INTERVIEW #2

INTERVIEWEES: Guy Thibodaux, Max Faget, Paul Purser
INTERVIEWERS: Robbie Davis-Floyd and Ken Cox
INTERVIEW DATE: Sept. 10, 1996 at the home of Guy Thibodaux in Clear Lake, Texas

RECAP: *Interview #1 was with Guy Thibodaux, the engineer and rocket propulsion scientist responsible for the propulsion work on Mercury and many other space projects, at his home near Johnson Space Center in Houston/Clear Lake, on Sept. 9, 1996. The following day we met again at his home, this time to conduct a joint interview with Thibodaux and his colleagues Maxime Faget, who was instrumental in the design of the Mercury, Apollo, and Gemini spacecrafts and the early shuttle, and is widely considered the father of spacecraft design, and Paul Purser, engineer and manager at Langley Research Center in the Pilotless Aircraft Research Division, which formed the early nucleus of the space program. Brief biographies of these three space pioneers can be found at the beginning of Interview #1.*

The following taped interview has been edited for clarity, organization, and flow. Both interviewers and all three interviewees have read and edited the interview transcript; their written commentaries are included below in italics or as parenthetical interjections. [Editorial comments from Davis-Floyd and Cox appear in brackets.] For background and context, interspersed throughout the interview text, in italics, are excerpts (sometimes adapted and amplified) from "Annals of Space: Max Faget and Caldwell Johnson," by Henry S.F. Cooper, The New Yorker, Sept. 2, 1991, pp. 41-69.

MAX FAGET: At the very top levels, these days, they don't know or care what happened. All they want to do is make sure that they've got their place in history. That's all they worry about. I never saw anything so screwed up as the history of Johnson Space Center. After they wrote a couple of chapters, they said, "Max, we want you to review these chapters and make sure that they are right." Well, I reviewed the first four, and then I said, "Don't bother to send me any more." There was no starting place. It was so wrong, it was so screwed up, that you can't make anything out of it. It was terrible—and it was supposed to be the history of JSC!

ROBBIE DAVIS-FLOYD: Are you talking about the book Suddenly Tomorrow Came?

MAX: I don't know what the hell they called it. It was written by somebody under contract with headquarters.

GUY THIBODAUX: That history that Joe Shortal wrote is one of the best histories I've ever read. It's a chronology of facts, that's what it is. I could live and breathe every page of that.

PAUL PURSER: All the historians just hate it.

GUY: I know, they say it's not a history, it's merely a chronology, and they almost refused to let him publish it.

MAX: Is that right?

PAUL: Sure!

ROBBIE: Last night Guy started at the beginning with his version of the early days of the NACA when you all were getting involved in beginning to think about creating what later became NASA. He was

particularly interested in that ten month period, in which you all played critical roles. But before we get to that, I'd like some background.

Louisiana State University

ROBBIE: I know that all three of you went to LSU. Now that's remarkable—three key figures in the development of our national space program came out of the same university, the same engineering department. So I would like to know who taught you, who your mentors were, what the program was like. Obviously, something went on there at LSU that produced the three of you in so compatible a mold, so what was it? First of all, Paul, why were you there?

PAUL: I was there because that was the college that I could afford. This was right in the middle of the Great Depression. My family would have liked very much for me to have been a lawyer, or a doctor—or a dentist would be acceptable. But, no, I wanted to go with what the Dean of Engineering at LSU referred to when I got over there as "aeronautics engineering," a synonym for "artistic hunger strike!"

But, I was hard-headed enough, and I was going to be putting up most of the money from state funds and various other places that I could get jobs, plus a double work scholarship where I would work 100 hours a month in the engineering labs for 25 cents an hour. And that was enough to take care of me. And my tuition, $62.50 *[**GUY:**$30.00]* was the right amount per semester and everyone had to make a contribution of $1.00 to the student loan fund per semester and all that was taken care of by my legislative grant money.

GUY: Room, board, and laundry was about $25 a month.

PAUL: On one year of junior college, I earned everything by driving the family car 15 miles from home to school with four or five other students who paid me to drive them. I had enough out of that to buy gas and oil for the car and buy my lunches and cigarettes and pay the little bit of tuition that I had to pay the junior college. When I got to LSU, I had a little bit of money from home. $25 a month with this double work scholarship. My job was to work in the Department of Aeronautics lab and that was the place that I really gained an appreciation for what technicians mean to the success of engineers.

We had a technician in the lab who had been an automobile and truck engine mechanic and had also been an aviation mechanic and had worked with some of the planes—in those days it was very popular to get some rich guy to build you an airplane with the biggest engine you could put in it because it said how wealthy you were. So, he had a lot of experience like that. The Head of the Department was a retired Army Air Corps Major and a political figure, and that's how he got to be Head of the Department.

The other guy was another retired Air Force Major named William G. Brown, who had worked at NACA for a while with H.J. E. Reid, who was then the Engineer-in-Charge of Langley Research Center. The third person was known as Fritz [Ernst E. Maser], and he had been a fighter pilot for the Germans in WWI. At the end of WWI, he had also done some flying for the White Russians who, a few years after the 1917 revolution, were still fighting the Red Russians. And then he wound up in China, for how long, I'm not sure, but I know that he got a degree from a university in China, because I'd seen the diploma on his wall.

And then he wound up in the U.S. as a design engineer for Fokker Aircraft. They were at that time building and selling the Trimotor, which in general appearance was very much like the Ford Trimotor. And he got involved with racing planes, primarily with the Wedell-Williams group in Louisiana. He designed racing planes which flew in the Cleveland Air Races and held many of the world's speed

records at the time, and he was our primary engineering instructor. He had a varied experience and a lot of knowledge and he loved to teach!

GUY: He had his own way of teaching, which was unconventional! *(laughter)*

ROBBIE: What was that way? How did he teach?

MAX: He'd just get up there and talk. He'd tell about what happened in his life and what he could do and things like that. It was not a very formalized teaching.

PAUL: Not a formal textbook prof. You had a textbook that you had to study in order to take the exam. But most of what you learned was just from listening to this guy.

MAX: He didn't like to say, "OK, we are going to take the next four pages in the textbook and we'll talk about them tomorrow." No way. You could ask him questions though. That was the good part. We could read the textbooks and ask him questions about biplanes and induced drag and all that good stuff.

ROBBIE: So you specialized in aeronautical engineering at LSU. And what year did you graduate?

PAUL: I graduated in '39.

ROBBIE: And did you know Max and Guy while you were there?

MAX: We graduated in '43.

PAUL: They came in either as freshmen the year I graduated or the next year.

ROBBIE: But you had the same teacher, this guy Fritz.

MAX: Fritz was head of the Aeronautical Engineering Department when I got there. Was he head when you were there, Paul?

PAUL: No, Fraim was still head. He left shortly after I did.

MAX: Fritz told me a story about this friend of his who was a barnstormer and he had one of these Ford Trimotors. Trimotors were three-engine airplanes. They were popular at the time--actually the Trimotor was still being used something like about twenty years ago in Canada. He came through to Baton Rouge and said, "I'm going to do a slow roll tomorrow in this Trimotor." So Fritz went out there and when his friend wasn't looking he threw a bunch of bolts inside the wing. During the rollover, of course, here come the bolts rolling down inside the wing. He says, "Boy, I could see you fly real steady around and land." *(laughs)*

PAUL: The wings were covered with corrugated metal which meant that they made a lot of noise.

GUY *(laughing):* There was no way he wanted to continue with these bolts on top of the cabin--

ROBBIE: --making a horrible racket!

After LSU: Langley, Here We Come

ROBBIE: Paul, when you left LSU, where did you go? What did you do?

PAUL: Well, Walt Williams and I — he had a car and I put in some of the gas and I had a seat to put on the seat of his car and enough money to buy my food. We took off and came up east hunting some kind of job. We had both taken the Civil Service Exam hoping to get on at NACA. That was because in the late '30s, this guy Lindbergh went over to Europe to see what was going on in aeronautics in Europe. He came back and told what an air force the Germans had built. And the press almost got him run out of the country. They thought he must be a Nazi to come back praising the Germans like that. He wasn't praising the Germans, he was answering the question what were they doing compared to what we were doing. This was a time when Congress and the powers that be in Washington decided to listen to advice from people who knew what they were talking about.

MAX: He was on the Aeronautics Committee, wasn't he? Lindbergh?

PAUL: I'm not sure whether he was on the Committee or not. He became a member later, I think. At any rate, Congress decided that the U.S. better get busy, and that NACA, which at that time had about 700 employees total, should expand markedly and steps should be taken to increase education in aeronautic engineering all over the country —really get busy.

So Henry Reid, the Engineer in Charge, wrote letters to all of the academic people he knew, particularly those who had worked with him, and said get your best seniors to take the Civil Service Exam because we are going to be growing like mad.

So we did, and Walter and I were both just waiting to get calls. I got called around the first of October that year. We had taken jobs as junior inspectors at Glenn L. Martin Company in Baltimore because those were the only jobs we could get. They were building a twin-engine attack plane for the French Air Force, and we were both doing inspections on that. Come the first of October I got called to NACA and that same day I went home and packed my clothes and caught a bus and headed for Langley. About six months later Walter got his offer and he came down.

ROBBIE: And what position did you start out in at Langley?

PAUL: I started out as a Junior Engineer in the Atmospheric Wind Tunnel. It was a seven foot high, ten foot wide tunnel that tested both complete models of aircraft and wing sections with various controls.

ROBBIE: So over the next four years you moved from Junior Engineer to what positions?

PAUL: Well, my first raise after a year was, I think, $100 a year. I went from $2000 a year to $2100 a year. Then another year later I went to a P-2--Professional 2--at $2600 a year. Then at the end of WWII, this guy John Stack that you've heard mentioned wanted more space to build supersonic wind tunnels so we could try to catch up with what we found out the Germans had been up to during the war. So they closed down the wind tunnel that at that time I was running and gave the building to Stack to put some small supersonic tunnels in.

I was offered the opportunity to either go into another subsonic wind tunnel and run it, or go to work for Gilruth with the screwballs he had fixing to fly rocket models off Wallops Island. And I decided well, I know enough about subsonic wind tunnels, I'd like to learn about this other stuff. So, I took the job with Gilruth.

ROBBIE: What was your position under Gilruth?

PAUL: I was one of the guys in PARD.

GUY: You didn't tell them about your stint in the administration office.

PAUL: *(laughs)* During the very early days just before WWII, they couldn't decide whether they should give the draft deferments to NACA or not. So, they had the War Manpower Commission conduct a study of what it would take, person by person, to retrain and replace every male employee throughout the whole agency. There were about six or seven hundred of us at Langley at that time. And somehow I got chosen as the host of the War Manpower people who were going to conduct the study, which meant that I was the local guy who was going to do the work and they would sign the report. *(Laughing)*

At the end of the War Manpower Administration study, I had a really good understanding of what was going on at the NACA, and someone higher up decided I knew enough about the whole picture to be the Laboratory's Budget Officer. I accepted the job for a six month trial period to see if I liked it so I agreed to take it on. At the end of six months I knew I preferred research and I was allowed to go back with no loss.

The study itself concluded that it would take a total of eight to ten years to replace everybody by training other people up to the level of experience that the Langley people held. So, they decided they were not going to draft all of us. But they got hold of the services and the Air Corps agreed to take the people at Langley and at Lewis Lab, and the Navy took the people at Moffett Field, because Moffett Field was a naval installation. So, as our numbers came up near draft status we would go ahead and get drafted and inducted.

This was the thing. We'd go up and take physical exams and line up, and they'd say, "So-and-so and so-and-so, you are hereby inducted into the Armed Forces of the United States of America and assigned to the Air Corps Enlisted Reserve on inactive status for the duration of the war or until the time that you leave your job at NACA.

ROBBIE: Good incentive to stay!

PAUL: So, I became a veteran with no active duty time *(laughs)*, because the ten seconds that it took to read that sentence were too short to list, as active duty time was listed in years and months! At the end of the war, I got discharged, got a sheet of paper that said, "You are hereby discharged with honorable status."

Guy and Max were getting discharged at about the same time but they'd been out fighting instead. They went by LSU to say hello to Fritz and other friends. They wanted to know what Fritz was working in on. He said he really thought that if they wanted some interesting work, that they ought to come up to Langley and talk to me to see if there was a place at Langley for them.

So these two boys came barreling up with their pockets full of discharge money—accumulated leave money and stuff like that. It just happened that PARD had reached a stage that they wanted a good chemical engineer or other equally qualified guy interested in solid rockets. And they wanted a good mechanical engineer or otherwise qualified guy who was interested in ram jet propulsion and liquid rockets. So Max and Tibby came in, they got officially greeted and put on the list as "visitors seeking employment." I was going to interview them, so we sat and chatted for—I don't know—two, three, four hours. At the end of the time, I said, "Well, I don't think we have any problem at all hiring you guys." I don't remember now what we were allowed to pay them.

GUY: $2644.80 a year. It had gone up from $2400 to $2644.80 a year. $133.66 I think was my biweekly paycheck.

MAX: Where did you get $133.66? It wasn't that much. It was $88.66 biweekly.

GUY: Oh, $88.66 (laughs).

PAUL: Well, when I started in '39, my monthly paycheck was $159.00.

MAX: I used to keep my paycheck. They used to tell us to "Please cash your paychecks." But I used to throw them in my top desk drawer and leave them there. *(laughs)* And they would call me up and tell me, "Would you please go cash your checks!" *[**GUY:** Me, too.]*

PAUL: Anyhow, I got Gilruth's permission to offer these guys jobs. And I did. "Well, we want to think about it." They said they wanted to go check out some other places up east and find out what kind of jobs were available up there. That was their story. But really what they wanted to do was go spend some of that discharge money having a good time in New York and Philadelphia and other places. But anyhow, they would "let me know" after they finished their job hunting tour.

ROBBIE: So what did you actually do on your trip instead of looking for jobs? *(laughter)*

MAX: Well, let's see. I knew girls in New York, and I knew girls in Philadelphia, and my mother had given me an address of a lady in Washington, D.C. She said, "You really ought to talk to this lady—she's got a lovely daughter."

GUY: We went up to see Billy in Rhode Island.

MAX: We did lots of things. We had a lot to do in New York.

PAUL: About two or three weeks later they came back and said, "Well, we looked and this sounds like about as good a offer as we can find. So we'll sign up with you."

GUY: The first of August 1946 was the day we started working.

MAX: Did we go all the way back to Louisiana and then come back out?

GUY: Yeah, we went back to Louisiana—

MAX: --and then came back up.

GUY: We never looked for another job, by the way, Paul. *(laughter)*

MAX: Absolutely! Never even thought of getting another job! I don't know who brought it up first but we started going up north, and I guess we'd been in the car maybe half-an-hour or an hour, and that's when we decided "Well, what the hell—we can have a lot of fun now!" *(laughs)*

GUY: I'd had a lot of job interviews but it turns out—I mean, we were pretty independent. Max and I had been through the war and we'd been through an awful lot of stuff. Most of the personnel people that I interviewed were snotty SOBs.

The other thing, the whole wartime economy had not been converted to a peacetime economy. Most of the people didn't even know what they were going to need to do about hiring people—who they were going to need. At Langley, they wanted us, and there was something for us to do. It sounded challenging and interesting, and it was new.

PAUL: One thing about the NACA I liked was that we didn't have too much bureaucracy, we didn't have a lot of red tape around who we were working with, doing what, how we worked, what kind of records

we had to keep. If you got a good idea, you'd work on that. If you didn't have a good idea, somebody would give you one to work on until you got one.

NACA's role during this period was to carry out research that would advance aircraft design and to pass its discoveries on to the military or the aircraft industry. Purser and Gilruth put Thibodaux to work on rocket propulsion; Faget got busy designing ramjets--jet engines that take air in at the front, heat it, and spew it out the rear fast enough for a plane to travel supersonically. His job was to see if he could make one thin enough to fit inside the wing of an airplane, and he came up with one a mere six and a half inches in diameter; it later powered a test aircraft to an altitude of 65,000 feet and a speed that exceeded Mach 3.

Thibodaux began by designing rockets to be used for launching aerodynamic scale models of supersonic aircraft at Wallops Island, a barrier island about 85 miles northeast of Norfolk. NACA had established the Wallops Island range because Langley's conventional wind tunnels choked up and became unusable at what are known as transonic speeds--speeds just above and just below the speed of sound.

"The NACA Nuts": Right People, Right Place, Right Time

ROBBIE: Who called you the NACA *[**GUY:** prounced nakker as in cracker]* nuts?

GUY: Everybody.

PAUL: All the people around the town of Hampton and in the population centers around Langley field. And some of those NACA folks were really nuts. I mean, if you think we're weird--*(laughter)*-- there was one guy who had a piece of white adhesive tape on the top center of his steering wheel and he would drive along solving mathematical equations in his mind and just glance down once in a while to see if the white was still in the middle! *(laughter)*

There was a hardware store in town that guaranteed their products. They had ice cream freezers and some guy bought one that was guaranteed not to rust. About six weeks later he brought it back all rusty so the hardware store owner replaced it. This was repeated about six weeks later. The third time the owner was asking, "What are you doing to these things?" "Well, I was just testing the guarantee out. I filled it with salt water and put it out in the back yard." So he did it every time for about six weeks. The hardware store owner said, "I can't afford this guarantee for you. I'll just give you your money back." *(laughter)*

GUY: Who was the guy there who eventually lost his clearances?

PAUL: Eastman Jacobs was the father of the laminar flow airfoil. Late in World War II he was assigned to work both at Langley and Lewis. He took his secretary with him and set her up in an apartment so he would have a home away from home. They were both part of a very left-wing group and someone dropped in the apartment when Jacobs was away and found a lot of classified material which was not locked up. That's the story as I heard it.

GUY: Paul Hill, our first boss, was a real nice guy who liked us and he did everything for us. Paul would go see a movie and if he liked the movie he'd buy tickets for us and he'd give them to us. If he had a book that he liked, he'd buy us a copy of that book. He had a sailboat. He'd take us out on the sailboat and go sailing all the time. He was really interested in us as people and in helping us get along. He was kind of a strange character, very, very strange.

PAUL: Very strange.

GUY: He was very strange. He was certainly very personable when he came with us.

MAX: He wrote a book on Unidentified Flying Objects.

PAUL: I didn't know that he wrote a book, but he was one of the first ones to report on seeing any in the Langley area. He had been known to spend most of his time slipping off with a couple of quarts of beer one way or another and most of us figured, well, he had must have had too much beer that night when he saw that thing flying by.

GUY: Paul Hill believed in luck, and when he had good luck he wore the same tie until his luck changed. It didn't matter how many gravy stains or catsup or whatever else there was on it. He always wore that tie until something bad happened, and then he'd change that tie. Other than that he always wore the same tie.

PAUL: I never had that problem because I never wore a tie anyway!

