Tape #1, Side 1
Interview with Urlaub:

RB - A brief introduction about your background in engineering, just to crank it up, before you came on board NASA.

Urlaub - I graduated from Duke U. in 1948, B.S. in Mechanical Engineering and my first job after graduation was with Ranger Aircraft Engines as a design analyst for about two years, and then I had about another year with the ~~then~~ old Glen L. Martin Co. as a structural test engineer. Then I joined the army in the enlisted status for about a year and volunteered for a direct officer assignment with another three-year hitch and part of that was to go to a guided missile school. I didn't know too much about it at that time, but it sounded like a pretty good thing to do. Then they shipped me off to a place called Redstone Arsenal in some place in Alabama which I couldn't find on the map in those days, called Huntsville. This was a Provisional Ordnance Officer's Guided Missile School. Since that time it has grown into a tremendous complex. I was through Class #3. At that time they started a new class each month which lasted about a year.

Urlaub - I learned a lot from that. Then graduating from that the army saw fit to send me out to Los Angeles to represent them in guided missile work with local contractors in the L.A. area on Nike, Corporal, dealing with jet propulsion laboratories, Firestone, Douglas. I spent a good 2½ years there--very interesting work learning how to deal with contractors and how to represent the interests of a group of people a couple of thousand miles away.

RB - Was this mostly with electronics or with guidance or with propulsion or with structures or what?

Urlaub - It could be anything to do with propulsion to guidance. As a resident office you're representing the interests of your mission arsenal which is what this place was in the army days. To the contractors you work within the framework of the scope of work of the contract, you intrepret the language of the contract--what we really mean by this, ____________ changes if it's within our perogative to do so, refer them back to home base if it's too complicated. It isn't that you have to be a specialist in any one field, but you've got to be a specialist in identifying whether you are dealing with a very complicated problem or a simple one. The idea is to know when to bring people out on such a long trip that required their special attention, or whether you are dealing with something that can be solved on the spot. Sometimes schedules will be a very important factor in determining whether you have to deal with this thing in a matter of two days and over the phone, or whether you can afford to take the time to set up a committee and give it a good technical treatment. I thought that was very interesting.

Urlaub - After that I came back here for just a few months and then they decided it would be a good idea if this guy, Urlaub, had a resident office of his own up in Detroit. So they sent me up to Detroit to represent the army to Chrysler Corp which was then making the Redstones. And at that point in time the Redstones were going out of their R & D phase and into the operational phase.

RB - Now you were working, von Braun was head of the engineering directorate or something at that time?

Urlaub: Yes, this was now in the ABMA days where Gen. Medaris had just come in. Well, he wasn't on the scene yet. It was von Braun at that time. He came on the scene about two years later. So I was involved in a resident office capacity for about 2½ years in Detroit with Chrysler. During that time we got with the Redstones in the operational phase and also the initial design phases of Jupiter. The Jupiter series was getting started then. To us at that time, jumping from a Redstone to a Jupiter was like jumping from a Saturn 1D to a Saturn V--a tremendous difference. And a lot of similar work was done on the West Coast, but I had my own office, my own staff. In that respect I found the work very interesting.

Urlaub:- After about 2½ years I came back here and joined the Jupiter program office...

RB - You had a military commission at this time?

Urlaub - No, I was out of the army then when I came back to the, from the West Coast.

RB - And you were at commissioned officer at the West Coast?

Urlaub - Yes, 1st Lt. Then when I was discharged from the army I decided to stay in the civil service capacity, came back to the home base they assigned me to the program office with Redstone and sent me up to Chrysler. That was in 1955 and came back down here about '57. Now about that time 1957-58 Gen. Medaris joined us, the ABMA was deeply involved in transferring the Jupiter program to the air force, and then shortly after that NASA was formed. I'm trying to remember the dates, but I just don't have a good memory. I stayed on with ABMA for a year after NASA was formed, closed out the Jupiter program in the sense that we transferred it to the air force and they in turn deployed them overseas. It was a very interesting assignment in that it involved some overseas travel and actual operational problems in Turkey and Italy in

getting these things set up. So that was a year well spent. When I joined NASA I joined as the S-IC project manager at that time. The S-IC was not called that, it was called S-IB which was a conflict with a previous vehicle called S-IB and here I was dealing with a stage called IB. We had a change that was confusing, but the IB or prototype IC was a four-engine job that had been competitively bid, Boeing had won the bid before I came on the scene. And I think that a week after the announcement was made that Boeing had won that bid and was to be the prime contractor on the first stage of the Saturn V I joined over here under Dr. ________________ and became instrumental in the IC.
Rudolph (?)

