Digital
Computer
Museum

One Iron Way
Marlboro
Massachusetts
01752

7 November, 1982

Dr. Charles S. Smith
System Development Foundation
181 Lytton Avenue, Suite 210
Palo Alto, California, 94301

Dear Charles:

The United States excells in three technology-based industries: agriculture, aerospace, and computers. Agriculture is represented by museums in almost every county; the federal government created a fine Air and Space Museum; and we have recently started The Computer Museum. Bob Everett, Ken Olsen and I began saving computing artifacts so that they would not be destroyed. The "museum" budget was $10,000 a year for a long time. Then Gwen Bell joined us in the summer of 1979 and in three, short years, has driven its development to become an independent non-profit public charitable foundation 501(c)3 with a collection and interpretive exhibits that are unexcelled anywhere else. (Charter, IRS application, and brochure are attached.)

Currently, Ken Olsen, President of Digital Equipment Corporation, is the main sponsor for the museum. Ken is Chairman of the Museum's Board and the company provides space within one of its facilities and up to two-thirds of its $400,000 annual operating budget. This provides a new holding pattern for the museum. The next plateau is in an independent museum building, probably equivalent to the size of The Lawrence Hall of Science (120,000 square feet), where the Museum could develop library, archives, and carry out research on the history of information processing. The System Development Foundation is the ONLY institution outside of the federal government that has the stature and vision to provide an appropriate long-term home for The Computer Museum.

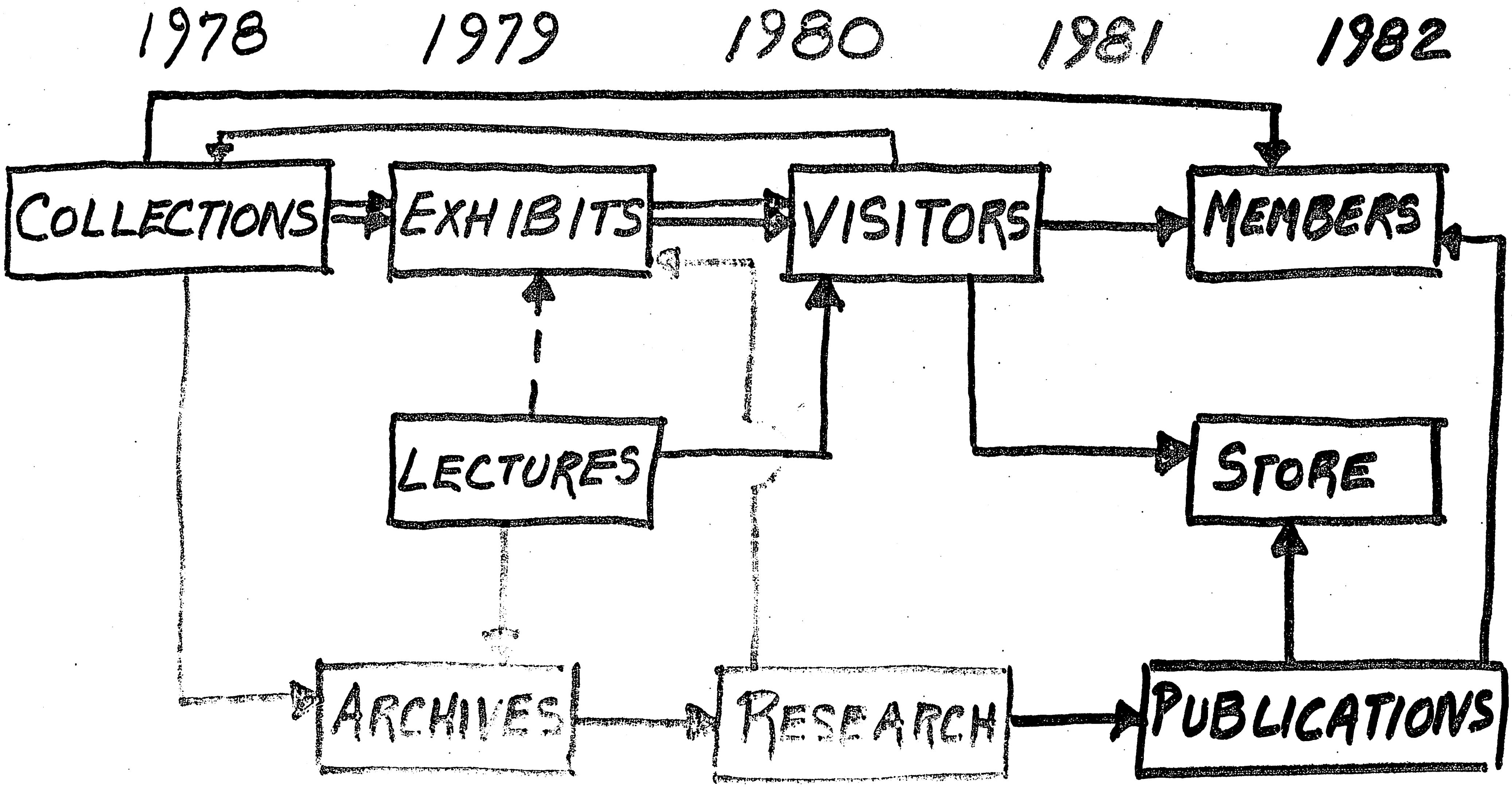
Conceptually, the museum is modelled after the American Museum of Natural History, with its focus on historic collections and their contemporary interpretation. Our collecting policy is based on the PMS notation that I developed with Allen Newell and is illustrated on the cover of our first <u>Report</u> that lists the collections up to May 1981. Then within computing, the museum's goals are complementary to those of SDC and SDF: many of the projects lead by SDC research and the current activites funded by SDF will have a major place within The Computer Museum. Just as SDC provided a major technology base for computing, SDF could provide for their preservation through funding the planning and building of a permanent home for The Computer Museum. This will provide a needed center for the deep understanding of computing that only comes from looking at the past.

We hope that this introduction and material will lead to a dialog in which both parties can refine their goals and collaborate in the preservation of this critical component of US history.

Sincerely,

Gordon Bell
Vice President, Digital Equipment Corporation
Professor, On Leave, Carnegie-Mellon University

System Development Fdtn. (SDF)



DIGITAL COMPUTER MUSEUM

POLICIES

- PRESERVE THE HISTORY OF COMPUTING.

