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[full name of interviewee]

about Mission Control Center and Systems
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CONTENTS:

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

Education - ________________

Career Path - AVRO (Canada) Corp; 1959 - NASA

Topics - automatic ~~abort~~ protection system; Mercury network ~~and~~ Control Center at Cape; logistics re remote sites; combination of voice and teletype transmissions; MSC Mission Control Center; Real time Computer Complex (RTCC); Charactron; ~~MSC [illegible]~~ communications & pneumatic tube system for local MSC; use of 2 ComSat satellites; switch from 7094 to 360 Computers; closed loop flight simulation; compromise between increased flexibility and increased complexity; controversy over carpeting in operations room; IBM and Philco contracts; strained relations with Philco.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND 20771

July 9, 1968

Dr. Robert B. Merrifield
Planning and Cost Support Office
Manned Spacecraft Center
Houston, Texas 77058

Dear Doctor Merrifield:

I shall be delighted to spend some time with you and assist in any way I can to provide the information on a history of the Manned Spacecraft Center. Normally one may be reluctant to admit that one is a part of history; but in the short, eventful years of the manned space flight program, it has indeed been very gratifying to have been a part of this history.

Since you indicate that you plan to be in the Washington area the latter part of July or early August, I tentatively suggest the following days for our get-together; July 31, August 1, August 7 or August 8. Please feel free to select a time which best suits your schedule.

Sincerely,

Tec Roberts

Tecwyn Roberts

Interview with Tecwyn Roberts
7/26/68

I came from the Avro group to NASA in early 1959. I was quite extensively involved initially on the automatic protection system of the Redstone and the Atlas launch support systems. This system was flown initially in an open loop configuration and then for the manned flights a closed loop configuration was employed to initiate an abort in the case of a catastrophic malfunction. We were forced to change our approach to problems because of the complexity of the launch vehicle. The crew itself progressively played a bigger role until today we employ an abort advisory system which makes a recommendation to the crew. This early phase of development on the Redstone and the
65 Mercury was very challenging work. People had been trying to figure out ways to escape out of supersonic airplanes, particularly fighter aircraft, for some time and no one really found a feasible system for speeds above 650 knots. Yet for Project Mercury, Gemini, and Apollo ways were found to protect their crews against catastrophic failure during the launch phase.

In late 59 or early 60 we began to firm up some of our ideas on flight control. It was August 1959 - Western Electric was given a
55 contract to develop the manned flight network. It was to be the Mercury Network Control Center in the Tel 3 Bldg at the Cape. Western was the prime
53 contractor and IBM was a sub in the computing area. Bendix Field
56.✓ Engineering, Bendix Radio, and Bendix Pacific all were heavily involved. It took only about 12 months to design and build that initial Mercury Network including the control center.

There were interesting problems with logistics. The original Mercury Network and its remote site stations were designed and built on the

concept of having flight controllers at each site. They would talk
56 with the astronaut in the spacecraft as it came over and monitor the
56-1 data that was being telemetered. All data transmission back to the
56-2 control center was by teletype. In the early days, the continental US stations had voice but the stations like Canary Island, Kano, and Zanzibar were entirely dependent on teletype. It was in 1961 before we got voice to most of the stations. The other stations like the Hawaiian station and stations in the continental US had always had it. At that time one of the most interesting problems in the network, probably the one that had never been attempted was to take highspeed tracking data at the Cape send it up to central computers and Goddard. After computing trajectory data, the computed information was returned over high speed lines to the control center where it was displayed. When the system went into operation,
277-2 there were many misgivings about the capability of this approach. That was August or September 1960 when we started. When you think today what is highspeed data, the far greater amount of information that is brought back from every one of these stations on the network around the world, we have come to accept for the most part that it is a matter of routine. There are computers talking to computers 12,000 miles away with sometimes as many as 7 or 8 computers in ~~a~~ series.

In the Mercury Control Center information was displayed on strip
61 charts, meters, etc. The design of the network and the control center was oriented to a specific project which in this case was Mercury. Moving
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277-1 from that, the next big step was to design the mission control center in Houston. Here we were able to call on a lot of things we had learned in Mercury. We were also fortunate in that short space of time of $2\frac{1}{2}$ years