RB - This is precisely the area that I need some help on. The thing that really strikes the historian going through this thing is the close relationship that Marshall had with Boeing, much more close than anybody else.

Urlaub - Yes, I agree.

RB - Now what was the rationale? Why did they go this route? /Urlaub - Well, first of all, there was a tremendous amount of work in house in preparing in proposals for bid. The bids themselves were very well defined. We knew the diameter of the thing, the shape of the thing. We had a configuration that was well advanced in the sense of descriptive material on paper.

RB - Was this more so than the S-II for example or even the S-IV ___________ Why was the S-IC so much more thought out then?

Urlaub - I think because the S-IC was a more natural derivative from Redstone and Jupiter. It was ~~number 1~~ RP-1, LOX kerosene. We were dealing with the old propellants as opposed to hydrogen and oxygen where Marshall Space Flight Center and our propulsion people had an expertise going back many years.

RB - But the LH2 was mostly at ______________ at that time.

Urlaub - Yes. The other thing was we had well along as a research project the development of the F-1 engine. It didn't start when we started building the IC. It had already gone through static firing.

RB - Since 1958 they started really cutting metal and stuff on it.

Urlaub - Yes, and we had under the design control at Marshall with Rocketdyne a going hardware program with the F-1 engine. So it was a more natural thing for us to do to be more detailed in the design description of the IBIC--it's not yet IC--in putting out that bid. Now, to get to your question then, Boeing was a new contractor to us. Boeing did not have previous large space vehicle experience. And they recognized this. Douglas had experience on ~~this~~ S-IV which was now could be applied to IVB.

RB - North American had been working on Navahoe and stuff like that.

Urlaub - I forget the names, but they were already in the hydrogen field. And then the S-II, which was the brand new element in the whole Saturn ________ stack, could draw on the experience of IVB--at least that, for instance, the engines were the same. IVB has one engine, S-II has five of them but they are the same ones. And so there was a link with history through IVB. But the only link with history on the IC was through Marshall into the Jupiter Redstone series. So, we were intimately involved in the design definition of the IB or first stage of Saturn V.

RB - So it was largely a factor, if I can summarize here, that the engines were already getting into the hardware stage, at least in the testing stage, and the engines being linked so closely with the stage and LOX RP combinations it was more natural for Marshall to go into this. Did they also go into it slightly because they wanted to accumulate more expertise in the dynamics of these exceptionally large diameter stages? Was that part of it too?

Urlaub - I don't think so, at least that doesn't ring any bell with me. If I might be more practical at the moment, one thing that may have influenced it, in my own opinion, is that both S-II and S-IVB were West Coast contractors far removed from this place called Huntsville, Ala. It was very difficult to communicate with and get to. We, more or less, let S-II and S-IVB be the complete design responsibility of the contractors with very light involvement in day to day affairs in design development, heavy involvement when there was a problem. But IC was designated for Michoud ____________ miles away, ____________ a government facility which was then under our organizational control, Michoud was an extended arm of Marshall Space Flight Center, but we had our own civil service people, administrative ______________. And we felt a closer relationship, a closer sense of responsibility with the first stage than we did with the others. I think, at least that's my personal opinion, and had an influence as to why we went in a little deeper in IC than the others.

Urlaub - Now the other thing, and this again is a personal opinion. We had a contractor who won a very difficult bid Boeing who had not had experience in large liquid propulsion stages, and who was used to, in past assignments working with the Air Force with a set of flight requirements, ______________ document and go. Saying "Don't bother me until a year later I'll show you the prototype." And we felt rather strongly that that mode of operation had changed so perhaps we overdid it. We said, "Boeing, you're not going to go to Michoud, and you're not going to stay in Seattle. You're going to come here first. And after they got over the shock, "Yes sir, how many and when do you want?" "Well, about 500. Let's have them tomorrow." They came in two weeks later.

