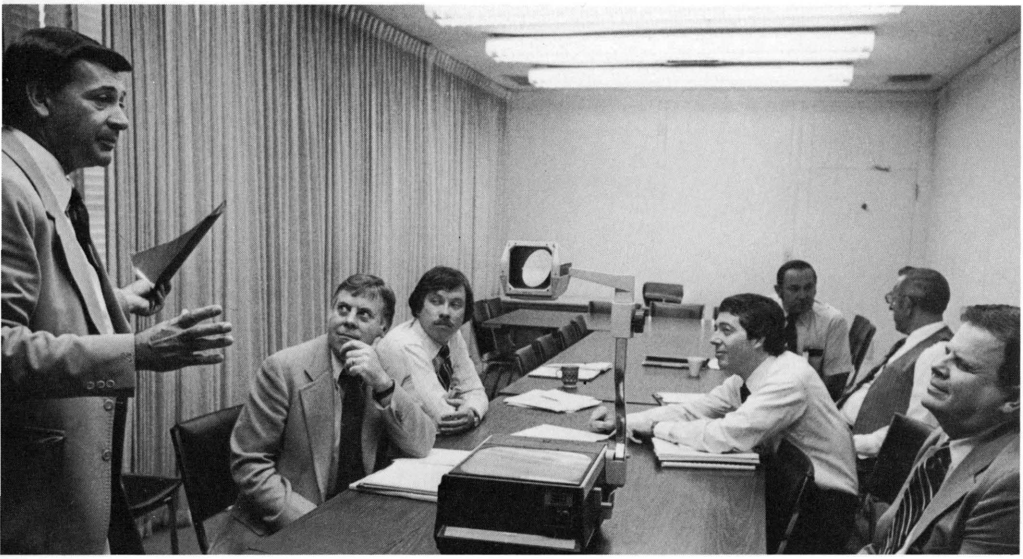
A Los Angeles Police Department patrol car equipped with components of SDC's ECCCS system is a major attraction of a November 1978 Open House. The interior of the car *(bottom photo)* shows one of the 850 ECCCS terminals used by officers for digital communication with a central computer, alleviating overcrowded voice channels.



Donald V. Black shows President Mueller one of the eighty data bases of SDC Search Service, the company's worldwide bibliographic retrieval service.

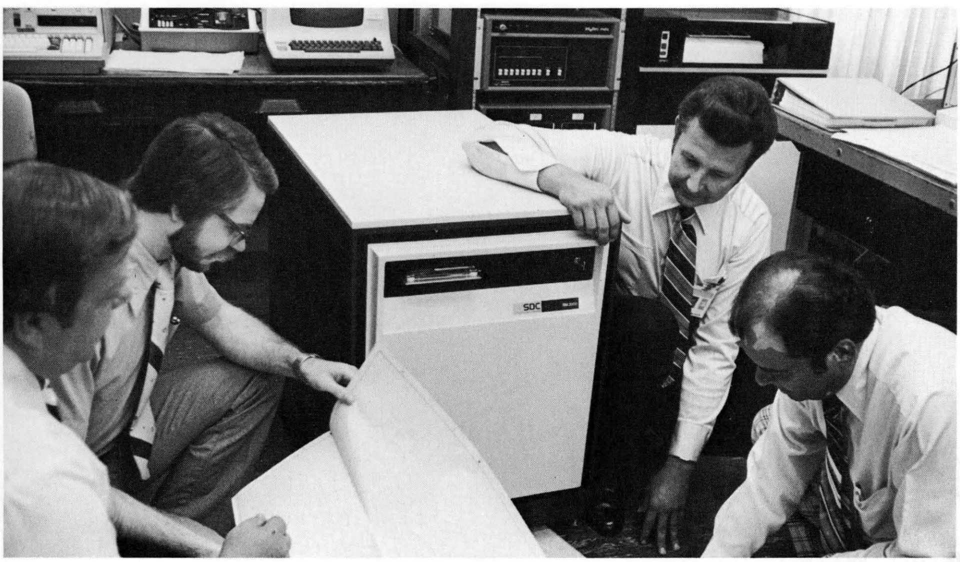
Of the rows of disk drives attached to SDC's Amdahl 470 V/7 computer, sixty are dedicated to on-line storage of SDC Search Service data bases. Project manager Thomas F. Collins *(right)* reviews requirements for 80 billion characters of storage with Richard I. Springer.

Atlantic Richfield Co. (ARCO) is one of many users of SDC Search Service. *(Above)* ARCO reference specialists Frances Bowman *(front)* and Lynn Ecklund conduct a literature search. *(Right)* Corporate Librarian Meryl Swanigan reviews the results with a corporate user.



SDC Products Group President Roger W. Johnson *(standing)* meets with his senior staff in November 1978: *(clockwise around table, from left)* J. Walter Lambertson, personnel manager; George R. Melton (SDC Services); Products Group Vice Presidents John G. Callahan, E. V. "Trip" Triplett, and Robert V. Dickinson; and Edward L. Glaser, chief technical officer.

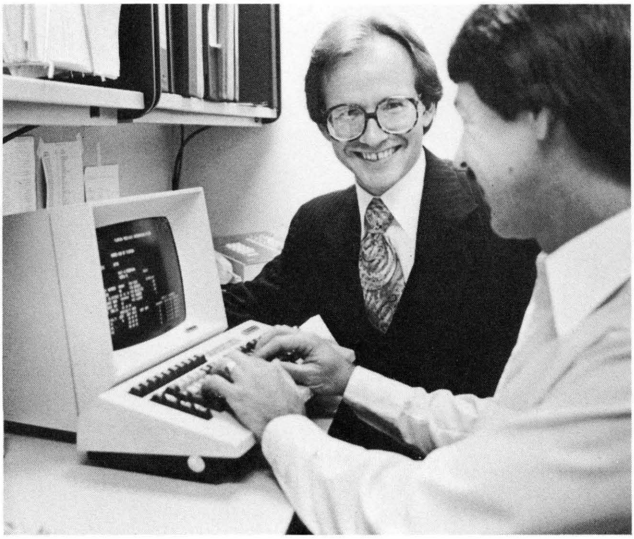
(Below) An early model of the SDC Records Manager is examined by SDC engineers *(l. to r.)* Donald L. Kueneman, James D. Hendrickson, Robert D. Fisher, and Raj K. Kapur in October 1979. *(Opposite)* SDC employee Carol L. Kalinowski is pictured with the SDC Records Manager.



