MRAZEK

(No Introduction)

" . . . project of the NASA special monograph and your working on a contract Universety of Alabama, Huntsville. So if you would maybe we could just begin summarize briefly your personal experience in the Saturn program and then mayber we could talk a little bit more about your role in the manufacturing indolent and some of the contractual devleopments that occured and some of the relationships with contractors."

"Well actually,I was very much involved in the beginning of the Saturn I even at the first clustered test item you know. It was '57,'58, where we got the first ten, twelve million for ∅ a demonstration of a clusterd enginefire. And well we had to take half of the money and get some engines, we were awahe that the S3D engine , we had the time which was used for the Jupiter, it's just unsuitable for clustering. "

"Could you explain why?"

"Simply it had a special thrust frame, the thrust frame had a three legs times eight are 24 hard points of the engine to the vehicle,plus all the suction lines and so on it would be really a nightmare, So what we first tried to do was get the ingine in the shape thatit's easier to cluster them, . And actually we suceeded by having only one attached point on the i engine/ to the thrust frame or to the vehicle or to the vehicle itself. Of course we had additional four (for) engine de- activator hot points. In the other case the activator haot points would have been in the thrust frame. But the total problem was somehow simpified by having the engine re-packaged. And we wereable to do the repackaging job ~~of~~ of the engine because somewhat was already done in advance

We had a program running, which looked at a simplification or a reduction of the componentsto an engine, and they came out with a simplified engine ."

"Is that the WEEP program? Is that what I'm thinking of?"

"Which one?"

"WEEP?"

"No, I don't know , I'm not aware of that. It was a S3D-X engine or something like that. So we choose the components and we were very successful of course. And we spent about half of our twelve million dollars to order some engines. And we had to practically steal our own programs including retired hardware, portions of exceptable usable usable hardware to manufacture the SHI engines . And the residual we the other 6 million dollars was supposed to have served us for the vehicle, that means for the container, and for the testsand modification. We really had a really hard time you know, to get along with half the money to establish tanks., and at that time we looked we of course looked in all possible solutions to save money. And the only way to save money was use tooling we had and withe that tooling we had we were able to fabricate 105 inch and 70 inch diameter tanks. And with those avaliable tooling we saved money and produced some tankage that was enabled us to demonstrate the firing on the tester. At that time nobody talked about a b vehicle,the first approach was just to have ademonstrations of the clustered engine, but we were tested in the process of going into the design o of the testing equipment. Then the request came , Now you make it f fly, . So there was no way around we just had to take with what we started, and now there came another request, of course that big vehicle cannot be launched from long for the US, we are looking for a quatorial equatorial longside . And for that f purpose the total first stage has not only to be broken down in pieces but has to fly. So we design the first

launch site

stage to be like a tinker toy, you know, to take it apart , to be air transportable, and to stick it together on the longside, and equatorial longside that was ye the first approach."

"And that included then the spider frameand so on?"

"Right. YOu know the point is the thrust frame was one major item and we had to design it so that the arms of the thrust frame could be taken out. You look at the first design, you can break it down to items not to exceed , to be transportable in an airplane. "

"Was there any thaought at that time of using the Saturn I and Earth Orbital Rendezvous?"

""Well that comes much later. I'M talking jaust about the first stages of the SIV. There was a stage in g between where we tried even to get the so called EI engine, that was a 380 lb. RP lux engine which was in a designed phase not even experimental yet., from Orchidine butthey wanted so much money we couldn't even afford it. I thought the solution would be the re-packaging a of the S3Bengine. 2MHI was really the solution. Naturally if we would have had enough money to optimize it we could have built a much lighter more effecient stage as we have today. The multi-cellular tanks theoretically the rate of the order cylinerar walls, is not bigger as if you would build it center tank, but the wieght of the multiple bulkheads and the line and so on, so we were definaltely off our optimium. But you know you just bated up your shoe ~~sh~~ and said this is a solution. It was so engraved in some people's mind that the evil of us was the S4 hydra stage and its monteculloe tank in some sloution. Some people, some companies offered it.

"Because they thought Marshall liked the multiple tanks?"

Yea, Marshall liked the multiple tanks. But it was not the point. We did like multiple tanks, we just had to go because

we didn't have enough money.

"When you went ~~to~~ from the S3D to the H1 there, ther wan't much of a reason to go out and advertise for new enigneers still trying to work with what you haddid it for the actually the Jupiter and Redstone tank as you were using."