RB - And that was the story around the old HIC Hick Building, right?

UrLaub - That was the HIC Hick Building. We had to find a place for them.

RB - And the Huntsville Industrial Expansion Committee, or whatever it was, they were the ones that did the HIC Hick Building or did the government get in there and do it.

Urlaub - No, no, Boeing did that. Boeing was, as I recall it, leased that building for a specified period of time ~~under~~ on the condition that it would be up to their standards by the tenant. And so the financial arrangement was through Boeing. They set up the requirements for office layout, how they wanted it, how many people. They worked with the construction and modification contractor on that. Now, how they found that building, what other buildings were available at the time, I don't know. We said, "Boeing, we can't put you all here on the arsenal. There's not enough space. You'll have to find space in Huntsville. And so go to it and the sooner the better." And they did.

Urlaub - Theirengineering talent was integrated right into our labs. We had a couple hundred design engineers.

RB - As I remember ~~at least~~ one figure there were ~~about~~ at least 400 people out here at one time working on site.

Urlaub - Yes, right on site in the labs, on drafting boards or with their slide rules working hand in hand with the, then, present people who knew the most about the stage. There was another reason for bringing Boeing to Huntsville. And that is that in dealing with the manufacturing aspects of the S-IC we, I mean Civil Service--Government, decided that the first ~~stages~~ prototype stages would be built here on base, assembled. That was the static firing bird--we called it the T-Bird. And we would build, the original plan called for the first three flight birds to be built here.

RB - I'm glad you mentioned that because that changed . . .

Urlaub - That changed subsequently. The reason for that was two-fold. No. 1, tooling was an unknown to us. This large, welding assembly pipe tooling was something that we wanted to prototype first before we went into to what we called hard tooling for production. And the way to work out the bugs in tooling is to build a set of what we call "soft tools", tools which could be changeable. And then once the bugs had been worked out of them then you build your production tooling which would automatically go to Michoud.. Parallel to this thinking, Michoud was in horrible state. It was an old tank factory. It had substructures on the ceiling that interfered with the 33-foot diameter clearances, cranes were located wrong, floor loadings were wrong. And a major modification effort had to be gone on over there which took at least a year and a half to two years. That vertical assembly building at Michoud had to be built. That was brand new. And when you go to Michoud you have to go down below ground as far as you go up just for the pilings. That stuff is all soft. Everything is built on pilings. There is no bedrock at Michoud. It was a long, hard process which at many times irritated Dr. Rees. He would go down to Michoud and he would look at the progress and he says, "My God, here we want to get to the Moon and you can't even put air conditioning in." And he really pushed us.

Urlaub - But, here we had a schedule to meet, the problems of prototype production to deal with. So it was a natural to do the assembly work up here. Now, that doesn't mean the details were, this means putting the whole thing together. Boeing was responsible for procuring components, building the tooling soft and hard. That's where Wichita got into the act.

RB - After you got the prototype more or less ironed out here then the drawings and specifications went to Boeing at Wichita and they built the hard tooling.

Urlaub - They built the soft tooling, too.

RB - Then they sent it down here and it was tested out and then the final specs for the hard tooling was let back there. Did it all go down to Michoud or some of it come here then.

Urlaub - Some of the soft tooling went to Michoud after we were done with it. We have to be careful with terminology. I use the terms soft tooling and hard tooling to distinguish between a prototype tooling phase and a production tooling phase. As it turned out, if you were to look at a particular tool, and ask yourself is that soft tool or hard tool, they looked the same. It turned out that way. There weren't as many problems as anticipated in going from prototype operational phase to a production phase. And I have to also give Wichita a lot of credit. Their tools were really beautiful. They took great pains in putting these jigs fixtures together, well thought out, documentation control on these things was as deep and as accurate as on a flight vehicle. We used Class I documentation control.

