

matter into consideration and take appropriate action, but it is not in the area of the responsibilities of this Board to see that the action is taken, as I understand our responsibilities.

Senator YOUNG. Well, maybe, Colonel Borman, maybe I should ask you this question: Since there are recommendations that the amount and the location of combustible materials be restricted in the future, that is in itself an admission, is it not, that there was laxity in permitting so much combustible material in the spacecraft?

Colonel BORMAN. Yes, sir; there were too many combustibles on board.

Senator YOUNG. Do you know personally whether thought had been given to the danger of that before?

Colonel BORMAN. Sir, we considered the danger of combustibles on board the spacecraft before our flight of Gemini 7, and we had done an extensive study of in-flight first. We were the first American crews to remove the spacesuits in flight, and when you fly without a spacesuit on, you lose the prime protection against fire when you are in orbit, which is to depressurize the cabin, so we were very particular in looking into means of controlling fires during flight.

We did not consider this problem sufficiently for test on the ground.

Senator YOUNG. But now hindsight shows that there really was negligence in connection with that.

Colonel BORMAN. Well, as I said before, sir, I guess you could call it negligence. We had over 3,000 hours of experience testing in a hundred percent oxygen. I believe it is in the record. I am sure it is over 3,000 hours. As you may or may not know, sir, when I fly, when I flew up here from Houston, I was using 100 percent oxygen all the way on my airplane, the T-38 that we fly. I am afraid that we overlooked the potential hazard of combustibles, pure oxygen and an ignition source.

COMMUNICATIONS SYSTEM

Senator YOUNG. Did you yourself at times prior to this tragedy consider that the overall communications system was unsatisfactory, was not adequate?

Colonel BORMAN. Sir, I was not involved in testing an Apollo spacecraft at the Cape. We had a different communications system for Gemini and it was adequate. But according to all the testimony that we had and the records of the tests, the present ground communications system at Cape Kennedy was inadequate.

Senator YOUNG. Do you know whether Dr. Thompson and others knew of that fact beforehand? Was it considered by you before this tragedy occurred that the overall communications system was not adequate or was somewhat unsatisfactory?

Dr. THOMPSON. No, sir. I learned about all this when I was assigned the responsibility as Chairman of this Board. I am stationed normally at Langley Research Center, and I was not—I am not familiar with all the operations at KSC. I am much more familiar than I was at the end of January.

Senator YOUNG. Well, are you able to expand on this determination for the committee, particularly with respect to why there was not provided a satisfactory communications system before this tragedy occurred? Can anyone answer that question fully?

Colonel BORMAN. Sir, if I may, I can tell the reason for it anyway. The spacecraft uses a four-wire system; the ground communications system at Cape Kennedy is a two-wire system. This results in the requirements for what we call voice-operated relays to transmit messages from the spacecraft to the various organizations.

Now, if these relays are all set to actuate at the proper level, the system works fine. The problem is in getting them all set to the proper level, and this communications system, although I must point, sir, that we found that it did not contribute to the accident, it nevertheless made the test difficult. They were holding at the time of the accident for a communications problem, as you may have read. So the Board said that one of our recommendations was that before the next manned flight we fix it.

Senator YOUNG. Yes.

Now, thank you Colonel, for your opinion on that. But do you know what organizations were responsible for the design, the building, and the operation of the communications system which you now know was not adequate?

Colonel BORMAN. I believe it would be the Kennedy Spacecraft Center, sir.

Senator YOUNG. Is that—

Colonel BORMAN. I am not sure, but I would say that is who it was.

Senator YOUNG. And you surely believe that should be corrected?

Colonel BORMAN. I certainly do, sir.

Senator YOUNG. As quickly as possible?

Colonel BORMAN. Yes, sir.

Senator YOUNG. Thank you. No further questions.

The CHAIRMAN. Senator Brooke.

SPACECRAFT SAFETY

Senator BROOKE. Colonel Borman, if I understood you correctly, in answer to Senator Smith's question, you said that in your opinion this spacecraft was safe at the time, and yet after reading the Board's findings it is inconceivable to me that you could make such a statement that the spacecraft was safe at the time. Is this statement based upon your beliefs prior to this accident or do you still believe the spacecraft was safe?

Colonel BORMAN. Sir, I am certain that I can say now the spacecraft was extremely unsafe. I believe what the message I meant to imply was that at the time all the people associated and responsible for testing, flying, building, and piloting the spacecraft truly believed it was safe to undergo the test itself which was being conducted at the time, and my opinion is based on many hours in a sister ship that I spent in checking, in testing of a sister ship.

Senator BROOKE. But one of the things that is included in the report was that the coolant leakage was a chronic problem.

Colonel BORMAN. That is correct, sir.

Senator BROOKE. And apparently this was known by you and by members of the spacecraft prior to this unfortunate accident.

Colonel BORMAN. That is correct, sir, and the last coolant leak that was discovered at Cape Kennedy was a leak of about five drops of coolant that was unexplained, and as a result of this leak of just five

drops the entire environmental control unit was sent back to the contractor, the launch date was slipped, and every effort was made to make sure that the leaks had been understood and corrected.

So these things that were problems along the way, we thought, had been corrected.

Senator BROOKE. But you knew that the coolant was combustible.

Colonel BORMAN. Sir, it is combustible, but it is extremely difficult to ignite.

Senator BROOKE. And you felt that it was—the fact that it was combustible did not necessitate the changing of the coolant.

Colonel BORMAN. That is correct, because, you see, the coolant is contained of course in plumbing, and hopefully if you do not have leaks, and if you have no ignition source, you will not have a fire.

Senator BROOKE. But you did not know about the joints and that you did have leakage.

Colonel BORMAN. Yes, sir.

Senator BROOKE. You recommended correction of that.

Colonel BORMAN. Yes, sir.

MANAGEMENT ASPECT OF PROGRAM

Senator BROOKE. Now, prior to this Board's report you had hearings, the committee had hearings, and if we were to believe what was said by those who appeared before us, the accident could not have occurred because everything was right, a hundred percent pure oxygen was right and everything else was right.

Now, of course, the Board, having made in-depth study, has obviously found some mistakes and some errors and some conditions that need rectifying.

Did the Board go in depth into the management aspect of the program?

Colonel BORMAN. No, sir, I do not believe so. I believe Dr. Thompson should answer that.

Dr. THOMPSON. We went into management to the extent that it impacted the things that were involved in our review; that is, as I was trying to visualize it one day, I said we started from inside and worked out. We did not look at management and then concentrate on an area of deficiency. We looked at an accident, something that had gone wrong, and then looked outward from that to see if there were management aspects of the operation that seemed to have impact on it. And to that extent we did look into certain management problems.

Senator BROOKE. If management had been proper, could not these findings that were relative to mistakes and errors in this spacecraft have been found prior to this accident and corrected?

Dr. THOMPSON. Well, we did not find any direct connection between the accident—the management and this accident. We saw things that we thought needed to be improved in the management as we looked into this problem. But I do not think any management is perfect on the point that there might not be something wrong somewhere.

The assurance of quality, I think, left something to be desired, but we have gone into that in considerable detail here, I think, in identifying those areas; to the extent that those areas reflect management, I suppose we are criticizing management.

I do not know exactly how to be more definitive about it though than we have in the statements we have made on it.

The assurance of quality is certainly a NASA responsibility, and we tried to impose on the contractor the direction and control, whatever it is, that will insure that the quality is, in fact, built into the spacecraft, and somehow or other that result did not come out exactly right.

DISCUSS EVENTS PRIOR TO FIRE

Senator BROOKE. Now, Dr. Thompson, your Board has not been able to actually pinpoint the cause of this accident, is that correct?

Dr. THOMPSON. We have established a most probable cause, and we have established conditions that support that kind of thing as being almost certainly the cause, but we are not certain that we have put our finger on the exact thing that ignited that fire.

Senator BROOKE. In your opinion, if the recommendations that are contained in this report were carried out, is it true that this accident would not have occurred?

Dr. THOMPSON. Yes, sir; that is the intent of our recommendations which is to remove the probability of fire, and we think that by following the recommendations that we have made and certainly a great deal of progress is already being made that we know of in that direction, that the probability of fire will be reduced to a very low level.

Senator BROOKE. Of course, hindsight is always easier than foresight. But assuming that these matters could have been found out previously, then is it not the responsibility of someone or some organization to have done what this Board did prior to this accident, and corrected these things which would have avoided this accident?

Dr. THOMPSON. Well, the stimulation has been very great here to go into a depth that, perhaps, has not been followed before. I think we probably have gone into greater depth than some of the reviews that have been made up until now and, of course, we have usurped a lot of manpower. We have had an overriding priority on all manpower to try to support this thing. So I do not think that the Agency would like to support this kind of review very often.

Senator BROOKE. This manpower could have been mustered previously, could it not, for an important operation such as this?

Dr. THOMPSON. It could have if the need had been identified in the way it was here.

Senator BROOKE. There was no question about shortage of manpower, shortage of equipment, in preparation for this operation?

Dr. THOMPSON. Well, in managing a program I think there is a shortage of manpower to do all the things. We have interfered with the ordinary use of manpower in a rather drastic way. So we have diverted manpower from their normal duties in a pretty extensive fashion.

Senator BROOKE. That is all, Mr. Chairman.

