Interview with James M. Satterfield
3/13/68

I came to work at Langley in February 1959. I was working for Hastings Instrument Company in Hampton where 3 of us were involved in engineering. It was a fairly small company making specialized pressure instruments and radio navigation systems. One of the boys in Engineering, named Bill Boyer, went to work for NACA in early 1958 and talked with me off and on about what he was doing. NACA became NASA in October 1958, the Mercury Program got cranked up, and the Space Task Group was started. He talked to me about coming to work for NASA, and finally I put in an application and was accepted.

The first job I had was with Barry Graves in the Instrument Research Division at Langley. Somewhere between February and April, the need for a network to support Mercury became apparent. The Space Task Group was on the east side of Langley Field in some of the old buildings. There was some question as to how they would go about getting the network cranked up. It was decided that since the Instrument Research Division had done instrumentation jobs in support of the research effort at Langley that a reasonable way to do this would be to form a special group drawing on the guys in IRD to select a contractor and monitor his performance on the job. I was asked to join that group and did.

We started out with about 10-12 people under Barry Graves and Paul Vavra in what we called the Tracking and Ground Instrumentation Unit of IRD. We got familiar with the needs of the Mercury Program insofar as tracking the spacecraft and supporting the flight controllers with data. We essentially laid out what the ground network ought to be and the station layout - what they out to have, where they ought to be. We wrote a statement of work which was fairly detailed. At that time Langley didn't do business the way we do nowadays, hiring a contractor to do the design work. We essentially did most of the design work ourselves and laid out what the equipment ought to be. We operated under Dr. Silverstein's various ground rules about putting computers and the communications switching at Goddard. We wrote our statement of work, advertised it, and selected the contractor, Western Electric.

At the same time, we felt we needed some assistance on some aspects, so we hired Lincoln Labs, on a consulting contract. They provided a good deal of assistance all through the life of the contract.

Meanwhile, the program was chugging along and it was obvious that we couldn't get the whole network together for the first series of shots, particularly the early Redstone suborbital flights. We decided we ought to put the emphasis on the facilities that would support the early Redstone flights, ~~and they called~~ Bermuda and the Cape CANAVERAL ~~- the~~ downrange facilities. In October 1959, after Western Electric had gotten onboard, we became a little more familiar with how DOD operated, what kind of support we were going to get from them, and what kind of problems we might expect. During this same period of time, even starting back around 1956, DOD had its own ideas of launching a man in space program and it eventually ended up being the Dynasoar Program. DOD also had its ideas on what kind of a network would be required to support such a program. Since the military had the Cape Canaveral missile range which extended down to the tip of Africa, they felt it was fairly reasonable extension of that range to tie it in with the Pacific Missile Range, add some stations in Australia and the Pacific areas, and come up with a network. But they were never able really to sell the plan, and in addition they had problems ~~selling~~ with Dynasoar. When we got into the picture, there was a good bit of consternation among the DOD folks that here was the Space Task Group--a group of people who didn't know a whole lot about worldwide operations, and yet were trying to implement a tracking network and trying to run a manned space program when all we had done was advise people on how to build airplanes. General Yates who was the commander of the Atlantic Missile Range urged Dr. Dryden and the Administrat~~ion~~or, Dr. Glennon, not to give the network contract to Western Electric, but to let the military do the work. But we had already signed a contract with Western Electric. Yates said in effect, you have already made one mistake in giving it to Western Electric so why don't you just let us operate it? Glennon ~~nearly~~ agreed with him except by then we had already picked nearly all of the sites for stations, and there were some in Africa and some in Australia. The State Department informed Glennan that the countries we had signed lease agreements with in Africa and Mexico had specified that there would be no military implications to the program. This was also a restriction imposed by Mexico because at that time there was a good bit of propaganda activity, pressure, and threats from Russia and Red China. So these African countries and Mexico were very careful, and in all of our agreements we had to exclude any kind of military participation. The State Department also advised us that it would be very unwise for the military to operate those stations for us because of this sensitivity. Glennan did agree that the military would support us at Cape Canaveral and downrange and on tracking stations on ships, in Hawaii, and in the United States. The DOD divided the work among the various ranges

that were closest to the tracking stations. PMR ~~would~~ wound up with Point Arguello, California, Hawaii, and Canton Island, and White Sands wound
53 up with Texas and White Sands. The Atlantic Missile Range wound up with
54 the Control Center and the facilities at the Cape area, the GBI and Grand Turk stations, and the 2 ships. That meant that what we had to do was to take our contractor and try to figure a way of integrating our generalized remote station design into what was already available from the military. In some cases what was available was either nonexistent or did not exist to the extent we had been led to believe. [The DOD had seen in the Mercury Program a good opportunity to build up its facilities with somebody else providing the justification.]