RB - Were they the ones that came up with the heat treat forming fixtures? Or was that a Marshall thing?

Urlaub - Yes, they--where the idea originated was here along with another group of ideas that didn't materialize. We were looking at, for instances, explosive forming at the same time. And then we were looking into bulge forming, which is what you referenced, where you use pressures to form it. And all of these were done under contracts out of our old Mechanical & Engineering Lab and some of those contracts weren't with Boeing. I think Weinglass was involved in one of them. I'm sketchy on that. But the concept was originated here. But applying that concept to S-IC and building the tool finally evolved out of that effort. That was done in Wichita and the tool was at Wichita. The forming of the gore segments was a job that was finally done at Wichita. The welding of each segment was done first here at Marshall and then ________________. That was built by Wichita.

RB - Is that thing that ~~Schwinn-Palmer~~ schwinghamer developed really a significant thing?

Urlaub - No, his magnetic hammer? Yeah, we used that in reshaping, if you will, the slight imperfections that came out of the assembled bulkheads. Its a magnetic hammer which shocks the material, gives it an energy shock in a very controllable manner. Boeing developed a portable, hand held magnetic hammer where you could take a bulge in thin metal which was very difficult to eliminate, place this thing right over it, and by turning certain dials on how much magnetic energy you want to sock this thing with--just flatten that thing out nice and smooth.

RB - The thing that intrigued me about it, and what I've got to try to explain in the history is that to the reader it may seem like a fairly small thing. So you've got a small bulge in the gore segment. As I recall, it was mostly for gore segments that they used it with especially around the fittings for the LOX lines. And I guess the answer to why one of the reasons it is so significant is that each one of those gores must have been fantastically expensive. And if you lost one of the gores--what would it be, several hundred thousand dollars to go back and get the material and go through the whole manufacturing process.

Urlaub - Each gore was chemically milled on the inside starting with about 1/4 inch thickness and then milling out to about 1/8 in areas to get rid of the weight.

RB - Did they continue with the chemical milling all the way through?

Urlaub - All of them had that except the T-Bird, the static firing bird, which was our first one we built. That had unmilled segments since it was a non-flight bird. And it had to be a stronger bulkhead to withstand the increased pressures in the tank that were needed to simulate the lack of the gravity acceleration on the suction. ________________.

RB - Getting back to the basic design aspect of it, can you say how much input into the basic S-IC ~~quantity~~ design Boeing made as opposed to Marshall? Was it primarily a Marshall design or primarily a Boeing design?

Urlaub - We had a phase there that we called "We're going to pass the baton," and when you talk in preliminary concepts, that is, what's the diameter, what's the length, what's the factors of safety, the pressure requirements, the general layout. That's all Marshall. Now when you talk about converting an idea to a producible item in terms of detailed drawings that you can contract on and specifications that you can contract on and assembly techniques that are repeatable and give repeatable results as opposed to one-time prototypes that was all Boeing. They did a tremendous job in an area where they had the expertise and we didn't. You get into building airplanes and the whole process of drawing generation breakdowns controlled quality, two loadings and how you make all the parts come together in a repeatable fashion one with the other, Boeing's got that expertise. We don't have that. Our expertise is in the R & D field and in initial prototype field. We can go in and solve a problem by putting a lot of people who have the technical expertise to do it, but once it's done we walk away from it into something else. But not production.

RB - What was the--can you explain the logic of going to separate tanks using common bulkheads?

Urlaub - That was a design decision which was very early in the game, and the trade-off was this. In the S-IC it turns out that you have to save about 14 lbs. in dead weight in order to gain one lb. in payload because it's the first stage. Here, on the S-IC, weight is not as critical a factor as it is in the upper stages where, for instance, the second stage I think the trade-off is four or five to one lb. And of course the IVB was one to one and the IU was one to one. So you don't gain much by having weight savings on the IC compared to the rest of the stack. Therefore we could afford to go to the simpler manufacturing method of double bulkheads, separable bulkheads. The common bulkhead was strictly an effort to save weight by combining a single bulkhead to separate ______ and hydrogen, whereas on the IC it wasn't necessary.