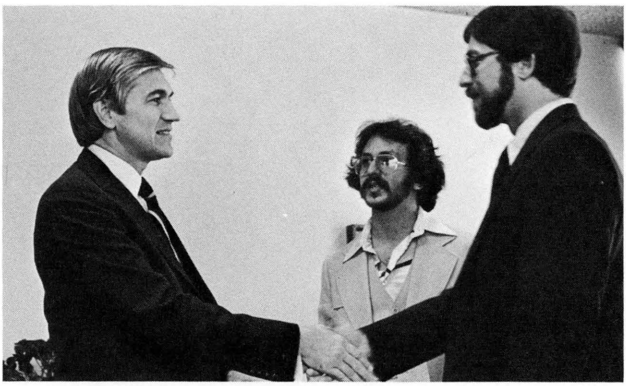
Dr. Mueller congratulates SDC's Gloria L. Grace on being named Woman of the Year (1978) in Science for Greater Los Angeles. Other SDC women honored by the YWCA that year included Judy Hamilton, Dorothy Johnson, Bobette Jones, Iris Kameny, Janice McCollum, Dolores Navarrete, Sandra Nelson, Betty Prior, Ming-Mei Wang, and Jean Wellisch.

SDC top management in 1979: *(l. to r.)* Controller J. Stanley Crum; Services Group President Edward J. Doyle; Executive Vice President James B. Skaggs; Chairman and President George E. Mueller; Vice President of Finance Gordon M. Binder; R&D Vice President Benjamin G. Walker; Systems Group President Grant L. Hansen; and Products Group President Roger W. Johnson.

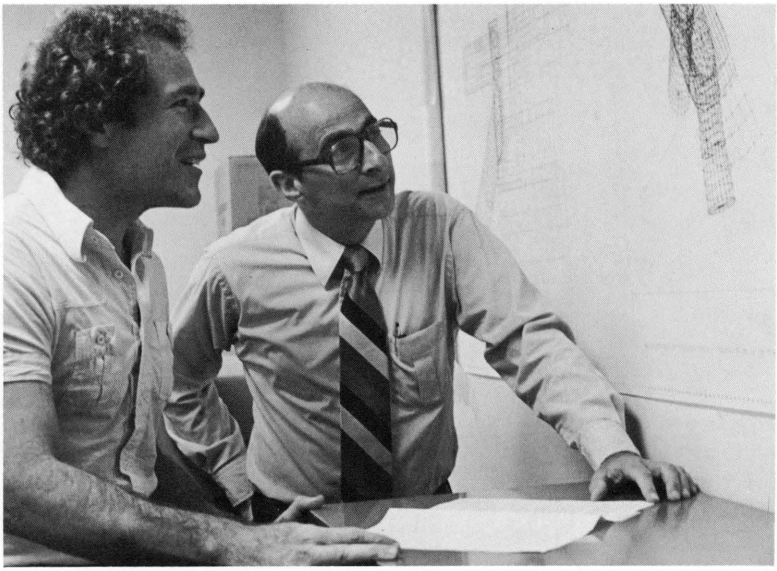
Executive Vice President James Skaggs *(left)* and Systems Group President Grant Hansen *(right)* welcome President-Elect Mikito Kono of SDC Japan in June 1979.



Helping to process a million Medicaid claims per month for the state of Florida in 1979 are two members of SDC's 180-person Tallahassee team: provider relations manager William L. Mincy and claims representative Dennis L. Leasure *(at terminal)*.

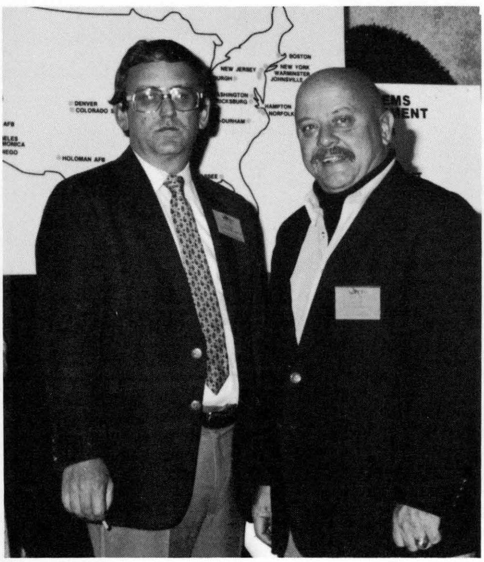


James Skaggs congratulates Thomas E. Philipp and Robert I. Karch on their achievement of converting over 500 programs in three months for the Iowa Medicaid software system.



Comparing the output of SDC's STARDYNE structural analysis system with the structure displayed on the wall are Fredric A. Cohan *(right),* Vice President in Energy and Environment, and Richard Rosen, system architect of the program.

(Below, left) Energy and Environment Vice President Roger W. Sadler *(left)* and Lee B. Gray, manager of SDC's support contract for the Gas Centrifuge Enrichment Program, represent the company at a national energy conference. *(Below, right)* SDC's Bill Freeman analyzes methods of improving power plant productivity.

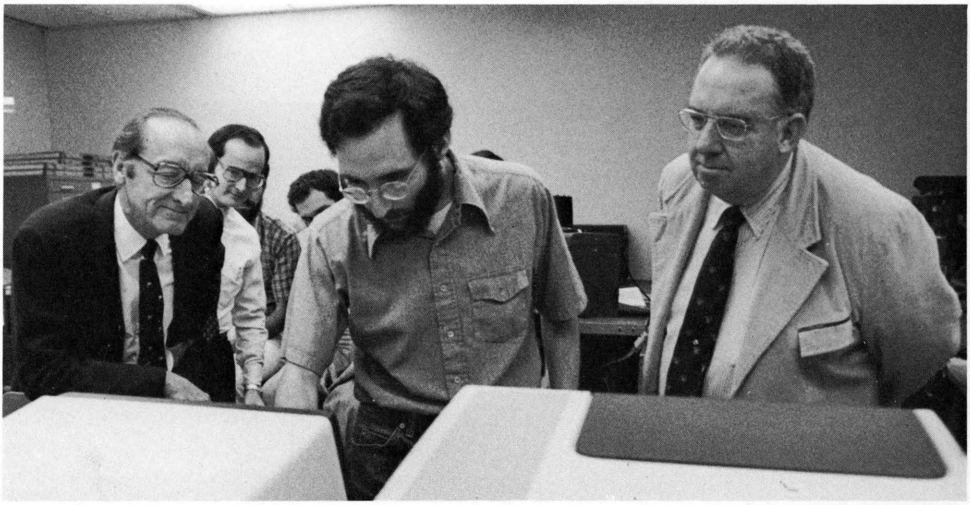


R&D Division management prepares for review of the fiscal 1981 research plan: *(l. to r.)* Clark Weissman, Chief Technologist and Deputy Division Manager; Morton I. Bernstein, Special Projects; Harvey I. Gold, Applied Research Department; Benjamin G. Walker, R&D Vice President; Charles A. Savant, Network Systems Department; and Cataldo U. "Tal" Falco, Plans and Programs.

