INTERVIEW WITH DR. STUHLINGER

Question:

How much criticism was there of the Saturn Program in specific, not Apollo necessarily, but Saturn Program and was the high water thing done kinda of an answer to Scientific Critics? or was it you simply had space available or really where did the high water program originate?

Answer:

The original high water , I believe, was many fold, there was criticism from some people who said we should not launch more into orbit as we did before and wo we decided to launch some but it would have to be something cheap and heavy at the same time because we needed a certain balance to try out certain ones and it occured to some members of this center, of the Marshall Center who worked in the Space Scientist Laboratory at the time that one possible answer to the request for a heavy, useful but still inexpensive payload might be the launching of large amount of water which would be released quickly at high altitudes and one would then study from an account how this water behaved when it is all of a sudden exposed to vacuum, and the weightlessness under space conditions. The design and engineering aspect of this experiment was relatively simple. Because there was nothing active in this except the command to rip the container open at the right point. The container was filled with water then and the opening of the container was done by was ignited by a command, I do not remember at this moment whether it was a command from a count or a timer, I believe it was a timer on topspacecraft. This can be read in the original reports. And then there were a number of observing instruments on the c among them film camera, and radiation centers. What we were after particularly was the question how quickly the water would vaporize and how quickly it would expand to what size it would expand how long the cloud or whatever would happen would stay there how long it would take that cloud to dissappear and was changed to an invisible system. We did make a number of experiments on the before the launch of high water in which we exposed more quantities of water to vacuum in laboratory experiments and we had some anticipation of what might happen in the flight experiment. Now I don't think that anybody saw that this experiment would be an extremely earthshaking and revealing experiment as far as the basic laws of physics or the knowledge of nature we are concerned

On the other hand we expect that we would have some interesting results which would tell us a little bit more about the behavior large amounts of metal if they are all of a sudden exposed to high vacuum. The experiment itself worked very well, it functioned as we anticipated, among the sensors not all of them worked fully, if I remember correctly then some of the specific regulation censors, I believe it was inforred did not work properly and one reason was because the whole experiment was to be a low cost experiment, and we could not spend a large amount of money to develop very elaborate experiments for cloud oberservations. On the other hand, we obtained very good movie pictures of the event and we could determine the speed of expansion of the cloud and the distance to which it expanded and we could find out the lifetime of the cloud in orbit. Now, if you like to have more precise data of this kind you should look them up in the report, which are in there, I don't remember them off hand.

Okay, then, I haven't gotten that far yet. I have done some research on but I just haven't done the high water.

Now, again high water should not be classified as an extremely important scientific experiment which clarified very sever problems manking was facing before the experiment was done. On the other hadd, we are glad we did make it because a good use of existing opportunities and of the capability of the vehicle to lift large amounts water into orbit. That's about how we look at it, now looking back at it today.

So it's just primarely a payload experiment in terms of balaised.

This is one aspect of it we had to balance the vehicle in a boyou to make it a realistic flight test for the vehicle and however in putting in some completely in earth like sent from the Florida beaches we decided we would like to make this experiment. And within that we are certainly going to say it was successful, it was a good experiment. On the other hand one would not have launched a Saturn particularly for atha purpose only in alter study but if one knew what it was doing if exposed to vacuum water one would not have justified a launching just for that purpose.

Question:
Were there any consideration that this might be an interesting experiment in terms of what might happen if the Saturn stage, say, ruptured before ignation. You have all of this

liquid hydrogen and oxeygen, does that give you any perimetner as to what might happen in that instance.

Answer:

It sure would, because well that's one of the things we studies was the influence of the cloud like this on communications. There was a possibility that it would interupt communications for some time because several effects can be solved which would be leading to this, for exemaple this cloud could stay there for a long time and could sheild off some of the ultraviolent radiation which produces the atmosphere so this cloud could in essence produce a hold in the atmosphere and the atmosphere, as you know is needed for the reflection of if you want to publicate that message at this time in this general area. So this was one of the effects we were after, we wanted to see how this cloud would effect coming occassions.

Question:

It didn't have any particular negative effect that you could ascertain.

Answer:

I do not remember that we found any real adverse effect, but again you should look it up in the reports.

Question:

You found that the cloud really didn't expand as far as you can see.

Answer:

The cloud did expand quicker and farther than we thought. In fact, it had a diameter of about ten kelimeters, which is a pretty big volume, you know, its of ten kelimeters diameter. We could see there that it was a beautiful veiw. The vehicle went up and, of course, we didn't see anything because it was to far away and the ignition was cut off and then it had reached its . The rupture of the water container occurred and all what you saw was all of a sudden within a tenth of a second there was a huge cloud bigger than the moon. White and a little tenieous than the moon, but bigger than the moon and it was all of a sudden there in the sky and then it faded away in the course of about ten minutes. It dissappeared. And the dissapearance is we believe because of the little ice crystals that form by the rapid expansion, that we are warned melt and vaporize because of

irradiation.

Question:

So you can call it the , correct me if this is incorrect, with the high water the first great experiment in the Saturn mission. Purel y scientific, but

The first large one, yes.

Okayy , now let me , is it okay your on the Pegasus now?

YYes

Okay, I guess the real question I'd like to know more than anything were there any statistics derived from these detection sattelites that really influenced the the design either of the Saturn launch vehicle or the Apollo space craft?

Answer

The Pegasus

Yes, Pegasus

By all means yes. The situation before before Pegasus was about the when you plot here the number of meteorites occuring or being there in the vicinity of the earth as the function of the . Then we had a few measurements of up here that means . Then we had a few measurements down there very irratic and few of meteorites. streak of light as meteors which can be seen. But this we are so we did not know how many meteorites there would be up of this size and this size about is important for space craft. We know what size they are too small and don't do any damage and about the size they are too rare to be afraid of them , ;but in here are those meteorites awhich are big enough to puncture the space vehicle. and still frequent enough to be of concern. and we did not know whether this curve in here was going like this or like this or like this. this is logarithim ic by the way. You understand what is logarithmic ? Anyway the diagram could have been had any shape of , any number of shapes, and since that is a logarithmic diagram here, the difference between here and

here would mean affevt of 10,000 of volume frequency. So we didn't know whether a mass of this kind here would occur three times a day or thirty thousand times a day. And it is of course extremely important to know because the design and the protection of space craft will depend on that. and so around 1961 or 62 when we bagan to design Saturn and to develop plans for Saturn, and for the Apollo, we were very uncertain of how the meteor danger would be. in space. And then at that time it occured , well in my laboratory at that time in space scientist laboratories, one of the subjects of research and studies which we had was to find out how many meteorites there are in space, how big they are , and in fact how the function would look like. We looked at that time through all the papers which were available and measurements and observations. and we found that there were jjust not enough available in this dangerous or important region to tell us how many there were and how thich we would have to design and build our space craft . And then we decided in that time the only way to find out more about it would be to bild a sattelite and to measure it and to observe it. And then we sat together and tried to find out how big that thing would have to be and how sensitive and so forthe, and how long it should be in orbit. so that we could obtain significant numbers . The problem here i the following: there are not many meteorites, but if a space craft in space is hit only once or twice in the course of a year that is too much. Now to NASA this number , one or two a year hitting a space craft, of say the size of this room here means of course that we should measure either with a large craft or for a lonnger time in order to pin down that mumber. because it is difficult number which varies quite a bit. and if we have only a small thing, maybe it hits us once a year and we still don't know what data change which then occurs once every hundred years or was it just a particularly good year when only one hit when next year we would count ten hits; we wouldn't know so the requirement was that we should have a large vehicle larger than normal space craft, then that it should fly and measure and observe the whole attitude a long time so that we can pin downthe statistical numberswhich we are after. This is a particular problem in this kind of measurement. We want to

measure a numberwhich is very small but we want to measure it with a good enough statistical significance so that we really can tell our designers how thick to build the wall a protective wall for the space craft.

