Recollections from Boeing Apollo Employees:

Stanley Barauskas works on the power and propulsion systems for the space shuttle orbiter and is responsible for the auxiliary power unit that provides the hydraulic power for the space shuttle that allows it to fly and land like a glider. Based in Huntington Beach, Calif., Bararuskas has had an interesting career supporting NASA's Apollo program while working at North American's Aviation plant in Downey, Calif.

Barauskas first job out of Newark College of Engineering in 1961 was working for General Dynamics on the Atlas missile program supporting the missile sites in Omaha, Neb. "As a kid, I was fascinated by space flight and technology. I read every Science Fiction book that was available at the time. It was my dream to work on some aspect of rocket flight." He eventually moved to San Diego where he was responsible for the Atlas rocket engines and the propulsion systems. The Air Force deployed 129 Atlas missiles across the country.

Barauskas grew up in Jersey City, N.J., but his father was born in Moscow and he lived in Lithuania. Barauskas was nine years old when he entered the United States in 1948 and had the additional challenge of learning to speak English. "At the conclusion of WW II, my parents decided not to return to Lithuania because it had become communist and had been taken over by the Soviet Union. We contacted our relatives in New Jersey and stayed with them until we could find our own home."

After the Atlas rockets were decommissioned, Barauskas joined the Apollo program for North American Aviation at the Downey plant in California in 1963. "I was accustomed to working on large rocket engines, but North American needed people to help out with the smaller engines." He began working on the attitude control engines for the Apollo service and command spacecraft modules. They used 100-pound thrust engines.

"Initially, I was worried about working on these smaller engines and that the contract would be over with in a year and a half and I would be out of a job again. I did not realize at the time how complex that little engine was," said Barauskas.

The small engines help orient the spacecraft correctly toward the moon and weighed only 5.4 pounds. They were rudimentary computer controlled engines and there were a total of 16. The engines were deployed in a quad format pointing left, right, up and down. There were two separate redundant systems and double the amount of engines and fuel tanks than were needed.

"My job was to see the engine all the way through development with the supplier and also for qualification and certification. When the engine was finally delivered to Downey, I was responsible for certifying the entire subsystem. We did most of the certification through hot fire tests." The specification for the test was to fire the engine for a thousand seconds, but the engines were not intended to fire continuously.

"The most critical element for the engine was called the minimum impulse. The engines had to fire so little so they could make very minor adjustments. The engines fired so little that the vehicle was turning slower than a minute hand on a watch," he said. He remembers the engines had burned up and caught fire during a number of tests during development. "During one test where we were testing the number of cycles at around 5,000, it blew up when it was suppose to last 10,000 cycles and that set us back by about a year in development and we had to redesign the whole engine." Barauskas wrote the final procurement specifications for the supplier.

"In the Apollo program we had to have double redundancy, while on the shuttle program many systems are triple redundant like the system I work on today," he said. He worked on the Apollo program for approximately nine and a half years and also worked on the Skylab and Apollo Soyuz Test Program.

He remembers the work environment as being very challenging. "The president had given us the challenge and we had a deadline to meet. Anytime there was a problem, Congress provided additional funding as needed. There was no question that you would not be able to do something because of a lack of funds."

"There were periods where we had 24 hour days and you just didn't leave the office. The longest I remember working straight through was 36 hours non-stop. People just made the sacrifice. Working on Saturdays and Sundays was commonplace. It was an exciting time and we closely watched the Gemini flights. All of those activities could be heard on the plant PA system and everyone would stop what they were doing when critical flight events occurred."

"For the Apollo 11 landing, it was the single biggest event in our lives at the time," he said. He was in the design group and was never called to provide any on-site support to the operations team during the launch and landing, but did work closely with the operations team in Florida for test and checkout and other preparations for launch.

Downey was the center of much of the Apollo activity. "I remember the critical moment when Buzz Aldrin was guiding the lander down and they were talking back and forth to the control center and I remember thinking I hope my engines work and they did." The very same engines were also used on the lunar lander. "I remember that Northrop Grumman team followed the development of these engines very closely and chose to use them. It was a good deal for them since North American Aviation had funded all of the development costs and all they had to do was take delivery of the final product."