  "YOU MUST FEEL LIKE THE DIRECTOR OF THE MUSEUM OF NATURAL HISTORY WHEN HE STARTED TO COLLECT BONES."

  JAN ADKINS, NATIONAL GEOGRAPHIC

- EXPAND "ORAL" HISTORY VIA LECTURES AND SEMINARS BY COMPUTER PIONEERS:

  "THERE IS NO HISTORY, ONLY BIOGRAPHY."

  ANDY KNOWLES

- MAKE THE MACHINES THEMSELVES FOCAL POINTS:

  "WELL-ENGINEERED MACHINES SPEAK ELOQUENTLY OF THEIR OWN ELEGANCE. MUSEUM DESIGNERS CAN'T EQUAL THEM."

  FRANK OPPENHEIMER, DIRECTOR
  THE EXPLORATORIUM, SAN FRANCISCO

- INTERPRET EXHIBITS FOR THE COMPUTER COMMUNITY:

  "HEY, THIS MUSEUM IS FOR US BIG KIDS."

  GEORGE MICHAEL
  LAWRENCE LIVERMORE LABORATORIES

- INVOLVE THE PRIMARY AUDIENCE:

  "THE MUSEUM DOES NOT HAVE TO CONVINCE THE COMPUTER COMMUNITY TO SUPPORT THE MUSEUM BECAUSE ITS ARTISTS ARE WORTHY; THEY <u>ARE</u> THE ARTISTS."

  HAROLD COHEN
  CREATOR OF THE MUSEUM'S MURALS

STAFF

JAMIE PARKER

EXHIBIT COORDINATOR
B.A. VASSAR 1979 - STARTED 11/79

SUE HUNT

ADMINISTRATIVE ASSISTANT - STARTED 7/81

CHRISTINE RUDOMIN

PROGRAM COORDINATOR
M.A. GEORGE WASHINGTON UNIVERSITY IN
MUSEUM EDUCATION - STARTED 3/82

GREGOR TRINKAUS-RANDALL

ARCHIVIST - START 9/82
M.A. LIBRARY SCIENCE, UNIVERSITY OF WISCONSIN, 1980

JAY MCLEMAN

PART-TIME FIELD SERVICE

JOHN MCKENZIE

TX-0 TECHNICIAN

BETH PARKHURST

PART-TIME RESEARCHER
BROWN UNIVERSITY PH.D CANDIDATE IN HISTORY OF TECHNOLOGY

7 SUMMER STUDENTS

DIGITAL COMPUTER MUSEUM

MAY, 1982
DCM003.72

SPACE ANALYSIS

SHARED SPACE	
(IN LOBBIES AND CAFETERIA)	4,000 SQUARE FEET
PIONEER COMPUTER TIMELINE	
TX-0	
SUPER COMPUTERS	
CREATED SPACE	
ARCHIVES 9/1/82	800 SQUARE FEET
PRIME SPACE (RENTABLE)	
OFFICES (1/82)	500 SQUARE FEET
FOUR GENERATION GALLERY (6/82)	2,000 SQUARE FEET
OFFICES (9/82)	500 SQUARE FEET
INTERACTIVE COMPUTING	2,500 SQUARE FEET
TOTAL	10,300 SQUARE FEET

FUTURE SPACE NEEDS FY 1985-1986

PRIMARY AND SECONDARY MEMORIES	2,500 SQUARE FEET
CARD COMPUTING	2,500 SQUARE FEET
ARCHIVES	1,000 SQUARE FEET
CALCULATING	1,000 SQUARE FEET
AN/FSQ-7 & OTHER MILITARY COMPUTERS	1,000 SQUARE FEET
TOTAL	8,000 SQUARE FEET

DIGITAL COMPUTER MUSEUM

MAY, 1982
DCM003-72

1982-1983 FUNDRAISING

RAISE $250,000 TO MATCH DIGITAL'S FY83 AND FY84 BUDGETED CONTRIBUTION OF $500,000 FOR THE FY83 AND FY84.

NUMBERS	CATEGORY		RETURN
50	CORPORATE FOUNDERS	@ $2500	$125,000
300	INDIVIDUAL FOUNDERS	@ $250	75,000
400	CORPORATE MEMBERS	@ $125	50,000
1000	MEMBERS	@ $25	25,000
	TOTAL		275,000

STRATEGIES

30,525
~~10,000~~

DIRECT MAIL
- 2250 LETTERS APRIL, 1982 - (REC'D $40,525 BY MAY 20)
- 4500 LETTERS & REPORTS, JUNE, 1982
- 6000 LETTERS & BROCHURES, SEPTEMBER, 1982
- 6000 FOLLOW-UPS OCTOBER, 1982

BROCHURE DISTRIBUTION

PERSONALIZED CORPORATE CAMPAIGN

SPECIAL GRANT APPLICATIONS

PROJECTIONS FOR FY83 AND FY84 WITH NO NEW FUNDRAISING BEYOND SEPT. '82

	FY83	FY84 RENEWALS
APRIL '82 LETTER (2250 SENT)	$50,000	$35,000
JUNE '82 PACKAGE (6000)	$50,000	$35,000
SEPT '82 FOLLOW-UP (6000)	$30,000	$20,000
SEPT '82 NEWLIST MAILING (TO 1,000)	$15,000	10,000
	$145,000	$100,000

DISTRIBUTION OF MEMBERSHIP

	June 9	Oct. 1 (Projected)
Members @ $25	158	1000
Corp. Members @ $125	9	30
Founders @ $250	56	130
Corp. Founders @ $2500	11	30

Note:

June 9: reflects results of April '82 letter only!

Oct. 1: projects results of June '82 package; Sept. '82 follow-up; Sept. '82 newlist

RESULTS OF APRIL '82 FUNDRAISING LETTER

(AS OF JUNE 9, 1982)

2250 LETTERS SENT
234 MEMBERS (10 PERCENT RESPONSE)

MEMBERSHIP BREAKDOWN:

	NUMBER	REVENUE
MEMBERS @ $25	158	$3,950
CORP. MEMBERS @ $125	9	1,125
FOUNDERS @ $250	56	14,000
CORP. FOUNDERS @ $2500	11	27,500
	234	$46,575
GIFTS IN EXCESS OF MEMBERSHIP FEES...		951
		$47,526

EXPENSES	FY 83	FY 84
LABOR (INCLUDING OVERHEAD)	165 (20)	210 (25)
EXHIBITS AND PROGRAMS	125 (20)	105 (35)
STORE	30	30
ARCHIVES AND PUBLICATIONS	65	70
OTHER	25 (20)	30 (20)
TOTAL	410 (60)	455 (80)

INCOME		
DIGITAL EQUIPMENT CORP	250 (60)	250 (80)
FUNDRAISING	125	155
STORE/INTEREST/FUNCTIONS	35	50
	410 (60)	455 (80)

() CONTRIBUTIONS BY DIGITAL THROUGH THE COST CENTER.