Now may I interupt here a moment? Now in the end this was an important design perameter because we were still talking about an earth orbit rondevue.

Very important perameter.

And thats where the whole problem is taking place. I meanit was in that earth environment that this particular

This is right. But it is still about a little, they are less frequent when you go further out. Because there is a kind of focusing effectnear the earth. But this is effect not too very strong. This means when you go out to the moon, it is still importantto be prtected against meteorites and you cannot simply say well I get out of the earthe orbit quickly into the lunar projectory and I'm safe. There are meteorites, and when you look at a picture of the moon itself you see what how many times it has been hit. Anyway, the problem is more simply, near the earth this is correctbut it is not disappearing when we go away from the earth. So that the problem are first, tanks near earth, that means tanks which are being used at the early time of the space flight , vehicle tanks, and then second tanks in space, of space craaft, and then third, the housing capsules of the astronauts. These are the three things to be considered and all of them must be prtected. If they grow short of time well they have a much larger area. As a rule they have thin walls, the tanks of the Atlas or the Titan or Saturn booster vehicle are very thin . This is the problem for tanks in space. They are , as a rule, they are smaller, but they are still thin enough in order to be light and then the capsules of the astronauts are still smaller and they are normally heavier because they also must provide heat protection. But these are the three problems. And around that time we set out to determine the design numbers

for these three prolem areas. And this was about the uncertainty, so we said every time we do any thing which is very large and it should be flown in orbit long enough to provide us with statistical information , meaningful figures. Then after we had determined what kind of vehicle we need, we immediately saw that we could only use a certain vehicle. to fly because others would be too small and the sensitive area would be too small to give us the figures. And then we found out that there would be in our Saturn I program at least one that could possibly be made available for such a flight. Then we proposed to our own management here that we would like to build a meteorite sensing sattalite for Saturn I launching and that we would be able hopefully to pin down this design figures. The importance and the significance of it was immediately recognized by our management and we were encouraged to procede and to go ahead and to make plans . And from then on it became a project which has been described in technical reports. We began our design by looking in the pay loadccapability and into the requirement for an orbit attitude. When you want to have a certainlife time for the space craft you have to go up high enough so that the does not bring it down too soon. Then this satellite would have to be a very big one. in order to provide enough sensitive area for the meteorite hits, so we had to go up relatively high in orbit. Then we determined how many pounds of pay load a Saturn could carry into that orbit. Realize that size sensors that could be carried into a high enough orbit and this was the basis then for the project. From then on its just normal story of a development project. Now we had not only one but we had three flights in the course of the development. It turned out we could use two and even three Saturn I's because the importance of this project was considered more important than any other payload that could be flown with these Saturns.

By the time that the Pegasus flight took place '65 alot of the design for the booster and space craft had been finalized. Did you find that these designs didn't need to be changed on the basis of information gathered ?

Answer:

In essence we found that the designs which we did use for the Saturn were verified and our conscience was quieted so to speak and we found out that the design figures were good enough. There fwere nof drastic changes, but we could settle down with uncertainty reduced and settle the question of how many meteorites there are within a very small error margin. You probably have these numbers with you. These curves are in the reports and we culd really determine what the number of meteorites of a given mass are in space and they came pretty much to the point we had hoped for and expected and which our designers had been using. It was a very good verification of our design number s .

Question:

What about some of the secondary experiments then? I was wondering if you really got alot of new information on earth

Answer:

Yes, we did. We had some experiments as you may remember, on thermal radistion on paintsfor example, protective paints and paints which at the same time would control the temperature of space craft. These were a number of experiments and they were excellent. We found out and verified and helped to determine th e white paint which was used on the Saturn vehicle from there on out.

Question:

Did you deliberately plot the orbit of the Pegasus ~~to~~ through the South Atlantic anomaly

Answer:

There is no other way . You know wthey went through the South Atlantic anomaly better and more accurately than any other space craft had done before. The Pegasus did. That was an additional bonus. But there is no way around it. There would be a way around it if you would put your satallite into an equatorial orbit . The south anomaly covers about an area like this one , about 10 degrees south . Now any satallite which has an inclination of more than 10 degrees must go through unless it is coming down very low .

Question:

You also found some things abuut the decay of star fishe electrons ., as I recall.

Answer:

They were also recognized, yes. They were recognized as being still there, yes.

Question:

Okay, then lets see. There were a couple of other specific questions.

Answer:

In fact the star fish electrons were recognized because of their time change, their change in time. The star fish population reduces in and decays and so we could measure some of this decay. And so we knew these must be star fish and not natural bodies.

Question:

Again, this was something that was just a . You had some radiation flux sensors on that. Is that how

Answer:

Yes The electron count actually.

Queation:

There was some tumbling. of the Pegasus.

Answer:

There was some tumbling, yes. And we knew that this would happen. It even happened a little as I remember correctly more slowly than we thought it would. And the reason why this tumbling would happen is quite well known . Its a well known law of mechanics. A bodie which rotates around some axis will gradually assume rotation around its axis of highest moment of inertia. If there is a mechanism to take energy out of it and this mechanism to absorb energy of its
of course the air brake and auto magnetic damping magnetic damping in the earth field and the air plane and this affects work together to finally make any motion of a body in space such that it rotates around its axis of largest moment of inertia. And in that case, it has a kind of propeller type motion.

Question:

And now, I readsome reports . I'm still a little confused on it. Was this welcomed because I read one thing that said that they actually accepted this movement because it gave them more a wider count of meteorite possible meteorite punctures of the space craft. Was the problem because the . You invented some stuff and maybe. Was there a problem because a couple of the early ones gave you a higher rotation

warning?

Answer:

This was on the first one there was some venting of the propellant. The central portion contains some tankage and there . Of course when you go into the side of it, then you do not burn all the fuel propellant. You juust cut off and you have reached that orbit. And so there was some propellant left and it was vented and it did not vent without exercisong a torque . on the space craft and this torque by the venting acted a lettle like a rocket in reverse . a low power rocket engine and it changed the rotation and the mold of the system to some extent.

Question:

Now in essay 10 too , the last of the Pegasus flight there is an experiment that I felt was kind of intriguing. And that was the removable panal . Do you remember that?

Answer:

Oh, yes. fWe had thought for some time that we could send them an astronaut out with a payload pair of pliars to clip off the little clamps which we designed and built for the movement. and which we could bring back. Then the problem was that the subsequent flight did not go , the manned flight , sto that altitude. You mustgo to a certain altitude in order to obtain a long enough life time and that was higher than our manned flights went. So

Question:

Wasn't there a moveable Where did their moveable idea come from? Was that such an unusual thing or just . It strikes me as kind of interesting.