Dr. THOMPSON. Could I add one more point about this?

The CHAIRMAN. Yes.

Dr. THOMPSON. In dealing with the fire, the assessment of fire, I think we, perhaps, made some mention of this earlier or it is implied in the record, that we have stimulated here a very important advance in the understanding of the risk of fire by this review.

Prior to this review the understanding of flammability of materials was dependent to a large extent on tests in laboratories of small specimens arranged in different ways, some horizontal, burning horizontal, some vertical, some upward and some vertically downward, even 45 degrees, samples of materials with various kinds of nap on them, and on a variety of results which were obtained, and there was no real standardized method for deciding on flammability of materials.

What has been achieved here is a utilization of a mockup over at the Command Spacecraft Center to get, I think probably for the first time, a reliable index of the flammability of materials for real useful application to this problem.

At MSC, the Manned Spacecraft Center, they immediately constructed a boilerplate model mockup of this vehicle arranged in such a way that it could simulate the vehicle rather carefully as regards the arrangements of combustible materials in it.

The first exercise was the attempt at duplication of the actual accident, and I think in two attempts, the first one was not arranged quite right—well, the simulation was not quite what it should have been—and the next one, the arrangement of the vehicle was very similar as regards combustibility of materials, the arrangement of combustible materials, and a very adequate simulation of the combustibility problem was achieved.

Now, this goes way beyond the use of just samples of materials. An overriding factor is: How are they arranged? How is nylon knit? Is it coarsely knit or is it finely knit? Does it have a fuzzy edge? How is it arranged as far as continuity is concerned? And all those factors, factors of the geometric arrangement, and the nature of the weaving are very important factors.

The important result has been achieved that a system or a method of testing and evaluation has been developed that will be extremely useful in qualifying the vehicles for future flight use.

This simulator will be used to evaluate the improved arrangement and selection of materials so that there can be a very good evaluation of what the flammability risk is and the extent to which it has been reduced, and I think it is a very important achievement that, as I say, has been stimulated here by the start of this review.

The CHAIRMAN. I think that is true, Doctor. We had a hearing about these materials, and the Senator from Illinois examined the material, as we all did, and I think a very important contribution has been made by it.

I did not mean to interrupt you, Senator.

Senator BROOKE. Dr. Thompson, aside from the flammability of materials, take, for instance, the training of the launch pad crews for emergency training. This particular operation was not classified as hazardous, I understand.

Now, presumably, you will go through this stage again or this phase again.

Would it be classified hazardous the next time and, if so, why would it be classified hazardous?

Dr. THOMPSON. Well, I feel pretty sure it will be classified as hazardous. But the criteria that were used, that were in existence at the time of the test, did not automatically classify it as hazardous because those criteria apply to the use of hypergolic fuels in the space-

craft, and the application of the criteria simply that were in use did not identify this as its operation. I am sure those rules will be changed.

The same spacecraft, in the vacuum chamber, was classified as a hazardous operation because it was in a vacuum chamber at KSC.

Senator BROOKE. That is all.

The CHAIRMAN. Senator Cannon.

MATERIALS PANEL BOARD

Senator CANNON. Thank you, Mr. Chairman.

Doctor, the Materials Work Panel stated that several inadequacies were found in materials control, control of flammable materials installation was exercised by several organizations which tended to act independently.

Now, from a systems management standpoint, what organization should have been responsible for establishing and monitoring such controls?

Dr. THOMPSON. Well, the Apollo program office had the responsibility for that, and then the execution of the installation is in the hands of the contractor, and then the inspection, I think, is in the hands of MSC.

I think this is the basis for the several organizations, and the way this works out is that there are certain criteria, guidelines, used for installation for these materials dependent on their sensitivity to ignition, as to how close they should be placed particularly relative to possible ignition points.

Our understanding is this: that the contractor's guidelines that he developed and used in the installation were checked by MSC walk-through inspections at various stages, and I think this is the basis for this evaluation.

The MSC criteria that were used in that walk-through inspection had been identified as being more rigorous than the criteria used by the contractor, and when a walk-through inspection was made at the plant, the application of that more rigorous guideline resulted in the removal of a substantial amount of material because of its proximity to what were thought to be possibly ignition points or wire models, I believe, are the main criteria.

Later on during the course of the progress of the completion of this vehicle and in getting it ready for flight, other materials, flammable materials, might have been added, and a walk-through inspection, another walk-through inspection, which according to our understanding would have used the same criteria that the Manned Spacecraft Center used, would have been employed at that time.

That walk-through inspection was to have taken place within a few days, I think only a day or so after this accident. It had not taken place. It had not been accomplished prior to the accident, and I believe this application of different criteria arrived at in this way is the basis for that statement.

Senator CANNON. From a systems management standpoint shouldn't there have been one organization responsible, directly responsible, to tie these loose ends together?

Dr. THOMPSON. I think there is room for improvement in that respect; yes, sir.

Senator CANNON. In view of the leakage problems experienced in the environmental control system in Spacecraft 012 prior to the accident, did the Board find any evidence that joint redesign or other corrective action was underway to correct the deficiency?

Dr. THOMPSON. In the joints we did not.

QUESTIONS ON REDESIGN

Senator CANNON. Wasn't that a failure from a management standpoint, with the history of leakage that had been indicated?

Dr. THOMPSON. As far as we know that design had been accepted, and it was not subject to redesign. There was apparently a different idea of what is appropriate. We differ with the program office on that score.

Senator CANNON. And you recommend now that there be a redesign, this is part of your recommendation?

Dr. THOMPSON. We recommend that there be a redesign to the extent at least of applying much greater strength at those joints to give it redundancy necessary to stand abuse.

Senator CANNON. Now, in finding No. 11 reference is made to "open items," and "engineering orders not accomplished."

What is the significance of these findings to good engineering, manufacturing, and quality control practices?

Dr. THOMPSON. Well, I think this is a matter of judgment.

As to how many open items are appropriate, there are always open items, there are bound to be some. But our view of the situation was that there were probably more than would represent what we considered a proper situation. We thought there were more of those than were consistent with what there should be.

Senator CANNON. In your judgment, what accounts for this number of discrepancies in operating practice in the spacecraft program?

Dr. THOMPSON. I think that Mr. Williams should answer.

Mr. WILLIAMS. I think you will find a lot of significant engineering orders were open at the time of delivery down at the Kennedy Space Center and 623 engineering orders were released subsequent to the delivery.

Senator CANNON. How many was that?

Mr. WILLIAMS. 623 engineering orders. I think the only thing here is that the spacecraft was continuing to be designed, or the engineering orders, at least, were putting improvements and changes into the spacecraft as it was going through the test at the Cape.

I think that is the significance of the 22 orders not on the books yet. There was a timelag between the release of engineering orders at Downey, and incorporation into orders down at the Cape.

Senator CANNON. Would you anticipate as the program goes along that you would continue to have discrepancies develop; that is, as your experimentation progresses?

Mr. WILLIAMS. No, sir. This is the first manned spacecraft, and you would assume that you would get several engineering changes, and so forth, along the way during the testing program. I think the number should decrease.

Senator CANNON. The number should decrease, but you would be constantly getting new ones, would you not?

Mr. WILLIAMS. Getting new ones?

Senator CANNON. Yes, having new items developed that you would find required them to be changed.

Mr. WILLIAMS. I do not follow.

Senator CANNON. Perhaps I would prefer to ask Colonel Borman that as a test pilot. Isn't it usual to find discrepancies develop as you go along in a testing program?

Mr. WILLIAMS. Oh, sure.

Senator CANNON. And you find new items occurring that were not initially on the list as old items are corrected?

Mr. WILLIAMS. Yes, sir.

Colonel BORMAN. Yes, sir. I think Mr. Williams just misunderstood your question.

Senator CANNON. I see.

In finding No. 8 you recommend tests with full-scale mockups and flight configuration to determine the risk of fire.

Did the Board consider that good engineering practice would have specified such tests prior to the accident?

Dr. THOMPSON. The fire hazard has been completely reassessed as a result of this, and I do not think that we would have acquired a new value in the scheme of things and, as I think I indicated, the important development of a very good scheme for properly evaluating the fire risk or the flammability, has been a development that we think should be really applied to any future programs, and that mockup scheme should be utilized, and I am sure that they plan to utilize it to qualify what new engineering approaches to this problem are employed. So that we would not have said this before the fire.

Senator CANNON. But you feel that it would be good practice to follow?

Dr. THOMPSON. We feel it is an extremely valuable addition to the whole technology of conducting proper qualification tests.

ASTRONAUT EAGER TO MAKE FLIGHTS

Senator CANNON. I would like to direct a series of questions here to Colonel Borman, and I presume that you will be in command of the next flight, is that certain now, in view of the reorganization? [Laughter.]

Colonel BORMAN. As a matter of fact, I may be back in the Air Force. [Laughter.]

Colonel BORMAN. No, sir. I was assigned to the third manned flight, sir, and since I have been at Cape Kennedy since the 28th of January, I understand that some of the crews have been realigned, but I hope that I will be flying one of the earlier flights.

Senator CANNON. Let me ask you these questions in the context of either your membership on the Board or as a pilot and a potential commander of one of the Apollo flights.

Colonel BORMAN. Yes, sir.

