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Oral history interview with Lynwood C. Dunseith
[full name of interviewee]

about realtime Computer flight Control Support,
[main focus of interview]

MSC Real time Computer Complex, Mission Control
Center, Software development.

Title: 1962- Flight Operations Division, ASPO
[interviewee's current and/or former title and affiliation]

1968 - Chief, Flight Support Division, Dir of
Flight Oper

Interview conducted by Robert B. Merrifield, Staff
[interviewer's name/position]

Historian at MSC
[location of interview]

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"Edited to remove extraneous ~~content~~
(per letter) material"

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CONTENTS:

Biographical - [date/place of birth; family background] _____

Education - _____

Career Path - USAF (detailed to NASA at Cleveland, Ohio);NASA Langley Research CenterTopics - realtime Computing work at Goddard Space FlightCenter; ^{Goddard Guidance Computer} flight support of Mercury Redstone I;combining Control Center + Flight Operations;MSC Realtime Program Dev Branch; ¹⁹⁶² Selection of IBMfor Real time Computer Complex; Philco for Control Center;Mission Control Center open vs closed loopSimulation; problems w/ binavicular ^{no picto} displays;Comparison of Mercury Control Center + Mission Control Center;improved. TV display system; description of ^{Mission} Control Center;^{engineering} test on Gemini II ^{Jan (1965)}; Prime support Gemini TVphase-over to second-Generation Computers; ^{IBM} (June 65)MSC Coordination w/ IBM; problems with softwareand management + Schedules; Mission support"Development plans" ^{now} (used by IBM & others)

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June 20, 1968

Lyn,

The transcript of your interview, edited to remove extraneous material, is attached.

If you will, please read the statement and mark those sentences with brackets [] that you would not want alluded to in a Center history for reasons of embarrassment to an individual or the Center. As I mentioned during our recording session, this interview is to be part of the source material for the history, and it is doubtful that I will quote from it verbatim. Therefore, please don't worry about a sentence here or there which might not be as polished as would be desirable were it to receive public scrutiny.

If you want to add information feel free to do so. Just tack it on at the end of the statement, unless you prefer that it be inserted into the text.

After you return the transcript to me, I'll send you a copy for your personal file.

Thanks,

Interview with Lynwood C. Dunseith

4/10/68

My first contact with what is now called realtime computing was at Goddard Space Flight Center. I had been working for NASA in Cleveland, Ohio, actually as an Air Force officer detailed to NASA at Cleveland. Project Mercury became a fact and the Space Task Group was formed just prior to the time that I was to be discharged. At Cleveland I had worked with a man whose name was Earl Huff, who was interested in computers, and consequently, I had learned to program the IBM 653 computers there and spent quite a bit of time in writing programs and running the computers.

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54 I got interested in manned spaceflight after talking to some of the people that had been transferred to the Space Task Group and so I took a job with the NASA at Langley to work on Project Mercury. John Mayer had a Branch at that time. A part of the responsibility of that Branch was the operations input to the realtime computing at Goddard. Western Electric had a contract for the Mercury tracking network, and IBM was a subcontractor to Western Electric to provide the launch data system and realtime orbital computing capability. It was decided to implement this computing system at Goddard. A large number of people cut their teeth on realtime computing in this facility, both in IBM and NASA.

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v73 Most of us are still involved with manned spaceflight computing in one fashion or another--Bill Tindall, Jim Donnegan (who is still at Goddard), Jim Stokes (who is chief of Flight Software Branch here now), Cal Packard and a number of other people who are still at Goddard. On the IBM side were Howard Bedford, Dick Hanrahan, and Jim Hamlin. Jim was the first Houston operations manager for the RTCC contract and it was Jim who had