GUY: Paul Hill was head of one of the Branches. Hill had the Propulsion-Aerodynamics Branch as we expanded. Paul Purser had the General Aerodynamics Branch, and Dave Stone had Stability and Control. Paul Hill was his counterpart in the propulsion area. Max and I were a couple of section heads. Max and I and Ray Watson were head of Paul Hill's sections. We are all still alive, the three section heads. We get together at a big reunion every two or three years.

PAUL: We'll be heading back to Virginia in two weeks for a NACA reunion.

GUY: You can't find three people who were happier or more interested in the work we did. We happened to grow up at a very challenging time in world history and happened to work for the right organization.

ROBBIE: Right people, right place, right time.

GUY: Right people, right place, right time. They were real people. No facade, no ego. If they had any egos, they never let them come out too much. We all worked for the good of the organization. If you did a good job at the organization, it took care of you. That's the way it worked. No awards. The reason I retired was because it quit being fun any more.

The X-15

At the time Purser hired Faget and Thibodaux, PARD was engaged in designing the X series of rocket planes, which propelled Captain Chuck Yeager through the sound barrier in 1947 and, in 1962, would put Major Robert M. White briefly into space.

MAX: The NACA sold the Air Force on a lot of good projects. They'd say, "We don't have the money to build an airplane, but we would certainly like to do this kind of flight research. Let's do a joint program." The Air Force was always very interested, because we had some pretty damn nice toys, you know? *(laughs)* We'd give them the idea for another good toy, and they'd say, "Oh, yes. We'd like to play with that one" –like when we did the X-15.

The case of the X-15 is very interesting. The Air Force bought the X-15. They contracted with North American for the X-15. What did NACA do? They made paper studies. We had a team of four people, primarily, who were put together to do these studies. They'd go back to their organizations for help. I

happened to be one of the four. I was in charge of performance, and I needed help on propulsion so I'd go back and Guy would tell me what kind of engine we ought to use.

GUY: We called the shots on the rocket engine and what propellant it would have—much to everybody's consternation, we made the decision on that. I think we convinced Hartley Soule' we knew what we were talking about

MAX: We had another guy that was doing aerodynamic design and he came up with the wing loading and where the wing was going to be and things like that—the kind of vertical fins we'd have, and all that. I had to decide how much it was going to weigh, how big an engine we needed, things like that. *(laughs)* The funny thing about that is, I couldn't figure out how much it was going to weigh so I got a hold of some stuff like—you know, wings weigh so much per square foot, and didn't weigh so much for skin areas. You know, using those kinds of numbers. And it turned out that the X-15 came within about 10% of what I predicted it would weigh. I've never done that good since! *(laughs)*

But we didn't know how fast it was going to go so I ran a bunch of different trajectories and it turned out that there was a kind of hump in the curve. You'd try to go much faster than Mach 6 and the vehicle was starting to get pretty big, so I recommended that we do Mach 6, and everybody said, "Oh, yeah, that's a good enough number, Mach 6." *(laughter)*

Sixty thousand feet a second was actually what I recommended, not Mach 6, but it comes out about the same. And I think it actually did do just about that. Then what NACA did was they went to the Air Force and said, "Hey look here. You can build an airplane that is going to be this size and have this weight, and you can carry it on the B-52î

GUY: Yeah, the B-52.

MAX: They said, "Oh, gee, that's gonna be a lot of fun, we really like that." Then the next thing we negotiated was, "Well, who's gonna fly?" They ended up just saying, "Well, there are going to be NACA pilots who are going to fly it and Air Force pilots to fly it and Navy pilots to fly it."

GUY: North American pilots? Scott Crossfield ?

MAX: They wouldn't let Scott Crossfield fly it to anywhere near its maximum performance envelope. He only flew it at low speeds to prove that it'd land. He was only allowed to fly to prove that he could land and that he could operate the engine. That was an acceptance flight. Then performance flights were done by the Air Force and other government pilots.

GUY: That program helped North American get those contracts.

MAX: Definitely.

MAX: And the next toy we were going to design for the Air Force was what Round Three was supposed to be about. Instead of going Mach 6, it was either going to go at least Mach 12 and hopefully Mach 15, as I understood it.

PAUL: It was going to be called the Dynasoar.

MAX: So that was going to be the next project and that's what we went to Round Three to discuss.

The Round Three Conference

In 1956 and 1957, there was a great deal of debate over whether the United States should continue refining the X series of rocket planes or build an entirely new craft to take a man into space. During their lunch hours and various spare moments, Faget, Caldwell Johnson, Guy Thibodaux, and other NACA employees at Langley had begun to kick around the idea of sending a man into space on a ballistic trajectory, inside an enlarged missile cone. Johnson said, "Max or I would say "There's no reason why we can't put a man inside this thing. We'd say, 'It would need a parachute for landing, but we've done parachutes before.. It would need a rocket to deorbit for re-entry, but we've done rockets before." One day, while they were playing pinochle in the Langley cafeteria after lunch, Faget said, "Damn it, I wonder how small they could make a nose cone and still get a man in it if we scrunched him up?' And then Johnson did a few drawings. But the ideas never got further than that.

On Oct. 4, 1957, the Russians sent Sputnik into orbit. During this time, a number of Langley hands, Faget and Thibodaux among them, flew out to a conference of NACA aerodynamicists at Ames. (On trips from Langley to the West Coast, which were often undertaken in an unpressurized NACA airplane, the engineers would play poker. As they flew high over the Rockies, Faget would watch his companions' fingernails, and when these turned blue--a sign that their owners were suffering from oxygen deprivation and thus might be a little addled--he would bluff outrageously and usually win the pot.) The meeting had originally been called to decide between two rocket plane designs, but the advent of Sputnik gave it a new focus--to put a man into orbit and bring him back without crushing him with G-forces or roasting him during re-entry.

MAX: At Round Three, the people from over at Langley, the people from Ames, the people from Cleveland, as well as from the Flight Research Center, were all going to be there discussing what this beast ought to look like. And we all had our different ideas. Langley brought all the flat bottom people, and Ames brought all the flat top people. That is something we don't have time to go into but it is a very interesting story. *(laughs)* But we always had our way—Langley always won these arguments.

GUY: We were the practical people. The other people were the eggheads.

MAX: They were real eggheads, they really were! *(laughs)*

GUY: I think that the Round Three Conference is really where we got started in the space program. Do you all agree with that?

MAX: It made a lot of things legitimate. The thing that bothered me about the Round Three Conference—I went to that conference really thinking we were going to build something that was going to go fast, an airplane-like affair. And I came back convinced that we weren't going to do that. The main reason is that O'Sullivan didn't tell us what was going on.

PAUL: O'Sullivan went by Headquarters' rules. He was forbidden to even tell Gilruth what went on at this conference that he had attended.

ROBBIE: Now, who was O'Sullivan?

PAUL: What could we tell you about O'Sullivan—he was a good guy. The only real scientist, I would say, in PARD. The rest of us were just darn engineers. *(laughs)* O'Sullivan could take an ordinary ten-inch slide rule and read it five significant figures. Most of us have trouble getting beyond <u>three</u> significant figures on a slide rule! He and Al Eggers had gone to a conference that was put on by one of

the armed services. Dryden [Hugh Dryden, Director of the NACA] gave orders not to identify the armed service or the conference or what they heard, except that at this Round Three Conference, Eggers finally just got tired of it and said "I'm gonna break the rules." Dr. Dryden said that we could not tell anybody what went on at this thing, but he told us what went on, and it became very obvious to Max and to me and to Al and to many others that we could not go with an airplane-like configuration [the hypersonic glide-bomber] at that time.

MAX: Well, there wasn't any need for it.

PAUL: There were two things: One, there was no need for it and second, it would have been much more difficult to do regardless of the difficulties that we could foresee.

MAX: The issue was very simple. I guess there are a lot of sub-issues, but the way I looked at it was that we had this thing called ROBO--a glide bomber. The idea was to launch an airplane in Turkey, or somewhere like that, overfly the enemy, drop your bomb, and land on the far side going at Mach 15. You'd go like hell and then you'd fly across the enemy territory but you couldn't go back. At that velocity you couldn't make a U-turn as we know it. No way you could make a U-turn! *(laughs)*

So, we were working on airplanes that might be able to go Mach 15, which was the purpose of Round Three. We'd gone Mach 6 with the X-15, and now they wanted to go Mach 15. The reality was, we knew that the Russians had the radar and the wherewithal to shoot these sons of bitches long before they got over the target. They would be sitting ducks. There was absolutely no strategic interest in a glide bomber. Absolutely none, zero, zip. We weren't going to do that. If you were going to go over the target, you'd go over it with an unmanned thing, and you'd dive it into the target and blow it up. That's what you'd do. So, we were working on something for which there was absolutely no practical military need. It was very difficult and it was going to be an extremely expensive technology challenge.

KEN: Now, at this point there wasn't a civil space program. These were all military considerations at the start.

PAUL: *(comment) From the time that Vannevar Bush (Science advisor to FDR and HST) declared that rockets were impractical and we must concentrate on airplanes, "Space" was an obscene word in Washington.*

MAX: Right, and there wasn't anyone really thinking about going into orbit except possibly for reconnaissance—that was one of the long range things the Air Force was thinking of, but kind of very dimly, you see. Before Round Three was when the Russians put this little Sputnik up. Scared the hell out of everybody because we were working on something that was going to put a grapefruit up and they had already put up a gallon jug!

PAUL: It was during the Round Three Conference. I don't think it was even a week before. I believe it was either the day before or during, because the news got to us when they were sitting there in the auditorium at Ames.

MAX: It was kind of a shock, and it changed the rules. As far as we were concerned, up until Round Three, it was a toy — because we were looking at trying to get new technology, the toy was going to be this ROBO and it was going to be a lot of fun to get involved with all this. The military said," We don't want that." So here are the Russians putting up another toy for us. So during Round Three, we got to thinking about getting up into orbit as opposed to discussing glide bombers—

KEN: So that's how the move into orbit first got started—

MAX: Yes, within NACA, with just a very few high-level people. Prior to that--you might remember this Paul, I know Guy does--we heard about the Naval Research Lab, or whatever it was—they had the Vanguard program to launch satellites.

PAUL: It was for the International Geophysical Year Scientific Payload.

MAX: Mr. Abbott from our Washington Office came to Langley for a visit, it seems like a month or so before Round Three, and we were all sitting around talking. We had just put up a rocket that had gone Mach 15. In fact, during the last year Bob Piland had put up about two or three Mach 15s. They were very small but they went Mach 15. And we got valuable data from Mach 15. Meanwhile there was a new class of larger rockets coming in. I got to talking to Guy, and Paul perhaps. We were sitting around at the conference table. I don't know how it came up but somebody brought it up. I said, "With five-stage rockets, I think we can put something into orbit probably before Vanguard does."

KEN: That was probably the first time that sort of idea came up.

MAX: Yes, because we were solid-rocket people. We understood solid rockets. We had a great deal of faith in solid rockets.

KEN: And that was the Wallops experience—what you had learned from your research on Wallops Island in PARD.

MAX: Yeah. We understood staging and how to get higher velocity. We'd look at these liquid rocket people and we'd kind of shake our heads all the time. All they seemed to have were aborts off the pad. *(laughs)* So, I honestly thought, and I remember saying it, "Why don't we think about doing that with solid rockets?" You know what Abbott said? He stuttered! He kind of stuttered and said, "Oh, oh, oh, we can't do that. We'd have to get permission from the State Department." Like, "I don't dare go before God. He might condemn me to hell!" *(Laughter)* That was Abbott's attitude.

GUY TO MAX: I told them about you and I coming up to Dryden in the lobby of the auditorium and talking to him about this. He gave us the same story. Dryden had told him that the Navy was the only one who was going to be allowed to put a satellite in orbit, and that we couldn't do it. And then Max sprang the manned thing on him.

MAX: It wasn't that great of an idea. You just look at the rockets that are available. You can pick the number of rockets that you think are going to be available and you stage properly. Each rocket would be maybe one-third the weight of the previous rocket, or somewhere between half and a third the weight of the previous rocket, and if you stage enough of them together, you can go up to Mach Infinity if you have enough stages. *[Guy comment: Not quite that fast!]* In our assembly we had made five-stage rockets. All of a sudden a string of rockets showed up that indicated to us that we could get up to orbital velocity.

KEN: But at this point you hadn't jumped to the manned space craft.

MAX: Oh no, no.

KEN: This is just an early part of "Put something up there." National prestige with the Russians and all that.

Eggers, Allen, and the Manned Space Craft

After the Round Three meeting was over, Faget couldn't wait to get back to Langley and run some tests on blunt bodies. He and another aerodynamicist, James Buglia, determined that a blunt body large enough to carry a man would return through the atmosphere without overheating with a deceleration of about eight Gs--a force that a man should be able to survive. Along with a third aerodynamicist, Benjamin Garland, Faget and Buglia wrote a paper recommending a ballistic capsule for manned flight. The paper, a seminal one for the space program, was a masterpiece of brevity: its text took up eight pages, and drawings and references took up eight more.

MAX: What got us into the manned space craft was Eggers. With his inside knowledge, Eggers had been working on putting a man in orbit. Eggers was not worried about what was going to put this guy in orbit, he was putting his attention to what kind of vehicle this man was going to fly in.

KEN: The spacecraft and the reentry.

MAX: He'd apparently put in, I guess, at least a half a year's work on it, because he had a fairly well-thought-out idea for a lifting-body spacecraft.

KEN: Eggers was NACA?

MAX: Eggers was NACA. He was out at Ames. He apparently, being away from Washington, had clued in some of his subordinates. He had a team of guys. There was this guy Wang who worked with him, a Chinese-American guy.

PAUL: He had about five people, I can't remember their names, but he had the blessings of his manager at Ames, Harvey Allen.

MAX: And he had come across what he thought was a neat idea, and it <u>was</u> a neat idea. You build something that uses solid-rocket fuel. You take a basic shape which is a cone with a hemispherical nose on the front of it. The cone with the hemispherical nose on it is stable. Then you slice it in two and move the center of gravity to the right place, and it's still stable. So, it's not only stable, but it's a stable body giving lift. And he thought that was a wonderful, neat idea. And I guess, you've got to admit it <u>was</u> a wonderful, neat idea--it was a great idea looking for a market.

KEN: An application.

MAX: An application. Meanwhile, Harvey Allen was there. *(laughs)*

KEN: Holding the court.

Harvey Allen

In proposing a ballistic design for the space capsule, Faget had been influenced by the work of Harvey Allen, an Ames engineer and manager, who had upset the conventional thinking that the best shape for any craft in the atmosphere was an aerodynamic one--one that minimized friction with the air--and that this principle would, of course, apply to any object reentering the atmosphere from space. Faget said that what he learned from Allen is that "the trouble with an aerodynamic form is that during reentry it is

going too fast in the lower layers of the atmosphere where frictional heat will cause it to burn up. A blunt body sets up a bow shock wave that absorbs and dissipates much of the frictional heat. And it will slow down higher up, where the atmosphere is thinner and the frictional heating is not as great. Harvey Allen said, 'Slow it up before it gets down too low,' and I listened."

MAX: When we went out to Ames for Round Three, we went to this Holiday Inn--which was not part of the Holiday Inn chain but it was an outfit called the Holiday Inn. That was just about the time the Holiday Inn chain started. We were staying there and we were very money-conscious. Everybody had to share a room. My roommate was Tommy Thompson—or I should say it the other way around.

KEN: You were his roommate.

MAX: That's where they put me, in the same room with Thompson. Of course, I was of a completely different generation than Thompson. Everybody knew that Reid was going to retire and Tommy was going to take over the Center at that time. I went out with the guys and came back in, it must have been about 9:30 or 10:00, about time to go to bed. Tommy Thompson was there with Harvey.

Harvey Allen was quite an interesting individual. He drove a real old car, a Dusenberg. Anyway I was ready to go to bed but there was Harvey, and he was drunk, really loaded. Tommy was lying in his bed with the pillows up against the wall about half asleep. Harvey was pacing up and down all excited about all that was going on. He was talking about running the Center. He said, "Tommy, I'm going to tell you how you are going to have to run your Center." All of this time, Tommy hasn't said a damn thing. Tommy kind of opened one eye and said "I know how to run my Center. Just the way I've been running it!" Then he closed his eyes again. *(laughter)* Meanwhile Harvey just kept pacing up and down. I was wondering what the hell I was going to do. I wanted to go to sleep!

PAUL: In one of the preparation talks for a major nationwide Industry, government, academia conference on the current or newest state of the art in a specific area of research which we used to have one or two of every year, some bright young guy from Ames got up and made a very learned statement about something. Harvey got up and essentially said, "Baloney." And went ahead and gave a simple explanation of what it really should be, and the young guy got very upset—"You won't let me have my say." Harvey said, "I did let you have your say and then I had mine. I am a firm believer that everybody in this room has a right to have his say. And I will defend that idea until your death!" *(laughter)*

MAX: Oh, yes. Harvey was a person in the NACA who has received quite a bit of renown. He had a pet hobby which was gathering meteorites. He had two hobbies. One was the people in Belize and the south part of Mexico, the Maya. He was a Maya fan. I didn't know if you knew that. Every time he would get a vacation he would go down there and look at all these old pyramids.

His other hobby was gathering meteorites. And he noticed that the little meteorites, the ones that were of any size at all, could get all the way to the ground, but they were pretty small. And they had a rounded nose. The nose had gotten round because the surface had melted, and it had melted in the position that made them, apparently, aerodynamically stable, as clear as he could tell. So the meteorites had an aerodynamically stable hemispherical nose on them with a small after-body which wouldn't have melted. And he got to looking at these things and he said, "The reason they survive is that they have a very high drag-to-weight ratio." So the way to get down from orbit is to slow down!

KEN: As you go through the atmosphere you limit the heating by slowing down.

MAX: So I was at Ames listening to both Eggers and Harvey Allen. I've always liked simple things, and I kind of liked what Harvey was saying. So when I went back to Langley I first wanted to check on how much heating the lifting body had versus the non-lifting body. I put two guys in my branch working on this to compare these shapes. We wanted to see which would be better. Of course, the full body would have just a pure ballistic entry, whereas the half body would skim along the top of the atmosphere. We found out two things. One of them was that even a pure ballistic vehicle tends to skip a little. Did you know that?

KEN: No.

MAX: It doesn't actually gain altitude. It tends to skip a little. It doesn't ever rise but it stops falling so fast. That was one of the things. But the lifting body definitely skipped. But if you used the right angle-of-attack you could keep it up in the air. Of course, Eggers recommended this to control its cross range. I think that was his idea.

GUY: None of these things had any real control. They were all passive reentry bodies.

MAX: Except that Eggers wanted to control the cross range. And sure enough, there was twice as much heat on the thing with lift as opposed to the one without lift, because it was in the atmosphere longer. A non-lifting body would end up maybe hitting 8 Gs and the lifting body only a maximum of 2 or 3 Gs. If you are decelerating at 2 or 3 Gs, it's going to take you longer to decelerate than at 7or 8 Gs. Intuition tells you it's going to be better to have the drag. And Harvey said it was better. Harvey wasn't particularly keen on Eggers idea because he thought, *w*hy don't we just slam into the atmosphere? You are trying to get out of orbit, after you've been up there long enough, enough is enough, get down. *(laughter)* You can't argue with that logic!