Answer:

No. It's an idea which came up at a number of places. As soon as there was a possibility of having astronauts doing extra regular activities, you ask what can he do. And we said, he can do bring back one of these

and see how the impacts of the meteorites look like on it and we liked the idea very much because for some time then we found there was just no way of going up to that high altitude.

Question:

Can you say that Pegasus was the biggest scientific experiment that Marshall in particular launched?

Answer:

By demensions and volume yes.

Question:

Was it the most important?

Answer:

That is very hard to say and I would not like to touch an importance figure. To scientific experiments. Now when you talk to an astronomer, then astronomy is by far the most important activity for findings in space. And we have a very good find I would probably agree to a large extent with an astronomer. Medical people say the most important scientific progress is to find out whether men can live ;under weightlessness. And again that is extremely important. And there may be many things coming out of these biomedi al investigations in the years to come which may prove to be extremely important . And then, of course, another extremely important thing to do in orbit is to look down at earth , at our own planet, . Find out how we can keep it clean. and in good shape for the years to come. Extremely important. Now this here was very important because it gave us the assurence that our designs were right as far as the meteor damage was concerned. And that was a very very good influence to have. We are very happy to have it.

Question:

Did participate in this experiment at all?

Answer:

I would like to add here if you would be interested in more in such questions as tumbling, how was the tumbling mold, and how did it build up and so forth, we have a man here who knows much about this . He wrote a few scientific papers about this tumbling . That is Doctor Nowman.

Question:

All right thank you.

Answer:

He was a member of this team here of this Pegasus team.

Question:

Now you had a questin about Houston.

Answer:

If you would like to know more about other experiments like the paint experiments, and measurementsand so on, Mr. Hellar would be the right man to talk to. Now you had a question

We were in close contact with their meteorite

That crew was by that time , or the man with whom we were mostly was Mr. Court-palais He was Houston's meteorite m n and he and we conversed very often. and exchanged ideas. and thoughts and we had a good contact with him and his crew. We also had contact with their people who were responsible for thermal design becaus e we obtained thermal design information for our paints and Mr. Hellar would know more abut it.

Question:

The alodine ?

Answer:

Yes Now then who could tell you more about the contacts with Houston wuld be Dr. Dozer. If you would like to exchange some views with headquarters people who were in this project, the man to talk to would be Mr. Kellar . He is at the present time in OSSA, Office of Space and he iis the man behind the grand tour , you know. He was deeply involved in our Pegasus project. He could possible give you some information .

Question:

I wonder if you could tell us something about the development of the space scientes lab and things of that type here . Yu began to turn up more using contractors . Is that right? And then developed a much larger in hourse ability?

Answer:

We always put emphasis on in house capability and effected. It was , it has always been

the laboratory which put most emphasis on in house capability. We tried to strengthen and pick up our scientific workby contractors and by contracts in many fields. and we had a number of contracts. but it was always a very important point for us to develop an honest to goodness scientific here. in our own grounds. withing the Marshall Center. That was in SSL, space science laboratory. Throguh the years we developed capability and activity and research activity in a number of fields. among them thermal physics, which included thermal design problems and radiation properties of metal and all kinds of areas of thermal control systems. In that activity in our laboratories we went really deep into the properties of metalwith respect to heat emission and heat absorption and heat conduction. Anumber of very good papers were written by members of the laboratory in this area, heat conduction, heat emission, heat absorption. Properties of surfaces of different types of . Another one was radiation physics. And here we went in two directions. First, we developed theories and computor codes and capabilities in estimating radiation effects of radiationforces on board a space craft. And this is the radiation forces would be radi isotopes, and nuclear reactors. Nuclear reactors as planned for and also for space power sources. Reactors as space power sources. And then we developed in the same group we developed knowledge and dwelt on actual radiation in space environment. This environment includes the Van Allen Belts cosmic rays solar flare radiation and artificial radiation. like star fish. And as I said was quite active in developing these capabilities. And with that capability in the rigt areas was the development of sensors . One sensor was the one on Pegasus which was developed by a company TRW was our close corporation. And then another

Question:

Excuse me. Of the radiation center?

Answer:

The electron center. Subsequent to that we began a number of years ago to develop a proton sensor and this experiment has come to fruition. very well. and this proton sensor is now a firm piece of equipment for Sky Lift. It is a proton sensor which senses the environment of protons out of the environment with respect to protons and it measures not only the total radistion but it measures the energy distribution of the proton radistion. which is very important

if we are to be charged wupon men. This radiation energy distributuon meter was developed in SSL and to some extent together with the university of Huntsville, UAH. Now .

Question:

Di d you have another area you wanted to add to that?

Answer:

These are two areas of SSL now. There are a few more. One is infrared astronomy and infrared physics. a very active area. Another area is meteorite physics in basis, Pegasus was just one part of it. But in this meteorite physics area we developed centers from the ground up to the sensors to get a look at the streaks of meteors. with their high sensitivity this center has been used from the ground and also from high flying airplanes . Then one activity which we tried to do for a number of years but we had to be reduced because the assignment was given to other centers, was electrical portion. The development of electrical portion was strong activity of SSl for a number of years.

Question:

That was one of your special interests.

Answer:

This is right yes. Thsi activity was then transfered to the Lewisburg center and then we had to go down to a low level of activity. Then when another area wasthe planning for scientific satilites and when this was down at a time when not much planning for scientific satilites was done by other groups and other places. For example, planning for the Satilite began , you know what the is, high energy astronomically? observitory? that began around 75 , 76 in SSL on a slow basis , then came up into a project level more recently, just two or three years ago. Much ground work on that study was done at SSL and by SSL contractors. From about 64, 65 on.

Question:

The one that stands out in your mind that . Was there one scientific project that had a specific influence on design changes or confirmation of the booster vehicle for the Saturn?

Answer:

I would say this was the Pegasus and the thermal investigations which were made on

Pegasus and on other space craft too. In fact, we began the measurements on Explorer VII. That was in 1960 or 1961. Mr. Heller would be the right source of information here.

Question:

We were talking about thermal coding in space.

Answer:

Thermal coding and the temperature in certain sensors , temperature certain sensors assume under certain conditions and coded with special coding.

Question:

When you were on your trip with Dr. Von Braun did you come up with any insight that had any influence on Saturn or Apollo program?

Answer:

I wonder whether you have seen the trip report which we wrote.

Question:

No I haven't.

Answer:

This would answer your question partially in this report. I could not honestly ~~infuse~~ say this influenced the Saturn. I would suggest that you take a copy of that paper from my secretary and there is a whole chapter in that paper in answer to that question. We cannot directly say that one particular finding in Antartica changed certain from one form into another form. And what we learned and the whole experience down there was certainly an influence on the project control and was

And in sense we learned a number of things. down there on how to handle scientific investigation in remote places when we are cut off from home base and cut off from laboratory and people cannot move and work as freely as they can here in normal environment. ,This was quite helpful to us, to see how they do it in Antarctica, how they handle this logistics problem from the men and to the whole place.