Senator CANNON. Referring to page 9 of the doctor's statement, assuming that item 2, an extensive distribution of combustible materials in the cabin is corrected, as has been described here today; assuming that the wiring deficiencies from a vulnerability standpoint have been corrected; assuming that the vulnerability of the plumbing items have been corrected, as they were described here; assuming that the hatch is redesigned to provide for a rapid-crew escape, and

that provisions are made on a standby basis for rescue or medical assistance, would you then be willing to assume position of command in that capsule with the sealed cabin pressurized with the oxygen atmosphere?

Colonel BORMAN. I would be willing and eager to, sir.

Senator CANNON. Now, relating specifically to the other findings of the Board, of course, finding No. 1 presumably relates to the cause of the arcing.

In No. 2, do you feel if the recommendation of the Board is followed with respect to finding No. 2, that that would provide adequate safeguards from the standpoint of combustible material there?

Colonel BORMAN. Yes, sir; if we go the additional step that Dr. Thompson has just recommended, and that we check out the reconfigured spacecraft with the full mockup test.

ESCAPE POSSIBLE WITH NEW HATCH

Senator CANNON. I take it that, of course, finding No. 3 just related to the causes, and would you consider that finding No. 3 would be adequately taken care of if you have the redesign of the hatch and the rapid egress available?

Colonel BORMAN. Sir, it is my opinion, and I believe it is shared by the other members of the Board, that had we had the new hatch installed on this command module the crew would have escaped, so I would say, "Yes."

Senator CANNON. In that connection, will there be a provision, a redesign provision, for a rapid dumping of pressure other than just the removal of the hatch?

Colonel BORMAN. Yes. It is my understanding—of course, I believe you should address this to the Program Office, sir. I do, from the knowledge that I have, believe that this is being incorporated also. It is certainly important.

Senator CANNON. Of course, if that were true that would take care of finding No. 4; would it not?

Colonel BORMAN. Yes, sir.

Of course, if we get the new hatch the rapid dumping of the pressure will lose its significance on the ground, but we would still like to have it in the air.

Senator CANNON. You would like to be able to dump the pressure in the air?

Colonel BORMAN. I should not say in the air, I should say in orbit, sir.

Senator CANNON. In space.

Colonel BORMAN. Yes, sir.

Senator CANNON. Now, finding No. 5, of course, I think it has been well identified as being a hazardous condition, so there would be no need for any further identification in that area.

On finding No. 6, I take it that it does not actually relate to the cause, as to this type of occurrence again, but simply better procedure; is that correct?

Colonel BORMAN. That is correct, sir.

Senator CANNON. And finding No. 7 likewise did not contribute to the cause of the accident in this instance, and you would assume that that would not contribute to a future accident.

Colonel BORMAN. Yes, sir. I would also hope that it does not happen again. I do not like to get changes in the test procedure the night before we are supposed to run the test.

Senator CANNON. Finding No. 8, I think, requires no comment there in view of your comments already on the full-scale mockup.

I believe also you have commented on No. 9 there accordingly.

Do you have any further comments with respect to finding No. 10, Colonel Borman, insofar as you are concerned as a pilot?

Colonel BORMAN. Sir, the only finding part of No. 10 we have not touched on is 10g, "No design features for fire protection were incorporated." By this we mean there were no auxiliary, or one of the implications is, there were no auxiliary oxygen masks to protect the crew in the event of a toxic atmosphere on orbit, and I would hope that this recommendation will be heeded by the Program Office also.

Senator CANNON. The recommendation being that investigation be made of the most effective means of controlling and extinguishing a spacecraft fire and also to consider that auxiliary breathing oxygen be provided to protect from smoke and toxic fumes.

Colonel BORMAN. Yes, sir.

Senator CANNON. Are there any matters that, in connection with finding No. 11, that you think should be commented on from your standpoint?

Colonel BORMAN. No, sir.

Senator CANNON. Thank you very much, Mr. Chairman. That concludes the questions I have.

The CHAIRMAN. Do you have anything else, Senator Young?

Senator YOUNG. Yes.

UNIFIED HATCH PREFERRED

Colonel Borman, you deserve our gratitude for your frank answers to questions, and I compliment you on being very, very knowledgeable in this subject, and, therefore, I am directing a question to you. From testimony at our previous hearings, it is unclear to me and there seems to be some confusion about the status of this redesigned hatch, and I believe you can clear up this uncertainty.

Now, I know that Dr. Mueller on February 27 stated that consideration was being given to three different hatch concepts: One—you will find it on pages 98 and 99 of that hearing, you are familiar with it—one, the present two-hatch system; a second was the three-man sized hatch to provide an opening large enough for simultaneous three-man egress, and then there was this third concept that he told about.

Now, he said that NASA is evaluating these three concepts, but you indicated in your testimony, Colonel, that a decision had been made prior to the time this tragedy occurred.

Now, will you please clarify that for me?

Colonel BORMAN. Sir, it was my understanding that the decision—at least perhaps a decision had not been made by Dr. Mueller, but I believe that I am safe in saying that the decision among the flight crew, at least indicating the desirability of the unified hatch, had been agreed upon prior to this accident, and I believe, sir, that this is the type of hatch that is now being designed, the one that is shown on page 99 of your Apollo accident hearings, part 2.

Senator YOUNG. Well, here again Dr. Mueller stated that "We are evaluating this design against the present design," and so has a decision already been made to put the new hatch on block II spacecraft?

Colonel BORMAN. It is my information, sir, that, yes, it has been made, and it will be the unified hatch.

The CHAIRMAN. What is the basis of your information?

Senator YOUNG. Yes.

Colonel BORMAN. The basis of my information is informants that—

The CHAIRMAN. The information we have is it was not.

Colonel BORMAN. Sir, the basis of my information is by contact that I maintain with my fellow flight crew people and people in the Apollo office that are dealing with this problem daily. We have members of our organization that are interested in this, and that have been following the developments of it, sir.

The CHAIRMAN. Would not Dr. Mueller have to be brought into this somewhere?

Colonel BORMAN. I am sure he will have to approve it, but I think he has already done so. I believe it would be better for you to ask him, though all I can tell you, it is my understanding.

The CHAIRMAN. We did ask him.

Colonel BORMAN. Yes, sir; but you asked him on February 27. I think perhaps he will tell you, if you ask him tomorrow, that it is being—I hope he will confirm what I have just mentioned here. [Laughter.]

The CHAIRMAN. I realize you have hopes.

Colonel BORMAN. I have my hopes, but I also have my sources of information, sir.

Senator YOUNG. But it appears there is a discrepancy at the present time, is that not right?

Colonel BORMAN. I think, sir, that perhaps when Dr. Mueller testified before you, that he was still considering them, and perhaps I was premature in saying that I was—the other two hatches, in my opinion, were so out of the question that I immediately settled on the one that we have here.

Senator YOUNG. Well, we may be impressed by your view and agree with you, but apparently if a decision has already been made to put that new hatch on this spacecraft, if that has been made, when is it going to be done?

Colonel BORMAN. Sir, it is my understanding that it will be available the latter part of this year. And may I just suggest, I would like to be able to tell you exactly, but this is really in the area of the program office, sir, and everything I am telling you is just information I picked up through communication with Houston.

Senator YOUNG. Yes; but we really cannot rely definitely on this except that it is your understanding, based on your information, is that not right?

Colonel BORMAN. Yes, sir.

Senator YOUNG. Because there is a discrepancy as the record now stands, is that not correct?

Colonel BORMAN. I think there is a discrepancy in that I testified that it was my belief that at the time of this accident, a unified hatch was on the design board, and Dr. Mueller said at the time of the accident there were three different approaches being considered.

Senator YOUNG. That are presently being considered?

Colonel BORMAN. Yes, sir; and I guess I had considered them rapidly and settled on one that I felt was proper.

Senator YOUNG. But you have been too optimistic.

Colonel BORMAN. I may have been mistaken, but I would be willing to wager if I could.

The CHAIRMAN. No bet.

Senator BROOKE. Mr. Chairman.

The CHAIRMAN. Senator Brooke.

FLIGHT CREW SATISFIED SPACECRAFT SAFE FOR TEST

Senator BROOKE. Colonel Borman, I would think that the flight crews, having worked with the spacecraft, make recommendations that programing would listen to and utilize.

Now, you knew the flight crew intimately. Had at any time any member of the flight crew ever brought to your attention anything concerning that spacecraft which they felt could have been rectified or should have been rectified which was not done prior to this accident?

Colonel BORMAN. No, sir. I might add that never in my experience with NASA—I have been almost 5 years now at Houston, never in this time period, in my experience, have I ever seen in any instance any item that was identified as affecting crew safety overlooked, turned down, or relegated to a lower priority for any reason whatsoever, and in this case unfortunately we did not identify the hazards.

But the hazards that have been identified have never been diluted for any reason that I know of, sir.

Senator BROOKE. To the best of your knowledge none of the mistakes which have been found by this Board were ever mentioned by members of the space crew.

Colonel BORMAN. Well, yes, sir. There is—we knew about the coolant leaks, we knew about the trouble with the ECU, we knew about the wire problems, but, as I pointed out, there was a continuing vigorous effort to correct these items, and we had hoped and believed that the action was sufficient and adequate.