KEN: Provided you don't burn up or something.

MAX: And so we at Langley did this analysis, and one of the guys, Ben Garland, said, you know if you turn it around and enter the damn thing backwards, the cone in the rear instead of the front, you are going to have a lot more drag." And I said, "You sure as hell will!"

GUY: The last time I talked to Al he says he still thinks you came in with the wrong end first!

MAX: I know that! *(laughter)* Anyway, the complete body of revolution that Eggers starts with before they sliced it in two—that's called a Discoverer shape capsule. And actually, that's the shape of the early warheads that the Air Force would use. And the ratio—well, all these things have parameters. One of the parameters is the radius of the spherical nose versus the radius of the rear end. That's a parameter. Another parameter is simply the cone angle. In playing around with these parameters, you can get all sorts of drag. You can make the cone angle very small and have a very small radius on the nose and you end up with something that has very low drag to weight. Or you can have a fairly large radius and a kind of a larger cone angle and then you end up with fairly high drag. So, it's playing that range.

But as it turned out after we got going, the Air Force proposed a manned ballistic vehicle with the Discoverer shape. You know what? They had a gimbaled pressurized sphere, mounted within the Discoverer capsule because they came in the wrong way. They had to position the sphere so that the astronaut would be taking the drag eyeballs-in going outbound, then they'd flip him over 180 degrees for the entry drag. He would then enter eyeballs-in. Whereas I just flipped the whole damn thing which was a hell of a lot simpler and about <u>half</u> the weight!

The Mercury Capsule

In a series of stormy meetings, Faget convinced his Langley colleagues that a ballistic design was the way to go, and Langley decided to back his design. But Ames went on record as preferring a craft with some degree of lift. Among Faget's opponents were the military flight surgeons, who thought eight Gs was too much for a man to take without blacking out over the minute or so of maximum stress during reentry. Faget argued that as a tradeoff for the G load, a ballistic craft would come to an easily predictable splashdown, even if the astronauts blacked out. There was only one path a ballistic craft could take, and therefore only one place it could land. The M2, a competing design, would have a crossrange ability of 1500 miles, and could end up anywhere. Besides, it weighed in at 4000 lbs, while the ballistic design, because of its great simplicity--Faget's trademark--ran the best chance of being held down to 2000 lbs. According to Faget, it was the weight consideration that eventually clinched the argument in favor of what came to be called the Mercury design--a name chosen by Dr. Abe Silverstein for this first American "messenger to the gods."

A group of Langley engineers began to work on details of the Mercury design in November of 1957 under an informal mandate from Bob Gilruth; they included Faget, Johnson, Thibodaux, and Chris Kraft. The group had its offices in one wing of a low building at Langley. Communication was close and informal. Faget would wander from office to office. Sometimes, to demonstrate how bodies with flattish bottoms might have just enough lift to skim a little, he would sail a Frisbee from the gallery. At first, the group had no budget; on their time sheets, they often had to fake their time onto other projects. Still, by the spring of 1958, the basic design of the Mercury capsule had taken shape, with Faget delegating different aspects of it as they came up.

MAX: Once you decide on the blunt nose, the very blunt nose, the next step we took was to optimize the bluntness. Part of our basic work was done in the blow-down jet at Wallops Island. This jet was equipped with a large pre-heated thermal mass that was just upstream of the nozzles feeding the test section. Consequently, we could do aerodynamic heating tests with air heated to the proper stagnation temperature. And we had a Mach 3 nozzle which was pretty good, although the run time wasn't very long. But it was long enough to measure the heating rate. That's all we really wanted.

So, Bill Stoney had a project testing a series of very blunt shapes, maintaining the same frontal diameter but changing the radius of curvature from one-half the frontal diameter (a hemisphere) to infinite radius of curvature (flat surface) to an inverse radius to include a slightly concave surface. We discovered that the within this set the least total heating was with a radius approximately equal to one-and- one half the frontal diameter. This amount of bluntness also produced a nearly constant heating rate over the entire surface--a bonus since the whole surface could be manufactured with a constant thickness.

The vehicle was stable. Well, you can understand how a spherical segment front end would be stable, because the pressures are focused at the center of the spherical surface. Since this point is well behind the center of mass we get something really stable. What it is not, however, is dynamically stable. It has the dynamic stability of a falling leaf. I've got to illustrate this because I love to do it. *(drops a piece of paper that floats back and forth and flips over before hitting the ground)*. It's dynamically unstable! *(Laughter)*

Woody Blanchard got very interested in all this and said, "You know, they have the spin tunnel over here which is nothing but a vertical tunnel. Let's make models that have enough drag and are sufficiently light so that they will float in the test section. Then we can change the length of the conical after-body until we get something that may wobble back and forth but will not topple."

KEN: Let me interrupt you. What you are describing is what you did that was new that the Air Force didn't do when they went through their ballistic missile. When their target came down they didn't consider any of this. This was new territory now.

MAX: You see, what happened was there was a big rush and people weren't thinking the problem through, particularly at the management level. I'm serious. I'm sure this was what was going on. The Air Force had a reentry body that they used as a ballistic warhead. It was both statically and dynamically stable. They understood the heating on that reentry body. They knew that if they scaled it up and if they reduced the angle of entry that the heat load per square foot would go down. So they thought, "Well, hell, that's good. That solves the entry problem. We'll just use that. Don't bother me with anything else. We've got a thing that works!" So, that was what they decided to use.

Now, they said, "We're going to put a guy in there." It turns out that they gotta put the guy in a gimbaled sphere and the sphere has got to fit within this shape— the spheres were a hell of a lot smaller volume-wise than the entire body, and they ended up with something that was estimated to weight about 4500 pounds. Whereas our original estimate on Mercury was 2000 pounds.

We put this Mercury capsule in a spin tunnel and made a scale model about that big around [approximately eight inches], then we added various conical after-bodies making them longer and longer and longer to reduce the dynamic instability as more and more surface became exposed to the oncoming air. Finally the oscillation was decreased to about plus or minus 60 degrees without tumbling. And we said, "That's good enough!" *(Laughter)*

That's how the length of cone on Mercury got established. We knew that it would always have to get to some angle of attack before the cone would get enough aerodynamic force on it to limit the oscillation. Now the vehicle was designed so that in the event that the attitude control system failed-- and we expected that attitude control system to fail--we would still make reentry. And it turned out just about that way on the very first flight that we made, which was Big Joe, which I'll tell you about later.

Who Ran NACA?: A Bottom-Up Organization

GUY: We bootlegged a lot of stuff after Round Three and before we became NASA. .

MAX: Yes, we had a lot of the research done before.

PAUL: Max and his guys did a lot during '57.

GUY: From '57 until we became NASA.

PAUL: On up through Round Three.

MAX: It was in '55, '56, '57 when we were—it just so happened we had three branches in the PARD, and the branch I had was the one that was dealing with very high speed and aerodynamic heating for ballistic missiles. So, we would study anything the Air Force asked us to study.

KEN: OK, that's where you really got your entree.

MAX: NACA would always study what the customer wanted. And the customer was the Air Force, the Navy, and a little bit of commercial aviation—those were our customers. But, we always, in our pride said, "Yes, we'll look at what you want, but we will always do some basic research to investigate the

problem further." That's what we were doing. We were looking at other bodies as well as the ones they wanted to use.

ROBBIE: Did you have a mandate to do that or were you just bootlegging?

MAX: Oh, we had a mandate. Our mandate was that anything the guys down in the lowest part of the organization thought was a good idea to follow probably had merit. You'd talk it over with your supervisor, if he thought it was a good idea, you'd get it funded. It was a bottom-up organization like you never saw before! It was a bottom-up organization with a big free ticket. It was a wonderful place to work.

PAUL: The ticket wasn't very big! We still had to go to Headquarters to spend anything over $5000.

MAX: Yeah, but that wasn't my problem! *(laughter)*

PAUL: Like with Shortal. Shortal is like Max and I. He was a little bit older. I got my experience in the R & D bureaucracy during the war. Guy and Max got theirs on a jeep in Burma and on a submarine in the Pacific. We were all equally mature but more experienced in different things. We all knew: who runs the Navy? The Chief Petty Officers! And who runs the Army? The Sergeants! And who ran NACA? Us! Dr. Dryden was smart enough to realize that.

And he was personally not in favor of NACA becoming NASA. But, he did as he always did—listen to the input from the people in the Centers who knew what was going on. So he was the primary salesman for having NACA chosen as the new place for NASA even though he really didn't believe in it. But that was just his personal opinion. His professional opinion, based on the advice of the people who knew the business, was positive.

And that is how NACA grew up as it did, and then had to turn around later when the fount of all wisdom became centered in Washington, and the Centers were told, do what we tell you to, write it down the way we tell you to, and don't bother us with these screwball ideas.

[Editorial note from Paul Purser: Dr. Dryden was a wise man in many ways. Although we never discussed it, I think he must have been as disenchanted as I have always been with the Washington arena. I turned down four separate offers of promotion if I would transfer to Washington.]

ROBBIE: So that was when it became a top-down instead of a bottom-up organization. At what point did that happen?

GUY: Apollo was certainly bottom-up. It began to change after Apollo, but through Apollo it was all bottom-up.

PAUL: Well, they thought it was top-down!

GUY: Well, yeah, they thought it was top-down. They never understood what went on!

PAUL: And they created lots of trouble by thinking that.

PAUL: But in spite of what they thought, it still actually worked from the bottom up.

MAX: The ultimate proof that it was a bottom-up working organization is that right in the middle of Apollo we started off with—who was it who was running the Apollo program—a guy from Ames—

KEN: I know who you are talking about. Charlie Frick.

MAX: Charlie Frick was running it. And, meanwhile, up at Headquarters they were building an organization to tell us how to do it. And Joe Shea was up there in that organization at headquarters. He'd come down and talk to me and I would say, "Yeah, OK, but we're going to do it this way," and he'd get real frustrated. *(laughs)*

So, finally Frick quits and Piland is put in there on a temporary basis and Piland really didn't like that job. It was too much pressure. So Gilruth was looking around for somebody to replace him and Joe came down and volunteered. I said, "Joe, how come you came down here?" He said, "You convinced me! Apollo is being run down here in the Center and I want to be part of it." *(laughter)* He said," I am tired of fighting you guys and getting nowhere!"

PAUL: He hadn't learned his lesson completely, because he was still the top dog when he got here. We still had to battle him just to start.

MAX: We always had this great big discussion between me and Shea--we got that pretty well settled after that.

PAUL: Just a few minor things like having a little bit of flammable material in the oxygen atmosphere of the Apollo Command Module. Joe insisted on approving a little bit of flammable material in the Apollo Spacecraft several times in spite of the continued *[**GUY:** and continued!]* advice to the contrary of Faget's material specialists and others.

MAX: He had to know everything that went on to every minute level of detail from everybody. I think he missed the big picture because he was looking so much at the detail.

PAUL: But the problem was he not only missed the big picture, he didn't comprehend all the details of each organization. He was hearing but not listening.

MAX: He never changed.

Structure of NACA/Langley: A Flexible Organization

KEN: Max, going back to the early Mercury days that you were talking about, what was your role inside NACA? I know you're considered the father of spacecraft design.

MAX: We had a structured organization. We had three associates or deputies—

PAUL: Three branches in PARD.

MAX: Three guys—Gilruth, Soule' and Stack .

PAUL: Thompson was the Director.

MAX: Well, Thompson was Chief of Research at this time. He had three deputies--Gilruth who had been head of PARD but had gone up there, John Stack—you've probably heard of him—and Hartley Soule.' Each one of these guys had about three divisions, three or four divisions. Paul, you were in PARD and had moved up on Gilruth's staff as I remember.

PAUL: There was a time when Shortal and I really weren't getting along too well, but he still couldn't turn me loose being that it was the General Aerodynamics branch. And Gilruth would borrow me for special jobs. There was a more than six months period when we were developing a lot of high temperature test facilities.

MAX: Shortal came in when Gilruth went upstairs and Shortal was the only bureaucrat in the crowd. He was a real bureaucrat, which we needed, you know. He was kind of like a traffic cop. *(laughter)* He kept records that would drive you crazy. All the time.

GUY: When you would challenge him or got him nervous, he'd start to stammer. You could always tell when you had him.

MAX: He was a great guy—he wrote that book on the history of Wallops Island. He was very proud of his division. But anyway, in PARD they had three Branch Heads. I was one of the Branch Heads. I had Guy Thibodaux's section, which was all the rockets, under me, and then the preflight jets. That all worked fine. There was another group that really did aerodynamics.

PAUL: There was Stability and Control, which was primarily working on missile stability. And the general aerodynamics group was working mostly for airplanes but also for missiles where there was an aerodynamics problem.

GUY: Paul Purser originally headed up all the general aerodynamics work. When he became head of the High Temperature Branch there was a substantial reorganization in the division and the general aerodynamics work and many of people working in that branch were transferred and reported to Max. And I and my section were transferred to Paul's new Branch

MAX: I think Bill Stoney was in the aerodynamics group. And Stoney used the preflight jet to make these tests. And we worked together. The thing was that you could just put the organization aside--anybody in the organization could have a good idea how to run the project. The higher up in the organization, the less time you had to run the project. *(laughs)*

But, when we got back from Round Three, I more or less turned the Branch over to my assistant, Carl Sandahl. He was a good Deputy Branch Head having been a Section Head in Purser's old Branch . I let him run the branch up until the time we turned into NASA. Then they created the Space Task Group. But, for a while there I had people from every damn division in NACA coming around and saying, "What can I do to help you?" We were really going strong on that thing. We were dropping test articles, parachutes, trying landing bags out, and everything else before the NASA got started.

PAUL: It took about three months, maybe four, after Round Three got finished, for Max to get I'd say the majority of NACA to really believe that what became Mercury was the best way to get a man in orbit and get him back safely. Once Max got that sold, he could get help from anybody within the 7,500- man NACA organization.

KEN: Is it fair to say that this was probably the key transition point from the military thinking they were the customer to the real beginning of the possibility of the Civil Space Program?

MAX: That's a completely different story.

The Early Space Program: PARD as the Center of Gravity

MAX: I would say in the first three months of 1958, there was talk—it was kind of interesting—the country acted very panicky to the Russian accomplishments.

KEN: This was the Sputnik.

MAX: Sputnik, yes. That really got them going. But, anyway, for a while, what I was doing was—we had a group that was trying to put something together with the idea that either the Air Force or the Navy was going to build this orbiting spacecraft.

KEN: That was the climate back then.

MAX: The first three months in 1958 we didn't dare think so big as saying, "We're going to be the agency." Like everything else that we came up with, we tried to sell it to the Air Force. Gilruth and Soule' got very interested in this thing (the orbiting spacecraft), and myself and Clo Wood. We put together a dog and pony show and we went to see various people in the Air Force, either Air Force medical or research people, about trying to sell them on this as a good project. And they showed a mild interest in it as we were toting it around. We didn't know then that this was going to be a civilian space program, and that we were the ones who were going to make it happen.

KEN: Were there three, no I think you mentioned four, Centers?

MAX: No, there were really three Centers. Dryden was not considered—It was like Wallops Island. You had people permanently at Wallops Island. Dryden started off as part of Langley with Hartley Soule' as its head and Walt Williams as the on site manager. Later on, Soule' turned most of the operation to Walt and then it gradually got some autonomy as the High Speed Flight Research Station

KEN: So what you've really said in this critical three-month period is that the three Centers were Langley, Ames, and Lewis, and Ames didn't choose to get heavily involved, so it was some combination of Langley and Lewis that formed the basis here.

MAX: And Lewis, of course, was the propulsion outfit, except they were not in rocket propulsion. *(laughter)* We knew so much more about rocket propulsion than they did, it made them sick!

KEN: So the real center of gravity was right at Langley.

MAX: It was right in PARD! Let's not kid ourselves. It was right in that one little division. No doubt about it! Everybody likes to gloss over this, but that is a fact. This one division, perhaps a hundred people within the NACA, was the focus, the eye of the storm, if you wish. Everything rotated around that. We were just lucky to be there---and clever enough to take advantage of it! *(laughter)*

PARD was a maverick organization in relation to other divisions at Langley with a peculiar magic that carried over into the early days of NASA and continued to cast its spell for years. Caldwell Johnson, who worked in Langley's Technical Services Department, said that

> *It was easy to see that PARD was a winner, a perfect place for new young guys to come in where they could take off and grow like weeds. Guy Thibodaux, for example, wound up as head of propulsion at JSC but didn't know very much about propulsion when he started. He was bright as hell. If a young man could get Gilruth's approval, he could develop his ideas into flying machines. And my department--Technical Services--would take the ideas and design them and make the models. The best people in Tech Services wanted to be assigned to PARD support. We worked closely together; we practically lived with them. We forgot which was our own department or who was our own boss. Sometimes fellows like Max had to compete for the*

services of the best guys in the shop. And we used that to our advantage. Someone like Max, who looked like a winner, got better attention. In a way, it was a vicious system. But it meant that the best guys got to the top.

GUY: Gilruth was one of the big drivers, though. He led us—he was the finest boss you could ever have.

PAUL: He and Thompson.

MAX: Tommy knew what he was doing.

PAUL: Gilruth and Tommy Thompson. Both had an ability to get anywhere from two to twenty people together and let each one of him have his say. And at the end they would say, "You know, we can conclude that we ought to do such-and-such." And nobody in the room could disagree. Not because they were knowledgeable but because they got the essence of what ought to be done from listening to everybody, putting it together, and at the end, summarizing it very briefly. And everybody would go away happy.

The Space Cadets, the Air Force, and the Pentagon Meetings

MAX: Around about March of 1958, the President's science advisor, what was his name?

KEN: James Killian.

MAX: Killian talked it over with the President, and the President said he wanted to have a civilian space program. Eisenhower was very concerned about the military-industrial complex in this country. He made a number of speeches about it.

ROBBIE: What were his concerns?

MAX: He was concerned because in Germany the military-industrial group took the country over. It really did. And he knew this. It led to dictatorship. They got so powerful, the combination of heavy industry and politics, i.e. Hitler. The form of government actually changed under Hitler. I'm not that familiar with German history, but it actually changed under Hitler. It went from a democracy, which was true after they got rid of the Kaiser, to a dictatorship. Hitler got industry behind him, among other things, industry and the young kids that didn't know better.

ROBBIE: So Eisenhower was worried about something like that happening in the U.S.?

MAX: I think so. I'm just trying to figure out what was in his head. He was certainly very strong on this point. Killian told him that "the NACA is your best cadre." So they got Dryden in there and they talked with Dryden. And all of a sudden there was a big panic at headquarters, because we had a bottom-up organization. And Headquarters was absolutely unprepared for the idea of running something like a space program—absolutely! *(laughter)* So, Dryden and Crowley got hold of the Centers and they said, "Please send some people up here to help us get ready for the transition."