Question:

~~What were the~~ Over the year there has been criticism that has been stirred alittle I guess by Apollo 15 and the lack of science in the Saturn and NASA program . Can you make some coments?

Answer:

Previous ones or future ones?

Question:

The previous ones. I'm talking about . Can you make some comments on the growth of the scientific effort within NASA during the last 10 years?

Answer:

Yes I would look at it in a following way. Thsi is 1960 , that is 1970. Now we began with this earth orbiting flite in '58 and the Russions in '57. Now the ir first flight was , this was very good and a fine accomplishment. And after that there were a number of more explorers and they did alot of exploring which is not too well known to the public but if you look into books on this subject you will be surprised to see how much has been found and discovered around this early program. This is a good and scientific demonstrates physics in scientific satilites and it is very amazing to see how much for the physists was found out of these early flights. This here, for example, the magneto fields. So now there is a very rich harvest which came out of these early flights even though the normal nonscientific citizen does not catch it so readily because it's fine science and science in areas which are not close to the average citizen. For example, the fact that there is a solar wind but it does not reach the earth because it is outside the earth's magnetic field. This is extremely important to science but you cannot drive a car with it., or a motor boat or feed a penny out of a solar wind adn so many people here are not close to it in this area. But for science it is very important. And science as a wholeof course, as a whole is very important to mankind in my opinion. That is to the highly civilized countries it is highly important because science is the out of which we feed our progress and sometimes our existence and our survival I would say . So even if the solar wind does not yet feed the taxpayer directly I think its one of the wonderful discoveries and findings, one of many. in science which will certainly have an influence on the our way of life and civilization and what there is to come. Anyway, there was alot of scientific developing here , but then around that time there was the decision to go to the moon. That was when Apollo was born with that line around here. And this was a tall order, of course, a very tall order to fly men to the mool and bring them back . So NASA had to put emphasis on Apollo during this decade and the objective of this was to fly men to the moon and bring them back alive. So this was the overruling and guiding thought in all our work. But in addition to that there was still

alot of good science going on. There were the Mariners, you know, going to Mars. There were a number of very good on our flights in our Lunar Orbiter and Surveyer, which were a whole lot of good science in addition to the fine figures for below. And there was very good astronomy OSO, orbiting solar observer, and then the OAO , the first real good one was launched in '68. But is was developed during that time. So there was quite abit of good science going on here. Now it was the understanding and the feeling and knowledge of I think everybody in the space program that this decade will be mainly the decade of science. The '70s. This will be the decade of Apollo, and this will prove that we can do it. We will fulfill the president's promise and desire. We will develop all these capabilities and from here on we would really utilize what we have done and accomplished and learned and develeoped in this decade. And so this decade was always in our planning in our feeling the decade of astronomy , of physics, of space pilotcy, and of earth sciences, earthe sciences seen from space, geophysics adn earth observasions, and other sciences that can be done from orbit and that concern our era. fI should include here planetary, planetary , and also more lunar exploration. This was the broad programafor the '70s. Now around that time one realized more and more that in order to do this we shougd have a cheaper launch capability and by expendable profits.

Question:

Came about '68 you're talking about?

Answer:

About yea. It's not a firm point , but around that time. We had the feeling that we do need a cheaper and more convenient launch capability than Saturns. which are expensive and are used only once, and it takes so long to put one together and fit everything in and then it's launched and then it's gone. So around that time the idea came out that we should have reusable vehicle , that is how the shuttle idea was born . most outspoken protagonist of that was Dr. Miller and his OLS grup. Around that time we planned for the shuttle was born , but with the idea that all of these things should be done with theshuttle but we can do it with the shuttle in a cheaper and better way than if we had to take acceptance for it. Now agan our thoughts around that time were that we could do both. build up the shuttle and at the same time go into the sciences. in a broud and a very efficient and faith moving way. As long as we had no shuttle yet to fly with we would fly with Saturns, with

Titans, with Atlases, and with develop these sciences as much as we could, including more lunar flights. including planetary flights, including large satilites to observe the earth from up there. including large satilites to do space biology and including flying telescope and flying star trackers and cosmic ray counters and so on. Now with this very low budget, we believe it's very low; some people say three billion is still too much, we are in a bad squeeze now . We would like to go on with this here, and we wuld like to go on with the shuttle, and we believe we are in very sood swing with all of these experiments and projects. We have done much in this program which ensourages us to do more. And we have some very good projects as you may know, the LST in astronomy, large space telescope, in earthe sciences we have some very good plans for the earth observations with cameras and different ray sensors and other sensing equipment. We have some very fine plans for planetary observation with Viking, and then a number of flights to individual planets. We plan orbiters and landings and certain returns. We have some very good plans for lunar exploration . All together this would be a six billion dollar program and we have about one half of it. Each of them would cost abut three billion, and now we have three billion and that gives us a problem. To go on with the shuttle and the very small basis does not make much sense because you would move so slowly that it would almost obsolete, whatever you built, you would never get it because you would not get up thereso to speak. And to move a small amount here would just not give us the fine and proper program which we could do now on the basis of what we have learned. during that time. Some people say that our program is unbalanced now with the put everything into the shuttle and have not much left for science. That is one of the criticisms which is heard many times, and this is not incorrect, but we want ed it differently. We wanted a balanced program between the shuttle and the science, and that would have been about a six billion dollar program. Now since we have less than that we are in very bad difficulty . Should we take the three billion only for the shuttle and do nothing up there. That would certainly be wrong and most we would advise violently against this. Should we forget about the shuttle and do only some small flying here. We would again advise against it. We have no long certainties you know. We have a few left, but then thats

it and we cannot save our vehicle until Saturns and all this. We don't have them. Production has been discontinued adh so we would not be able to move as we had thought of moving around this time here. We do need a Saturn now to go on with a shot and shot in a few years. We have to spend a certain amount of money and we cannot afford it either to drop this effort because if we put everything into the shuttle, we may have the shuttle in 1980 but not until to fly in, to fly in the shuttle. And this a very bad situation now, very difficult one.

Question:

And sll you can do is hope for support in the future?

Answer:

That's what we hope. Some support to make these projects possible in the future. We need each ot er. The shuttle needs science to justify its existence. It'snot only pure science as you see, earthe scientists work direct in the to better earth. To save our resources and to keeping the earth cleaner than we do right now.

Question:

Well, we asked for an hour and you've given us an hour.

Answer:

But does it make sense?

Question:

It certainly does, and I'd like to . You're really helpful. Three bookd on space physics and other titles . One is "Willmot Hess editor intorduction to Space Science" boy Goddard Space Flight Center and NASA The second book Donald P. McGally, editor LeGalley and Allen Rosen entitled Space Physics. The third book William R. Corliss Scientific Satilites, a NASA publ ication . and a fourth book that Dr. Stuhlinger just put down Robert J. Mackin Jr. and Marsha Neugebaur editors, A Solar Wind by Pergerman Press; a book on space physics is published by John Wyley and sons.

RB

INTERVIEW WITH DR. STUKLINGER

Question:

How much criticism was there of the Saturn Program in specific, not Apollo necessarily, but Saturn Program and was the high water thing done kinda of an answer to Scientific Critics? or was it you simply had space available or really where did the high water program originate?