Senator BROOKE. This crew believed that everything that could have been done at that time had been done.

Colonel BORMAN. Sir, I think I can say that at the time they entered the spacecraft, they were satisfied that they had a spacecraft that was not only adequate but safe for the test that they were performing.

ALARM SYSTEM NOT WORTHWHILE

Senator BROOKE. Will the new spacecraft have an alarm system?

Colonel BORMAN. Sir, the old one had an alarm. We had an extensive caution and warning system. We do not have a reliable means of picking up fire detection. Fire detection is in its infancy, and we do not have that, and I would not propose that we install one.

Senator BROOKE. You do not propose to install one.

Colonel BORMAN. No, sir.

Senator BROOKE. Why?

Colonel BORMAN. Because of my experience in the aviation business where they have sometimes caused more troubles than they are worth.

I just do not believe that if we do the other things that we have recommended that they will be required for this item.

Senator BROOKE. Would you agree with that, Dr. Thompson?

Dr. THOMPSON. I agree with that. I am afraid if you put in a system, it might not see the fire, we might not know where it is going to occur, and I doubt that we know enough about where it is going to occur to properly sound an alarm that would be effective. If we did, we would fix that place so that the fire did not occur, and my understanding of fire alarm systems is that—like Colonel Borman's is—they might be much more hazardous than they are safe.

Senator BROOKE. The second reason would obviously be sound, but the first reason of course we did not know in this instance what could have happened so that would not necessarily be a justifiable and valid reason for not having a fire alarm; is it, Dr. Thompson?

Dr. THOMPSON. Well—

Senator BROOKE. If you feel it is going to be hazardous.

Dr. THOMPSON. I think it would be a very difficult problem to have an alarm that would provide a useful purpose arranged in such a manner that would give any reasonable additional assurance to reliability of the vehicle, and I would be willing to be convinced if I saw one, but I would be very skeptical. It would be very hard to prove to me that the system was not just another gadget that perhaps was more risky than it was safe.

Senator BROOKE. No further questions.

The CHAIRMAN. Mr. Gehrig has some questions.

Mr. GEHRIG. Dr. Van Dolah, the fire occurred in three phases, is that correct?

Dr. VAN DOLAH. Yes, sir; we have described it.

THREE PHASES OF FIRE

Mr. GEHRIG. Would you put into the record a chronology of the fire giving each of the three phases, the duration of the phase, and what characterized that phase?

Dr. VAN DOLAH. Yes, sir.

Mr. GEHRIG. If you can just furnish that for the record, it would be fine.

Dr. VAN DOLAH. All right, fine.

(The information referred to follows:)

First phase approximately 21:30:55 to approximately 21:31:19—relatively slow burning—intensely hot flames.

Second phase approximately 21:31:19 to approximately 21:31:25—turbulent burning—violent conflagration.

Third phase approximately 21:31:25 to approximately 21:31:30—rapid decrease in oxygen, rapid increase in soot and carbon monoxide.

Mr. GEHRIG. At what time did the third phase of the fire start?

Dr. VAN DOLAH. The third phase started at the time that the cabin atmosphere returned to atmospheric pressure, which we estimate to be about 25 seconds after the minute, that is 23:31:25.

Mr. GEHRIG. At what time did the third stage end?

Dr. VAN DOLAH. Well, again, as it can only be estimated; but we again estimate it to have lasted about 5 seconds so that it would end at 30 seconds after the minute.

Mr. GEHRIG. Dr. Thompson, panel 11, the Medical Analysis Panel, determined that the suit of the command pilot failed prior to the rupture of the pressure vessel which occurred at 23:31:19 G.m.t., as I understand it. In other words, at 19 seconds after the minute. Do you agree with that?

Dr. THOMPSON. I agree with the findings that have been determined by them; yes, sir.

Mr. GEHRIG. And the origin and the propagation of the fire estimates are that significant levels of carbon monoxide were present in the spacecraft atmosphere by 23:31:30, 30 seconds after the minute. Or 11 seconds later after the rupture.

Dr. THOMPSON. Yes, sir.

Mr. GEHRIG. Since one suit had failed, these gases are introduced into all of the suit loops, as I understand it; is that correct?

Dr. THOMPSON. Yes, sir.

Mr. GEHRIG. And therefore the crew was exposed to a lethal atmosphere right after the first suit failed. What is the best determination as to when the crewmembers lost consciousness?

Dr. THOMPSON. I think it is written in the record. I cannot recall the figures.

Mr. GEHRIG. As I read the report, the medical panel estimates that consciousness was lost between 15 and 30 seconds after the first suit failed.

Dr. VAN DOLAH. That is correct.

Mr. GEHRIG. And since the first suit failed prior to the cabin rupture at 23:31:19, that means that the medical panel estimated that unconsciousness did not occur until 23:31:34, which would be after the fire occurred. Is that correct? And perhaps not as late as 23:31:49.

Dr. VAN DOLAH. I do not think that is quite correct; no, sir. There is no precise knowledge as to when the first suit failed. We only know it failed prior to the burst of the cabin which occurred about 19 seconds after 23:31. But that suit could have failed many seconds before that, sir.

Mr. GEHRIG. What time did the fire start? As I understand, it started at about 23:31:04.7—no, I am sorry.

Dr. VAN DOLAH. That was the beginning.

Mr. GEHRIG. 04.7.

Dr. VAN DOLAH. That was the beginning the first verbal report of fire, sir.

Mr. GEHRIG. But it could not have started you think before 23:30:50.

Dr. VAN DOLAH. We do not know when it started.

Mr. GEHRIG. You have no estimate at all of when the fire started.

Colonel BORMAN. Yes, we estimated it started—

Mr. GEHRIG. You estimate it started at that time.

Dr. VAN DOLAH. Yes, sir.

TIME OF DEATHS DISCUSSED

Mr. GEHRIG. Did the medical analysis make any determination as to the time that death occurred?

Dr. THOMPSON. Medical opinion?

Mr. GEHRIG. Yes.

Dr. VAN DOLAH. The estimate is that chances—

Dr. THOMPSON. I think at this point it would be very well to have Dr. Berry, who is—who just walked in the room here, testify.

Mr. GEHRIG. Was Dr. Berry a member of the medical panel?

Dr. THOMPSON. He is head of the medical group. He heads up the medical group that we had on our panel and is very conversant with this whole matter; and we have relied very heavily and, as a matter of fact, our position has been established by the people who worked for Dr. Berry, who are on our panel with the assistance of Dr. Berry.

Mr. GEHRIG. I think the committee would prefer to hear Dr. Berry another time, Dr. Thompson. We would prefer to have the Board's views now.

What I am trying to establish is the sequence of events. As I understand it, the medical assistance panel did not make a determination as to the time death occurred. They only made a determination—an estimated—as to when unconsciousness occurred.

Colonel BORMAN. We have it right here, sir. I think on D 11-8, the determination, right above No. 15, gives you the best estimate of that. It is estimated that the time consciousness was lost was between 15 and 30 seconds after the first suit failed. "Chances of, resuscitation decreased rapidly thereafter and were irrevocably lost within 4 minutes."

Mr. GEHRIG. Dr. Thompson, does the Board feel, that is, is it the judgment of the Board, that death occurred before the fire was extinguished or before the fire ended?

Dr. THOMPSON. I think about the same time. This comes about the same time the fire ended but while they were in a very lethal atmosphere of carbon monoxide, the termination of the fire ended up with a chamberful of a high concentration of carbon monoxide.

Mr. GEHRIG. It would cause unconsciousness.

Colonel BORMAN. The hatch was not removed until about 4 minutes, 36 seconds. Your survival would be minimal.

Mr. GEHRIG. Is it reasonable that the—

Colonel BORMAN. Thirty-six, excuse me.

Mr. GEHRIG. I am sorry, 36 what?

Colonel BORMAN. Thirty-six seconds.

The CHAIRMAN. Would you start back your sentence and repeat it?

Colonel BORMAN. Yes, sir. The hatch was removed 4 minutes and 36 seconds after the crew report of fire, and it was the opinion of the best medical advice that we can have, that we have had, that the crew was beyond revival at that time.

Mr. GEHRIG. But then one can reason if there had been proper emergency procedures established for the ground support people outside they would have been able to remove the hatch within 90 seconds that perhaps some crew members could have been saved.

Colonel BORMAN. I think this is conjecture. You certainly would have to have some feeling, I think, for the intensity of the fire and the toxicity of the atmosphere.

From talking to the witnesses who were on the pad at that time, it was a very violent reaction. There was an intensely toxic atmosphere around the outside of the spacecraft, heavy smoke, and the efforts at rescue were severely impeded not only by the lack of equipment but by just the sheer lack of visibility.

Mr. GEHRIG. So if the proper equipment had been available, they could have worked on the hatch door.

Colonel BORMAN. That is correct.

DISCUSS TESTS PRIOR TO FLIGHT

Mr. GEHRIG. How many manned tests are run on the pad before there is a manned Apollo spacecraft flight?

Mr. WILLIAMS. If you will take a look at the test program, you run a detailed systems test first and then an electrical mate test between the launch vehicle and the spacecraft and then an integrated test with the launch vehicle and the plugs-out test followed by FRT test, flight readiness test, which is followed by servicing of the spacecraft on the launch pad.