that tremendous strides had been made in data transmission, computational facilities, etc., so when we started to lay down the design criteria for the new mission control center we were able to use our Mercury experience as a backstop in preparing for the demands of the Gemini program. To some extent we were also projecting ahead because the Apollo program had been approved, and although we couldn't anticipate quite as well what its demands would be (for example, the impact of lunar landing mission on the control center), that was one important thing we had learned by this time and that was we needed versatility and flexibility in the control center. That was the biggest difference between the two control centers. The control center at Houston was designed and built to provide a focal point for flight control of a manned space flight operation without getting tied to major requirements of a specific project. We departed from the technique of decommutating and putting it as analog information on strip charts or meters, and moved into a phase where virtually all the data, not just the tracking data, was handled through the computers and the computational facility. In other words, in the control center at Houston, all activities hinged on the realtime computer complex. We had to have a display system which would permit us to look at digital information and perhaps in the next 2-3 seconds enable operators to look at analog information and 5 seconds after that perhaps he would have to look at some combination of both. This is why we went to the CRT type of display and the system we picked provided us with a high degree of confidence that would give us this flexibility. The data from the computer we brought out on a charactron and then looked at with a TV camera. The main advantage of this was it allowed us to use in the same equipment as a display instrument to provide the flight controller with pictorial information as well as closed loop TV from the Cape. The launch itself could be displayed on the same monitor. One of the reasons we went this way was it enabled us, by mixing the two data, to initially alleviate some of the computational loads since the computers could put out the dynamic or changing data whereas the more static or background information could be taken care of in predrawn slides. What we had was a TV camera looking in a charactron at the dynamic data and thru an optical system simultaneously projecting the background information. There have been many changes made in that display technique. But in early 1962 we laid down these requirements in some of the study contracts with Philco. Subsequently with the implementation of the RTCC contract with IBM and control center instrumentation, the network itself started moving toward a much more automated information flow, where remote sites instead of having to read ~~stuff~~ data off a strip chart, were actually able to take ~~its stuff~~ data into computers and automatically generate summary messages back to the control center. But it was still teletype traffic. The onset of highspeed data on most of the network came in a much later phase, really for Apollo in the 1965-1966 time period.

There is a mixture of things in the control center. Here was a sophisticated computer driven display system, and along side it was a pneumatic tube system of the type that has been around for years, for transporting paper around the building. Some of the distances were quite large so we were faced with a very large messenger service requirement to deliver this information to the Flight Control people in the Operations Center of the Mission Operations

Control ~~Group~~ Room (MOCR's we called them). We could see we would need an army of messengers around the place who at the least would cause a great deal of distraction. I think it was Gene Krantz who suggested the idea of the pneumatic tube system.

The single biggest difference between the Mission Control Center V77-1 at the Cape and the one at Houston was the emphasis that was put on the computer usage at Houston. Inherent in this was the greater complexity of the trajectory problem of Gemini as compared to Mercury. The Gemini program had great maneuvering capability once it was docked with the Agena--something we hadn't experienced before, and by comparison with Mercury I would guess that the various possibilities that have to be considered and the need that existed to rapidly compute the effect of various maneuvers, probably increased the complexity of the software between 1 and 2 orders of magnitude.

Between Gemini and Apollo the greatest switch in emphasis was not insofar as the trajectory information was concerned but in the systems 306 306-1 information, in the amount of the telemetry data and the method by which it was handled. We are ~~not~~ now beginning to find that the amount of data, the limitations and combinations as to the meaning of much of this data was such that it is necessary to extract actual information from the measured quantities. Here again the computers played a major role. The network relied significantly on the two ComSat satellites--one in the Pacific and one in the Atlantic -- which together with the Pacific greatly increased worldwide network communications, and enabled us to bring back highspeed data automatically remoted from just about all the network sties. The data is received from the spacecraft, decommutated,

fed into a computer onsite, compressed or pertinent information extracted,
343 and shipped back to the control center at Houston into the RTCC, and out of the RTCC directly to display system of the Flight Controller. It's quite fascinating to watch a spacecraft pass come up over Carnarvon Australia, and Within seconds after they acquire the spacecraft, people in the Control Center in Houston are looking at information that is being radioed to the ground from the spacecraft.

The contractors played a major role in the design of RTCC and control center, the type of display system, etc., but the contractor was dependent
277-1 on the MSC flight control people for functional requirements (the concept of the operation, the manner in which we were going to operate, and tradeoffs that had to be made). Some of the things we wanted weren't practical from the standpoint of the state of the art of hardware design at that point in time. The control center didn't use any basically fundamental new systems. We simply didn't have the time and couldn't afford the risk associated with such a program. But by no means was it technically backward; it was one of the first facilities in the country that switched over from the 7094 computers to the 360's.

In the Control Center there is one area that was very significant, and probably nobody will ever know how important a part it played in the
306 306-1 success of the flight control aspects of the mission. That is the simulation activity. Whereas the Flight Operations Directorate in itself was not primarily involved the design of the spacecraft simulator (that prime role being the responsibility of the Flight Crew Operations Directorate). We were very much involved in the use of those trainers in the Control Center as a realistic simulation tool. Here again, the increased complexity

of the spacecraft, and the increased versatility of the spacecraft, its
maneuvering capability, all introduced new problems. In Mercury we had
some very realistic simulations but some were not. In Mercury our simulations
were based on prescripted information and prederived tapes. In one
training exercise, the simulation people had expected that the flight
119 control team would abort the simulated mission. However, it was a
93 borderline case, and ~~since it was a toss up whether it was an abort
situation or not~~ the flight control team decided ~~it was not, and did~~ not
abort. As it happened the trajectory simulation tape ran out into
orbit, and when everything stopped because the simulation had not been
planned beyond this point and there was no more data. Prescripted
information was impractical for Gemini because there were too many sets
of variables and there was no way to predict the action that either the
ground or spacecraft crew might take. We would have had to have an
infinite number of data tapes, etc. With the advent of the Control
Center at Houston the trainers were tied into the computers to provide
a much greater degree of closed loop simulation; action initiated by the
crew and a corresponding reaction by the ground led to the next sequence
of activity.