Since we had to get the Cape and Bermuda going pretty quickly, it was decided to get somebody down there because there was more to getting the job done than just having our contractor go into a remote area and build a facility. In October, Barry asked me to go to the Cape, and live there while I got that operation going. At the same time, one of the other former Hastings boys, ~~named~~ Dalton Webb, who had come onboard about 3 months after I did was sent to Bermuda to get that station running. Bermuda was one of the stations we operated ourselves through an agreement with Great Britain. That station was built on land that Great Britain had given us in exchange for the destroyers we gave them in World War II, and we had several plots of land which were reserved for our use based on the 1942 destroyer deal.

I went to the Cape in the first part of November. We had already gotten a building on the Cape itself to use as a Control Center. It was a photography warehouse. We moved the photography people out, and after looking at the building we decided it would be necessary to build a wing on the thing so we could get a Control Center that didn't have columns and posts in it. We had our A&E contractor who was working for Western Electric do that design work for us, while a team of NASA-Western Electric engineers sat down with the range engineers and laid down our generalized ground station plan against what already existed. We worked up an integration plan whereby we would put in some equipment and DOD would let us use some of its equipment. Together we ~~would come~~ came up with a total tracking facility. We wound up ~~pulling~~ putting in the telemetry receiving station and the voice transmitting and receiving equipment. DOD supplied the command transmitters, the radar system, ~~the telemetry system~~, and antennas both at the Control Center building and at another backup telemetry facility.

It took about 6-8 months to get through the negotiations. It was a difficult job because the DOD was accustomed to having missile contractors who would come in, shoot a missile off, and only aske the range to record telemetry data. Under such an arrangement, the range would decide what of the existing equipment its people would use, how they would use it, and how it would be set up. Now we were coming in telling them we were going to put in some new instrumentation of our own. We got it all done, went downrange to GBI Grand Turk and arranged for space in some existing buildings there for our specialized telemetry gear and to erect our antennas. We had very good cooperation from the technical part of the range. [Although General Yates was a headstrong man, he was also a real smart guy and real fair.] With Walt Williams' experience at Edwards in working with the military, he was 58 able to pave the way in our dealings with General Yates and this helped us get a lot of problems solved and a lot of potential stumbling blocks removed. General Yates had a staff meeting every week on the Mercury support and there we aired our problems and what we would like to do. His firsthand knowledge of what was going on and his ability to react quickly helped us out in a number of instances. For example, we needed some tracking ships. 56-1 Our original plan called for the use of some surplus liberty ships which would be run by MSTS. He felt that would be a waste of national resources because he had some ships that would do the job. He told the range contractor that he was going to give us two of the range ships and they would have to figure out how to support the DOD range programs with what they had left.

We had some problems checking out the stations once they were built around the world. We were planning on using aircraft and we wanted to get some airplanes from the range or from the military stockpile. The range 56-1 people figured their airplanes could do the job very well. As it turned out they couldn't because they were basically telemetry receiving airplanes 62 and what we needed was a flying spacecraft mockup inside the airplane that radiated as well as received. I explained this to Yates one day at the staff meeting and that afternoon he called General White at the Pentagon and within a week we got two C-54's. [He was a difficult person to get to know, but he was straight forward in his dealings and fair and you knew where you stood with him.]

We got the Control Center going although we had a fair amount of problems with the existing operational structure. The standard practice was to run the range through the superintendent of range operations and the people who were using the data they collected were never involved in the operation. Tapes and data records were simply delivered after the flight was over. The important thing in the Mercury operations was real-time flight control and in that the range had never had any experience. The only realtime control they had was command-destruct in blowing up the booster if it went off course. We finally hammered out an agreement whereby RCA technical people who were going to support us in the control center would work directly for us without having to go through the superintendent of range operations. The flight director could ask for a certain job to be done in the Control Center and get it done quickly.

We were about finished on the control center when MA-2 was launched into the rain. We were not really supporting it because most of the equipment was not ready, but we did get some records. We were ready for the Redstone Program and we supported all the Redstone flights. We continued to develop our policies and practices of operating with the ranges. A military man, General Yates, was coordinator of all DOD support for Project Mercury. He worked with the Pacific Missile Range and White Sands as well as his own range to establish procedures as to how we were going to tie together the various elements of the range to make a complete tracking network out of it. After much work we developed an operations document that would provide common ground rules for anybody operating a station whether they were Bendix people in Nigeria or Mexicans in Guymas or US range contractors in Texas.

