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ORAL HISTORY TRANSCRIPT

RAYMOND F. MELTON
INTERVIEWED BY JENNIFER ROSS-NAZZAL
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ROSS-NAZZAL: Today is January 22, 2003. This oral history with Ray Melton is being conducted in Las Cruces, New Mexico, for the NASA Johnson Space Center Oral History Project. The interviewer is Jennifer Ross-Nazzal, and she is assisted by Rebecca Wright and Sandra Johnson.

Thank you for joining us this morning. I'd like to begin by asking you a general question about your background in engineering. Could you talk to us about your interests and how that developed?

MELTON: Well, I think it started real early. I was always interested in airplanes and rockets and science in general. I liked taking things apart and putting them back together, if I could. I liked the sciences, physics, and chemistry. Chemistry was pretty cool, especially if I could make it loud and stinky. I built rockets, homemade rockets in junior high school, and that was cool. Some of them went up in the sky. Some of them just went "blooey" on the ground, but that was all fun.

I think that probably the biggest scientific event in my early life was in 1957. I was fourteen years old. I was carrying papers for the *Denver Post* on the day that the Russians launched Sputnik, and I had 104 papers to fold and deliver, and 104 times that day I was reading about how the Russians had beat us into space, and how the United States was so far behind and the Russians were ahead, and that was really pretty depressing. I remember shivering on a cold, crystal-clear Denver [Colorado] night, looking up in the sky and watching somebody else's first space satellite going silently overhead. I was both inspired and angered. I said, "Man, oh, man, we can do better than this," and I kind of resolved even right then, I said, "Man, I like rockets. I want to do something to get us back ahead."

So I took a bunch more science classes in school. I went and learned Russian, just so perhaps I could perhaps pick up on some of the things that they had gotten ahead of us in. So I began to kind of structure my life [in that direction]. Yes, I wanted to work with rockets, work in the space program somehow.

ROSS-NAZZAL: And you ended up majoring in engineering at New Mexico State [University, Las Cruces, New Mexico].

MELTON: Right. I wanted to go into aeronautical engineering because I really loved airplanes, but New Mexico State didn't have an aero engineering option, so I took mechanical engineering. That was about as close as I could get at the time. At the same time, I was taking a bunch of chemistry and chem [chemical] engineering classes. That enabled me to get a job working with the Army as a mechanical engineering co-op at the Army missile range [White Sands Missile Range, White Sands, New Mexico]. NASA White Sands [Test Facility, Las Cruces, New Mexico] had not even been built yet. And so I got to work with rockets and missiles, the real ones, not just model ones, as soon as I got into college. And boy, that was a big step up from my homemade rockets. I'm so lucky I didn't blow myself up making my own homemade rocket fuels. At first it was kind of clandestine, just go launch them out in the back yard, but the neighbors pretty soon ratted on me, and Mom and Dad pretty soon found out, and they said, "You're not going to do that stuff around here, [you're going to blow us all up]!"

And I [said], "[But Mom], I really, really want to. [I'll be careful—promise.]"

They said, "Okay. Well, if you do it in a good, structured and safe way, we'll let you make your own rockets."

And I ended up getting permission through the Army that had a test range down by

Socorro [New Mexico]. I was in Albuquerque [New Mexico] at the time. They let us launch our own rockets from that gunnery range down there. I had already joined the National Association of Rocketry, which is an amateur rocketry group. So, in 1960, I built a series of rockets, which were actually pretty cool for a high school kid back forty-some-odd years ago, and set at the time the unofficial altitude record for amateur rockets. Built a two-stage rocket that went over 30,000 feet high. That was fun doing it as an amateur. And then finally, by the time I got into college, [I] was able to start working with the [real] rockets and actually get paid for it.

ROSS-NAZZAL: That's great.

MELTON: Then, even better, be able to, as soon as I graduated, turn that into a real job with NASA.

ROSS-NAZZAL: You actually started working for NASA in '66.

MELTON: Right. As soon as I got out of college. I already had a wife and a baby, and I was [planning] to go on to graduate school, but had hungry mouths to feed, and there [were] exciting things going on out there, and so it was time to go out and get a job.

ROSS-NAZZAL: How did you find out about the opportunity at NASA?

MELTON: Actually, there was an advertisement in the paper, and it was in their chemistry lab. I said, "Well, okay. I need a job. I don't care what I'm doing." So I went out there and interviewed for the job as a chem lab technician, and basically, they told me, after talking with me, they said, "Well, jeez, you're actually kind of overqualified for the job. We don't need a graduate chemist," which is what I was by then. They said, "We need a technician."

I said, "Oh, well, okay—[thanks anyway]."

As we were walking down one of the hallways in there, I looked off to the side, and, hey, wow, there was a real rocket engine. I [said], "Wow! Who does that kind of stuff?"

They [said], "You even know what that is?" Because to most people a rocket engine looks just like a pile of stainless steel hardware or something like that. They wouldn't know whether it's a portable generator or a rocket engine or what. They [said], "Yes, the people at NASA do that."

At the time, I was talking to a contractor. I said, "Well, can I talk to some of them?"

They [said], "Yes, sure." So they introduced me to the Chief of the Rocket Propulsion Section, and he [asked], "How did you know we had a job opening?"

I [said], "I didn't." I didn't. It turns out that one of their fellows had announced his retirement coming up in just another couple of weeks. So I interviewed with that fellow on the spot, who became my first boss. I was lucky.

ROSS-NAZZAL: What great luck.

MELTON: I lucked in at the right time at the right place.

ROSS-NAZZAL: What sort of activities were going on at White Sands Test Facility when you arrived?

MELTON: The entire installation at that time was dedicated specifically to supporting Project Apollo, and as a former name of the installation, Propulsion Systems Development Facility, indicated, it was focused entirely on testing the rocket engines for the Apollo spacecraft, and "spacecraft" particularly meaning the part that operates in space once you get up off of the ground. So it was the Apollo lunar module and the command and service module. It wasn't the big engines for the Saturn V. They couldn't test those things out here. Those engines are just too big, and the engines put out a lot of heat. A lot of heat requires a lot of water to quench it. Also, the vehicles are so big that, you might remember, they traveled by barge. We don't have very many barges here in New Mexico! So they focused on the smaller rocket engines for the lunar module and the command and service module. And that was really the primary focus, just rocket engine testing. [At the time], the laboratories existed merely as a support function providing [cleaning and] chemistry and metallurgical support, analytical work to support the rocket engine test stands.

ROSS-NAZZAL: So what were your first duties or responsibilities when you first came to White Sands?

MELTON: Well, I was a fledgling liquid propulsion systems engineer, and back then NASA had an unstructured but pretty effective mentor and protégé system of getting the new employees up to speed. I don't remember going to more than one or two classes whatsoever, but [I] just hung around and shadowed a veteran engineer and followed what he did throughout the whole day, learned not only his duties, but also the interactions, the documentation necessary, the people that were necessary to talk to—some of the thought patterns and philosophies of a successful propulsion systems engineer.

ROSS-NAZZAL: Did you find that program to be successful?

MELTON: I thought so, because within a few months I was pretty much on my own up in the rocket engine test stands, and basically that just meant monitoring and tracking and recording the progress of the test programs, particularly on—I got to work on all of the major systems. The service propulsion engines and the LM [Lunar Module] ascent, descent, and reaction control systems, but I tended to focus mostly on the LM engines, the lunar module stuff.

Within less than a year, I was able to transition into actually working on and helping to monitor [and conduct] the actual test progress. That means what is going on while you're firing, what instruments and parameters are being measured, and then what is done with the data afterwards to see whether the rocket engine system met its performance requirements.

ROSS-NAZZAL: Let's talk about your work on the Apollo service module and the lunar module. Could you describe the various test facilities that were used to conduct these tests?

MELTON: Yes, sure. The actual physical facilities out there, well, first of all, the entire place we knew had been built on a temporary basis, so there [were] a lot of temporary buildings out there. There [were] a few main structures which had been intentionally built to last only a decade, but the place was growing so rapidly in the 1963 to 1966 time frame that there were way more people than there was room for. So we had huge trailer farms with these ten-by-forty office-type trailers, fifteen, twenty, thirty trailers end-to-end and side-by-side clustered around the buildings in at least three major areas.

So, yes, there [were] a lot of people that didn't even have offices whatsoever. A typical engineer's "office" was not an office at all. Engineers didn't have offices. Only managers had offices. So engineers worked in a big bullpen, which was a very large, open room with a bunch of big flat tables in the middle, typically twenty or thirty feet long, just littered with blueprints and foldout schematic diagrams showing the electrical systems or the piping runs inside the facility, or even inside a rocket test article. Then the engineers' little spaces were around the perimeter of the room, with their backs to the data tables. Then like every ten feet or so, there was a little Plexiglas divider that separated you from your other co-worker. So all you had was a desk and maybe a little file cabinet and that was about it.

It was constant activity and pandemonium going on back there, so there was no privacy, no quiet time. There were at least half a dozen of these mechanical calculating machines, Friden or Monroe types [in the bullpen]. So those things were constantly [going] "chuggity, chuggity, chuggity, chuggity," [clacking away in the background, churning out numbers].

Nobody had computers back then. We did lots of work with our slide rules and pencils and graph paper. People didn't type things; only secretaries typed anything. Most of your reports were done in longhand and handed to a secretary, who turned it into a written report. [And almost everything was typed in duplicate with messy carbon paper in between, and if there was a mistake, it either got typed all over again or she went in and tried to make a decent-looking erasure on each page. It was usually ugly! They didn't even have "white-out" in those days.]

Now, the actual rocket engine test facilities, those were really cool. Particularly in the LM test areas, we had to simulate the vacuum environment of outer space, so those rocket engines would think that they were firing in outer space. It turns out that that's necessary because rocket engines perform better in space than they do here on Earth, and so all the rocket engine manufacturers, well, they can test their engines just by firing them on the ground and measure the performance, but once you get up into a vacuum, they perform actually even better, [primarily] because there's no air in the way to get in the way of the rocket engine exhaust. Heat transfer is also different here on Earth where there's air. Like air flowing over the radiator in your car to cool off, there's no [airflow] up in space to cool off a rocket engine, so firing it in a vacuum makes a big difference.