119 initially attempted to put the software development on an engineering basis and did a lot of good in that area. I worked on the launch program of Mercury, where we took the high speed data from the GE-Burrough guidance computer and from the impact predictor complex, processed it at Goddard and read display information back down over the high speed lines to the Mercury Control Center. Initially, at Goddard we were going to support just the Mercury Atlas portion of the flight program, but when the flight program slipped some, the Control Center implementation stayed pretty much on schedule so we were able to support the Redstone Program as well as the Atlas Program. The first flight that we supported out of Goddard was Mercury Redstone I. During this period of time the building construction at Goddard (building No. 5) had lagged considerably. Actually what we had at that time was a shell of a building without doors or windows and in the center of this shell was a room completely finished off with airconditioning and power and a temporary wall inside the permanent wall. Within this room were the IBM computers and the associated communication equipment to allow us to operate with Cape Kennedy. There was no parking lot, no bathroom, no doors or windows on the building. To get in you walked through the mud, and they had a big piece of canvass hung over where the doors now are, and you would track mud into the computer room. We had considerable problems contending with mud and dust and dirt in keeping the computers running.

56-2 The first attempt to launch MR-1 resulted in a shutdown in the Redstone. The escape tower was jettisoned and the spacecraft sequenced through the entire flight while still sitting on top of the Redstone on the pad. This was somewhat traumatic for us up at Goddard because

we got all the telemetry events--tower jet, Redstone cutoff, etc., and we weren't quite sure if the system was haywire or if something was radically wrong down at the Cape. Finally the flight dynamics officer was able to brief us on what had happened and we felt considerably better.

93 Despite the problems at the Cape and the impossible working conditions at Goddard, the computing and control systems worked beautifully.

119 As Apollo and Gemini became approved programs, it became obvious that the Mercury Control Center at Cape Kennedy and the Goddard computing center were not going to be adequate to support either the Gemini rendezvous or the lunar landing. We began studies as to what the next generation Control Center should consist of, and one basic conclusion that we came to was that the computing complex, the Control Center and Flight Operations organization should be located in the same area. This was primarily because of the close contact that would be required between the computing support and the flight controllers as the realtime flight planning aspects of the computing system grew in size and complexity. While still in Virginia we wrote an RFP for the computing complex.

93 At about the same time, John Mayer established the Realtime Program Development Branch and I was selected as its Chief. At the time we came to Houston, the Branch consisted of me and two other people. It presently has about 57 people. The job of this Branch is to manage the realtime computer complex contract. We went through the evaluation of the proposals in mid-1962, and selected IBM as the RTCC contractor in October 1962. Around March 1963, Philco was selected as the Control Center contractor with responsibility for the equipment in the Control Center other than the computing complex. At the time we let the contract

we had a very tight schedule for project Gemini. One of the requirements of the RFP was that the computer contractor immediately establish an interim computing facility and start the software development for Gemini. IBM constructed a building on the Gulf Freeway down just below the Houston Petroleum Center where the Flight Operations Director te had offices at that time and installed the first 7094 computer in January of 1963. This only took about $2\frac{1}{2}$ months after the contract had been awarded (The Suniland Furniture Company now uses that floor space to sell budget furniture). From January 1963 until November or December 1964, the whole Control Center was in a detailed design, specification and implementation phase.

The Mission Control Center--the control rooms, the computing complex, and the display and control equipment--was designed to support the Gemini rendezvous mission and the Apollo lunar landing mission. The basic capabilities of the Control Center were designed to support a mission and a simulation simultaneously. This concept led to the decision to have two control rooms, which would be able to support the two operations simultaneously, the associated equipment for each, and the computing capacity to support both. One of the things we learned from Mercury was the need for simulation capability. In Mercury we used the procedure trainers to some degree but primarily depended on trajectory tapes and spacecraft systems tapes that were sent out to the network and played back in real-time. This was what has been called an open loop simulation. "Open loop" means any action the flight controller or crew takes has no effect on subsequent data. However,

