

1. AAP CONCEPT (ENGINEERING)

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GILL: I would like to call your attention to a reference which was given by Dr. Geratwohl: "Survival of Micro-organisms in Space," by Drs. Hotchin, Laurentz, and Hemenway from the Dudley Observatory, published in Nature magazine, May 1, 1965.

You are going to learn about the possibilities for biological experiments to be carried on manned vehicles in the near future, the nature of the capability of those vehicles for carrying out your experiments, and for men to carry out your experiments, and then you will learn some of the hard facts which will be related to making your experimental dream come true. Finally, there are three speakers this afternoon to give you the three aspects of the program. Also, there will be a chance to ask questions of the various speakers.

With that, I think we will begin with the first speaker, Mr. William Taylor, who comes from the Apollo Applications Office, and he will review the general problem for you, the general possibility.

TAYLOR: I am not quite sure I know what "review the general problem" means, but what I would like to do this afternoon is to spend a little time giving you our current thinking on what the objectives of the Apollo Applications Program are, and this will be very brief: Some time scale or reference schedule type of information to set in context the time scale you should be thinking of in the possibility of flying bioscientific experiments on the Apollo and post-Apollo missions; a brief summary of some of the configurations that we are talking about for the follow-on capability or the follow-on missions to Apollo; and then I thought it might be interesting for me to run through the results of some of our feasibility studies, particularly as they apply to a bioscientific mission, or a mission whose primary objective was the acquisition of bioscientific data, and show you some of the things that we ran across in doing this feasibility study, the capabilities and constraints that this type of mission both provides and imposes.

I will try to cover these items, and I will be available for the question-and-answer session. I will try to leave a little time right now for questions, so if I say something that does not make sense, or that you would like to nail me on, please do not hesitate to do so.

The current definition of the objectives of the proposed Apollo Applications Program is summarized as follows:

Acquire scientific, technological, and operational data and experience:

In Earth orbit, lunar orbit, and on the lunar surface

By the early 1970's

To lead to capabilities during the 1970-80's for ...

Space stations in Earth orbit

Lunar observatories

Manned planetary exploration

Through use of Saturn/Apollo hardware, production capability, and operational experience

The primary objective is to acquire data and experience in the lunar region of space, near Earth, lunar orbit, and the lunar surface, in the time frame of between now and the early 1970's—1971, 1972, and 1973—and as a sort of leading edge or steppingstone or bridge to the follow-on, or the next generation of spacecraft or space vehicles, such as permanent space stations in Earth orbit, manned lunar observatories of a temporary or permanent nature, and ultimately possibly a manned planetary exploration—all of this through the use of the hardware and the capabilities, both ground and flight hardware capabilities, which the Nation is developing for the Apollo program.

So in summary, our objective is to acquire data selectively from areas of primary interest to the scientific community, the technological community, or what is in the best interests of the Nation. These areas are summarized in the following list:

Major Areas of Interest: Space operations and technology
Meteorology
Communications
Earth resources
Astronomy and physical sciences
Bioscience
Lunar exploration

A later speaker, Mr. George, will discuss in some more detail the types of experiments and the numbers of experiments in these major areas which we are looking at, which have been identified, and which we feel are within the capabilities of our system.

This is not supposed to be in any priority order.

We feel that timewise the capabilities to conduct space operations and develop the technology are the first on our list of things that we must do if we are going to do any of the remaining ones. In the basic Apollo program, the space operations capability to live for 2 weeks in space, to land on an extraterrestrial body and return, this is really the objective of the Apollo program. To extend these capabilities to stay longer, to rendezvous for extended durations, and that sort of thing, we class as a major area of experimental interest for the Apollo Applications Program.

Similarly in meteorology, communications, Earth resources, these types of areas of interest really are an extension of the current activities that are going on in NASA's program and in the U.S. program generally, and we look on the Apollo Applications Program as a system which can take the results, for example, in meteorology of a Tiros or Nimbus satellite, and communications from the Early Bird or the Syncom, and Earth resources or lunar resources from a lunar orbiter. For example, we can take what we learn from those and apply that equipment and technology to manned flights in the Saturn-Apollo Applications Program which could then lead to either improved performance in manned systems or intermittently manned systems, or permanently manned systems thereafter. So we do not look on these as an end in themselves, but rather as a steppingstone in the technology.

In astronomy and physical science, in the bioscience areas, we feel particularly in the bioscience area that we may now have the capability for long-duration flights attended and in-flight monitored by man in the spacecraft, so it is long-duration zero gravity or space environment that we look to in the bioscience area.

In the lunar exploration area, again back to our basic objectives, the lunar exploration, of course, is one of the primary goals of the Apollo program, and extending that appears to be well within the capability of the Apollo system to get the data necessary to determine whether you are going to really establish permanent bases there.

All of these then, to some degree or another, can lead to the next generation of space vehicles for space exploration in the 1970's.