SDC's Image Processing Laboratory in Santa Monica is a key element in corporate research and production of environmental data processing systems.

Seen through stacks of documented research results, R&D's Charles H. Kellogg, Marjorie P. Templeton, and Iris M. Kameny test SDC's EUFID natural-language processing system.

Robert R. Everett, president of Mitre Corporation *(center),* views SDC's automated speech recognition program demonstrated by Beatrice T. Oshika in March 1980. Other observers are George Mueller *(right),* Ben Walker *(left),* and Harvey Gold.



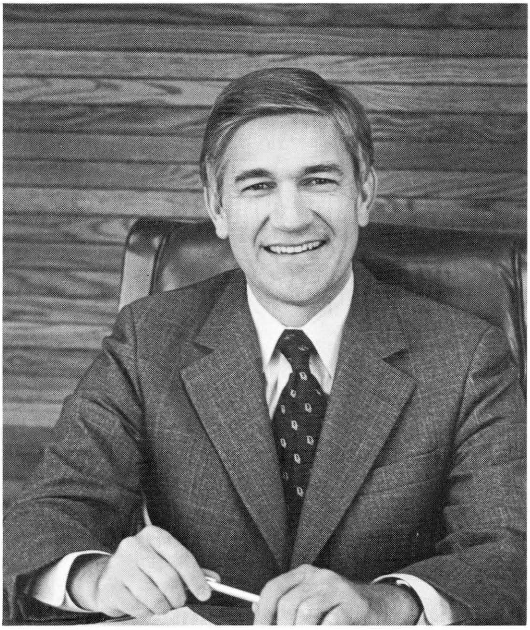
President Mueller *(left)* and SDC Board member and consultant Frank W. Lehan *(right)* view the advanced technology network being built by an R&D staff headed by Jay B. Eaglstun *(center)* and technical area manager David J. Kaufman *(behind Mueller)*.

SDC's research computing network is used for on-line programming, electronic mail, and word processing. Reviewing system usage in 1980 are R&D Manager Benjamin G. Walker, Roy O. Gates, and Henrietta Noiseux.

SDC Board of Directors approves merger with Burroughs Corporation on August 13, 1980: *(l. to r.)* Norman F. Parker, Frank W. Lehan, Bobette Jones (corporate secretary), Chairman George E. Mueller, Brooks Walker, Jr., John F. Bishop, and O. Meredith Wilson.

The merger of SDC and Burroughs is discussed in August 1980 by *(l. to r.)* SDC President George Mueller, retiring Burroughs Board Chairman Paul S. Mirabito, SDC Executive Vice President James Skaggs, and Burroughs Executive Vice President Donald E. Young.

SDC stockholders meet December 8, 1980, to approve the proposed merger into Burroughs Corporation. The gathering includes members of the company Board and Foundation *(top view, left front)* and representatives from Burroughs *(bottom view, right front)*. Portraits on walls of SDC Commons Room are of Presidents Melahn and Kappler *(top)* and Mueller *(bottom)*.



James B. Skaggs became SDC's fourth President and Chief Operating Officer on January 28, 1981. Dr. George Mueller retained the positions of Chairman and Chief Executive Officer of SDC and was elected Senior Vice President of Burroughs.

SDC's executive staff poses for an informal portrait, prior to their weekly meeting of May 18, 1981: *(starting opposite page, l. to r.)* R&D Vice President Benjamin G. Walker; Commercial Services Division Vice President Robert K. Floyd; Systems Group President Grant L. Hansen; Vice President of Personnel Marvin J. Franklin; Vice President of Finance and Administration Jack C. Cannady; SDC President James B. Skaggs; Vice President of Technical Operations John "Jack" B. Munson; Services Group President Edward J. Doyle; Vice President and General Counsel Bernard Fried; and Vice President of Planning Jerry C. Zinser.

"The Burroughs-SDC relationship is virtually a model for how an acquisition merger should work," Burroughs' Chairman and Chief Executive Officer W. Michael Blumenthal tells more than 250 members of the SDC Management Association in Santa Monica in May 1981, as he amplifies the areas of synergy between the two organizations.

"SDC is well positioned to play an important role in the coming technological revolution," states SDC Chairman and Chief Executive Officer George E. Mueller in a June 1981 forecast of the growing role of computers in all facets of society during the 1980s and beyond.

to Mueller in September 1978. The first-quarter results for fiscal 1979 validated management's projection of a strong profit year, even with a sizable investment in product development. After some weeks of top-level reviews, Mueller handed the document back to Johnson. "You planned it," he said. "Now, how about doing it?"

Recalling his reasons for accepting the challenge, Johnson reflects, "All the ingredients for success were there—an exciting new information technology, a corporate history of innovative development, a superior software capability, and a supportive management with a visionary at the helm, which is what you need if you're going to do something different."

Johnson was correct in asserting that the products area would be "something different" for the corporation. According to Skaggs, "SDC had typically developed individual, complex, forefront systems for different customers—what I've called 'building the "one-time miracle" many times.' The new product was a sharp departure. We intended to build this 'miracle' once only—then volume produce it as a standard product."

Within several months of the formation of a Products Group in October 1978, Johnson had attracted a set of experienced managers from industry to staff its key slots. Robert V. Dickinson, vice president of Engineering and Product Planning, had been director of Product Management at TRW, after a number of years as an engineering manager at Singer. John G. Callahan, named vice president of Manufacturing, brought a varied materials and factory management background gained at General Electric, Memorex, and Singer. The group's vice president of Marketing, Sales, and Service, T. Eugene Smith, counted twenty years at Texas Instruments in his broad managerial career. The controller, Nozer S. Haladwala, was previously controller of Manufacturing Operations at Memorex. The sole SDC veteran on the staff was the personnel manager, J. Walter Lambertson, who helped mediate between SDC's traditions and the new products team.

As the Products Group quickly reached one hundred people, its subgroups evidenced sharply different chemistries. There were the newcomers—hardware design and production engineers and manufacturing personnel from companies like Burroughs, CDC, and Xerox. Their software counterparts, on the other hand, were mostly long-term SDCers. A third contingent was composed of R&D personnel who had labored on the DATAVAULT system. And because the Text II system was an SDC product, the Electronic Publishing Systems Division was also moved into the new group.

Products Group personnel credit Johnson's management style for welding these diverse elements into an effective team in a short time. Described in *Business Week* as a "consummate team builder," Johnson relies on a combination of strategic guidance, delegation of authority, and close personal interaction to lead and motivate his people.

In a ten-page "strategy statement" issued two weeks after the formation of the Products Group, Johnson had captured the essence of the group's—and the corporation's—objectives in product development.

"Near-term objectives are to establish an effective organization with a winning attitude and professional management at all levels; to meet current operating commitments for revenues, profits, and cash; and to develop, obtain approval for, and implement market and product plans that position SDC in one new major segment by the end of 1980."