Barauskas also remembers that the Rocketdyne division of North American Aviation had competed to produce these smaller rocket engines but NASA chose another supplier called Marquardt in Van Nuys, Calif. because of their lower cost. "It was interesting for me to work with a competitor of Rocketdyne during that period." The same company won the contract to do the attitude control engines for the Space Shuttle program.

At the end of the Apollo program, Barauskas remembers his last day. "I remember my boss telling me on a Friday morning that when I come back on Monday to report directly to human resources department for your termination interview." Lucky for him, the company was awarded the space shuttle contract and the visit to human resources never happened. North American Aviation had about 34,000 people employed on the Apollo program at its peak and the company ended up laying off around 28,000 people. The layoffs began before the Apollo 11 landing when most of the design and production work was completed.

His advice for space shuttle employees facing another drawdown like Apollo is. "I think it depends on where you are in your career. The opportunities will be in the new NASA programs like Orion, Ares, etc. Those programs will go many years and chances are you could spend your entire career working on those programs."

Barauskas has about 48 years in the space business and has no plans for retirement. "I went into semi-retirement in 1999 when I retired from Boeing, and came back as a contractor for the last 10 years for Inconan Temporary Services and have been on a six-month renewable contract basis. I am working on a part-time basis for now."

He is a strong supporter of the nation's plans to return to the moon and as a training ground for future missions to the Mars. "Keep it going and the funding needs to be there and the

many discoveries that came out of Apollo came from our ambitious goal. We should not cut the NASA budget as it will affect our future."

His biggest lesson learned from the Apollo program was how you deal with set-backs. "If you have technical setbacks, you have to remember there are always ways to work through them and to not give up. I think we have enough ingenious people around that we can come up with solutions."

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Retired Boeing and NASA engineer and senior manager **Harold F. Battaglia** spent many years working on the Apollo program and continues to pursue his passion in space as a technical advisor to the NASA Constellation Safety and Engineering Review Panel. Battaglia currently works for J&P Technologies, a company under contract to SAIC.

During the Apollo missions, Battaglia worked in the Life Systems Division/Space Suit Design Section in NASA with an engineering focus on space suit design features that provided advancements in the space suit glove to improve dexterity, tactility, and flexibility, and in the space suit shoulder joint to improve flexibility, reach and joint rotation. During this period, he also worked on suit design features that improved donning and doffing capability of the space suit.

Battaglia was born in New Orleans and joined NASA in Houston, Texas after graduating from Louisiana State University in January 1962 with a degree in mechanical engineering. "I believed that the space program was going to provide a tremendous technology development opportunity for our country and the ability to do things and go places no one had ever ventured. I interviewed for a job with NASA at the LSU campus in Baton Rouge and was offered a position in Houston starting February 1962," he said. "I had some good job offers from other companies, but I felt very proud that I was able to be hired by NASA."

"I came to Houston with my wife and one child in an old Oldsmobile that barely made it here. I started in the Lane Wells Building on Wayside Drive which NASA was renting at the time because the Manned Spacecraft Center had not been built yet. It provided two floors of office space and laboratory facilities for the people who worked in the Life Systems Division. We had some very humble beginnings back then," he said. The center, which was built a couple of years later, was run by Dr. Robert Gilruth, who he remembers as a super center director who was very well respected.

"The spacesuits during the Mercury period had very limited mobility and had come from designs to accommodate pilots in high altitude aircraft. The suits were like a rigid balloon," he remembers. "The big challenge we had was to build a suit that had much more mobility and reach capability that permitted the astronauts to exert less effort to move the joints in the suit because the joints were so rigid from pressurization. We had to design mechanically assisted joints in the suit that allowed the range of movement that was required," he said. "Our challenge was to build a suit that was easy to move inside of and not overtire the astronauts while providing good reach capability for them to be able to operate switches and move about," he said.