KEN: What time reference from March--

GUY: March to October, actually.

MAX: I am talking about when they created this.

GUY: Initially it was March. It was in March of '58.

PAUL: May, June and July—

MAX: --was when we actually started going up there.

PAUL: The Space Cadets were on the sixth floor of the Dolly Madison building.

ROBBIE: What Space Cadets?

MAX: Us! *(laughter)*

PAUL: That's what they called us—the Space Cadets! *(laughter)*

MAX: There are the three of us and probably not more than two or three other survivors. We were it!

GUY: I've got a list of all that are still alive.

ROBBIE: Did you call <u>yourselves</u> the Space Cadets at the time?

GUY: This is the committee I was telling you about yesterday, the one I said didn't have a name. Hell, I don't know if it had a name. Do any of you know if it had a name? *(Raucous laughter)*

ROBBIE: What did the people at Headquarters call you?

PAUL: The <u>people</u> at headquarters called us the Space Cadets. Now, what the <u>officials</u> at Headquarters called us, I don't know. *(laughter)*

GUY: There were just a few guys who knew what we were there for. We had a whole floor and they weren't allowed to talk to us! *(laughs)* Everybody knew that we were going to possibly transfer the space program. It wasn't that secret. They didn't know what was going on, what we were doing in detail.

PAUL: It wasn't a question of confidentiality. It was just that we didn't have time to explain it to people. We were too busy doing it!

MAX: It was a completely ad hoc organization pulled together essentially by saying, "We think you could help!" "OK, I'll volunteer." You could say, "No, I don't want to do that." Ames did not send anybody up there because the travel time was too long between Ames and Headquarters.

GUY: I think Bob Crane came once or twice from Ames, and Al Eggers came once or twice.

MAX: Lewis was about the same distance from headquarters as we were. Maybe just a little further, but hardly noticeable. We'd go up there on a Monday or Tuesday and come back on Friday. One guy in the organization, Zimmermann, would stay over quite often. He's the only one who drove. He had a little VW at that time, and he used to drive back and forth. O'Sullivan was with us. I think we had, how many would you say—like 10 or 12 people go up there.

GUY: Clint Brown joined us. Cortwright came in. Tischler was my kind of engineer--propulsion. Neil Sanders was Abe Silverstein's egghead, I guess—he was sort of like the O'Sullivan from Lewis.

MAX: Silverstein came. Abe decided he wanted to lead.

GUY: All I can recall—I gave Robbie a list of them. There are quite a few still alive. There are only about 4 or 5 dead. I couldn't locate Clint Brown. I think he lives in Baltimore. I have a list of all the Clinton Browns in Baltimore here with their phone numbers. I have all the Eggers out in California. We had you and me and Paul, Brownie, Zimmermann, O'Sullivan, and Stoller, and Zavasky from Langley, Tischler, Newell Sanders, Ed Cortwright and Abe Silverstein from Lewis, Dryden, Crowley, Abbott and Clo Wood from headquarters, and secretaries.

We were the key ones from Langley. There is nobody else from Langley that I know of — do you know of anybody else? Later on various people were pulled in from various organizations at Langley on special assignments. Abe occasionally brought others up on a temporary or one-time assignment. There was a guy named Callaghan who came up once or twice and he was afraid Abe was going to transfer him up there, and he didn't like to travel so he quit coming—I don't know what happened to him. I think that's about it.

MAX: Yeah—Lewis didn't send as many people as we did.

GUY: No, not as many as we had. Sanders, Abe, Cortwright, and Tischler were the ones from Lewis. Tischler was my counterpart in Propulsion. And Newell was O'Sullivan's counterpart. Newell Sanders—kind of a meek, mild little guy. And that was it.

Yesterday I told Robbie what our basic job was, when we used to run through the Pentagon like we owned it—I don't know how we found out about those meetings. Zimmerman or someone gave us a list where all the meetings were at the Pentagon. And somehow the ground had been cleared for us to go, and we'd go to any damn meeting that we wanted to over there, and either be quiet or participate.

MAX: I spent most of my time over in the Pentagon talking with the the Manned Space Panel. The Department of Defense—I think there were five or six people on the panel. NACA had two, including myself.

GUY: Was Flickinger one of the guys?

MAX: No I don't think so. He was Air Force. Fuche was there. The guy we were trying to convince was Fuche. In the end, a doctor came in and made a presentation to us on aero-medical research. He was a Brigadier General—I forget his name. Of course, in those days the instrumentation was not as good as we have now. He had this one chart which showed—one of the instruments they were going to have in the control room was called a Death Meter.

KEN: A Death Meter?

MAX: A Death Meter! *(laughs)* And after the meeting was over, Gilruth came over and said, "It was everything I could do to stop myself from laughing when he explained the Death Meter." The Death Meter—they combined about three of four parameters, and some of these parameters in the best medical understanding of the Department of Defense showed how close the guy was to death: his breathing rate, his pulse rate, deep body temperature—

PAUL: When your temperature gets low enough, and your respiration rate gets low enough, and your heart rate gets slow enough—you're going to die.

MAX: You gonna die! He was going to watch the Death Meter in case the astronaut got too close to death *(laughs)*,and then we were supposed to bring him down, I think!

PAUL: Nobody knew, really, how these things all were going to run.

MAX: No one was going to run experiments either! *(laughter)*

KEN: You weren't looking for the edge? *(laughter)*

PAUL: And any combination could kill you at a higher level!

MAX: I forgot what that guy's name was. I don't think it was Don Flickinger, but he was deadly serious *(laughter)*.

ROBBIE: Tell me more about your time in the Pentagon.

MAX: The Pentagon institutions we dealt with mostly were ARPA (Advanced Research Project Agency) and IDA (Institute for Defense Analysis) as well as the service organizations. IDA was the subcontracting institution, really a way to get around the limits of Civil Service compensation — Herb York was the big cheese up there. They had one committee. They did have a committee on manned space. And that was very interesting. I went there and a guy named Caesaro from headquarters—Dick Caesaro—I don't know why he went but he went to all the meetings that I did.

PAUL: He was the Headquarters spy to see what Max was up to, keeping track of what Max did. *(laughter)*

***GUY** (comment): While on Naval Reserve Duty in Johnsville, Pennsylvania, Max had learned of some solid fuel ram-jet work being conducted by the Bureau of Mines under the auspices of the Army Ordnance. Max wanted to visit these people to learn more about the work. It was his first official travel other than going to Wallops Island. I had been to Washington and the Army Ordnance Department which sponsored this work many times so Gilruth asked me to go with Max and "keep an eye on him." I don't know why. I'm as blunt as he is and except for the first time I meet someone, I don't have any more tact than Max! We were also asked to make a courtesy call on the Lewis Research Center and tell them what we were up to because they were working on ram-jets also.*

MAX: The interesting thing is that we didn't have a good idea what the Atlas performance was, up until I got on that committee.

PAUL: We didn't have a need to know.

MAX: We had only implicit, not explicit, information on what its performance was. Implicit information said it could not get into orbit. Our initial design used the second stage of the Polaris (a solid rocket). It had the Atlas carrying the Polaris second stage and then the Mercury on top of that.

KEN: This was the early Mercury?

MAX: Yes, the early Mercury. But we didn't call it Mercury—we just called it "the capsule". Abe Silverstein's big contribution was that he named it Mercury *(laughs)*--his only contribution to the program that I can recall. *(laughs)*

PAUL: There was a nuclear propulsion stage.

GUY: I spent a lot of time over at the AEC and the Pentagon with General Kearns, Jack Armstrong, Howie Schmidt, and Stan Gunn, and was briefed about that.

MAX: There were interesting things going on in that manned spacecraft meeting of ours. The Navy had a program—

PAUL: There was a Navy proposal, an Army proposal, and there was an Air Force proposal.

KEN: There were all three?

PAUL: There were all three.

MAX: And in addition to that, the San Antonio aerospace medicine people had a proposal *(laughs)* which got shoved aside, kind of.

KEN: NASA wasn't formed at this point?

MAX: No, we're still in the NACA.

KEN: So the NACA had a proposal.

MAX: Well, we didn't really have a proposal. We had a design. *(laughs)* Our group was set up with the idea of deciding how this thing was going to be built, and who would build it. But the Air Force, more or less, refused to admit that Eisenhower knew what he was talking about. *(laughter)*

KEN: That was my impression.

MAX: Absolutely. They really were gung-ho that they were going to do this. Furthermore, they kept pointing out to me—they would say, "Well, you know, we have the launch vehicles and we have the range, why don't you let us run the project?" *(laughs)* That's what they were more or less saying. They came to that meeting one time, the Ballistic Missile Division (BMD), who were then running three programs--Thors, Atlases and Titans. It turned out the BMD managed the Thor. They used Ramo-Woolridge to do their R & D. That was their brain group—the Ramo-Woolridge Corporation.

Ramo-Woolridge (later TRW after Messrs. Ramo and Woolridge bought out Mr. Thompson and all his products) had supported them in the early design and development of the Titan. Well, the Titan was still at least a year or a year-and-a-half from first launch. And the Air Force couldn't imagine using that. And they hated the idea of using the Atlas. General Dynamics had developed the Atlas before BMD got so well organized. *(laughs)* So they came in one time to a meeting and said, "What we'd like to propose is making an upper stage for the Thor, and in order to get the performance, we are going to start work right now on a fluorine engine which is going to give us 560 seconds of impulse or something like that *(laughs)*--you know, I just listened to all this—I couldn't believe it! *(laughter)*

There was another one that Kantrowitz proposed to the Air Force—a metal cloth parachute that had a capsule that was nothing but a pressurized sphere. They put this thing in orbit on an Atlas. And when they got ready to come down, they'd deploy the parachute. By changing the rigging of the parachute for variable drag they could navigate the desired downrange location. *(laughs)*

KEN: An early design concept, clearly!

MAX: Absolutely! *(laughs)* And it was going to weigh two thousand pounds. But there was a guy from General Dynamics, a man named Frank Dorr. So when we had a break, and I got Dorr out in the hall, and I said, "Frank, what's this about putting two thousand pounds into orbit with the Atlas?" He said, "Yeah we call it the 'Bare Atlas.' It will put two thousand pounds into orbit."

PAUL: That was the first time we ever knew information on what Atlas could do and what a spacecraft had to weigh.

KEN: That gave you information on the first spacecraft mass requirements.

MAX: At that time I knew we could do it without having to use a second stage. Previously when we had a solid rocket upper stage we also had an escape system in the event the Atlas failed. Now suddenly we had no escape rocket. Shortly after we decided to go with the Bare Atlas, Bob Gilruth said, "Max, what are you going to do when the Atlas blows up?" I said, "I don't know!" He said "Well, you'd better figure something out!" *(laughter)*

Woody Blanchard had invented this tow rocket. Do you remember he had designed a system that had a rocket with two canted nozzles that was positioned on the far end of the launch arrangement? It had a towing cable about fifteen feet long fastened to an eye between the nozzles. The other end of the cable was fastened to the test vehicle which was resting on the rear of the launcher. Both the tow rocket and the test vehicle were equipped with fins for individual stability. The test vehicle was released at burnout and provided aerodynamic data during subsequent costing flight.

GUY: It was the cart before the horse. I had to redesign the rockets so the jets didn't impinge on the model and also design the pyrotechnic separation system.

Max *(laughing):* Anyway, Woody had invented the tow rocket. When Bob gave me the escape problem. I thought "Gee, all we have to do is use a tow rocket but it has to be in place all the time to pull the capsule away from the launch vehicle.

KEN: That was their launch escape tower.

MAX: That's where the launch escape tower came from — Woody's tow rocket. *(laughs)*

PAUL: We should mention that Max made it a metallic parachute.

MAX: What did they call that thing?

PAUL: I can't remember what it was but Kantrowitz was very influential. One, he was a licensed professional.

MAX: He was an <u>arrogant</u> licensed professional.

PAUL (*nodding agreement)*: An arrogant licensed professional.

MAX: No one would dare argue with the guy.

GUY: His boss had some Italian name. I remember you sticking your finger into his ribs one time and trying to scare the hell out of him. *(laughter)*

PAUL: Anyhow, we were at a meeting in Secretary McElroy's Office—he was the Secretary of Defense—at a time when they were trying to decide about the ABMA—what kind of heat shield they would use on their Redstone. They were planning on using an ablating material which would neither melt nor otherwise loose mass and Kantrowitz was working on the big copper shell for the ICBM and he spoke of a stainless steel cone that would take care of the rest of it. I said, "I don't believe it will." He said, "What do you mean you don't think it will?" I said, "Well, I got the 4000 degree ceramic pebble-heated air jet we'd built."

So, after we showed some ablation materials, before and after, they had asked for the idea of stainless steel. We thought we would try that too. So here's what we did. We put stainless steel in there and it looked like a flash bulb, it burned so fast. And that is why we both think stainless steel is a very bad idea. Marshal used ablative material for the Redstone. And Wernher von Braun was sitting in the back yawning. Kantrowitz had this sheepish look on his face for about ten seconds and then he kept on being arrogant about something else.

MAX: Kantrowitz worked at Langley until after World War II ended, then went to Princeton and later he went to work in Industry. He was with AVCO at the time.

PAUL: He had been exposed to the NACA way of doing things. But he didn't learn enough from it.

MAX: You know those guys in the Air Force were trying to make that Discoverer nose cone work — they were determined to make that thing out of copper, because copper has a high conductivity. High conductivity was necessary. Normally heat would travel into the mass of the nose cone as opposed to just the surface. And at the onset heating rate of a ballistic missile coming in on a ballistic flight path, if the copper was more than two inches thick the front end got just as hot. Anything beyond two inches the conductivity wasn't great enough to keep the surface cool.

Anyway, the big name called Ramo-Woolridge had decided that the cool surface compared to a hot one provided a stabilizing effect to the boundary layer which in turn would reduce the heat transfer rate. So, we had Leo Chauvin fly highly polished nose models. And the shops used, I think, four different grades of diamond grit to polish them. They got polished to an extremely shiny surface. You thought you were looking at a mirror! It still overheated compared to their theories. We had their guys come out and look at it and everything else before launch. We very carefully kept a piece of plastic over it that was pulled away about five seconds before liftoff so it wouldn't have any fly tracks on it or anything. *(laughs)* That was part of our education: that theory was great but don't depend on it *(laughter)* unless you have experimental correlation!

GUY: One thing I talked to Robbie about yesterday was the fact that when we were up there in D.C. from March to October we used to stay at the old flea bag down there, the old Francis Scott Key. And Bob and Abe used to get the room by the coffee shop and every night on the way home, we'd stop at that liquor store close to Bob Hunt's seafood place and buy a bottle and we'd go in there and sit down and we'd give them a verbal report of what the hell was going on during that day. She wondered if any of us could remember specifics about what the hell went on during those meetings. I don't recall anything specific.

ROBBIE: Do you remember what went on when you'd pass around that bottle? Do you remember any of those conversations?

MAX: No, I remember it was very nice. *(laughter)*

GUY: They were very open and honest discussions amongst everybody about what was going on and about what we think we should be doing or things like that.

ROBBIE: So, during these NACA meetings on the sixth floor, Max was hanging out with ARPA and Guy was running around the Pentagon going to meetings.

GUY: Yes, I was going through the Pentagon with the Propulsion Science with the Nuclear Rocket Program, and with other areas working on big liquid rocket engines and dealing with various things. I already knew everything going on in the Solid Rocket world. Sometimes I went to a meeting with Max if it seemed like there might be some propulsion item. We'd choose. We'd get a list of the meetings that were available for us to go to and what the subjects were. Zimmermann, I assumed, got those from somebody. I don't know how we were cleared to go over there. I don't remember. All I know is I showed up and they let me in.

MAX: I think I had a badge.

PAUL: Dryden arranged to have our people have access to all of these meetings on the basis that we weren't trying to steal anything from them, we were trying to help them. Our job always had been to help the customer on the part of the U.S. government.

GUY: My feeling was that I was trying to steal everything, I was trying to bring everything in that was related to space!

PAUL: We were trying to learn what their people were up to so we could get an appreciation for the problems that they were facing and know what we could tell them about what we knew based on their needs, not just what happened to be of interest to us.

MAX: But to end up—when NASA was created we had to have a space program. That was the final, the ultimate goal. What is the space program for next year going to be all about? You have manned space flight, you have unmanned space flight, you can look at the planets and a bunch of things like that, and we also had to have a technology program. That was it! And it had to be created by our group. When it was all over, Dryden divided NASA up into two groups, one under Silverstein for Space Flight, and one under Crowley for Aeronautics, airplane flight. Aeronautics and space were then two separate entities.

GUY: Well, later on, it expanded, and they formed a Tracking and Data Acquisition group and a science group.

MAX: This Air Force general was in charge of Propulsion.

GUY: Oh, that was Bill--a little pug nose character, one of the many people given that assignment in the early days. I remember he knew a little about propulsion.

ROBBIE: So while Max was going to the ARPA meetings, and Guy was at the Pentagon, what were you doing during these final NACA days, Paul?

PAUL: I was doing anything that I was asked to do. One of the things was to justify building the Goddard Space Flight Center on Department of Agriculture grounds out in Greenbelt, Maryland. I didn't think we needed it, anyhow, but Dryden had been working to get NACA to become NASA, and like a good trooper I said, "I don't believe in it, but I will write you a good story about why we ought to have it." So I did and Dryden approved it.

GUY: Didn't Dryden have some contact within the department?

PAUL: Yeah. One of Harvey Allen's favorite statements—he used contacts like this—"Even though it may seem a little like nepotism or incest, it's all right as long as you keep it in the family." *(laughter)*

MAX: That sounds like Harvey!

PAUL: That's the kind of guy that Harvey was! If there was a way of getting his point across, he would make his point. But anyhow, I did that. Some of us—a guy Ray Zavasky who was mentioned earlier was very much of a budget guy. He was working on the budget that it would take to do this.

And I think one of the Lewis guys and I had to do a real rough and ready story about if we should someday go to the moon, what would be the value of the stuff that we could bring back? Was there anything there that might be intrinsically valuable if we brought it back? And we could concluded that even if it were paved with cut diamonds, it would probably not be a commercial success for the first flight. *(laughter)* It might someday be one, but we wouldn't be able to justify space flight on a direct economic basis. So, we needed to figure out other good reasons why we ought to be doing this.

I went to some of the same type meetings that these guys did. I had built up some credence with the groups, likely because I rescued them from Kantowitz's suggestion that they just use the stainless steel cone instead of ablation on the Redstone. I was talking to them about what they knew, what they thought a space program should do, what we could do in the space program that could help them? As I recall, back in those days, whatever seemed to be a pressing problem that day, I would try to do something about it.

