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Oral history interview with Dr. John D. Hodge
[full name of interviewee]

about Mission Control, Communications, remote tracking, inter-center relations.
[main focus of interview]

Title: 1963 - Flight Control, Flight Operations
[interviewee's current and/or former title and affiliation]
1968 - Dir of Lunar Exploration Working Group

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

Transcript and tape(s). [for inventory only: # pages 27; # tapes 1]
master 1

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

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Education - _____

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Career Path - _____

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Topics - 1959 AVRO (Toronto) engineers join NASA; Jim Chamberlin accompanied advance groups; work for C. Mathews; pre-launch operations; remote site communications network (teletype); Redstone missions; Apollo command module ground support. GT&C (Grape) operations (Preston); flight control team make up; location of new (bldg) Control Center at MSC; Bermuda Station operations; control center Contract to IBM; Gemini 4 mission 1st for MSC (Houston) control; concurrent mission control capability; DOD-NASA Apollo tracking ships; Communications Satellites; Ground Support Project Office (GSPO) Shea new Apollo Prog Mgr; working rel. w/ MSFC & KSC; attempts to estab HQ Operations Directorate; need for better "future" planning.

1348

May 9, 1968

John,

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,

Bob Merrifield

BN

Bob, I've gone over this and marked up a few places. It's a bit incoherent and you'll have to do some organizing. Also some of my statements amount to conjecture.

I'm looking forward to your final product.

JUN 4 1968

check item ~ p. 10

Interview with John D. Hodge
3/15/ and 3/18/68

When the trauma occurred at AVRO Toronto and the program we had was cancelled, most of our people weren't aware that NASA existed as a space agency. Of course we had made a tremendous use of NACA material in the past and understood what it was and what it did, but that was the old NACA. Shortly after the program we were on was cancelled, Jim Chamberlin who was always a man who looked after his people, and Bob Lindley who was the chief engineer at AVRO began looking around for places to put people because it was obvious that the company would have to reduce drastically in size. Jim Chamberlin discovered that the new NACA ~~did~~ existed and that it did need some people. In fact, it was having a great deal of difficulty in getting engineers in the States to join the federal civil service to participate in this program.

I think Gilruth had about 75-80 people in the Space Task Group at that time and was desperately in need of more personnel for the Mercury Program. One of the people we interfaced with at that time was Abe Silverstein, ~~at~~ NASA Headquarters. When permission was given to hire us, I was quite impressed. Quite frankly I had always looked upon civil service in England and in Canada (and assumed it was the same elsewhere) as rather a lethargic thing, particularly in the area of hiring. But it was quite the opposite in this case because once the idea had been set up that we could be hired, Jim Chamberlin came down to Langley Field, talked to Bob Gilruth and got a complete rundown

on the whole organization as it was at that time, its people, and the slots that were available. Jim told Gilruth that there were 2000 engineers available at AVRO and recommended a couple of hundred that he felt would fit in the Mercury organization. The Mercury Project interviewing team came up to Canada on a Friday as I recall, it must have been around late February or early March 1959. It consisted of Gilruth, Chuck Matthews, Zimmerman, Kimble Johnson (who was administrative at the time for STG) and Paul Purser, and they very methodically went through something like 50 interviews in the next day and a half. Here we were all confronted with a Form 57 for the first time. We were completely unfamiliar with the techniques of filling one out and Kimble Johnson gave us a lot of help. We were particularly amused by such requests as where we had lived all the way back to goodness knows when. The next day, Sunday, Jim Chamberlin called about 35 of us together and said STG was going to offer jobs to us. There was intense interest among the AVRO people and they were telephoning all over Toronto to find out who was tapped and who wasn't. We had been a close knit team and were all very interested in what was going on. Within a week we had the official paperwork from personnel organization at Langley making us a formal job offer, and within a month people left for Langley Field.

Before we got there we had another hurdle to get over--visas. Under normal circumstances, it takes at least 4 months to get a visa because of the thorough checking that is done, but of course we had been dealing with the United States for some time with our aircraft program and most of us had security clearances through the Canadian Government.

The Canadian Government was very keen to see that the people in AVRO had somewhere to go, for which we were very grateful. The Company also was very good about helping us get placed. The Consul at Toronto facilitated the process of getting us through the system. Again we were obliged to fill out forms but we did that as a group because we descended on the Consulate in Toronto enmasse with our wives and kids, and all went through medical exams, x-rays, and filled out forms. I think we all found out a lot of things about ourselves that we hadn't realized before when we started looking at the family history; such as the date grandma was born, etc.