Answer:

The original high water , I believe, was many fold, there was criticism from some people who said we should not launch more Fla. sand into orbit as we did before just to ballast our vehicles, and wo we decided to launch some thing better than sand. but it would have to be something cheap and heavy at the same time because we needed a certain ballast to try out certain ones and it occured to some members of this center, of the Marshall Center who worked in the Space Scientist Laboratory at the time that one possible answer to the request for a heavy, useful but still inexpensive payload might be the launching of large amount of water which would be released quickly at high altitudes and one would then study from an account how this water behaved when it is all of a sudden exposed to vacuum, and the weightlessness under space conditions. The design and engineering aspect of this experiment was relatively simple. Because there was nothing active in this project except the command to rip the container open at the right point. The container was filled with water then and the opening of the container was done by primer cord was ignited by a command, I do not remember at this moment whether it was a command from a count or a timer, I believe it was a timer on topspacecraft. This can be read in the original reports. And then there were a number of observing instruments on the c among them film camera, and radiation counters. What we were after particularly was the question how quickly the water would vaporize, and how quickly it would expand, to what size it would expand, how long the cloud or whatever would happen, would stay there, how long it would take that cloud to dissappear, and was changed to an invisible system. We did make a number of experiments on the ground before the launch of high water in which we exposed more quantities of water to vacuum in laboratory experiments and we had some anticipation of what might happen in the flight experiment. Now I don't think that anybody saw that this experiment would be an extremely earthshaking and revealing experiment as far as the basic laws of physics or the knowledge of nature we are concerned

On the other hand we expect that we would have some interesting results which would tell us a little bit more about the behavion large amounts of metal if they are all of a sudden exposed to high vacuum. The experiment itself worked very well, it functioned as we anticipated, among the sensors not all of them worked fully, if I remember correctly then some of the specific regulation censors, I believe it was inforred did not work properly and one reason was because the whole experiment was to be a low cost experiment, and we could not spend a large amount of money to develop very elaborate experiments for cloud oberservations. On the other hand, we obtained very good movie pictures of the event and we could determine the speed of expansion of the cloud and the distance to which it expanded and we could find out the lifetime of the cloud in orbit. Now, if you like to have more precise data of this kind you should look them up in the report, which are in there, I don't remember them off hand.

Okay, then, I haven't gotten that far yet. I have done some research on but I just haven't done the high water.

Now, again high water should not be classified as an extremely important scientific experiment which clarified very sever problems manking was facing before the experiment was done. On the other hadd, we are glad we did make it because a good use of existing opportunities and of the capability of the vehicle to lift large amounts water into orbit. That's about how we look at it, now looking back at it today.

So it's just primarely a payload experiment in terms of balanced. ballast

This is one aspect of it we had to balance the vehicle in a boxoa ballast to make it a realistic anyway flight test for the vehicle and however in putting in some completely in earth like sent from the Florida beaches we decided we would like to make this experiment. And within that framework we are certainly going to say it was successful, it was a good experiment. On the other hand one would not have launched a Saturn particularly for atha purpose only in alter study but if one knew what it was doing if exposed to vacuum water one would not have justified a launching just for that purpose.

Question:
Were there any consideration that this might be an interesting experiment in terms of what might happen if the Saturn stage, say, ruptured before ignation. You have all of this

liquid hydrogen and oxeygen, does that give you any perimetner as to what might happen in that instance.

Answer:

It sure would, because well that's one of the things we studies was the influence of the cloud like this on communications. There was a possibility that it would interupt communications for some time because several effects can be solved which would be leading to this, for exemaple this cloud could stay there for a long time and could sheild off some of the ultraviolent radiation which produces the atmosphere so this cloud could in essence produce a hold in the atmosphere and the atmosphere, as you know is needed for the reflection of radio signals if you want to publicate that message at this time in this general area. So this was one of the effects we were after, we wanted to see how this cloud would effect coming occassions.

Question:

It didn't have any particular negative effect that you could ascertain.

Answer:

I do not remember that we found any real adverse effect, but again you should look it up in the reports.

Question:

You found that the cloud really didn't expand as far as you can see.

Answer:

The cloud did expand quicker and farther than we thought. In fact, it had a diameter of about ten kelimeters, which is a pretty big volume, you know, its of ten kelimeters diameter. We could see there that it was a beautiful veiw. The vehicle went up and, of course, we didn't see anything because it was to far away and the ignition was cut off and then it had reached its apex. The rupture of the water container occurred and all what you saw was first this blue sky + nothing; all of a sudden within a tenth of a second there was a huge cloud bigger than the moon. White and a little teneous than the moon, but bigger than the moon and it was all of a sudden there in the sky and then it faded away in the course of about ten minutes. It dissappeared. And the dissapearance is we believe because of the little ice crystals that form by the rapid expansion, that we ~~are~~ were warned melt and vaporize because of solar radiation.

irradiation.

Question:

So you can call it the , correct me if this is incorrect, with the high water the first great experiment in the Saturn mission. Purel y scientific, but

The first large one, yes.

Okayy , now let me , is it okay your on the Pegasus now?

YYes

Okay, I guess the real question I'd like to know more than anything were there any statistics derived from these detection sattelites that really influenced the the design either of the Saturn launch vehicle or the Apollo space craft?

Answer

The Pegasus

Yes, Pegasus

By all means yes. The situation before before Pegasus was about the following: when you plot here the number of meteorites occuring or being there in the vicinity of the earth as the function of the their mass . Then we had a few measurements of up here that means small masses . Then we had a few measurements down there very irratic and few of visible meteorites. Make a streak of light as meteors which can be seen. But this ~~we are~~ This were diffuse so we did not know how many meteorites there would be up of this size and this size about is important for space craft. We know what size they are too small and don't do any damage and about the size they are too rare to be afraid of them , ;but in here are those meteorites which are big enough to puncture the space vehicle. and still frequent enough to be of concern. and we did not know whether this curve in here was going like this or like this or like this. this is logarithim ic by the way. You understand what is logarithmic ? Anyway the diagram could have been had any shape of , any number of shapes, and since that is a logarithmic diagram here, the difference between here and

here would mean affect of 10,000 ~~of volume~~ about in frequency. So we didn't know whether a mass of this kind here would occur three times a day or thirty thousand times a day. And it is of course extremely important to know because the design and the protection of space craft will depend on that. and so around 1961 or 62 when we bagan to design Saturn and to develop plans for Saturn, and for the Apollo, we were very uncertain of how the meteor danger would be. in space. And then at that time it occured , well in my laboratory at that time in Space Scientist Laboratories, one of the subjects of research and studies which we had was to find out how many meteorites there are in space, how big they are , and in fact how the funtion would look like. We looked at that time through all the papers which were available and measurements and observations. and we found that there were jjust not enough available in this dangerous or important region to tell us how many there were and how thick we would have to design and build our space craft . And then we decided in SSL that time the only way to find out more about it awould be to b ild a sattelite and to measure it and to observe it. And then we sat together and tried to find out how big that thing would have to be and how sensitive and so forthe, and how long it should be in orbit. so that we could obtain significant numbers . The problem here is the following: there are not many meteorites, but if a space craft in space is hit only once or twice in the course of a year that is too much. Now to NASA this number , one or two a year hitting a space craft, of say the size of this room here means of course that we should measure either with a large craft or for a lonnger time in order to pin down that mumber. because it is difficult number which we varies quite a bit. and if we have only a small thing, maybe it hits us once a year and we still don't know what data change which then occurs once every hundred years or was it just a particularly good year when only one hit when next year we would count ten hits; we wouldn't know so the requirement was that we should have a large vehicle larger than normal space craft, then that it should fly and measure and observe the whole attitude a long time so that we can pin downthe statistical numberswhich we are after. This is a particular problem in this kind of measurement. We want to

measure a numberwhich is very small but we want to measure it with a good enough statistical significance so that we really can tell our designers how thick to build the wall a protective wall for the space craft.