Mr. GEHRIG. So how many manned tests are there? I do not know if I caught it, five or six.

Mr. WILLIAMS. About five or six.

Mr. GEHRIG. What test number was being run on January 27 when the accident occurred?

Mr. WILLIAMS. 0021, the plugs-out test.

Mr. GEHRIG. And had manned tests been run on the pad with the spacecraft prior to this test?

Mr. WILLIAMS. Yes, sir. The detailed systems test, the electrical mate test, and the integrated test with the launch vehicle.

Mr. GEHRIG. With men in the spacecraft.

Mr. WILLIAMS. With men in the spacecraft.

Mr. GEHRIG. During any of these prior tests, was the spacecraft—the spacecraft pressurized with 100 percent pure oxygen at 16.7 psi?

Mr. WILLIAMS. No, sir; not on the pad. It was pressurized with roughly 16 pounds in the altitude chamber four different times.

Mr. GEHRIG. So January 27 was the first time that the Apollo spacecraft was pressurized on the pad with 100 percent pure oxygen.

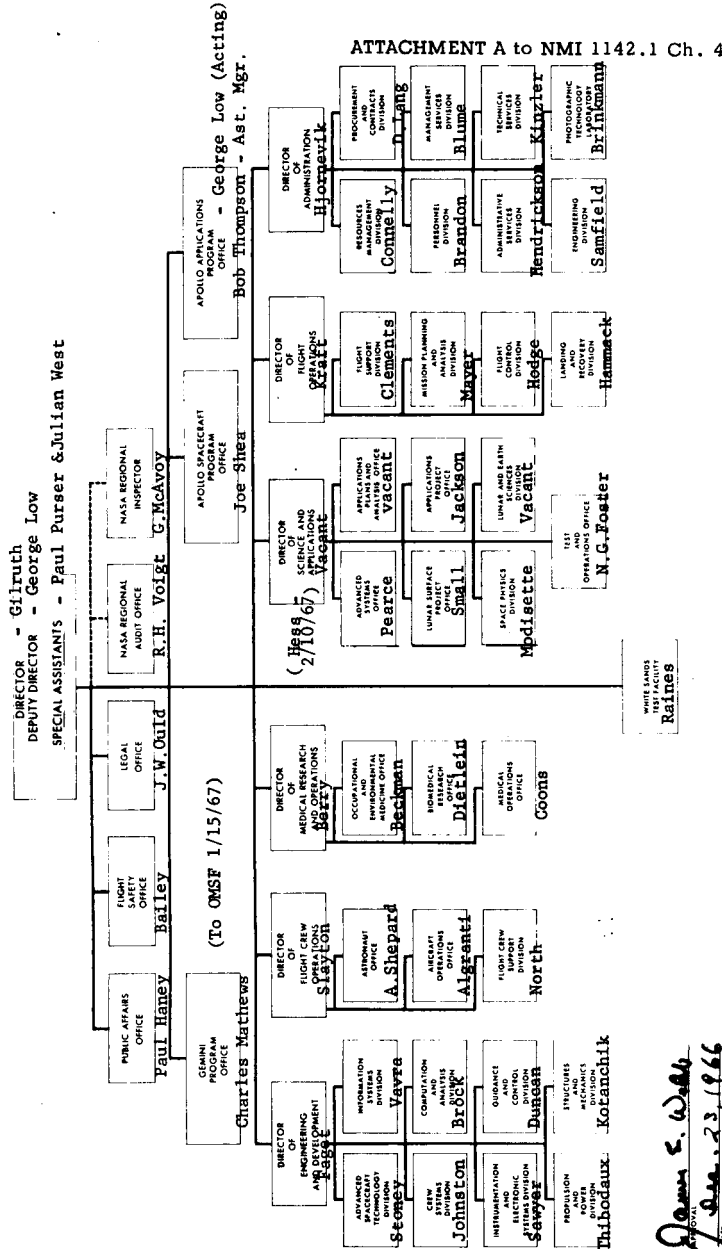
Mr. WILLIAMS. On the pad, that is right.

Mr. GEHRIG. Mr. Chairman, may I suggest that we put into the record some organization charts that we have used here of the Office of Manned Space Flight, the Manned Spacecraft Center, the Marshall Space Flight Center, and the Kennedy Space Center, and I would also recommend that the Board put in the record at this point an organizational chart of the North American Aviation Co.

The CHAIRMAN. Without objection.

(The charts (see figs. 77-86) referred to follow:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON TEXAS



ATTACHMENT A to NMI 1142.1 Ch. 4

FIGURE 78

James E. Walsh
APOLLO ACCIDENT INVESTIGATION
1/23/1966

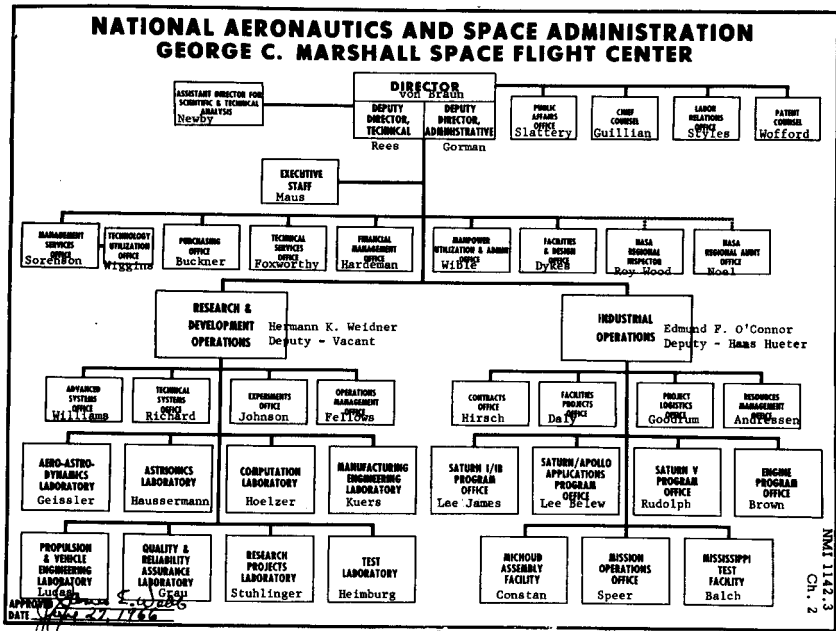


FIGURE 79

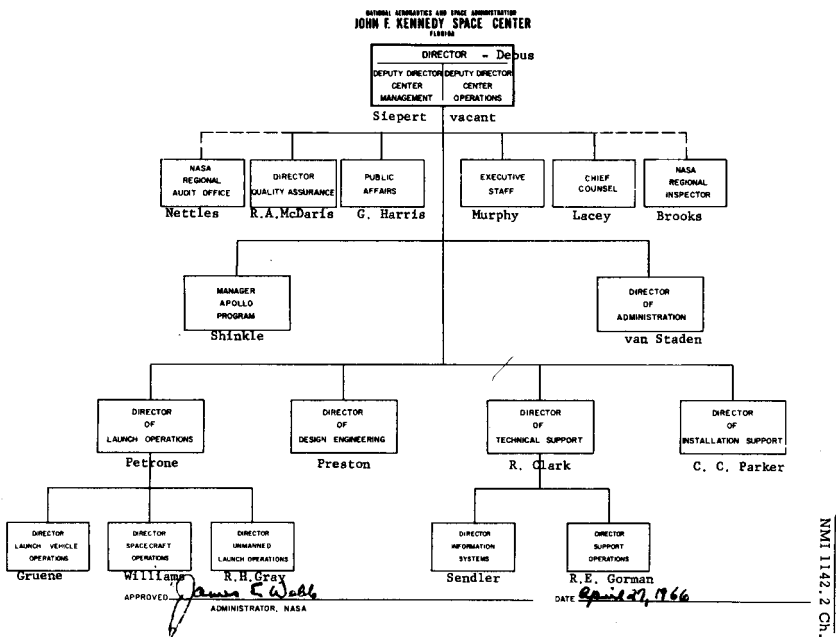


FIGURE 80

(The material on North American Aviation referred to was submitted as follows:)

Transmitted herewith is the North American Aviation, Inc. organizational structure together with a brief narrative of the organization and management of the Apollo Command and Service Module Program.

DIRECTION AND CONTROL OF APOLLO COMMAND-SERVICE MODULE (CSM) PROGRAM

I. ORGANIZATION AND MANAGEMENT OF APOLLO CSM PROGRAM

North American Aviation (NAA), by the nature of its organization and the policy of its management, makes available to the customer the full resources of the company in support of the Apollo CSM Program. Program management has been assigned to direct and control the Program to satisfy customer technical, schedule, and cost requirements.

A. Corporation

The Space and Information Systems Division (S&ID), which is responsible for the Apollo CSM and Saturn II Programs is one of seven NAA operating divisions supported by corporation administrative organizations. Each division is headed by a division president who is also a vice president of the corporation responsible to NAA President, J. L. Atwood. Mr. Atwood is also Chairman of NAA's Board of Directors. The corporation establishes and administers the broad policies which constitute the framework within which each operating division functions. Chart "X" shows the NAA corporate organization.