306-1 rendezvous in the Gemini program or for the lunar landing mission requires a significant degree of maneuvers in earth orbit, translunar orbit, or lunar orbit. This means that a predefined flight plan is infeasible. The magnitude of the maneuvers and the times of the maneuvers must be adjusted depending on the time and place and orbit of the spacecraft in the mission. The flight plan also changes according to dispersion or malfunction. In order to train flight controllers for this kind of dynamic situation it was decided that a closed loop simulation was required. "Closed loop" means that any action the flight controller takes he is going to have to live with, because all subsequent data is going to reflect the results of that action. As a consequence, we could not use taped data as in the past. The technique selected as a replacement was to provide a software system called a ground system simulation computer. It simulated the network and the spacecraft systems and would accept commands and other information from the flight controllers and would respond appropriately. Data would be adjusted to correspond to whatever the particular action was. The open loop simulations were extremely useful in Mercury. The closed loop simulations used for Gemini and thus far for Apollo have been superb.

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306-1 Another item in the Flight Dynamics area was carried over from Mercury. In the Mercury Control Center we had a very limited number of digital displays. These were so called binaview (?) displays. Consoles had built-in units which could be accessed by the computer and would present digital information to the flight controllers. One of the problems

277-1 we ran into was lack of flexibility. In that type of display system, only as many digits could be presented as there was binaview (?) display capability. It was difficult to program the computer to present different information at different times.

306 277-1 When we developed the display system for the Mission Control Center in Houston, a digital television display system was employed. It can present a large volume of digital information to the flight controller on a single display format. It has considerable flexibility in terms of display system.

277-1 Another great difference between the Mercury Control Center and the Mission Control Center in Houston had to do with computing requirements. The computing required to support the Mercury Control Center was 100% flight dynamics or trajectory related computer processing and display. All of the telemetry data was handled either by low speed summaries back from the network stations or by analog devices which presented the telemetry information to the flight controllers in the Control Center at the Cape. After coming to Houston the telemetry processing was included as a part of the realtime computer complex, and actually now in terms of the size of the computer program, about 60% of the program is telemetry related processing.

306 306-1 One other consideration which has always interested me is the growth in computing and communications capability. They seem to go hand-in-hand. During Project Mercury, the only high speed communication we utilized was in transferring trajectory data from the Cape area to Goddard and this was a thousand bits per second. On the other half of that line

display information was transferred from Goddard back to the Cape also at a thousand bits per second. The communications with the network were limited to teletype traffic. There was concern over the possibility of losing communication between the ground and with the spacecraft and as a consequence, an alternate Control Center to support launch and launch abort was built at Bermuda. We have gone from that kind of environment to an environment now where the network is fully remoted. There are no flight controllers at the remote sites. We are completely dependent upon communications capability to get back to Houston to support the flight. We supported 502 (Apollo 6) in a completely remoted configuration. We have 40.8 kilobit interface with Goddard and Cape Kennedy.

306 The growth of communications both in terms of band width and reliability has been tremendous. Interesting enough, as we get more and more capability to bring data back to a central point, the processing requirements for that data grow correspondingly. So we have had a kind of a foot race between computing capabilities and communication capabilities, and at this point they are running pretty much neck-and-neck. The next generation of computers seems to be able to absorb the increased communications capability of comsat and other innovations.

306 A problem that we grossly underestimated when we designed the realtime computing system in the Houston control Center was the impact of the TV display system on the size of the computer program. The computer program required to support Project Mercury used an IBM 7090 computer

at Goddard capable of handling 32,000 words of code, both in instruction and data. It expanded through the Mercury program to roughly 45,000 words of code. The output was approximately 50 parameters for flight control use. In comparison, the Gemini computer program ran on an IBM 7094 computer. Its size was about 525,000 words of code, and with the TV system it could output thousands of parameters for the flight control use. The thing that allowed the flight controllers to access this much data and correspondingly affected the size of the computer program, was the flexibility of the television display system. We had approximately 500 different TV formats for the Gemini rendezvous support available to the flight controllers during the mission. These formats could contain up to around 100 parameters in digital form. So in initial planning for the Mission Control Center, we really underestimated the effect on the size of the computer program that the television display system was going to have. Fortunately, we were able to obtain the additional storage that was required. For example, when we started off, we estimated it would take about 98,000 words of core storage to do a Gemini rendezvous mission. As it turned out, it was over 1/2 million. The operations wing of the Control Center is laid out on 3 floors, which are equivalent to a five story building in height because extra ceiling height is allowed for the tiers in the control room and viewing room. A mission operations control room and associated staff support rooms are located on the third floor. Also on the third floor is the recovery control room. The second floor is a duplicate of the third floor, except for the recovery control area, which services both floors. Our first floor

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consists of realtime computing complex, the communications equipment, and the pneumatic tube equipment. The display equipment associated with each floor is located on that floor.