"We had to design a glove that allowed for good dexterity and tactility that was needed to feel the various switch positions and button depresses. Back then, we had very rigidized gloves and your hands and fingers got tired quickly. It took many trials and efforts to get a good glove design and today the astronauts do very well accomplishing their EVA tasks with the improvements that have been made over the years."

He later transferred to a facility design and test section within the Crew Systems Division and had the responsibility for conducting thermal-vacuum chamber testing on the Extra-Vehicular Mobility Unit which comprised the Suit and Portable Life Support System. The purpose of the testing was to support Apollo crew training activities and checkout of the EMU (space suit and portable life support system) performance parameters.

When asked about what he was doing on the Apollo 11 mission and his fondest memory, Battaglia remembers doing many EMU tests with the astronauts and other test subjects during that period. One of the things that Battaglia remembers that made them successful in designing a new suit was going out and buying a wide variety of suits that were built by the military and by other countries for use in high altitude aircraft. "We studied those design features and either used some of them or made improvements to allow us to build the best suit that we could at that time," he said.

The designs were tested in an 8 foot diameter altitude chamber. Besides working on the suits and backpacks that went to the moon, the Crew Systems Division was also responsible for the environmental control and life support systems (ECLSS) in the spacecraft that were needed to keep the astronauts alive for their journey into space. "We used the altitude chamber to prove out the concepts and designs, and perform crew training" he said. The moon had 1/6th of the gravity on Earth and the team used mechanical counterbalance weights and harness arrangements attached to the suit to simulate the gravity environment on the moon.

"We got feedback from the astronauts on how we could improve the shoulder joints and pressure points in the suit. These were points in the suit that pressed against the body while the astronauts were exerting motion and eventually would cause some bruising and irritation. We tried to remove those pressure points that caused discomfort to the astronauts." He stated that the suits continued to improve during and after the Apollo mission as they got feedback from the astronauts.

Battaglia worked in the Crew Systems Division in the Engineering Directorate as a space suit design engineer, facility testing design engineer, test conductor, project engineer, and thermal-vacuum chamber facility manager on the Mercury, Gemini, Apollo, Skylab, Apollo-Soyuz and Shuttle Programs, for 18 years.

"Although I never sought to get into the Crew Systems Division, I had always wanted to work in an area with a lot of test equipment to prove out designs in different environments. I liked working in a laboratory test facility environment and was able to learn a lot. I enjoyed designing test equipment that was needed to support those tests that we ran with the astronauts."

In 1979, he transferred to a new office called Shuttle Payloads Integration and Development Program Office (SPIDPO). At the time, the Space Shuttle was being used to fly commercial, government and university payloads/communication satellites to geosynchronous orbit and low earth orbit. He served as a Payload Integration Manager to aid the payload customer in integrating his payload into the National Space Transportation System (NSTS) and developing the documentation agreements and requirements between the government and the payload organization.

Following the Challenger accident on January 28, 1986, he was asked to help with the return-to-flight (RTF) efforts and was assigned to lead a Project Integration Office in the Shuttle program office for Return-to-Flight (RTF) activities. Following RTF, he served as the manager for Payload Safety and assumed the role of chairman for the Payload Safety panel for 12 years. Battaglia retired from NASA in February 1997 after 35 years and went to work for Boeing for 11 years on the International Space Station (ISS). He worked in the ISS Chief

Engineer's Office during most of his tenure at Boeing. After retiring from Boeing, he was asked by NASA to help with the Constellation program and is serving as a technical advisor on a panel that does the safety reviews for the new hardware.

Although Battaglia was only 30 years old when Apollo 11 landed on the moon on July 20, 1969, he remembers that event clearly today. "I was sitting on the floor in my home with my wife and children watching the TV when the Lunar Excursion Module landed and Neil Armstrong descended down the ladder and stood on the lunar surface. We were all in an emotional state of mind cheering and in shear amazement that America had beat the Russians to the moon. I couldn't have felt more proud to be an American and that we had accomplished this amazing feat in less than the period of time that President Kennedy had annunciated during his speech at Rice University."