B. S&ID

S&ID is headed by Division President, H. A. Storms. This division is responsible for the Apollo CSM and Saturn II Programs which are being carried out under separate program managers. The Apollo CSM Program is directed by Apollo CSM Program Manager and S&ID Vice President, D. D. Myers, who is responsible to both NASA and Division President, H. A. Storms. Advanced Programs Development, and Research, Engineering and Test furnish special technical support as needed. Other S&ID functions provide administrative support—Chart "Z" shows the S&ID organization.

C. Apollo CSM

As shown in Chart "L," the Apollo CSM Program Manager, D. D. Myers, is assisted by Deputy Program Manager, C. H. Feltz, and four Assistant Program Managers. Directors of four functional areas report directly to the Program Manager. The Director of Quality and Reliability Assurance is responsible to the Program Manager in technical matters although reporting administratively to the S&ID Director of Quality and Reliability Assurance. The Director of Apollo CSM Operations, Florida, J. L. Pearce, is responsible to the Apollo CSM Program Manager although he reports administratively to the NAA General Manager of the Florida Facility, W. S. Ford. This organizational plan gives the Apollo CSM Program Manager direct control and responsibility over all phases of the Program including all subcontracting, which is administered by Apollo Material.

D. Florida facility

The overall Florida Facility organization is shown in Chart "Q," and the Apollo CSM Florida organization, in Chart "E." The Apollo CSM Florida Director, J. L. Pearce is supported by three managers, the Chief Project Engineer, R. W. Pyle, and the Technical Support Chief, R. E. Franzen. The three managers have separate areas of responsibility: Test Operations, J. M. Moore; Test Sites, R. E. Barton; and Quality and Reliability Assurance, J. L. Hansel. Very close liaison and control between Downey and Florida Apollo CSM operations is maintained.

II. PROGRAM HARDWARE RESPONSIBILITY

S&ID is responsible, with NASA concurrence, for the overall development, design, manufacture, and test of Apollo CSM hardware.

A. Spacecraft configuration

The Apollo CSM configuration is shown in Chart ZZ. S&ID is responsible for the command and service modules, the launch escape system, the spacecraft/lunar module adapter, and most subsystems pertaining to these modules. S&ID is responsible for coordinating the physical and operating interfaces of these modules and systems with the Associated Contractors (shown in Chart LC), and NASA.

B. Ground support equipment (GSE)

NAA supplies GSE as directed by NASA to support Apollo CSM test and checkout operations at all test sites. This GSE consists of checkout equipment, auxiliary equipment, servicing, and handling equipment. NAA is responsible for the design, manufacture, and checkout of this GSE.

C. Subsystems

The following Apollo CSM subsystems and modules are being produced inhouse at NAA:

Subsystem or Module and Division.—

Command and Service Modules (Complete) : S&ID ;
 SLA (Complete) : S&ID ;
 Launch Escape System Structure : Los Angeles Division ;
 Sequencer System : Autonetics ; and
 Command Module Reaction Control System : Rocketdyne.

Units that are made at other NAA divisions are designed, manufactured, and tested under S&ID supervision and control.

D. Subcontractors

Major and minor subcontractors are selected with NASA concurrence by S&ID, and are under S&ID surveillance. The subsystems they fabricate are designed, manufactured, and tested under S&ID supervision and control. Chart R shows the Apollo CSM major subcontractors and the systems for which each is responsible.

E. Suppliers

S&ID buys hardware for the Apollo CSM Program directly from over 12,000 first tier suppliers of which 9,000 represent small business; and the remainder, large business. All such hardware must be bought from S&ID approved sources and the hardware must be certified and tested as required to meet applicable specifications. Suppliers of these first tier suppliers represent many thousands of additional firms.

III. PROGRAM CONTROL PROCEDURES

A. The baseline for NASA and NAA management of the program is contained in the contract. The particular control baselines are the technical, master end item and specific end item specifications, the contract plans, and contract change notices which become incorporated into the baselines by specification and supplemental agreements. The controlling plans are the Manufacturing Plan, the Quality Control Plan, the Configuration Management Plan, the Ground Operations Requirement Plan and the Reliability Plan.

B. Control Tools—Cost, Schedule and Quality. Program control procedures are implemented only after formal Joint NASA/NAA interface agreements. These interfaces consist of contractual, technical and schedule meetings and documentation. Contractual direction is given by NASA to NAA through (bilateral) Supplemental Agreements and Contract Specification Change Notices and through (unilateral, by NASA) Contract Change Authorizations. Technical direction is given by NASA through Program Management Meetings, letters and wires to the NAA contracting officer and in formal reviews and Interface Control Documents. Formal joint reviews are Preliminary and Critical Design Reviews (PDR's and CDR's), First Article Configuration Inspection (FACI), Customer Acceptance Readiness Reviews (CARR) and Flight Readiness Reviews (FRR).

Through the S&ID Apollo CSM Program Manager's Office, control is exercised over CSM program costs, schedule and quality. The control media include the following:

1. *Cost Control* is provided primarily through Joint NASA/NAA negotiated and approved "work packages" with individual work package managers assigned to control costs, schedule achievements and quality. The choice of work package breakdown structure has enabled individual cost control of functional elements within S&ID as well as major subcontractors which supply CSM subsystems. NASA, NAA division and corporate policies assure proper make or buy decisions, subcontractor bid selection and the like.

2. *Schedule Control*, is provided by use of a "Master Development Schedule," a formal schedule change system, a PERT reporting system of scheduled milestones and formal critical problem reports. Major schedule changes receive concurrence of the NASA Program Manager prior to NAA implementation. The selection of schedule milestones, monitored by PERT are also identified in the cost control work packages, yielding an integrated cost/schedule measuring device.

3. *Control of Quality* is provided by (a) jointly approved hardware qualification test-selection, criteria, test surveillance and test report approval, (b) Joint NASA/NAA mandatory inspection point assignments and surveillance, and (c) step-by-step inspections (NASA/NAA) through manufacture, checkout and pre-launch operations. A failure reporting system assures follow-up on potentially discrepant hardware. Control of subcontractor quality is provided in a similar fashion, with NAA and NASA approvals obtained as described in paragraph E.

C. *Management Control Documents*—Management control documents for Apollo CSM hardware exist at both the program level and at the first-line level of NAA S&ID management. The top documents serve to record design and product cer-

tification and flight readiness. These are the jointly approved minutes of PDR, CDR, FACI, CARR, Design Certification Review (DCR) and FRR.

The first-line level management control documents are:

1. *Design*—Master Change Records (MCR), drawings, process specifications, interface control documents and measurement lists.
2. *Manufacturing*—Fabrication and inspection record tickets, planning tickets, tool orders and parts replacement requests.
3. *Material (Purchasing)*—Purchase order, purchase order change notice and specification control documents.
4. *Test and Operations*—Operational test plan, operational checkout procedure, not satisfactory report, test preparation sheet, development test procedure.
5. *Quality and Reliability Assurance*—Inspection test instructions, material review disposition and quality control specifications.

D. *Configuration Management*—Configuration Management is practiced through compliance with the NASA Apollo Configuration Management Manual and NAA Division Policies as implemented by the Apollo CSM Change Control Board, chaired by the Assistant Program Manager. Configuration changes with major program impact are resolved at Joint Change Control Board meetings between the NASA and S&ID Program Managers.

Changes imposed on program baselines originate from both NASA and NAA. NASA directed changes are processed by Contracts through the Change Control Board for preparation of proposals. In-house changes are processed by the Apollo CSM chief project engineer also through the Board for evaluation and direction. Change control documentation is in the form of a Master Change Record (MCR) which defines the change and is the basis of an order to the functional departments to provide cost and schedule information for necessary evaluation, prior to final implementation. The MCR can be used, as above, to determine details of a change prior to implementation; however for urgent changes the purpose of the MCR is to initiate action, which is accomplished upon MCR approval by Program Management for "Release to Production".

Configuration records are maintained in mechanized records of released engineering drawings and specifications. These records provide indented drawing lists, parts lists and alpha-numeric parts or drawing lists. The manufacturing planning system assures drawings and engineering order (E.O.) compliance utilizing Fabrication and Inspection Records (FAIR) and a Change Verification Record (CVR) for each end item. The FAIR provides both fabrication instructions and inspection verification; the CVR provides E.O. records and verification of compliance.

During Downey, Houston and Florida testing, a Test and Inspection Record (TAIR) system provides identical configuration and inspection information.

E. Subcontractor control baselines consist of (a) approved design specifications, drawings, components, qualification test plans and reports, acceptance test plans, critical process specifications, and component failure histories. A FACI is conducted for complex (major) procurements by S&ID with a NASA audit. Other procurements are subjected to FACI at NAA, utilizing subcontractor data. All baselines are re-verified to NASA at the SC 101 (Block II lunar capable vehicle) FACI.

Conformance of the subcontractors is controlled by "freezing" component changes at FACI, strict part number control, identification and reidentification, source or receiving inspection to formally approved drawings and baselines and component repair or overhaul, controlled to the configuration specified in the approved baseline.

Changes are justifiable only for NASA or NAA requirements modifications; failure in qualification, during production or in operational tests; or for significant cost reduction. Change controls parallel the NASA-S&ID change control procedures. This method of subcontractor control is in effect at such major subcontractors as Honeywell, AiResearch, Beech and Pratt & Whitney.