Aerospace Medicine, Animal Research, and the Form-Fitting Couch

MAX: About a month after Sputnik, the Russians sent the dog up in the spacecraft. They didn't bring the dog down but it stayed up and stayed alive for about a week, I think. They were taking measurements on it. Our aerospace medicine people were just absolutely going crazy *(laughs)*. They were jealous. The Russian doctors were getting all this information and they weren't getting anything. So, they had their own project.

PAUL: One of the so-called "spook" agencies in Washington came down asking the guys at the PARD what kind of data you might get about how animals and people would react in space, but they couldn't tell us where they got the questions they were asking. They couldn't tell us what agency they were from, and it was none of our business, because our business was to provide information to anybody that the government thought ought to have it. That's what we did, all our professional lives—any authorized government person could come in and pick our brains for anything. We didn't try to hide anything. We answered every question as best we could based on our knowledge and our understanding of the question.

And it wasn't until a couple of years later that I finally figured out who these people were. They were monitoring all the Russian telemetry work and trying to figure out what these wiggly lines meant. They didn't have the foggiest notion what they meant!

MAX: They were getting flight data and probably decoding them. But all they were getting was squiggly lines and they didn't know what the measurements were, because they didn't have the calibration, they didn't even know what it was hooked up to. That was kind of interesting.

This was before NASA. You see, as we said there was this period up until March where we didn't know who was going to run the space business for the United States. The aerospace medicine people in San Antonio really wanted to get in on this. They had a large colony of primates to study the effects of the environment of flight such as radiation, acceleration, and atmospheric pressure on these animals. And they also wanted to spend some of their research dollars on space. They had a desire to do some

experimental flights. We had a desire to test a vehicle that they could use on such flights. We were kind of discussing things together to see if we could team up. But Gilruth was scared to death of these doctors.

ROBBIE: Why was Gilruth scared of the doctors?

MAX: Well, they were saying we've gotta fly so many monkeys and so many chimpanzees before we put a man into orbit. You might recall the first cosmonaut went up about a month before Shepard did. Well, at that time when he went up we were in a big argument with the medical people and the National Academy of Science on how many chimpanzee flights we ought to make. They wanted us to make ten chimpanzee orbital flights before anybody could go up. We said no, we would make one, and if it was successful we would go ahead. They wanted ten because one was not "a good sample." Statistically, they didn't believe in one.

ROBBIE: Neither is ten! *(laughter)*

MAX: That's right!

MAX: We said "we are going to put a guy up in sub-orbital flight for six minutes of weightlessness and we think we'll have a pretty good idea of things after that."

PAUL: They said they wouldn't require the ten chimp flights if we would kill 100 chimps on the centrifuge.

ROBBIE: You mean kill them while you were testing them?

PAUL: These were professional MD, PhD researchers, accomplished scientists who would compromise from ten chimp flights down to "just" killing 100 chimps on the centrifuge.

ROBBIE: Why did they want to do that?

PAUL: To learn more about the effects of these high accelerations as well as the flight take off.

ROBBIE: So they just wanted to keep stepping up Gs until they died, 100 times.

PAUL: Of course with that blastoff, they needn't. For one, that would have decimated the world's supply of chimps. We didn't have that many. Plus, we didn't have the time to make 100 centrifuge runs.

MAX: We were doing things that no one had done before. One of the things we got criticized about right away—we knew that during entry, the crew would take an acceleration of 8 Gs, plus or minus a half-a-G, something like 8 Gs, for an extended period of time. Now, people had taken 10 Gs for very short periods of time and it was great to see how well they could do.

I got a hold of a bunch of reports that the Germans had written during World War II for centrifuge tests on their fighter pilots. They were ahead of us in flying jet airplanes and rocket airplanes. They actually had some with rocket power. They could say, "Yeah, these can go fast but they will be taking a hell of a lot of Gs if they try to maneuver them." They were trying to figure out how to do that. They had run some tests with people in the supine and prone position for an extended period of time. I forget the exact data, but they indicated a really good probability that in the supine position, which means on your back, that you could take 8 Gs for a good period of time. At that time, we came up with the idea for the form-fitting couch. If you look at the body and put it under 8 Gs, you say, "That's not much different than whipped cream at 8 Gs. It's going to sag."

PAUL: We also used a couch with the body immersed in water. And Max said, "Well, how much water do you need?" He decided finally that just the water content of your epidermis really is enough. So, he built a form-fitting couch.

MAX: Then we had to test it! Along about this time the Navy had given up the idea of being the agency for flying people in space. But not the Air Force—some of our most vigorous critics now became the Air Force medical people. They were very concerned that they were not going to be in charge of this project, and they were criticizing everything we did. Fortunately, it was the Navy that had the best centrifuge--at Johnsville—a fairly large one. So we sent a test pilot, Bob Champine and his form-fitting couch, to Johnsville, along with one of our young engineers to go out there. A man named Heberlig — you know Jack Heberlig.

KEN: Oh, yeah—sure!

MAX: Heberlig helped me with the couch in figuring out how to make it form-fitting. We'd actually made plaster-of-Paris casts of Mr. Champine in the supine position, and then used that female to make a male plug and then you'd make a couch that form-fit the plug. Champine rode it up to 8Gs. That's what we wanted him to do, go up to 8 Gs. We had the profile, which was pretty much a duplicate of what you're experiencing in entry. It was just a straight line ramp up to an eight-G level period of about fifteen seconds and a straight line ramp down. That's what we specified for the test.

ROBBIE: Was this after you killed the pig?

MAX: No, this is early on, before we killed the pig. This is when we were trying to make sure the couch would work during flight, not during a landing. There was this guy named Carter Collins who was part of the centrifuge staff. He was a little bit slimmer than Mr. Champine. And he'd been doing all sorts of tests to increase human tolerance to sustained levels of high Gs. They actually had a metal suit in a sitting position that they would flood with water with a test subject inside. This minimized the effect of the Gs on the test subject since the body has the same density as water.

KEN: Oh really?

MAX: Yeah. I don't know how they were going to put that in an airplane. *(laughter)* That really worked pretty good. So, Carter Collins said, "Gee, you know, I would like to try that couch out." So he found himself some styrofoam and some other kind of hard foam And he made some wedges so he could use Champine's couch. Every time Champine would take it up to a high G, Carter Collins would take it to the same G. So when they got it up to 8 Gs, Champine said, "Well, I did my job" *(uses hand-washing motion)*. He was ready to go home!

PAUL: He headed off to Edwards

Max *(laughing):* He was not going to be a damn astronaut, he was a test pilot. A professional test pilot.

KEN: Those were the days when astronauts weren't all the big heroes.

MAX: However, Carter Collins said, "Well, let me see if we can go a little higher." So he went up to ten, and then he went up to twelve. Management out there wouldn't let him go but two Gs higher every time. So he went to twelve Gs, and Jack called me up about that time and he said, "You know, Carter Collins has gone up to twelve Gs."

Meanwhile we'd run a few extra trajectories. What happens if the Atlas fails at a velocity near to 18 thousand feet per second? At that velocity the centripetal force from circling the earth at constant

altitude would only be about one-half G. So you would start falling and end up entering at about a ten-to-twelve degree flight path angle. A ballistic capsule would then experience about 18 and one-half G's deceleration from drag. So, I told Jack, "If he is willing to ride it up to 18 and a half to twenty Gs, I'd be forever grateful." The next day, in two G increments, he rode up to 14, then 16, 18, and 20 Gs.

ROBBIE: Did it hurt him? Was he injured?

MAX: He was not injured but he was some kind of sick! *(laughter)*

KEN: I'll bet!

PAUL: He was pretty well pooped out.

MAX: He was pretty well pooped out. What happens is your inner ear gets affected with these high Gs. Your inner ear is what tells you what's up and what's down. It does with three semi-circular fluid filled canals that provide a function similar to a set of gyros. Each canal has some little hairs that sense flow of the fluid when the head is rotated. Your sense of balance is primarily related to the output of the inner ear. Carter's inner ears were badly traumatized by the centrifuge from the combination of excessive forces on the inner ear sensors and the Coriolis effect. Of course he's holding his head real still. What really happened is that his inner ear got extremely overloaded and lost its sensitivity. He left the centrifuge around four or five o'clock right in the middle of traffic. He had to drive, I believe, fifteen miles.

MAX: He said he had to stop three times to vomit on the way home.

KEN: So he got the early motion sickness.

ROBBIE: But there was no permanent damage to his ears?

MAX: No, no permanent damage to anything. He was in great shape. The Air Force was upset. You know what their attitude was? "Those guys in that Navy centrifuge facility are taking terrible risks!" *(laughter)* They were trying to invalidate the data—sorta like "You can't bring that up in trial. You didn't have a warrant for taking this data, so the data is invalid." *(laughs)*

When the time came to test the couch for the Gs the astronaut would experience during landing, Heberlig designed a couch for a pig, who was to be hoisted to a height of 16 feet and then dropped into a sandbox, where it would land at a velocity of 30 feet per second--the predicted rate for Mercury. But, strapped into the couch, the pig died before the first test could begin. Heberlig was baffled, and for a while there, it looked as if humans might never get up off the planet because they couldn't come back down! But finally the farmer who had sold Heberlig the pig explained that pigs <u>always</u> die if they are kept on their backs for any length of time, as their organs press on the lungs and the pig suffocates. As a result of the farmer's explanation, the period between strapping in and launch time was drastically shortened, and the tests were a success.

Formal Education, or the Lack of It, at Langley

PAUL: There was this argument about should NACA become NASA or should the Air Force or somebody else run the space program? The National Academy of Sciences had a little study panel to evaluate the various places. Since Langley was kind of the top NACA Center, being the oldest, and we thought the smartest—of course, others didn't really agree with that—anyhow, this panel decided to do an evaluation of Langley to see just how qualified we were to run a big program. They came down and

in just a few minutes they decided we were totally unqualified. Do you realize that of the 3500 employees that we had at that time, we had only three "professionals"?

ROBBIE: According to whom?

PAUL: According to this National Academy of Sciences panel!

ROBBIE: And how were they defining "professional"? A college degree?

PAUL: An earned PhD! We had three on the staff that had earned PhDs in some branch of science.

ROBBIE: Which three were they?

PAUL: Karl Kaplan was one.

GUY: Kennedy Rubert was another one and I think John Houbolt had gotten his by that time.

ROBBIE: All of you had college degrees but not PhDs?

PAUL: Well, some of us didn't even have college degrees. The best design guy, Caldwell Johnson, had two years of college—

GUY: In the Langley Apprentice School. *[**MAX:** And I think the University of Virginia.]*

PAUL: In terms of brain power, he should outrank anybody!

GUY: You have to realize in those days, very few people even got a Master's degree. Most people, particularly engineers, did not go on to the PhD. If you were an engineer and you got through your Bachelor's degree, you were going to go out and work and make money. Engineers were not in it for academic achievement—they wanted to get the job done!

ROBBIE: And the three of you had stopped after the BSc degree.

GUY: I was afraid if I went back to graduate school, when I got back some young kid who had a Bachelor's degree would be sitting in my desk holding down my job.

Interruption from Mrs. Thibodaux concerning dinner. Tape off. She starts telling a short story. Tape on:

*Background from **GUY:** Paul and I were attending a Solid-Propellant Conference in Huntsville, Alabama. I planned to take leave after the conference and drive to Louisiana in my automobile. To save money, Paul rode with us and flew back.*

Mrs. Thibodaux: We're en route to Alabama. We get there and he had his toothbrush and a bar of soap and a razor. He used the bar of soap to take a bath, to brush his teeth, to shave, and to wash his clothes. *(laughter)* He'd come home every night, wash out the shirt, wash out his underwear.

ROBBIE: That's called traveling light!

PAUL: In those days, per diem was still close to six dollars a day. That was for room and board and everything.

The Creation of the Space Task Group

By the summer of 1958, it had become obvious that NACA would be the nucleus of a new civilian space agency. The National Aeronautics and Space Act was signed on July 29, 1958, and the power of Eisenhower's vision for a civilian space program became clear. Congress, however, had still not come up with funding for Mercury. What it needed to see was a small-scale model of the final configuration. Jack Heberlig arranged to have one built at the Langley machine shop. "I bootlegged it through the shop, " Heberlig said. "I faked it through on Atlas Warhead Requisition No. 263--I still remember that number." Gilruth and Dryden took the model to Capitol Hill at the beginning of August, and presented to the House Select Committee on Astronautics and Space Exploration, which approved it and a 30 million dollar request for funding.

On October 1, 1958, NACA became NASA and Eisenhower appointed T. Keith Glennan as its first administrator. NASA had been in business but a few days when Gilruth's PARD team presented their bootlegged plan for putting man in space. Within two hours they had approval of the plan and a "go-ahead," with Glennan advising Gilruth to go back to Langley and put together a group to manage it. This group, although it would be located at Langley, was not to report to Langley but directly to Abe Silverstein, who was now head of space projects in the new NASA. Back at Langley, Gilruth asked his boss, Floyd Thompson, how he could get men transferred to his new--and now official--Space Task Group. Thompson suggested that a simple memorandum to him would allow Gilruth to name those he wanted. Gilruth noted that from the group of people listed in this memo has come a good share of the leadership of the American space program. Guy Thibodaux's name is not on the list because after a point Thompson freaked at the number of good people Gilruth was taking away from Langley and he wouldn't let Thibodaux go. So Tibby just continued to provide informal support to his compatriots in the Space Task Group, and eventually rejoined them at JSC.

ROBBIE: Let me ask you guys, why didn't Guy go with you into the Space Task Group?

PAUL: That's because some of the other leaders at Langley complained to the head director, Floyd Thompson, that Gilruth was taking all the best people, and that he was going to have to compromise down and just take a few of the real good people in place of some of the top notch people.

The only one that I have any recollection of was this one guy from the Instrument Research Division--that went right up to Thompson to sign it and his boss said, "No, you can't have him. Get somebody else."

GUY: I told her yesterday that the Director of Langley, Tommy Thompson created the Space Task Group, actually. Headquarters didn't do it. Thompson wrote the notes that said that.

ROBBIE: Are Tommy Thompson and Floyd Thompson the same person? You guys had me really confused for a while.

GUY: Tommy was his nickname just like my nickname is Tibby. Tommy was for Thompson. Thompson's main claim to fame, you know what he was the proudest of, was that he designed the attack submarine. He told me he felt that that was his greatest accomplishment. It was not in the field of aeronautics. It was in the field of hydronautics.

ROBBIE: How did we the Space Task Group get created? You guys were all up there in DC.

MAX: Well that's very interesting. That's a good story all in itself. I was with Bob Gilruth about October 10th, or something like that. NASA got born on October 1st, 1958. We had been working on this manned capsule program ever since early spring. [***GUY:*** *Silverstein wasn't yet involved to name it Mercury.]* We'd already done a lot of tests. We'd done some escape tests using some rockets that Guy came up with. We'd done parachute tests. We'd done landing tests to check our landing bag—we'd done a lot of stuff. It was all kind of basic research—it was charged to the research budget of the NACA. So we went up to talk to Glennan [the first NASA Administrator], who had come in about a month before—he came in around the first of September.

PAUL: This meeting was not held until October 4th or 5th.

MAX: Yeah, it was the first official meeting on manned space flight. So we were briefing Glennan. He hadn't had a briefing on the program. That was the purpose of going up there. Bob and I went through the whole thing of what we'd done and where we were and what we were planning to do, we just gave him a complete status report. When we got all finished there was a long period of silence. Finally, Glennan said, "Well, what comes next?" Bob looked at him and says, "Well, you know I've got to have authority to go ahead." Glennan said, "Oh! OK, you've got the authority." Bob knew he was supposed to be running the program but he hadn't been assigned a staff or offices and other facilities that would be needed. He just had authority to do it. He had a budget—he had a thirty-million-dollar budget.

PAUL: Bob told me that the actual words that Glennan used—the first three words almost gave him heart failure. They were, "Get the hell--" and Bob was sure he was going to say, "out of here." But the next four words were "on with the project!" *(laughter)* That's how it got authorized.

MAX: Bob went back and talked to Tommy Thompson and said, "You know, I got to have some people." So Tommy said, "Well, let's form the Space Task Group."

ROBBIE: Where did he get the name, why did he think of it as the Space Task Group?

MAX: It was a silly name! We had to have a name—it was going to be a temporary name. Tommy Thompson actually created the organization. He directed me to organize the Space Task Group. See, it's not in capitals here. (*Looks at the actual memo [see below], laughs)* That was kind of presumptive because the administrator never talked to Tommy Thompson, but he said to implement a manned space project. "This task group will be located at Langley Field," and so forth and so on. Finally in the second paragraph he puts the capitals on it—Space Task Group. And here I see Bob Gilruth signed the damn thing—I thought Tommy did.

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[Here we provide a reproduction of the original memo]

NASA - Langley

November 5, 1958

MEMORANDUM for all concerned

Subject: Space Task Group

1. Effective this date, a Space Task Group reporting directly to NASA Headquarters is established at Langley Field, Virginia to implement a manned satellite project. Mr. Robert J. Gilruth has been appointed as Project Manager and Mr. Charles J. Donlan as Assistant Project Manager.

2. The following Langley Research Center employees are hereby relieved of their present duties and assigned to the Space Task Group:

Bland, William Jr. (PARD)
Bond, Aleck C. (PARD)
Chilton, Robert G. (Flight Research)
Donlan, Charles J. (Off. Assoc. Dir.)
Faget, Maxime A. (PARD)
Fields, Edison M. (PARD)
Gilruth, Robert R. (Off. Assoc. Dir.)
Hammack, Jerome B. (Flight Res.)
Hatley, Shirley J. (Off. Serv.)
Heberlig, Jack C. (PARD)
Hicks, Claiborne R., Jr. (PARD)
Kehlet, Alan B. (PARD)
Kolenkiewicz, Ronald (PARD)
Kraft, Christopher C. (Flight Res.)
Kyle, Howard C. (Instr. Res.)
Lauten, William T., Jr. (Dyn Loads)
Lee, John B. (PARD)
Livesay, Norma (Off. Serv.)
Lowe, Nancy C. (Off. Serv.)
MacDougall, George F. , Jr. (Stab.Res.)
Magin, Betsy F. (PARD)
Mathews, Charles W. (Flight Res.)
Mayer, John P. (Flight Res.)
Muhly, William C. (Planning Office)
Purser, Paul E. (PARD)
Patterson, Herbert G. (PARD)
Ricker, Harry H., Jr. (Instr. Res.)
Robert, Frank C. (PARD)
Rollins, Joseph J. (Off. Serv.)
Sartor, Ronelda F. (Fiscal)
Stearn, Jacquelyn B. (Off. Serv.)
Taylor, Paul D. (Full-Scale Res.)
Watkins, Julia R. (PARD)
Watkins, Shirley P. (Off. Serv.)
Zimmerman, Charles H. (Stab. Res.)