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In our original schedule, we felt that the Control Center was not going to be ready to support Gemini until the first rendezvous mission. The Control Center at Cape Kennedy and the Goddard computing complex would thus support the first four Gemini flights. As it turned out, the Gemini flight schedules slipped some, and at the same time, the schedule for the Control Center held reasonably well. So the Control Center was actually used as prime support for two Gemini flights prior to the Gemini IV and V rendezvous missions. By about June 1964, most of the equipment had been installed in the Control Center, and testing had begun. By the fall of 1964, it appeared that we might be able to use the Control Center in an engineering test environment for Gemini 2 which was scheduled for December. A team of flight control people were located in the Center and the Control Center supported Gemini II on engineering test basis when the mission was flown in January 1965. We still didn't have full display capability, and we only had about 12 channels of TV as opposed to the 28 which were operationally required, but we had tie in to the launch area, we manned the flight control consoles, and we had display capability. This test also taught us how to establish a countdown to prepare the Control Center systems to support a launch. We also learned quite a bit about procedures for handling the Control Center systems during the premission and mission period.

306-1 We brought the Control Center up for Gemini III with essentially the same people but with different emphasis. Gemini 3 was a test directed by Flight Control and supported by the development people. John Hodge and Glenn Lunney were the flight directors for the Gemini 3 support, and this was a full test of the Control Center as an operational mode. In Gemini 3 we learned enough to commit the Control Center to prime support for Gemini 4. This was a difficult decision for Kraft to make, as there was a fair amount of testing left to do and not too much calendar time left to do it in. But the Control Center turned out to be ready for Gemini 4, which flew in June 1965.

306 The Control Center was built and went operational in roughly two years. Strange as it may see, it was in this period, around mid-65, that we began doing some detail planning on phasing over to the second generation computers in the realtime computer complex. The computer programs had been much larger than we had anticipated, and the response time and volume of data was higher than we had anticipated. What this meant was that we were right up against stops both in storage and computing speed. When Headquarters directed that the last Gemini flight would fly in the fall of 1966 and that there would be no Gemini flights in calendar 1967, this meant we had a firm termination date for Gemini support, and could begin planning to phase over to the second generation computers. We prepared a modification to the IBM contract and this was presented through the management chain up to Headquarters. It involved the phase-over to the second generation through an extended contract. Both the Gemini and Apollo programs had slipped some in calendar time and we needed to cover the realtime computing complex contract

for a longer period. There was considerable discussion and reservation at all levels of management in regard to the wisdom of sole source selection of IBM--not so much for the programming aspect, which everybody seemed to be unconcerned about, but rather computer procurement.

306 Dr. Seamans in July 1965, appointed a committee which was to be chaired by MSC and would have representatives from Headquarters, Bellcom, and other NASA centers. The task of this committee was to review the requirements for the phaseover and to recommend how the phaseover should be accomplished. John Mayer of the Flight Operations Directorate was the chairman of this committee, and I was a member. We reviewed the requirements for the phaseover, the available computing hardware that was capable of supporting those requirements, and prepared a report and a briefing for Dr. Seamans. The recommendation was essentially the same as the procurement package we had prepared. The primary concern of the committee was the length of time required to get the second generation computers operational.

306 As it turned out, it was a well founded concern because we had considerable difficulty in getting the 360-75 hardware and operating system software operational. In fact, they were about 5-6 months late. The recommendations of the committee were concurred in by all levels of management within NASA, and the contract was amended and the phaseover of the computers began. We got the first 360-75 in about May 1966.

