IV. 4

INTERVIEW WITH

DR. ARTHUR RUDOLPH

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INTERVIEW OF DR. ARTHUR RUDOLPH

by

David S. Akens
David L. Christensen

See corrected copy in MSFC files!

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Mr. Akens:

Dr. Rudolph, what do you consider the most important problems that were overcome in the Saturn program while you were head of it? Do you have any major problems that come into mind?

Dr. Rudolph:

Yes, I think the major problem is that in big programs like the Saturn V you have many people involved and usually people want to go off on tangents. And the biggest problem is really to get them all to sing from the same sheet of music, to put it in the simple fashion. That's the biggest problem.

Mr. Akens:

When do you consider the Saturn program as having begun? You know we date it in the history about April 1957 when the government came through with this request for this large vehicle. How long ago was it when you first became associated with this clustered engine concept?

Dr. Rudolph:

Yes, I was with the Army. You remember that I had to stay behind. So I got back into the big vehicle section when I left the Army. I joined the Office of Manned Space Flight - Systems Engineering under Brainerd Holmes and that was in October 1961. I think in November or December I was in the first meeting that Brainerd Holmes had with Dr. von Braun where the Saturn V concept was firmed up. I remember for instance distinctly that at that time the first stage had only four engines. And in that very space here in the center, he cries for another engine. Dr. von Braun said that Brainerd calls for another engine (pointing to center of the first stage base).

Mr. Christensen:

I have an idea it was designed with that in mind to start with.

Dr. Rudolph:

From then on, being a member of the Office of Manned Space Flight, I was reasonably up-to-date on the launch vehicle. Getting on the Saturn V program, you know that. I started that in August, 1963. By being a member of Systems Engineering in the Office of Manned Space Flight, I got, of course, exposed to the configuration changes, the performance requirements, schedules, dollars, etc.

Mr. Akens:

I know that this question is not specifically in your area. When do you think the clustered engine concept started? Do you remember any date -- Peenemunde or anything like that?

Dr. Rudolph:

No.

Mr. Akens:

Probably here, don't you imagine?

Dr. Rudolph:

Yes. See the V-2 was such a tremendous step forward from a solid rocket or a Fourth of July rocket. We were glad we got this one.

I think the requirement for clustered engines came about in the United States on the Saturn. Now the Russians, as you know, started the whole concept with the V-2 and the clustering of V-2 engines. Speaking in cross terms, essentially V-2 engines. The old space vehicle, or launch vehicle, built was many more engine clusters than we have. You may have seen these photos of the Vostok.

Mr. Christensen:

Twenty-five engines or so?

Dr. Rudolph:

Yes. The clustering of the engine and even the clustering of the propellant tanks for the launch vehicles were demonstrated very well on Saturn I. Right?

Mr. Akens:

Yes.

Dr. Rudolph:

The Saturn V has clustered engines in the first and second stages but no clustering of tanks and so clustering really did not pose a very major problem. It worked.

Mr. Akens:

While we are on the question of clustering, what is the advantage of clustering eight engines over sixteen engines? I mean, why do you stop with eight? Do you have any thoughts on why we clustered eight on the Saturn I rather than sixteen or four?

Dr. Rudolph:

This was determined by the size of the missile. The performance requirements determined the size of the over-all dimensions, or better, the configuration. Money is always in short supply so what to do then is to save money. Well, use the available Redstone and Jupiter tanks. Therefore, I mentioned a tank clustering which on the Saturn I and IB would be very significant. And that naturally determined the number of engines, and you could fit that many in an envelope and come out with eight.

Mr. Christensen:

Was it coincidental in your opinion that the diameters of the Jupiter and Redstone tanks were ideally suited to clustering or do you think it was originally designed with this potential in mind? The ratios were very optimal.

Dr. Rudolph:

As I said, the Redstone tanks were readily available if not produced. Jupiter tanks? Why not use what is already there? You don't have to tool for it and fit them in an envelope. Nine tanks would be out, but maybe not, but nine was basically out so it turned out that way (cluster of eight Redstone 70-inch diameter tanks around the Jupiter 105-inch diameter tank).

Mr. Akens:

Do you imagine the F-1 engine is about as big an engine as we are going to have on rockets?