Well, it takes a huge facility to actually create that vacuum environment inside the big rocket engine test cell. The test cells were big enough to accommodate the entire mated lunar module. So they were like thirty-three feet in diameter, thirty-eight feet tall. You put the big test article, full scale, like a full-scale lunar module into the test cell by taking the lid off of the top and lowering it down into the test cell, bolting it into position, then closing the lid on it, and then the rocket engine fired down into a great big exhaust duct that looked like a culvert that connected to the big altitude simulation system.

The altitude simulation system itself was a masterpiece. It was a marvel of complicated engineering. It used three converted rocket engines to create high-pressure exhaust gases of steam. It burned liquid oxygen and isopropyl alcohol to create high-pressured steam, and then they pumped 1,000 gallons per minute of water into the flame underneath [each engine] to create [even] more steam. And they pumped that steam over some orifices and a set of convergent-divergent nozzles to create the shock waves which then literally sucked, all of the air out of the test cell, and sucked all the rocket engine exhaust out at the same time. So you could fire a rocket engine in there that's putting out twenty pounds per second of exhaust gas, and yet that altitude simulation system could continue [pulling] all that exhaust gas out and maintain an altitude similar to—simulating being over 120,000 feet above the Earth. So that was close enough to simulate being in a vacuum.

That steam generator itself put out nearly a million horsepower. It was a deafening roar while it was operating. It spewed a [cloud] of high-pressure steam and exhaust gas for several hundred feet in the air. There was a big, huge white cloud of this steam and exhaust gas coming out from this roaring monster. People down in the administration area nearly two miles away could always tell when there was a rocket engine test firing going on because they could hear this low roar, and then look up on the horizon a couple of miles away and see this big cloud of steam and exhaust gas rising up there, and it was pretty spectacular. The ground would rumble and shake. We knew that with that much horsepower going on, that there was always a chance of some of that power getting loose. And so, yes, there were a lot of inadvertent shutdowns and minor leaks and little minor explosions and occasionally some fairly major accidents where equipment got damaged just because that was a very powerful system.

ROSS-NAZZAL: What was your role in the testing of the SM [Service Module] engine and the LM?

MELTON: Within a year or so after joining, it turns out that I was quite interested in doing some of the actual performance analysis of the vehicle, and they had a need for somebody who could technically compare how the engines did, compared with what was required out of the test objectives. So that meant starting from scratch while setting up a test. We would read through with the contractor, the engine manufacturers, what were their requirements for this test. What were they trying to demonstrate? Were they trying to demonstrate a particular sequence of events and firings called a mission duty cycle, which was the simulated firing durations and thrust levels, etc., as might be expected on a particular mission going to the Moon and returning?

After looking at the required objectives, we would determine what kind of instrumentation is necessary to gather that information, then watch through all the installation of the instrumentation, load the vehicle with the correct amount of propellants. Sometimes we had to simulate hot or cold conditions. For example, [when the lunar module is sitting] on the Moon, one side of the vehicle is exposed to the sun, and the other side is exposed just to [the darkness of] deep space. So one side would get hot; one side would get cold. So sometimes we would have to do hot or cold propellants. [In the case of the Apollo spacecraft when it was traveling on the way to and from the Moon, they intentionally rotated the spacecraft to even out the solar heating, sort of like a rotisserie. The real term was PTC, for Passive Thermal Control, but everyone called it "Barbeque Mode."]

We would also explore the limits of the engines to see, okay, what does it do if the pressures are at the high end of the specification, or how does the engine run at the low end of its pressure or temperature envelope? There’s something called a mixture ratio, and that is the ratio of fuel to oxidizer that is being squirted into the engine. It’s sort of like the amount of gas and air that your car’s carburetor or fuel injection system gets. Anyway, so all of those things are performance parameters that need to be measured and then compared with the required specification values.

So then after we got the vehicle loaded came the actual test. The test procedures had been worked out [weeks or months] in advance by a team of dozens of people. The test procedures were extremely detailed. A test firing document was typically sixty pages deep, and it had detailed instructions for every person in the test team and every move that they were going to make. So, for example, the test conductor would read through this—it looked just like a cookbook, and he would say, "EFCS, position valve MV-40[9] open."

And the technician at the EFCS (Engine Firing Control Station) would position valve MV-409 open. Click. He'd say, "MV-409 open, verified," and a quality-assurance fellow sitting also at the console would get out his stamp and stamp that particular step that says "Verified."

Then they go to the next thing. It says, "Test stand 401, verify the fuel sight glass reading is 33 [+ or – 2] inches."

And the guy out at the test stand would radio back, "Sight glass reading is 33.3 inches," and the quality-assurance man would stamp [that] step, and it went on that way in very detailed, formal fashion.

My particular role during most of the firings was at—I was off in the data room where they had rows and rows of strip charts. A strip chart is just a way of displaying a particular pressure or temperature or accelerometer or strain gauge or something like that, measurement, with a moving pen on a strip of moving paper, and it rolls up past the pen and makes marks on it. There was this entire panel called TMP, test monitor panel, that had about fifty or sixty [strip chart] measurements on it all throughout the whole vehicle, pressures and temperatures in the helium system, in the rocket fuel and oxidizer tanks, and down in the engine itself, as well as a few pertinent things for the facility, particularly the altitude pressure inside the vacuum test cell.

So I had to monitor [all] those things both during loading, so we got the right amount of propellants [and helium] aboard the vehicle, and then during the firing was when the tense times really were, because you had to be watching half a dozen different things, very powerful, very high-energy system where things, if they got out of hand, could destroy a multi-million-dollar vehicle within a couple of seconds. So I had my eyes [glued] on critical parameters during the firing, constant readouts of whether things were going okay or not.

Then after a test was done with, we got into the data analysis portion of a test, which could take—there was always a quick-look data analysis done just that day, and that was a gross examination to see, "Okay, well, did we see anything that really looked bad? Did anything fail?" And that was combined with a visual examination of the engine and the rest of the test article.

After the quick-look examination and a short report was written, then we'd get into the detailed performance analysis, which started out being done almost [entirely] longhand, but subsequently developed some programs for computing some of the parameters and measuring those things and displaying them out in a standardized format. So [finally] we'd have to write a big report on the test, comparing it to the performance objectives that had been set out in the original test directives.

ROSS-NAZZAL: Sounds like a long process. How long did the firings take?

MELTON: Believe it or not, a typical firing was only a couple of minutes. The longest firings were probably on the order of ten minutes continuous, and that is ten tense minutes with all your fingers crossed that nothing really happens, that nothing happens out of the ordinary. So there's weeks and sometimes even months of preparation for a firing, and then it's all over with in twenty tense minutes.

In many cases, you can't go back, because those rocket engines back then, they could only be fired once. The combustion chambers were typically not made of metal like they are now. They were made out of fiberglass phenolic resin, sort of like the body on a Corvette. When the engines fired, the fire inside the combustion chamber was on the order of 5,500 degrees. Well, that's like an acetylene torch, and it tended to melt and vaporize the [phenolic part of the] combustion chamber material.

Well, that actual vaporization is what cooled the combustion chamber. Just like evaporation of water from your skin makes you cold, well, the evaporation of the phenolic resin out of this combustion chamber cooled the chamber, [and the heat] turned it into a charcoal briquette, but it was still stiff enough to maintain the pressure inside, [as] it [slowly] burned itself away. It was called [an] ablative material. It burned itself away during the firing and lasted just long enough to make it through the mission.

The material was similar to that that they used on the heat shield for reentry. The heat shield was made out of those same kind of materials, and literally kind of burned themselves away, sacrificed themselves protecting the space capsule from the heat of reentry. That's the same way that these rocket engines worked.

But if you had done something wrong during a test or if the engine performed unexpectedly, you couldn't just go back and repeat it, because now the engine was all cooked up and couldn't be used again.

ROSS-NAZZAL: Did you participate in any flight-readiness reviews?

MELTON: The flight-readiness reviews that you're probably talking about are the formal ones done for an actual mission, so I didn't personally participate in those. Those were done by people down at the Cape [Canaveral, Florida and at Houston]. But, sure, we had test-readiness reviews [for our tests] out here, which was a panel of the major participants in our tests, and our tests in many cases were true mission duty cycles, simulations where the rocket engine, the whole system thought it was going into space. So you would fire it for a certain duration, then let it [rest for 2 hours or 6 hours or whatever] as if it's coasting on the way to the Moon, and then fire it again, particularly like with the LM descent engine. That thing was throttleable, so you could run it at different power levels. Most rocket engines, they're either all the way on or they're all the way off. The LM descent engine, you could throttle it [from full power all the way down to 10 percent power]. And that was necessary to lower the vehicle down onto the

Moon in a controlled manner. So anyway, we would run through the entire throttling sequence of the LM [descent] engine [as if it were slowing down from lunar orbit, hovering a few feet off the surface while looking for the right spot, then throttling back to gently settle on the surface].

But anyway, all the test-readiness review [items] had to get a go-ahead for readiness from each of the major participants in a test.

ROSS-NAZZAL: What sort of challenges arose when you were doing this testing on the LM and the Apollo service [module] engine?

MELTON: During the actual test, the major challenge, I think, was watching this ultra high-energy system and making sure that something wasn't getting out of hand. For example, some of the very early LM engines had what was called combustion instability, and [for example], you see evidence of combustion instability in a gas stove where the fire is flickering [or wobbling] or something like that. Well, in a rocket engine, if that fire is flickering [or wobbling] inside the combustion chamber, that means that there may be pressure waves being set up inside the engine which can destroy the boundary layer coolant effect that protects the inside of the combustion chamber from the 5,000 degree heat of combustion and can melt it through in the space of less than a second. And they called it acoustic instability because the frequency of those combustion oscillations [was] in the range that you could hear. In fact, there [were] times when you could stand outside and listen to the engine, in addition to just the roar. If it started going unstable, you would hear the thing, and it would squeal like you stepped on a cat [Loud growl].

Literally, you could watch some of that instability action on the test monitor panel, and you knew that that was way bad. So as soon as something like that came up, it was my responsibility to give the shutdown signal. And that was always very tense, because you were watching for that kind of stuff.

Also, with later engines like the Shuttle [orbital] maneuvering engine, that thing used its own fuel to cool itself, sort of like pumping gasoline through the radiator of your car before you put it into the carburetor. Well, if that fuel got too hot as it passed through the passages in the cooling channels on the rocket engine, that fuel could actually detonate. Or if there [isn't] enough fuel flowing through there and it [gets] too hot, it boils, and then it boils into vapor, and that vapor doesn't carry any heat away, and the rocket engine overheats in that location and can burn through. So I was constantly watching some of those critical kinds of parameters.