F. Field Site Control—Apollo CSM Program Field Site efforts with activities at Florida, MSC-Houston, White Sands, New Mexico and El Centro, California, are managed as are similar efforts in Downey. The management differences are caused by the fact that hardware at field sites has usually been transferred to NASA-owned, and also is governed by NASA field site management procedures, rather than NAA or NASA-MSO.

Hardware flow through the field site is controlled by the Ground Operations Requirement Plan (GORP) contractual document, as modified by operational changes and deviations approved by the NASA-KSC or other field site change board.

Hardware changes evolving from NASA and NAA sources, identified previously are processed through the Downey system for incorporation in a similar manner to other changes.

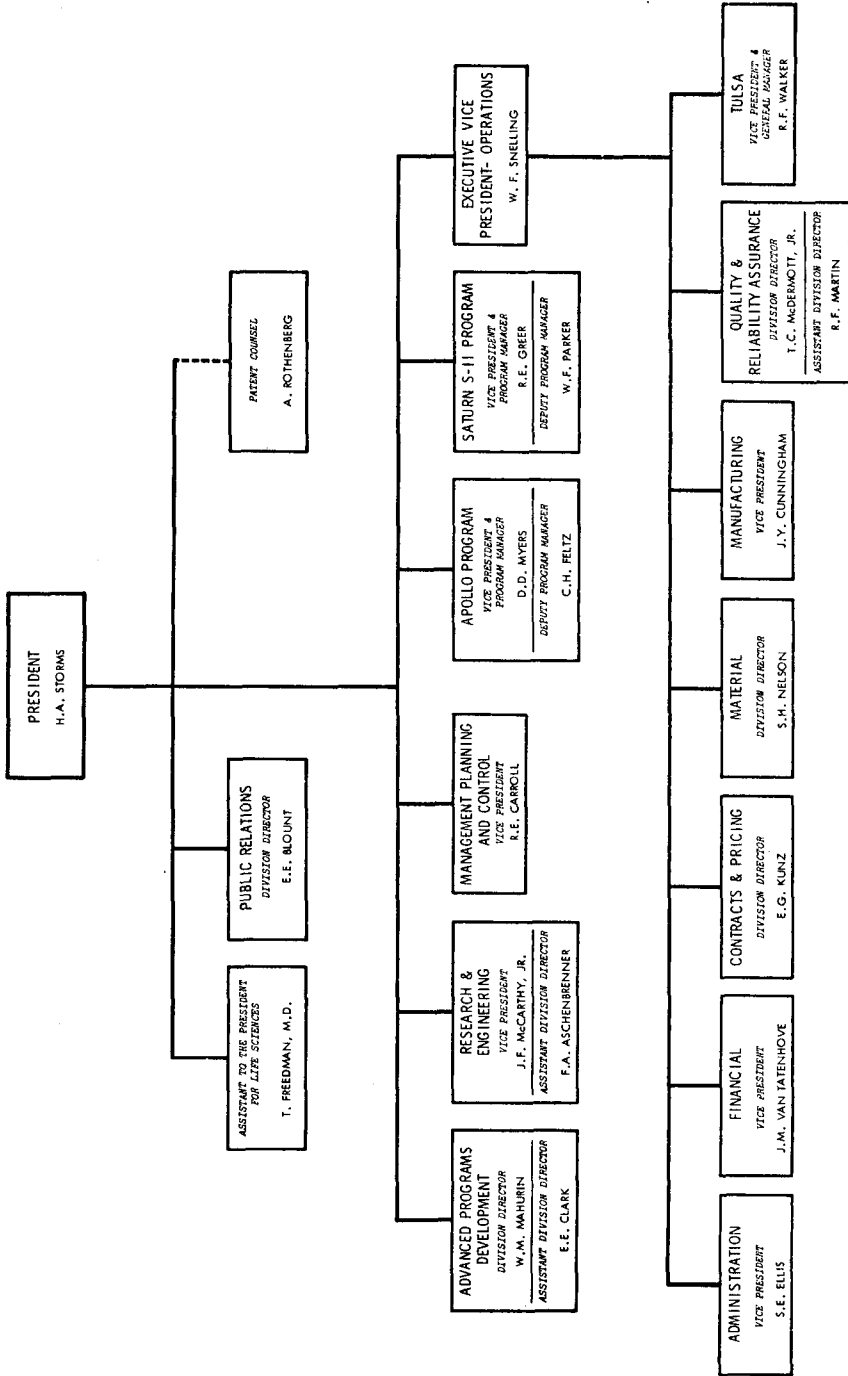


FIGURE 81

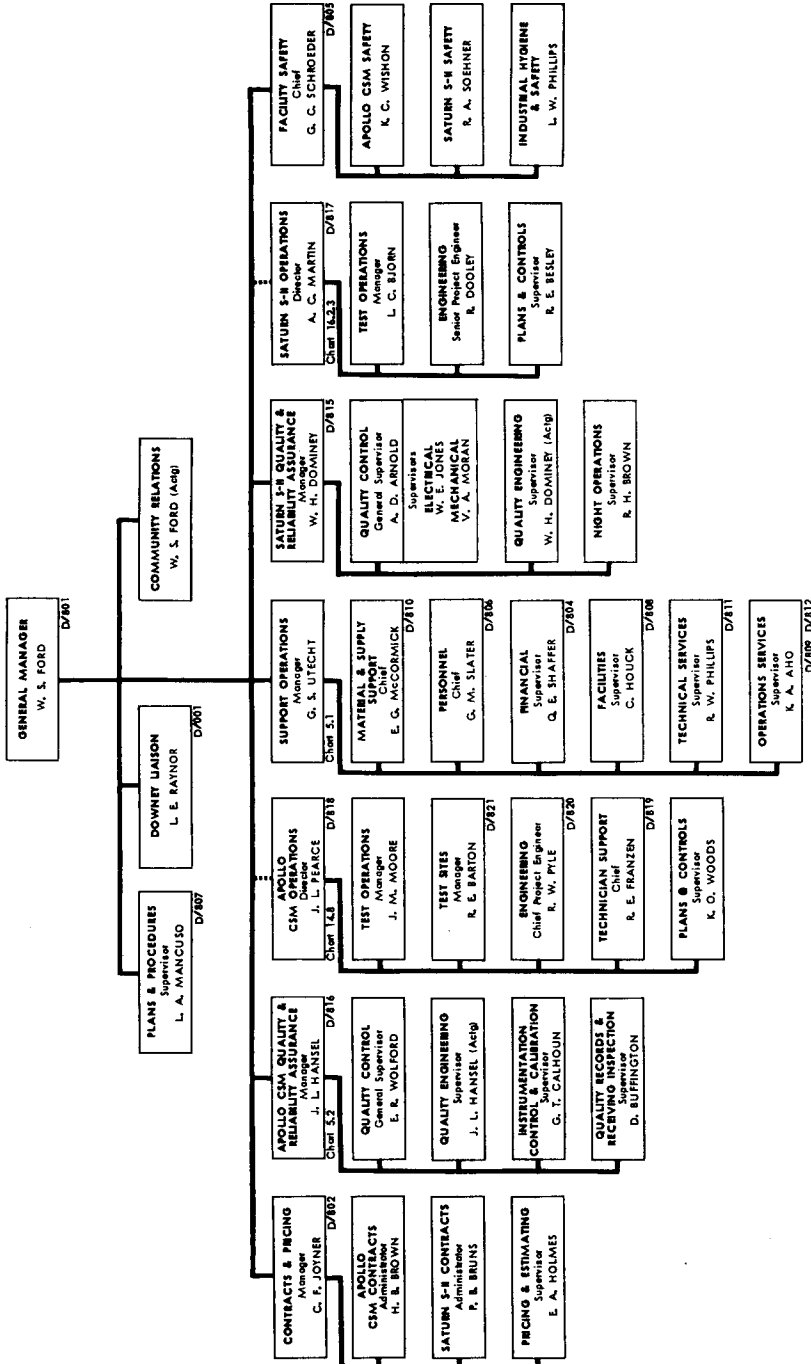


FIGURE 82

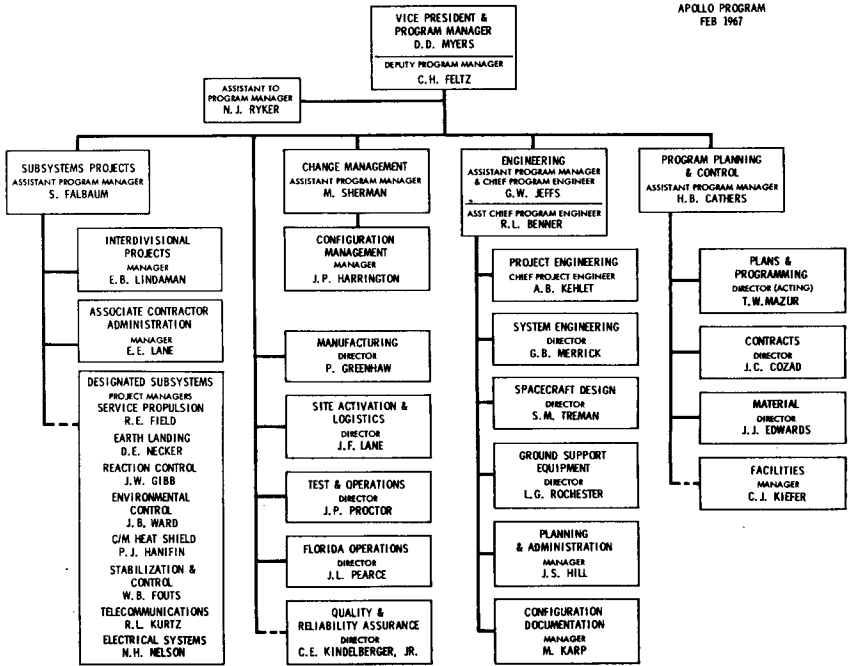


FIGURE 83

APOLLO ASSOCIATE CONTRACTORS

17AP86788

MIT	GUID & NAV EQUIP. - TECH MGMT
AC ELECTRONICS	GUID & NAV EQUIP. - MFG
CHRYSLER	S-I
BOEING	S-IC
NAA S&ID	S-II
DOUGLAS	S-IV & S-IVB
GENERAL ELECTRIC	ACCEPTANCE CHECKOUT EQUIP.
GRUMMAN	LUNAR MODULE
HAMILTON	
STANDARD	SPACESUIT & PORTABLE EQUIP.