Jim went to Langley almost immediately with the advanced group, which was about 4-5 of the people and I stayed back in Canada helping to get the people organized who were making the move, and doing all the various things that had to be done. We were hoping for the possibility of additional AVRO people being hired. I think eventually another 4-5 did come to Langley in addition to the ones who came originally. My wife was about to have another baby so I stayed in Canada for another couple months and was one of the last to arrive at Langley. We finally got to Langley in April and by that time everybody had found themselves a job and were very enthusiastic about the whole program. It was just tremendously exciting, being able to come into an organization of this kind and start right on the ground floor. And again, we were caught up in the fantastic enthusiasm on the part of everyone. There was so much to be done and so few people to do it--I guess there were no more than 120 people in STG at that time. It is incredible when I look back on it how much work was done in that first year and a half.

During my interview, I personally got the feeling that Chuck Matthews and Bob Gilruth wanted me to be in what would be the Program Office part of the organization under Max Faget. By the time I got down to Langley, I ended up as a technical assistant to Chuck Matthews in the operations organization. Chuck had about 40-50 people at that time and was responsible for everything in the way of operations -- the Cape operations, medical operations, what became flight control organization, Mayer's present organization, and a large part of what is now Crew Systems Division -- were all under Chuck Matthews. Preston had I think 15 guys at the Cape, and was getting ready for Big Joe I. The guys were working in a small part of Hangar S, formerly used on the Vanguard Program. There really wasn't a great deal of publicity associated with the program at that time. People had a job to do and did it. It was still rather difficult to hire people because there was a concern on the part of most engineers that this kind of business wasn't here to stay. Maybe this attitude developed as a result of some of the Vanguard problems.

After I went to work for Chuck I concentrated first of all on prelaunch operations. These were things that had to be done at the Cape, such as the interfaces with the AFMTC, what kind of checkout we were to have to do, what kind of testing we were to do, whether the vehicle was designed to be used for manned flights, whether it had the right kind of redundancy in it, and how we could maximize our successes. Booster technology was built on the principle that the vehicle was something that had to work for only a few minutes but had to be very

highly reliable. We had to meld booster technology and aircraft technology because we were putting a man into the system. It was a fascinating problem particularly from an operational standpoint. One of the things we started to look forward to was what sort of a schedule we would be working on when we started flying the manned flights, rather than test flights. We spent quite a bit of time at McDonnell, as I remember, particularly in the area of ground support equipment requirements, and determining how we were going to check out these vehicles when they got to the Cape. We had written a contract for 19 capsules (spacecraft) and the contract didn't include any support services associated with checkout at the Cape. We had to spend a lot of time deciding what kind of telemetry vans we needed, how we would phase the McDonnell people into the operation, how the crew would fit into the system, what part of the checkout would they be involved in, how we would insure that we had a good system when we first lifted off. It was a completely new business, melding a man into that system. We got a lot of help from the Redstone people who were involved very heavily with the first manned flight and they gave us a lot of information on the early booster flights. The Atlas people and the McDonnell Company had a great deal of experience in aircraft and so we got good help from them.

I believe that Walt Williams came in at that time as a deputy to Bob Gilruth. Specifically for operations to pull this whole thing together because it was obviously getting bigger and more complex. Walt, I guess had really fathered the X-15 program, and it was the closest thing that we had done to date that could be compared with

space flight. There was a clash of personality between Chuck Matthews and Walt; they had a different way of doing things. Sometime later, Preston's outfit had moved to the Cape because it was obvious that we needed a fairly significant base there. Although a contractor was to do most of the checkout, a fairly large number of NASA people were required, so Preston went down to head up what was called Cape Operations. Chuck moved out to do more advanced work in the engineering and development area. Chris Kraft took over the flight operations organization.