Another big difference between Mercury and the Control Center and
the Control Center at Houston was the need for greater flexibility in
777-1 Houston, and of course there is always the danger that an increase
in flexibility will also increase the complexity to the point where there
is a sacrifice of reliability. We made a continuous effort to exercise
judgment as to what was a reasonable compromise situation.

Still another major difference in the Control Center in Houston as compared to the Mercury Control Center was that Mercury Control Center and network were built under one contract. This even included modification to old Tel 3 Bldg and facilities around the world. At Houston we found ourselves in a situation where the design criteria called for the construction of the bricks and mortar part of the control center long before either Philco or IBM were onboard. The facility was being built under the supervision of the Corps of Engineers. In the middle of 62, demands began to be levied on us for dimensions, specifications, etc., for Bldg 30. At this point the A&E design work was way ahead of the point where we would know we had little concept what kind of electronic system or equipment we were going to put in the building. The thing that proved as valuable as anything at this stage of the game was the study contract we had with Philco. Philco had been selected in January 1962 to study various concepts of a control center. We were forced to take the bull by the horns in some instances, make decisions for structural reasons, and adapt the electronic equipment or concept of operation to it afterwards. Walls were put up before the equipment was delivered and it couldn't be put in, cables couldn't be run, etc. The actual contractor constructing the building was receiving his directions from the Corps of Engineers and they were interfacing with the MSC Facilities Division. Then you had a separate group in the Flight Operations Directorate to establish the design of the Control Center. There were many arguments, some of them heated over such matters as carpeting for the operations room. We were pushing for carpeting because of the inherent high noise level. We had learned from Mercury that unless we went out of our way to keep the noise level down in an operations room, it was killing. The Facilities people didn't understand--after all, this wasn't the Center Director's office. Carpeting was controversial. Lighting was also a problem. A little later in the latter part of 1962 and early 1963, the two contractors came onboard in what would normally be considered the reverse order, inasmuch as IBM won the competition for the realtime computer complex and then approximately 3 months later Philco won the competition for the control center proper. Thus we had 3 separate elements - one put the electronic equipment in, another put the computers and wrote computer programs, but he didn't know for what kind of display equipment ~~quite what for~~, and to top it all off the building, compared to the rest of the Center, was 30 days behind schedule and the bricks and mortar man was going hell for leather regardless of what was going to be put inside it. Nevertheless the facility that emerged has been remarkably successful and I think much credit is due the MSC Facilities Division and to the Corps of Engineers.

IBM came onboard as the RTCC contractor in November 1962 and Philco became the Control Center contractor February 1963. Much of the conceptual design work on the MCC had been going on for a 12-month period. About that point a group of people were brought in under Paul Vavra to run the MCC. These people had a very different background from those of us in the Flight Operations Directorate. They were primarily electronic systems engineers. They had spent most of their careers v15

in electronic systems development. Most of them came from the Instrumentation Systems Division at LRC, whereas Chris Kraft and most of the key people in FOD had been in the Flight Research Division at LRC and had a background in aeronautical engineering and mechanical engineering. The flight control - flight operations people were interested in defining functionally what they wanted and were looking for the contractor to develop this equipment, construct systems, etc. The ground systems program office under Vavra with its electronic engineering background wasn't oriented toward the total mission ~~complex~~ concept but rather the electronic systems that made the MCC run. They didn't want the contractor to make fundamental design decisions on the electronic systems. This was a role that they wished to aggregate to themselves. They wanted the contractor only to supply and install the equipment. There was also probably another factor. I think there was a certain amount of animosity or prejudice on the part of the GSPO people, toward the work that had already been done on the MCC. Many decisions had already been made that they felt they should have had a voice in. They had not had the opportunity of being a party to this decision making process and as a result were inclined to be supercritical and to "knitpick" some of the decisions that had been made earlier. This attitude was especially trying, when it didn't really contribute anything to the problem at hand. Since many of the GSPO people had played a major role in the development of the Mercury Control Center and network, they had an established rapport with IBM but had not had any previous significant contractual relationship with Philco. Although several of us in the Flight Operations Directorate had had earlier interface with Philco (we had a small number of

Philco people on contract as flight control systems monitors), we also knew very little about Philco. In other words an established proven confidence in IBM existed but was lacking in the case of Philco. This caused strained relations between the Program Office and Philco, and of course created tension between IBM and Philco. I found I could work quite well with GSPO and both contractors, although I didn't always agree with their views and they certainly didn't always agree with mine. I always felt confidence in them to look at a piece of electronic equipment and make a determination as to its suitability. My disagreement with them would have been on those occasions when they seemed to lose sight of the overall objectives by paying too much attention to what was within a particular black box.] However, we needed both types, undoubtedly, if we were to have a successful overall system.