Dr. Rudolph:

No, you could build a bigger one. There was once talk about a M-1 engine. I forgot what the thrust of it would be. The basic investigation was started - whether one was built escapes me.

Mr. Christensen:

The M-1 hydrogen engine of 1,000,000 pounds was tested for the upper stages (components tested only in ground tests).

Dr. Rudolph:

I might be mistaken, but surely you could build a bigger one.

Mr. Akens:

And probably then, rather than clustering more engines, we would build bigger engines for the larger vehicles of the future. What do you think?

Dr. Rudolph:

I would be in favor of clustering.

Mr. Akens:

More of our F-1 engine sizes rather than building larger engines?

Dr. Rudolph:

There again you have an optimum - clustering is better than going to fewer engines. If you have more engines, you have redundancy. If one engine is lost, at least you don't have a complete loss. If you lose the engine in the S-IVB (the single engine) for starting out of orbit, then you have lost your mission. See on 502, we didn't ignite.

Mr. Akens:

I guess if you had a hundred engines, it would be better than having two.

Dr. Rudolph:

Then, of course, you have the other problems and therefore we talk about tradeoffs. So you trade. You have the advantage of redundancy. You have the disadvantage of complexity and also getting the engine in a way in tune and you know that also can fall into resonance and create all kinds of problems.

Mr. Christensen:

While we are on that subject I was wondering, in your opinion, do you think this is more or less a dead end or do you think this Saturn V would be enlarged or do you think the next generation would be recoverable?

Dr. Rudolph:

There is no end to it. You could enlarge it and make it longer and get more out of it. You can increase the performance of the existing engines. But, in my opinion, our large vehicle systems, and I talk here of the whole thing not only the launch vehicles, are much more sophisticated and therefore expensive and sensitive. They catch all kinds of human errors and environments and I'm of the firm opinion, they are too sophisticated. So, in the future, simpler - much more simpler - systems should be built where you have to do less testing, less calibration, and less tweaking (that is the electronic term).

Mr. Christensen:

So you lose a little efficiency but you lower the cost tremendously.

Dr. Rudolph:

Yes, you lose a little efficiency but you can then probably reinduce that by making it more powerful so you will have something to spare. And don't try by over-sophistication to shave the latest capability out - then they are always sensitive if it just doesn't come out that way. Nothing is 100%. You have tolerances anywhere and if you lose a little tolerance it doesn't work. It doesn't do what it is supposed to do.

Mr. Christensen:

On the other hand though, you say that we can advance the over-all state-of-the-art and we can now somewhat capitalize on these advanced, sophisticated technologies that have been developed for this program. In that respect, wouldn't you say that it was beneficial pushing the state-of-the-art?

Dr. Rudolph:

It is always good to push the state-of-the-art. On the Saturn V we had to go through horrible experiences in improving the welding techniques and introducing all kinds of very strict inspection methods to eliminate human error. Or, if you built it with a less sophisticated welding process that is somewhat heavier, make the engine more powerful, make the missile more powerful, you are better off. And since dollars are always the big issue (together with performance), it is always the overriding vote in the end. We see it now if something goes wrong, all the people who don't like it in the first place will write it is too expensive, give it up, forget it. It goes in cycles. For that reason, make it simple, make it simple, make it simple!

Mr. Akens:

Development of a rocket isn't really like the development of an automobile. Is it? The automobile actually becomes more sophisticated from the time Henry Ford built his car, you know. We become really sophisticated but now we are looking for the big bus and we don't need all the fancy gadgets. In rocketry, I guess we are looking for the Greyhound bus or something that will really carry a big load out there.

Dr. Rudolph:

I think this in a way is quite correct. The Saturn V has such a tremendous payload capability, we don't even know what to do with it right now.

Mr. Akens:

Oh, I see. We can't really use what we have.

Dr. Rudolph:

You need a tremendous number of people to launch it and that's a detriment. So, make it simple so you can do it with a handful. Then, it becomes less costly.

Mr. Christensen:

Instead of tying up a lot of people waiting.