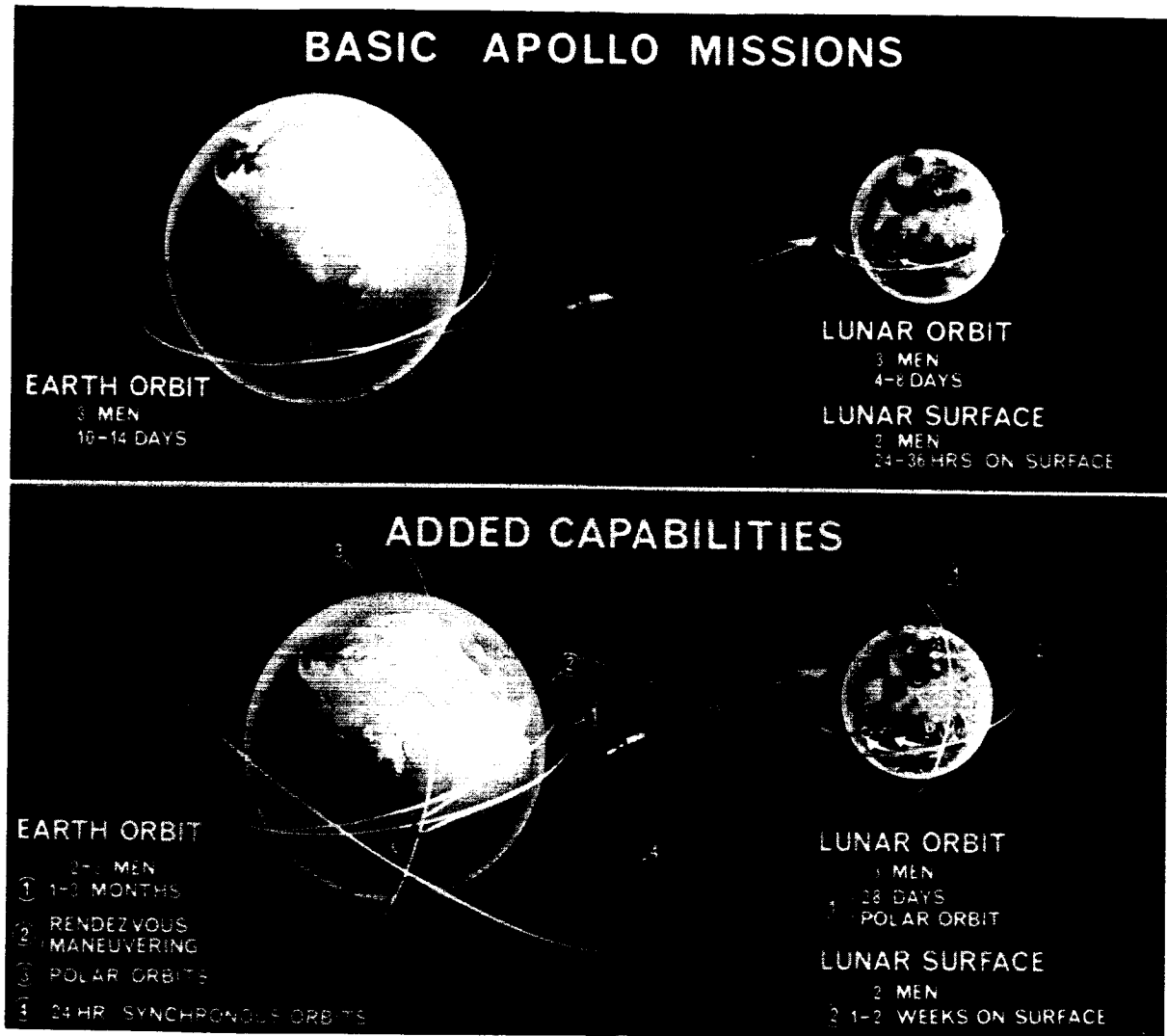


Figure 1.—Basic Apollo missions and added capabilities.

Figure 1 summarizes in a somewhat oversimplified form the capabilities that we are talking about, space-vehicle-wise. As I think you may be aware, the basic Apollo system with the Saturn IB launch vehicle, Saturn V launch vehicle, and the command and service module, and the lunar excursion module, has the performance requirements indicated in the top half of figure 1. In Earth orbit, a three-man crew for the order of 2 weeks, generally in a low inclination near equatorial orbit, since that is all that is required for the qualification for the prime objective of the lunar mission. The capabilities in lunar orbit are up to 8 days if there is not a landing, and the lunar landing has a design capability of 1 to 1-1/2 days for two men on the surface. That, then, forms the design goal of the basic Apollo program, and our studies over the past 2 or 3 years have indicated without any significant changes in even the launch vehicle spacecraft, we can achieve these kinds of capabilities indicated in the lower half of figure 1.

You can operate the spacecraft with a two-man crew as well as a three-man crew. It appears you can add expendables to the spacecraft and redundant subsystems, if necessary, to run the life of the spacecraft up to the order of 6 weeks on a single mission, and by combining two missions by rendezvous, you can get up to 3 or even 4 months, if there are particular experiments or areas of interest to be covered.

It is possible to go into polar orbits with the basic system or into a 24-hour synchronous orbit over either the Equator or a part of the Equator.

In the lunar area, capabilities with this long-duration spacecraft with the added expendables, you could probably get on the order of a month in lunar orbit, which in a lunar polar orbit would permit the complete observation of the lunar surface. On the lunar surface, if we are smart enough, we can get up to 2 weeks' duration for a two-man crew on the lunar surface by various combinations of the operating techniques planned for the basic program.

These, then, are sort of an envelope of the capabilities we see for the basic Saturn-Apollo system.

In figure 2 at the top, the two large black lines indicate the current plans for flight activity of the Saturn IB and Saturn V launch vehicles with the Apollo spacecraft in accomplishing the currently approved lunar landing mission. It shows that the Saturn IB flights will start in 1966, and this is on schedule. Figure 2 also shows they will run through 1968, or about 3 years of Saturn IB flights' activity, the last 2 years being manned, the first year being qualification flights.

Figure 2 also shows the Saturn V activity starting in 1967, unmanned; manned flights in possibly late 1967 or early 1968 in Earth orbit for qualification; and the possibility of the lunar mission occurring in 1969. It is conceivable it could occur earlier than 1969. So the flight activity there in some 15 launches extends from 1967 through 1969, possibly into early 1970.

So that is our basic frame of reference, and in planning the Apollo Applications flights (fig. 2), we then have worked from the technology to be developed and demonstrated there. We have split it down into generally three phases of flight activity.

The first phase indicated in figure 2 as 14-day orbital mission would be those flights which might be flown as alternates to the primary objective lunar missions during the 1968-69 time frame. It may be possible, either by variations of the mission priorities or because the lunar mission program is going better than anticipated, to have a number of launch vehicles and spacecraft from the initial or basic program at the top of figure 2 made available for flying alternate missions in Earth orbit or lunar orbit during 1968-69. I will talk more about those in a moment with some configuration drawings, but the principal point here is: there may be as many as six or eight missions that we can fly on Saturn-Apollo hardware in 1968-69 that are not directly oriented toward the lunar mission. This would require that these missions use the basic lunar hardware, since we will not know until quite late in the game whether or not these flights could be flown to meet the alternate objectives.

The next phase of activity in figure 2 is the follow-on missions, both long-duration orbital missions and long-duration lunar surface missions. The long-duration orbital missions are something on the order of 45 days in Earth orbit, or 28 days in lunar orbit, and the lunar surface mission is something on the order of 14 days on the lunar surface, using a combination of the launch vehicles and spacecraft under the lunar program.

In figure 2 there are a couple of shaded areas in the bar graphs that I would like to discuss, in talking about the alternate mission phase here, which indicates that the first possible alternate mission might be possible as early as 1968. This indicates there is some degree of time dependency on our actions right now. For example, experiments to be identified, defined, and developed in time to fly on missions in 1968 or 1969, 14-day missions in Earth orbit, should be in the reasonable state of definition and approval cycles at