RB - There is another question I wanted to get in there too...

(end of Tape #1, Side 1)

Interview with Urlaub:

RB - ____________________. This is the ullage for the fuel tank. And those helium bottles up there, was that liquid helium stored in there or gaseous?

Urlaub - No, that was gaseous.

RB - OK, I'm confused then, they still had to run it through heat exchangers mounted on the engine someplace. Why did they have to do that, expand it even more?

Urlaub - I think I told you wrong, wait a minute, you're right it is liquid helium inside. You're talking about the four tanks that are clustered together inside the LOX.

RB - They're up there in the LOX ___________

Urlaub - Yes, that is liquid helium. And then they are routed manifolded on down to the engines, they are heat exchange converted to gas and routed back up again. The reason they are inside the tank is for the LOX environment to __________________. I was thinking about another system, you're right.

RB - There's something else, too, as long as we're on that. Apparently, and it doesn't seem to follow__________, but under cryogenic conditions quite often aluminum strength is actually increased or something like that. Can you enlighten me a little bit on that?

Urlaub - I don't know whether I can enlighten you on that. We used, throughout the stage, this 2219. It was not selected for any increase in strength characteristics under cryogenic temperatures. It was selected for weldability and still have ~~and still have~~ the proper strength characteristics and still be welded. You might be correct, that under cryogenic temperatures, the material increases in strength; but I don't believe that was factored into the design loads in the 1.4 safety factor. I don't recall ever being in conversation where it was necessary to have that increased strength in order to meet a 1.4 safety factor.

RB - On some of these things that I come across I'm vague about. I really don't know. OK, there's another specific question maybe you can help me with. This one I had written down here. We talked about the original 4-engine __________ SIC, and the reasons why and when it came up to five. Now, of course everybody's got his own version of this, I guess. In some of the notes and interview notes I had Milt Rosen said, "I was right in there punching for 5 and Mitch____ came out of one of his Headquarters Committee things," He's even got a date on it 6 Nov 1961, and I've seen that document and it does, more or less, put its blessing on 5 engines, but was that really where it occurred?

Urlaub - Well, as I remember the conversation or deliberations on this point, when we were in the 4-engine configuration, that which we bid on, we weren't considering performing the mission by putting two Saturn Vs in Earth orbit in assemblying the command module, service module, and I think final propulsion stage for escape velocity doing all that in Earth orbit and then going on to the Moon from an Earth parking orbit. Now with four engines you did not have any other option. You didn't have the option to go direct to the Moon and do your lunar orbit maneuvers where you separate and part of you stays in ~~orbit~~ lunar orbit, and the lunar module goes down to the Moon and then back up and rendezvous. You didn't have that option with the four. You have that option with the five and also the advantage that you do it with one vehicle.

Urlaub - So the trades were, do you want to trade the safety of an Earth orbit assembly operation where the men are in view, they have options to return to Earth if things don't go right. But it's more costly, you need two vehicles to do it, high launch rate. That set a trade vs. the trade of one launch, simplified operations on the ground for one launch, and then assume the added risks of separation and rendezvous in a lunar orbit where the men don't have the option to return safely to Earth if something goes wrong. That's always a very tricky maneuver and it happens behind the Moon where we're out of transmission with them. They have to fire the service propulsion module in order to go into a lunar trajectory for landing. And when they fire to come home they have to fire the service propulsion module behind the moon. It's strictly an astronaut function. There is no protection of the control center monitoring their operations, making sure they're going through their check list correctly. It's strictly up to them. They are on their own. If they don't make it it's their own fault.

Urlaub - It's those kind of trades that were deliberated and the decision was finally, yes, we'll go to five engines. We'll have the vehicle that has the capability to go directly to the Moon with everything on board that's necessary to perform the mission. One of the things that I think swayed that decision, which came out a little later in the deliberating process was this concept of free return, where if something goes wrong during powered flight or in what we call the translunar trajectory, as happened on Apollo 13. They exploded something in the service module. They have a free ride home. That is, if they do nothing the trajectory is such that she goes around the Moon and comes back in to a direction toward Earth and in that return trajectory they do have to do some correction to bring it back in.