The strategy statement included guidance on markets, technologies, financial objectives, manufacture-or-buy alternatives, personnel policies, and other key concerns. By emphasizing goals and guidelines, and not only budgets and schedules, Johnson provided a common set of objectives for all team members, inducing the cooperation and trust essential to an interdependent development team.

Products strategy was translated into "position guides" for each manager, providing the objectives for the function being performed. Senior managers then developed guides for their subordinates, and so on down the line.

"We're not just told *what* to do," stated an engineer, "but why, and how it fits into the big picture. That approach allows me to think in terms of alternatives if I reach an impasse."

The spirit of teamwork was vital to mastering the challenges confronting the fledgling organization. A foremost corporate priority, entailing hard planning and firm action by Products personnel, was to ensure the turnaround of the Text II business—satisfying customers, rebuilding a marketing team, pushing the enterprise into the black, and locking it there.

Other Products personnel were evaluating likely products for their sales potential. After some months, they concluded that the cryptographic device invented and built by SDC, while technically an excellent security safeguard, lacked the mass market required for profitability. The company's word processor, adapted from the Text II system, also judged technically competitive, presented a problematic entry into an already crowded field. Meanwhile, several remaining potential applications of the DATAVAULT technology were being narrowed to one product line.

In addition to developing operational objectives, the group needed to establish its hardware-oriented norms amid a labor-intensive SDC culture. Products' forecast of attaining a revenue base with only 15 percent labor content was nearly the inverse of the rest of the company's ratio of labor to materiel. In virtually all areas of its operations—master scheduling, standard-cost accounting, volume discount purchasing, test marketing, electronics manufacture—the group differed from "the way things are done at SDC." A gradual process of mutual education, punctuated by some friendly elbowing, resulted in a Products Group that was largely self-sufficient, while maintaining the integrity of SDC's basic policies and blending with them.

In January 1979, the definitive product that SDC was to bring to the marketplace was christened "the SDC Records Manager." Motivated by the inventive retrieval strategies contained in the DATAVAULT system, custom-fit to the needs of a new commercial market for SDC, and capped with generous doses of the Johnson team's pragmatic approach to product planning and engineering, an "electronic filing cabinet," intended as the hub of an office information system, was about to take its place on the corporate center stage, between SDC's systems and services.

In homing in on the SDC Records Manager electronic file, the Products team had been led by the following considerations. Stimulated by the wide acceptance of word processing systems, the so-called office of the future had, in fact, already arrived, forming one of the fastest-growing segments of the information processing industry. Yet, despite major investments in word processors, copiers, printers, and other office automation hardware, office productivity had increased only slightly since 1965, in comparison with factory productivity which had nearly doubled. As confirmed by authoritative surveys, the core of the problem lay in the office-products industry's focus on the *generation* of text—not on its efficient storage for optimized information retrieval.

The SDC Records Manager appeared to provide a remarkably effective and economic solution to this dilemma. Since the system required no special identity codes for storing memoranda, letters, and reports—or for later recalling them—it offered the capability of accepting and retrieving data already generated by word processors or computers, thereby capitalizing on the customer's prior investment.

"We don't want our salespeople to make prospects feel guilty about their 'mistake' in buying word processors last year," stressed Johnson. "Instead, we want them to feel wonderful about enhancing those word processors with the SDC Records Manager."

In its ability to retrieve either documents or text through a "friendly" user interface, the product would be tailored to the so-called knowledge workers—managers or other professionals—and to their supporting clerical staffs, without need for special training.

Housing a microcomputer and disk storage unit in an attractive cabinet, and capable of being connected to as many as sixteen on-line terminals, the unit obviated investment in a separate computer or special software typically required for information retrieval.

A 1980 report on office automation by a group comprising thirty of America's leading corporations compared the SDC Records Manager with conventional retrieval systems and concluded: "For customers, the extraordinary result could be a coherent text storage and retrieval system... at a fraction of the incremental investment, since existing word processors could continue to provide input."

Beyond these advantages, SDC management believed that the product's greatest appeal lay in its open-ended retrieval strategy, enabling users to locate documents even when the subject was not precisely identified or the query contained misspellings, synonyms, or other variations of words in the stored text. One enthusiastic bank executive who ordered five systems was quoted by *Business Week:* "The Records Manager looks like the answer to our prayers. With other electronic files, the document can be lost forever if you file something incorrectly or don't make the precise query."

Validating the utility of the SDC Records Manager with prospects who had never confronted anything quite like it was not easy. "We tried to explain that the system replaces the mental associations people use in searching manual files," recalls an SDC sales manager. "If you are looking for a half-remembered letter, you just type in a request, in simple English, for 'that letter I wrote to Jones about fire insurance or accident coverage' and the system displays anything related to those facts."

Eventually, a simulated SDC Records Manager got the message across. Reactions and suggestions of both enthusiastic and skeptical prospects were fed back to the product engineers for consideration in the final design. Human factors specialists continued to simplify the user interface and the English-language query capability. While some group members were refining the product, others were identifying market segments and target cities, while a third set instituted a manufacturing discipline.

A serious challenge to this smoothly advancing operation came with the recognition that the DATAVAULT algorithms were not efficient or flexible enough for use in the SDC Records Manager. The sophisticated DATAVAULT logic for inexact retrieval was to have been embedded in two highly complex custom microcircuits; after the limitations of the algorithms were recognized, SDC abandoned that route. The unconventional structure of DATAVAULT, a hierarchy of data layers of increasing abstraction, was, in the words of an SDC engineer, "very elegant but impractical to implement at this time."

Using the DATAVAULT concepts as a starting point, a handpicked team of engineers, programmers, and linguists, headed by Robert Dickinson, charted an alternate course by creating more adaptive algorithms and combining them with a more conventional, although still novel, data structure, to arrive at the original destination: a distinctive information capability tailored to the office systems market.

Among the features in the first model were high-speed retrieval; frugality of storage through data compaction; password protection for secure files; a tutorial for new or occasional users; and three types of search capabilities: exact search, to retrieve the exact word string specified; inexact search, the most popular retrieval mode, to find information related but not identical to the search request; and relational search, which sorts the data according to numeric or alphanumeric comparisons.

By June 1980, SDC had built several hardware prototypes and preproduction units. Sales offices were being staffed in Los Angeles, Chicago, New York, and Washington. By the end of 1980, some forty position orders had been received for the SDC Records Manager—from Security Pacific Bank, ARCO, General Electric, the U.S. House of Representatives, Aetna Life Insurance, and other organizations. One customer immediately wrote a check to ensure his place in the queue.