(signature)
Floyd L. Thompson
Acting Director

TMB.KOH

Copies to: Director
Associate Director
Assistant Directors
Chief, Technical Services
Chief, Administrative Services
Assistant Chief, Tech. Services
Assistant Chief, Adm. Services
Division Chiefs
Branch Heads
Section Heads
Unit Heads
Each affected employee
NASA Headquarters
Files (3)

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MAX: But anyway, Gilruth went and negotiated these people from Thompson.

PAUL: Tommy had decided to release the people. He was still outrunning Gilruth at that time.

MAX: Man, you talk about lifting yourself up by your bootstraps, that's exactly what happened! *(laughs)* It was a very informal thing.

ROBBIE: What happened next?

MAX: When we got word that NACA was going to be NASA, Chuck Matthews joined us. Chuck asked me what to do. I said, "Well, we ought to start working on getting a contract." So he got a group together to write the specifications and that included people like Caldwell Johnson and others. See, I was going to Washington every week with these guys and Chuck was back there doing the specifications. This was before it was the Space Task Group

ROBBIE: OK, because once the Space Task Group got established you guys didn't keep going up to Washington any more, did you?

MAX: No, no.

ROBBIE: Because then you had to run the program.

GUY: We still went up to Washington a lot to testify before Congress.

MAX: Yes, but not any more to plan the agency. By that time, it was up to Dryden to tell Glennan what to do, I guess. *(laughs)* The fat was in the fire!

ROBBIE: So when you guys got created as the Space Task Group, was your first agenda to implement a manned space flight project?

MAX: Oh, yeah. And we concentrated our full effort on that. We actually had a Request For Proposals out by late November. NASA had only been in existence since October the first.

ROBBIE: This was November 1st when the group was created.

MAX: By late November we were out trying to contract for it with the specifications.

ROBBIE: How did you do it so fast?

MAX: Because we didn't have a bureaucracy—you just go do it! *(laughter)*

GUY: Nobody was telling you you couldn't do anything!

MAX: We had a procurement office— Sherwood Butler was in charge of procurement, and he'd say "Well, all I need is a specification, and I'll help you guys procure it." So we wrote him the specification. That's what Chuck had been doing and we just tuned it up a little bit and turned it over to Butler. (***GUY:*** *Butler was an electrical engineer from VPI who had been assigned to procurement much as Paul Purser was assigned as budget officer, and stayed on and became head of the Procurement Division.)*

PAUL: All of us had kind of learned over the years that it's a helluva lot easier to figure out how we can do it instead of to think of all the reasons why we can't do it. So when they said "Do it" we could! That's when we had the most fun -- when we were doing it.

MAX: One of the good quotes now is "Just Do It!" You know, we'd been "just doing it" for a long while! We had a lot of practice just doing it.

In his memoir, PARD Director Bob Gilruth writes:

> *In those first early weeks, we prepared a specification for the Mercury capsule that was to go out to industry with a request for their proposals within the next two or three months. As a matter of fact, the entire time span from the go-ahead in October 1958 through the RFP, bidders,*

briefings, source selection activity, and placing of the contract all occurred before the middle of January, less than four months later. This kind of performance could only occur in a young organization that had not solidified all its functions and prerogatives….

During this same period of time, we established an arrangement with the Ballistic Missile Division of the Air Force for the procurement of the Atlas launch rockets and for launch services. We worked out a plan with General Medaris and Dr. von Braun for the Redstone Launch Vehicles, and we started work in our own staff for a design and specification for the Little Joe rocket to be used in tests at Wallops Island.

We gave to Lewis the job of creating a full-scale Mercury model spacecraft for an unmanned flight at an early date to establish levels of heat transfer and stability in a full-scale free-flight test on an Atlas booster at Cape Canaveral. Scott Simpkinson of Lewis was the key man in this project. He and his group, working with a small group at Langley under Jack Kinzler, created a spacecraft called Big Joe, which was the first major step in providing the capsule design.

Simpkinson and his people did the lower part of the capsule, the instrumentation, control system, and the heat shield, while Kinzler's group did the upper heat shield and the parachute deck. The project was started in December 1958 and flew successfully in September 1959! (From Bob Gilruth's "Memoir: From Wallops Island to Mercury 1945-1958," unpublished ms. presented orally at the Sixth International History of Astronautics Symposium, Vienna, Austria, Oct. 13, 1972)

GUY: After he'd created the Space Task Group, Thompson cleaned out first some areas over in the east area and he gave you all quarters and set you all up with all of the things you needed to operate.

MAX: We were working in the office area in the Unitary Plan Wind Tunnel. We had temporary quarters there. I spent half of my time in the Unitary Plan Tunnel building and in my PARD office up until Thompson cleared out a space for us in the East Area. We made it our regular administrative building. That was a nice place. It had its own reception area. It was a good move, and it kind of separated us from the rest of Langley—a geographical separation. Everybody at Langley used to carpool, and right away we stopped carpooling because we were never able to quit at quitting time. When you carpool, everybody's got to quit at quitting time. In a matter of a few weeks, everybody in the Space Task Group realized they were not going to be in a carpool any longer.

(From Gilruth's memoir:) All of our people worked holidays, evenings, and weekends. We even worked on New Year's Day that year, but we did take off New Year's Eve. Those were the days of the most intensive and dedicated work of a group of people that I have ever experienced. None of us will forget it. We were making tests of escape rockets over on the beach at Wallops Island, testing parachutes in full-scale drops from helicopters, and measuring water impact loads on capsule configurations at Langley Field.

ROBBIE: Why did you feel such urgency to work such long hours? *(laughter)* Was it just that it was fun or was it Sputnik, or what was it that drove you?

MAX: Both! We knew that the Russians were trying to put a man up there, and we didn't want them going up first.

GUY: That carried all the way through the Apollo program. Everybody I had working for me was willing to work whatever amount of time was necessary with no overtime pay.

MAX: Everybody accrued a lot of leave, and finally they put a cap on the leave you could accrue.

GUY: All you had to do was drop the word that there was something that needed to be done. You never had any trouble getting the people to do what was needed. Everyone was dedicated and challenged and interested to whatever was to the limit of our abilities. We were all in our mid-to-upper thirties and full of vim and vigor and were enthused about everything. The other thing was that we didn't have any bosses who put any impediments in our way. That was one of the real keys to working in that operation. It was a total team effort where everybody could participate to the limit of their abilities.

MAX: Let me go on with the schedule. We got the procurement package out and we got the response back. We only gave them four weeks to respond. We got the response back just before Christmas, and we worked over the Christmas holidays evaluating the proposals. I remember that well. We borrowed a lot of guys from Langley to help evaluate the proposals. We chose the winner, McDonnell the first part of the year and had him under letter of contract by the second week of January. Meanwhile, while all of this was going on, I was negotiating two Atlases just in case we needed them.

ROBBIE: On the side! *(laughter)*

MAX: I was going out to California anyway and just bumped into the fact that I could get two Atlases.

ROBBIE: Tell that story. How did that happen?

Big Joe

Guy (comment): Little Joe was used for the early tests of the Mercury Capsule launch escape tower and recovery system at Wallops Island. The next step was to do more severe tests of the Capsule including reentry and recovery; for that the Atlas at Cape Canaveral was used. As it was bigger, someone decided it should be called Big Joe.

MAX: Along about two months after NACA became NASA, and the program was officially authorized, I was in California at BMD—the Ballistic Missile Division—trying to get an Atlas D, and one guy said, "You know, we think we're going to have two surplus Atlas Cs, and we don't know what we're gonna do with them." I couldn't help but ask—you know, we'd been through hell with the damn guys at Redstone trying to get them to give us a decent schedule. So, I said, "When do you plan to use those?" He said, "We're going to fly them if we have a use for them—we'll probably fly those next August." Now this was in November when we learned they would fly them next August!

KEN: Less than a year.

MAX: So I said, "OK, we'll take those two and we'll use them to launch some full-scale reentry heating models." These were what were often referred to as "boiler-plate" vehicles since the structure was heavier, and they were equipped with a minimum of operating systems.

KEN: That's how Big Joe got started?

MAX: Now wait a minute. At that time we had the Mercury Request For Proposals out but had not yet chosen the contractor. We didn't know what the shape, the final shape, of the vehicle was going to be. We put out a work statement which said, "We think it ought to be this shape or something like it." Of course McDonnell Douglas comes in and they changed the lines a little bit. They made the size change a little bit. We got them under contract in the middle of January. The minute we got a letter of contract with them, we had a shape, a final shape. *(laughs)*

We sent half the work for the boiler-plates to Lewis. They agreed to do part of it, and Langley was going to build part of it. Lewis was going to put the attitude control system in it. They sent two of their two attitude guys to Langley. We used a compressed air attitude control system. And we didn't get the damn thing built in time. We actually got through about two weeks late. *(laughter)*

KEN: That's remarkable given that time period!

MAX: Like I said before, the vehicle was designed so that in the event that the attitude control system failed, we would still make reentry. And we expected that attitude control system to fail. Now on the very first flight that we made, which was Big Joe, we had the damn thing— a full-scale external aerodynamics exactly like the Mercury with a parachute in it and an attitude control system. We planned a trajectory that would reenter down range closely duplicating a return from orbit. So we put the thing on the Atlas and launched it. The Atlas failed. It failed to stage.

KEN: This was the first time you ever put anything on top of a booster like that, wasn't it?

MAX: Yes, it was about the third time the Air Force ever flew an Atlas—the third or fourth time *(laughs)* successfully. They had a bunch of launches where it blew up, but this one didn't blow up. But the engines failed to stage off. It had three engines, two big ones, and at—oh, I guess about 120 seconds or something like that, the two big engines are shut down and the flight is continued with the center engine. The big ones are supposed to be jettisoned. But the big engines did not drop off.

So, the Atlas keeps going with the unaccounted for weight of these engines. The Atlas was supposed to reach a velocity of something like twenty-four thousand feet, at which time it would shut down all propulsion. But because of the extra weight of the two big engines when it got up to about eighteen thousand feet a second it ran out of propellant. It never turned off the propellant valves. So when combustion ceased some propellant and the gases that pressurized the tank flowed through the nozzle and continued to produce a low level of thrust. This was enough to continue the production of micro-acceleration. *(laughter)* So, it was going along probably to two-one hundredths of a G.

KEN: It was still struggling!

MAX: Big Joe had a backup separation trigger. It was timed to implement separation five seconds after the predicted time for the cutoff signal from the Atlas. Of course, Atlas never transmitted the cutoff signal. So the thing goes along until finally the backup timer on Big Joe comes in. This releases the Marman clamps that were used to attach Big Joe to the Atlas and it's ready to separate. The Atlas was equipped with retro-rockets to help effect payload separation. These were to be fired by the cutoff signal which never came. And the Atlas didn't back off and there was still sufficient thrust coming from tank gases exiting through the nozzle to keep the Atlas plugged into Big Joe. Meanwhile, about ten seconds after expected separation, the Big Joe attitude control system is implemented by timer. It was instructed make Big Joe do a 180-degree flip. So, it burned up all its compressed air trying to turn the whole Atlas around. So no attitude control system! But, it made a good entry! *(laughs)*

KEN: It did? So you still got the entry information in spite of a non-working attitude control system.

MAX: And we did have a failure on the first launch.

KEN: And you did have a failure. You didn't plan on it, but you got the chance.

MAX: The aerodynamic shape was such that it weather-cocked. We had one instrument in there that was very interesting. It was a sound detector. Nothing but a microphone and a tape recorder, is all it

was. We had that on tape and we could hear the entry. It would go whoosh, whoosh. The whooshes would get louder and faster. Whoosh, whoosh, whoosh, whoosh, whoosh, whoosh, whoosh, whoosh, whoosh (*increasing tempo)*. As the Gs went up, the frequency went up and the amplitude decreased. This is the same effect you get when you strum a banjo or you get a rubber band and you flick it. You get one frequency, and if you pull it tight, you get a much higher frequency. Frequency goes up, amplitude goes down. Well that's exactly what we could hear going on during entry! *(laughter)*

PAUL: He had figured this out sometime before, because when people would think that the thing doesn't have any aerodynamic stability, it does in that flight plan because as it's coming in the air gets denser and denser to do this deal of tightening the string.

MAX: We've done that analysis before. That wasn't an unexpected thing. We got confirmation on the whole thing right there. You couldn't have asked for a better flight. *(laughs)* The only bad part was that the pickup ship was supposed to pick up, I think, at about seven-hundred to a thousand miles further down range. *(laughs)*

K *(laughing)*: Small details.

MAX: We had airplanes out there looking for it. We had a signal coming from it, a locator signal, and one of the airplanes picked up the locator.

Tibby's Propulsion Work

ROBBIE: Did you participate in Mercury even though you weren't part of the STG?

GUY: I did.

MAX: He did <u>all</u> the propulsion work on Mercury.

GUY: I did all the rockets—the launch escape rockets and the retro rockets, I was the guy who went and worked with McDonnell Douglas on this part of the program. Even though my travel was coming out of Langley's budget no one ever denied a request when I traveled in support of the Space Task Group

MAX: Before that we had to design a for-instance rocket for the escape rocket—we had to get an escape rocket—manufacture it. Of course we needed something to put in the specs so we had a for-instance rocket which was nothing but a paper design. But we also needed an early rocket for some early escape tests. For that we had to modify an existing rocket—to a three nozzle affair so that the jets would not be directed right at the capsule. Guy was able to obtain the existing rockets—Guy got them to change the nozzle. We finally made our first flight about time the NASA was authorized.

GUY: When we were evaluating the proposals to build the Mercury capsules, we used a numerical rating system to rank the contractors. I was in charge of the propulsion review team and gave one contractor a zero. Bob Gilruth called me in and said "Guy, you shouldn't give anyone a zero. Why did you do it?" I said, "Because I couldn't give them a minus." They knew the escape rockets resultant thrust should be along the capsules axis, so they had all the nozzles pointed down right at the capsule so they passed through the capsule's center of gravity!

We had a wonderful shop that could make anything you wanted. We had designers that could pick up your ideas and design them. There was no turnaround time—it was instant.

MAX: We didn't build those modified nozzles ourselves, though, did we, Guy-? We could have.

GUY: Yeah, the shop built them.

MAX: We put a new rear end—

GUY: Yeah, put a new rear end on the rocket. I used to cut them in half and I used to—

MAX: We put a graphite insert in the throat. We figured anything that industry could do we could do and we could do it our way. Our way was the fast way, so we would do it.

PAUL: We had a bunch of technicians in the shop at the time that could make anything out of anything.

GUY: If someone was able to manufacture it, they damn well could do it too.

PAUL: And they could do it better, because they did it more carefully—to work, not just to meet specifications.

GUY: I let the industrial contracts after Langley did a few prototypes on some new rocket designs. No one but our own shops could ever build those things back in those days. They would build them and make them work. A couple of outfits almost went broke trying to build them.

MAX: These were composite material--?:

GUY: No, just regular 4130 heat-treated steel, 40-inch diameter sphere with 56 thousandth of an inch wall thickness. They did all sorts of things that were necessary to make that damn job work. They manufactured them and I tried to get industry at the time to try to build them in quantity.

MAX: The only thing I think our shops couldn't do was casting.

GUY: They went over to the Navy yard over at Portsmouth, Virginia for large forgings. Later on, Langley could do an adequate job with small castings.

Von Braun, Little Joe, and the Issue of Control

Once they were no longer needed as designers for Mercury, Faget, Johnson, and others went to work on flight-testing full scale boilerplate models of the capsule, models built by McDonnell under Caldwell Johnson's supervision. Several test launches were on Sergeant and Recruit rockets. Other tests were held at Cape Canaveral using Redstones, Atlases, and a Scout. Before the first test with a Redstone, Faget got into a memorable row with Wernher von Braun and his people at Marshall Space Flight Center. Von Braun told Faget that he wanted Langley's boilerplate capsule at Marshall three months before the launch, so that his men could mate it to the rocket and test the systems of the two together. It would then be unmated for the trip to the Cape. Faget suspected a turf battle for control of the Mercury program. "Why should we do that?" he asked. "All we want is to put our capsule on top of your rocket." He had designed a simple interface between the two, consisting of a clamp ring and four connecting wires, 2 for aborting a mission and 2 for effecting separation of the capsule from the rocket. He saw no reason why the capsule and the rocket could not be sent separately to the Cape and mated and tested there before the launch. After a lot of arguing, von Braun backed off.

The same arrangement would link the Apollo spacecraft to the Saturn rocket. According to Caldwell Johnson, the simple interface between the rocket and the capsule was one of the best management

decisions ever made. He said, "We figured that the interface was like a sheet of plywood, with everything on one side belonging to Marshall and everything on the other side belonging to us. We felt that it was cheaper even to have two separate guidance systems--one for the rocket and one for the spacecraft--than to have to go through all the meetings and the paperwork that would have been required if we'd had to agree on a single guidance system for them both. NASA no longer thinks in those terms. Several centers will be involved in a project nowadays--often as a result of congressional pork barreling--and their engineering teams spend a lot of time and money arguing with each other." For example, one trouble with NASA's space station before its scaling down and resdesign was that it was to be divided among ten major contractors and NASA centers, for a total of 90 interfaces.

GUY: I had an interesting talk with von Braun. Remember you were always talking about putting Thors and Jupiters in the Air Force's Big Joes or something?

MAX: We were going to fly Jupiters.

GUY: You were going to fly Jupiters, and of course von Braun was playing hard to get—the price was real high.

MAX: Three and a half million dollars each.

GUY: I told her about—I don't know if you are aware that Dryden sent me down to ABMA [the Army Ballistic Missile Agency in Huntsville] to case the joint one time. Once he got wind of the fact that he might have to pick up von Braun's whole operation, he called me in person and said, "I want you to go down there and then come back and tell me what's going on down there, what size of operation they have." That was a very interesting trip because here I am, I guess I had just made GS-15. We flew in on a Redstone airstrip, and military protocol meant they had to have at least a bird colonel meet me at the airplane. It turns out that I was the only passenger on a DC-3 or R4D and I had a GS-15 pilot flying me in too *(laughter)*. That kind of shook them up.

Dryden didn't tell them what it was all about but he kind of supported where I went and talked to on the Army side. The ABMA was split into two groups. They had the small missile group that did the Lance and all those other things, and then they had von Braun doing the Redstone and Jupiter. It turned out that most of the in-house work was von Braun's operation because they did everything in-house. And I talked to a few bird colonels, I guess to put up a smoke screen to show I was interested in all the things they were doing and not give my mission away.

Frank Williams gave me a rundown on the size of the operation and told me about what they were doing. And Willy Mrazek took me on a big tour, let me walk inside the Redstone and see how big they were. Then they let me look at the Jupiter. I met with von Braun and he invited me up to his office, and I had lunch with him over in the Executive Dining Room. I was telling her the eerie sense I had when I walked down the hall that every German did that brace and clicked their heels and came to attention when von Braun walked by. It was a very eerie feeling. Then we got in the Executive Dining Room and no one could pick up a fork and eat until he sat down and started eating. I gave Dryden a verbal report that "I believe there are about 6500 people you are going to have to pick up down there. It's almost the size of NACA." He hadn't understood what he was getting into.