Urlaub - But that free return, I think, was the thing that helped make the decision to go to a single launch capability which required five engines.

RB - But the LOR mode really wasn't finalized, as I recall, until the spring of 1962. So even before then you're thinking about...

Urlaub - Oh, yes, all I'm saying is that with a four-engine vehicle you didn't have options. You had to do it in Earth orbit.

RB - OK, he could do it either way then...

Urlaub - With five engines you can still do it in ________________. But five engines gave you that other option that you could look into, which was the ~~operation~~ option of separation and rendezvous in lunar orbit rather than earth orbit.

RB - Is there any credence to the assumption that Headquarters was kind of urging Marshall more strongly than Marshall wanted to go with five engines.

Urlaub - I can't answer, I don't know. I couldn't detect somebody having made up their mind and trying to force their will on others at that point. I think that was rather a joint thing. Where there was a very definite pattern of forcing Marshall into doing something against its will is on the question of when is the first manned flight and the all up concept. Now there we had very strong feelings. We wanted an active IC ____ and then gradually build up the stacks for an R & D program of ten vehicles before you man it. And we were, I would say, very strongly convinced against our will--George Miller's office. He's the all up concepter.

RB - Back to the five engines. If I recall correctly, too, there were some technical considerations involved in terms of the possible accumulation of gases in the gap for the fifth engine finally went, and that sticking another engine in there would help relieve some of those back gases and eliminate some problems there.

Urlaub - That was a technical concern, but not a driver in the decision-making process. The four-engine concept, all engines were gimballed in a square pattern. With the five engine all four outboards are gimballed and the center one is fixed--no gimballing capability. Our SIB vehicle has eight engines, but arranged in a square center pattern.

RB - One square is kind of offset against the other.

Urlaub - One square is offset, you look at the internal diamond, those are fixed engines, four of them in a center cluster, and then the outer four are gimballed. We had a lot of experience in the pressure base regions between the engines from IB which told us that if you did not have that center engine, a thrusting center engine, you would have a problem on base heat shield pressure in that __________

RB - Now why...

Urlaub - But that wasn't an unsolvable technical problem. It was a region where we didn't have any experience and would require additional testing, but it wasn't a ___________

RB - In looking at it, though, why wouldn't you put one in there in the first place. Would the argument against that be, perhaps, well that means we've got to produce that many more engines and go through that much more testing and add so much more cost to the program.

Urlaub - No, it was a question of control authority. You needed four engines to give you the control authority for an unstable vehicle, which is what the Saturn V is. In other words, it doesn't go in the direction you want unless those engines have gimballing capability. Your center of gravity is ahead of the center of pressure--your center of pressure is ahead of the center of gravity, that's the way it is. And so the vehicle is not like an arrow that wants to aerodynamically stabilize itself in the direction it's going. You had to have four engines, all gimballed. You couldn't put three on the outside and one fixed in the center. And, the, I forget whether, it's not roll, it's pitch that we were worried about.

RB - OK, going back to the relationship between Boeing and Marshall...

Urlaub - Oh, there was another thing too, there was engine out capability _________ ____

RB - The Boeing-Marshall relationship ____________ here. Were there any real problems that you recall between Boeing and Marshall that had to be ironed out--either technical or managerial or anything? Again, I'm thinking about the readers, a lot of this stuff is just going to be one success after another and they're going to say, "It didn't always happen that way. There must have been some glitches." What happened and how did you work them out?