Dr. Rudolph:

Right. And also from tying up a lot of people checking, checking, checking. And tying up a tremendous amount of sophisticated stuff. In each case you need a specialist. I think it was cheaper driving a Model T Ford than driving

a car with power steering, power brakes, etc. We don't really need it. It is for comfort. But you don't look here for comfort but for efficiency.

Mr. Akens:

Speaking of size, are we ever going to need all that land in Mississippi (MTF) for testing these things?

Dr. Rudolph:

This is a very controversial issue. I myself am a firm believer, unshakably, in captive testing and a thorough checkout and that is because the thing is so sophisticated and sensitive. You discover the human errors that way. The human errors we have is what we cannot solve. If you make it very sensitive, then the human error plays an even bigger role. If a mistake is made by an assembler, a solderer, a welder, or a fitter, that's a bad deal and the gal has a problem. We are all human beings. We have our problems and its shows up in the work. You even attempt to control all that. You can't, so you institute all kinds of checkpoints but they are so expensive and the checker can feel bad so get rid of that as far as you can. You can't completely, certainly not, but you eliminate human errors more and more and it should be built so crudely that a human error doesn't have any effect. Or not a serious effect. Did I make myself clear?

Mr. Akens:

Yes, you did. Along that line, from your experiences and your imagination, is there any reason why we couldn't test rockets right out here (MSFC) twice or three times as large as the Saturn V?

Dr. Rudolph:

This depends on the diameter. The thing here has 33 feet diameter. Say we go to 40. I don't know what it would fit.

Mr. Akens:

Oh, I see. We would have to enlarge the tower of the test stand.

Dr. Rudolph:

I don't know. Our philosophy has always been to giving off much of our tolerance so you can fit it in. But this doesn't work always, you know. I come back to what I said before. Making all of them sing from the same

sheet. This is especially difficult if you have interfaces. Interfaces are always a problem. Even if you fit two pieces of material together to weld it - if you don't fit it right it won't work. If you fit the ideas of people together, it is much more difficult because each one says his way is the only way to do it. The hardest part is getting these guys to agree. Speaking again of dimensions, the Saturn engines sit down in the launcher hole 25 feet I think.

Mr. Akens:

The engine sits down 25 feet in the hole.

Dr. Rudolph:

It starts rising. Therefore, it has 25 feet to go to get out of the hole (points to Saturn V model). I don't have the launch umbilical tower here or the launch umbilical tower platform. And there you have the so-called close-in equipment, that is the hold-down arms and the service masts. We swing away and there is only four inches of space. Why? Because the one equipment was designed by the vehicle designer and the other was designed primarily by the launch systems designer.

Mr. Akens:

So they weren't all singing from the same sheet.

Dr. Rudolph:

In launching 501, the thing could hit and also it would hit a tower and all these things I have gone through to determine what to do to be reasonably sure that it won't happen. Three days before the launch of 501 we had to take ropes to pull covers back. Simple ropes.

There are two categories of people I have dealt with as a manager. One category you only have to touch on the problem and if the guy has been with you long enough, he will catch on right away. And without long discussions. He knows what the problem is, he knows that this is what bothers me, and something needs to be done and if he says yes I'll do it, I didn't have to worry about it, and it would be done. These are the great guys. The guys who really can do what you had in mind and carry it through. They, in turn, of course, have to convey the message to others and it becomes more and more difficult the further down you go. The other category - they hear it and they have the best intention but they lack the capability to stay behind it and see that it is being done.

I think I was fortunate that most of the fellows who worked for me - my product managers, stage managers or hardware managers, and my functional managers - in the majority of the time would go and do it and I wouldn't have to check. In the minority I had to check. And this minority then takes most of your time. See how it looks - the perspective. You have had this experience, I'm sure, Dave. That wasn't easy to establish. It means the minority again. It means continuous consultation.

Mr. Akens:

Could you give us the names of some good contacts to get more information from?

Dr. Rudolph:

Bill Sneed. He's one of the guys that is just tremendous.

Mr. Christensen:

He also handles the documentation, liaison, etc.