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During this time the computers were at Goddard and we were having a number of problems getting data up and back from Goddard. Here again we were plowing new ground. No one had ever transmitted high speed data over telephone lines for long distances, essentially in real time, and using this data to make decisions on. We measured the position ~~o~~of the spacecraft at booster cutoff and sent it to Goddard. The Goddard people used this data to predict the projected orbit to see if the spacecraft could get around at least one time. They then relayed this information back to us on telephone lines and it was used for the basis of a go-no go decision, which had to be made in a period of about 30 seconds. The booster would impact in Africa if it weren't going to make it and we had to know in time to cut it down before it got to Africa. The telephone company had had a good deal of experience piping television signals around the country and they had experience in what to do when the lines broke and in switching to new lines. But the characteristics of the circuits that were required for the television signals were greatly different from those required by the realtime data system of ours. When they would switch in new links on us it would foul up our data system and we would lose data until they got the lines set up again. [They didn't have good test equipment for measuring what was going on on the lines.] In addition, we were using our own devices at each end of the line to condition the signal, so quite often the telephone company would suspect that the problem was in our own equipment rather than in their lines. I talked to Lincoln Lab people like Dr. Herb Sherman, Ronald Entignap, and Jack Arno, and Jack suggested that we ought to go tell them what we were trying to do. I set up trips to the various telephone company centers with the help of the telephone company representative (who?) working with us. I set up meetings in Orlando, Jacksonville, Atlanta, Charlotte, and Richmond--the principal centers that our circuits went through. I went to each of the places between Shepherd and Glenn missions and told the guys how we were using the circuits and what we did with the data we got over them. I showed them movies of Al's flight, of the control center and facilities at Goddard, and how we worked. I told them they weren't just piping around a football game; they were really piping around data on which somebody's life depended. The results were very encouraging - the service improved after the people better understood what we were after and were made to feel that they were part of the program.

In attempting to get John Glenn's flight off we ran into all sorts of problems with the ground support equipment. When we finally got the flight off, there was all the anxiety that went with the uncertainty as to whether the heatshield was securely hooked on or not.

During the latter part of 1961, Jim Chamberlin had begun planning a 2-man spacecraft and we had already embarked on the Apollo Program. MSC was getting ready to relocate. My involvement with MSC was a result of location ~~rather~~ rather than organization ~~tenuous~~ because I started out at Langley in Tracking and Ground Instrumentation Unit which was part of Langley Research Center, not part of the Space Task Group. I stayed with Langley until the middle of 1961, when

Goddard was completely built and activated. At that time it was decided that the tracking guys had essentially finished their jobs and the operation of the network would go to Goddard, rather than MSC. Our people were then all transferred from Langley to Goddard. I was still at the Cape and I was transferred on paper to Goddard along with the others.

Because of the problems we had had with range support, and our ability to do things we wanted to do in our Control Center had been hampered by operating in somebody else's building with somebody else's troops, that fact was one logical reason for locating the control center in Houston. A more overriding reason was the inherent travel involved. Most of the Flight Operations Division had to pick up stakes at Langley and come to the Cape for each of the flights and in the early days when we had countdown holds the flight would take 3-4 months to get off. It was a real job for Kraft to be able to run a division and support a flight at the same time when the same guys were having to be moved around. They traveled about two-thirds of the year. For that reason, both personal and business, it looked like it would be economical to put the control center in Houston. Naturally, being an engineer and having been associated with the birth and growth of the control center at the Cape, I wanted to have a part in building the control center in Houston. Sometime in the spring of 1962, I talked to Kraft about the possibility of transferring from Goddard to MSC.

There was, however, a consideration that affected this transfer and that was the fact that I had graduated in 1949 from school and it was now 1962. We were using digital computers, transistor circuits, and a lot of other things that weren't in existence in 1949 when I graduated. I began to realize that I was having a problem directing the work on systems ~~that~~ to which I had never been exposed from a theoretical standpoint. I decided that I should go back to school and get more education. I already had made application to North Carolina State and what I planned to do was take ~~leave~~ LWOP commencing in September 1962. When I talked with Kraft about going to work at MSC, the buildings at the permanent site were just under construction. He and I agreed that I ~~should~~ could go to school during the 1962 -- 1962 school year.

I transferred to MSC in May 1962. During the first part of 1962, MSC had gotten a contract with Philco to study the needs of a new control center and to come up with general specifications for a control cneter. The study group came to the Cape and I talked with them about what we would like to have and the changes we should make in the control center, and then in the summer of 1962, I moved to Houston for one month and helped with some of the initial work -- getting the statement of work ready, and getting ready to select the contractor to build the control center here in Houston. We also had a good bit of involvement with the Dynasoar people. They were chugging along and they needed a control center and some advice so we worked closely with some of their Boeing people for about 6-8 months during 1961-62. We explained to them what our experiences had been and we gave them a lot of information and spent a good bit of time with them on developing their control center.