To me, that was a pretty important responsibility. There [were] many times when I would be watching a temperature creep way up towards a red line. The rocket engine is firing, and there's a red line established that says, "Don't let the temperature get any higher than this". And it's creeping up, and it looks like it's going to [keep going] and exceed that temperature, and I've got a responsibility. We've got ten more seconds left in the firing, or thirty more seconds left in the firing. Do I let it go two degrees too high? Does it look like it's going to get too hot or [should I] just wait and see? You've got to kind of know the philosophy behind, why did they establish that temperature [limit] in the first place, and how firm is it? What could happen if I let it go too long?

In some cases, if you let it go, the engine could burn through. On the other hand, if you [call] it off too soon, you may have wasted a multi-million-dollar-engine test that would have to be repeated, and they'd say, "Well, why did you shut it off so soon? It might not have gone any higher," or something like that. So that was an important part of a real challenge during the actual rocket engine tests.

ROSS-NAZZAL: It sounds like it was a very delicate balancing act.

MELTON: In some cases it was. Most of the time, you just watched things hum along just like they were supposed to, but there were several times early in the programs where, yes, you would actually have failures, and I found that you tended to learn much more from failures than you do from successes, because when things are successful, you never really know how close you were to failing. When it fails, then it forces you to go back and really learn and understand all the things that are going on inside your system there and understand why it finally exceeded the limits and what to do to try to make certain that doesn't happen again, what redesign or whatever is necessary.

For example, when—and we'll probably get into it a little bit later. We can talk about the things that [we] learned from the Apollo fire and from the *Challenger* incident. But yes, you tend to learn a lot more from failures than [you ever] do from successes.

ROSS-NAZZAL: That's interesting that you mentioned that. That must be an engineering mindset. I heard Chris [Christopher C.] Kraft say that failure is good, and it's something that I never think of. Whenever I think of failure, I think, "Oh, that's not so great." But—

MELTON: The failures from a technical standpoint are really interesting, when and if you can remove the human element from it, the tragedy element from it. If it's just a piece of hardware that blew up or burned through, yes, that's really interesting, and you [can] really learn a lot from those.

ROSS-NAZZAL: Let's go back to some of the first questions that we skipped over. Let's talk about the relationship between the Manned Spacecraft Center, now the Johnson Space Center, and White Sands Test Facility.

MELTON: White Sands Test Facility was always a part of the—I [sometimes] still call it MSC, Manned Spacecraft Center. We were created specifically to do the kinds of things for the manned space program that could not be done in a populated area like down in Houston [Texas]. So that's why they put the place out in the boondocks, 800 miles away, so that we would not expose a big population to these poisonous rocket fuels and the loud noises and the possibility of explosions and things like that.

So, yes, we were totally dependent upon [the Manned Spacecraft] Center for our work direction. We conferred with those subsystem managers on a daily basis. They provided us our bread and butter. They provided us our budget [and overall project direction]. They were then, and still are, the official office for all of our hiring and firing, all the personnel records, all the legal, all the administrative support, still comes out of Houston. [But] it did more so back then than it does now. We've become considerably more independent. Since the demise of the Apollo Program we have taken on considerably more reimbursable work, and the place is a bit more independent, so to speak. We always had to have a real high degree of independence just to be able to survive out there 800 miles away from the parent organization. So we had our own administration group and finance group and the technical people and all that kind of stuff so that we could pretty much operate on our own out there; warehousing and logistics and maintenance and all that kind of stuff, instead of depending [entirely] upon Houston.

ROSS-NAZZAL: What impact did the Apollo-204 fire have on the White Sands Test Facility?

MELTON: Oh, boy. I'd only been with NASA for a few months, and so I was still really wide-eyed and impressed with all the things that were going on. Then in January of '67 when that fire struck, boy, it was an immediate personal tragedy for everybody involved, but as soon as the shock of that tragedy wore off, boy, we immediately jumped into our role of doing—kind of a new role, of doing flammability testing on virtually every component that ever went into the test article. So that was really kind of a major watershed for us.

We'd been doing small amounts of compatibility testing, which means making certain that materials will operate in the environment that they're supposed to. Like if you have something that's going to be exposed to hydrazine, well, you've got to test it in that rocket fuel.

If it's going to be in the crew compartment, then it has to be exposed to, in this case, pure oxygen, and particularly the behavior, the flammability behavior of materials in pure oxygen was relatively poorly understood and certainly underappreciated.

You might remember back in high school, you might have had some chemistry experiments or something like that that showed, well, jeez, you can't burn steel wool in air, but you just heat some steel wool and then put it into a little test tube of pure oxygen, and my golly, the thing lights up like a filament on a light bulb and burns away. So the astronauts found out the hard way that things really burn much differently in oxygen. Things that will not burn in air will burn rapidly in [pure] oxygen. In high-pressure pure oxygen, even things like stainless steel will burn like a torch. Titanium that is used in the combustors for jet engines, obviously it doesn't burn in regular air, but in pure oxygen, titanium will burn like a Fourth of July sparkler. So things get really dangerous in oxygen. So that led to a whole new role out there at White Sands Test Facility, and that evolved into a materials testing role that is now at least 50 percent of our whole work out there.

But since the propulsion system was not involved in the Apollo fire, that didn't really affect my job in particular, so we didn't have a significantly different role. The big change was up in the laboratories. So the laboratories, beginning that day, they were no longer just a support group; they had a life of their own, that was to evaluate materials.

Yes, boy, they learned a lot from that fire. Much of it was in different materials that were more fire-resistant. There were a lot of workmanship issues also involved. But as a result, the subsequent missions did not suffer a similar kind of a problem, and given what they found, all the things that now in retrospect, we say, my golly, those were some of the wrong things to do, wrong materials, and putting some things too close to each other, and putting things in such a way that a fire could propagate very rapidly, you say "those were all the wrong things to do." Well, we now learned what not to do, and the subsequent missions were successful because of it.

ROSS-NAZZAL: It's a good example of how failure brings about knowledge that you were talking about.

MELTON: You bet.

ROSS-NAZZAL: Could you tell us about the safety program at White Sands Test Facility during the Apollo Program?

MELTON: The safety program was something that was there and all around us, but as a test stand engineer, I almost didn't recognize it as an "organized program." I just knew that there was a bunch of both contractor and NASA safety people. You could always tell them because they had a green hat or a green band on their hat. And they were around just looking over all the operations to make certain that industrial safety precautions were handled. It was just a part of life. It wasn't something that seemed that you had to invoke specifically. They were just there all the time, but, yes, you sure did get educated real early about some of the specific hazards of working with these high-energy and poisonous propellants.

The oxidizer is nitrogen tetroxide. It's a relative of nitric acid, and if you get it on your skin, it burns the skin and turns it all orange and crusty, and if it gets down deep enough, it can poison your blood. But its main problem is, if you inhale it (and it boils at 70 degrees, so you almost always encounter it as a vapor), a dark reddish cloud always signified an oxidizer leak, and it smells sort of like chlorine, [but] actually it acts even worse than chlorine on your lungs. When it comes in contact with moist tissue like in your eyes or your nose or your throat or your lungs, it recombines with that moisture to form [nitric and] nitrous acids again. So if you take a deep breath of it, you end up creating nitric acid in your lungs, and so it eats you out from the inside. So it's really pretty bad stuff.

The fuel is equally harmful in kind of an insidious way. The fuel was unsymmetrical dimethyl hydrazine and hydrazine. Now, in the Shuttle Program, we use monomethyl hydrazine, but they're all chemical relatives of each other, and they're [all] known to cause cancer. If you get a drop of it on your skin, it makes these burns and lesions that take months and months to heal, and ooze. It's also a blood poison and kills your liver. So it's some way bad stuff.

The fuel stinks. It smells like an old dead fish that's been soaked in ammonia. [Sniffs] You can tell when you're smelling the fuel, just because it smells rotten. But, the fuel is so bad for you, that by the time you can smell it, the detection level is greater than the exposure limit, so by the time you can smell it, you are already being exposed to more than it is allowable for a regular workday. So even back in Apollo days, and certainly now, we have automated vapor monitors going all the time, every kind of activity around there. You have these fuel and oxidizer vapor detectors. Some of the guys even carry little lapel panels sort of like a radiologist carries to measure the amount of exposure that they are being exposed to during the day, in case they get perhaps out of range of one of the monitors.

Now, some operations required people to work where they knew that there [were] leaks of these—where they were likely to be exposed to the propellants. So, for example, if there was a leak, you had to get somebody in there to replace the fittings or replace a valve. So we had special suits for the guys, big vinyl suits that were totally enclosed, and they had their own breathing air supply inside, called a SCAPE suit, Self-Contained Atmosphere Protective Ensemble. It looked like a big [gray or] pink rubber spacesuit. And literally, they could get sprayed or splashed with the fuel or oxidizer, and it wouldn't hurt them. You could work inside a big poisonous cloud that was so bad that if you took one deep breath, it would kill you, and the guys would work for even a couple of hours inside that [suit], totally protected.

Everyone was well educated into the hazards about it, so people knew what the potential hazards were, how to deal with it. We had procedures to make certain that an exposure didn't happen, but then you also had suits to protect you when that was unavoidable, and there [were] emergency procedures in case there was an accidental exposure. So we had showers all around the test stands, and so [if you got some propellant on you], all you did was just run over to this little shower, and you'd step on the little grate, and it would douse you off and rinse everything off. They had things that looked like drinking fountains, but they were eyewashes, so it would squirt water up there to get it out of your eyes.

Luckily—we weren't just lucky; we were good, but it helps to be lucky, too. There were some close calls, and there [were] really only a couple of serious accidents that I recall, that involved these dangerous rocket propellants. One of them happened real early in the Apollo era, just right before I got there. One of the technicians was working on a line that had the rocket oxidizer in it, and the procedure had called for some valves to be closed off so that that line didn't have any more oxidizer in it, and drained off. So he went in there, and he had on what was called a splashsuit, which was just like a rubber rainsuit. [He] even had a splash mask on, which was a clear shield over his face so that something couldn't come straight into his eyes or face.

Then as he was opening one of the fittings with a wrench, it turns out that a valve had been leaking and had actually let some oxidizer back in, and he opened the fitting, thinking it was empty, and some of this liquid squirted out towards him, and it squirted him kind of—the liquid hit this rubber on the chest, and it squirted up underneath his face mask, underneath this clear face shield, and got him in the face, [right] in [the] eye.