Dr. Rudolph:

Let me tell you what I saw in him. Jewel Moody is another one. Sit down and discuss it with him, then says "okay, Jewel?" All right, we do it. Then he comes back at a certain time and says okay. I have initiated it. And when it is all through, it is finished. First of all, I talked about the hardware managers, or stage managers, or product managers which is the best generally accepted term. That is one category of managers. If you look at a usual organization chart, you call that the line even if you are in a program office. Then you have sort of a split post there - the staff. I made it clear to my fellows that they were not staff. They were for me as managers just as the hardware managers. You have the responsibility, and authority, and you manage. You function (like quality and reliability). And therefore my whole setup was a matrix. The horizontal cut - hardware, the vertical cut - the functions. Engineering goes across the board. Systems engineering is most important because it is the least understood. There is a lot of confusion through the whole world. And in other engineering functions, quality and reliability, testing -- it's an engineering function but you don't call it that because otherwise it gets more confusing and you can't handle it, manage it. It is too much for one guy. You break it up. Therefore, you have the verticals: systems engineering, testing, quality and reliability. Then, you take the whole stuff - the hardware - the functions, all managers - not staff - and put them in an envelope - that's program control. That is what is needed. This is my particular concept. Many, many people don't agree with that but it worked. That's the best answer you will find.

Mr. Christensen:

I was going to ask you if you had a unique management arrangement. Sounds like you did.

Dr. Rudolph:

That's it in a nutshell. Very, very much over-simplified. Not a staff who are advisors but managers. Each one is a manager and in the control center his name appears up there and also the subsystem manager. I don't address an anonymous office. I address a fellow, a man.

Mr. Akens:

Did you use this concept over at the Army also?

Dr. Rudolph:

I started it in August 1963. By the way, Jim Bramlet, who was there under Oswald Lange as the Saturn V manager, had the same concept. Jim Bramlet had been with me on the Pershing. Bill Sneed had been with me on the Pershing. So something rubs off and therefore we had no disagreements. Also, Jewel Moody was with me on the Pershing. He wasn't directly - how shall I say it - I didn't own him but he was assigned to me.

What is necessary - what really made the Saturn V program work while I was there was a certain set of documents and these are available.

Mr. Christensen:

Yes, this is what I'm particularly interested in on this trip - to go into the documentation base, analyze the documents and how they were used. I think this is very important.

Dr. Rudolph:

There was also a mutual understanding already back in 1958 through 1961 or so with these fellows. Howard Burns is another outstanding member in testing. Very, very competent. And, of course, there are many others which usually do not appear even in name somewhere, which are just as valuable. Therefore, if you can get them all to sing from the same sheet of music, well, fine. Now this is the management aspect I talk about. Now you have to interface this with the laboratories -- the strictly technical fellows -- and therefore I started struggling with that either in 1964 or 1965 to have also a matrix

that means all the ones involved. If I have a S-IC stage manager in my program office, who is his counterpart at a contractor in the same position? Then, it is broken down into subsystems. Who are the counterparts by name -- not just an anonymous office -- so I can call on these counterparts and say you are so and so. So this is the contractor and also in the laboratories we have another individual. Finally, after so many initial problems and struggles -- we have such a book. I don't have one with me - I don't need it anymore.

Mr. Christensen:

There is a people name book of counterparts in your office?

Dr. Rudolph:

Yes. You get it from Bill Sneed.

Mr. Christensen:

This would be very useful for later interview in each of these key areas.

Dr. Rudolph:

I also started out by establishing program directives which are really more policy papers or guidelines. I have this thing here, I think. Yes, I had a copy when I left but I broke it up in two books - one classified and one unclassified.

Mr. Christensen:

A complete index!

Mr. Akens:

Very good. Along this line covering the various things that took place, as you look back, were there really any crossroad moments in the program? I mean where a major decision had to be made and you were real pleased with the way it came out. In other words, what were the moments of decision? I know there were many moments of decision but were there any real great moments?

Dr. Rudolph:

Yes, there was one very major decision. Really outstanding. That was to switch from the earth orbit to the lunar orbit.

Mr. Akens:

Yes, I remember that.

Mr. Christensen:

It affected the whole program.

Dr. Rudolph:

Yes.

Mr. Akens:

There were some who afterwards were still for the earth orbital. You are strongly for the lunar orbit approach, right?