At that time, I had to decide whether I was going to go down to the Cape with Preston or stay at Langley, and I decided to stay at Langley. I had become less interested in the Cape Operation than what was being done on the network. I got heavily involved in the preparation of the RFP to build a network. The contract was eventually awarded to Western Electric and we shifted our concern to the Control Center. Chris Kraft together with Tec Roberts, another of the AVRO people, had been largely involved with the establishment of requirements for the Control Center and I was assigned the remote site and network aspects. We had to determine for example what kind of people we would need on the ground to help the flight crew, and how we would get this information back to central sources. We had to find someway to get it back to the control center so that key decisions could be made. We started off with the assumption that we were going to have to have some people at the remote sites because that was the best way to interpret the information. We didn't have worldwide communications

networks in those days. It's amazing it's just 10 years ago and yet worldwide communications have improved by orders of magnitude. We wanted the people there to look at the information and then send back teletype messages stating what was going on as the vehicle went over their particular site. I got quite involved in establishing the configuration of the remote sites, how many people we would need, and where we were going to get these people from. The term CapCom (Capsule Communicator) and systems monitors came up at that time. It seemed very logical to us that the best place to get flight controllers for the Mercury program (that was the one we had to solve and there wasn't too much discussion about programs in the future), were the people who built the vehicle. Use these to interpret the data and give the information to the man who was in charge of this team who became known as the flight director later. We went to Max Faget and asked to borrow systems engineers. We would provide the capsule communicators and would put teams together to go to the remote sites and control center. That was the way we ran the first mission.

The Redstone missions of course were run strictly from the Cape we didn't need the network because they were of short duration. We made a great deal of use of the Air Force facilities. We have had a tremendous amount of support from the DOD. In fact, they gave us everything we needed down at the Cape in the way of facilities to get started. These people were extremely cooperative as were the Air Force people on Atlas and later on the Agena vehicle and the Titan vehicle. And of course the Navy gave us tremendous support in the recovery forces.

The question of whether the Space Task Group would be a continuing thing or not concerned many people. When President Kennedy announced there would be an Apollo Program, the question was answered. All of us expected to move to Beltsville at that time. For a time the STG was a part of the Goddard Space Flight Center and a lot of the equipment around MSC still has GSFC written on it. When the Apollo Program was officially announced it became obvious that it was big enough so that it would require a Center of its own. We were redesignated the Manned Spacecraft Center, and the question of location came up again. Coming from outside the country, I wasn't even sure where Houston was when I first came into the States. I knew it was in Texas but that was about all. And even after we decided to come down to Houston, I think most all of our people wondered just what Houston would be like. At the time the decision was made to move to Houston, I think we were about 900 people. In the operations area by this time we had become quite a bit more sophisticated. We had never had voice lines around the world and couldn't talk to the remote site people. We thought teletype communications would be sufficient, but it became obvious quickly that things happen more quickly than you can handle effectively through use of a teletype. So we started putting voice lines to the more prominent sites like Bermuda and the Canary Islands and eventually set up a worldwide communications system. The Goddard people did a tremendous job setting up that network for us, and it has been extremely reliable. Through its use we were more able to get information back to the Control Center in time to make critical decisions. We were a fairly small organization

to have an operational project and getting ready for both Gemini and Apollo with only a total of 900 people.

Apollo right from the beginning was designed to be a completely self-contained vehicle - that the requirements for support from the ground would be absolutely minimized. From our parochial viewpoint in operations we thought that that kind of vehicle probably couldn't be built in the time we were talking about and there were all kinds of discussions about what the relative interface between the onboard crew capability would be and what the requirements of the ground system would be. Lots of interesting arguments developed--for example, should we have a updata link in the command module (which we eventually got) and then correspondingly should there be one in the lunar module (which we also got). It became obvious that the whole business is a very subtle melding of the capability that you can build onboard within the state of the art. The amount of work which the crew has to do to perform on this complex a mission, as against the amount of support function from the ground and duration of the command relationship, decisions as to the kind of a flight plan to be flown and the kind of mission termination decision that should be made - all seem to have developed into a very good working arrangement. One of these days when missions become a lot longer and onboard systems become a lot more reliable, then some aspects of the interfaces will change. We have often wondered whether the space flight control business will ever become a FAA routine. It will be interesting to see how it develops in the next 10 years.

When the STG organization at the Cape was set up under Preston, I was working as Chuck's liaison between Langley and the Cape. Our Cape people were working out of one small corner of Hangar S. We were working on the kind of ground support equipment we would need. Simpkinson was there sort of as crew chief. People like John Williams, Moser, Donolly, and Harold Johnson were working on details of the instrumentation and checkout. We gradually expanded until we filled up the whole of Hangar S. Even so it was tremendously crowded. When I first arrived at Langley I shared an office with Preston who was the deputy chief of the division. We could hardly walk around our desks because they were jammed so close together.