I went to school, returning briefly to Houston in December 1962, to review bids to build the control center. While I was in school, the decision was made at MSC to create a ground systems program office to monitor and manage the control center. Barry Graves and Paul Vavra, who had been in charge of setting up the Mercury network, came to MSC and took over that activity. Now in setting up the Mercury network there were some personality clashes, and we soon ran into the same sort of problems at Houston. I wasn't involved with the Langley operation long enough to understand all the implications, but there was a fair amount of animosity between STG and Langley people. I don't understand where it came from except that apparently a good number of STG personnel had originated in the Pilotless Aircraft Research Division at Langley that had been run by Faget. PARD people apparently never got along very well with anybody, probably because they were building little rockets on their own and making people put instrumentation in impossible places. There seemed to always be a problem with those guys on the east side of the field so to speak. We did manage to get along although there was still a lot of friction between Barry Graves and Walt Williams over who was doing what and how the network was supposed to be built. When we got down to Houston, there was a major policy clash between Barry and Chris Kraft over Philco's performance on the control center contract. Chris desired that the job get done with as few compromises as possible and Barry and Paul desired that Philco do an outstanding technical job, and they wanted to review everything Philco was doing. While the control center was under construction, Philco got fed up with the close scrutiny they were being subjected to. About this time the Ground Systems Program Office was disbanded: part of the guys stayed and formed a new division in E&D called Information Systems

Division. Part of them went to the Flight Operations Directorate and formed the Flight Support Division - (I think they called it Control Center Program Office at the time and later the Flight Support Division).

I was due to come back in September 1963. I came down in August and talked to Barry and to Chris. At that time I had come to the conclusion that I had gotten a lot of education at NC State and I would like to do some research work that would settle this education into my brain and give me some research experience. I talked to them in terms of not coming back here but transferring to Langley. Another reason I had thought of doing this was that I had great regard for Barry and Chris and Walt. I thought they were 3 of the best engineers, administrators, and managers that I had ever seen. I looked at each of their backgrounds and they all 3 had worked at Langley for a long period of time. While there were a lot of things that were done at Langley that a person didn't necessarily agree with, in terms of policies, etc., I felt there must be something of value there for such people to develop the way they did. I thought maybe a longer tour at Langley would help me professionally and careerwise as far as the Agency was concerned. I convinced them I ought to go back to Langley, which I did, and I spent 2 more years at Langley with a lot of the fellows from the former Mercury network group. I ~~was given a little organization called~~ headed the Tracking Systems Section that was devoted to research and development of new tracking systems and in general to the improvement of the state of the art and to support the Langley research effort in reentry programs.

While I was at Langley for these 2 years, I came to two conclusions: one was that I probably made a mistake in coming back to Langley because I found that I was doing more management than basic technical work. The other was that I thought I had done Kraft and Graves a disservice in not staying in Houston, as I understood things weren't too hunky-dory as far as the control center was concerned. [I also found out that even though Graves, Kraft, and Williams all cut their teeth at Langley, and I admired them, I found they were all gone from there which indicated that perhaps they saw greener pastures elsewhere.] I realized that in a research environment, you have to go slow, have to think about progress in terms of 5 year plans, etc., and my recent experience with Mercury had geared me to operate on a day-to-day fast-paced schedule which wasn't compatible with the kind of work I was doing at Langley. I called Kraft in the summer of 1965 and said I would like to come back down and help him with the control center. He agreed, and I took over the Engineering Branch of the Flight Support Division in September 1965.

At that time, the control center had been completed and had supported several Gemini flights. We still had some problems with a good bit of the equipment and procedures, and I did what I could to get it straightened out. I was involved in several organizational changes. The simulation group in the Flight Control Division had an equipment engineering unit headed by Jim Miller and we thought they ought to be in the Flight Support Division, so we convinced John Hodge to transfer that crowd over to us, which he did. This move generally improved our position.

The original contract that Philco had with NASA for implementing the control center ran out in the summer of 1965, and was extended for move to p 8

a year and in the summer of 1966, we negotiated a new contract on an incentive basis with Philco. It was a 2-year contract with a 3-year option.

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Because of the press of time on Mercury, we had to get the computer facility at Goddard set up and running. We put computers in a half finished building in a half finished Center--a tremendous handicap to overcome.

One of the problems we had with Philco was that they had had a lot of experience doing business with the Air Force. [Philco had made most of the systems decisions and the Air Force passed on the gross details.] As many companies found out with NASA, NASA engineers were sticklers for a fair amount of detail. When I ~~first~~ came to work ~~down~~ here, at MSC, we were doing business with Philco by Change Requests. We would tell Philco we needed something changed and they would design the fix. [I told our guys that as far as I was concerned there was no need in tieing up engineers to administratively review things that Philco was doing and that we should be doing the systems engineering and let Philco do the detail design engineering, installation, and fabrication, etc.] To get the right connotation we changed the name of the procedure from Change Request to Engineering Order so Philco would get the idea that it was an order from us and not a request, and it had to do with engineering of the systems. Systems Engineering is what some people call conceptual engineering or black box engineering where the problem is considered and a gross approach is agreed upon as to what kind of system is needed to solve that problem--such as what the major components would be. A decision might be made which calls for a system that has a computer in it, some interface boxes,