Dr. Rudolph:

I wouldn't say I was strongly for it. I did not have any inputs in that decision. This decision was made before I took over the program. Considering all the aspects and considering the time frame everywhere in the program, I think the decision was the right one. I was convinced. Maybe I convinced myself, you see, but I at least thought it was the right thing to do. Now in retrospect today I think it was. There is, however, one disadvantage and that is (interruption .....). The fundamentals for a space station sort of got pushed in the background.

Mr. Christensen:

You lost that steppingstone?

Dr. Rudolph:

Yes. So this was a disadvantage. I'm not really too sure whether it set us back now or not. I would have to do some thinking, and I don't want to go into that right now. I'm talking off the bat, you realize that?

Mr. Akens:

Yes. This is correct.

If you had had all the money you wanted to increase or speed up the program, how much more relatively speaking, I mean percentage wise, could you have used? Twice as much effectively?

Dr. Rudolph:

No!

Mr. Akens:

A half? Any more?

Dr. Rudolph:

No! At the time I got into the program, George Fuller also got on the program in Washington and there was not a lack of money. Not in 1963, 1964, 1965, 1966, or even 1967. The money crisis appeared only in 1968. By the way, the Saturn V money supported practically the whole center. We saved dollars, we even gave dollars back. Millions, $30 to $40 million in addition to that. By controlling - controlling is maybe not the right term - but by just knowing where the expenditures were, by reasonably good forecasting, and by displaying it. You know this is one of the major points - this Saturn V control center. This was really the key. It took a year to get it approved. Bill Sneed, Harold Price and Martin Sedlazek. Jim Bradford played a major role because I sent him to fight all the battles to get it (the control center). So we finally got it. And this showed now. And you know what's the use if I know it, and we want to do a project together, and you don't. And if I scribble my notes down and you scribble them down but he doesn't scribble them down and we don't discuss it.

Mr. Akens:

You have to communicate.

Dr. Rudolph:

Right. So show it to all of them and then they can sing from the same sheet. It comes back to this very fundamental thing.

Mr. Christensen:

Plus the impact of the visual story.

Dr. Rudolph:

Which helps. A picture is worth a million words.

Mr. Christensen:

I'm glad to hear that. In fact, I was going to ask if you would mention some of the techniques that could have advantage in the future. I think this control center should be one thing, I know of, that is a management tool.

Dr. Rudolph:

I'm afraid that I'm the only guy that is really convinced, and Bill Sneed.

Mr. Christensen:

One other area along that line would be configuration management. Do you think there are any techniques here that could be applied, for example, in some of our social analyses where you make a change here and it affects this and this?

Dr. Rudolph:

Sure. All these techniques - configuration management. That has been my experience - in the Army and NASA and Peenemunde - you never knew where you stood. To have the visibility of what happened. In complex systems, you need that. It is not any more like it was a hundred years ago where you knew everybody. Big organizations, many political issues, influence it. If you don't know all the facets or at least the major ones, and influences, you get stuck - because you are sidetracked - you don't know what is going on.

Mr. Akens:

Do you believe that many staff meetings are helpful?

Dr. Rudolph:

No.

Mr. Akens:

Not too helpful.

Dr. Rudolph:

If you hold a meeting where you have the necessary visual aids like your control center and use the display, then it is useful. And even very long ones are useful and mine are usually very long. There was a fellow in the

Army who threw little slips of paper out of a window and said "Help me, I'm in a Rudolph meeting." Therefore, I have fewer meetings but very intensive treatment of the issue.

Mr. Akens:

Back to one point we raised a while ago on the money. We had more money. You know in the Army we used overtime quite a bit. Here could we have used quite a bit more overtime and speeded up the Saturn program?

Dr. Rudolph:

Let me put it the following way. I think I know what you are driving at. I still have to say money was really not a problem. We had enough money to buy the facilities, tooling, material, to pay the contractors. Sure, the costs were high but at least we made progress and sudden mishaps which appeared like the explosion of the S-II T at Mississippi - a billion dollars in addition wouldn't have done a thing. It needs also time, and here again (I used that term before) a handful of guys always make the profound decisions, not a big mass. So you see you get yourself two additional guys maybe even as consultants and it is significant. Now, in the beginning of the program it was underfunded. Tremendously underfunded. As usual, the programs are underfunded. The guys who have to spend the money just don't like the high figures. I think that is most unfortunate. They kind of back into it instead of seeing the issue in the beginning and then really sticking with it. The first you get is not enough. Finally, they catch on. There's plenty of money and then in the end they try to take it away again because it didn't turn out exactly that way. Not realizing that it is all really research and development and not mass production.