The
Computer
Museum

One Iron Way
Marlboro
Massachusetts
01752

OCT 21 1982

October 14, 1982

George Michael, Leader
Computer Research Group,l-76
Lawrence Livermore Labs
University of CalifOrnia
P.O. Box 863
Livermore, CA 94550

Dear George:

Enclosed please find Gordon's trip report from our very successful excursion to North Bay and Ottawa. I wish that all of you could have shared this experience. With some luck, we should be able to inaugurate the ANFQ7 exhibit at the Annual Board Meeting, May 6th.

In conjunction with next spring's board meeting, a Symposium on Archiving Computing History is being planned for May 5th and 6th. I have personally talked to those people concerned with archives at the AFIPS History Committee, The Charles Babbage Institute, IBM, Intel, MIT, MITRE, Lawrence Livermore, and the Travelers Insurance and find concern about what materials should be saved. Great potential exists for sharing, since resources for such activities will be necessarily limited. Attendance at the Symposium will be limited with priority given to Corporate Founders of the Museum. From the Museum's viewpoint, we envision that this will help establish a network of information sources and identify how best the Museum can serve the needs of computing history. Let me know if you have any ideas or recommendations.

Our fall programs are progressing nicely, with very interesting talks on the Sunday "Bits and Bites" program and a lecture by D.H. Lehmer that amplifies the new exhibit of his machines. The moment we had the exhibit together (after the machines had been in Lehmer's basement since the 1930's), Scientific American sent a photographer here to take a set of pictures. The bicycle chain machine will appear in the December issue.

The Museum continues to provide pleasant surprises of new, interesting things. I hope to share this through occasional letters to you, the Quarterly Report and our Annual meeting.

Cordially,

Love
Gwen

Gwen Bell
Director, The Computer Museum

GKB:ds
CM001.36

Enclosure

THE COMPUTER MUSEUM MEMBER'S FIRST FIELD TRIP
TO NORTHBAY AN/FSQ7 SAGE SITE AND TO THE
CANADIAN NATIONAL MUSEUM OF SCIENCE AND TECHNOLGY

Gordon Bell

Curator, The Computer Museum

10 October 1982

The first Computer Museum members' Field Trip just returned from a spectacular trip to Northbay Canada visiting the SAGE AN/FSQ7 computer prior to its decommissioning this winter, having been operational since 1962. The "Q7", once known as Whirlwind II, grew out of the Whirlwind project, initially started as an aircraft simulator. Becoming a prototype for air defense, this technology in turn formed the basis of modern air traffic control! (Lesson: what you get may not be what you start for when project aims are high.)

Seventeen museum members made the trip via chartered DECair, including Bob Crago from IBM, one of the key designers; Kent Redmond and Tom Smith, historians stet. writing the SAGE story; Henry Tropp, who is writing an article for the Annals of the History of Computing; and Richard Soloman who photographed and videotaped as part of an MIT Project on the History of Computing. The flying and trip arrangements were flawless. We left Friday noon, 8 October, from Bedford, Mass. for Northbay, arrived and visited the "hole" where we were completely briefed by members of the staff and original installation team, had dinner with the Canadian Air Force leaders, including the Commanding NORAD General (U.S.), flew on to Ottawa where we spent the night prior to visiting the National Museum of Science and Technology and returned Saturday afternoon.

THE Q7

Bob Everett's paper on the Sage computer was published in '57, and the machine was operational in Canada in '62. The machine created many patents as by-products, including perhaps the first associative store (using a drum). The machine is duplexed with a warm standby (I mean warm since the duplexed machine uses about 1 Megawatt of power to heat 55,000 tubes, 175,000 diodes and 13,000 transistors in 7,000 plugins!). The 6 microsecond, 32-bit word machine has 4 X 64K x 32-bit core memories and about the same memory in 12- 10.7" diameter, 2900 rpm drums, 6 of which are for secondary memory. There is no use of interrupts and i/o is done in an elegant fashion by loading/unloading parallel tracks of the drums with the external world completely in parallel with computing. That is, the i/o state becomes part of the computer's memory state. A single i/o channel is then used to move a drum track to and from the primary core memory.

The main i/o is a scan and height radar that tracks targets and finds their altitude. The operator's radar consoles plot the terrain and targets according to operator switch requests. The computer sends information to be plotted on 20" round Hughes Charactron (vector and alpha gun) tubes or displayed on small alphanumeric storage tubes for supplementary information. Communication lines connect neighboring air defense sectors and the overall command. The operating system of 1 Mword is stored on 728 tape drives and the drums.

The computer logic is stored in many open bays 15' to 30' long, each of which have a bay of voltage marginal check switches on the left side, followed by up to a maximum of 15 panels. The vertical panels are about 7' high by 2' wide and hold about 20 plug-in logic units. The separate right and left half of the arithmetic units are about 30' each or about 2' per bit. Two sets of the AMD 2901 Four-bit Microprocessor Slice would be an overkill for this 32 bit function today. The machine does vector (of length 2) arithmetic to handle the co-ordinate operations. The room with one cpu, drum, memory is about 50' x 150', and the two cpu consoles, tapes, card i/o. printer room is about 25' x 50'. The several dozen radar consoles are in a very large room.

UNDERGROUND SITE

The enormity of the machine was dwarfed by the underground building which encloses it. The building hollowed out of stone by hardrock miners is 600' beneath the surface, and connected by a 6000' tunnel which can be sealed off in seconds if there are very large, atmospheric disturbances. The building is about 150,000 square feet and has 10 standby 100 Kw generators and an air conditioner that can operate closed loop into an underground pond.

COST AND RELIABILITY

The machine and software cost about $25M in 62 and the site about $25M. The facility costs several million to operate per year, including about $1M to IBM including 10 people. Three people are needed to maintain the software. Initially, one hundred people were used to install the machine and set up its maintainence. When you count the radar, planes, etc. and operational costs, the computer cost is almost an incidental.