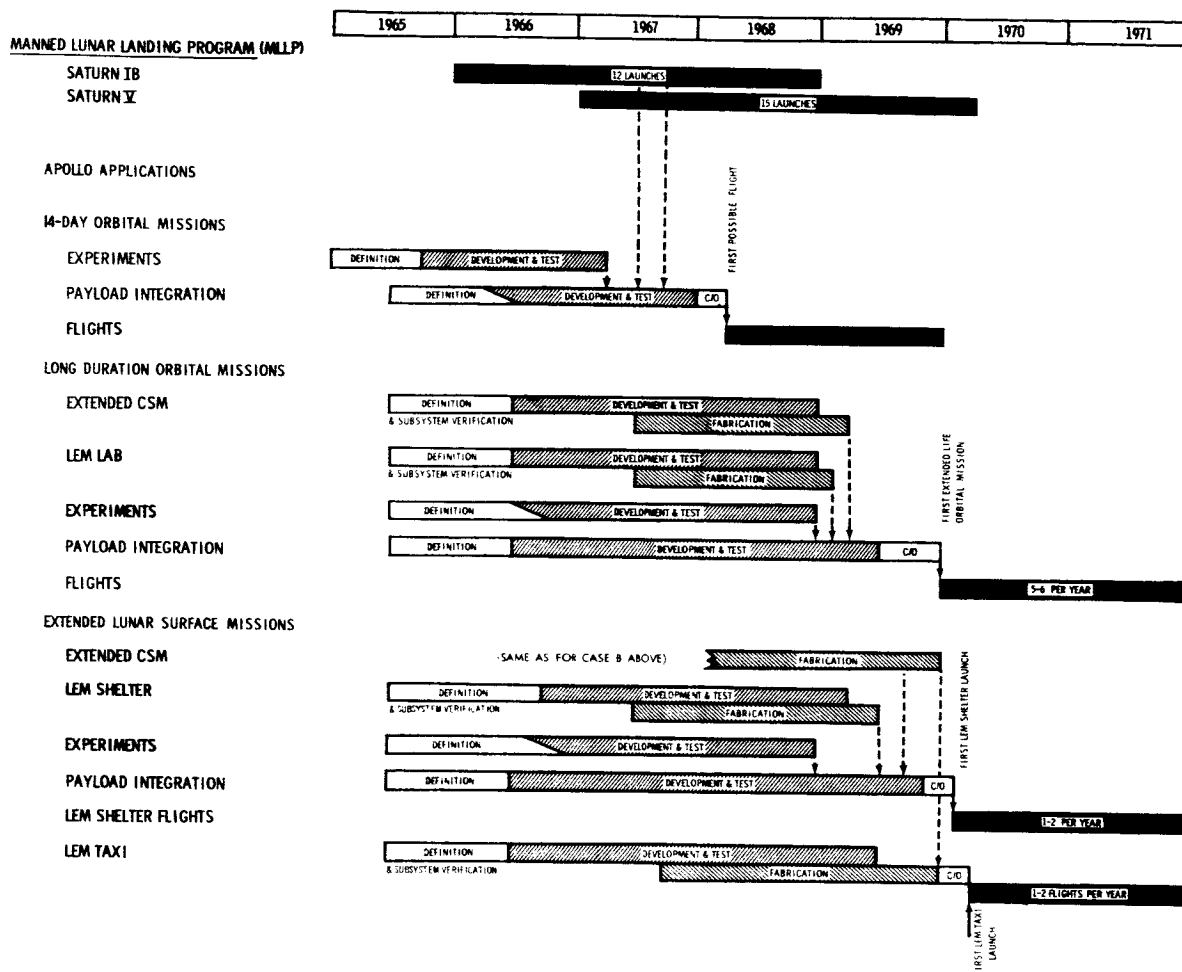


Figure 2.—Apollo applications planning schedules.

this point in time. We have identified a number of experiments. We do not have hard approvals on many experiments at this point in time, and I believe, Dr. Gill, this is one purpose of the discussion today, to let you know what our capabilities are, and what the time frame is. So experiments for these early flights, we feel, should be identified in the very near future.

There is another thing that figure 2 shows, and that is a payload integration function which I can elaborate on during the discussion session, if you will.

By payload integration, we mean the software activity, which is the design and the specification writing, the qualification testing, and that sort of thing, as well as the hardware activity, building prototypes of flight hardware, assembling it and bringing it together with the spacecraft into an integrated flight vehicle in the form of a payload. This activity is also a long lead activity, because between the spacecraft people and the experimenters, there has to be very early in the game a close correspondence, communication, and working back and forth. I think Mr. Small from Houston, who will talk later this afternoon, will talk about that.

We do feel that there is a fair leadtime associated with the payload integration function, and in the case of these alternate missions, this function should begin both on our part and on the experimenters' part some time during the calendar year 1966, the first interplay back and forth.

Let me go now to looking at some spacecraft configurations for these three phases of activity. Figure 3 is a sort of pseudo-engineering drawing of the Apollo spacecraft as it is being configured for the lunar mission. On the far right of figure 3 is the command module which houses the crew during launch and reentry, and most of the time in orbital flight.

For the early alternate Apollo missions I described in the first phase of activity, that command module would be unchanged from that being developed for the lunar mission. The only possible changes might be the addition of some expendables of a nature to supply or support the experiments that are carried in the command module and the installation of some experiments in the command module.

Now, I think you may have heard this morning, and you will hear this afternoon of some of the things that are being developed for the command modules to accommodate experiments, such as a small airlock. That kind of thing, of course, would also be available to fly the alternate Apollo flights.

The service module of the basic Apollo spacecraft shown in plan view and in elevation view (fig. 3), contains the main propulsion system for the spacecraft, including its tanks and its engines, as well as the electrical power system, the fuel cell, and the cryogenic fuel for the fuel cell system.

The Block II service module, as it is now being built and tested for the lunar mission, is shown in plan view. Below, on figure 3, there are six pie-shaped sectors, and sector 1 has been purposely left vacant to accommodate experiments. At the moment, our studies are focusing in on two classes of experiments or one major class of experiment which can be accommodated in sector 1 on the Apollo and the early alternate mission flights.

One type of experiment is a camera system which we are studying for possible use in lunar orbit for selection and certification of landing sites for follow-on missions. Another category of experiments would be those which could be accommodated in what we call an experiments pallet. Again, Mr. Small will discuss this later this afternoon. But the pallet shown at the top of figure 3 is really sort of an interface device or a glove that fits into the spacecraft and isolates the experiments from the interference, and so forth, of the spacecraft but marries the experiments to the spacecraft structurally and electric-power-wise, and things of this nature. I will not elaborate. Mr. Small will.

This, then, is the principal carrier of experiments, I believe, during the early alternate Apollo phase of Apollo Applications flights. That thing is big. It can accommodate something on the order of 3500 pounds of experiments, the total weight being about 5000 pounds. The dimensions of it are about the size of three tables put together, so it can accommodate a significant payload of experiments. The three-man crew riding in the command module can operate a significant number of experiments. We will go into this later.

Finally, in the early configuration, the LEM will be used, and we are planning its use as an orbital laboratory without landing gear and without some of the subsystems uniquely required for the lunar landing. It does provide an additional 250 cubic feet of pressurized volume for the crew to operate in, and subsystems to supplement the command module, and service the subsystems in orbital flight.

So during the period 1968 to 1969, and maybe early 1970, it is this type of spacecraft that we are talking about, the capability to carry experiments and crew for a nominal 14-day mission; we believe that this spacecraft itself can probably be extended by adding just expendables in a limited quantity for the order of 3 weeks or so during that time frame.