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and some signal conditioning and display equipment. What I wanted our guys to do was that kind of work, turn it over to Philco and let Philco worry about the design of the transistor amplifiers, the decision as to how big the box was going to be, what kind of metal slides it would have, do the wiring and interconnections, and make sure the signal levels were compatible from one box to another--in other words do the detailed work. [We got our people involved in that activity and away from reviewing what Philco had already done which in most cases was too late to correct anyway.] Under the Engineering Order scheme we would tell them what we wanted, give them a system approach, and let them come up with some specifications that we reviewed. They would then go ahead with the detail design. The original contract was a cost plus fixed fee contract. The incentive scheme of contracting had meanwhile become very attractive to everyone so the contract we negotiated for the '66-'68 period was an incentive contract that provided cost plus incentive fee. It provided for a number of tasks for Philco to do and then a common grading scheme. It was a relatively easy job to set up the grading system for operational support. These were the people actually in the control center who turned knobs, etc. If a box broke during the mission and failed to support it, then we could very easily grade them down. We did have some problems in the engineering area because we didn't know at the outset exactly what engineering modifications we would be asking them to make. We couldn't set up before hand a very objective way of scoring. What we had to do was set up a subjective scheme. In essence we would instruct them to do a task. Philco then gave us a schedule which provided for accomplishing that task. We compared the schedule with the actual performance We then knew from that and the design they actually came up with, how well they did the job we asked them to do. It was objective in some parts but subjective in the overall concept. That scheme helped as much as anything toward getting Philco to be more responsive to what we needed.

Recently we have made one more alteration. That's the specialized assignment of various design teams in Philco by area. In the past we had perhaps 200 engineers doing all sorts of jobs -- now we have maybe 20 engineers doing a display job, and say, 25 doing television, and perhaps another 15 doing a simulation job. They always do that job. They don't get shuffled around. With this dedicated force, we have been able to further improve our support from Philco. The incentive provisions of grading coupled with the requirement that we look at what they do and consciously grade them, has resulted in a very noticeable overall improvement in Philco's performance.

We ran into a lot of problems after we built the control center at the Cape, which we took into consideration when we later built the new control center. Our impression when we built the control center at the Cape was that we were building a facility for somebody to use to control a flight that they could fairly definitely specify. In other words, they could say I want so many channels of information on a strip chart recorder, they are going to be from a certain place, I want so many consoles, I want this information displayed, thus and so. We essentially tailored the control center at the Cape to the Mercury spacecraft and the needs of each individual flight controller who was involved in that thing and who was going to sit at the console and look at things. We had a fairly rigid system in terms of being adaptable to change.

We found out quickly that the flight controller's initial ideas of what they wanted to look at and their final ideas of what they really needed were quite often two different things. In particular this was true for the strip chart recorders, meters, and the things that were displayed on the meters. The things that were wired to them were quite often the things they didn't want to look at and we had to develop schemes using patchboards and internal connection blocks to be able to rapidly change what was being displayed in the operations room. Since We didn't build the system that way, ~~and~~ we ran into a fair number of problems. We ran into problems with meters because if a man wanted to look at cabin pressure for example on the meter and later on decided he needed to look at battery voltage, we would have to change the scale and change the calibration and that took an hour or so to get done. We found our communication system was fairly flexible and well suited to the needs of the job. When we started building the control center at Houston, one of the most important considerations was the display system and the need to make it flexible. We had a problem also at the Cape with the world map. It was a display that showed the world and the ground track of the orbit, and the way we showed the ground track of the orbits was to paint a line on the map. That was fine as long as you were going to use the 3 orbit Mercury mission, but when we got up into the 18 orbit Mercury follow-on missions, pasteing all these lines cluttered up the map badly. We ended up with a modified system where we had a projector hanging from the ceiling and it projected sets of ground track lines on the world map.

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It was evident that if nothing else, we needed flexibility in what was displayed and how it was displayed. It is obvious that you can't rapidly change the strip chart recorders and meters, so we looked around for a different kind of display system. We also looked for a display system that would be compatible with a computer interface. Up through the Mercury program we had a fairly straightforward old fashioned telemetry system that didn't require any computing. But in Gemini and later in Apollo, we had measurements made on the spacecraft that had to be compared with something else. We had to take rates and integrate them to get angles and positions. We had to have a display system that would also work with a computer, and since it had to work with the computer, it had to be something that was capable of being driven at a very fast rate and be changed rapidly. We looked at some various schemes of taking data out of a computer in a telemetry ground station and displaying it rapidly. It came down to the point that we needed a television monitor arrangement where we could display the ~~stuff~~ data on a television tube and essentially pick different channels for different kinds of information that we wanted. During the development of the control center design we looked into two different kinds of systems: one which used a special purpose cathode ray tube that formed letters, numbers, and lines by sweeping a beam across a mask and displaying this on the face of the tube and then taking a picture with the TV camera. The other scheme did this inside of a box that looked like a digital computer and generated all ~~this stuff~~ the letters, lines and numbers by virtue of the logic that was built into it.