It was interesting how the interfaces with the range down there, the AFMTC, began to develop. We had to learn how to work with a range of that size. They had all kinds of projects going on and we were just one of them. We also had to learn how to get the facilities we needed - just simple things like getting a truck to take the spacecraft out to the pad, where to order fuel needed, how we would handle the escape tower rockets, and how do you fill out all the paperwork needed in the way of safety and facility requirements. There was a lot of learning to do about the general business of the booster game that most of us in the aircraft business hand't really been used to.

We also had to develop the flight control team. We spent a great deal of time deciding what kind of people to hire and where we would get them from. We went all over the country looking for them because they had to be a combination of a flight test engineer and a man who knew something about range facilities. We had to decide whether to take

an airplane man and teach him about booster problems and range problems or whether to take the range guy and instruct him in the problems of manned systems. In the end, we got people from both areas. We got many people from the aerospace industry, flight test organizations - Gene Krantz was an outstanding example. We got a lot of people from FAA, people who had been communicators, because our whole business is really communication. We got people from the ranges, Ed Fendell was one of the range guys. He became known as a sort of super CapCom of the network, and now is one of the section heads in Flight Control Operations Branch. We got people from some of the technical support contractors, such as the Philco tech rep organization. We really combed the country for people who had an operational bent, which is different from the things that motivate design people. Once we got them, we had to train them, and it became a fairly significant part of our business. Things happen so fast, particularly in a 3 revolution mission ($4\frac{1}{2}$ hours complete from beginning to end), so we had to make sure that we were ready to take care of these emergencies. After all the purpose of Mercury was to find out if man could operate in space and so the design of the vehicle was sort of a semi-automatic with a manual takeover. We had to be prepared to do a lot of things on the ground to help. Of course it quickly became obvious that the man was very capable in the space environment and we tended to use the manual system as much as we did the automatic system. But we had to plan for such contingency situations as the manual backup.

With the Gemini program coming on and the Apollo program coming along it was evident that we needed a new Control Center. There was a big question about where to put that Control Center. The vehicle

communication systems were advancing in the state of the art and we needed all kinds of new facilities on the network too. So we put a group together to decide what kind of a Control Center we wanted and to recommend how we would phase the network into it. That was a very interesting time for me, because I really enjoyed that business of deciding what kind of Control Center we needed. The first thing we had to decide was where to build it. Chris and I had talked a lot about that and Chris had come to the conclusion that maybe the best place to put it was at the Cape. What we were really trying to do was to get some basic decision made as to whether the flight operation organization was going to be part of the design center or part of the operations center. Kennedy was coming into being at that time and there was a question whether Preston would be part of Kennedy, and of course he became part of it. I remember Chris writing a memo that summarized the trade-off--the advantages of being close to the development center or close to the operations center as far as the Control Center was concerned.

Travel had become a major problem. Our people spent a lot of time away from home at the Cape or out on the network, and we felt it would be better if more of our people's time could be directly associated with their work and less lost through this excessive travel. Our initial impulse was to put the control center at the Cape where the other one was, but in the end the decision was made to put it here at MSC. I think all along we were really hoping that that was going to be the answer. But we put the negative argument forward.

While all this was going on, we were still flying the Mercury

Program. I had become the Flight Supervisor of the Bermuda station and it was interesting to see the development of a station while it was being built, and being readied for a mission. The Bermuda Station had a very special position in the network because it was the very first one that the vehicle went over after leaving the Cape, and in fact it did cover the insertion period - the booster cutoff-- and because of the communications, Bermuda served as a backup control center. We had to arrange the facilities at Bermuda so that they were a miniature replica of the Control Center.

I was chief flight controller at that station. I had planned to go out there during the MR-2 flight, as the station was practically ready and we were going to go out there to monitor the vehicle - MR-1 and to see how the station was coming along. I had a stomach ache at the time, and I went to the doctor to see if I should take that trip to Bermuda. It turned out I had appendicitis. My appendix were promptly removed, and Chris ended up going in my place. That was the first trip made by the flight controllers to the Bermuda site.