"In some respects, I do miss the days of the heightened excitement and commitment to go to the moon. I also miss the support and enthusiasm the space program had from Congress on the moon landing. My fondest memory is the small part that I had in contributing to the Apollo Program and being a member of a dedicated team of young, energetic and talented engineers that were relentless in overcoming the many challenges to get to the moon and safely return."

Battaglia says much of the talk about weight problems with NASA's Constellation program is no different than what was faced on Apollo. "Historically, on new programs, there has always been a need for a weight management program for tightly controlling mass to orbit. The Saturn rocket built by Dr. Werner Von Braun fortunately had the capability to lift a lot of payload mass to allow us to go to the moon, but it was not without a lot of pain to keep the mass down and to tightly manage the mass budget that was allocated to each of the subsystems."

He also thinks the benefits of the space program are noteworthy. "The space program is a very large engine that fuels technology development. Exploration and discovery has always been the destiny of mankind. Our space program has produced numerous spinoffs in communications, medicine, electronics, computer technology, discoveries of the universe, to name a few, for relatively little investment. We need to continue to provide adequate funding and oversight in the space program and establish international goals that will help our country and other nations in the world to work together to achieve common objectives and joint exploration."

Going to the moon taught engineers a number of lessons. "The biggest lesson learned from my perspective is to institute a rigorous and substantial test program to validate the design and performance of the hardware and software necessary to meet the mission objectives. We should do no less than provide our manned and unmanned spaceflight programs the reliable and verified flight assets that are needed to be safe and successful."

"The laws of physics haven't changed. Today's engineers are competent and well educated, they just need the experience. The biggest change I can speak about in the engineering field is the analytical tools that have been developed over the past 45+ years and the computational power and modeling that is available for solving complex engineering problems. I graduated from school using a slide rule. We didn't have computers to use back in the late 50's and early 60's."

"The space program is an exciting and rewarding career for those who want to be challenged in their jobs. If I didn't believe that, I wouldn't have worked in the space program for nearly 50 years." During the Apollo era, Battalgia says people had a different attitude about the space program. "I think everybody recognized up front that there were going to be some significant challenges that needed to be overcome. I always felt we had tremendous support

from congress and the public. There was a lot of interest and the news media was much kinder to us back then. People were more understanding about how difficult the job was."

At the height of the space race with the Russians, Americans rallied around the space program. "Back then, if you were asked to take on a task that was associated with the programs whether it was Mercury, Gemini, Apollo or even the space shuttle in the early years, you felt privileged and honored to be asked to work on that task. You never thought of complaining about the long hours of work that you performed. There were times when I would not get home until 2 or 3 a.m. in the morning running tests in our vacuum chambers because we had a mission to do. We had a tremendous sense of pride in being picked to work on these programs."

"We need a change of attitude towards our space program. Gene Kranz once said we need people in the space program with fire in their bellies. We need to make things work and need to believe in what we do. We need the support of congress, more funding and less bureaucracy. In the 1960s and 70's, we did not have all of the boards and panels that we do today to have a decision made." Battaglia thinks the nation needs to return to the moon before taking on the more challenging Mars journey. "Trying to go somewhere else like Mars first doesn't make much sense to me. We have to be able to demonstrate that we can live, work, build, harvest and survive on the moon, our nearest neighbor, before we can venture greater distances. We shouldn't just jump off the diving board and go directly to the Mars."

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John Bowen, a Boeing engineer who worked in launch control during Apollo, had a bit of an accidental entry into America's space program. "I'd been taking my flight-school physical for the Air Force and was waiting on my letter to start – and it got lost in the mail," he says. "So, I went to work. I ended up at Cape Canaveral by chance."

Bowen began working on the military side of Cape Canaveral, Fla., but eventually moved back and forth to the space side. "I was working for Marietta on military programs, and they transferred me to Gemini to work on the booster. From there, I went back to the military program for a year, then came back to Apollo with North American.
"NASA was really just getting started. We had to build all of the launch platforms, as well as Johnson Space Center in Houston. That was the beginning of NASA."