FIGURE 84

S96AP84509D

APOLLO SPACECRAFT

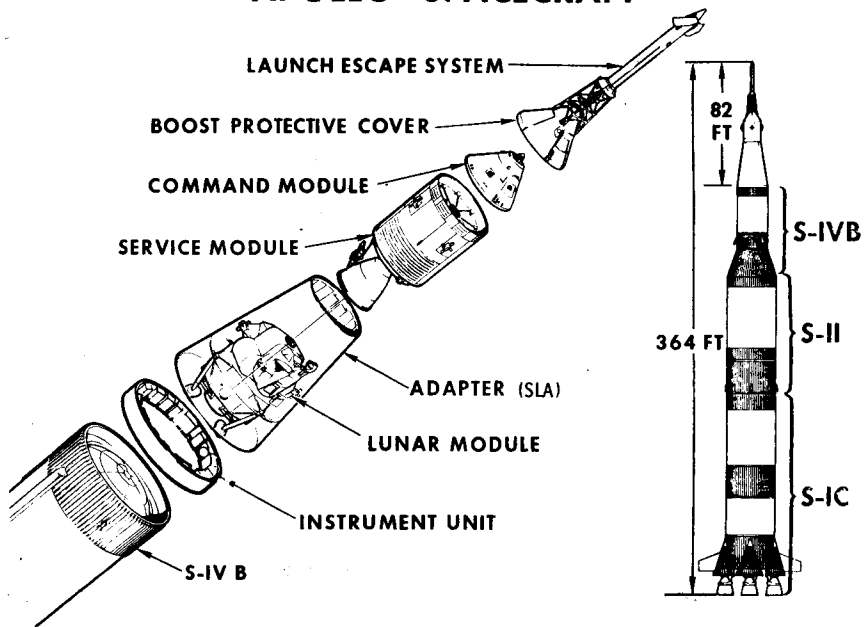


FIGURE 85

APOLLO MAJOR SUBCONTRACTORS

<u>SUBSYSTEM</u>	<u>SUBCONTRACTOR</u>
SERVICE MODULE PROPULSION MOTOR	AEROJET-GENERAL CORPORATION
CM HEATSHIELD BRAZED STRUCTURE PANELS	AERONCA MFG CORPORATION
ABLATIVE HEATSHIELD	AVCO CORPORATION, RESEARCH & ADVANCED DEVELOPMENT DIVISION
SUPER CRITICAL GAS STORAGE	BEECH AIRCRAFT CORPORATION
COMMUNICATIONS AND DATA	COLLINS RADIO COMPANY
ENVIRONMENTAL CONTROL	GARRETT CORPORATION, AIRESEARCH MFG. DIVISION
MISSION SIMULATOR TRAINER	GENERAL PRECISION, INC. LINK DIVISION
STABILIZATION AND CONTROL	HONEYWELL
LAUNCH ESCAPE AND PITCH CONTROL MOTORS	LOCKHEED PROPULSION COMPANY
REACTION CONTROL MOTORS (SERVICE MODULE)	THE MARQUARDT CORPORATION
EARTH LANDING	NORTHROP CORPORATION, VENTURA DIVISION
ESCAPE TOWER JETTISON MOTOR	THIOKOL CHEMICAL CORPORATION, ELKTON DIVISION
FUEL CELL	PRATT & WHITNEY AIRCRAFT, DIVISION OF UNITED AIRCRAFT CORPORATION

FIGURE 86

NASA-CONTRACTOR AND STRUCTURE QUESTIONED

Mr. GEHRIG. Dr. Thompson, the chairman asked a question early this afternoon as to whether or not the Board felt that there was a division of responsibility which contributed to the fact that desired quality levels were not achieved. For example, divisions of responsibility between the Manned Spacecraft Center and North American Aviation, et cetera, that were not properly defined. As I understood your answer, you said that the Board had found these—the gist of your answer was that there were not divisions of responsibility, but that does not seem to be the same as your determination under finding No. 11, and I wonder if you can speak to that determination and amplify this for the committee.

Dr. THOMPSON. The problem, I think, that we have identified is more the interface between MSC and KSC. As the spacecraft is moved from the custody of Downey, the contractor, under MSC control, cognizance, to Kennedy, KSC, where in effect another group of NASA employees take over but still under the control of MSC, and I think that in the development of working interfaces there of MSC retaining the control over the spacecraft as far as design changes in things that affect the cost are concerned, or changes to the spacecraft, that there is some—a problem of cumbersomeness or what was defined to us as cumbersomeness, that relates to working out in an effective way those relationships. This is, I think, as close as I can come to, or is about as well as I really understand the problem.

We heard quite a lot of talk about this in our considerations here, and I believe that it is the development in this evolving area that is not yet perhaps resolved. All the interface of the NASA organization working with another set of contractors, another contractor group, too.

Now, North American has 8,000 employees at Downey and something like a thousand at KSC, so the spacecraft moves from one group of people to another but—two different groups, in effect, with the necessity for actual control remaining always at MSC, and I think that the problems are the interface problems that have not been sufficiently smoothed out to deal with the flexibilities required, or the quick response that is required with the necessity for actual restraint, and I do not believe that I can go much farther than that.

Mr. GEHRIG. So that there are some management problems. There are some management problems, in this area.

Dr. THOMPSON. There are management problems in every program I have ever seen and this is one that probably is not fully resolved yet. The lines of organization seem to define these things to a point that it does not appear in the line organizations.

Mr. GEHRIG. Mr. Chairman, those are all the questions that I have.

The CHAIRMAN. We will go back again. We want to see if there are additional questions.

Senator Curtis?

SAFETY GIVEN TOP CONSIDERATION

Senator CURTIS. Just one question, and I am sorry I had to be out. If this has been covered, why, I will not go over it again.

Colonel Borman, this morning I asked you about the fact that you had objections to the wiring before you went on this Board. Did you express those objections to anyone?

Colonel BORMAN. Sir, I believe you asked me if I knew of deficiencies in the wiring, and I said yes, I did. The deficiencies were continually being corrected, and they were known, and they were modified, and as far as I know at the time of this test the wiring was accepted.

Senator CURTIS. In other words, you are referring to some deficiencies that were known and—

Colonel BORMAN. And had been fixed.

Senator CURTIS. And when it was mentioned they were taken care of.

Colonel BORMAN. Yes, sir.

Senator CURTIS. So you were not referring to some deficiencies that, after they became known, were neglected.

Colonel BORMAN. No, sir.

Senator CURTIS. Do you know of anything in the space program where such a thing prevailed?

Colonel BORMAN. Sir, while you were out I mentioned to Senator Brooke that I know of no instance in my 5 years with NASA when there has been ever any compromise when a question of crew safety was involved in any respect—time, schedule, money, and everything—everything was sacrificed to provide a safe vehicle.

Senator CURTIS. Did you ever receive any rejection of questions or inquiries about something? Was there freedom to express a concern about something that ought to be improved?

Colonel BORMAN. Yes, sir; I think speaking again as a flight crew-member, this is, in my opinion is, one of the very great assets of NASA as an organization. The opinions, the considerations, and sometimes even the desires of the flight crew are always listened to and very often heeded. We have a very willing and able access to every level of management.

Senator CURTIS. Well, I will not pursue it any further, and I am pleased that Senator Brooke did follow through, because I was afraid this morning we may have left a record that to some would indicate that you were aware of some deficiencies that somebody failed to take care of.

Colonel BORMAN. I am sorry I left you with that impression.

Senator CURTIS. No; I think it was the questioning that would have left that.

BOARD UNANIMOUS IN FINDINGS

The CHAIRMAN. Dr. Thompson, we know that each member of the Apollo 204 Review Board has formally signed the Board's report indicating concurrence in the findings included therein. However, I think it would be well that the record show that this committee has been assured that no Board member has any reservation concerning any aspect of the report or any of the findings and recommendations.

Therefore, if any member has any such reservation, would he please stand up, identify himself, and state what part of the report he wishes to have qualified insofar as he is concerned?

You have to speak now or forever hold your peace.