In preparation for production, SDC leased a facility in Camarillo, fifty miles north of Los Angeles, in the fall of 1980, and also purchased land there for building a permanent plant to house four hundred people. Following a "beta test" period, during which a prototype model of the system was installed and used in a cooperating customer's facility, engineering and manufacturing operations were under way at the new site.

Corporate management had intended not only that the SDC Records Manager become a self-standing product but that the capability, along with its underlying technologies, would find its way into SDC's systems and services contracts, providing a unique "value added" ingredient for competitive leverage. Jim Skaggs expressed management's view of the synergism among SDC systems, services, and products as "a three-legged stool, with each leg reinforcing the other." As the SDC Records Manager matured during 1980, parts of the technology were already being incorporated in SDC's systems, and the five-year plan completed in January 1981 emphasized this objective.

In providing several years for the evolution of this novel office information system, from conception to production, SDC management had recognized the wisdom of spending enough time, effort, and money on a product to give it a strong chance in the marketplace. The result—the SDC Records Manager—was a unique embodiment of the corporation's classic expertise in online user-oriented information management, encased in precision hardware, and designed, manufactured, and marketed through a new products capability. Twenty-five years into its history, SDC had finally achieved the elusive goal of volume producing a "one-time miracle."

GROWTH IN SYSTEMS AND SERVICES

In stimulating growth for SDC systems and services, the new game plan was an unqualified success. Fiscal 1980 yielded a record $270 million in contract awards, a 40 percent increase over the prior year's high mark. Equally gratifying to management was the soaring proposal win rate, which showed SDC winning 68 percent of all proposal dollars bid. Moreover, in an industry in which a *competitive* win rate of 25 percent of dollars bid is considered respectable and 50 percent outstanding, SDC had won 55 percent of its competitive proposal dollars. The result was a record contract backlog, including options for future work, of $370 million, representing about two years' worth of sales—the largest and longest-term backlog in corporate history.

BIGGER SYSTEMS

Grant Hansen, president of the SDC Systems Group, attributes a good share of its marketing success to a reorganization of June 1979, in which he decentralized the group's marketing staff to report directly to the six vice presidents managing each business area. The vice presidents responsible for the six divisions at that time were: Don Biggar, Technology and Advanced Programs; Bob Carroll, Energy and Engineering; Julian Davidson, Command-Control and Washington Operations; Bob Hamer, Software Engineering; Frank Morris, Systems and Space; and a new corporate executive, Dr. Robert A. Levine, Human Systems. Another vice president, Fred Tschopp, provided financial and administrative support.

Two challenging awards came from the Air Force Weapons Laboratory at Kirtland Air Force Base in Albuquerque, New Mexico. This laboratory's mission of advanced weapons research and modeling required the largest computational capability of any Air Force center. In the fall of 1978, SDC won a competitive contract to design the laboratory's new Integrated Computational Center—a sophisticated network of supercomputers, mass-storage devices, and other processors operating under several levels of security.

With its prior experience of defining the complex computer system architecture for the two "ARCs"—the Acoustic Research Center for the Defense Advanced Research Projects Agency, and the Advanced Research Center for the Ballistic Missile Defense Advanced Technology Center—this procurement reinforced SDC's position as designer of the nation's most advanced computing complexes.

One year later, in September 1979, SDC won one of its most keenly contested and widely publicized awards—a $24.4 million contract for the Fourth Generation Advanced Computer System (FACS) program. This contract, for acquisition and integration of new supercomputers in the Air Force Weapons Laboratory, appeared to have been awarded to SDC's competitor, Control Data Corporation, after a hard-fought competition. SDC protested, first unsuccessfully to the Air Force and then to the General Accounting Office and the U.S. District Court, that CDC had not performed the required benchmark tests with an "announced commercially available computer," as specified in the request for proposal, whereas SDC had performed its test with an existing Cray-1 supercomputer.

The outcome of SDC's most determined protest, led by Vice President and General Counsel Bernard Fried and the Systems Group's Frank Morris, was heralded throughout the trade press, as exemplified by this article in *Electronic News:*

"The Air Force last week reversed its earlier award to Control Data for three Cyber 203 supercomputers and gave it to System Development Corporation, which bid Cray Research System 1 computers for a $24.4 million contract.

"A second round of bidding was forced when the General Accounting Office upheld an SDC protest charging the CDC Cyber 203 computers had not completed mandatory benchmark tests.

"The GAO agreed the Cyber 203 was still in development and had not run all the mandatory benchmark tests by the bid deadline—despite eight months extra delay given to CDC by the Air Force.

"SDC will install and integrate three Cray-1 supercomputers at the Air Force Special Weapons Center, Kirtland Air Force Base, N.M. The computers will be connected with four existing CDC computers—two Cyber 76 and two 6600 computers."

In 1980, the company won one of four coveted awards for design of the National Oceanic Satellite System (NOSS), as part of an RCA team. Supported by NASA and DoD, NOSS was intended to provide both civil and defense data on the climates of the world's oceans from a free-flying spacecraft launched from a space shuttle orbiter. SDC drew upon its experience in signal processing and satellite ground data handling to specify the processing of the large data streams expected from NOSS.

The company also intensified its international marketing. Resulting awards included design of an integrated airspace control system for Argentina, building of a meteorological data center in India, and development of software for a Japanese naval system, under subcontract to the Fujitsu Corporation.

In the energy field, SDC's experience as the quality assurance contractor for the Trans-Alaska Oil Pipeline was rewarded with a similar role for the Alaska Natural Gas Transportation System. Under a $16.5 million subcontract from Unified Industries, Inc., SDC was providing the Office of the Federal Inspector with technical, environmental, and system engineering review of the design, construction, and operation of the 4,800-mile gas pipeline.

Concurrently, SDC was capturing other awards: renewal of the longest contract in the company's history—the twenty-year-old integration and development role for the Air Force Satellite Control Facility; development of software for a Marine Corps tactical program, a paramedic communication system, and a nationwide automated flight advisory system; and new contracts in interoperability, networking, and security.

In the evaluation and training area, the corporation prepared for the retirement of Dr. Launor Carter, whose twenty-five-year career at SDC made him the longest-tenured executive, by bringing in Dr. Robert A. Levine as vice president of the Human Systems Division in the Systems Group. An economist and ex-deputy director of the Congressional Budget Office, Levine had the charter to broaden SDC's customer base in the evaluation of federal-aid programs beyond the U.S. Department of Education. The first success was a $3.5 million contract from the Department of Agriculture in which SDC determined the impact of the School Nutrition Program on the health and well-being of the nation's youth.

In June of 1980, after an intense year-long competition, SDC won by far the largest systems award in its history, a prime contract with a potential value three times that of any prior award. This procurement for a highly classified system culminated ten years of corporate work on related contracts, beginning with the Ocean Surveillance Intelligence System in 1970 and continuing with a preliminary design contract in 1976.