The reliability is fantastic! With ONE COMPUTER, AVAILABILITY IS 99.83% and with DUPLEX OPERATION, AVAILABILITY IS 99.97%. Having wondered why such an obsolete computer (somewhere between an 11/44 and 11/70) would be still used, it was clear: the reliability and the overwhelming fixed costs for radar, airplanes, etc. There's a parity bit. Marginal checking and incredibly conservative design were the key. Each week they regularly replace 300 tubes and an additional 5 tubes that are showing signs of deterioration.

Even though the program is about 1Mword, written in assembly language and Jovial, the key here is the aging and the fact that the program is NOT interrupt driven. The program simply cycles through the job queue every few seconds in a round robin fashion. This is an excellent example of superb software engineering with an incredibly simple overall structure since it is non-parallel, all the bugs that an interrupt driven system would have had are avoided. Users identify overload by the lengthened cycle time. The high reliability demonstrates learning curves as applied to reliability. This obvious notion just occurred to me: since all the software I see is always changing, it doesn't reach ultra-high reliability.

REPLACEMENT

Hughes has installed a new computer that occupies less space than the computer console.

BOTTOM LINE

I doubt if any of the existing personal computers that operate today will either operate or can be found in 20 years, simply because technology will have changed so much in performance and reliability as to make them uneconomical at the personal level. How many of us still repair and use our 10 year old HP35's? Furthermore, all the floppies will have worn out and we'll be glad to be rid of them.

VISIT TO THE NATIONAL MUSEUM OF SCIENCE AND TECHNOLOGY

Although relatively short on space for computing, the 5,000 square feet is still larger than what the Smithsonian allocates. Ted Paull, the section curator has put together an excellent exhibit on computation. They are archiving relevant Canadian artifacts including the FP6000, a circa '60 machine which could timeshare, and was until recently the basis for the ICL products. In addition videotapes, lots of terminals,and animated displays are used to teach about computing principles and history. A very elaborated, animated soup making machine is used to show analogies to computers (recipe/program, ingredients/data, store/memory, chopping,etc/processing, etc.).

The use of computers within the museum was well ahead of any museum I've seen, probably because the staff is small and willing to take risks. Also, the museum is new and not entrenched with traditional museum personnel who themselves may be museum pieces. The museum is run by a VAX-11/750 which sits in an open computation center within the museum, showing what a computer center is like. About 50 terminals are distributed through the Museum. The user applications include: the usual games, Eliza, questions answering, map generation to find your way through the museum, and descriptions of artifacts and technology A visitor can fill out a form on line to comment on the museum... something all museums should have. The administrative applications run by staff include: word processing, administrative reports, scheduling tours, and a large archive accessed by the Database program, Datatrieve. Their goal was originally to not have papers, typewriters or card files except in the exhibits.

As an extra treat, the original director, Dr. David Baird was there visiting and gave us a talk on how he got it together in a short time. He was a professor before being their first museum director, which explains why the museum is so good. He's now building a new museum of Palentology and says he will aim even higher to automate and self learn via computers.

ARCHIVING THE Q7 AND ITS RELATIONSHIP TO THE MUSEUM

I don't think we can do justice to the SAGE story and am delighted that Bob Everett is doing the videotape with various people including the historians, Redmond and Smith who're writing the history, as a follow-on to the Whirlwind story. I would like to encourage MITRE and IBM to decide who's going to be responsible for archiving the history of the project in toto, including saving many relevant artifacts. I will assume we will not take on this very large burden. However, I'd like to get some kind of commitment from Bob and IBM before we finally decide what to do precisely!

Basically, I think it's a worthwhile machine to go after for the Computer Museum because of its completeness into an integrated application. This is a classic, and it has so many historical firsts vis a vis real time, etc. Also there's the obvious relation to Whirlwind.

Here's what I think The Computer Museum should archive:

1. A set of logic schematics.
2. Theory of Programming (the reference manual which has instruction times, their operation, i/o, etc.)

2a. Any other overview documents that help define the system, especially the consoles and radar programming.

2b. I'd like to look at how big the whole set of Theory of... manuals would be. These would be enormously useful to future scholars in understanding precisely where things fit in such a large scale system. Afterall, this about the largest system ever built by that time.

3. Representative logic bays which have the large array of marginal check switches on the left (facing the bay). Here, I'd like the mag tape control (about 6 + 1 bays) or 12 feet. Alternatively, I'd like two, sawed off sets of bays: switches+logic and 2 logic together... about 4'.
4. 1-713 card reader, 1-723 card punch, 1-718 printer, 1-728 mag tape unit. Here, the idea is that we are moving lots and we might as well take the opportunity to move all this at once rather than later.
5. A 64K core stack in its cabinet (about3 x3 x 8). Not the electronics. This was about the largest stack built and came directly from the large memory work of the tx0 design (used to test it).
6. Spare plugboards (get all they have up to 50 with any wires they have). These are to sell them in the store.
7. 100 Spare plugin units to sell in the store.
8. 2 drums without cabinet. We'll have to sit it somewhere. This is a spare to eventually trade.
9. 2 sets of Sage Radar consoles (I think there are 3 types). One set is for trading.
10. Main CPU console. I talked to Ted Paul about this. This is the left part of the console that has lights and switches to access the registers of the machine. It has a phone in it, and its the half that you stand up to and there's a little lip forming a table.
11. Photographs of the machine as you look down the aisles, in the console room and in the radar console room

(batteries of radar consoles with people at them).

12. Block diagram of the system with the various parameters on it, showing the duplexed machines.

13. A scale model of the machine. I'd give anything for theirs which would come out of the plexi underground model. Let's try to get this now from them or Mitre. Maybe Mitre can do this with IBM.

14. Site diagram showing the tunnels, hole and building. Photographs of the site door, tunnel, above ground.

15. Patents coming out of SAGE. This is something we'll have to ask MITRE for.

16. An overview of the use of the whole system including the operating system. This is an excellent vehicle to understand real time computing of the earliest kind. It also argues for simple program structures.

The museum would display the console for now and probably the core together near the Whirlwind core. The documents and diagrams are essential for understanding and making the display and for eventual understanding in many years.