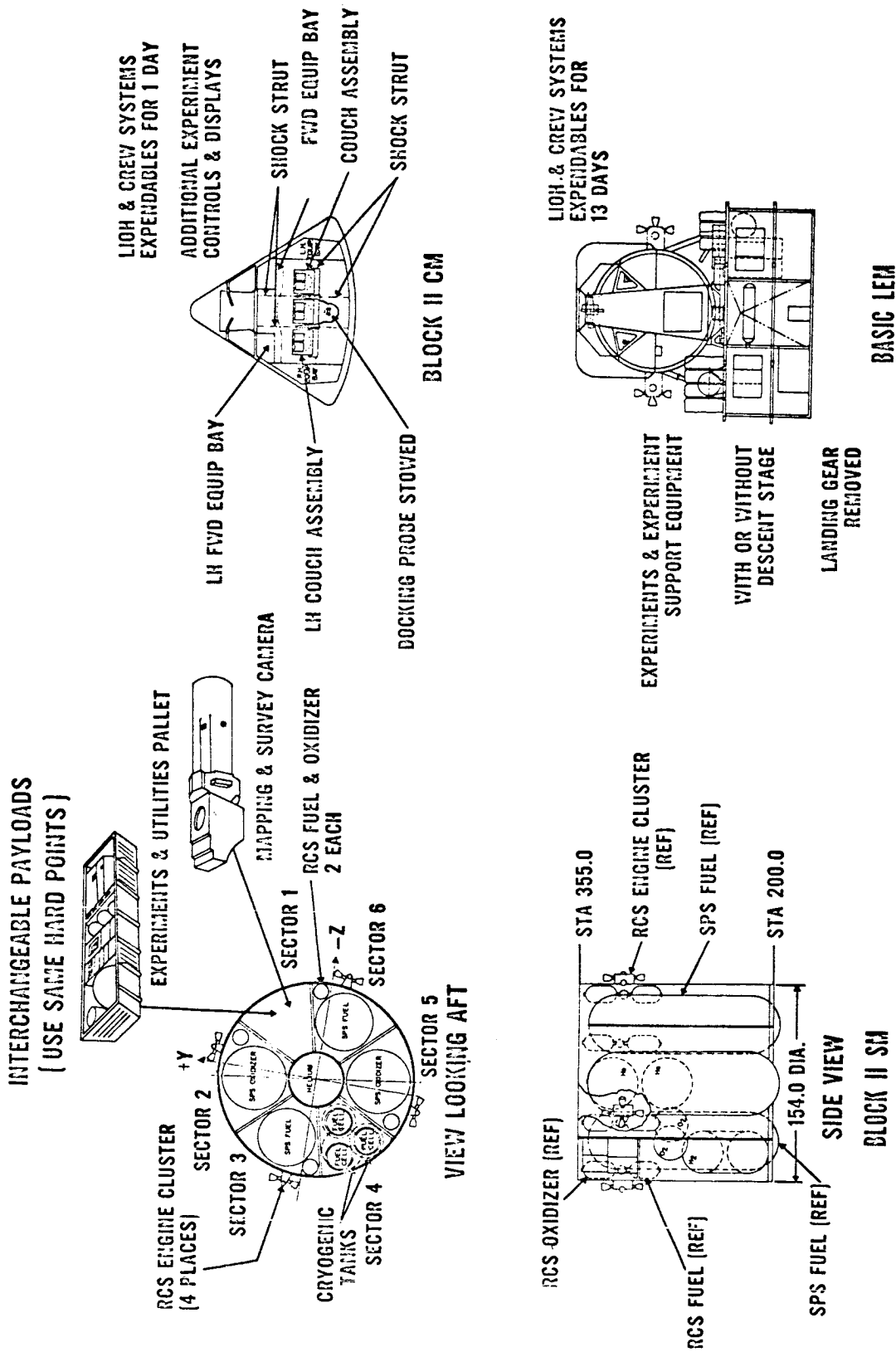


Figure 3. —Configuration for early flights.

Now, beyond the lunar landing, we feel then it would be possible and we should plan to make some minimal modifications to this spacecraft to really extend its length. This is where we get up to the 45-day or maybe 3 or 4 months by rendezvous, which I mentioned earlier.