Back in 1962, and early 1963, this electronic system was not fully proven so it was decided we should go with the tube system that was made by Stromberg Carlson and was called Charactron. It satisfactorily interfaced with the computers and gave a very fast interface to pass the data from the computer to the system. It gave us the capability of selecting a number of different channels, depending on how many of the special tubes we put in. Because it was a TV system, we could pipe the TV ~~stuff~~ anywhere you wanted to in the building and display it on any console with no more than just a coax cable ~~to pipe it along~~. That took care of our problems with strip chart recorders and meters by replacing them with TV tubes.

Then we turned our attention to the world map and the group display. We looked at a lot of different group displays, like edge-lit panels you write on the back of, electroluminescent displays that form letters and numbers by using segments of these electroluminescent displays, and projection plotters that projected the desired information from a slide onto a large screen. We decided that the projection plotters were ~~really~~ best suited for us although they did have some problems. A projection screen requires a fairly dark room or a tremendously bright light source to get any brightness off the screen. That was a problem. It was like viewing a ground glass from an oblique angle--it doesn't get much light. The angle at which the screen is viewed is restricted and the tolerances that have to be adhered to are tremendous because of the need to take a 35mm slide and project it onto a 10'x20' screen. When the picture is reduced back to slide form, there is a real problem trying to prevent distortion. The projection system gave us the most trouble, and it didn't get really operational until the latter part of 1965.

We bought the ~~whole~~ system which had been ~~from a company called Finsky, Fisher & Moore. They~~ developed ~~the system~~ in California ~~and sold it originally to~~ for the Air Defense Command Headquarters in Colorado for displaying the tactical situation. ~~They didn't do too good a job because of all the servo problems and mechanical accuracy problems they had. LTV bought them out and delivered the system to us.~~ After a fairly long development effort by partly LTV and partly Philco, we got the system to work.

Incidentally, we still have a problem in that area. There were a large number of change orders issued by Philco to LTV to get the system to work. LTV regarded them as changes in the scope and asked for more money. Philco regarded them as changes necessary to make the original system work and declined to pay it. They are still arguing over whether they are going to pay it or go to court. The system does work now and it is very good.

In the beginning, we had a 9-months' contract with Philco to define what we might need in the way of a control center. Some of the people working on that were Bob Cronhardt and Bob Murphy, and they and others later formed the nucleus of the Philco office here when Philco got the contract to build the control center. The man who was selected by Philco to head up their effort once they got the contract was Dr. Walter Laberge. I listened to LaBerge give the first quarterly progress report made by Philco in August 1963. Without a doubt Philco's performance on this contract was largely due to LaBerge's ability as a technical administrator. He was a very smooth talker and a very competent technical person. I believe he could sell anybody anything if he set his mind to it.

While I was gone and while they were building the control center, Laberge was replaced by Dr. Cortright. He had been Laberge's technical assistant and was a very competent though fairly excitable man. He deserves great credit in pulling the whole control center together into a smoothly working unit.

There were a fair number of problems during the life of the contract. We let a contract to Philco for the design and operation of the control center and supposedly to integrate the data system that IBM was going to build for us. We let a contract to IBM for the computer because without a doubt they had the capability to do the job over and above anybody else. They had done this job for Mercury and they were the only people who knew anything about realtime computer system design and operation. It was apparent from the beginning that Philco was going to have a hard time integrating IBM, because I suppose the white shirt and "think" philosophy of IBM and their feelings that they were pre-eminent in their field. They sure didn't want anybody like Philco telling them what to do.

The problem was that the computers had to talk to the display system. The computers were built by IBM and the display systems were being furnished by Philco. Eventually things got settled by sort of admitting to a standoff and having the NASA people more or less integrate the whole thing. IBM also made some changes in their management. ~~This was to plague us later because~~ in early 1966, we undertook the development of a new type of display system along the lines of the electronic system that wasn't quite available in early 1962-1963. We asked Philco to do it and they did it without very much consultation with IBM, and although Philco had been here for 3-4 years, they designed the system which wasn't compatible with the RTCC that IBM ~~was supplying.~~ had supplied. We spent a fair

amount of money for a systems specification and design that wouldn't work with the control center computer complex. We terminated that effort and physically made IBM and Philco sit down together and find out what each other did and how it worked. That's the problem you get when you get good contractors. If you don't have any problems with your
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contractors it is probably because neither one is worth a damn. If you have good people, they are likely to be temperamental and high strung, and if they are going to fight about something, they fight about it because they really believe in it. That's really the kind of atmosphere you want although it means you are going to have to control the flareups that will occur. At least you know you have good qualified technical people. It's a necessary incidental to getting the job done. It's like having to put up with the temperament of a genius.