MAX: Von Braun was a neat guy. He was a real character. He'd charm the pants right off of you.

PAUL: He had built-in loyalty from this group. He was always Herr Professor. He was not Dr. von Braun, he was Herr Professor. In Germany that was a much better title.

ROBBIE: When did he retire?

MAX: I think he retired in the late 60's.

MAX: Someone wanted to get rid of him. They put him in some little cheap job involving advanced programs up in Washington.

GUY: I'm not sure whether he died first or retired.

ROBBIE: Why did they want to get rid of him?

MAX: I don't know. He might have wanted to go to Washington.

ROBBIE: Guy was saying yesterday that von Braun was so famous that no one even knew who his deputy was because everyone just concentrated on him.

MAX: Well that's for sure. The whole approach was so obvious. They knew von Braun and they used his name, just like if you've got an Earl Campbell on your team or somebody like that, it gives the team a lot of publicity. They used von Braun. The whole center used von Braun as a figurehead--he was very charming and of course he could open any door for them. You can understand--these people came over in this so called Operation Paper Clip that you may have read about—they got themselves out of Germany before the Russians got them. At first we put him in New Mexico, at White Sands, and Alamagordo. Then they moved him to Huntsville. They were concerned about their heritage. So von Braun was not only their boss, but he was their social leader. The Germans really adored that man. And he kind of deserved it, because he was more than just a good rocket scientist—he was a hell of a leader. He had all of the top qualities of a good leader. I dealt with him both as a companion and also at one time as a competitor during the first part of Mercury.

ROBBIE: What were you competing with him for?

MAX: Well, he really wanted to take charge.

PAUL: Walt Williams worked on him a few times.

ROBBIE: Von Braun wanted to take charge of the manned space flight program?

MAX: When I was with the ARPA people, they had their own program which was to put a man on top of a Redstone rocket in a Jupiter nose cone. This nose cone was not an ordinary cone—it was cone-shaped with a small-radius round nose on it of ablative material. They had—have you ever plugged a watermelon? Well, they kind of plugged this nose cone. Think of it as a solid. They drilled a hole right through it about thirty inches in diameter, right through it. And they put a capsule, a thirty-inch diameter capsule, that just fit inside this nose cone. The capsule was only about 4 feet long. They had this one little German that was gonna ride this damn thing. Remember him?

PAUL: Jack Kuettner.

MAX: That's right. Well, Kuettner was a test pilot for the V-1 buzz bomb used to bomb London which was powered by a very noisy pulse jet. Yes, the Germans used test pilots to fly the experimental versions of the V-1 because they were having serious problems with stability and the auto-pilot. Kuettner was even shorter than I am. And he was going to be von Braun's test subject—he was going to ride this thing. It would make its normal vertical flight and then release its nose cone to reenter the atmosphere, and when it got down to about 10,000 feet, it would blow this little capsule out the side and

the parachute would open and the capsule would be lowered to the ground. Kuettner would ride. All he was, was the test subject—you could have a monkey or anything else in there that you wanted—a bunch of mice, chickens—didn't they fly chickens on the first balloons?

ROBBIE: This thing never flew, I take it.

MAX: No, he didn't fly this mission but it indicated that von Braun was very interested in it. Of course, this is the kind of thing our test pilots hold their nose up at—this idea of a medical specimen.

But, when we got the authority to go ahead with Mercury, Bob Gilruth said "You know, we've got to have a test plan," and he told me to go put together a test plan. I talked to a lot of people and we came up with a balloon flight to test it at high altitude—remember that? We dealt with Otto Winzen who had the high altitude balloons that could carry the capsule up to something like sixty or eighty thousand feet and expose it to a vacuum for like a day, 24 hours, and drop it for recovery on a parachute.

Then the next thing was to put it on top of a Redstone and essentially make the same flight they were planning with the Jupiter nose cone. I thought, gee, you know, those Redstones, they fly them all the time—this is going to be something cheap and easy to do. We went down to negotiate the costs of the Redstone. The damn Redstone cost almost as much as the Atlas. Remember that? They had all kinds of overhead they put on the effort. And furthermore, after we got all signed up for the Redstone, we more or less were told, "Deal with von Braun because he's the head of the Redstone project."

And they said, "Well, when are you going to send the capsule down here to Huntsville?" We said, "We aren't going to send the capsule. Aren't you going to launch it down at the Cape?" "Oh, yes, but it has to be integrated with the Redstone." "Well, what do you mean?" "Oh, well, we've got to make sure that it doesn't have any electronic interference with the Redstone." They had this great big metal cage, a Faraday cage is essentially what it was. And inside external electromagnetic waves interfere with the integrated test.

PAUL: Radio waves.

MAX: Yeah, radio waves. They were going to talk to the Redstone and they were going to tell it "we're going to talk to the Mercury." And they had this great big program. And we had a deuce of a time trying to get that thing within reason. I think we finally did have to send one down there, but we really shortened the program. But he was going to take over at that point. *(laughs)* No doubt in my mind about it.

Meanwhile, we wanted some short flights to test out our escape tower and also to make some other short flights with monkeys. So, Paul Purser and I came up the idea of what we called Little Joe. Do you know what Little Joe is?

ROBBIE: I was wondering where you got that name because I just know Little Joe from Bonanza, Little Joe Cartwright. I was thinking, why would they name a rocket after that?

MAX: No. Little Joe from Bonanza was named after the same thing as Little Joe the rocket ship. Throw a pair of twos, that's called a Little Joe.

GUY: Four the hard way is "Little Joe" in Crap shooters language. Four the hard way is two and two, you see. There is only one possibility. You can have a 3 and 1, or a 1 and 3. There are two chances to do that, but there's only one chance to shoot two and two. That's shooting four the hard way. That's crap shooter's lingo.

MAX: Well, we had four rockets on it. And the four rockets were all bundled together--1, 2, 3, 4--in a bundle. Then we put a container around them, just an aerodynamic shell. Rockets burn their propellant very rapidly and we didn't want that high acceleration so we fired two and then we fired the other two. So it was two plus two—Little Joe!

GUY: You never know why things get named the way they do. You can't guess—you've got to ask.

MAX: No pornography here. *(laughs)* Just a good crap shoot. That rocket--I think we bought all of our Little Joes for the price of one of von Braun's Redstones. We contracted with Langley for the construction and launches at Wallops Island. By that time the Space Task Group was a separate entity.

GUY: I was up at a meeting of the American Rocket Society in New York one time, and I talked with this guy from Chrysler (von Braun's brother Magnus worked for Chrysler) telling him that you [the Space Task Group] would really like to have had the Jupiters rather than the Thors, and the reason that the Thor was winning out was that the Jupiter just cost too much. So, man, von Braun comes onto me like I don't know what. He wanted to know who I am and what the hell is going on. I told him, "You are just playing too damn hard to get. If you are really interested in doing this you are going to have to do something about getting the price down to where it is competitive with the other people bidding." *(laughs)*

PAUL: He had an automatic one million dollar R & D overheard on every system. I don't know what the number was on the Jupiter but it was bigger. No matter who bought!

MAX: The Atlases were cheaper than the Jupiters. It didn't make sense. We were going to launch this sub-orbital flight with Jupiter but then we got the Atlas so we cancelled the Jupiter. We had our sub-orbital flight, sub-orbital reentry. Maximum heating reentry was what it really amounted to. That took care of that. We went on from there. I don't know, but I'll tell you, von Braun really took care of his organization.

GUY: There was always a lot of competition between the two Centers. I don't know. I think maybe because the management between the two Centers really didn't see eye to eye on a lot of things.

MAX: When the whole thing started coming apart was when we got into the lunar program. We needed a very big rocket to do the lunar program. We had a rocket that had eight engines on it—what was it called?

GUY: The Nova.

MAX: Yes, the Nova rocket. Eight engines. When it came down to, you know, fish or cut bait, Wernher said "Five engines is all I can go." They actually started out with 4 engines and put the one in the middle because they recognized that there would be an awful lot of hot gas running back up inside. But that wasn't big enough. So we had to use either a lunar orbit rendezvous or an earth orbit rendezvous. He wanted to use an earth orbit rendezvous which kind of, again, would put the whole program much more under their control than ours.

ROBBIE: So why didn't you want it to be under von Braun's control? Why didn't you just want to let him have it and work with him instead?

MAX: We trusted ourselves more than we trusted anybody, maybe even Jesus Christ! *(laughs)* We were just that arrogant.

ROBBIE: Why wasn't von Braun just part of your team?

MAX: We'd been having this trouble with him with the Mercury, trying to get agreements with him. He was somewhat hard to deal with, on occasion.

PAUL: He was very convinced of the validity of his own thing. When you could talk to him quietly and explain, if you made sense, OK, and I was able to get along with him very well, but then Walt Williams came along, and he and von Braun drew sparks off of each other like mad. He was hard to deal with, even with good friends! Von Braun was almost at the stage of really being a member of the team, until Walt started working on it.

Lunar Orbit Rendezvous

MAX: Anyway, the problems with earth orbit rendezvous was that it required two launches to get to the moon. It required an awful lot of time in earth orbit before you could deploy. There were just a lot of question marks, a lot more program risks in earth orbit rendezvous. You might say there was less human risk in the earth orbit rendezvous than in lunar orbit rendezvous because we were going to have to make a rendezvous at the moon, and all the people involved would be right there. The number of abort options were not well understood then. It turned out that we had a lot of abort options. But, getting the program done in a decade was damn tough, at least we thought so, and I still think it would have not have been so tough had the fire not occurred.

PAUL: The reliability is to a large extent affected by the number of pieces. Adding another piece to make it more reliable could actually make it less reliable because that piece you add has to be enough more reliable than the other pieces so that when you take the total reliability to the nth power of the number of pieces, you could actually get an increase in your reliability instead of a decrease.

MAX: Well the other thing is we started off with the idea of what you would call all-up lunar flight—launching a huge rocket. It would land on the moon, and the same vehicle that landed on the moon would come back. And the vehicle that would land on the moon would have to reenter the atmosphere. We started on the design of this vehicle, and the more we studied it, the more we realized that it was going to be a very, very complex animal.

It turned out that the only way we could land on the moon was to use what we called a lunar crasher. You could not take a single rocket and depart from earth on the single rocket and have that rocket land on the moon, because the rocket, by the time you landed, would be such a huge thing that the return capsule would be way up high and it would be very difficult for the pilots to land this thing. I was convinced that you could have landed in an auto-land mode *(**GUY:** We did this with the Surveyor before we made a manned landing]* but it was very clear that that was absolutely unacceptable to the crew. They were not going to accept an auto-land mode.

The main thing the lunar module had to do was land on the moon. It was designed just for landing on the moon, not for traveling out to the moon, not for traveling back from the moon, not for reentering the atmosphere, not for entry steering. So we divided, we cut a very complex problem into two compound problems. To tie it all into one vehicle ended up with the complexity that we frankly got pretty much frightened of. Once we understood the implied difficulty of designing a pilotless vehicle arrangement that could both land and launch itself from the moon, then reenter Earth's atmosphere and land by parachute, anything but lunar orbit rendezvous was unacceptable.

We had two people we had to convince *(laughs).* We had to convince von Braun, and we had to convince Harrison Storms. (***GUY:** Stormy, head of the North American team building the spacecraft that would have landed on the moon had we used a bigger Saturn or had we used Earth rendezvous.)* North

American wanted to have their vehicle land on the moon. That's what they wanted the contract for -- to transport the astronauts to the lunar surface. They would be willing to build the lunar module to fulfill their contract. We said "No, you are not going to land on the moon. You are just going to provide the transport to lunar orbit."

ROBBIE: Less glamorous.

MAX: Yes, less glamorous.

ROBBIE: What about the name Apollo, where did that come from?

MAX: That came from our self appointed namer.

ROBBIE: Why name it for the Sun God when you were going to the moon?

MAX: I don't know! It came up on Silverstein's list and he called it Apollo. He felt that it was his privilege to name these things so he called it Apollo.

GUY: We use to name all the rockets that I had developed, give them a special name. One of them I named after my Cajun heritage—we--Bryce Wilhite, Thiokol's Chief Engineer at Elkton, also from Louisiana, and I--called it Cajun. It was a high performance replacement for the Deacon and was used as a workhorse sounding rocket during the International Geophysical Year as well as in our general purpose launch vehicles for PARD models.

Then as I got into the space program, I assigned one young kid I had working for me the task of coming up with some names of the new rockets we were having developed. I said, "Every rocket that we have developed for the Scout you have to name after some sort of astronomical body, whether it be a star or planet or what. You have to keep the name no more than three syllables. And you have to be able to find it in Webster's Collegiate Dictionary." Those were the requirements I had for naming things. So we had the Cignus, and the Cetus, and the Algol, and the Antares and that's how we named the various stages that I had developed for the early space program. John Smith was the guy. I told John, I said, go get the dictionary, you find me some names.

Max flew one on Little Joe. I had estimated the motor which was used as the second stage of the Scout required much higher performance than the one they used on Little Joe—it had to be. They were both built with identical case designs, even though they had a different propellant and nozzle. Since they were twins, we called them the Gemini twins—one of them Castor and the other one Pollux. Pollux was the one they flew first on Little Joe and Castor was second one flown on the Scout. Sometimes there was no rhyme or reason why we named things *(laughs)*. One workhorse rocket sometime used as a sounding rocket was named the Deacon. Other prototypes were called Vicar and Curate by Dick Winer and the group at Allegheny Ballistics Laboratory. They were named after characters in dirty limericks, not for ecclesiastical dignitaries as the guy who wrote NASA's history of sounding rockets said.

Visions for the Future: The Rules of Risk

> "If you're not willing to take a risk, you'll never get off the ground!"
>
> –Guy Thibodaux and Max Faget

ROBBIE: There's a question I really want to ask. What is your vision for the future of humans in space? If you could paint the picture any way you wanted, what's your vision? What would it look like?

MAX: I think the long range vision is probably that humans will at least explore the inner planets. I'm not sure they'll go much beyond Mars, unless they get something that science fiction calls hyper-drive or something like that and the human race is really going to move to another solar system. We need space for more and more things. The commercial use of space could probably hardly be done without the human applications.

I'll make another prediction that's not original with me because Bob Gilruth said it long before I did. He said, "Next time we go to the moon, the people who do it are really going to find out that it is very difficult." I would agree with him on that. With the modern ground rules, it's almost impossible to do. The military talks about "rules of engagement." Well, I'll talk about rules concerning risk and so forth. Those rules we have imposed on ourselves almost preclude the possibility of a reasonable landing on the moon in the next thirty or forty years. That's my feeling. We either change the rules or we won't get there for another thirty or forty years.

ROBBIE: Because of the structure of NASA now?

MAX: It's the mindset of the bureaucrats on what's safe and what's not safe, and it's the culture of the country where human life is so precious and it can't be wasted. We've got rules against killing people even if they are murderers. They're not hard rules, but you've elevated the value of human life out of proportion to its true value. That's all there is to it. I'm talking as an engineer who is used to looking at big pictures and understanding what's going on.

ROBBIE: So you think risks have to be taken to get back to the moon and they won't be willing to take those risks.

MAX: Every endeavor in the future has to be more risk free than the previous ventures. You just have to look at history to understand that.

GUY: There's no joy to success without an opportunity to fail. Absolutely not. If you can't fail, then there is no point in trying. Anybody can do it. It's not a challenge.

ROBBIE: So are you saying the astronaut that gets in the next rocket has to be willing to die?

MAX: I didn't say you'd have to be willing to die, but you have to understand the risk. The risk right now of flying is acceptable because it's an existing machine. But if you designed another one now you'd have to preclude a lot of the risks that are acceptable on the shuttle—they'd have to be ruled out.

GUY: Many of the astronauts live around here--Buzz Aldrin, David Scott, Dick Gordon, Gene Cernan and Mike Collins all went to the moon. Jim McDivitt, Rusty Schweikert and Walt Cunningham flew on pre-lunar missions as well as Gemini missions. My wife knew all of their wives. She said, "Well, what's the difference in working in NASA?" And every wife told her, "We go to fewer funerals these days" because they were all test pilots, and the death rate on test pilots is far more severe than any other group in the United States.

ROBBIE: How do you reckon the true value of human life? You said that they are overvaluing human life right now and that's hurting them.

MAX: Well, see that's the problem. It depends on what you're talking about. The place where a human life is valued the least is in the Highway Department. I can go up and down this road here and show you situation after situation where humans are at unnecessary risk because of the way the highway is constructed and so forth and so on. They're slowly getting rid of these things, but I think the highway department probably used a formula—a million dollars for a human life, something like that. Now, if it's

a criminal, the life of a convicted criminal is probably worth about $20 million. You understand? You spend $20 million dollars screwing around with him after he gets the death sentence. That's ridiculous. We send them to the gas chamber in five or ten years. It doesn't make any sense.

GUY: I'll tell you how I feel. I've worked in safety. I've worked in the most hazardous part of the operation. Everything I had could explode and detonate and do all sorts of damage and all of the failures of anything I had to do with were going to be the most spectacular things you ever saw. Consequently, I was very heavily involved in safety. My attitude toward safety is that if in order to save one man's life I have to spend more than one man's lifetime trying to do that, there's a net loss to humanity. That's a very cold-hearted way of looking at it. It's a very practical way of looking at it. If I have to spend a thousand man years of effort to save one man's life, then it's a great loss to humanity. That would not be a very popular opinion, but I've always looked at safety that way. I lean more toward the safe side, but that pretty much expresses my feelings about risk, for example. Knowledge of what you are doing, how it works and personal responsibility of the people doing the work is what makes things safe.

I remember a story about all the accidents people were having operating a press. People were having fingers cut off and other damage to their hands. Some bright guy got the idea to put the operators hand in shackles so when the press came down, the man's hands were pulled out of the way. The union struck. People were not going to be subject to the machine. So some bright guy put a ring with a small amount of harmless radioactivity in it. The press sensed when the operator's hand was near and would not operate. The machine was now subject to the man. You have to know a lot about human nature and human behavior to be a successful safety expert.

MAX: The best way to be safe is simply to understand what the hazards are. If you understand what the hazards are and the people that are involved understand what the hazards are, then you've gone a big step forward toward safety. A lot of our safety now is what you might call "plastered-on safety." It hasn't got anything to do with making the thing safe, but we've got a committee to sit in review, we've got special organizations that specialize in safety.

The special organizations that specialize in safety don't understand the problem near as much as the guy that is working with the problem. You know--you've got novelists that write good novels and you've got critics. The critics themselves would love to be a good writer but they don't know how to do it, so they become a critic. Same thing with movies. They don't know how to act or they don't know how to produce a movie, so what the hell, I'd like to be a critic. It's cheap to be a critic. Well, you've got these safety organizations of nothing but critics. That's what they are. Most of those people have never really done real engineering themselves. They had a brush with it or they've got an engineering degree, but they don't know how to make things work, they can only criticize the work of others. *(laughs)*

ROBBIE: As you speak, I am remembering that if you had been listened to in the design of the Challenger, there would have been no O-rings.