Now may I interupt here a moment? Now in the end this was an important design perameter because we were still talking about an earth orbit rondevue.

Very important perameter.

And thats where the whole problem is taking place. I meanit was in that near earth environment that this particular

This is right. But it is still about a little, they are less frequent when you go further out. Because there is a kind of focusing effectnear the earth. But this is effect not too very strong. This means when you go out to the moon, it is still importantto be prtected against meteorites and you cannot simply say well I get out of the earthe orbit quickly into the lunar projectory and I'm safe. There are meteorites, and when you look at a picture of the moon itself you see what how many times it has been hit. Anyway, the problem is more ~~simply~~ severe, near the earth this is correctbut it is not disappearing when we go away from the earth. So that the problem are first, tanks near earth, that means tanks which are being used at the early time of the space flight , vehicle tanks, (boosters) and then second tanks in space, of space craaft, and then third, the housing capsules of the astronauts. These are the three things to be considered and all of them must be prtected. ~~If they grow short of time~~ For a shorter time well they have a much large area. As a rule they have thin walls, the tanks of the Atlas or the Titan or Saturn booster vehicle are very thin . This is the problem for tanks in space. They are , as a rule, they are smaller, but they are still thin ~~enough~~ in order to be light and then the capsules of the astronauts are still smaller and they are normally heavier because they also must provide heat protection. But these are the three problems. And around that time we set out to determine the design numbers

for these three prolem areas. And this was about the uncertainty, so we said at least every time we do any thing which is very large and it should be flown in orbit long enoggh to provide us with statistical information , meaningful figures. Then after we had determined what kind of vehicle we need, we immediately saw that we could only use a certain vehicle to fly, because others would be too small and the sensitive area would be too small to give us the figures. And then we found out that there would be in our Saturn I program at least one that could possibly be made available for such a flight. Then we proposed to our own management here that we would like to build a meteorite sensing sattalite for Saturn I launching and that we would be able bopefully to pin down this design figures. The importance and the significance of it was immediately recognized by our management and we were encouraged to procede and to go ahead and to make plans . And from then on it became a project which has been described in technical reports. We began our design by looking in the pay load capability and into the requirement for an orbit attitude. When you want to have a certainlife time for the space craft you have to go up high enough so that the air drag does not bring it down too soon. Then this satellite would have to be a very big one. in order to provide enough sensitive area for the meteorite hits, so we had to go up relatively high in orbit. Then we determined how many pounds of pay load a Saturn could carry into that orbit. Realize that size sensors that could be carried into a high enough orbit and this was the basis then for the project. From then on its just normal story of a development project. Now we had not only one but we had three flights in the course of the development. It turned out we could use two and even three Saturn I's because the importance of this project was considered more important than any other payload that could be flown with these Saturns.

By the time that the Pegasus flight took place '65 alot of the design for the booster and space craft had been finalized. Did you find that these designs didn't need to be changed on the basis of information gathered ?

Answer:

In essence we found that the designs which we did use for the Saturn were verified and our conscience was quieted so to speak and we found out that the design figures were good enoggh. There fwere nof drastic changes, but we could settle down with uncertainty reduced and settle the question of how many meteorites there are within a very small error margin. You probably have these numbers with you. These curves are in the reports and we culd really determine what the number of meteorites of a given mass are in space and they came pretty much to the point we had hoped for and expected and which our designers had been using. It was a very good verification of our design number s .

Question:

What about some of the secondary experiments then? I was wondering if you really got alot of new information on earth

Answer:

Yes, we did. We had some experiments as you may remember, on thermal radistion earth albedo, on paintsfor example, protective paints and paints which at the same time would control the temperature of space craft. These were a number of experiments and they were excellent. We found out and verified and helped to determine th e white paint which was used on the Saturn vehicle from there on out.

Question:

Did you deliberately plot the orbit of the Pegasus ~~to~~ through the South Atlantic anomaly

Answer:

There is no other way . You know wthey went thrsugh the South Atlantic anomaly better and more accurately than any other space craft had done before. The Pegasus did. That was an additional bonus. But there is no way around it. There would be a way around it if you would put your satallite into an equatorial orbit . The south anomaly covers about an area like this one , bbout 10 degrees south . Now any satallite which has an inclination of more than 10 degrees must go through unless it is coming down very low .

Question:

You also found some things abuut the decay of star fishe electrons ., as I recall.

Answer:

They were also recognized, yes. They were recognized as being still there, yes.

Question:

Okay, then lets see. There were a couple of other specific questions.

Answer:

In fact the star fish electrons were recognized because of their time change, their change in time. The star fish population reduces and decays and so we could measure some of this decay. And so we knew these must be star fish and not natural bodies.

Question:

Again, this was something that was just a . You had some radiation flux sensors on that. Is that how

Answer:

Yes The electron count actually.

Queation:

There was some tumbling. of the Pegasus.

Answer:

There was some tumbling, yes. And we knew that this would happen. It even happened a little as I remember correctly more slowly than we thought it would. And the reason why this tumbling would happen is quite well known . Its a well known law of mechanics. A bodie which rotates around some axis will gradually assume rotation around its axis of highest moment of inertia. If there is a mechanism to take energy out of it and this mechanism to absorb energy of its of course the air brake and auto magnetic damping magnetic damping in the earth field and the air plane and this affects work together to finally make any motion of a body in space such that it rotates around its axis of largest moment of inertia. And in that case, it has a kind of propeller type motion.

Question:

And now, I readsome reports . I'm still a little confused on it. Was this welcomed because I read one thing that said that they actually accepted this movement because it gave them more a wider count of meteorite possible meteorite punctures of the space craft. answer: yes. Was the problem because the . You invented some stuff and maybe. Was there a problem because a couple of the early ones gave you a higher rotation

warning?

Answer:

This was on the first one there was some venting of the residual propellant. The central portion contains some tankage and there . Of course when you go into the ~~side~~ desired of it, then you do not burn all the fuel propellant. You juust cut off and you have reached that orbit. And so there was some propellant left and it was vented and it did not vent without exercisong a torque . on the space craft and this torque by the venting acted a lettle like a rocket in reverse . a low power rocket engine and it changed the rotation and the mold of the system to some extent.

Question:

Now in ~~essay 10~~ SA-10 too , the last of the Pegasus flight there is an experiment that I felt was kind of intriguing. And that was the removable panal . Do you remember that?