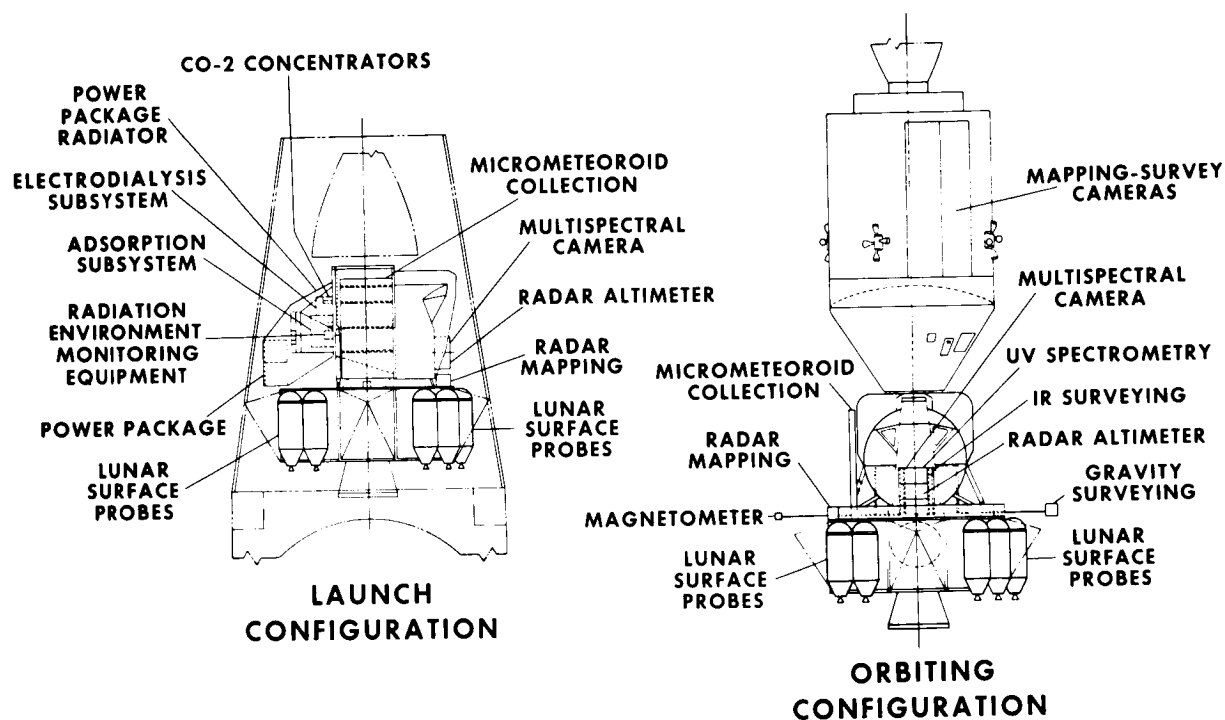
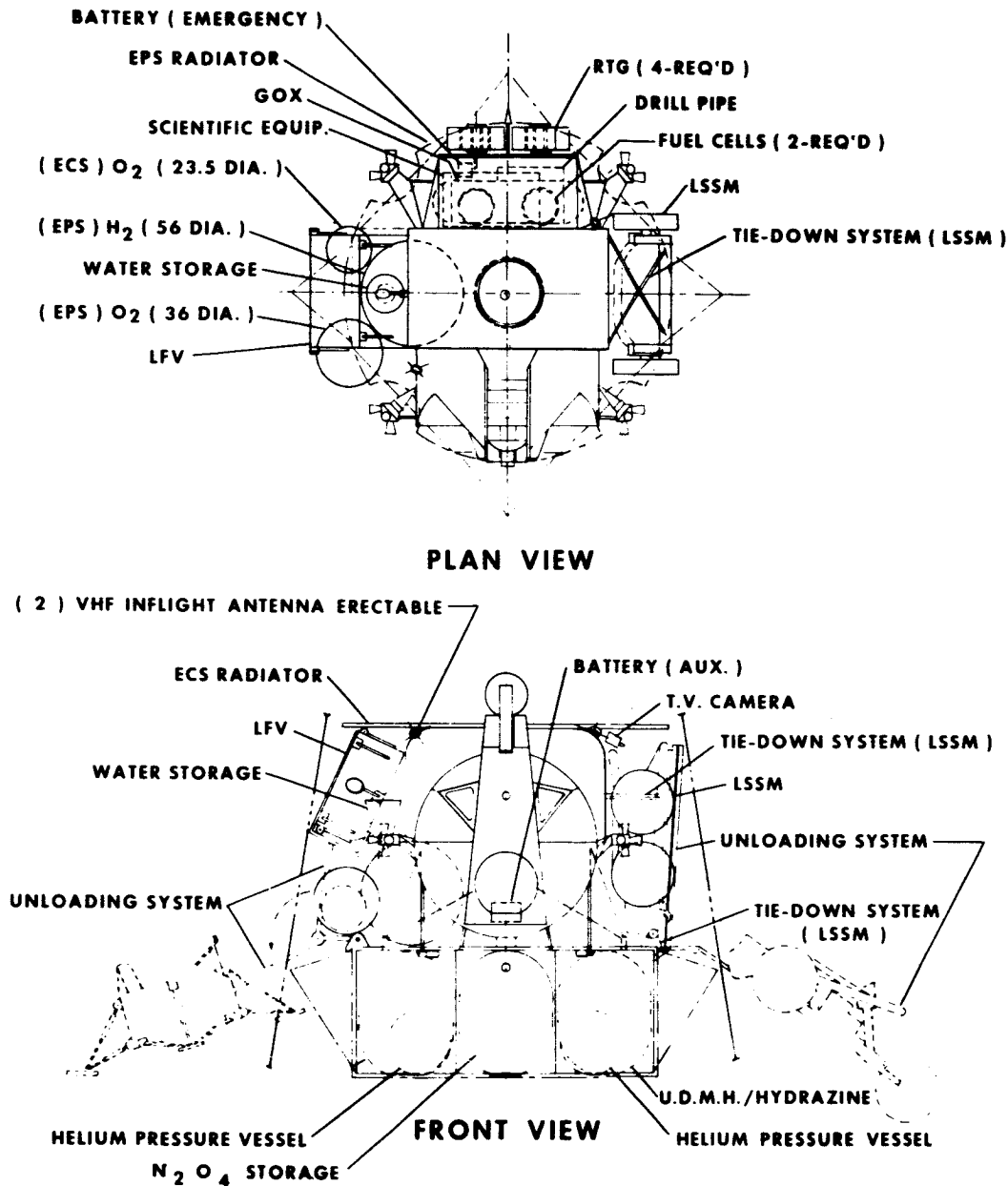


Figure 4. —Lunar orbiting LEM laboratory.

Figure 4 is sort of a Mickey Mouse drawing of what an extended-duration lunar orbital spacecraft would look like. I will not dwell on it other than to point out that it again uses a LEM laboratory; it does not have the ascent propulsion capability that the normal lunar excursion module has, because it does not land on the surface and come back. Therefore, weight has been made available for applying experiments. In this particular configuration, which might be the 28-day around-the-Moon configuration, there are cameras mounted back in the service module shown in figure 4; there are probes mounted around the LEM descent stage for unmanned delivery to the surface of sensing probes. There are radar mapping sensors, meteorite collection, etc. I will not go into this, because I do think this may be of less interest than a typical bioscience mission which I would like to come to in a moment.

Figure 5 is a pseudo-engineering drawing of the lunar excursion module as it might be configured for supporting the crew for up to 2 weeks on the lunar surface. In this case, we land this so-called LEM shelter unmanned on the lunar surface, so it would be on the surface, and would be in the nature of a shelter and a laboratory for the crew to arrive on a subsequent launch, and land next to it and operate out of this LEM laboratory or LEM shelter for a period of up to 2 weeks.

This thing, then, has to sustain life on the surface for 2 weeks and, further, it has to survive on the surface prior to the arrival of the crew for maybe as much as 2 or 3 months. So the kind of changes here are, first, since it lands and does not have to come back up for a



CHANGES FOR 3 MONTH PRE-USE STORAGE & 2 WEEK EXPLORATION ACTIVITY.

Figure 5. —LEM shelter.

return to Earth, you pick up some 6000 pounds in the propulsion system required normally for the ascent. Offsetting that, you have to add added protection for survival on the lunar environment over a period of a couple or 3 months, and that leaves something on the order of 3000 pounds of scientific payload for a lunar surface operation. This compares to about 250 pounds of scientific payload in the basic Apollo configuration which carries the crew down and brings the crew back. So we find it feasible by this means, then, to have an increase of an order of magnitude or so in the amount of payload, which means scientific

payload or exploration payload, and which means you can then have an adequate weight margin to carry such things as a small roving vehicle, for example, or some type of mobility device to operate on the surface, as well as a drill, for example, which the lunar geologists at Woods Hole felt was most desirable, as well as the types of subsystems to keep the people alive for a period of 2 weeks.

Figure 6 shows the basic LEM now configured as a LEM taxi, which brings the crew down to land next door to the LEM shelter shown earlier. This has to do everything that the standard lunar mission LEM does, plus survive on the lunar surface for the 2-week period while the crew is operating next door in the LEM shelter. This means some additions in terms of protection, electric power, and radiators because of the lunar thermal problem, but it appears that this is feasible, although it is going to be a tough job weightwise.