"On Apollo 11, my role was working the control room during launch. I was titled stability control system engineer, and I had responsibility for flight control systems, including the things that moved the engines around. I was on back console," he says, referring to the data terminal in launch control. "Once we did our functional test, we were monitoring most of the time."

What Bowen appreciates about the Apollo experience is the degree to which it represented a national accomplishment. "In Apollo, there was a lot of individual things done by individual people – all over this country, not just by us down here. Millions of people had something to do with making that hardware. They did a good job, made it safe. They were all happy to do it. The American people do a good job in what they want to do."

"For the Apollo landing, I was sitting in my home watching TV. Johnson Space Center was in charge at that point, so I was like just about everybody else in America watching it on TV.

"It was real exciting just to know we'd put that guy that far to land on the moon. My whole family was excited. The kids were real small, but later on they began to understand what was happening.

"I have to say that my space shuttle and space station experiences have been just as exciting. All of the things that were done with computers at the beginning of the Space Shuttle Program – they hadn't really been done before. It was a big deal," he says.

"I've sat on console for 60-70 launches, not just Apollo. Over the years you learn what you're doing and what you're trying to do. The exciting thing is the countdown… getting down close to zero.

"You have to realize what your vehicle is going to do and how it responds. It's pretty safe because you've already worked out anything that could happen. If it's going to be bad. It's going to be bad early."

Apollo brings back other fond memories for Bowen – some of which won't be found in the history books. "I can still remember when the first hand calculator came out," he says. "We'd been working with slide rules. Now I have to show my kids what a slide rule is," he laughs.

Still working for Boeing part-time at Kennedy Space Center, Fla., Bowen is excited that, nearly forty years after Apollo 11, NASA is working once again to return to the moon. "I think it's a stepping-stone to go to other places. It's not going to be efficient to go in and explore space with unmanned capsules. We need a space program. We're getting lots of information. It's going to be very exciting for young people if they get out there and participate."

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Software engineer **John Erickson**, who works for Cimarron -- a subcontractor to Boeing's International Space Station program where his "ECZ" group supports the software that runs the radiators and the Solar Alpha Rotary Joint (SARJ) system that moves the solar panels on the International Space Station. He retired from Boeing before assuming his present duties and has been in the space business since June 1966.

Raised in Highland, Indiana, Erickson remembers his start in the Apollo program. "My advisor at Purdue suggested I take this new stuff called computer programming in 1964. Purdue had just bought a new IBM 7094 mainframe computer. I learned the original FORTRAN and assembly language. Back then a computer would fill a large room of a building. When I got out of college at Purdue University, a friend of mine was working at the Manned Spacecraft Center at the time, and he suggested that I apply. I was on the NASA team that built the original lunar module procedures simulator (LMPS). He has worked at Johnson Space Center in buildings 4, 5, 35, 9 and the Sonny Carter Training Facility.

"After building the simulators to train the crew, they realized that they needed simulators to train engineers to fly it, so they could instruct the rest of NASA. These simulators would also be used for troubleshooting procedures by the engineers. We figured out the abort procedures in this lunar procedures simulator. I wrote the software for the descent and ascent engines and for the mass properties of the lander itself."

The lunar module had two control systems. The Primary was a digital system but was not entirely trusted at the time. The backup "AGS" system was analog. "At the time, I did not know much about simulators, but my boss, Dave Lang, taught us a lot about it. The lander design was evolving and when we learned that the thrusters were impacting the vehicle's body we updated the simulation to include some deflectors to redirect it."

He remembers standing outside the door with a team of others during the last training session for Neil Armstrong and getting the opportunity to shake his hand before he went to the Cape. "He was very serious at the time and we did not get to talk too much. I remember seeing

him at the reunion 30 years after the Apollo 11 mission and shaking his hand again, but this time he was smiling a lot more than when I met him the first time."