Mr. Christensen:

It's all simultaneous.

Dr. Rudolph:

The money was a problem in the beginning. When I came on the program, the S-II stage - I don't exactly remember the dollars any more - had about $70 million a year and that was by far not sufficient. By far, underfunded. No wonder that we ran into all kinds of problems. There, more money earlier would have greatly helped. So I doubled it. I didn't even ask for it. I just took it off the big pot and shifted it. So here, the S-II stage was sorely underfunded.

Mr. Christensen:

That was part of the biggest technical problem that you had, wasn't it? The S-II stage as far as advancing the state-of-the-art?

Dr. Rudolph:

It was the most glamourous one if you want to use that term. There were others which didn't show up. Advancing technology it is true, yes. We also had tremendous problems in the so-called ESE equipment. It was actually as a problem worse than the S-II. It was worst because I think you had 28 different contractors. The Astrionics Laboratory ran the contracts while the Program Office stood by without any influence. So, as I said before, they didn't sing from the same sheet. So how to meld that together, that was a backbreaking task. Fortunately, I got Col. Murphy to help in the management of the task.

Mr. Akens:

Do you think we are doing the best way of contracting? Can you think of a better way?

Dr. Rudolph:

No. I think also that the incentive contract was a good move. Very few people will agree with that, but it is. Incentive contracting is very good. It sure gets the cost down. Under a cost plus fixed fee contract, the contractor does all kinds of goofs. You pay for it. He's always in the clear, and does nothing to earn the money. If you have an incentive contract and, of course, he gets more fee if he spends less dollars, this gives better performance whenever you have set up the parameters, that has paid off handsomely. No, you cannot do it right from the beginning. Again, there is a optimal point where you can start it and early in R&D would be dead wrong. The incentive contract has also an incentive for the government. Not to change. Very few changes or you pay. But it becomes more controlled and formalized. It becomes more visible. It doesn't take any flexibility away - none whatsoever. That is usually what is said - but it's not so. You change before, but right! It makes you do your homework - on the government side especially, and every inventor doesn't try to get his specialty, his pet issue in the system later.

Mr. Christensen:

One of the comments I heard from industry on a recent trip is this. They feel the government should have taken a little closer look at the capabilities of the different companies instead of having one rigid specification or approach - they should consider the fact that the various contractors have different ways of doing things. Do you agree with this? Getting back to the theme of advantages from using the same sheet, do you think there are also disadvantages?

Dr. Rudolph:

What do you want to talk about - at the beginning when the contract was established on the Saturn V?

Mr. Christensen:

Probably so. In other words, they had their own way of doing things and here's two companies with two different philosophies and here's NASA with a different philosophy coming in and writing the specifications early in the program. They feel that NASA probably should have leaned their specifications toward the individual companies instead of going jointly to both of them with the same set of specs.

Dr. Rudolph:

I disagree with that. Unfortunately, and I had nothing to do with the establishing of the contract - that was before me, that was Dr. Lange and he sure had a battle on his hands. Good man. Wow! What an assignment! It was worse than mine. You are caught in a dilemma because the policy is made upstairs - not here - it only appears that way. All the decisions were made upstairs. For instance, North American was picked upstairs, not here.

Mr. Christensen:

Political decisions.

Dr. Rudolph:

And probably for good reasons. I won't even argue about it. If we had had at that time an Apollo specification and a Saturn V specification, it certainly would have been much easier. We would not have had all the time delays and the technical problems we experienced.

Mr. Christensen:

At North American this is still a problem because they have one set of specifications from Houston on the spacecraft and here in the same company they are also working on the S-II from Huntsville specs. And the same man might be working on similar parts for both centers with two different specs.

Dr. Rudolph:

The type of specs I talk about here are in-process specs - not performance specs. To my mind (maybe I shouldn't say that here) ...