Eventually I got to go there often, in fact, I guess in the next year and a half, at least 9 months were spent in Bermuda. Most people would be thrilled to spend 9 months in Bermuda, but in this program, once you get into the technical aspects, people start working 14-16 hours a day. It was nevertheless a very interesting time for all of us in building that station. We were particularly fortunate in the choice of people at the site. Ben Gallup, in charge of the Bendix maintenance and operations contract was extremely capable, and we had a

very close relationship with him, as we did also with Dalton Webb, the NASA head of the station. It was ~~only~~ on the Air Force station at Bermuda so we got to know the Air Force people. We had a piece of their property way out in the corner of the airport. The Bermuda station is still there, although of course it has changed considerably in the years since I first went there. It would be interesting to go out there again sometime and see just how much change there has been.

Somewhere along in 1962 or 1963 it was obvious that communications were getting better and that we really couldn't afford to keep sending people out to the network forever. Our people were experienced by this time and had become very knowledgeable in the kind of things that had to be done. We felt that it should be possible to get information back here to the Control Center without having people on the network. I put forward the idea that maybe we should try this once before we decided to make such a significant move. We decided to use the Bermuda site to test the feasibility of this idea. A cable had been laid to Bermuda around that time, which allowed us a high degree of confidence in communications. So during MA-7 we put that cable operation into effect and started to bring the information back to the Control Center. Lo and behold, it worked. So on MA-8 we shut down the flight control aspects of the Bermuda site, brought back all of that information to the Control Center. That was really a significant step forward.

By the time of the MA-9 flight, the 1 day mission as we called it, (although it was really about 35-36 hours), it was obvious that we needed more than one team in the control center, and we needed more flight

directors. Chris had become the first flight director in the system, and I became the second. ~~We decided to run the MA-9 mission at the Cape.~~ We also found out that working out of the Control Center at the Cape for 36 hours in a row with only 2 shifts of people was a pretty difficult thing to do, and in fact we would need more flight directors than two in the future. We would also need more than two flight control teams.

We were really quite a small group of people who put together the ideas for a new control center. Largely it was Chris Kraft, Tec Roberts, Dennis Fielder, and myself. This was a most desirable working arrangement. We had a study contract with WDL out on the West Coast. What we were trying to do was to put together ideas more than anything else, to come up with a method of operation for the things we thought we needed for the future. One of the things I had pushed for was the need to distribute data within the flight operations team in the control center. The television distribution system emerged from this proposal. Also there was an obvious need to process systems data whereas in the past we tended to use meters and stripcharts and things of this kind. The way we had been doing this represented a very inefficient use of people because we could only look at maybe 15-16 parameters that way. In the past we had relied on computers for trajectory data, and of course the trajectory problem continued to be of major importance, particularly when we talked about rendezvous and lunar missions. But still the data systems area was the one we seemed to have unresolved problems. These are the areas where we need the information in a hurry and in a reasonable format. These 2-3 years around 61, 62, and 63 were interesting years for one while we were putting together our philosophy on the control center.

When we ran the various RFP's through the system, we had been in a hurry to get the processing side of the thing started, and we let the contract with IBM thinking we would later be able to make IBM associate contractor or subcontractor in the Control Center. That never really came about and there has always been a sort of dichotomy. Philco eventually got the contract to build the Control Center and IBM always remained a separate contractor. As a consequence the data system itself has always been somewhat separate from the data distribution system in the Control Center. I suppose that's one of the things you learn about letting large contracts of this kind--that you've got to let them in a timely fasion in order to insure that you really have complete control of the whole contract.

We started building the Control Center in 1962. We had it well under way by the time of the Gemini 2 flight. What we did on Gemini 2 was to tie the Houston Control Center into the Cape. We were still using the Cape Control Center, and in fact, intended to use the Cape Control Center for all missions up to the rendezvous mission, at which time we would transfer operations to Houston. As it turned out, the slips in the mission schedule allowed us to use the Control Center here sooner than we originally planned. So for test purposes only, we monitored the Gemini 2 flight from the Houston Control Center. When we got to the Gemini 3 flight, it became obvious that we were going to need some more flight directors. So we named Gene Kranz and Glynn Luney as the next 2 flight directors in the system. Gene assisted Chris on the Gemini 3 flight. Although it was of short duration flight it was a good experience for Gene and it helped Chris a lot. I stayed at the Houston