You are using the Redsonte and the Jupiter tankage of the S3D engine which had a thrust flame which was of the dimensomnals were even fitting the Redstone gager. The 4 for instance had to use that some source field of flame be laid out and those rocedines would sometimes go for a Redstone engine gager because we thought it would be , we would have a chance to operate the Redstone by using our P locks and at that time as they started the S3D and all the other they were asking what kind of saucescreen would you prefer? We thought, OK built it for the Redstone. So the 65 inches sauceframe connecting board on the diameter of 65 inches , they took that stuff. That's how it ____ ?????. So what that engine never was used on the Redstone but perhaps on the A1, A4 engine.

"Why was there so much doubt about the validity of the Custered concept, they thought that there would be too much variation in thrust that it would sky the vehicle around."

There was several actually doubts, first the dianamic behavior of those long tanks. They could probably be excited in certain modes like reeds you Know. By the aironamic forces and that was for the first firing quite a big, had quite some investigation, had some discussion on the dynamic behavior of the multiple tanks.

"This is the 201 then."

Yea. That was 201. Not the 201, that was before. Oh! It was , yeas Ok the 201. First Saturn 1 firing.

"Were there any other doubts outside of this problem of vibration?"

No, the vibration and of cousre of the propanduanization. The emting of the tanks determines the offical of the stage.

"How did you manage that? Did you have to come up with some different electronics gear to get thouse presituals down even?"

We made quite some effort in ~~flow~~ snow models to find out how they behaved.

"And you had no trouble either with runnung all these lines underneath that?"

No. It was a nice design job you know, to get at the inter-connect lines properly into the skirts and the connecting lines the engines and then we have the wrap around lines around the engines which ~~look~~ allow the swiveling. That was quite a , dispite of the , we had a nice diameter for 220 inches it goes quite counted.

"~~What~~ Well it turned out to be a pretty successful vehicle.

A very successful vehicle.

"Would you be willing to go that mode again if you ...."

Yea. The only thing that I had these engines I wouldn't use multiple cilender tanks, I would use semir tanks . I think it would be a much more efficent stage.

"How about, when Chysler came into start working on these things were there difficulties in getting Chysler people geared up?"

Oh no, not at all. We didn't, we have a very good team because they were working on the Jupiter and were working on the Redstone and those programs were actually still going as Chysler shifted over to the actual Saturn I vehicle.

"So there is a very good background of personalities?"

A very good backdrop of nicely trained people which really understood the problem and that was a transition, ~~but as~~ which has proven very successful. We designed the first vehicle inhouse and transferred afterwards the desgn to Chysler, but we had already, on that inhouse design, gobs of people in training so this transtion was even easier.

"As I recall a sequence the Saturn I vehicles of which there were ten, we got up to the S207 which was qualified at that point and was very successful flight and then the last three were Pegasus flights. But instead of going 208 209 and 2010, we did 209 and then 208 which was the first Chysler vehicle. Was Chysler's slow at one point or did you have to ...."

It was it was it was a build up of the misufer faculity which runs slower as expected. So we had to put ~~our mind~~ ahead and have 8 out later.

"And you are still building the rest of them up here then?" At that we time we were still building them here.

"What major things , besides operating the engines, did you do in terms of structures when you went into the S1B?"

The S2, of course cleaned up, oh there was another point in the middle of work on this, but one 1, at that time the Air Force

did not have any vehicle for the Dinasour firing and we abtained the order : Preserve the capibility to fire the dinasour with the Saturn 1 and that required that we put a fence fins on, which were orbondous you know. We had all the designs finished and they were in the shop practically then came the order again to forget about the Dinasour. We were still on the same scale before and whatever, the only thing we could do was practically chop off the fins, you know? You can emagine that the loads of these over-hanging fins you know over designed now these short fins so the leak was absolutely ____ all the way. You just couldn't help it because the scale well there you had to remain on schedule. And as soon as we re-designed it to be Saturn IB we optimized the exhaust frame first you know and took the large fins off designed the smaller fins and we gained o almost, over ten thousand pounds of payload, by those redesigns."

"You were involbed too then with the SIC?"

"At thattime we were not yet, but we started very soon to work with the SIC. I was at that time the actor of the laboratory. I was character responsible for the SI, not only for the design, I also had the monetary management of the project, from the beginning on ,in the s Stars and Mechanics Laboratory. Later we were already deeply into desing and actually procuremint, we had already s started with e inter-facing, upper stages. Where ~~we~~ the whole activety of the management was transferred to the Saturn office, which was newly created, at the beginning the total project responsibility was in S&M."

"Could I ask you a question, about interfacing using the SI for example, when you got into finally working with S Douglas with the S4 and everything, what kind of difficulties of or problems did you

have with the inter facing or were there notne at all?"