THE OTTAWA MUSEUM AND US

COMPUTER USE

This was truly impressive. Ted and his staff have done a great job and have shown us that computers can be used to really run a museum. I haven't seen any museum this far along. This is the right way to do the job. I think a museum should have NO typewriters or file cabinets outside unless they're part of the historical displays. Ultimately, videodisks have to be available to illustrate the whole world if one wants to probe deeper into a subject (eg. a computer). I'd like to provide an exchange service for video tapes and disks dealing with computing. Also, I liked many of his photographs and displays. I'd also like to see us think about building these so as to get history without errors and to show the agreed upon significant events. Getting the errors out of exhibits and showing the relevant events is a terribly hard and tedious project... and it's impossible to do it in very many places. History should not be too geographically dependent.

EXHIBITS

In addition, the 5000 feet of the exhibit is really put together well. I liked the long blurbs and photographs that went with the history. There were logic lab booths that demonstrated adders, ands, etc. I didn't care for the videotape or the talking dummies of pythagoras and ?.

LOGIC TRAINERS AND US

I think we ought to get some logic trainers (either the big faced modules that DEC made for the army, or the logic labs, or possibly even the original set of lab modules) to show how the logic functions are performed. I can argue that logic training was important and we would simply show various forms. We would put a trainer on the wall together with some circuits that could be tested there by anyone who wanted to do it. My tendency would be to put the trainer under glass with some wires leading outside to non-destructable switches. Here, show: AND, NAND, NOT, NOR, OR, an ADDER of 1 or 2 stages, a counter of several bits that advances one anytime anyone does an experiment. This could all be wired up in a single logic lab! If we got some trainers by others, including ones that Ed Fredkin's brother's company made, we could show some impressive stuff, with very little work. The Fredkin/Minsky Muse was initially done this way. Of course, we would put them behind glass and simply allow push buttons in the same way that people operate calculators. This is for next summer and for the students, so we ought to start collecting.

Digital
Computer
Museum

One Iron Way
Marlboro
Massachusetts
01752

July 6, 1982

George Michael
Lawrence Livermore Laboratory
University of California
Leader, Computer Research Group, L-76
P.O. Box 808
Livermore, CA 94550

Dear George,

Thank you so much for coming and taking the Museum so very seriously. I think I have more or less recovered -- Gordon's being in Japan is helping a bit -- there are only one set of problems to worry about. As a result of the Seminar on Archiving and the first Board Meeting several operational changes are occuring at the Museum that will be it more clearly on the track of being a truly history Museum with the potential of offering a center for scholarship.

The first decision is to change the operational name of the Museum to The Computer Museum. It should be an unnoticeable transformation for those who are familiar with the Museum but remove the Digital connotation for those who were disturbed by it and in introducing the Museum to new people. We intend to waste not in making this operational: and Charles Bachman at that first Executive Committee Meeting noted it wouldn't matter if the name appeared in several different forms at the same time.

The second decision is that we plan to establish a library along with the archive. Gregor Trinkaus-Randall will start to develop these when he arrives the second week of September. Physically, the library, film archive, and working offices will be housed in new space that we will have January 1. The space is on the lobby floor located just below the new Four Generation Gallery and is approximately the same size, about 2500 square feet. The library and archives will become very valuable and useful for scholars -- not in the immediate future -- but when one looks at the future with a long view. A local advisory group will include Professors I. Bernard Cohen and Bill Aspray from Harvard, Ithiel de Sola Pool and Richard Soloman from MIT (who have a grant from the Sloan Foundation to video-archive computer history), and Ed Galvin from MITRE.

And third, we have devised a "second level" of museum speaker. On Wednesday afternoons this summer and next summer, Beth Parhurst is arranging gallery talks (program enclosed). We provide a small audience (we had 12 for the first one - Jack Gilmore, operating manager of the Whirlwind and 35 for the second - Alan Kotok on computing at MIT circa 1958-62: the TX-0 and the PDP-1) audio-tape and transcribe the talk for the archives. Then if appropriate, one of the summer interns then writes it up for a forthcoming issue of the Museum Report. It is a kind of "oral history" or at least "biography" and lets us capture those who won't write it down. We don't pay the speaker and don't really expect much preparation. On Sundays for a fall and spring season we will do "Bits and Bites" -- a similar set of sessions, only

Digital
Computer
Museum

One Iron Way
Marlboro
Massachusetts
01752

presumably sort of popular and anecdotal about some of the exhibited material -- Gordon Welchman will speak on the enigma; Danny and Brian on the tinkertoy, etc. We don't have a program for the fall or spring as yet and would welcome your suggestions.

My goal is to strengthen the Museum as an industry-wide center of activity for the history of computing. Each of the present exhibitions will be improved in the coming year; but no new exhibition will be opened. Instead we should have a library and archive for you to see.

Last week I had lunch with Professor I. Bernard Cohen at Harvard. If you don't know I.B., he really did all the work that let Charles Eames put together A Computer Perspective for IBM and he continues to consult on all IBM's history projects. He is also a superb scholar and has watched the gradual unfolding of the Museum. He has now been totally won over. He said to me, that he generally states that the US has three major economies: aero-space, agriculture and computing. The first has a wonderful museum and the second is covered in every county museum in the country, but there is none for computing. And now, he says -- The Computer Museum is it and needs to be independent -- a position that is slowly evolving. I.B. is also on the Board of the CBI and sits on the AFIPS History Committee and will be the editor of a new book series on the history of computing from MIT Press. He's in the catbird seat and can be choosy.

Within the context of these comments and as chairman of the nominating committee, I'm sending you a copy of the letter from Eric Block. The IBM Communications are going to visit the Museum this summer accompanied by I.B. We will certainly use their services for exhibit material. Having watched what happens to Museums as part of Universities or Governments, I certainly think the Computer Museum is a grand enough and important enough concept to be independent. But where it is finally housed is a question that is up for grabs. All of this takes time.

There is a wonderful photo of you and Jamie knocking heads over photos that I intend to use in the next report -- we're saving the one of you and the 6600 for a later issue.

I'm enclosing a dozen brochures and six issues of the first report for you to distribute as you see fit. What are the chances of the Lab becoming a Corporate Founder? (If it is possible, then let me know if I need to do anything.)

One final thing: can you move quickly on tying down Teller. Is there anything that I can do to help this?

Thanks again,

Cordially,

Gwen Bell
Director

Enclosures

DIGITAL COMPUTER MUSEUM CATALOG

INTRODUCTION

Starting a computer museum today presents analagous problems to those that of the second duchess of Portland. Born in 1714, she was an insatiable shell collector who relied on artistic arrangements until she hired a student of Linnaeus (1707-1778) the father of botanical classification systems. Then the collection was re-arranged according to a taxonomy that would help the viewer understand evolution and relationships. Computing devices -- as beautiful as shells to many people -- need a theory-based classification system.