Control Center and monitored the complete flight from here. The idea was that we would validate the Control Center and would be able to do the Gemini 4 mission from Houston. That is what we did. Gemini 4 was a 4-day mission so we needed three sets of flight directors--Chris, Gene, and myself. However, we still wanted to be absolutely sure that we could handle things so we used the Cape Control Center as backup launch control center, and Glynn Luney was in charge of that for the Gemini 4 mission. As it turned out, the launch was normal and we had no problems with the system, so we were able to completely control the mission here. This really gave us a feeling of security, because it showed that the Control Center conceptually would work well, and it allowed us to use it on a trial basis before we had to depend on it for the dual vehicle mission configuration that was coming up with the rendezvous of the Gemini spacecraft and the Agena vehicle. In this kind of business very often it seems that the only way you know you have what you want is to try it out. In fact, it's more like the old aircraft flight testing game.

Then we moved on to Gemini 5 and Gemini 6. We were gradually increasing the length of the missions. One of the interesting things we found in the longer duration missions was that we had to pay more attention to flight planning than we had expected. Where we had been running the short duration missions, up to around 2 days in duration, it turned out that all we were able to do was what we had planned. We weren't able to replan the mission when things went wrong. With the long duration missions, it appears that we can expect that things are going to go wrong with the vehicle and that the flight plan will not

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occur normally. We have to have a very good method of approaching that problem. We will almost have to redesign the flight plan on a daily basis. It really gave us good insight as to how we would be running missions in the future. Not so much Apollo, but for AAP, where we are talking about mission durations of 28 days, 56 days, 90 days, 6 months and a year, and where flight planning and facilities planning were going to be a rather big part of the total flight control job.

We were looking toward Apollo around this time and had built the Control Center in such a fashion that we would be able to run missions concurrently on separate floors. We would be preparing on one floor while we were flying the other mission on the other. In the same way we were modifying the network for the Gemini mission. We needed new equipment of one kind or another because of the changes in the communication system, but we had more or less retained the old flight control appraoch where we sent flight controllers out to the remote site and used them as a data compression source. We did have a limited capability to bring data back here to the Control Center and although it wasn't complete by any means, it certainly helped. But we still had this basic idea that a knowledgeable man on the site with all the data at his fingertips was extremely useful. Going into Apollo, again we had a brand new communications system and we had to increase the size of the network because we were encountering deep space operations--going out a 1/4 million miles. So we had to talk in terms of building facilities similar to those used by JPL. In fact we decided to co-locate them with the JPL facilities at Goldstone, Madrid, and Canberra.

The thing we had to decide was whether we were going to build the Apollo remote sites on the basis of completely remoting the network, that is bringing all the information back to the Control Center, or continue sending flight controllers out. There are lots of disadvantages to sending flight controllers out. There is the whole complex business of travel--getting people to the right place at the right time, having to send them out before the final launch decision was made which invariably meant wasted time whenever there were slips in the mission schedule. Just the general business of getting all the information together and the logistics associated with it was sufficiently complex that we thought we would be better off if we could bring the information back to the Control Center. It had worked at Bermuda and worked well. But there was still some doubt as to whether we could really count on getting the information back from some of the remotest stations, particularly the ships.

We also had to decide whether the Mercury ships, which had been modified for Gemini, were suitable for the Apollo-type mission. It turned out they weren't. They were getting old, they were small, they couldn't really be modified in time for Apollo. We were obliged to put together justifications for the purchase of Apollo tracking ships, which we did jointly with DOD. The Apollo ships we have now are joint DOD-NASA facilities.

We decided we couldn't really rely on the availability of long range high reliability communication and that we would build the remote sites to be operated by flight controllers as insurance and

until such time as our automated communications capability would come to pass. We completely computerized this system so the information was readily available to the remote site flight controllers and at the same time could be remoted back to the Control Center.

In the same time period, the whole business of communication satellites started to advance, and it advanced much more rapidly than we anticipated. Furthermore, satellites began to be built specifically with a capability for NASA use, and this tremendously increased the reliability of communications, particularly to ships and to some of the remote sites where communications facilities were rather primitive. At the same time much more reliable cables were strung around the world. Where formerly we had one into Australia, we now have two. Additional cables were laid across the Atlantic. There were still some areas like Africa where communications were difficult, but the satellites made up for that. So sooner than we expected, the capability to remote the network came into being. On top of that we had schedule slips in the Apollo program. Although we used the remote site capability on the Apollo network for the earlier Apollo missions, by the time we get to the first Apollo manned flight this year we will have a completely remoted network.