Urlaub - Whenever you get two large organizations that haven't worked with each other before, thrown in the same room, you've got some adjustments to make. Whether I can classify them as real problems, no, I think I'd classify them as growing pains. As I mentioned earlier, Boeing had been used to working with Air Force contracts where they were very much on their own. They had to learn how to deal with Marshall and work with Marshall which they had never done before. And we were, in those days, a pretty proud organization too. We felt we knew what we were doing, and this guy over here called Boeing, who had never been in the missile field before can't come in here and tell us what to do. We had that attitude. ____ some design perogative there. And Boeing also had a very strong sense of accomplishment up to that point, and they knew that they had built large airplanes before, and this vehicle isn't that much different. In fact they priced it on the basis of so many pounds, so many dollars per pound from aircraft experience. And it was a matter of getting these two to work together. And there were some adjustments to make, getting the peckin order right, and it isn't always in favor of Marshall. It's in favor of the guy who knows most about the program. And we had some pretty, what I'd call, low-levelpeople here at Marshall who knew so much about their area that they were at the top of that peckin order in that particular field. There were others at Boeing. As a generalization, Boeing was outstanding when it came to applying cost effective principles to production setups--taking this thing from the paper stage, a bunch of drawings, and actually converting it to hardware. Our strong point was getting it down on paper, getting the concepts right.

Urlaub - I don't know where else we had a problem.

RB - The SIC seems to have sailed through reasonably well compared to the SII, which I guess stands out. There really weren't any terribly serious problems, that I remember, with the SIVB, but the SII really had a lot of difficulties.

Urlaub - The SII was a brand new stage. You can say SIC was brand new too, but as a matter of the designs that went into it, it was not new to us. It was still LOX kerosene. It was larger engines, but we had experience on those engines. The diameters were larger, but it was still a large Jupiter to us, the separable bulkheads as opposed to the common bulkhead. Thrust structures that were, in design principles, an outgrowth of previous vehicles. Then, too, there was a lot of Marshall conservatism built right into the basic design that you just couldn't get away from. The system had at least two or three redundant backup systems in the sensitive areas. We were not weight sensitive in the sense that SII and SIVB must be. We didn't have this one-to-one ratio that IVB has-- 14 to 1. We could afford to be a little bit more conservative on the IC. And that was really built in. We took advantage of that.

RB - There's another question I'd like to ask of a very general nature. Some historians, in analyzing previous engineering feats of great magnitude, something like the Saturn V, sy the construction of the Panama Canal, or the construction of the Erie Canal back in the 1820s. They have gone back and look at this and said, "Out of these massive projects a kind of style of engineering evolved." Do you see a different style? Can you characterize a kind of style that evolved out of the Nasa __________ of the Saturn program?

Urlaub - Yes, I can see a style that evolved. It wasn't there in the beginning. I think maybe it's one of the lessons learned out of Apollo. Let's go into the operation or production phase where essentially Marshall was out of it as the leader of the design. We had, what I like to refer to, as a check and balance system, that gradually evolved, that said, "Regardless of where the idea originates for change, improvements, or some shortcoming that hasn't been given proper attention, if it originates, for instance, with a contractor then we at Marshall played the role of the check and balance." There was a separable uninvolved group of people who could look at that proposed change objectively. If the change originated here at Marshall the contractor played that role believe it or not. And he objectively looked at it from a different point of view. And this check and balance system, when it operated as most effective manner, to me characterizes the engineering involvement with Saturn more than anything else.

RB - There's another question that kind of bothers me personally, I guess, maybe because I've almost become identified emotionally with the Saturn project __________ with Marshall to it, and that is that it seems to me what you're talking about is very closely related to the old arsenal concept. You've got a strong in-house capability. Is that correct?

Urlaub - Yes.

RB - And I've heard disparaging comments made about this at Houston and also at Headquarters, especially Headquarters talked about the tinsmiths down at Marshall. And that in ~~ways~~ some ways they are trying to phase out this arsenal concept. Do you want to react to that?

Urlaub - From my own experience, I react very negatively. Let me put the argument as I understand it from them. They say, gee, we'll never put together another large program the way we did on Apollo because it's too expensive. Money was no object on Apollo, therefore we could afford all these things. On the other hand, from what I have seen of programs which are driven by cost, where cost becomes more important than doing the job right from the beginning, those costs go sky high. If you keep your mind on what is truly essential you have to come up with the concept that you do the best you can from a technical point of view, from a design point of view and let the costs be secondary to that.

RB - Because the costs will follow.