The purpose of the Digital Computer Museum, to document and preserve the evolution of the computer, from its earliest origin to the latest developments, demands a rigorous, disciplined classification scheme that focusses on the computer itself.

Intuitively, those who have tried to understand computer evolution to consider a tree structure -- the basis of taxonomies -- but none have been fully developed for the purpose. (Bell and Newell, 1971; Bell, McNamara and Mudge, 1978; Rogers, 1980; Science Museum, 1975, Sieworek, Bell and Newell, forthcoming). The National Science Foundation tree (Fig. 1) of early computers shows roots and connections but does not name branches. A number of partial systems and some generally agreed upon terms exist for defining a classification system. The Computing Reviews classification system for contents works very well for the extraordinarily broad range of materials including "mathematics, engineering, the natural and social sciences, the humanities, and other fields with critical information about all current publications in any area of the computing sciences." (Sammet, 1980) The work of the AFIPS Taxonomy Committee, Taxonomy of Computer Science and Engineering, provides a confusing semi-lattice covering all possible issues. (AFIPS Taxonomy Committee 1980) Other trees look at only a part of computing. (Weizer 1981, Sammet 1969) The evolutionary model has also resulted in the identification of generations. (Rosen, 1969)

THE GENERATIONS

Within the broadly accepted idea of technological generations, clear criteria can be identified to mark each one. These are:

- A new base technology

- A new machine structure
- Satisfaction of a need constraint
- Significantly different use.

Generational change is modelled by a series of distinct steps with a new base technology at a significantly different level. The technology base never meets the aspirations and dreams of mankind -- perceived needs are continually rising. A new base technology only creates a higher takeoff plane. (Maslow, 1943) With each new invention, one or two prominent people often note that it will fulfill all the future computational needs; but each time the aspiration for more computational power only grows.

Computers themselves are a technology that may influence a wide spectrum of other phenomena, such as communications and manufacturing. Since the fifties they have become one of the prime movers of technological advance.

A number of ideas and machines are designed and even built out-of-phase with a technology. Ideas that occur before their time often lie dormant in the inventors notebook until the technology evolves to match the idea. Later historians illuminate these early concepts, showing the contemporary entrepreurs that they are not inventors but only implementers of ancient ideas. In the mid-twentieth century, some letters of Wilhelm Schichard dated 1624 were unearthed. These contained the drawings for the first known digital machine to perform calculations. (Cohen 1980) It is very doubtful that these ideas transmitted from Schichard to his friend Kepler influenced any of the mechanical calculators that were subsequently developed. Similarly, Leonardo's notebooks included drawings for many engineering devices including a calculator, but the mechanical technology at the time had simply not progressed to the necessary degree. The actual inventors that develop a baseline machine for a technology are often tinkerers with that technology and not scholars searching the literature for ideas.

When one or more significant ideas are transformed into a project, then its execution includes inventions that become part of the technological base. A new generation is marked after the project has proven itself, shown not to be a fluke, and adds a new layer to the technological base. The Computer Revolution and beginning of the electronic generation added the technological use of vacuum tubes in orders of magnitude never before experienced in the ENIAC project and the use of magnetic core memory from the Whirlwind project. Since a generation is a convergence of technology and inventions, marking its emergence by a single event is inappropriate. A clustering of events, including patents, publications, and start-up dates that converge are used to justify the selection of a particular year, that then has approximately a five percent accuracy.

The Museum collections begin in 1620 with the beginning of the "Craft Generation". Prior to that information processing was carried out manually, much the same for all of history. Using the product of processing rate and memory size to measure computing power, a 20 order of magnitude increase can be counted since people used stone-based, single register for arithmetic. The most significant gap -- a revolutionary change -- occurred with the beginning of the computer era. Before then, memory size was essentially constant at one. Afterwards, computing power began to increase at roughly twice the exponential rate of all past generations.

The name of the generation indicates wide-spread application and use of a predominant technology. The idea that leads to a project triggering a new generation always occurs before the beginning of that generation. The starting date of a generation is marked by the incorporation of a technology into production of a new product, concurrent with significant use. In most cases devices from a previous generation continue to be designed, manufactured and used, often supplying a base on which the new generation is built.

Table 1 lists the need, use and representative inventions for each of the generations. During the pre-computer generations, evolution was exponential -- each period being half as long as the one preceding it. The rapid change is similar to manufacturing learning curves, whereby a particular unit cost declines by 10-20% each time the cumulative number of units of a given type are built. In the Computer Age, the naming conventions given by industry have been used, and they seem to accurately fit the model.

Generations are primary organization element for the collection and its representation in the catalog. The first four sections present the pre-computer generations. Then the fifth section is devoted to the pioneer computers that spanned the revolutionary bridge. And the remainder of the catalog and collection is open ended; inclusive of all historic generations, i.e., at least one generation removed from the present technological generation or fifteen years old.

THE TAXONOMY

Structuring a taxonomy has paralleled the development of the collection and the exhibits at the Digital Computer Museum. The PMS classification describing the structure of computing structures provides the basic framework. (Sieworek, Bell and Newell forthcoming) PMS allows any computing or software structure to be described hierarchically in terms of eight basic information processing primitives; but does not deal with functional behavior, eg., interrupts except those that can be implied by a structure. The PMS system is generally used to provide a structural representation of the components of digital computer systems. In contrast, this taxonomy only encompasses whole computing systems and their antecedents. The following compares the two breakdowns:

MUSEUM TAXONOMY	CODE	CODE	PMS
Memories	M	M	Memories
Controls	K	K	Controls
Transducers	T	T	Transducers
Links & Switches	S	S	Switches
		L	Links
Calcula	D	D	Data Operation
		P	Processor
Digital Computer	C	C	Computer
Automata	A		

The criteria defining the tree is the structure of the computing device, neither the organization that made it nor the purpose that it was meant to fulfill. To make an analogy with the animal kingdom, if the bone structure of a horse is that of a fine race horse then it would be classified as such; it would not matter if it were bred by the government and used to pick up garbage. In computing, the EDSAC, built at Cambridge University, is neither classified as an English or university computer but an EDVAC-related machine in the same family as the Maniac and ILLIAC. Thus, differentiation of manufacturers, countries, or by intended users is not part of the taxonomy.