374-1 The first mission that we actually supported with the 360-75 was the 501 mission. That was in November 1967. However, the system was really ready to support it in about April 1967. We had a very good system, As good as the 7094's had been in April of 1967. The support to the 501

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mission and the LM-1 mission and the 502 mission has been superb. The second generation system has actually considerably out-performed the 7094's in capacity, and it has been as stable or more stable than the 7094 system was at the end of the Gemini program.

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We had our problems with the hardware and with the 360 operating system during the phaseover. IBM did an excellent job in solving those problems. We have an extremely good computing system. We did the right thing in phasing over even with the problems that we had. I really don't know of anything that we would have done differently during the phaseover from a technical standpoint except to allow more schedule time for development.

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In staffing for the IBM contract some of the management techniques that we have used have been developed by a combination of IBM and NASA people. Initially, IBM worked for us in Houston and was made up primarily of IBM programmers that had been associated with Project Mercury at Goddard. The manager of the programming effort was Howard Bedford, the lead programmer in Project Mercury, and toward the end of the Mercury Program project manager of the IBM effort at Goddard. Mr. Bedford can staff an organization better than any single person I have known in my life. He recruited and hired a large number of very competent software systems personnel.

The fact that we were able to build and to test a system as large and as complicated as the Gemini rendezvous system turned out to be, is almost entirely due to the quality of people that IBM was able to acquire and put on the contract. In mid-65, Mr. Bedford was transferred another job within IBM. We were fortunate that IBM chose Mr. Richard Hanrahan as his replacement. Dick had also been a programmer

on the Goddard computing system for Project Mercury from the very beginning. At the time he transferred to Houston he was a manager of the Goddard operations for IBM. It was with Dick Hanrahan and John Lilley that the management techniques, which I am about to discuss were fully developed.

306 In my experience with computer programming, it has always been difficult if not impossible, to lay out a firm schedule for putting together a computer program. The software portion of the computing systems was more of an art form than an engineering job. The standard response by a computer programmer to questions regarding schedule, why it took so long, what really had to be done to test the program, or how long it was going to take to test it, was "you just don't understand computer programming." This was made more difficult by the fact that such tools were not available from industry. As the realtime computing complex software problem grew, we began attempting to develop management tools so that non-computer programmers could understand the development problems associated with software and schedules. We have been fortunate enough to hire some people within NASA who had been associated with the Sage Project, and they had some good ideas regarding software management based on that experience. We largely developed our own techniques and controls which fell by and large in two areas. One was development planning and the other testing of the software system.

314-1 We set up what we called a development plan. This was a plan put together for each mission support system. It contained a line-by-line item of each processing capability that had to be coded for that system

with target dates for completion of subsystem and final system. The plan included the test specifications required to test the system, and estimates of computer time required. The thing that made this workable management tool was the fact that IBM used it as a working document. It was reviewed internally within IBM by their Technical Management once each week. The IBM resources and work effort was controlled by the development plan and the results of the development plan review. In addition, the development plan was reviewed weekly with FOD management. We began using the planning information more and more and both IBM and NASA people discovered additional information that should be included.

374-1 The result of this effort is that we have now standard management techniques and information for developing large scale software systems. Within the Flight Support Division we have used these same techniques-- development plan concepts, system test concepts, tape control concepts, discrepancy reporting, and clearing concepts and procedures--to all of the other software systems which are developed by FOD. These include the MIT development of the onboard software for Apollo, the development of the simulation checkout and training systems software within the Control Center, and the development of the communications command and telemetry system by Univac also within the Control Center. These management techniques have been the biggest fall-out of the RTCC development. We have discussed these techniques with various people around the country who are involved in software system development, primarily the DOD and Aerospace Corporation personnel in the MOL project.

In addition, IBM has applied these same techniques as standard practices for other software developments within its Federal Systems Division. The people who deserve major credit for development of these management techniques were Dick Hanrahan and John Lilley of IBM and Jim Stokes who is not the chief of the Flight Software Branch in FOD.