Answer:

Oh, yes. fWe had thought for some time that we could send them an astronaut out with a ~~payload~~ pair of pliars to clip off the little clamps which we designed and built for the movement. and which we could bring back. Then the problem was that the subsequent flight did not go , the manned flight , sto that altitude. You mustgo to a certain altitude in order to obtain a long enough life time and that was higher than our manned flights went. So

Question:

Wasn't there a moveable Where did their moveable idea come from? Was that such an unusual thing or just . It strikes me as kind of interesting.

Answer:

No. It's an idea which came up at a number of places. As soon as there was a possibility of having astronauts doing extra regular activities, you ask what can he do. And we said, he can do bring back one of these and see how the impacts of the meteorites look like on it and we liked the idea very much because for some time then we found there was just no way of going up to that high altitude.

Question:

Can you say that Pegasus was the biggest scientific experiment that Marshall in particular launched?

Answer:

By demensions and volume yes.

Question:

Was it the most important?

Answer:

That is very hard to say and I would not like to touch an importance figure. To scientific experiments. Now when you talk to an astronomer, then astronomy is by far the most important activity for findings in space. And we have a very good find I would probably agree to a large extent with an astronomer. Medical people say the most important scientific progress is to find out whether men can live ;under weightlessness. And again that is extremely important. And there may be many things coming out of these biomedi al investigations in the years to come which may prove to be extremely important . And then, of course, another extremely important thing to do in orbit is to look down at earth , at our own plantt, . Find out how we can keep it clean. and in good shape for the years to come. Extremely important. Now this here was very important because it gave us the assurence that our designs were right as far as the meteor damage was concerned. And that was a very very good influence to have. We are very happy to have it.

Question:

Did participate in this experiment at all?

Answer:

I would like to add here if you would be interested in more in such questions as tumbling, how was the tumbling mold, and how did it build up and so forth, we have a man here who knows much about this . He wrote a few scientific papers about this tumbling . That is Doctor Nowman.

Question:

All right thank you.

Answer:

He was a member of this team here of this Pegasus team.

Question:

Now you had a questin about Houston.

Answer:

If you would like to know more about other experiments like the paint experiments, and albedo measurementsand so on, Mr. Hellar would be the right man to talk to. Now you had a question

We were in close contact with their meteorite group That crew was by that time , or the man with whom we were mostly was Mr. Court-palais He was Houston's meteorite m n and he and we conversed very often. and exchanged ideas. and thoughts and we had a good contact with him and his crew. We also had contact with their people who were responsible for thermal design becaus e we obtained thermal design information for our paints and Mr. Hellar would know more abut it.

Question:

The alodine ?

Answer:

Yes Now then who could tell you more about the contacts with Houston wuld be Dr. Dozer. If you would like to exchange some views with headquarters people who were in this project, the man to talk to would be Mr. Kellar . He is at the present time in OSSA, Office of Space and he iis the man behind the grand tour , you know. He was deeply involved in our Pegasus project. He could possible give you some information .

Question:

I wonder if you could tell us something about the development of the space scientes lab and things of that type here . Yu began to turn up more using contractors . Is that right? And then developed a much larger in hourse ability?

Answer:

We always put emphasis on in house capability and effected. It was , it has always been

the laboratory which put most emphasis on in house capability. We tried to strengthen and pick up our scientific workby contractors and by contracts in many fields. and we had a number of contracts. but it was always a very important point for us to develop an honest to goodness scientific here. in our own grounds. withing the Marshall Center. That was in SSL, space science laboratory. Throguh the years we developed capability and activity and research activity in a number of fields. among them thermal physics, which included thermal design problems and radiation properties of metal and all kinds of areas of thermal control systems. In that activity in our laboratories we went really deep into the properties of metalwith respect to heat emission and heat absorption and heat conduction. Anumber of very good papers were written by members of the laboratory in this area, heat conduction, heat emission, heat absorption. Properties of surfaces of different types of . Another one was radiation physics. And here we went in two directions. First, we developed theories and computor codes and capabilities in estimating radiation effects of radiationforces on board a space craft. And this is radiation forces would be radi isotopes, and nuclear reactors. Nuclear reactors as planned for and also for space power sources. Reactors as space power sources. And then we developed in the same group we developed knowledge and dwelt on actual radiation in space environment. This environment includes the Van Allen Belts cosmic rays solar flare radiation and artificial radiation. like star fish. And as I said was quite active in developing these capabilities. And with that capability in the rigt areas was the development of sensors . One sensor was the one on Pegasus which was developed by a company TRW was our close corporation. And then another

Question:

Excuse me. Of the radiation center?

Answer:

The electron center. Subsequent to that we began a number of years ago to develop a proton sensor and this experiment has come to fruition. very well. and this proton sensor is now a firm piece of equipment for Sky Lift. It is a proton sensor which senses the environment of protons out of the environment with respect to protons and it measures not only the total radistion but it measures the energy distribution of the proton radistion. which is very important

if we are to be charged wupon men. This radiation energy distributuon meter was developed in SSL and to some extent together with the university of Huntsville, UAH. Now .

Question:

Di d you have another area you wanted to add to that?

Answer:

These are two areas of SSL now. There are a few more. One is infrared astronomy and infrared physics. a very active area. Another area is meteorite physics in basis, Pegasus was just one part of it. But in this meteorite physics area we developed centers from the ground up to the sensors to get a look at the streaks of meteors. with their high sensitivity this center has been used from the ground and also from high flying airplanes . Then one activity which we tried to do for a number of years but we had to be reduced because the assignment was given to other centers, was electrical portion. The development of electrical portion was strong activity of SSl for a number of years.

Question:

That was one of your special interests.

Answer:

This is right yes. Thsi activity was then transfered to the Lewisburg center and then we had to go down to a low level of activity. Then ~~whoux~~ another area wasthe planning for scientific satilites and when this was down at a time when not much planning for scientific satilites was done by other groups and other places. For example, planning for the Satilite began , you know what the is, high energy astronomically? observitory? that began around 75 , 76 in SSL on a slow basis , then came up into a project level more recently, just two or three years ago. Much ground work on that study was done at SSL and by SSL contractors. From about 64, 65 on.

Question:

The one that stands out in your mind that . Was there one scientific project that had a specific influence on design changes or confirmation of the booster vehicle for the Saturn?

Answer:

I would say this was the Pegasus and the thermal investigations which were made on

Pegasus and on other space craft too. In fact, we began the measurements on Explorer VII. That was in 1960 or 1961. Mr. Heller would be the right source of information here.

Question:

We were talking about thermal coding in space.

Answer:

Thermal coding and the temperature in certain sensors , temperature certain sensors assume under certain conditions and coded with special coding.

Question:

When you were on your trip with Dr. Von Braun did you come up with any insight that had any influence on Saturn or Apollo program?

Answer:

I wonder whether you have seen the trip report which we wrote.

Question:

No I haven't.

Answer:

This would answer your question partially in this report. I could not honestly ~~infl~~ say this influenced the Saturn. I would suggest that you take a copy of that paper from my secretary and there is a whole chapter in that paper in answer to that question. We cannot directly say that one particular finding in Antartica changed certain from one form into another form. And what we learned and the whole experience down there was certainly an influence on the project control and was

And in sense we learned a number of things. down there on how to handle scientific investigation in remote places when we are cut off from home base and cut off from laboratory and people cannot move and work as freely as they can here in normal environment. ,This was quite helpful to us, to see how they do it in Antarctica, how they handle this logistics problem from the men and to the whole place.