They rushed him off to the dispensary and cleaned everything off of him, but it couldn't save his eye. That quick exposure ate his eyeball out. So he was blind in one eye. That fellow came back to work. They got him a—he got a glass eye. He went to work no longer working with those fuels, but [as] an electrician. He still works out there today. So he survived, but that sure was a real lesson to us, and so we never used those face shields again.

Then there was another fellow in the very early 1970s, and he and another guy had been doing some materials compatibility tests, and that involved taking just a sample of a piece of rubber that was going to be exposed to oxidizer somewhere in the rocket engine system, and they wanted to make certain that this new kind of rubber was going to be compatible, not going to react with the oxidizer, so the way they'd they do it was they got a stainless steel bottle that was filled with the oxidizer, and then you put this little piece of rubber in it. It [was] actually a little rubber O-ring, like the washer on your faucet. Then they put a big stainless steel cap back on it and bolted it on, and they would take it down to the laboratory, and just let it sit in a temperature-controlled environment and monitor the pressure in there. So if the rubber was going to react with the oxidizer, things would decompose, and the pressure would rise inside there, and they could monitor that pressure rise in the laboratory as an indicator of compatibility. If the pressure didn't rise, it says okay, the rubber probably is okay.

And then at the end of a week or two or something like that, they would open the thing back up, and they'd take out the little rubber washer, and they'd measure it to see if it swelled up like rubber does in gasoline or something like that, or see if it shrunk up and turned hard. And they'd also do some chemical analysis on the oxidizer to make certain that some of it hadn't dissolved into the oxidizer. So that was a way that the test was supposed to go.

So this one particular day, the guys had gone and they plunked the little rubber washer into the stainless steel canister, which is about three or four inches in diameter, about a foot long, it has a three-quarter-inch-thick stainless steel cap bolted onto the top of it, and then put in there, bolted the cap on it, and they'd done this for a couple of samples, and then it was break time.

So they had these called Hoke bottles—H-O-K-E was the name of the manufacturer—in the back of the pickup truck, and they were sitting on the tailgate of the pickup truck, union break time, and smoking a cigarette, and without any warning, there was this big explosion in the back of the truck. The rubber sample had been reacting violently, [but] they couldn't tell it because it's inside a stainless steel container. It blew the end—blew that big three-quarter-inch-thick four-inch diameter steel disc, weighed about a pound or so, blew it all the way through Jimmy Carrillo. It blew it through his back, out the front, largely disemboweled him. It [barely] missed his spine.

He maintained consciousness! He was still conscious! His buddy stuffed as much as possible back into his body, wrapped his shirt around him very tightly, drove him rapidly to the dispensary. The nurse at the dispensary kept him engaged and conscious so that he did not lapse into shock. They got him to the hospital. They did, obviously, lots of emergency surgery on him. He came back six months later, minus about twenty feet of intestines, with a colostomy bag, and went back to work for us. [His courage and dedication and attitude]—it was pretty moving. [I was so proud of him for that.] Anyway, boy, did we ever learn a lot. You learned something from that, too.

But anyway, those are the only two significant incidents throughout the thirty-six years that I've been there and the nearly [forty] years that the whole base has been in operation. So I think attests well to the overall safety program. Like I say, it was not as organized as it is right now, but I think it was still pretty darn effective.

ROSS-NAZZAL: That's a pretty impressive record. I know JSC keeps records at the front of the site.

MELTON: Yes. We weren't keeping track of all that kind of stuff [back then]. Now if somebody [even on a spilled coffee] slips or twists their ankle on a rock, oh man, that [immediately] goes up on the safety numbers [on the safety sign at our own gate]. That wasn't exactly how the safety program was organized back then.

ROSS-NAZZAL: Let's move on to something a little bit more positive. What was your role during—

MELTON: Actually, I didn't want [anyone] to get depressed with Henry Ickstadt and Jimmy Carrillo, because actually, I think that their stories are educational and really inspiring. Those guys liked their jobs so much that, hey, they still wanted to come on back, and they also were personally convinced that we in the system had taken the necessary precautions so that that wasn't going to happen to them again. So in a way, I think it was actually kind of a positive, another way of learning from some failures, both of them the hard way.

ROSS-NAZZAL: A successful failure, so to speak. What role did you play during the actual Apollo missions, if any?

MELTON: During the Apollo missions, the White Sands Test Facility maintained our test articles in a flight configuration with the propellants at the same load levels and temperatures as the actual vehicles. At least that was kind of the intent. So that if a problem were to occur in the flight, that then they could perhaps quickly call back to White Sands and say, "Hey, we've got this kind of a problem going on. See if you can simulate it."

Well, it turned out that the time lag between discovering a problem in space and trying to set up and simulate it back here was just too great. There was just no way to simulate the stuff in real time. So that turned out to be not really so valuable. Now, we, the [WSTF (White Sands Test Facility)] base, did indeed then do a lot of post-flight anomaly resolution, so if a problem had come up during a flight, like a regulator is supposed to maintain a helium pressure at a certain level, and, jeez, the thing failed, and it ran away, and the secondary regulator had to catch it, well, we would try to simulate the conditions that did that. Sometimes that meant inducing an intentional failure somewhere else to see, well, did that trigger the event? But those were [usually] kind of post-flight operations.

During an actual Apollo mission, at least on two occasions, I was lucky enough to be asked to participate in an actual flight as a consultant on the LM engines, particularly the LM ascent and descent and reaction control engines. So that was really pretty cool.

Going back to the White Sands [role] after [a] mission, we at White Sands were often requested to go back and simulate a portion of a flight to see if we could replicate a problem and come up with a solution, and so if a procedural or hardware change was necessary, we did some follow-on testing to make sure that the proposed fix really did work as planned. An example of that was, you might recall right after they landed on the Moon, they had to dump the pressure out of the helium pressurization system, called supercritical helium. Well, that venting of that pressure forces ultra, ultra cold helium gas through a heat exchanger, which is full of rocket fuel. But the rocket fuel is no longer flowing, and so it would freeze. [The ultra-cold helium] froze the [fuel in the] heat exchanger, making a block of ice, trapping the liquid rocket fuel between the closed-off engine valve and this block of ice up there.

Now the rocket engine is [still] really hot, because it has just finished its firing [from] landing on the Moon, and the heat is soaking back up into that liquid. The liquid not only expands when it gets hot, but particularly in the case of the fuel, if it gets real hot, it can spontaneously decompose and blow up. So they were quite worried on the very first flight, Apollo 11; when they saw this temperature and pressure in this short section of line rising, rising, rising, and they were perhaps even worried that that pressure and temperature might get so high that that section of line would explode. And if it were to explode, it would destroy [not only] the LM descent stage, but also the ascent stage on top. So the astronauts even had to wait inside the ascent stage for this pressure/temperature problem to be resolved in case it started getting out of hand. They were prepared to have to blast off before even getting out of the LM.

So luckily, in that case, one of the valves relieved it. The backpressure was high enough or maybe the ice block was not a total solid ice block, and the pressure bled through and reduced. But for the next missions, they built a tiny little eighth-inch-diameter bypass line around the heat exchanger, which would not affect the total [fuel] flow during operational conditions, but would let the pressure bleed back [if the heat exchanger froze]. So we had to test those little things here after a flight.

On an individual level, I was thrilled to death to be asked to go down and work in the spacecraft analysis room during the actual flights of Apollo 10 and 15. The SPAN [Spacecraft Analysis] Room is right adjacent to Mission Control, and their role is to monitor continuously everything that's going on in [every system on the vehicles, including] your particular system of expertise. So [in my case], that was all three LM propulsion systems.

Those particular days, I think, are still some of the most exciting of my whole career. You got to participate in the moment-to-moment events of a flight. You're right on the circuit, listening to all the conversations between the astronauts and the grounds. No, we didn't get to talk to the astronauts directly, but it was still cool watching everything that was going on, all the unexpected little glitches, all the frantic conversations, the little workarounds, maybe helping some of the other groups besides propulsion, like guidance or navigation or the life support system, help them thrash out some of their problems, especially if it involved a propulsion maneuver or something like that.

Although we didn't get to speak directly with the astronauts, we were listening in on their minute-to-minute conversations as they proceeded through their flight plan. The flight plan is a book that's about the size of a Sears catalog, and it is a timeline that shows exactly what every one of the three crewmen is supposed to be doing every minute of the entire flight [from launch through splashdown]! So there [were] three columns on the page, [one] for the commander, [one for] the LM pilot, and [one for] the command module pilot, exactly what they're supposed to be doing [at any time]. One guy's supposed to be eating. Another guy is supposed to be doing some experiment. Another guy is supposed to be putting on a suit or something like that.

So you were right in the thick of things the whole time. [And] it was really exciting to be part of the succession of all these little mini crises and little mini celebrations each time a significant milestone was passed throughout the whole duration of the flight, from liftoff to splashdown – [nearly a whole week or so]. Those were some long days and long nights, because things don't happen just on a regular eight-to-five schedule in space. They're doing things at all hours of the night or day. So that was way cool back then, especially for a twenty-five-year-old guy.

ROSS-NAZZAL: You mentioned a couple of missions. Where were you when Apollo 11 landed?

MELTON: The night that Apollo 11 landed, I had worked a regular full, whole day [out at WSTF]. And the mission had begun a couple of days earlier with the liftoff, so, of course, [at work] we were watching all the procedures and things that were going on. But by then, the White Sands job was really over, and so White Sands did not have a real active role in the mission. So from here on, it was just me as a personal spectator, like all of the other millions of people throughout the world. So the night that Apollo 11 landed, I got my son and my wife up early, and went over to the in-laws' house. They had a better TV than we did. So my little four-year-old kid was there snoozing while we watched the first steps on the Moon.

People that didn't know a whole lot about it, they were all just really excited. I was a mixture of excited, and I was awestruck. In fact, the hair is still up on my arms right now [nearly 34 years later (gestures)], even remembering it, because I knew of [some of] the problems that we still had, and those guys were [ready to fire the LM descent engine]—I kept thinking, "[Wait], we haven't totally resolved this 400-cycle pressure oscillation in the LM descent engine, and that might be a real problem." [And what about the dozens of other little unanswered questions the engineers all over the country still had?]"

[But] those [astronaut] guys were, "Let's go." They're going to fly it anyway. There's all sorts of little things that the public didn't know weren't totally, totally resolved. We [knew we didn't have absolutely] everything worked out. But when those guys landed, I cried. I was so happy, I just cried. [Sort of like at a wedding, when you're actually real happy, but there are so many emotions going on and so much stress relief, that it just comes out in tears.]