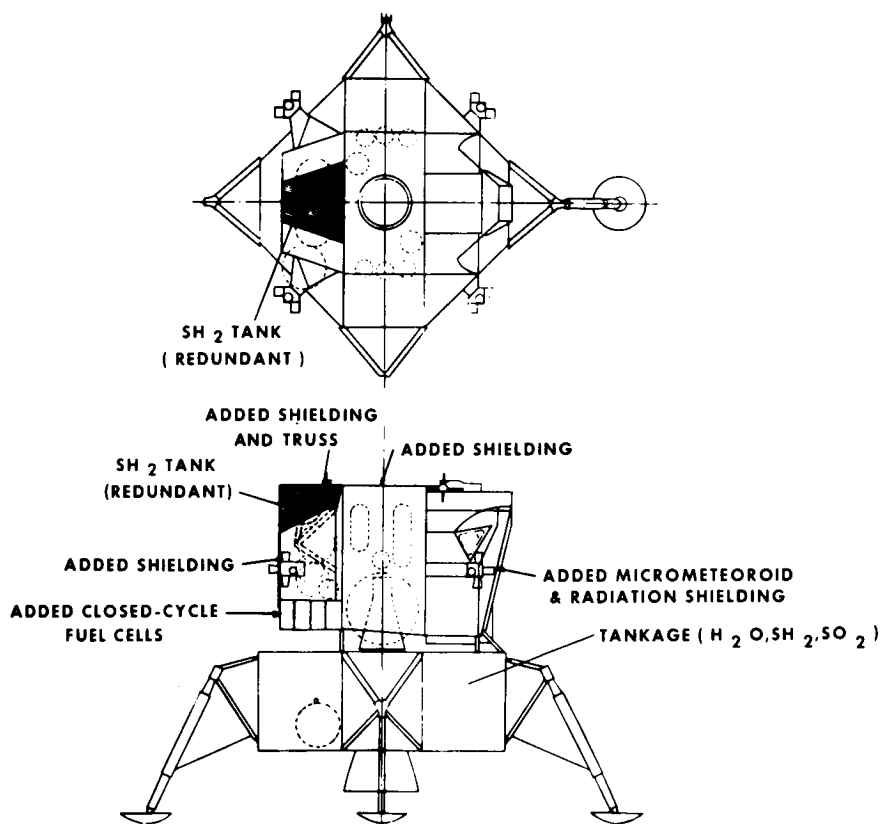


Figure 6.—LEM taxi. Additions required to LEM for 14-day lunar surface stay time.

So much for the general overview. I would like to discuss what we hope is representative of a bioscience mission that we studied earlier this year (tables I, II).

As we see the mission planning activity in Apollo Applications, each of the missions which we plan to fly will have a basic or a primary mission objective, in terms, for example, of astronomy, or bioscience or operations technology, and that sort of thing. This primary mission objective will determine the parameters of the mission, will determine what orbit it is in, what its duration is, what its attitude hold requirements are, and so forth. So in configuring the mission, we would give priority in the mission planning to those

Table I. —Space Operations/Bioscience Laboratory, NASA Mission 4, Outboard Profile

No.	Experiment	Name
1		Fuel cell assembly
2		H ₂
3		O ₂
4		O ₂
5		Water tanks
6		
7		Tunnel and docking ring
8		Docking probe
9		LiOH
10		GOX
11		Safety line
12		Equipment radiator
13		Fuel cell radiator
14		Mission 3
15	0302	On-board centrifuge
16	0302	Centrifuge counterweight
17	0406	Spaceborne micro-organism cartridges (stowed)
18	0406	Spaceborne micro-organism cartridges (exposed)

things which are required by the primary mission objective. An astronomy mission, for example, might well require synchronous orbit and very fine attitude tolerance or attitude-holding capability on the part of the spacecraft.

In configuring this mission, if there were, after we had satisfied all of the requirements for the primary mission, additional capability in terms of either weight or electrical power or attitude-hold requirements, or more importantly—and one of the most important commodities which apparently comes out of this—is the availability of astronaut time to conduct the experiments, if there is a margin in all of these areas of mission capability, then secondary experiments can be added to the spacecraft, to the mission, as long as they do not degrade the objectives of the primary mission.

Figures 7 and 8 show how we have studied and configured a mission which would have its primary objective as the acquisition of bioscientific data. There are some secondary experiments conducted on this flight. I will touch on them briefly. But they are such that they do not, at least in our study, would not degrade the objectives of the primary bioscience experiments.

On the left of figure 7 is the launch configuration. Here is the launch vehicle, the Saturn IB. The command and service module is located above, and within the adapter area is located the LEM laboratory. On the right is the orbiting configuration, and in this particular mission, this was a rendezvous mission where the spacecraft here was put into the same orbit as the preceding spacecraft, shown below. The two rendezvoused then and came together to form a combined spacecraft with two LEM laboratories. In other words, by resupplying rendezvous, it will be possible to get a 90-day mission capability from the combined mission.

Now, in the spacecraft, in this particular spacecraft, its mission was primarily bioscience, and I will read you the experiments which were hypothesized and identified for us as a basis for doing this feasibility study. I want to make it really clear that these are not

Table II. —Space Operations/Bioscience Laboratory, NASA Mission 4, Inboard Profile

No.	Experiment	Name
1		ECS
2		Tunnel and docking ring
3		Film storage
4		GOX
5		Fuel cell assembly
6		H ₂
7		LiOH
8		Mission 3 laboratory
9	401, 2, 3, 4, 5	Freezer
10	401	Lyophilization
11	401, 403, 404	Chemical and equipment storage
12	401, 402, 406	Incubators
13	401, 402, 406	Microscope
14	401, 402	Refrigerator (-15° C)
15	402	Refrigerator (-20° C)
16	402	Culture flasks
17	402, 403, 404	Supply cabinets (includes 35-mm camera)
18	402	Scintillation counter
19	402	Particle counter
20	402	Centrifuge
21	403	Chimpanzee container (pressurized)
22	403	Waste management (chimpanzee)
23	403	Food management system
24	403	Instrumentation for chimpanzee panel
25	404	Planaria and newts chamber (pressurized)
26	404	Refrigerator (-5° C)
27	405	Rat cages (pressurized)
28	405	Food storage
29	405	Waste storage
30	405	Quick freezer
31	406	Refrigerator (+5° C)
32	302	On-board centrifuge
33	302	Centrifuge counterweight

approved experiments, but are under design for the purpose of this study. Some of them may be, but these were identified for us so that we could exercise and determine the limits of the capability of our system for handling this type of thing.

The bioscience experiments that we used in this study included one on the genetic effects of 45 days of weightlessness on micro-organisms, particularly the recombination of DNA and mutation rates and phage production. The second experiment was the effect of 0 G on the morphology, the growth, the gas-liquid separation in micro-organisms and unicellular organisms, and in animal tissue cells. Neither one of those takes up an awful lot of weight and volume, but they do have some peculiar requirements which I will refer to shortly.