He worked on the Apollo program until the end and then transitioned into the space shuttle simulators. "Eventually the space station program began and I had worked for NASA for about 18 years and they would not let me transfer to the station program." So, he left NASA to join McDonnell Douglas and eventually Boeing. He worked on the design for the database used by the mission build facility (MBF). The MBF is the repository for all the Space Station flight software. I decided to stay technical for most of my career with Boeing."

He remembers watching the Apollo 11 launch at Cape Kennedy and watched the landing on the moon with his wife in Houston. The reaction of the public was that it was hard to believe that they had accomplished this milestone. "It was impressive how everybody was working together. We took our simulator code and sent it over to IBM to get their opinion to see if they could find anything wrong with it. There was no paperwork involved and a week later we had a few redlines and things circled."

The word "object oriented" code had not yet been invented, but that was the way we were developing the software at the time. One of the ways you know you are designing your software in an object oriented approach is that you have the minimum amount of data going back and forth between the software modules. That's what we had to do to make it work due to the limitations of the computers at the time. Designing the software to work properly back then is similar to what we do today with the exception that we no longer use keypunch card operators to type in the assembly language."

Back in high school, Erickson was always interested in space and was active in the local astronomy club and even built his own telescope. When he joined NASA, he was instrumental in helping to establish the first astronomy club for Johnson Space Center. He is still active in that same astronomy club. "We moved the club off-site so everyone could attend the meetings and we are now associated with the Lunar and Planetary Institute and that is where we meet today in Clear Lake." To learn more about the club, visit http://www.jscas.net/

Erickson says it was an exciting time to be on the Apollo program, but he personally enjoyed his time with the space shuttle program the most. "I am kind of sad to see the space shuttle retired, but I can understand why."

His fondest memory on the Apollo program was going over to his boss's house to have sing-alongs. "I remember singing Alligator Man over at his house when he held these parties for his team," Erickson recalled. The teamwork was very important back then, he said. He says it was a race to get to the moon and remembers working many long hours during that time.

Erickson hopes that the country returns to the moon again. "I would like to see us put a telescope on one of the craters that is in total darkness all of the time. Also, there are lots of places that should be explored. Mars is a lot tougher." He added he would like the international model established for space station to also apply to our country's plans to return to the moon.

He think today's engineers are better suited to the task of returning to the moon. "Engineers now have the experience of the past as opposed to Apollo. I remember the Apollo 1 fire. I was working on the simulator and Gus Grissom walked in to meet the crew for lunch. I got to show him how the computer worked and what the memory looked like. A few weeks later, he was killed in the fire. That was very sad. I hope the engineers today remember how important safety is."

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Boeing Iridium engineer **Mike Fraietta** was only 12 years old when the Apollo 11 landing occurred, but even back then he was an avid astronomer and fan of the Apollo program. He collected the Apollo cards, which were made by the same company that made baseball cards with a stick of gum, clipped out newspaper and magazine articles and create his own scrapbook to keep a record of what was happening. He still has that scrapbook from when he was kid living in New York.

"I started following the space program during the Gemini years and remember being very excited about the space program and that excitement grew with the Apollo program," said Fraietta. He grew up in Dobbs Ferry, N.Y. During that time he made his own telescope and while in college made a more sophisticated eight inch telescope. Fraietta was also an avid Star Trek fan and very interested in science.

"I was living in a two family house with my grandparents who lived on the first floor and our TV went out that day. Mom, Dad, us five kids and my grandparents watched it on my grandparents TV. My grandparents came from Italy and were from the horse and buggy days, and I remember them having a hard time with the landing on the moon -- they were surprised by how much technology had happened in their lifetimes. We followed the coverage hour-to-hour and they had great coverage of the space program back then. It was an important part of my childhood"

Mike was the oldest of five children and two of his brothers were also interested in the space program and he remembers everyone cheering during the landing. He recorded the subsequent spacewalk on a 3 ½ reel-to-reel portable audio recorder, that he still has the tapes from that television broadcast.