The classical scientific taxonomy system with its seven levels has been adopted to organize and classify all species of relative inventions. The two top levels, kingdom and phylum, are technology and information, respectively. The Museum collection deals with seven classes within the phylum of "information." (Listed above) Each class, like a specie, has life that starts within a given generation, flowers, and then becomes functionally incorporated within another class. Each started, almost as an independent thread, but are now beginning to merge into two dominant classes: computer and automata.

Memory is probably the oldest class starting with early markings on caves and continuing both as significant parts of computers and automata and also as all kinds of human-readable aids to the brain. See ..... for more complete explanations.

Controls reach back to early analog devices, such as the Greek water clocks, and have been significant in the mechanization process. At the beginning of the 19th century, card controlled looms gave the notion of sophisticated pattern control to industrial processes via the use of a larger scale memory data-set than hitherto used. Card control ended with a great flourish in the early nineteen sixties with the tabulating machines. Again with the computer on the chip, earlier technologies of control devices are rapidly becoming obsolesent to be replaced by the "on-board" micro-processor.

Transducers take information in one form and put it into another. They are often associated with memory systems, allowing their replication, printing use type (an intermediary form) to duplicate the information into books, the books are then "secondary" memory for people. Transducers really began with the Guttenberg's movable type and include teleprinters, tape transports, the telephone, and television sets. These machines are becoming more and more sophisticated and less and less able to be differentiated from computers.

Calculators, other than the manual bead devices, did not develop until the 19th century and have now virtually been displaced by computers. These are the data operators to do the arithmetic in PMS notation. Either calculators are embedded in computers or computers (as they have miniaturized) are embedded in what has traditionally been considered a calculator. The taxonomy of Class Calcula is worked out and explained in the text. (See ....)

Links and switches evolved out of the need for a large number of subsribers all desiring the use of a single system. The first telegraph was a simple device transferring information from a to b. But the growth of the telegraphy and telephony systems in the late nineteenth century created a need to establish elaborate networks linked together with a switching system. The current generation of computers still depend on new methods of linking and switching for cross communication.

Digital Computers emerged in the late forties from a combination of calculator, control, transducer, links and switches, and memory technologies. The section on Pioneer Computers shows the combination of elements that were adopted by the first 16 machines, many of which were patched together with emphases on different Classes. The Class Digital Computer, itself that emerged is certainly more than the sum of these parts, as each has converged and been modified and molded into a new phenomena.

Automata actually started very early with man's desire to replicate himself and their great population explosion took place in the sixteenth century. But only recently, have useful automata been put to work for human purposes and are contemporary to the latest generation of computers. Thus, this class is presently not included per se in the collection; but will be included in the future.

Each of these seven Classes is broken down into Order, Family, Genus, and then identified by Species. Table 2 lists the criteria used for the breakdown of the Classes. Specific descriptions for each of the class are found throughout the catalog.

TABLE 1.

PRE-COMPUTER GENERATIONS

	MANUAL	CRAFT 1620	MECHANICAL 1810	ELECTRO-MECHANICAL 1900
NEED	Taxes	Trade Exploration	Industrial Land Division	Census Business
USE	Counting	Arithmetic Navigation	Surveying Weaving	Sorting Accounting
MACHINE	Abacus	Tables Gunter's Rule	Planimeter Jacquard loom	Hollerith Census Machine Friden calculator

COMPUTER GENERATIONS

	ELECTRONIC 1950	TRANSISTOR 1960
NEED	Defense Weather prediction	Space Science
USE	Firing Tables Weather Forecasting Management	Simulation Training programmers Accounting
MACHINES	Whirlwind UNIVAC 1 ERA 1101	CDC 160, IBM 7090, IBM 1401 PDP-1

TABLE 2.

Criteria used in differentiating orders, families, and genus.

CLASS	ORDER	FAMILY (Technology)	GENUS
Memory	Machine interface	Storage material	Structure of access movement
Controls		Complexity	
Transducers		Phenomena	
Links & Switches		Complexity	
Calcula	Analog or Digital	Complexity	Structure
Digital Computers			
Automata - to be developed			

Fig. 1: The Collections

```
          Period that the exhibit covers:
          Craft   Mechanical  Electro-mec   Electronic  Transistor  IC
           1600     1810          1900         1950        1960     1970

MEMORIES  MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM
including books and magnetics

CONTROLS  KKKKKKKKKKKKKKKKKKKKKKKKKKKKKKKKKKKKKKKKKKKKKKKKKKKKKKKKK K K
including water clocks, and governors

LINKS & SWITCHES              SSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
including telephony and telegraphy

TRANSDUCERS       TTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT T T T
including typewriters and printers

CALCULA      DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD D D D D
including analog and digital calculators

DIGITAL COMPUTERS                           CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
including processors

AUTOMATA  AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
including robotics
```

DMCAT1.6

PROGRAM FOR THE COMPUTER MUSEUM BUILDING

The Computer Museum presents the once and future vision of the entire scope of the information society; the most recent layer on the socio-economic system. The information society is characterized by the manipulation of information, development of knowledge systems, and evolution of new art forms. The Computer Museum focuses on where the information society has come from to gain sharper perspectives on where it is going.

The audience is "the information society" -- people who continue to learn throughout their life, for whom formal school only provides the prelude. Because of the nature of the worklife schedule major attendance will be drawn from people in academia, attendees at conferences and symposia, the partially employeed (especially retirees), and weekend excursioners. A core audience of members and founders will come from the information professions and will be drawn to the Museum by its programs. The Museum's vitality will increase if it has close proximity and a good working relationship with a major university and conference center.

Because The Computer Museum has a unique one-of-a-kind collection, audio-visual and print publications will provide outreach to its international base of support and interest. It will also make materials available on a loan basis to other museums and educational institutions.

The home of the Museum should provide a place where the professionals can feel at ease and among friends; in fact, it should become a place where you can "bump into your friends" -- crossing academic and industrial boundaries as an ecumenical center.

THE FACILITIES

The facilities need to house (1) Permanent exhibitions, (2) Temporary exhibitions, (3) Study collections, Archives, and library, (4) Visitor services, and (5) Museum exhibit production and administration, equalling 80,000-95,000 square feet.

PERMANENT EXHIBITIONS: 30,000 square feet.

Twelve galleries are needed to encompass the major components of information processing (as outlined outlined in the first issue of The Computer Museum Report.) Each of these galleries -- while permanent -- would be updated and refreshed every 2-4 years to accommodate new acquisitions and interpretations.