One of the reasons we pushed this decision was the need for multiple programs on these remote site computers and the limited time to set them up. This business of software development is very tricky, and we still have a lot to learn. Part of this tradeoff to remote the network was based on the consideration that it would be very difficult to build dual programs for these remote sites.

When we started to run Apollo missions concurrently with the Gemini missions in the Control Center--the 201 mission, 202, 203, and we were ready for 204 which ended with the accident--we were going ahead with Gemini. The attempt to rendezvous on the first mission had to be aborted when we lost the Agena. This led us into the oddball situation of flying two manned spacecraft, Gemini 6 and 7, at the same time. It turned out that our experience on Mercury conviced us that we had the capability to fly that mission. We simply ran one vehicle like it was a Mercury spacecraft with remote site flight controllers and one vehicle like it was the Gemini spacecraft with the data remoting capability that we had, though it was quite small.

It was obvious that we were going to need another flight director so we named Cliff Charlesworth around that period. We decided the thing to do then was to let Glynn and Cliff carry on with the remainder of the missions after Gemini 9 (I had taken Gemini 8). We had that inflight problem which was quite something for us, but the system apparently was able to handle that which was very gratifying: the Control Center worked very well, the remote site network worked very well, and the flight control people worked very well together as a team. Gene took on Gemini 9 as the lead flight director and that of course was a very successful mission. Then Glynn and Cliff took on 10, 11, and 12. We decided we would try to two-shift it since we really didn't want to name any more flight directors at that time. The missions were on the order of 2-3 days' duration, which is on the borderline of what we said was acceptable. We had Apollo to get ready for, and Gene, Chris, and I started to get ready for the 204 mission. We 3-shifted it because

Chris and I balanced off in the early Apollo missions as a phantom third shift--a flight planning shift. Since the missions were fairly short, there wasn't a great deal of realtime flight planning so it worked out well. I doubt we'll be flying missions that short again, but if we do, that kind of process worked quited adequately.

When we were in temporary quarters in Houston, we had some organizational changes. Walt Williams left the Center, I guess largely over differences of opinion on whether the Center should be split into two elements--an operations organization and an engineering and development and program management element. Walt was right insofar as organizational structure is concerned. When flight crew and flight operations report independently, it tends to create more problems than are solved. Of course it is important to have the right people in any organization.

At that time, we had been working with an organization called the ground support project office. It was a program office for budgeting and design of the Control Center. We in Flight Operations Division were mainly placing requirements on the GSPO and its people were building the Control Center for us. When we moved to the site, the Control Center was essentially complete, at least as far as design concepts were concerned. The GSPO was dissolved and the operations function was taken over by Chris' new Flight Operations Directorate, and the long range design functions went into the newly created Informations Systems Division of E&D. Something had gone wrong

with the directorate that Barry Graves had been in charge of. Apparently he didn't agree with the way things were done at the Center.

Chris intended to maintain the split between the requiring organization and the building organization and in carrying out this philosophy created a separate division here, the Flight Support Division. In doing so took away some of the functions of the Flight Control Division. That allowed our division to concentrate on flight control functions. I have never really been sure whether that was a proper split to have made at that time because it created a requirement for one more person between the flight control personnel and the man who builds the hardware. It also involves a communication problem as much as anything else. It is always difficult to know whether you should split an implementing organization away from the others in that fashion. I guess only history will tell which was right.

Around that time, a new Apollo program manager came in -- Joe Shea. The Program Office became very large, and the E&D subsystem manager principle was evolved. Now the E&D Directorate began to be used as a body shop rather than a systems design organization. There never really has developed a total systems integration organization within MSC, and we have very large program offices that tend to do a lot of engineering.

In the meantime, Chuck Matthews had taken over the Gemini Program from Jim Chamberlin, which had reached the operations phase. Incidentally, Gemini was a very well designed vehicle so far as operations were concerned. We'd learned a lot from Mercury. It was a second generation spacecraft built by the same company, with ease of maintainability, servicing, and replacement of parts. Chuck ran the program office in

a slightly different way because he really had the subsystem managers within his program office and so essentially all the engineering was done there, and by the contractor. That was an entirely different method of using a program office.