ROSS-NAZZAL: I think it was a very, very proud moment for a lot of Americans.

MELTON: Oh yes. It was just really—it was really way cool.

ROSS-NAZZAL: I think it's especially moving for everyone who worked on the program.

MELTON: Yes. [A bit overcome with emotions.]

ROSS-NAZZAL: Would you like to take a minute?

[Tape recorder turned off.]

ROSS-NAZZAL: During the break, you were actually talking about astronaut Frank Borman. Did any astronauts actually come out to the White Sands Test Facility while you were doing any testing?

MELTON: Oh yes. In fact, I think that virtually all of the astronauts at one time or another came out to White Sands, and that means not only the Apollo-era astronauts, but specifically also the Shuttle-era astronauts. So, yes, that was kind of a fringe benefit. During Apollo days, the astronauts would come out just to watch [and] see how some of these rocket engines systems were working, because [it's] the only time that they could ever see them in action until they actually got on the vehicle. Remember, these were one-time-shot engines, so you couldn't just go fire them for demonstration.

So, yes, we met many of the astronauts, even if it was just kind of in passing, or you would see them in a visiting party. Sometimes you actually got to talk with them. Sometimes if they were going to stay a whole day, they'd even have lunch with you. So, [yes], that was fun, even way back in Apollo.

Now, when they started the Shuttle Program, they even had an astronaut indoctrination program that specifically takes the astronauts around to every one of the NASA Centers so that the astronauts understand what goes on at each of the support installations that are working on some aspect of their flight. The astronauts are expected to be very articulate, knowledgeable spokesmen of the whole program, so they need to understand what goes on not just at Johnson Space Center, but all the other Centers [as well], and that includes White Sands Test Facility.

So kind of a neat part of my current job is I arrange with the Houston Astronaut Office for these visits of all the new AsCans, the astronaut candidates, the brand-new incoming astronauts. So, they bring them out to White Sands Test Facility along with all the other NASA Centers, and we take them around for usually two days. We spend a day taking them around to the engine test stands and the materials test areas and that kind of stuff, and then another day over at White Sands Space Harbor [White Sands Missile Range], where they train how to land the Space Shuttle.

So, yes, you get to go [to] dinner with them and kick around one day and then have a lunch with them and give them briefings and that kind of stuff, so they understand what's going on out here. So, yes, I've met lots of the astronauts and got all kinds of autographs and things like that. So, yes, that's kind of a fringe benefit.

The neat part of that is that it humanizes the individuals. You get to recognize them as, jeez, if they didn't have that blue suit on, you would just think that, hey, now, that's a sharp fellow; or, my golly, she looks like she ought to be a tennis star or something like that, and she's a Ph.D. mission specialist or something like that.

They are regular people, but they are more than regular people. I'm particularly impressed with how well-rounded the astronauts end up by the time they actually fly. They know those systems so well, and they have so many systems to understand. I mean, they have to understand not just the rocket engine systems, but all the way through all the electrical and guidance and life control systems, [and so on]. And, boy, they know how <u>all</u> of that stuff works.

I've spent a lifetime just trying to be good and learn stuff about one system, and those guys have mastered almost all of them. So they're really pretty special.

ROSS-NAZZAL: Yes, they're pretty impressive.

MELTON: I think so.

ROSS-NAZZAL: We've interviewed several of the Shuttle astronauts, and we're always amazed by how much knowledge they have.

MELTON: They're knowledgeable and articulate.

ROSS-NAZZAL: Let's go back to the Apollo Program. In '68, the Manager of White Sands Test Facility, Martin [L.] Raines, recommended to George [M.] Low that he start issuing phase-down orders to the contractors. What sort of impact that did that have on the morale at White Sands Test Facility?

MELTON: Well, remember, in 1968, that was still real peak times for the Apollo Program. In '68, we flew the first mission to the Moon, Apollo 8, in December of '68. So, yes, there [were] lots of activities still going on there. So when the word came out that, okay, there's going to be a phase-down, well, jeez, everybody kind of knew that from the very beginning. We had known from the very start that, hey, this was not going to last forever. The whole base was built on the assumption that they would abandon it at the end of the Apollo Program. As soon as they landed on the Moon, our job was basically pretty much done. Our job was to prove that we could get there. And so by the time they got there, our job was done, and we were ready to move on. So, I don't think it really bothered people a whole lot. We were pretty much unconcerned. We were busy around the clock, and besides, "That phase-down [is] in two years, don't bother me with that now. I've got work to do for the next two years, and we'll worry about that later." So, yes, [the '68]—the beginnings of the phase-down didn't bother people very much.

However, another couple of years later, when the General Smart committee came around with some actual structured means of phasing programs out, stopping work, sending people, transferring people off, it was actually going to involve layoffs, well, boy, that [became] a different story. By that time, our role was coming to a close. We'd already proven that they could do the Moon landings. So as soon as Neil [A.] Armstrong set foot on the Moon, we knew that our job was done and our days were numbered out there. We'd been having so much fun, and we did what we thought was a really good job on it, and nobody really wanted it to end, but that was happening. Some people took it really well. Others took it pretty hard. I know two guys that committed suicide. So, yes, it was a stressful time

When the reality really finally hit that, hey, my job is over and, hey, the program is over, and it was clear by then that there wasn't going to be anything else, we'd been going along thinking, "Okay, well, we're going to go to the Moon, and then we're going to build this big Nova booster, and then we're going to Mars, and things are just going to be a progression." So when the reality sunk in that, jeez, they cut off the last three missions, and, no, we're not even going to fly those last three missions after all, and the public had kind of waned in their enthusiasm, and Congress had waned in their enthusiasm, and the money was drying up and ugh-oh, there isn't going to be any more, well, then that's when things got a little bit more depressing.

So, the place went from a population of 1,800 in 1966, down to 200 people. There was nothing but a skeleton crew. It was a ghost town. No real work there; just a maintenance and management crew to keep it operational. [It was] just one step away from mothballs. So a lot of people got transferred, but a surprising number of people decided that they liked it so much here that they'd rather just get laid off here than return to their former workplace.

The most notable of that was all the Grummanites [employees of Grumman Aircraft

Engineering Corporation], the guys working on the lunar module that had, back in 1964, they had complained so much about having to go out to the boondocks out here, that they demanded, and got, salary concessions and all these special bonus programs. They called it the "10-40" program. They got a 10 percent salary increase and a guaranteed 40 hours per month of OT [overtime], if they could handle it. So, that was a big incentive for them to come out here. It was sort of like hazardous pay, as if coming out here was [hazardous] duty or something.

So, they had come here. Many of them knew that they were going to be out here for five or six years, so they sold their houses back in high-dollar New York, and came out here with a salary raise. So, boy, all of a sudden, they had money. They had enough money to get the nicest places in town. They drove the best cars, because they made more money than anybody else around here. So they lived the high life for those five or six years. But now that it was time to go home, they found that, "Well, jeez, this boondocks isn't quite so bad as I had thought. As a matter of fact, I kind of actually like it here."

So the same guys that back in 1964, when they [were told], "You're going out to White Sands," they said, "Hell, no, we won't go," now they [were told], "Okay. You're going to go back to Bethpage [New York]," and [once again] they [said], "Hell, no, we won't go." [Laughs] So they decided, "Okay, I'll just get laid off here, and fine."

So it was really pretty cool. They [said], "Go ahead. Lay me off." They took unemployment. Here they took other odd jobs around town waiting for the next upturn in the aerospace business. That worked out really lucky for us that they had done that, because within the next few years or so, the Shuttle Program had been approved. We didn't know whether that really was going to get approved. It wasn't the go-to-Mars program that people thought, but, hey, it was better than nothing. So we were gearing back up again, and these people came back from their odd jobs and actually formed [the] core of our post-Apollo workforce out there. So we really depended upon their experience, and that's what enabled us to really hit the ground running with Shuttle testing, depending upon those people that decided to stick it out here.

ROSS-NAZZAL: You mentioned the Grumman folks out here. Could you talk about your relationship with the contractors out at White Sands Test Facility?

MELTON: You mean at that particular time?

ROSS-NAZZAL: During the Apollo Program, and even during the Shuttle Program.

MELTON: Well, especially during the Apollo Program, my relationship with the contractors was—the overall relationship that I noticed was that there was constant bickering and infighting at the upper-management levels, and yet there was constant cooperation and camaraderie at the worker levels. So, since I was at the worker level, hey, that worked fine for me. The guys out at the test stands, they were co-workers and they were good buddies, and we'd go drinking or have parties afterwards together, and let the managers cuss and fight each other. The upper-level management guys, let them go ahead and fight it out.

We would hear about some pretty legendary confrontations, [you know, some of it] downright ugly. But people would come back to work the next day, and people didn't carry grudges, well, at least most of them didn't. I think things are a lot calmer these days. Individual personalities are not so much of a factor anymore. That may be because nobody is getting pushed as hard. We're no longer working to a national mandate. We're not working to a real tight schedule or anything like that. In a way, things are much more professional these days, but sometimes almost a bit bland, not that I welcomed some of the big hassles and fights and yelling and screaming at each other and all that kind of stuff, but things got done real well, and it was exciting and stimulating. Today seems almost calm and boring by comparison.

I worked with virtually every one of the vehicle and engine manufacturers or prime contractors that came out here in a succession of projects. The great part of it was that you got exposed to the brightest and best of their engineers' touting and proving their product and working with us to develop it. So the participants [were] a roll call of the major aerospace companies, many of which don't even exist anymore because there's been a lot of consolidation in the aerospace industry, like Grumman and North American [Aviation Inc.] and Rockwell [International Corporation] and Douglas [Aircraft Company Inc.] and Boeing [Company] and Rocketdyne [Division of North American Aviation Inc.] and TRW [Inc.] and Aerojet [General Corporation, Marquardt [Corporation] and Bell [Aero Systems Company]. A lot of those names don't even ring a bell with you anymore because they've all bought each other, and there's only three or four major companies left anymore.

There [were] also a lot of subcontractors, and those are names you never hear again either, like Zia [Corporation], or Ram, and L&M and Unique [phonetic], [and] things like that, all these subcontractors. So just that variety was a real good opportunity.

ROSS-NAZZAL: Sounds like you worked with a number of people.