The R&D Division captured a major contract to specify protocol standards for secure computer network systems—a task designed to facilitate cross-communication among networks developed for the 1980s.

BROADER SERVICES

By 1980, the Services Group had attained the largest number of employees among SDC's operating groups, testifying to the growth and diversity of the company's services business. New opportunities surfaced in all established areas—proprietary transaction services, mission support services, and social services—with the last making the widest gains in reaching new clients with new applications.

The management that had guided the group through its period of rapid growth remained in place. Vice presidents reporting to Group President Ed Doyle were Bud Drutz for Social Services, Bob Floyd for Commercial Services, Frank Irons for Integrated Systems, Bill Maley for Government Operations, and "Trip" Triplett for Data Systems. Arthur Schwartz, an SDC financial executive dating from the Cordura acquisition, became the Services Group controller.

By 1981, SDC's transaction business, including the supporting Santa Monica computer complex, had grown to a profitable $15 million operation. SDC Search Service was reaching on-line subscribers in forty countries on five continents through sales and service offices in the United States, Europe, and Japan. Its more than eighty bibliographic data bases contained fifty million citations, averaging a hundred words each, for a total of five billion computer-stored words—one of the world's largest automated libraries. Customer access to this monumental data store had been streamlined by an upgraded version of SDC's ORBIT information retrieval system, helping to sustain a 35 percent annual growth rate for this service.

The company's other major proprietary service—the Claims Administration System—was processing medical insurance claims for some three million employees and dependents of thirty subscribing U.S. companies and organizations, including Lincoln National Life Insurance, Garrett Corporation, and American Cyanamid Company.

A landmark accomplishment was the development of the world's largest on-line health claims service for the Australian Health Insurance Commission, achieved in a remarkable ten months from contract award to installation. Called Medibank, this system, headquartered in the capital city of Canberra, was built to process more than fifty thousand insurance transactions per day for five million subscribers over six hundred video terminals located throughout Australia.

The mission support business also expanded as SDC successfully recompeted for or otherwise renewed fifteen of its support contracts, including a five-year "re-win" of the CCTC contract supporting the Joint Chiefs of Staff and Secretary of Defense. Amid heavy competition, SDC won a new $15.5 million award from the U.S. Department of Transportation to support another of the nation's most advanced research facilities—the Transportation Systems Center in Cambridge, Massachusetts. SDC's 200-person staff of analysts, programmers, and machine-room personnel was at work on real-time scientific applications and on operating the Center's DEC PDP 10 computer as well as minicomputers and microprocessors. The eighty-odd projects supported by SDC included increasing fuel economy for automobile engines, minimizing aircraft noise through improved takeoff and landing patterns, developing new urban mass-transit systems, and load-balancing communications among aircraft controllers.

Following the Florida Medicaid contract award in 1978, SDC's social-services automation business expanded with new awards estimated in January 1981 at a total value of $100 million. On the heels of HEW certification that the Florida system met federal standards and a two-year extension for that contract in 1980, SDC won its second job as Medicaid fiscal agent for the state of Iowa.

Characterized by the *Des Moines Register* as a $4 million saving to the state, SDC's contract, won in competition against thirteen-year-incumbent Blue Cross/Blue Shield, placed a hundred SDCers in Des Moines. SDC's Santa Monica computer complex was powering the Iowa Medicaid system remotely, using programs adapted with The Software Factory system approach.

Medicaid provided the springboard for SDC to enter the broader market of automated benefits processing. This area was projected to expand in the 1980s, as federal, state, and local governments place increasing emphasis on disbursing their limited funds as accurately and prudently as possible.

At the heart of most such programs is the eligibility module—the automated check and balance system that ensures the timely provision of all benefits, and only those benefits, to which recipients are entitled. The eligibility systems developed by SDC detect such aberrations as persons with more than one Social

Security number or persons claiming benefits while reporting sizable incomes; they also reveal benefits owed to eligible recipients who overlook them or who may be entitled to reimbursement from private carriers.

Three competitive awards illustrate the diverse applications of SDC's capabilities in automated benefits processing. In October 1979, SDC won a multi-year contract to support the development and installation of the New York State Welfare Management System. This on-line system, operating with approximately twelve hundred terminals throughout fifty-seven counties of upstate New York, will aid welfare workers in providing medical assistance, public assistance, food stamps, and other services to eligible recipients. About one hundred SDC personnel were assigned to help develop and install this largest automated welfare system for its time.

In the fall of 1980, SDC was selected to design and implement a first-of-its-type Electronic Payment File Transfer System for the Human Resources Administration of New York City. According to Bud Drutz, vice president of the Social Services Division, "The novelty of this program lies in its use of automation to streamline the distribution of benefits in the form of direct cash payments to welfare recipients. With SDC's subcontractor, Manufacturers Hanover Trust, we expect our fully implemented system to be processing eighteen million transactions annually for public assistance and food stamps for a half million eligible families over an on-line system, using close to sixteen hundred terminals at six hundred locations. This pilot program is regarded as a national model for a more efficient time- and cost-saving approach to benefits processing."

A third contract with an eligibility focus—a $27 million, multi-year award from the U.S. Department of Education for computerized processing of Basic Education Opportunity Grants for five million U.S. college students—solidified SDC's broad position in benefits processing. Addressing an expanding national market for automated eligibility and disbursement systems, SDC was well on its way to providing total system management for social service programs.

A NEW OWNER

On July 1, 1979, exactly ten years after its for-profit conversion, SDC enjoyed its strongest position since that memorable date. Corporate profits for the fiscal year just ended were 40 percent greater than those of any prior year. The decentralized profit centers for SDC Systems, Services, and Products were meeting the objectives set for them in the corporate strategic plan. It was timely for top management to turn, once again, to the issue of liquidity for the foundation and for its other stockholders.

The members of the foundation, ever aware of the growing pressure to complete their charge of distributing, for the public's benefit, the proceeds attributable to SDC's profit conversion, were beginning to weary of the year-to-year rounds of meetings, discussions, and proposals.

Six of the original eight members of the 1969 foundation were still serving by 1980. They were: Arnold Beckman (chairman), Edwin Huddleson, Augustus Kinzel, Lloyd Morrisett, Donald Putt, and Ralph Tyler. All had previously been members of the nonprofit SDC Board of Trustees. Huddleson had been a founding trustee of SDC back in 1956, and the others had served SDC interests for nearly that long. (Guyford Stever and Bethuel Webster, who had also been members of the original foundation, had resigned for personal reasons.) SDC management was keenly sensitive to its obligations to the dedicated members of the foundation and to the national interests that had originally given rise to nonprofit SDC.