Question:

~~Whatoverredde~~ Over the year there has been criticism that has been stirred alittle I guess by Apollo 15 and the lack of science in the Saturn and NASA program . Can you make some coments?

Answer:

Previous ones or future ones?

Question:

The previous ones. I'm talking about . Can you make some comments on the growth of the scientific effort within NASA during the last 10 years?

Answer:

Yes I would look at it in a following way. Thsi is 1960 , that is 1970. Now we began with this earth orbiting flite in '58 and the Russions in '57. Now the ir first flight was , this was very good and a fine accomplishmént. And after that there were a number of more explorers and they did alot of exploring which is not too well known to the public but if you look into books on this subject you will be surprised to see how much has been found and discovered around this early program. This is a good and scientific demonstrates physics in scientific satilites and it is very amazing to see how much w for the physists was found out of these early flights. This here, for example, the magneto fields. So now there is a very rich harvest which came out of these early flights even though the normal nonscientific citizen does not catch it so readily because it's fine science and science in areas which are not close to the average citizen. For example, the fact that there is a solar wind but it does not reach the earth because it is outside the earth's magnetic field. This is extremely important to science but you cannot drive a car with it., or a motor boat or feed a penny out of a solar wind adn so many people here are not close to it in this area. But for science it is very important. And science as a wholeof course, as a whole is very important to mankind in my opinion. That is to the highly civilized countries it is highly important because science is the out of which we feed our progress and sometimes our existence and our survival I would say . So even if the solar wind does not yet feed the taxpayer directly I think its one of the wonderful discoveries and findings, one of many. in science which will certainly have an influence on the our way of life and civilization and what there is to come. Anyway, there was alot of scientific developing here , but then around that time there was the decision to go to the moon. That was when Apollo was born with that line around here. And this was a tall order, of course, a very tall order to fly men to the mool and bring them back . So NASA had to put emphasis on Apollo during this decade and the objective of this was to fly men to the moon and bring them back alive. So this was the overruling and guiding thought in all our work. But in addition to that there was still

alot of good science going on. There were the Mariners, you know, going to Mars. There were a number of very good on our flights in our Lunar Orbiter and Surveyer, which were a whole lot of good science in addition to the fine figures for below. And there was very good astronomy OSO, orbiting solar observer, and then the OAO , the first real good one was launched in '68. But is was developed during that time. So there was quite abit of good science going on here. Now it was the understanding and the feeling and knowledge of I think everybody in the space program that this decade will be mainly the decade of science. The '70s. This will be the decade of Apollo, and this will prove that we can do it. We will fulfill the president's promise and desire. We will develop all these capabilities and from here on we would really utilize what we have done and accomplished and learned and develeoped in this decade. And so this decade was always in our planning in our feeling the decade of astronomy , of physics, of space pilotcy, and of earth sciences, earthe sciences seen from space, geophysics adn earth observasions, and other sciences that can be done from orbit and that concern our era. fI should include here planetary, planetary , and also more lunar exploration. This was the broad programafor the '70s. Now around that time one realized more and more that in order to do this we shougd have a cheaper launch capability and by expendable profits.

Question:

Came about '68 you're talking about?

Answer:

About yea. It's not a firm point , but around that time. We had the feeling that we do need a cheaper and more convenient launch capability than Saturns. which are expensive and are used only once, and it takes so long to put one together and fit everything in and then it's launched and then it's gone. So around that time the idea came out that we should have reusable vehicle , that is how the shuttle idea was born . most outspoken protagonist of that was Dr. Miller and his OLS grup. Around that time we planned for the shuttle was born , but with the idea that all of these things should be done with theshuttle but we can do it with the shuttle in a cheaper and better way than if we had to take acceptance for it. Now agan our thoughts around that time were that we could do both. build up the shuttle and at the same time go into the sciences. in a broud and a very efficient and faith moving way. As long as we had no shuttle yet to fly with we would fly with Saturns, with

Titans, with Atlases, and with develop these sciences as much as we could, including more lunar flights. including planetary flights, including large satilites to observe the earth from up there. including large satilites to do space biology and including flying telescope and flying star trackers and cosmic ray counters and so on. Now with this very low budget, we believe it's very low; some people say three billion is still too much, we are in a bad squeeze now . We would like to go on with this here, and we wuld like to go on with the shuttle, and we believe we are in very sood swing with all of these experiments and projects. We have done much in this program which ensourages us to do more. And we have some very good projects as you may know, the LST in astronomy, large space telescope, in earthe sciences we have some very good plans for the earth observations with cameras and different ray sensors and other sensing equipment. We have some very fine plans for planetary observation with Viking, and then a number of flights to individual planets. We plan orbiters and landings and certain returns. We have some very good plans for lunar exploration . All together this would be a six billion dollar program and we have about one half of it. Each of them would cost abut three billion, and now we have three billion and that gives us a problem. To go on with the shuttle and the very small basis does not make much sense because you would move so slowly that it would almost obsolete, whatever you built, you would never get it because you would not get up thereso to speak. And to move a small amount here would just not give us the fine and proper program which we could do now on the basis of what we have learned. during that time. Some people say that our program is unbalanced now with the put everything into the shuttle and have not much left for science. That is one of the criticisms which is heard many times, and this is not incorrect, but we want ed it differently. We wanted a balanced program between the shuttle and the science, and that would have been about a six billion dollar program. Now since we have less than that we are in very bad difficulty . Should we take the three billion only for the shuttle and do nothing up there. That would certainly be wrong and most we would advise violently against this. Should we forget about the shuttle and do only some small flying here. We would again advise against it. We have no long certainties you know. We have a few left, but then thats

it and we cannot save our vehicle until Saturns and all this. We don't have them. Production has been discontinued ach so we would not be able to move as we had thought of moving around this time here. We do need a Saturn now to go on with a shot and shot in a few years. We have to spend a certain amount of money and we cannot afford it either to drop this effort because if we put everything into the shuttle, we may have the shuttle in 1980 but not until to fly in, to fly in the shuttle. And this a very bad situation now, very difficult one.

Question:

And sll you can do is hope for support in the future?

Answer:

That's what we hope. Some support to make these projects possible in the future. We need each ot er. The shuttle needs science to justify its existence. It'snot only pure science as you see, earthe scientists work direct in the to better earth. To save our resources and to keeping the earth cleaner than we do right now.

Question:

Well, we asked for an hour and you've given us an hour.

Answer:

But does it make sense?

Question:

It certainly does, and I'd like to . You're really helpful. Three bookd on space physics and other titles . One is "Willmot Hess editor intorduction to Space Science" boy Goddard Space Flight Center and NASA The second book Donald P. McGally, editor LeGalley and Allen Rosen entitled Space Physics. The third book William R. Corliss Scientific Satilites, a NASA publ ication . and a fourth book that Dr. Stuhlinger just put down Robert J. Mackin Jr. and Marsha Neugebaur editors, A Solar Wind by Pergerman Press; a book on space physics is published by John Wyley and sons.