"No, no wait a minute,that didn't go so fast until we go to the Douglas contract. First we were stated to use whatever upper stages available, that means we had to design the upper interface so that we are ready to take whatever it's force coming, we had to look into the Atlas, and we had to look at the type of theupper stages. And at that time we decided that the type might be one usable upper stage which is IOO twenty inches, so we had a monstrosity. But that is not the whole story, in the mean time we also, of course you know the stages are pretty expensive, somebody got the idea you better recover the stage. So we had in the first three stages the design, to design into the stage a recovery possibility. /So we had actually,if you look in the design of the old stages, we had designed into it a container for a parachute, we had to start the parachute development. It was on and off, onand off, nad finally we decided there was no money, we had to take it out. So at that time we were already seriously thinking of recovering the stages. Whether it would have been economical we don't know, but we started parralel studies of dunking engines into sea water and taking them out and just drying thime ou tand firing them. We succeeded in a way, but you know it's not only the i engine there were a lot f of electronic equipment and so on. Actually if you would have a recovery of the stage yyou would have broken it down into components, inspect all the components and all assembled it. And you would use twice the amount o of manpowere taking apart and assembling it. It was probably more economical to build a new stage, because a certain per centage of the components would have been ejected an as unusable. So we also had at that time this parachute container begin to design out as soon

as westarted to get into the S4 proposition. And Douglas that time was chosen based on competitive bidding, they came out with a very intigueing and new proposition."

"How was it intrigueing?"

"It was the first use of a 4 Saturn (47)?) . . . that's another story, I mean that is so complicated. There was one of thosefans we used with the director of Lewis, Silverstein, yeah there was one coming after the otherand really quizzing us, I know I had to justify the re design on that monstrosity. It was designed to be taken apart, and I had to justify why I intended to re-design the tale, because it was much too heavy , building it under entirely different ground rules. Now there was one committee, the people were talking about the upper stages,and obviously neither needed the Atlas nor the Titan was in any way performance-wise and diameter suitable. So at that time, somewhere in S December they had a meeting and Von Braun was up there and he called me up and told me, we are very seriously considering to use hydrogen-oxygenas propellant for the upper stage. One engine is being tested now and there will be about thirty Centaur flights ahead of the S4 flight, before you fly it, do you think that you will be able to handle that? And I said of course,30 flights we will have a lot of background. Well we built a stage and we flew the S4 stage a ahead of a successful Centaur flight. They fired one firing ahead of us but it was a failure and we had the first successful S4 firing. And in the whole program we were faster firing the ten engines inethe S4 than they were with the Centaur. "

"That's a very intrigueing story, now if you knew some insights on how you were able to do that so well?"

"Tha was a very very ticklish problem technologically, this was the first time such a large stage was built. And there were many new

technologies. If you look at the stage number one it was hydrogen, hydrogen has obviously some special properties, and then we had first time entirely insulation, which is a problem in itself. We ah had the first time a common bulkhead, we were brave enough to say, ok it makes no difference whether common or uncommon it a has to be tied anyway, otherwise with hydrogen you have problem you know. Because the combustion range and the explosion range is from 4% to 96%so wherever you are you know youexplode. So you ahve to be tied, and therefo rewe were brave enough to say, if we have tied we have to be sure so we can also go to a common bulkhead, and the specific design of Douglsa which seperated the oxygen and the hydrogen by a common bulkhead , and we insisted at that time that the space in between be checked and tested a on the fo control. So we had to have a so we had to have a sniffere on t he insulation of between the two bulkheads."

"Was tah that a largely a Douglas innovation, that particlar style of bulkhead?"

"the common bulkhead it was brought by Douglas. It was always somewhere in the drawings whenever you design a guided a mmissle, you know. You find very fast that you pay a lot of links, by having double bulkheads, and the obvious solution is to have a single bulkhead as we had in the, for instance we had it in the Jupiter, we had a single bulkhiad in the Jupiter. But we ha d lux and RP. And that was a single faced bulkhead and the oxygen level was only high enough not to touch the upper p bulkhead, So we gained somehow on length, already with that approach. The Jupiter was a pretty stubby vehicle. The next step, of course, would have been something similar but the temperature difference from lux to hydrogen requires insulation.

"Well Douglas apparently came up with a better design,than Conrad down at the Centaur."

"Yeah,"

"I think they used something like honeycomb too."

"Yeah, this was a long time ago."

"OK, then when you started on the SI you really had no idea of the overall configuration of the S4."