Three earlier attempts to develop a public offering had been aborted because of deteriorating market conditions. A tender offer in 1977 had provided some liquidity to stockholders. Management decided to repeat the process by providing a second increment of liquidity to stockholders, thereby enabling the foundation to pay the final $2 million installment of its $4 million voluntary contribution to the U.S. Treasury.

In the second tender offer, initiated in August 1979 and completed in October 1979, the foundation sold 275,000 shares at the established share price of $14. SDC also repurchased 50,000 shares of stock and 94,000 warrants tendered by other holders, for a total cash payout of $5 million.

The foundation had earlier donated shares of its stock to four educational and other nonprofit institutions in California. Still, it held about 850,000 remaining shares, for which a means of disposition had to be found and implemented prior to 1989 if the foundation was to retain its tax-exempt status.

In November 1979, Mueller assembled a group of eight corporate executives, including himself, and a set of external advisors representing management consultants, investment bankers, and industry, to initiate a series of brainstorming sessions on SDC's alternatives. Conducted in informal settings away from corporate pressures, these free-ranging exchanges, stretching over two months, yielded the insights management needed to explore its alternatives from a fresh perspective.

First, the experts pointed to the October 1980 period—that is, about a year from then—as a likely time for SDC to attempt a public offering in a potentially receptive market, should it wish to do so. On the other hand, SDC had to recognize that the foundation could not dispose of all its stock in one offering—that two or three might be required—with the attendant uncertainties about future market opportunities.

An alternative was the disposition of SDC stock in a merger. Again, the consultants provided insightful scenarios. The corporation might engage in a reverse merger, buying a small public company to serve as the vehicle for trading SDC's stock. Alternatively, SDC might look to be acquired by a company in a different line of business, increasing the prospects for continued independence but foregoing the opportunity for synergism that a more closely related parent would hold out. Third was a "creative merger," which transcended financial considerations and provided a newfound source of technical strength to the parent company. Recent acquisitions of this nature had commanded the payment of high premiums by the buyers.

Mindful of the difficulties SDC met in 1968 and 1969 to find a suitable acquirer, the executive group nevertheless agreed in January 1980 to explore the possibility of an SDC merger with a desirable partner under acceptable terms. Failing to achieve that goal by September 1980, the company would proceed with its second alternative—a series of public offerings. The plan was presented to SDC's Board of Directors at a special three-day meeting in February 1980 and gained the board's approval.

The following month, SDC engaged a leading investment banker, Goldman, Sachs & Company, to assist in the selection process. The executive group established the criteria for selecting a partner, addressing such concerns as what arrangement served the best interests of SDC as a company, its stockholders, its employees, and its customers. Assisted by Goldman Sachs, the group then trimmed an initial list of sixty potential partners to a more manageable thirty in April 1980 and was primed to start the contact process in May.

While Goldman Sachs was initiating tentative feelers, there occurred one of those rare conjunctions of events regarded as minor coincidences if nothing comes of them and manifest destiny if something does. Practically the same day and hour that the banker was contacting Burroughs Corporation, Burroughs was knocking on SDC's door with much the same intent.

With its roots in the company founded in 1886 by William Seward Burroughs to make and sell the adding machine he had invented, Burroughs Corporation had grown to be the nation's second largest computer and office systems manufacturer, with sales of nearly $3 billion in 1979. The company's most recent long-range plan called for growth in six major areas, four of which neatly matched SDC's strongest capabilities: systems, services, software, and office automation. In particular, Burroughs was seeking a strong systems engineering capability to augment its hardware expertise across a broad range of applications. SDC's capabilities in these areas were well known to Burroughs through early team efforts in SAGE and BUIC, the collaborative PEPE and MADS programs, and recent joint proposals.

Burroughs Executive Vice President Donald E. Young visited SDC President Mueller in SDC's Santa Monica office on June 5, 1980. At the end of the half-day meeting, both men remarked on the unique fit between Young's Diversified Products Group and

SDC. Two major units within Diversified Products were the Federal and Special Systems Group, developing systems and services for the U.S. government as well as for other clients and countries; and the Office Products Group, responsible for a range of office automation equipment and systems. The first Burroughs entity closely matched the SDC Systems Group; the other overlapped the office automation systems of SDC's Products Group.

Later in June, a group of Burroughs executives spent a day being briefed on SDC and touring the Santa Monica facilities. In July, Donald Young returned with W. Michael Blumenthal, who would become chief executive officer of Burroughs in September 1980 and chairman of the board at year-end, for more concentrated discussions.

With each meeting, the interest of both companies intensified, as the closeness of fit began to resemble matching pieces in a jigsaw puzzle. There were Burroughs' hardware strengths and SDC's software and systems expertise.... Burroughs' solid commercial reputation and SDC's sound government credentials....Burroughs' worldwide manufacturing, marketing, and service capabilities and SDC's product plans.... Burroughs' line of office automation products—word processors, optical character readers, facsimile communication systems—and the SDC Records Manager.... Burroughs' financial strength and SDC's goal to undertake larger procurements.... Burroughs' commanding California presence—seven thousand employees, nine production plants, eighty offices—and SDC's concentration of personnel and facilities in that state.... The complementary R&D programs of each organization.... Mutual emphases on networks, distributed processing, computer security, operation of data centers, international airspace systems... the list kept growing.

At the same time, another large corporation had become interested in SDC and was conducting its round of visits. The next series of meetings between this potential partner and SDC's line management was scheduled for August 11, 12, and 13, 1980, in Santa Monica.

On Tuesday morning, August 12, President Mueller received a phone call asking if he could be available that evening for a meeting with Burroughs' Donald Young and the investment bankers of both companies. Mueller said he could.

Young arrived at SDC about eight o'clock. He presented Mueller with a Burroughs offer to acquire SDC in a cash merger, authorized by Burroughs management that same morning. "That was the first time we had ever heard their offer," states Mueller. The two men negotiated for some hours. At midnight they shook hands. By the terms of their agreement, Burroughs would acquire SDC as a wholly owned subsidiary, paying $69 per share of stock for the company.

The next morning, at a regularly scheduled board meeting taking place in SDC's facilities in Santa Clara, California, Mueller and the investment bankers unfolded the Burroughs offer. The board, at that time, included four of its initial members—John Bishop, Frank Lehan, O. Meredith Wilson, Brooks Walker, Jr.—and Norman F. Parker, president and chief executive officer of Varian Associates, Inc., who had been elected in September 1979. The investment bankers expressed the opinion that the offer was fair in terms of comparable mergers. The board deliberated—then gave its unanimous approval.

"Amazingly, the entire process was suddenly compressed into two days," remarks Mueller. The swiftness of the negotiation surprised even the SDC insiders who had been tracking the Burroughs discussions.