MAX: The rocket would have been all one piece. It wouldn't have had any joints.

ROBBIE: So that means it wouldn't have blown up.

MAX: But that was not a politically acceptable solution.

ROBBIE: Right, I understand. Guy explained yesterday that it should have been built by the company near Cape Canaveral which could have made it all one piece, but the rule was it had to be put up for bids, which meant it had to be in two sections just so it could be transported. So design simplicity is one of the ways to stay safe?

MAX: Of course it's one of the ways to stay safe! If it's simple, now you know that the possibility of a hidden problem is very low. If it's complex, your probability of a hidden problem is very high. If the problem is hidden, I don't give a damn how many safety committees review it, if it's hidden to the people that knew and developed the system and worked on the project, who have the most intimate knowledge of what's going on, the chance that these outside reviewers will find it is probably one percent compared to the probability that the actual guys working on it will find it. So they might add one percent improvement in the chance of finding the hidden problem at best. And if you don't have any hidden problems, now you should have a reasonably safe system, assuming no terrorists or bombs.

ROBBIE: Max, you are famous for the simplicity of your designs. Can you pick a few examples and describe to me how you stuck to simplicity in the face of pressure to make the design more complicated?

MAX: Well, probably the best example I can recall had to do with the lunar program. This was in a period when there was no strong Headquarters group that was trying to outguess us. (It was shortly after Kennedy pronounced the commitment to go to the moon in a decade that was already two years old.) So the bidding contractors were told that only storable hypergolic propellants could be used for the vehicles that we were responsible for. This meant that the propulsion system would be much simpler and more reliable than those using cryogenic propellants.

However, there was a really reliable little rocket engine made by Pratt and Whitney, the RL-10. It used hydrogen and oxygen, cryogenic propellants. It used the hydrogen to cool the thrust chamber. The warm not hot hydrogen would then have enough energy to drive the turbine that powered the propellant pumps. Nothing ran very hot and the engine could run for hours. Not only that, but it was simple to start and shut down. Naturally the Pratt and Whitney rep came to see me. I sat through a long lecture on the many virtues of the RL-10. And agreed with him. But an engine is only part of a propulsion system. To make the lunar mission we anticipated a number of shutdowns and subsequent restarts. With cryogenics you have to deal with boiloff, settling the propellants, pressurizing the tanks and measuring the used and remaining propellant. While some of these requirements would also apply to storable propellants, the method used to deal with them are ever so much simpler and reliable. So we had to eschew the RL-10.

GUY: Luckily Max didn't ask for my opinion on this or I would have straightened him out! With Apollo 13, we had this huge Board of Investigation—every Center director of NASA was on the board. Floyd Thompson, was he the head of it during Apollo 13?

MAX: Are you talking about the fire?

GUY: No, I'm talking about the failure review board on Apollo 13. The investigation team. We didn't do like they did on Challenger. Thompson or someone got on it right away and appointed the board, and he put every Center director on the board. We had Hans Mark, the guy from Goddard Jack Clark, and all those others.

MAX: Are you comparing Apollo 13 and Challenger?

GUY: I'm talking about how we went about the investigation. We never got any real outside help. We did it all internally on Apollo 13. Even the people who were assigned to investigate it, they didn't play a really big part. We are the ones who solved our own problems, fixed our own problems. Nothing ever came on the outside. The reason that happened was that the attitude that we had was "Hey, we've had a problem. What we are going to do is not try to fix the blame. No one is going to be blamed for this. It obviously was a strictly an accident, an honest accident.

What we are going to do is that we want everybody to come forth and to tell us everything they know about what happened. No one is going to be punished and there is going to be no retribution. All we want to know is that we have to discover exactly what happened so we can go fix it." And we had absolutely no trouble. The people who were responsible for the accident became sort of heroes afterward for fixing their own problem. That's the way Apollo 13 worked out, anyhow.

A lot of the people who were on that committee—like Willy Mrazek the chief engineer from the Marshall Space Center--came up to me and said "Hell, you don't need us here. You've got all these facilities. You don't need any outside help. You've got the total capability to take care of everything right here. We don't need to be here talking to you folks or listening to all this stuff. It's a waste of our time." He was one of the few Penemunde people who wasn't a German, he was a Bosnian.

With the Challenger, if someone in authority would have jumped on that thing right away and not let it get out of hand, it would have been handled much better than it was. It would have never gotten as far as it did--there was a big cover up. They made all the mistakes they could possibly make. And we didn't do that. I had talked to Barry Goldwater about Apollo 13--all sorts of people came by. You just had to tell them what was going on and they were just as nice as could be. No one ever accused me of being the goat messing up or any of the other guys who had responsibilities for the hardware that failed. That's just the way it worked. The agency handled it in a very good fashion, that's why it turned out different than the Challenger investigation did.

Of course, we didn't kill anybody then either. In the end, I told George Low that we had to make two small changes, one to a switch and one to a procedure to fix the problem. He couldn't let us do something that simple because of the outside pressures to do something major so we spent about $10,000,000 on an unnecessary redesign. Privately, he admitted I was right.

ROBBIE: Tibby, what is <u>your</u> vision for the future of humans in space?

GUY: I was up at the University of Nebraska during Engineers' Week and they asked us about going to Mars. I made a prediction over 25 years ago that if we want to do the big things in space, one country is not going to do it alone, it's going to require total international cooperation. It's too big a task and too expensive for one country to do it alone.

Our future in space is the same as it always was. The reason we're in space is we're able to make observations from a totally different platform or viewpoint. You see, here I am on Earth, and all the instruments I have to make measurements are subject to gravity or various other constraints that our environment places on us in making observations and the ways we go about making observations. If we get free in space, we have a totally different viewpoint. We're free of a lot of things. And we'll be able to discover things by going into space that we are not capable of discovering here on Earth. I'm convinced of that. That's the real purpose of going into space. That we'll look at things, after we've been up there we'll see things from a totally different viewpoint.

All these things we are concerned about now, fusion energy and various other things, might be discovered if we can get up there and look at a lot of things from a different viewpoint—we see that in the Hubble Telescope. Putting man in space—there is no such thing as an unmanned program. Man's always up there, whether he's a passenger on board the spacecraft or not. That's the value of space, to look at things from a different viewpoint, just like Hubble is doing right now. There are other fall-outs. Everything that goes into space has three important requirements. It must be small and light. It must work for its entire life unattended. And last, it must hardly use any power. That's why all your electronics and TV last for years without failure or why you can use all these miniature electronic controls in every conceivable application even as small as watches, etc.

MAX: The astronomers on the ground get just as much information and can control what they're looking at through the Hubble telescope just as they do with the camera.

GUY: We can put men in space too. I'm not saying we shouldn't have men.

ROBBIE: Paul, I want to ask you the same question. What's your vision for the future of humans in space?

PAUL: I think we should go work hard on the space station for all of the good reasons that Guy just mentioned, and I think we should either revisit the moon or go to Mars. As to when and how, we're not going to do it until somebody outside the United States does something to shake up the establishment and the press, because that's what it takes to get the U.S. to move, is somebody outside the system.

For example, I remarked on how NACA grew during World War II and then how it grew again when it became NASA. But NACA started in 1915 when somebody else went to Europe to find out why they were building airplanes in Europe and not very many here, and he came back with a report that the Europeans had more military aircraft than we did. We had 14 military aircraft in this country in 1914 and '15. The Europeans had 1400 and they came back and reported that. And NACA was formed as an advisory committee to study the problems in flight with a view to their practical solution. And by the mid-30's we were the leading air transport nation in the world but we were still behind militarily because the German military-industrial complex was itching to take over. When Lindbergh came back and reported that, there again, we got up and did something about it.

If you go back even before then to the middle 1800s when the Industrial Revolution was underway in Europe, they said, "Well, we have to find out what's behind this. They came back, made recommendations to Congress. They set up the National Academy of Sciences to inspire scientific and technical work. They set up the Land Grant College program—all of the A&M colleges in the U.S. were based on grants of very valuable federal lands to the states to fund those colleges. You hear about Texas A&M— Georgia Tech is an Aggie college, Alabama is an Aggie college. Mississippi State Univ. and A&M. Every state in the nation has a land grant college or more than one.

MAX: If you go down the list of the first 25 football teams in the country, I'll bet you that all except 2 or 3 are land grant colleges—what it really means is all the <u>great big</u> universities.

PAUL: "Louisiana State University and A&M College" is where <u>we</u> came from.

GUY: We are Aggies, Louisiana Aggies! *(laughter)*

Robbie (comment): In other words, they are products of one of the universities that were intentionally set up by the federal government to make sure America kept up with Europe's agricultural, technological, and military progress.

Back to the Future: Bootlegging the Space Program

Robbie (comment): In Interview #1, Tibby says that Gilruth would often walk around to everyone's desk to see what they were up to and how they were feeling about it. He would pull up a wastebasket and sit down on it (without turning it over); this put him lower than the guy he was talking to. In other words, PARD was "new paradigm" before new paradigm was even heard of--its operations exemplified the new paradigm's lateral, networking management and communications style and lack of attachment to status and hierarchy. As Caldwell Johnson put it in the New Yorker article, "We forgot which was our own department or who was our own boss."

The bootlegging that Thibodaux, Faget, and Purser keep referring to is another good example of this "new paradigm" style: you can only get away with that sort of thing in a lateral organization where the workers have the complete respect and trust of their bosses. It took me a while, from listening to these three NACA/NASA pioneers, to realize that in fact, just about the entire space program was bootlegged, starting with the Mercury capsule—and thus from its beginnings was a model of "new paradigm" values on trust, egalitarian relationships, open communication, and the untrammelled creativity they tend to foster.

ROBBIE: Guy and I talked a lot yesterday about how you all would often bootleg a project—"just do it"—and then later get an official mandate. Can you give me some more examples of bootlegging?

PAUL: Max bringing up those two Atlases was a perfect example. He had no authority to buy two Atlases! They agreed to sell then, he agreed to buy them. He came home and took care of the paper work.

GUY: The whole Mercury project was bootlegged. We did it without having any authority to do it. From the time in the Round Three Conference when we, I guess Max came back and he and I talked to Gilruth—I wanted to get the Scout started and Max wanted to get the manned thing started and Gilruth said go ahead.

MAX: Scout was bootlegged at first—but then we had Dryden approve the Scout program while we were still NACA..

GUY: Some things we didn't have to bootleg. Paul Purser was head of the High Temperature Branch and he had authority. We did things on a shoestring, by the way. We had a lot of in-house capabilities to build things. We didn't have to spend any outside money. The people's salaries were paid and the cost of materials was not much so it was very easy.

We had a whole team of talented people, and when you wanted to do something, as long as you could get management's authorization to write what you called a Job Order—the Job Order was something people charged their time to in order to tell you how much effort you are putting forth. It worked all right. I would write a Job Order. I don't know everyone in the loop who approved them. All I know is I wrote Job Orders and they all got approved!

PAUL: If you could keep it under $5000, you didn't have to go to Headquarters.

GUY: We would build whatever we wanted. Sometimes we had to go to Headquarters. We built a lot of those big pebble heaters. We built the high temperature arc jets, light-gas gun test facilities, laboratories for whatever, you know. Getting research tools to do the work was one of the easiest things—with the management we had. The management was very amenable to any good idea and they would let you go ahead and do whatever implementation you needed, buy all the necessary tools to do the exploration you needed to do.

MAX: Getting a new facility--Guy even had a particular dough mixer, like in a commercial bakery. He used it to mix these synthetic rubber-based propellants. *(laughs)*. He'd mix it up into a heavy slurry and pour it into molds.

GUY: You had to go through Congress with some of the bigger facilities and construction. But with these little things—I told her how I built my first rocket plant. Gilruth's signature authority was only a thousand dollars, and if I could buy everything for the rocket plant for $999.99, "Go buy it!" He could

justify the building as though it was going to be an assembly shop. He could give it a name and get that done pretty easily. That's the way we did business.

ROBBIE: How much of Mercury was already done before the Space Task Group was formed?

MAX: The concept was pretty much nailed down. What you do now is you make a Request For Proposals and the modern rule is you cannot dictate a design. You've got to just say this is the requirements that we want. Of course you could influence the companies that are going to bid by showing them your existing designs. More than that, you get them to study and help you come up with the concept. That's the requirement now—you've got to go through a bunch of paper work. But what we did was, we just said, "Hey, these are the specifications." We don't put specifications in Requests for Proposals any more. Specifications means specifics.

ROBBIE: So did you have the specs ready before the Space Task Group was formed?

MAX: Oh yeah, we did that while we were still NACA. NACA wrote the specifications and had it all done before we became NASA.

ROBBIE: So you knew the design of the capsule, what it was going to look like?

MAX: Damn right! We had perfected it in wind tunnel tests and spin tunnel test to make sure it was stable and things like that. We'd done some trajectory work on the computers to understand things like that. That had all been done.

ROBBIE: And did you have a mandate to do it while you were doing it or were you just doing it?

MAX: We were just doing it. I mean, we created our own mandate. Everybody knew what we were up to—we weren't making any secret about it. This was no covert operation, by any means.

ROBBIE: But this had not come down as a mandate from above to create a manned space capsule?

MAX: Well, they knew that we were doing it, and they didn't tell us <u>not</u> to. *(laughs)*

ROBBIE: It's a great example of a bottom-up organization.

PAUL: If you don't ask, it's hard for them to say no to a specific idea that you have, if you don't specify too closely *(laughs)*, then you can avoid doing what they tell you not to do by going ahead and doing it before they could say "no"!

GUY: By the way, Max and I even kind of started bootlegging the space shuttle. Max had a kind of a skunk works over in Building 36 and asked us to supply the people. We had Jim Chamberlain. Jim had been Chief Engineer for A.V. Roe. He was another real odd duck, but when it comes to pulling things together I thought he was absolutely first class because I watched him in that operation and he really knew what he wanted and what needed to be done. Well, Max asked me one time, he said, "Guy how do you think we can do this shuttle program cheap?" And I gave him the only answer possible. I said, "Start with a new agency!" That's the only way we could do it.

There's one unique thing. If you ask me what's the most remarkable thing about the shuttle, I can tell you what it is. It's not a technological achievement, it's a management achievement. The shuttle was done in an environment where we had constant yearly dollars over the entire program . Every other program you did, you started out slow, you built up to a peak in production and management, and then you began to lay people off, to tail off. The shuttle program had to be done within a constant budget, real dollars, all the way through. And in order to make a program effective or reasonably efficient, every

part of that program has to run a dead heat to the finish line. If one part gets done too soon, you're paying for that operation to sit there idle. You can't abolish it because you can never restart it again. It has to be planned and organized so that every part of the program runs a dead heat to the finish line. I don't know how that got masterminded, but I've got to say that the most remarkable thing about the shuttle program was the fact that it was done in that environment. And as it will never be done again, no one knows if it could have been done a better, more efficient way.

One of my observations about the difference between the management of the NACA and how NASA is managed, is that when in the NACA we used to have one or two discussions every year on some phase of our work, we put everybody in from all the Centers to talk about basic decisions. At one time or other, we covered all phases of our work and there was complete free interchange of ideas and thoughts. All the bosses themselves actually got in some big knock-down-drag-out arguments about everything, letting us know exactly how they felt. All the troops around were actually permitted to see the damn fights. It was like a big ring. Your champion would have his say and somebody else's and they'd all get up there and talk about things. I've come to realize that the only truth I know is how I feel, and how I feel is the result of all my life's experiences. Truth is different from facts. Nowadays, no one wants to let you know how they feel about anything.

At NASA the way they run JSC now is like how Big Nick the crap shooter shot craps. What they do is, they roll the dice and they hide the dice under the hat and then they tell you whether they made their point or not, you see. It's like trying to hold a world championship fight and having all the audience around there and then putting a big tent over the damn fight that is going on—is the way this operation is run over there right now. Before, we knew <u>everything</u>. All the troops knew everything that was going on and all the ideas and the feelings of everybody who was around. Over here they try not to tell you anything is that going on. They just want to tell you everything you must do and how to do it.

Among Mercury's legacies to the future, larger NASA was the fact that the early members of the Space Tack Group maintained their key positions long after the group had moved to JSC--and they remained in a position to influence the design not only of Apollo and Gemini but also of the shuttle. Because of the trust and camaraderie they had developed during the Mercury days, these men kept their lines of communications open even as the bureaucratic walls thickened around them. The informality and partnership of their interactions at Langley carried over to their work at JSC, where Thibodaux became head of propulsion and Faget of engineering. Purser, as second in command of JSC under Bob Gilruth, was instrumental in the logistics of its design, building, and day to day operation.

Thus, for many years, when someone needed something, from a box of paperclips to a full-scale lab, one phone call to Paul was usually all it took. As Thibodaux indicates above, Faget was able to carry this intimate, person-to-person style as far as the initial design stages of the shuttle. Ivy Hooks, an engineer who worked for Faget at NASA from 1963 to 1981, tells her part of that story:

> *In 1969, after I'd been in Faget's division for six years, I got a phone call from his office, from someone who said simply, "On April 1st, you are to go to Building 36, third floor. That's all he said; he wouldn't tell me anything else. I didn't know who he was. I didn't know where Building 36 was. When I got there on April 1, I joined about 20 other people in a big room, with chairs and stuff stacked everywhere. We all thought we were the victims of an April Fool's joke. Then Max arrived. He unzipped a bag, pulled out a balsa-wood model of an outlandish-looking flying machine, skimmed it across the room, and said, "We are going to build the next generation spacecraft." That was the first any of us knew about the space shuttle. The first Apollo astronauts hadn't even landed on the moon yet.*

For the rest of that year, during Apollo 10, Apollo 11, and Apollo 12, the twenty of us worked on the basic definition of the shuttle. There was a guard at the door to keep other people out. We thought about what the shuttle would do, what it <u>could</u> do. We set the boundaries for it: its size, its weight, how long it would stay up, how far it could fly, when you wanted to come down from orbit and land, how you could control it, how much power it would have. We beat out the whole concept together, all of us working in one room. My job was to look at different ways to separate the external fuel tank and the boosters from the orbiter after their fuel had been used up during the ascent. I remember an older engineer looking over my shoulder and saying, "Don't try hitting them away. On Gemini, we tried a device that would hit the nose cap away, and all it did was ring--the nose cap just stayed there and hummed." We wound up using small thrusters to push the boosters away. But it was that kind of thing. I could just walk over to, say, the thermal people, and ask, "If I did this, what would that do to you?" Max left us alone--we didn't see much of him, but every once in a while we'd come in in the morning and find changes to some of our drawings, and we'd know he'd been there.

MAX: Shuttle was the last hurrah. The infidels were finally taking over. *(laughs)*

ROBBIE: The barbarians were at the gates! *(laughter)*

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