"Absolutely not,we did not have any indication, I told you, they spent over testing configuration, to a flight configuration to be broken down and shipped by air to a configuration using Atlas'S Titans upper stages witha possible recovery designed to be compatible with the Dinosaur. And then we finally went to the S4, so that means that ~~with~~ with the S4 we had to re-optimize and get all that junk out we had designed it before due to the zig-zaging specifications requirements. . "

"I'm still a little uncertain I guess, why the S4 was so succesful as opposed to the Centaur I suppose Douglas went to the interior. ."

"No,it was a straight forward engineering and we very carefully watched the total design to be on the conservative side."

"After I asked you that the Centaur was an Air Force thing,? and I wonder if , I don't want to put words in your mouth, from the ABMA days ~~Amadaze~~ and the Von Braun team, you would think a little more conservatively and alittle more deliberately and this in the long run gave you success, in terms of successful a ~~of~~ launching."

"We definately, the Centaur was again stainless steel plus a stabilized structure with insulation to be blown off. That in t itself has certain operational difficulties, we definately with the man in mind, you cannot make these extavaganzas. Of course we had an a Atlas and also a man on top and it worked. But at that time we intended to go down safe, if we o loose the pressure we don't collapse.

And if the wind is higher on the Cape as it went up to almost 06 60 miles, 60knots,and still we standing freely /// and be succeeded and have no failure. It was a relatively positive drift design."

"Ddid you have any , you mentioned that tyou had some doubts perhaps in the first launch of the SA20I because of the tankageand the vibration problem, I've forgotten it must have been the SA205 or AS205 that was the first live second stage I wonder if . . . ."

"No you are mixing up the 20I designayion came with the SAturn IB,and we had the Saturn I before, there was Saturn I2345. First we fly only first stages we had that high water payload, and the Pegasus where then ////// riding on 6,7,8,/ or 9,8,IO,the last three. And the II I2 was cancelled recycled into the 200 series, whatever was possible to be recycled. You know the time that's only ten years ago and you forget something like that pretty easy. "

"We're amazed to that so many of the people we talk to can go back and ////// get started and can remember too."

"Some of the things are really engraved in your mind, because you labored hard, in thaose days to get to some decisions."

"Did you find it easier in the SaturnI periodto doth things than you did in the Saturn IB and the SaturnV because management hadn't been so crystallized and there wasn't so much paper work?"

"Definately not , because at that time I said we go that way and we went that way, there were no other people there who started to doubt youknow. And it's easy to make 98 right decisions on time and reverse yourself from 2-5% because you may deliver it to early. And it's more commendable and more successful to wwork that way than wait until you have every thing together to make I00% right decisions,. And we had to take some chance in some areas, calculators, calculators, risks , for instance we didn't have any heat transfer on the base area the design had to be frozen before we had

any data on the base heating of the booster. We had no idea, what happened to the hydrogen that bombed earlier (boundary layer), we had to make a decision to take the hydrogen off the upper stage, out of the boundary layer. The oral tin (RL-10) engines had a cool down time of 6 seconds to my recollecti on , where they run freely hydrogen through the engine and dumped it overboard. Dumping overboard into that open booster doesn't make you feel comfortabel, so we had to make the decision just to get rid of the hydrogen in any possible way , because measurements were not available , what that p open configuration was doing you n know the wind can whistle practically past the container. And there were many decisions to be made based on script engineering judgement and partially on only o incomplete information. But it was important that the schedule was kept and we were pusheing forward."

"You know some of these questi ons that you apparently had it's even more amazing that you really did make the schedule. You really did Not have any major problems."

"We had a pretty good design threw together,and they were pulling hard andreally tried to gibe us a good solution. "

"Can you say that the SIB was really that much more of a sophisticated vehicle than the SI or simply was the designation for a booster for Apollo spacecraft?"

"It was known that it has to carry the Apollo, the SIB not the SI; So there was a weight requirement, that means, we had to up the performance, that required re-design,. The S4 stage was toosmall . We went to the S4B with the J2 engine which became available. s So we knew that the SIB had to be re-designed. "

"And the fins were different, how do you account for the differentiation inthe fins? WAs it again aero-dynamic loads?"

"These one fins there designed for a much larger span, for the Dinosaur capability. And we chopped them simply off because there

was no time to these ,and we had h just to cut them off."

"Yeah the SIB design does look a little more aero dynamic."

"The SIB looks all little bit better. There we had only . . .

"OK well I know I'm keeping you from your things and I don't want to do that, hold you down any longer here. "

"I hope you have enough."

"Yes I think so and hopefully then if we do run in to any specific question then we can pick up the phone and call you.? And sooner or later there will be a review."

END