Computers: (1) The Pioneer Computer Timeline (now occupying 100 linear feet of space.)

(2) Super Computers (now occupying about 2000 square feet in the main entry -- with possibilities for lots of growth.)

(3) Evolution of Computer Hardware Technology including semi-conductors (at present in the four generation gallery and new semi-conductor exhibit being developed.)

(4) Evolution of Programming Languages, Concepts and Software -- partially included in the four generation gallery and elsewhere.

Calculators: (5) Evolution of Digital Calculating from the abacus or Pascal's adder through totalisators, number sieves, card calculators. (Now cramped in the first floor corridor spaces with additional pieces placed in storage.)

(6) Evolution of Analog Calculators from Oughtred's slide rule through bomb sites, harmonic analyzers, differential analyzers and other devices. (Only a few items now on display.)

Links and Switches: (7) Interconnect devices ranging from cables to switchboards, Arpanet, Ethernet, and onward. A few of these are on exhibit in the four generation gallery.

Memories: (8) From books of tables and mechanical memories such as music box disks to primary and secondary computer memory. (The primary memory exhibit in a closet is a start. A variety of secondary memory devices and early examples are in storage.)

Transducers: (9) The new gift of the typewriter collection, materials from Xerox and Data Products are starters for this exhibit.

Controls: (10) Water clocks, cybernetics, and use of control devices in machinery and factories illustrate a hidden dimension of the interaction of information processing on everyday life. An invisible car showing all computer controls and an invisible man showing all possible computer control implants (insulin diffusers, pacemakers, artifical cocclyeas, etc.) could make this understandable.

<u>Robotics:</u> (11) The psuedo-robots, 18th century automata and early 20th century movie monsters, provide dramatic contrast to the seminal attempts at Rand with Shakey, Shannon with his mouse, and Minsky with his arm - and forward to current state of the art.

<u>The Arts:</u> (12) An audio-visual produced "show" -- updated every two years -- could trace this history. This could be an important part of the experience of the Museum; just as "where's Boston" is an important part of a visitor's trip to that city or the simulated space flight an important part of the visit to the Air and Space Museum in Washington D.C.

TEMPORARY EXHIBITS AND HALLS. 20,000 square feet.

(13) A gallery for temporary exhibits would provide needed change and variety for the Museum's "local" clientele. The Museum would also act as an occasional producer of travelling shows, such as one on the life and times of Charles Babbage -- bringing together major artifacts and other materials.

(14) A general theater for seating 300 people should be kept fully booked for lectures, concerts, symposia, performances and appropriate events. This should be supplemented by one or two smaller spaces.

STUDY COLLECTIONS. 5-20,000 square feet.

<u>Archives and Library:</u> (15) Printed materials, audio visual materials, and photographs need to be kept in an accessible place for resident scholars, staff, and to service inquiries. At present we receive at least two calls per week for photo and audio-visual materials, many of which we can't fill. The archives are presently housed in a 600 square foot room and complete listing is available; we have about 100 video-tapes and two file drawers of excellent historical photographs. These materials are rapidly expanding.

Artifacts: (16) "A basement or attic" is needed to have on-site storage for new acquisitions prior to display and a reasonable amount of important secondary artifacts for study purposes. In addition, some off-site, low-cost storage will also have to be maintained.

VISITOR SERVICES. 20,000 square feet.

The facts are that the visitors will probably spend as much time eating or shopping as they will in a single gallery. Having attractive, pleasant places to linger is important to the feel of the Museum.

(17) Restaurants. The place for a cup of coffee, such as The Museum of Modern Art's garden, and a good restaurant are both important.

(18) Shop. The Museum's store is being developed now: its size will depend on the diversity of products that are found to be appropriate within the constraints of providing a facility unique and special to the Museum. Mail order is likely to provide a large portion of the business.

(19) Restrooms, cloakrooms, waiting rooms -- places to make the visitor comfortable.

MUSEUM ADMINISTRATION AND EXHIBIT PRODUCTION. 5,000 square feet.

(20) Museum administration will be linked into a computer system that will also service the entire museum. Terminals throughout the Museum should let visitors communicate to appropriate parts of the staff -- correct text for the curator, join the museum association, comment on the exhibits, reserve at the restaurant or for a lecture, and access some information files. The administrative offices will include central administration, fundraising, public relations, program development, and publications.

(21) Exhibit production will include all the curatorial and historical work. Computer based demonstrations throughout the Museum will show how things work and demand programmers; audio-visual presentations with all exhibits will require facilities for television productionand skilled media personnel; and finally a traditional workshop will be needed for some on-site fabrication.

GETTING FROM HERE TO THERE

The pivotal point will be a major grant that will provide the catalyst to raise the necessary funds to endow such a building. The following scenario assumes obtaining such a grant and being able to announce it June 24th, 1984 will...

May 1983:	Present concept to Board. Concentrate on building up a large number of founders for the Museum: 1,000 individuals and 100 companies at a minimum for a total of 500K.
May 1984:	Open up final gallery in Marlboro; tie up details with Board.
June 24, 1984:	Complete founding period. Annouce major building gift; site of Museum (land); endowment program; and competition for a building.
Issue:	New site or old building. The "old buildings" reused include a convent for the Capitol Children's Museum in Washington D.C. and warehouse for Boston's Children's Museum, the coliseum like building for The Exploratorium in San Francisco, a bakery for the National Museum of Science and Technology in Ottawa, and a power station for the electric tramway for Sydney's new museum of Applied Arts and Science. If an old building were selected, it would need to have large, flexible spaces, with room for expansion, parking, and close proximity to rapid transit. Government aid should be sought in obtaining land or a building.
Issue:	Fundraising categories. Keep annual giving to maintain the operation in Marlboro. Go out for the following from major foundations and individuals -- to be pledged over the five year period ending before 1990 -- the completion of the building:

5 of	1,000,000	=	5,000,000
10 of	500,000	=	5,000,000
20 of	250,000	=	5,000,000
100 of	25,000	=	2,500,000
200 of	5,000	=	1,000,000
Endowment			18,500,000

Issue:	Once the Museum were opened at a new site, entrance fees would be established that would provide the fundamental cushion now provided by Digital's annual contribution.
May, 1985:	Announce prize winning design for the Museum.
May, 1987:	Open first third of Museum and close Marlboro -- taking the Marlboro exhibits for the second third.
May, 1988:	Open second third of Museum based on Marlboro exhibits.
May, 1990:	Open final third of Museum.