Speaking to a large group of SDC's senior managers shortly thereafter, Mueller explained that, with Burroughs, SDC would remain a separate entity under its present management, reporting administratively to the Diversified Products Group. He stressed that "affiliation with a total hardware company, coupled with SDC's tradition of objectivity to choose the best of our own and other companies' hardware, will greatly strengthen our competitive position."

Asked why this merger was good for SDC employees, Mueller amplified:

"First, there are the greatly expanded opportunities for your career growth—Burroughs needs the kind of experienced people who are SDC. Second, the financial strength of Burroughs will make it possible for us to pursue very large systems opportunities, which we have not been able to do. Third, there is the synergism of Burroughs' technology with our own; combined, we should be able to assume a position of technical leadership in our chosen fields. Fourth, Burroughs' integrity and personnel orientation will continue to provide us with the kind of environment we have enjoyed over the years at SDC. Finally, for each of us there are exciting challenges and new vistas made possible by the merger."

Widely hailed as an ideal marriage, the Burroughs-SDC merger was characterized as "a match made in heaven" in *Business Week* of September 1980. Retiring Burroughs Board Chairman Paul S. Mirabito expressed his confidence that "SDC will provide an important impetus to Burroughs growth plans."

Addressing Burroughs employees in October 1980, its new chief executive officer, Michael Blumenthal, said of SDC: "They are outstanding managers and experts in the development of large-scale computer-based systems and have a very successful service business. We believe that their expertise in the software and systems areas, and their knowledge of government business, both in the United States and elsewhere, will add substantially to our strength in the development of total systems."

At the Burroughs offer price, the value of SDC's stock, including outstanding options and warrants, was $98 million. As owner of approximately two-thirds of the stock at the time of merger, the System Development Foundation realized some $66 million, including proceeds from prior tenders. Whereas the merger stood to benefit the future prospects of SDC and its employees, as well as its more than six hundred stockholders, the primary beneficiary was the U.S. public, in whose interests the foundation would distribute its millions.

By working patiently over a decade to combine profitable growth with prudent stock liquidation, SDC had repaid its commitments to the U.S. public at a sum that represented nine times the equity and 270 times the net income of the last operating year of its nonprofit predecessor.

In anticipation of the merger, SDC Products Group President Roger W. Johnson was also appointed general manager of Burroughs' Office Automation Division. The two companies formed a dozen task forces to initiate joint planning in key areas.

On December 8, 1980, at 10:00 A.M., SDC stockholders gathered in the company's Commons Room in Santa Monica to vote on the merger. The large audience included stockholders and warrantholders, members of the SDC Board of Directors and the Foundation Board of Trustees, SDC officers and managers, and representatives of Burroughs management. Looking down on the scene were portraits of the three men who, each in his own way, had helped to move SDC forward to this historic moment: M.O. Kappler, Wesley Melahn, and George Mueller. At 10:35, corporate secretary Bobette Jones announced the vote to the assemblage: 1,271,960 in favor, and 409 against.

The effective merger date was January 5, 1981. A new board of directors for the wholly owned subsidiary SDC was established. Chaired by George Mueller, it included James Skaggs and Burroughs officers Michael Blumenthal, Jerome Jacobson, Donald Young, Eugene F. Smith, and Kenneth L. Miller.

TOWARD THE TWENTY-FIRST CENTURY

SDC's twenty-fifth anniversary year held many causes for celebration. Based on partial results, the company was well on its way to reaching its $200 million sales target and having another good profit year. In the ten years of George Mueller's presidency, the company had grown, diversified, and prospered. It had achieved the three primary objectives of the 1971 strategic plan: to become a prime contractor for total systems, to develop a profitable services business, and to enter the volume products market. In merging with Burroughs, SDC had resolved the lingering issue of stock disposition and, to most minds, strengthened the corporate future and enlarged the opportunities for its employees.

As SDC was putting the finishing touches on its long-range plan in December 1980, with new growth objectives facilitated by the Burroughs merger in the areas of command-control, space, energy, support and transaction services, and product development, George Mueller reflected on past and future advances in computer systems technology.

"There's no question that we can process information today with greater sophistication and at greater volumes and speeds than ever before. But the basic concepts of on-line user-oriented information management, optimized by efficient system engineering, are as fundamental to today's most advanced intelligence network, or to SDC Search Service, or to the SDC Records Manager, as they were to SAGE when SDC implemented them twenty-five years ago."

For the 1980s and beyond, Mueller foresaw an age in which people will employ computers in every facet of their lives. He projected a society of reduced travel in which people will work, shop, and communicate over interactive terminals from the home; a paperless society in which business correspondence and financial transactions will be handled electronically; and a data-dependent society, in which computer systems will generate and store enormous volumes of data to provide information essential for daily decisions.

"SDC is well positioned to play an important role in this technological revolution," he concluded. "All of the company's skills, products, and technology are concentrated in these areas of national priority, and we will extend these resources in the years ahead."

Growing from developers of the first modern information systems into architects of the electronic society, the system builders of SDC paused to look back at a quarter century of corporate progress... then moved confidently into a new chapter in the story of SDC.

EPILOGUE

Following the merger of SDC and Burroughs Corporation on January 5, 1981, the following significant events occurred.

On January 28, James Skaggs was elected president and chief operating officer of SDC, becoming the fourth president in the company's history. George Mueller, who retained the position of chairman and chief executive officer of SDC, was elected a senior vice president of Burroughs.

Concurrently, the SDC Products Group was merged with the Burroughs Office Automation Division to form a new Burroughs Office Systems Group under Roger Johnson. Johnson was named president of the group and a Burroughs vice president and group executive. SDC's Robert Dickinson was named vice president and general manager of the Text Management Systems Division of the new group.

In February, Burroughs' Commercial Data Centers were merged into SDC's Commercial Services Division, which became a separate corporate organization under vice president and general manager Robert Floyd, reporting directly to Jim Skaggs.

In April, SDC's corporate-level financial operations and administrative functions were consolidated in a Finance and Administration organization under Vice President Jack Cannady.

In May, James Skaggs designated Jack Munson as SDC vice president of Technical Operations, with broad responsibilities in corporate technical concerns.

In June, SDC negotiated the first phase of a contract for a foreign airspace control system, estimated at a record value to the corporation of several hundred million dollars over its contractual life.

INDEX

Colophon

Manuscript prepared with UNIX word processing technology from Interactive Systems Corporation of Santa Monica.

Book designed by Graphics Two of Los Angeles, California.

UNIX tapes processed and text photocomposed by Technical Type and Composition of Salem, Oregon.

Other type set by Hi-Speed Typography of Los Angeles, California, and Omega Repro of Tarzana, California.

Photographic sections designed and produced by Corporate Relations Department of System Development Corporation.

Book printed and bound by Halliday Lithograph of West Hanover, Massachusetts.

SYSTEM DEVELOPMENT CORPORATION

1956

25 YEARS

1981

People with Ideas