There were experiments on mammals, both rats and chimpanzees; experiments to determine the cardiovascular effects, the respiratory effects, hormone production, mineral and

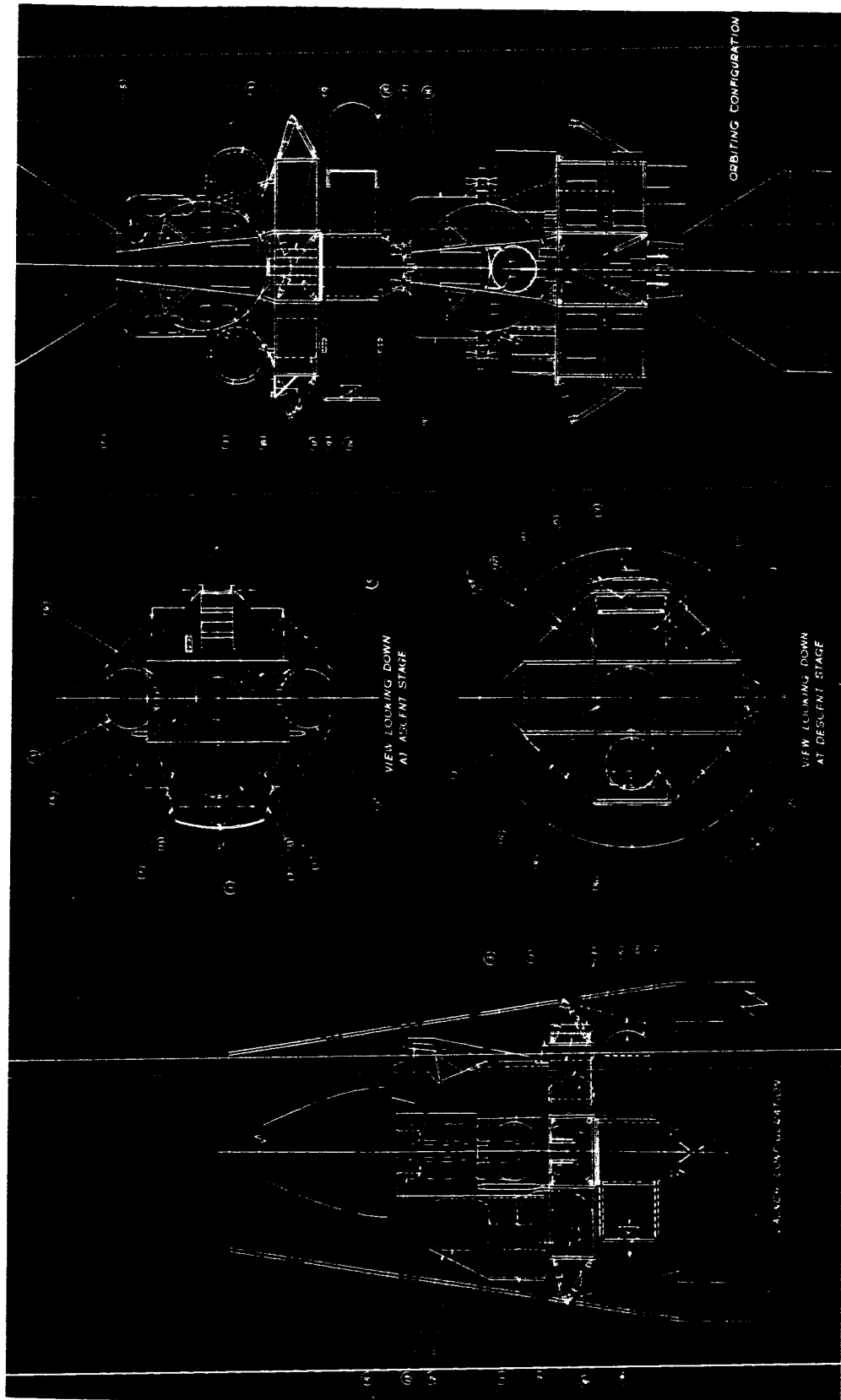


Figure 7. Space operations/bioscience laboratory, outboard profile.

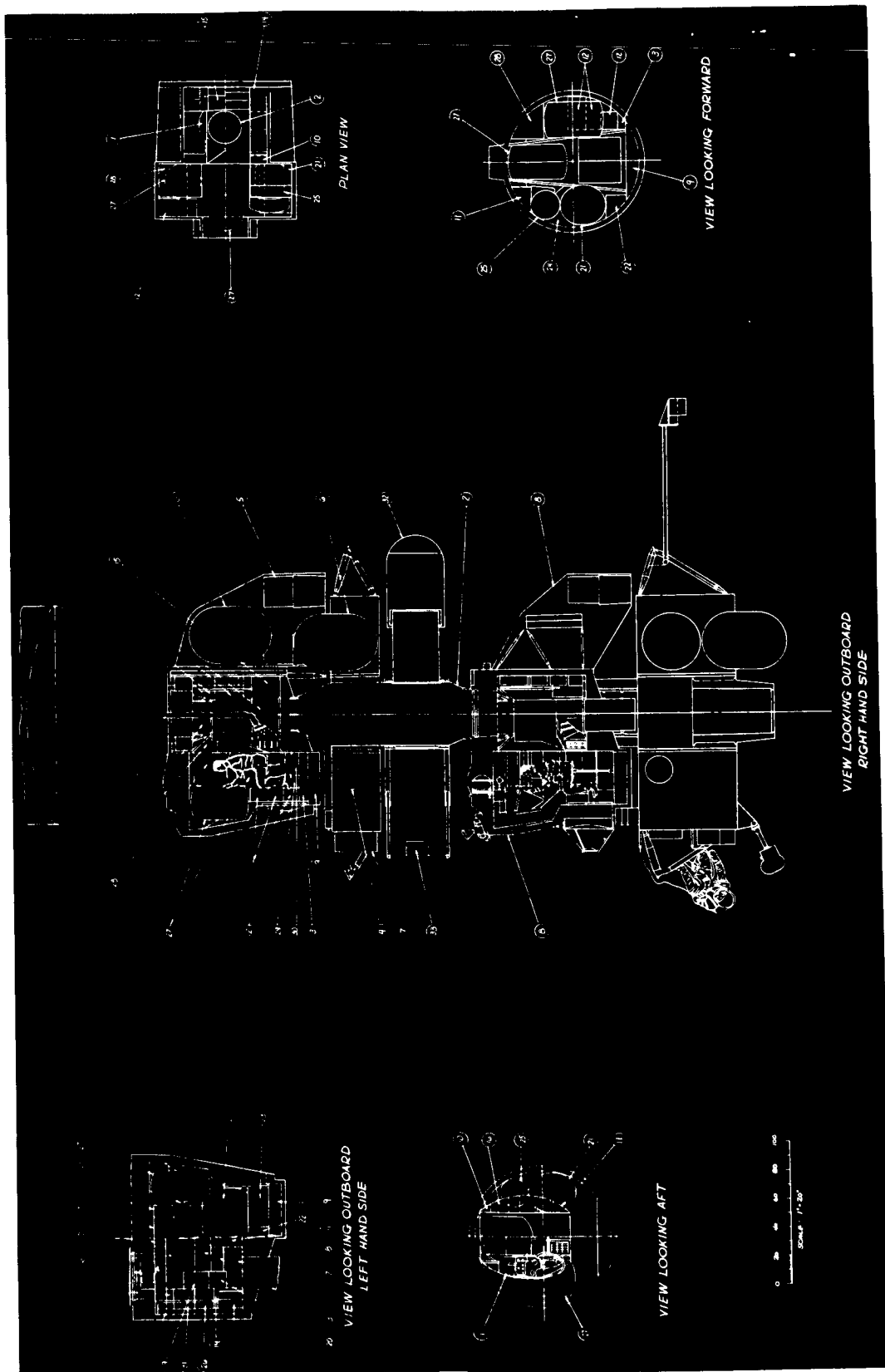


Figure 3.—Space operations bioscience laboratory, inboard profile.

water metabolism, brain mechanisms, operant behavior and biorhythms, and the attendant engineering problems were significant for those experiments.