MELTON: Oh, my golly. Yes. Since the original mission of the base revolved around rocket propulsion testing, in a way, everybody else was sort of set up there to service your needs, and we didn't feel like we were the big dog on the base, but everybody sort of treated you like you were, so the propulsion people had a lot of access and a lot of support all through the facility, so, yes, you got to know people everywhere because the laboratories, the machinists, and the metallurgists and the chemists, they were all working to help you get your job done. All the computer, electronics people, they were working to help do the data processing for you, and check out new instrumentation for you and things like that. So, yes, [those were] fun times.

ROSS-NAZZAL: You had already mentioned the Space Shuttle Program, and I'm wondering if you could talk about how the program impacted White Sands Test Facility in terms of the facilities themselves and the workforce.

MELTON: You mean like in the transition from Apollo into Shuttle?

ROSS-NAZZAL: From Apollo, yes.

MELTON: Well, the main thing was that we knew that, well, yes, the Shuttle was going to need some new engines, but it was not going to be some of the cutting-edge engine technology like before. So, because of cost constraints, it was going to have to make do with engines that either already existed or [were] kind of follow-on things. So there was going to be a lot of engine testing to do, but money was real tight. So, we did lots of work to streamline our procedures so that it took less time, which means less money, so it took fewer people to do some of the work. I remember that, yes, budgets were tight, and that meant that we didn't have as many people to go do as much work, [and] so I think workloads did increase.

We spent a lot of time fine-tuning and revamping some of the physical facilities to make them easier to operate with the reduced number of people that we had. I know, for example, we spent a lot of time revamping the big steam generator, the altitude simulation system so it would be more reliable, less downtime, less maintenance. We also modified it so that it didn't have to run at full power. That thing cost about, even back then, it cost over 1,000 dollars a minute to run it. But it was big and designed to accommodate the power of the Apollo LM engines. Well, the [RCS (Reaction Control System)] engines on the Space Shuttle were a little bit smaller, and so you didn't have to run it necessarily at full power, but it took some design changes to enable us to run it at partial power so that you're not using so much propellants, you know, wasting it. There's no sense having a 400 horsepower engine if you can only go fifty miles an hour. So, we did a lot of modifications on our systems to make them more cost-effective and able to run with fewer people.

The biggest change, though, was in the laboratories where, particularly because of the experiences during Apollo, they're now required to do lots and lots of tests on compatibility and flammability and outgassing on virtually every item that ever went into the—particularly the crew cabin of the Orbiter. And that was in addition to development and limits-testing on all these new components that didn't exist back during Apollo.

The reusability aspect of the Shuttle was a big change in philosophy for us and required lots of testing. The things on Apollo were designed so that they would operate very reliably once. The things on Shuttle had to be designed so that they could be reused over and over and over again, and in many cases the only way you can test whether something will operate over and over again is to [just] do it. So, you run multiple repetitive tests or accelerated aging tests to see how things will behave. You're trying to compress ten years' worth of missions into less than a year's worth of testing so that you can make some design changes now to enable a system or a component to still be working reliably ten years from now.

ROSS-NAZZAL: Tell us about some of the programs and projects you worked on during the seventies and eighties.

MELTON: Well, let's see. By the 1970s, the Apollo Program was just about over. We did the very last Apollo support tests in about '72. We did some work on Skylab, which [was] our first Space Station using leftover Apollo parts. And the main testing then was to qualify and demonstrate that those parts that had been planned for use on Apollo for only a day or two now could operate for months, and it turns out that most of the designs for the systems on Apollo had been so overdesigned and so conservative and so well done, that even though they were originally made to operate only for a couple of days, they worked quite well when pushed way beyond those limits.

One of the shining examples of that was the little baby reaction control engines, and there were thirty-two of those on the spacecraft. There were sixteen on the lunar module and sixteen on the command and service module. And each engine had a combustion chamber about the size of a flashlight battery, about the size of your fist. They put [out] one hundred pounds of thrust, and they were used to position the spacecraft, the attitude control. They were made to fire in tiny, short little bursts; "bam, bam, bam, bam." And a typical burst, typical firing pulse, was shorter than the blink of your eye. And yet the Skylab Program required those things to operate night and day, night and day, for as much as three months, instead of three [to ten] days like a typical Apollo mission.

Then when the Space Shuttle came along, they modified the design a little bit, but it still was supposed to run in pulse mode, "burp, burp, burp" mode, and yet they found that as soon as we got into operations with the Space Station, now the Space Station periodically needs to be reboosted. There's still a few molecules of air up there even at that higher altitude, so it drags the Space Station down, and the original system to reboost the Space Station is still not available, and so they have to use the Space Shuttle when it's docked onto the Space Station, and use the engines on a Space Shuttle to lift the whole pair, the whole combination, back up to the higher altitude necessary. So now they have to use these small engines that were originally designed to fire only for short little durations, like I say, shorter than the blink of an eye, and in order to boost the Space Station up, they now have to run them continuously for an hour and a half, which is way beyond what any of the engineers had thought that thing would be required to do.

So we've done a lot of testing to verify that, yes, these things can operate way beyond their design lifetime. Sometimes it took some design changes or materials changes to make them last that long, but yes, those were some of the things that we were doing even back in the early seventies.

Then by mid-seventies, by like '73 and '74, we started getting into pure Shuttle work. Apollo and Skylab were over, and then we were moving on into Shuttle. The first work was the Shuttle [orbital] maneuvering engine selection, so they had a runoff between competing contractors and their different prototype designs, and that was pretty cool because you got to work with each of these competing manufacturers: Aerojet, Bell, TRW, and Rocketdyne. And they each brought their prototype engines out here, and we fired the things, and we used the performance evaluation program that I'd helped develop late in Apollo to evaluate those engines against a constant standard, so you could compare apples to apples and evaluate the performance of those engines, [eventually] leading to the selection of Aerojet to [build] that orbit maneuvering engine.

After you select the production engine, then you go into development, which means, okay, you work out some bugs and then make some design changes, and then we demonstrate that the thing will actually do what it's supposed to do. So there's development while you make changes. Then you freeze the design, and then you put it through all the certification test requirements to demonstrate that it really will perform in space.

There wasn't always enough work to do in the propulsion area, so for a year or so I worked up in the laboratories, even. I worked on some experiments that were going aboard the Skylab, so that was interesting, but I still liked working on rocket engines the most.

So, by '76 or 1977, we'd already selected the OMS [Orbital Maneuvering System] engine manufacturer [Aerojet], but it turned out to be a very conservative design. They wanted to make real certain that this thing was going to last and last, but in order to be a conservative, very safe design, the thing didn't extract all the last bit of horsepower out of the engine that they could have, and so one of the tradeoffs is between high performance and combustion stability. And so typically, engines that are very high performance may run on the ragged edge of this combustion instability, which can destroy an engine in half a second. So if there were a way to suppress some of this combustion instability, you might be able to get even more horsepower, more performance, called specific impulse, out of the engines.

So another fellow from JSC and I worked on a year-long project developing some alternate means of damping these instabilities in rocket engines that without those suppression devices in there were spontaneously unstable and would destroy themselves in a second or so. And by so doing, we could increase the performance by 2 or 3 percent, which is a huge amount in the rocket engine business. Anyway, so that was kind of a pure research program that I got to work on for a while. Turns out that they decided not to adopt it. They [said], “Well, the performance is good enough as is, and we don’t need the extra complication of this suppression device. Besides, it sticks out a little bit too far around the side of the engine and we’re kind of cramped for space for that. So we’re just going to stick with the original design.”

But, yes, that was a fun program to work on in the mid-seventies up into the 1980s.

ROSS-NAZZAL: Now you work as a technical assistant to the manager. When did you take on that position?

MELTON: That started in 1981, and that happened when my boss, Rob [R.] Tillett—and I think you even talked with him—was it last year?

WRIGHT: Maybe it was the year before.

ROSS-NAZZAL: Yes, I think it was ’99 or something.

MELTON: A year or two ago. Anyway, I worked for Rob Tillett as a test operations director, ended up working for him for twenty-six years. Anyway, he was a cool guy. I really enjoyed him— [he was really intelligent and knowledgeable about a really wide variety of subjects that I also was interested in, and we shared several hobbies, like dirt bikes, and guns, and astronomy and photography. He really taught me a lot about many of those things, as well as the technical aspects of doing my job.] Anyway, he was chief of propulsion test operations [for a dozen years], and then was selected as manager [in late 1981]. So, he asked me to come join him. He

[said], "Do you want to come move up the hall with me?"

[I didn't hesitate long, and said], "Well, okay."

He said, "I particularly need somebody who can write."

So I could tell, all right, well, I'm going to be getting out of the rocket engine test business, but by that point in time, the rocket engine world had gotten pretty, fairly mundane, I thought. We weren't doing anything new. The Shuttle was already flying, so now we were just working on life-cycle-extension kind of things, and the rocket engine world wasn't so appealing anymore, and besides, there was a promise of a promotion. "All right!" A little bit more money! Maybe not quite as much fun, but anyway, it was a new job.

There hadn't ever been a technical assistant to the manager, and he said, "Well, I'm just going to need a hand in a lot of technical areas [here]." So it really kind of combined the duties from a lot of other overloaded people around. So, it was like specifically I was supposed to be the technical manager of the support services contract. Now, the previous guy—we made a real distinction to call it the technical manager <u>of the contract</u>, because the previous guy had called himself "technical manager." Well, that became a real ego sticking point, because the manager, rightfully, thought that he was the top dog there, and here's this other underling, some GS [General Schedule]-14 there, calling himself "technical manager." Anyway, that title was kind of abused, so, well, we made certain that I was called technical <u>assistant</u> to the manager.

I also then became responsible for public affairs and security and legal office liaison, and technical editing, like I was supposed to review all technical publications out of our base for technical accuracy and correct usage and that sort of stuff.

[After a dozen years, and thinking I was on the verge of retiring], I eventually dropped the technical manager aspect in 1998 with the advent of a whole new [performance-based] contracting type out here. [This] was a whole new [kind of] contract, and we were no longer a level of effort kind of a contract. [I thought] it was [just] a politically-driven change in the overall format of the contract, [and I wasn't real convinced that it was the best way to do it, but had no choice but to go along]. So I was pleased to move [out of that and] on to something else. However, there was a whole new set of responsibilities coming along in the world of export control, which basically [aims] to protect NASA knowledge and technology from uncontrolled proliferation and usage by people that shouldn't be using our information that way, mainly to help protect and maintain America's competitive edge in technologies. [So I took on that responsibility.]