We have a serious problem finding competent NASA people to monitor the contract. The problem is how you divide up all the work that has
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to be done. The kid fresh out of school, or the man from industry who has been doing a fair amount of design work, would like to have control and direction of what is being built. At the same time, it isn't realistic to hire a contractor to do a sophisticated job and then reduce him to a job shop operation where we do all the engineering for him. This is not logical. It is necessary to devote careful attention to how to divide the work that has to be done between inhouse people and the contractor people and still keep them all happy.

When I first came, about all we did was review what Philco was doing, and a lot of the people didn't feel they were involved in an engineering sense in what was going on in the control center. I tried to get them working on the systems, and let Philco have the responsibility for integrating systems and doing the detail design. When we get a guy in from school or industry we can now tell him honestly that there is an engineering job for him to do and he doesn't have to worry about being a contract monitor per se. The systems engineering part of his work is important as it establishes which road to start down. If you start the wrong way and have gone a fair distance, to deviate and get back in the right direction is right costly.

One of the things we found out at the Cape was that there was a good bit of training required. With only one control room, it's hard to train for a flight and change that control room around to support another

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flight, maybe of another vehicle. Early in the design of the Houston Control Center, before the contract was ever let and while Philco was still studying it, we decided we probably needed 2 control rooms. At that time the rationale was that Apollo and Gemini were going to overlap in their schedules and at the minimum we would need control rooms for

1ath Apollo and Gemini so we wouldn't have to change back and forth (they used different data systems and had different display requirements). We cranked into our conceptual design of the control center, a control room on the second floor and one on the third floor. We put essentially all the common use stuff on the first floor - computers, the communications, the interface with the outside world, the telemetry, etc.

We also had plans for a remote station here in Houston. That was

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another dream of ours--to have a complete tracking station here in Houston and part of the third floor was going to be this station. We would have an antenna outside. But subsequently, we found that the noise level in this area was a good bit higher than what we could tolerate to do good tracking and get good data from the spacecraft. We already had a station at Corpus Christi. We would have to justify tearing down an existing station to build one in Houston. When we put the Charactron display system in, we had sized the building on the basis of an electronic system and when we put this other system in, it took a whole lot more room, power, air and space, so we did ourselves out of that room. We were lucky to get what we did into that room considering we had to go to the Charactron System.

One of the aspects of the display system which was different from the old one, was that the TV tube won't furnish a permanent record of what is seen on video, in contrast to a strip chart recorder. We needed a way of recording all this data that was being displayed.
306 306-1 So we had built into the display system what we called a hard copy recorder, and which was nothing more than a 70mm camera which photographed a TV monitor. If a person wanted a copy of what he was looking he would push a button and that button would then signal this recorder and tell it what position the request had come from and what channel the man was looking at. It would then take a picture of that channel, make a print of it, enlarge it, and it would come out an 8x11$\frac{1}{2}$ print of what he was looking at on the tube.

This represented a fair message load that had to be distributed around the control center. The teletype messages represented another load.

Written messages constituted an additional load. It was obvious that we were going to have a lot of messages floating around. So we went to the department store pneumatic tube system for handling our paper traffic. We put in 3 systems; 2 automatic systems to service each control room (one apiece). They are automatic to the extent that they allow a message to be sent to a certain room at the push of a button after the carrier is put in the tube. It is then automatically routed to its destination. The third system was a general purpose system which deadheaded at a central location. The address was prewritten on the message, it would be sorted there and put in the right tube. The system worked very well. It provided for a volume of traffic that we didn't anticipate. During these recent 8-hour Apollo missions, we made as many as 30,000 hard copies of TV tube displays, which means 30,000 pieces of paper that had to be distributed around the building. On a long mission we have something like 40-50,000 messages per day that have to be distributed to various people who want the information. The control center is a combination of the old and the new applying each where it can be used.

We were also able to use a scheme that we basically developed at the Cape. We had a little room at the Cape Control Center that we called the Data Reduction Room. We had an idea that as the spacecraft came overhead, some of the program people would want to look at the records that were derived from the telemetry and make some judgment on them, so we provided a small room with chairs and a light table so people could stretch out telemetry records and reduce them. That was fine but they had to be able to tell somebody about what they'd found out. They had a communications loop and after looking at various parameters would call the important data over the communications loop. But there were times when we wanted to plot trends of things. We had a number of problems in Mercury on heater controls and inverter temperatures, and we needed to look at the trends, and it was hard to tell somebody a trend over the telephone.