Another experiment was limb regeneration and wound healing, using newts and planaria. Another experiment was to determine the effects of drugs on mammalian behavior in 0 G, again using the chimpanzees and rats. An experiment on the soft capture, enumeration, and identification of spaceborne organisms, should they exist.

So these experiments, then, the acquisition of these data, form the primary objective for the purpose of this study for this particular mission. In addition to those particular experiments, there was the operational experiment, if you will, of rendezvousing and providing a 90-day mission by rendezvousing this flight with the preceding flight. Also in figure 7 you may notice that there is shown for the purpose of this study a small centrifuge located between the two spacecraft. Actually it is mounted, a one-man centrifuge offset for 0 G or artificial gravity conditioning, should that be required. What we went through was the engineering exercise associated with providing these things to determine if they could be done, and what would be the effects on the other experiments.

I would like to summarize some of the mission characteristics and some of the things that are important to us as a result of doing this and, we think, without degrading the mission objectives of the experiments that I have indicated.

First of all, the mission was studied for a 200-nautical-mile, low-inclination, $28-1/2^\circ$ inclination orbit; two hundred miles, because for a 45- and 90-day mission, atmospheric drag will degrade the orbit severely and require orbit-keeping propellant if you try to maintain a lower orbit. It did not appear to us that the bioscience experiments required lower orbits, and were sort of insensitive to what the altitude was, so long as it was 0 G and essentially in a space environment.

Two hundred miles is probably as high as you want to go until you get considerably higher for this long duration because of the radiation belts and the effects primarily, of course, on the crew, but also on the experiments in this particular case.

This was a three-man crew. The launch vehicle was a Saturn IB. The total experiment weight of both the bioscience experiments and the operational experiments, the centrifuge, etc., was 3960 pounds. The total weight of the spacecraft and experiments was 32 910 pounds, which gave something like a thousand pounds' margin between the total spacecraft weight, including the experiments, and the launch vehicle capability.

I mentioned the importance of astronaut time availability in planning a mission like this. For three men, for 45 days, which is what this crew would be up there, the total is some 3240 man-hours available. Of this, some 70 percent, and the estimates vary from 50 to 70 or maybe 60 to 80, but something of the order of 1900 man-hours of the total of 3200, are required for the crew to eat and sleep and operate the spacecraft. Therefore, something on the order of 30 percent might be available or would be available, would be scheduled available for operating experiments, or some 1335 man-hours.

In running through the time lines on what the crew would have to perform to accomplish these experiments, it appeared that something of the order of 1200 man-hours would be required to accommodate this particular grouping of experiments. Of that 1200 hours, some 93 hours was extravehicular activity, either taking samples outside or I guess replenishing some of their spacecraft supplies that are carried externally.

I only dwell on this because we found, and I think the experience to date--you can bear me out, Dr. Gill--in the Gemini flights, this is a very critical parameter in your mission planning, the time of the crew, and we feel that we cannot necessarily load the spacecraft up with this to its weight limit and expect to have useful results from the experiments. Rather, a fairly detailed planning of what the astronaut has to do with the experiment, and how much time it takes him to do it, and some margin for setup and shutdown, and things not going

perfectly is most important to us in planning these missions. So in the identification and definition of experiments, we would hope that the experimenters would give a fair amount of thought to what they want the astronaut to do, and how long it should take him to do it.

The other parameters turned out to be less important than that, but still important. On this particular flight, out of the total of some 600 cubic feet of pressurized volume in the command module and the LEM, the experiment payload shown in figure 8 required 75 cubic feet internally, and some 410 cubic feet mounted externally to the crew compartment. Figure 8 shows a lot of things mounted external to the LEM and down between the two LEMs.

The return weight of the data acquired during the mission, the estimated total from this mission analysis, was 48 pounds for this class of mission, assuming the return of samples and data on tape, and assuming that some of the observations are telemetered or communicated back to ground during the flight for real-time analysis on the ground, to tell the astronaut to change the conditions thus and so. But the actual weight of the return data in this mission was 48 pounds.

Now, obviously on an Earth-sensing mission or a lunar orbital survey mission the return data weight becomes a very important factor, on a lunar orbit mission, for example, there would be a lot of film. It does not appear to be, from this particular mission, that important. As a matter of fact, with the margin that we feel we have here, it would be possible to bring back maybe a complete chimpanzee which might be desirable after the mission.

The other parameters we looked at are electrical power, and from this grouping of experiments the average power was 350 watts, the peak power was some 750 watts. This compares to an average of some 1500 watts just to keep the spacecraft operating. The total energy consumed by the experiments during the 45-day mission is some 400 kilowatt-hours, which is well within the capability of the fuel cell system, and the fuel storage system of the spacecraft, since it is sized for something like 2600 kilowatt-hours.

Another factor we look at, not limiting in this particular mission, is the amount of attitude-control propellant required. In this particular mission, some 790 pounds of attitude-control propellant was required to hold the attitude to the tolerances specified by both the primary and secondary experimenters. This is well within the capability of the spacecraft, which for the extended spacecraft is sized for about 2500 pounds of attitude-control propellant.

This is just a brief summary of the types of things we have to do and we have to look for and design against and accommodate in planning a manned mission to accommodate a variety of experiments. I think I would like to leave just one thought, and we can get back to it later in the discussion. This is that on the Apollo mission and on the Gemini mission, these are primarily for developing spacecraft and space operations technology and capability. In the program that I am talking about, the Apollo Applications Program, which we hope to have defined in the next year, to the point where we can actually start into hardware development, roughly a year from now, the conduct of experiments is the principal reason for the program's existence, the conduct and acquisition of data or the use for the purpose of satisfying users' requirements in the bioscientific community, the astronomers, the political scientists, or what have you. The conduct of experiments is the primary objective, and the acquisition of data is the primary objective of this program. I think this reflects a maturing of the space capability that is being developed, or reflects the application of the use of the space capability that is being developed under the Gemini and Apollo programs. So we do, and I do appreciate the opportunity to talk to a group like this at this stage of our definition, which I think you can probably see is a relatively early stage of definition, and I think that a strong two-way flow of communication between our guys, the engineers who are trying to define the missions and define and build the equipment, and you as the potential users of the system is most important, and you cannot start too early, particularly in view of the fact that we may be able, roughly 2 years from now, to fly the first alternate mission on the Apollo system.