Urlaub - The costs will follow. And sometimes it's a pretty bitter pill to throw in 20 million bucks for a reliability program, in the beginning of your program, which we had to do. But it paid off in the end in that we had all our components reliability tested before the first flight. Now, if we didn't do that we would have saved 20 million bucks, on one hand. But I don't know what the cost would have been if we'd lost the vehicle. I can't prove it. All I know is that it worked. And I don't know of a better substitute.

RB - One of the incredible things that strikes me is the way that all of the Saturns performed, the I, the IB and the Saturn V. There were no major glitches in any of the launches.

Urlaub - We had a very heavy ground test program, very costly, we had a static firing vehicle, we had a dynamic testing vehicle, we had a facilities vehicle all of which didn't fly. We had structural test components which we tested on the ground, we had a flight simulation. I'm talking about the bread board now, where our taped programs, for the flight program were run and rerun and all sorts of possible anomalies were introduced to see what would happen and we guarded against it. Heavy ground involvement before the first flight. Very costly, but that's what you have to pay for a good flight program. Otherwise you learn your lessons in flight.

RB - There is no comparison then to the kind of test program and quality reliability approached in terms of the shuttle vehicle?

Urlaub - I can't see a comparison. I see that, but I don't know how much ~~of this~~ I want this to be quoted because Im getting now into maye some things I shouldn't be...

RB - I don't need to quote it really.

Urlaub - I'm seriously concerned, for that reason. The shuttle is being driven by costs, not total program cost but yearly cost. You've got a budget for this year. If you don't meet that budget then we budget for next year gross. And there's that ________________________. It continually gets larger and larger. As you roll it on out to the end you're going to have to look at that thing and wonder, my golly there must have been a better way. Front end load the program, get a heavy ground test program. You need it on a thing like that, otherwise you're going to pay for it in flight.

RB - If the first one goes up and its gone, that's a big hitch in the program. Before we cut off at the last here, how do you view von Braun in terms of, you've known him for a long time obviously. You've worked with him for years and years. Can you make any generalizations as von Braun as a managerial spy on the von Braun team?

Urlaub - He was great.

RB - What made him so successful?

Urlaub - Well, he had a particular capability of converting the highly technical language that you have to deal in to the common, ordinary, every-day layman's type of understanding. I could sit in a meeting with him, a hundred people ________________. There would be a presentation there by some highly skilled representative from the lab. He would go on for thirty minutes. He'd lost me in the first five and I'd think, well maybe I'll study my notes. And von Braun wouldn't say a word. He would sit there and let him go for thirty minutes, and then right after that he'd say, "Well, now let me tell you what I think you said." And in five minutes he had it, he explained it to everybody else in the room that I could understand. That's a skill that not many people have. The other thing that I think von Braun had, was his own personal involvment was always five to ten years ahead of us. He was out looking, where is the direction of the space effort going. Where should it be going? Are we doing today the necessary things to prepare us for things that are going to happen 10 years from now? In the way of getting small study programs going. The F-1 engine. We didn't know about going to the Moon, yet we had an F-1 engine going, a million and a half pound thrust engine going on a previous program which was a tremendous jump.

RB - That brings to mind, when they were first talking about the Juno V and then I think became the Saturn I, do you remember anything about who came up with the idea of clustering the engines and tanks together--anything about the origins of that idea?

Urlaub - I don't know who came up with the idea. I know part of the concept and why it isn't clustered one on IB. And it turns out that the center element of the cluster has the diameter of the Jupiter vehicle. And the outer cluster has the diameter of the Redstone. So the idea was to take maximum advantage of the tooling and the fabrication techniques associated with Jupiter and Redstone in cluster with IB.

RB - As I remember now, Bostwick made a _________ a bargain-basement booster or something like that. Although ARPA came through with the funds they had fairly constrained funds as I recall.

Urlaub - Very constraining and we had additional tankage left over from Redstone. And all of the tooling could be adapted. All you had to do was put a spider beam on top and a spider beam on the bottom _________________. Then you didn't have to worry about such things as I think the Thor program was running into where their tankages were so marginal they had to be kept under pressure to keep from crumbling.

RB - Or Atlas, which was even more_________

(end of Tape #1, Side 2)