One of the things we started to learn in the Apollo Program was how to work with another Center - with Marshall. This has been a very difficult thing to get used to: There were in fact 3 Centers involved (including KSC) and program management was basically out of Washington. MSC was responsible for spacecraft design, mission design, and flight operation. Marshall was largely responsible for booster implementation, and KSC for launch operations. How we should work out the details between the Centers has not been properly defined. There are a lot of ways for things to fall down the crack. We have used the technique of coordination panels to communicate between the Centers, but I have a feeling that they don't really work as well as they should, and something should be done about this in the future. Interestingly enough, Marshall is structured organizationally exactly the opposite of MSC. Their R&D organization has tremendous strength and a true program function exists in the program side of the house. As a result, on inter-Center panels, the co-chairmen from Marshall were apt to be research organization people whereas here at MSC the co-chairmen were almost entirely out of program office. This difference resulted in some interesting sets of communication. Oddly enough there was only one area where the opposite was true. The flight operations panel of which I was the chairman and not out of the program office, but the co-chairman at Marshall came out of the program office. We were exactly 180° out of phase in all areas. I think this is something that will have to be

worked on in the future in order to improve our relationship.

Again, at one time there was a very neat little split between the launch vehicle and the spacecraft and it was easy to see the division of responsibilities between MSC and Marshall. It isn't going to be so easy on the AAP, and this need for inter-Center communications is going to increase by an order of magnitude over the next few years. AAP development itself has a nebulous functional foundation and it's not easy to pick an x-number of missions, or specifically what we are going to do, and the split of responsibility between us and Marshall is going to have to be worked out fairly carefully.

I've talked quite a bit about management in one way or another and I've mentioned how we used the Control Center for two sets of missions--the third floor for the Gemini Program and the second floor in getting ready for Apollo. Another decision that I guess we haven't come to grips with yet because it becomes important only in the era of AAP, is whether we should be able to support simultaneously activities on the 2nd or 3rd floors, rather than concurrently.

When Walt Williams left, he went up to Headquarters to establish what was going to be an operations directorate in Headquarters. Its function was to bring all of the operations functions together: flight operations at MSC, and launch operations at KSC. Walt didn't stay in that job very long, but the idea stuck, and Christianson came in to do those functions which Walt was to have done. That function has never gotten off the ground and there has always been a feeling among the operating Centers that operations can really only be controlled out of the Center. It has resulted in quite a bit of discussion between the Centers and

Headquarters and quite a few heartaches I guess on both sides. In general the principle of mission directors, their function and their interfaces with the Centers, is still rather hazy. You can say that the program office at Headquarters has established the mission director function as one that is largely concerned with insuring a capability without participating heavily in the mission itself. That seems to be a pretty good mode of operation. The direct responsibility for launch resides at KSC and the responsibility for flight is maintained at MSC. That the communications between us, KSC, and Marshall are sufficient to make sure that nothing slips through the crack is the function of the mission director, and whether it is necessary again, only history can tell. In general, the 3 Centers are very competent in the fields they have and the split up of functions has been rather clear. We shall see.

One of the things that seems apparent in the Center and maybe in NASA as a whole is the lack of real goals and plans for the future In general MSC has grown up on a single program concept and with the idea that today's program is the most important although it won't be here tomorrow. On the other hand there is the ultimate philosophy that says if you don't look out for tomorrow, there won't be a tomorrow no matter how successful today is. I guess we still haven't given that sufficient attention. The tendency of NASA to separate manned and unmanned programs can be expected to be reconsidered in the future, I am sure. I think the AAP and programs of that kind will allow a closer relationship between the manned and unmanned part of the exploration. Having developed an operational capability we know more

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or less how to build vehicles now, we know how to man those vehicles and we can exploit our capability. But I think it can best be exploited jointly between the manned and unmanned probes and I think that that kind of thing will be an important consideration in future planning. But it needs to be established quite firmly so the Centers can plan accordingly. There is no doubt that we do need to plan for the future to some extent, and by the future I mean something beyond this program, or even somewhat beyond the next program. How we use the facilities we have and the people we have will have a bearing on what we do. We need to examine our organizational arrangement and functional roles. Whether we need to change the mode of operation in the program offices is another subject that needs to be looked into very carefully. We also need to plan our relationships with our other sister Centers and with Headquarters so as to increase the effectiveness of all.