Mr. Akens:

In other words, just between us people.

Dr. Rudolph:

The fire could have been prevented. This goes down into the process spec area. It goes into such things as vendor surveys, strict quality control, selection of critical components. Very basic. Big companies say "we are much smarter than government guys. Government peons. If we do it, you can be assured that it's the best." This varies with the individual company. They think they are better than the other. This isn't so. There are variations, and what is good for one company is not necessarily good for the other. In the process spec area, there, our laboratories really wrote hot-shot over the contractors and they resented that deeply. And they complained and said "we control our vendors. You don't have to come and tell us that." Well, Houston had that concept. They left it all up to the prime contractor and what happened? The company hadn't even been there, not a single guy. They sent the purchaser there, yes. The purchaser doesn't know enough about quality and performance and the environments that the stuff has to live in to be able to even touch it.

Mr. Christensen:

These companies tell me now that the Air Force is coming back over to the NASA line of thinking as far as quality factors, etc. So, you may have influenced the Air Force.

Dr. Rudolph:

We had the Air Force inspectors doing the work for us and they must have seen the benefits. But even today, big name companies say that this is all much to much. They feel over-controlled and they want to do it and they don't even want to go to their vendors despite the Army experience. What

goes on in their head? Well, they have an _____ (garbled). "If it doesn't work, I get paid to make it work."

Mr. Christensen:

I think all this is true from my experience at Rocketdyne in the 1950's. In fact, I asked them while I was out there - why do you always start out with a complex design and come back later with a simple approach? It should be the other way. I think you are right. You hit the nail on the head. I came to that same conclusion ten years ago.

Dr. Rudolph:

These fellows don't realize that it finally backfires. Today, in the aerospace industry, they have hurt themselves.

Mr. Christensen:

Going back to the fire for just one quick moment, would you elaborate a little bit on the effect this had on the over-all Saturn schedule? I get the impression that the fire made the schedule a little more realistic because you were waiting on the spacecraft.

Dr. Rudolph:

I wouldn't say that. The launch vehicle was really ready in May 1967. Now the fire brought about the delay until November. It had, however, one benefit. It put emphasis on safety - flight safety, ground safety, checkout safety. And so suddenly, out of the blue sky you might say, came a requirement to check all elements for safety. There again, Jewel Moody did a grand job with the Cape. This was of benefit, undoubtedly. We found also a lot of shortcomings which might have not shown up and which could have shown up. For instance, we have now redundant, if I remember right, safety valves to introduce, which became a tremendous headache if the stuff didn't work in the vibration environment. Nothing had happened on the IB, but on the IB neither did a ASI line fail or a POGO problem crop up. It's just a different vehicle and this by the way shows what happens. You can't simply upscale an engine and make it bigger. You have to test again and almost start with a completely new program in quality. That's the odd thing. You start inventing the wheel again. Amazing - what a waste of money and time and there are no handbooks about that. On every program you start all over again. It's really funny. A guy at the next desk, he has it all there - why is that? I think one of the explanations is that the thing smacks of dictatorship and such things and, of course, that you don't even want to think about.

Even so, the whole thing has its good points. The discipline, formalization - without killing inventiveness and the progress, but it isn't hard. It sure is not. How far to go? How far to refuse?

Mr. Akens:

For the first Saturn V flight, I believe that the newspapers quoted you about your confidence. How confident were you?

Dr. Rudolph:

I said I was confident.

Mr. Akens:

Were you 90% sure?

Dr. Rudolph:

I didn't use any figure but you can even dig out what I said.

Mr. Akens:

We'll find that. That's all right. I just wondered if you used a percentage.

Dr. Rudolph:

No. If you have the first vehicle, you cannot use numbers. You shouldn't use numbers. I was very confident. I had a guts feeling it would work and it did. I also had a guts feeling on the second one that something was wrong.

Mr. Christensen:

I can only ask how do you feel about the next one?

Dr. Rudolph:

It will work. Strangely, I have a guts feeling not only on this issue but also on many other issues which are elusive. So you hear a hundred engineers, or a hundred accountants, or a hundred per cent. What do I get out of it? An impression - nothing more...(tape ended) .....

END