I ended up writing lots and lots of policy documents and position papers and did a lot of strategic planning kind of work to position NASA in the marketplace, in addition to editing all of these technical publications primarily out of the laboratories and things like that. I'd have to do all the periodic reports summarizing our activities for higher-ups. In particular, it seemed like there were almost yearly attacks by [NASA] Headquarters [Washington, D.C.], almost always by somebody out of Headquarters [that] had never been out to White Sands Test Facility, didn't know really what we do, but they see us as a forty-million-dollar-a-year budget line out there and says, "Hey, we're in [a] hurt for money, so let's get rid of these guys."

So there'd be a committee formed, and [there'd] be some people from Headquarters to come out here to see. "Okay. Well, show us why we can't get along without you," or, "Show us what we're going to lose, because we're going to plan to close the base."

So this became almost a recurring event. So I'd be part of the team, usually the main one to compile all the papers, the position papers, or impact statements, they were usually called, typically [a hundred] pages long or something like that, to show to these guys. We called them boarding parties, because we considered them pirates. They [were] going to try to take us over or put us out of business. So those were major recurring jobs as technical assistant.

ROSS-NAZZAL: When was the last time that you had to [help] write one of those impact statements? Do you remember?

MELTON: Well, the biggest [one, the biggest], most recent one was in '92. There was another big one in '96. But they've kind of backed off [lately]. Maybe we have pretty well convinced them that this is a very value-added installation that has really been held up as a model of cost-effectiveness and is certainly not the best place for them to cut their money.

ROSS-NAZZAL: I just [have] a few more questions. Can we talk about the *Challenger* accident and the impact that it had on the White Sands Test Facility?

MELTON: Yes, sure. Again, like the Apollo fire, once the shock and the personal tragedy was absorbed, we got down to business and did a lot of tests on some of the redesigned components. Particularly the laboratories did lots of tests to determine [in] even better detail the safety and flammability of different materials and components used throughout the Orbiter. Up in the propulsion world, we tested some of the alternate escape mechanisms, which in some cases, in one case, even involved having the astronauts attach themselves to like a bazooka rocket, and the rocket, they'd attach a lanyard onto this rocket and fire the rocket and [it] would jerk them out of the side of the Orbiter. So, "Okay, [well], we'll test that if you think it's a really good idea." [Laughs] It turns out that, yes, the engines would work, but the probability of being able to really use that as an escape mechanism was really pretty low.

Our guys did some of the video analysis of the explosion of the *Challenger* to see exactly—they wanted to back into a prediction of how big that explosion really was, how powerful it was, how much of the propellants had reacted. Of course, to people on the ground, it looked like a huge explosion in the air, but most of what we saw was really just condensation and vaporization of those ultra cold cryogenic propellants. If that much oxygen and hydrogen had really fully reacted, it would've looked like an A-bomb up there. It would've been much, much bigger than that.

So one of the things that NASA really needed to know for any of the upcoming missions is, okay, well, how bad would an explosion be if you mixed these propellants together? In particular, we had some missions coming up going to Jupiter, Galileo, and then some of the other deep-space missions like Cassini [going to Saturn]. Now, those missions use radioactive power generator sources, and those RTGs, they're called, radioisotope thermal generators, it's necessary because once you get far away from the sun, you no longer can use solar panels to create energy, and batteries don't work [long enough], and so these things create [electrical] energy by [using the thermal energy of] radioactive decay. But you want to protect that plutonium source in there so that in the event of a rocket explosion, you're not scattering plutonium all up and down the eastern seaboard and poisoning millions of people.

So the RTGs are encased in a very heavy protective casing. But we wanted to make certain that, okay, well, if the Shuttle were to explode, would that explosion breach the protective shell on it? So since you can't really simulate the full explosion of a Shuttle, we did some subscale tests mixing oxygen, liquid oxygen and liquid hydrogen together to determine how big an explosion would be.

We even ended up building a special test facility or high-energy blast facility to do fairly large-scale tests up to a ton of rocket fuel and oxidizer together exploding to see, [okay, well], how big would the explosion be? And some very important conclusions were reached by those programs. In particular, there is an equation called the quantity-distance relation. It means how much quantity of propellant can you have, and if it were to react, how far away do you need to have structures and people so that they don't suffer damage. And the Department of Defense for many years had used an assumption that if you had liquid oxygen and liquid hydrogen and they were to mix together and blow up, you would get an explosion equal to about 60 percent as much as the same amount of TNT. So it's called a TNT equivalency of 60 percent. So that meant that, boy, you would have a mighty big explosion if you had half a million gallons of TNT go off.

It turns out that our several years' worth of experiments, after *Challenger,* showed that that number was way too high, and so instead of 60 percent, the real number turned out to be somewhere between about 8 and 16 percent. So that meant that the fuel and oxidizer did not really react very well together, and so they did not make an as big an explosion as the Department of Defense had been assuming. Actually, what happens is as soon as the first layer of fuel and oxidizer get together, yes, they react and they explode, but they blow away the rest of the reactants. So it doesn't always get a chance to mix and actually blow up after all.

So the military was very interested in that. For example, Vandenberg Air Force Base [California]. Vandenberg was originally proposed as the western launching place for the Space Shuttles. And you notice, jeez, you never hear about Vandenberg anymore. Well, Vandenberg is on a very small spit of land, and the launch control center is necessarily pretty darn close to the launch pad. Not only that, but in order to get the exhaust gases out from underneath the Shuttle, they made like a little underground tunnel to deflect the exhaust gas out, and you might even see some indications of that down at the Cape. The exhaust goes out kind of sideways.

Well, in the case of Vandenberg, because of the geometry and the geography of the launch pad, that was into a great big, large-diameter tunnel. It's okay as long as exhaust gas is going through there, but somebody posed the question, what would happen if you had what was called a pad abort, and you start up the SSMEs, the [Space Shuttle] Main Engines, and something is not happening right with them, and you have to shut them down, even before you light off the solid rocket boosters. In that case, when they shut down, they dump about 400 pounds of excess pure hydrogen out. That's the amount that's still trapped in the engine, and it all goes out, and now there's all this hydrogen contained in this tunnel which is open to the atmosphere, and a single spark could set off that hydrogen in there.

So some of our tests indicated that it was quite conceivable that the ignition of that trapped hydrogen in the exhaust duct at Vandenberg would literally blow the Shuttle right off of the pad. So, as a result, Vandenberg was scrapped as a Shuttle launch facility, so they will never consider launching a Shuttle from Vandenberg. So that's why you never heard about Vandenberg ever again. So that was some of our work done out there in the post-*Challenger* era.

ROSS-NAZZAL: One of your other duties that we've read about was your responsibilities related to inspection days.

MELTON: Yes, inspection days was the JSC Center Director's idea of how to acquaint not just the general public, but the rest of the industrial complexes with what the Johnson Space Center not only did, but also perhaps could do for them, looking for maybe some spinoffs and ways that aerospace technology down at JSC could be used in some of the commercial businesses.

So every year for, I think beginning in 1996, they would open up the Johnson Space Center and have exhibits showing off some of their new technology and capabilities both in machining and software electronics and things like that. And they'd invite industry leaders from all over the country, but primarily from the Houston region, to come in there and see "what do you do and what perhaps could we do together?"

And so White Sands was invited to bring exhibits just to show what we did out there. So I was responsible for putting together the team and all of the exhibits and training the staffers to go down there for the three-day event every year, to tell the White Sands Test Facility story to those people; even though everyone recognized from the beginning that there's not very much that this rocket engine test facility 800 miles away can do for these industry people down there in Houston, but at least it was an opportunity for us to tell our story.

It turned out that even though I don't think it was of very much value to the industrial people that were invited to come see it, it was a great opportunity for the people at Johnson Space Center itself to see what their buddies in the boondocks were doing, because most of them have no experience with us whatsoever. They see that White Sands Test Facility organizationally shows up as a little line under Johnson Space Center, but most of them don't really know what we do. And so since we were right there on campus, it was a good chance for them to go by and say, "Oh, [yeah], hey, we've heard of you guys. Oh, neat place you got out there. Jeez, yes, you do some cool stuff." So, it gave a better appreciation for the general populace down there at Houston into what we were doing.

ROSS-NAZZAL: We've spent a lot of time talking today, and I'd like to ask you just some general questions. What do you think has been your most challenging assignment during your career while working out at White Sands?

MELTON: Well, I knew you were going to ask me that, and I thought about it for a long time, and it's difficult to think about, okay, what does she mean by a challenge? Does that mean something that was the most difficult to do for me? Yes, maybe so, in which case I think that probably my biggest challenge was the recurring requirement for constantly evaluating the support contractors' performance on [both] a macro and a micro level. That was the technical measure of the contract aspect. Jeez, I did that for twenty years. And that involved creating and implementing and constantly evolving these fee-bearing evaluations into a fair and timely management tool to incentivize and reward the contractor for doing the job that they were supposed to do.

The reason I consider it a challenge was because, first of all, it wasn't something that I trained for. I didn't go to school to be a contract manager, so it was a little bit out of my original focus. The other thing is, the process just always seemed kind of pressured and contentious among all the different multiple NASA participants. They were all senior to me, and they all had their own diverse and divergent opinions and agendas and priorities for evaluating how the contractor was doing their job. And this was a part of our job, to manage the contractor, and you gave them money based upon how well you graded their jobs, graded their performance on doing the job.

I thought it was a painful process, and it consumed nearly a third of my total hours as technical manager, and so every six months, in addition to bimonthly meetings that consumed two solid days of listening to people griping about how the contractor had done, which put me in a position of passing judgment on my [contractor] peers, and I was not always real comfortable with that, but, yes, it's a necessary part of the job, and you start separating the people from their performance, and that was the important part. You just look at the performance and not bring the people into it.

So that was every two months, and then every six months we had to write up this sixty- or seventy-page document that detailed all of this performance evaluation. Then an oral presentation to the committee and the JSC Director, and George [W. S.] Abbey was particularly good at grilling and questioning nearly every conclusion and grading criterion and rationale.

[Then] there evolved a mentality that "if you can't measure it, you can't manage it," which I suppose has some merit. The idea behind all that was to take some of the subjectivity out of the contract management and evaluation process and turn it into measurable milestones and things that you can say, "Okay, well, you took this test and you got an 80 on it," not just someone saying, "Yes, I think you did pretty darn good, and I'm going to give you an 80 percent grade on it," because then they'd come back and say, "Well, gee, why don't I get a 90?" Or the other side would say, "Well, jeez, we expect you to be competent, and so if you do the things that we tell you to, hey, that should be average. So you should only get a 60 or a 70 for that."