As it turned out one of the pieces of equipment used with a tracking antenna is the television camera. It is used for boresighting to make sure the electrical and optical axes of the tracking antenna coincide and this is done by taking a television camera, mounting it on the antenna and focusing it on the target to see if the optical and electrical readouts coincide. It turned out we had an extra one of these cameras at Wallops Island at our test site. I got them to ship it down to us and we rigged up a little closed circuit TV system between this Data Reduction Room and the Operations Room. We put a little monitor up ~~there~~ where the flight director could see it and had the camera back in the Data Reduction Room. We were then able to pass this visual information around. That concept grew from Mercury to Gemini and Apollo in to the staff rooms that we presently have, in recognition that the system support required by advanced spacecraft like Gemini and Apollo is much greater than that required for Mercury. We couldn't have one man looking at the environmental system and another looking at the control system. We had to have a team of experts banded together to analyze all the data as it comes in. From this little room and relatively crude closed circuit TV scheme that we developed at the Cape, we have gone into the scheme of having 6 staff support rooms in the control center that support the people in the main operations room during the operations. They still have their closed circuit TV scheme but we call them opaque televiewers now. A TV camera is hung above their table and they can put on it any kind of written material, charts, or whatever they want to display. The TV camera views it and then it is available to anybody in the front room that has a TV monitor.

In some cases we had to do things in a bigger way. The communications, teletype, and data traffic is an example of not necessarily doing things differently but doing them in a bigger way. In Mercury we had a teletype system that routed most of our data and administrative traffic around the network, and we used a routing system that the teletype equipment people had developed. It read information that was contained in the first part of the message to tell the equipment where to route the information. In those days we had very few teletype circuits. We had one teletype circuit from each site and just a few machines at the Cape. Now here in Houston we have 11 circuits coming down from Goddard and about 80 customers Just in the control center. In addition we have a large number of high speed data circuits coming in. So we had to go to a computerized routing scheme to handle all of the communication interface plus the telemetry, high speed tracking data, and the teletype data. We have a new device we call a Communications Processor, which is a special purpose computer programmed to take the data as it comes in and route it to the right destination wherever that might be. It can do this very fast because it's a stored program computer operating in microseconds. In the Mercury days we had a data system that was comprised of teletype lines which fed data into a computer with no intermediate switching except to the teletype equipment itself. Now we have a proliferation of lines feeding into the control center from all over the world both high speed data, teletype traffic, and what not, which is handled by this computer, and then feed into the realtime computers.

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ORAL HISTORY INTERVIEW

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LOCATION OF DOCUMENT [Numeric Shelf Address] = 091-~~0~~4

SUBJECT OF DOCUMENT: [use relevant bold-face introductory terms]

Oral history interview with James M. Satterfield
[full name of interviewee]

about Mission Control Center, ~~and~~ tracking systems + contractor relations.
[main focus of interview]

Title: 1963 - Ground Systems Project Office, Info + Control Systems
[interviewee's current and/or former title and affiliation]
1968 - Systems Engineering Branch, Flight Support Division, Dir of Flight Operations

Interview conducted by Robert B. Merrifield - Staff Historian
[interviewer's name/position]
at MSC ?.
[location of interview]

Transcript and tape(s). [for inventory only: # pages 29; # tapes 1]

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CONTENTS:

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

Education -

Career Path - ~~Hampton~~ Hastings Instrument Co; 1959 1961 - Langley, Instrument Research Div.
mid 1961 - transferred to Goddard; 1962-3 ~~[illegible]~~ School NCSU;
1963-65 Langley, Head of Tracking Systems Section
1965 - Engineering Branch, Flight Support Div.

Topics - STG Mercury Program; Tracking & Ground Instrumentation Unit of Instrument Research Division (IRD); design of ground network; Contracts to Western Electric & Lincoln Labs; DoD Dynasoar program; military presence denied by some tracking station countries; partial integration w/ existing military stations; Bermuda station & 1942 land-for-destroyer deal w/ Great Britain; negotiating w/ DoD; station check out; Control Center Operations; common remote station procedures; computers initially at Goddard SFC; Working w/ telephone Company on signal transmission; MSC Control Center; MSC personality clashes; ~~Tracking Systems Section at Langley;~~ Philco Contract extension; Change from "Change Request" to "Engineering Order"; specialized assignments; flexible display system; TV monitor arrangement; Charactron; projection plotters for group displays; LaBerge w/ Philco; IBM - Philco relations; contract monitoring; decision for 2 control rooms

(OVER)

hard copy recorder in display system; pneumatic tube system for paper traffic; plotting telemetry trends; closed circuit TV; communications processor for high speed data, teletype traffic, etc.