And then the contractor would say, "My golly, do I have to walk on water to get a 90?" And I'd say, "Well, [yeah], and if you can walk on water without getting your feet wet, well, then, we'll give you a 95." They'd say, "Well, gee, what do I have to do to get a 98?"

So there was a lot of philosophizing and constant adjustments going on, so there's a constant challenge, and although I eventually came to dread the process every six months, I'm proud that these evaluations were often held up as a model for others to follow at JSC. George would finally, after he finished grilling us, would say, "Okay, guys. Well, I agree. You're doing a darn good job, and I wish most of our guys were doing as well on it, too." That was really pretty—in a way I would consider that probably the most challenging aspect because it was repeated for so long.

As far as significant accomplishments, it's hard to say. I'm not even real sure that anything that I ever did was really significant, certainly not in terms of the overall space program, certainly no breakthroughs or advancements for the program. Maybe even just barely perceptible even on a local level. People have short memories. There's a lot of turnover, and most of all, the culture is not one that individuals do spectacular, recognizable things. Most things are done by teams or committees or something like that. So, you just notice it. ["Okay], well, hey, something finally got done. Hey, that's good." And nobody ever asks, "Well, who invented that?" It's not important for somebody to stand up and say, "Hey, I did that. Give me a star," or something.

For example, [even though] I bet that none of today's propulsion engineers at White Sands even know [it]—and it doesn't matter to me—I was primarily responsible for creating in the late sixties and early seventies the first rocket engine performance analysis, and the standard correction program, which became the core of all those performance analysis programs used since then. Now, I didn't do it all by myself. I took some ideas from some of the experts that I had met from Rocketdyne and Aerojet, and put some of their ideas and applied them directly to our needs out here, [and it] become a really useful tool not only for my own data analysis and test report prep [preparation], but for all the rest of the guys that followed me, even though I was the main driver, but I'm not a programmer, so I didn't invent the whole thing myself. It takes lots of other people to do it.

Another thing that I'm pretty pleased with is our website. And again, I'm not a real computer guy, but I was the one that sat down with the computer wizard for nearly a year to come up with the content and presentation for our first website in '96. Now again, I took lots of ideas from the other organizations as propulsion and engineering in the laboratories and all that kind of stuff, to get these ideas and put them into a new kind of format. That was only six or seven years ago, and people no longer even associate me with the website. I've moved on. My name no longer appears as the responsible NASA person on there. We've reorganized, and now that person who is the responsible guy, he isn't responsible for the content. He's just responsible for like the HTML coding on it or something like that. But the first website was really an outgrowth of my responsibilities as public affairs, where I had to keep making these capabilities brochures that were used for marketing as part of [our] strategic planning. You were supposed to be able to send out these capabilities brochures so that people would say, "Oh, wow, you guys can do cool stuff. I think I'll bring my business and my money here."

Well, things got so they were evolving so quickly, that a paper-based brochure could hardly keep up with the changes in technology and our rapidly evolving capabilities. Production costs for paper were real high, [and] when the website stuff came along, my boss really kind of forced me into it. He said, "I think we need to develop a website." So, yes, I was the primary one to do that, [but like I said, I had plenty of help].

I'm also quite pleased [that] I've had the opportunity to really enhance our facility's security posture with a really well-disciplined, well-equipped, and well-trained staff. We got the latest, greatest state-of-the-art equipment to ensure the safety and security of the people and the property and the assets out there. And again, the people from Houston who come up here out to our base and visit often remark that, jeez, they wish their security force down there was operated as well as it did out here.

And even though it may not have really been significant, I'd still have to say that the times I was able to actively participate in real missions like Apollo 10 and 15 or during one of our tests to be able to catch a runaway rocket engine problem, maybe just a few seconds before it destroyed itself, or just to be on the team that found and fixed a problem that was a real stumbling block to certifying an engine or a system, those are fleeting moments that I'll really remember. Not famous. Nobody remembers who did it, but, boy, I was pleased to be in on those things. That was enough for me.

ROSS-NAZZAL: That's quite a list.

MELTON: The thing that is really noticeable is the—I think the general atmosphere is way different now than it was back then. I think that the people were a lot more driven then. The enthusiasm was just so high, it was really exhilarating. I know myself personally and everybody around me, we were just really pumped.

ROSS-NAZZAL: What about technology? How has technology changed out at the facility?

MELTON: I'd say that, well, for sure, the computers, the advent of the personal computer [was] the biggest thing. Back in the early days, back in the Apollo days, my golly, we'd get the job done, but we'd have guys with slide rules and writing longhand. And if you had anything done that required math work, you had the mechanical calculators. You would have to write up a special work order to have anything done on a computer. Secretaries did all of the actual writing, to turn things into final form. So certainly within the last ten years, the computerization has made just a huge difference out there.

We used to kind of brute-force things, all the spreadsheets and management tools—in a way they've actually <u>increased</u> rather than decreased the [individual] workload, because [of] the things that we used to segregate out—for example, project engineers never used to have to worry about budget. No, that was an entire organization that worked about the budgets. Now the project engineers, they have to do all that stuff themselves. They also had a scheduling department; the scheduling people took care of that. Now the project engineers have to do that. Well, they're doing it largely with canned programs, you know, [like] Microsoft Project Manager. You plug those things in, and it does all the scheduling and resource allocation, the manpower and the money and the cost-tracking codes and things like that, that never before were consolidated all into a single individual. So there's a lot of responsibility on a single guy.

In addition to the human resources aspect of supervising your people, [you've] got to do the technical and [the] budget and scheduling and all that sort of stuff. These are [tasks] that ordinarily would've been broken down into at least two or three separate jobs. So, yes, that, I think, has been the biggest technological change out there that's probably mirrored at every other NASA Center.

ROSS-NAZZAL: If you don't mind, I'd like to ask Rebecca and Sandra if they have any questions for you.

JOHNSON: I just have one quick one. I was just going to ask you, you talked about the reports and the Friden calculators early on, and it just reminded me of some interviews we did out at [NASA] Dryden [Flight Research Center, Edwards, California]. I was wondering if you had any type of help like mathematicians or anybody helping you write those reports or to [look at those] strip [charts] or anything.

MELTON: No. Basically, I was taught how to do it myself. So, yes, the data interpretation was something that each engineer pretty much did by himself, but as soon as I say that, I realize, no, shoot, no, I always had others guys around me. We'd be poring over these charts and the data printouts to come to a kind of a consensus about what this little squiggle here meant or whatever.

I know some of the early data would come out not only in number form, just numerical, during this half-second time slice a chamber pressure read so many pounds per square inch, and the injector temperature was this much, not only in digital data, but there was [also] a lot of analog stuff back then, so it would be a chart really either with ink on a piece of paper, or we had some high-speed stuff called oscillographs, and that was where a moving beam of light would write upon a rapidly moving piece of photosensitive paper, and that paper could move at up to 156 inches per second. So that allows you to spread one second out into thirteen feet.

So, during a test, when you had to watch something that was going to be over with in a quarter-second, you would choreograph the guy running the machine. Then he'd press the button a second early to give the machine time to get up to speed, and it would spit and spew paper halfway across the room, and you'd end up with 150 feet of data, and you had something that was over within ten seconds. Then you'd go back and you'd look for this little spike in pressure there. At that speed, an eye blink is three feet long. So you could see all the little fluttering in the muscles in the eyelid or whatever. You could watch all the pressure oscillations in a feed line during a start transient as the rocket fuels begin to combust and then go into final steady-state combustion.

They used some special tools called a Gerber scale to measure out and scale, okay, well, if the peak is four inches on here, well, how many pounds per square inch is that? So you'd measure it off. Okay, well, if four inches is a hundred pounds per square inch, and this little spike here is three inches, well, that means that it's seventy-five pounds per square inch. So you'd measure the little squiggles with [the] special [Gerber] ruler. And then you'd kick it around and decide what that really meant and then write your report based on that.

But, no, there wasn't a team of mathematicians or anybody like that, that I knew of to call on, probably because that part of it wasn't necessary.

JOHNSON: Thank you.

WRIGHT: I just have one on a lighter moment. When you first started your interest in rockets, your parents wanted you to do something that was safe. Did they find when you went to NASA, was that a safe environment, or were they concerned?

MELTON: I think they were just—sure, they were worried about their son blowing himself up, and in fact, I have a deformed thumb here [gestures] where I got stupid and almost blew my hand off with one of my little homemade rockets [back in junior high]. Of course, they didn't want their basement blown up or their house burned down either, so they had some very valid reasons for emphasizing the safety on it. But they both grudgingly finally accepted that I really wanted to do this, [and] was actually doing things as safe as I knew how within the limitations of a teenage boy that wants to go do some of these kind of off-the-wall things. Safety certainly was not my big, overriding concern. I just wanted to do these things, and, yes, in many cases I was lucky, because I probably didn't even know how close I came to either hurting myself or hurting the house or something like that.

WRIGHT: It must have been very interesting for them to watch you grow into a career doing what you had wanted to do as a child.

MELTON: Yes, [although they] never really expressed it that way. There was never any pressure to do anything in particular, to be anything, although there was a big emphasis, "Yes, we really think you ought to go to college." I mean, that was just a given from day one. It was portrayed in pretty easy-to-understand terms, "Hey, you go to school, yes, you suffer going to school, but, you end up with a better job, one that you like a little better, one that doesn't require you to be out digging a ditch when you're sixty years old, something that may end up paying you a little better, maybe a little better way of life, and especially something that can hold your interest and really be satisfying for you years and years later."

So, yes, just that general orientation worked out real well, and I really—I had my dream job. I had the rare opportunity to start my career at the top. I mean, this is really what I [always] wanted to do, and I lucked into it, but it was just an all-time high to be able to be on the team that was going to the Moon. I mean, this was something that mankind had dreamed about doing for thousands of years, hundreds of thousands of years, and by golly, we were the ones that got to do it. So that was pretty amazing.

WRIGHT: Thank you.

ROSS-NAZZAL: You've had a great career with NASA, and we're happy that you've shared it with us.

MELTON: Well, obviously I've enjoyed it, and it ain't over yet.

ROSS-NAZZAL: Thank you very much for joining us today.

[End of interview]