"The landing inspired me to be a part of the space program. During college, one of the professors took an interest in me and guided me on where to go next and eventually I earned a physics degree from Manhattan College. After that I was working for the Goddard Institute of Space Studies for Dr. Jim Hansen, the same person who has been in the press about global warming." After three years, Mike decided to get married and applied for a job at McDonnell Douglas and worked on the flight design system for the space shuttle in 1982. He has spent most of his career in Houston area. He joined the Iridium program in 1994 and today works on the orbit determination software.

When Mike is not supporting the Iridium constellation of communication satellites, he is supporting Boeing's plans to compete for the new lunar lander called Altair and will support the study contract when NASA eventually awards a new contract. "I hope to someday to be a part of a future lunar mission."

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Engineer **Charles H. Lowry**, a parachute expert from the Apollo days, is lending his knowledge and experience to NASA's current efforts to return humans to the moon. "I am working in a consulting role with the CEV [the Crew Exploration Vehicle, or Orion crew capsule] program. The people involved today are very interested in the things we learned on Apollo. They want to take advantage of everything we learned and produced. I have memories and documents and contacts, and I am able to bring in answers to some of their questions."

As an engineer with Rockwell, now part of Boeing, Lowry was involved in the parachute, ordnance, and docking, and other systems for the Apollo Program. There were many critical

systems on Apollo and a lot of good people that worked on those systems, he says. There was no space program when I was a kid. But I was always interested in aircraft. Early in my career I got involved in aircraft escape systems and parachute-related stuff. Then the Mercury Program came up and flew, then Gemini. Our company got the contract for designing and building the Apollo spacecraft.

So, in 1962 he moved with his family to the West Coast to be a part of it. There were many Apollo flights prior to the lunar landing. Apollo 8, which circled the moon on Christmas Eve, 1968 was a huge event which focused the world's attention on the upcoming Apollo 11 moon landing. "But aside from the public interest and the tension we felt in trying to ensure safety and hold schedules, Apollo 11 was just another spacecraft in a row and not much different from the others. I watched the moon landing from home. I was very nervous. There were thousands of things that could go wrong, and being in the business, I knew what many of them were. People out on the street don¹t know about those worries, so they don't have the same tensions. It was an amazing accomplishment when you think about all the parts and procedures that had to work right.

"My kids had grown up with space talk in the home and didn't think it was a big deal," he says. "My wife and I realized how big it was."

That's why Lowry is eagerly watching -- when he's not participating in -- the latest developments in America's space flight program. "I have a great interest in seeing the International Space Station stay in place. I think our space presence is important for many reasons, national security among them. China and other nations are trying to pass us up," he says.

"With the space shuttle winding down, and CEV not winding up for several years, I see a serious void in America's manned space presence, which I consider a national weakness. The problem is funding, which is driven by public interest and priorities. But if we can keep CEV going -- bigger and better than Apollo -- we'll be back in space in a big way."

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Like many high school and college students in the 1960s**, Larry McWhorter** was mesmerized by the Mercury launches he was watching on TV. Those images, combined with hearing Werner Von Braun speak about human space flight during his senior year in high school, set the stage for McWhorter's long and varied career in the human space flight industry.

McWhorter began that career in September 1966 as a co-op student with NASA at Johnson Space Flight Center in Houston, Texas. McWhorter was an aerospace engineering student at Texas A&M University, and in his first assignments with NASA he worked on the rendezvous procedures for Apollo – basically, how to get the command and lunar modules to fit together.

"I got there just in time for Apollo," he said. "There was a lot of excitement and questioning – could we really do it? Is it going to be safe? Could we beat the Russians?"
In 1970, McWhorter graduated and joined NASA full-time, working in the same group he'd worked in for five semesters as a co-op student, continuing to analyze crew and flight data. "For me, as a 21-year-old working with flight crews, I was a little bit in awe," he said, "working with astronauts like Buzz Aldrin and John Young and lead engineers who taught me the benefit of working in a group.

"Even 40 years later, it's still hard to explain the feeling and atmosphere after the first successful Apollo mission, just knowing that we had accomplished what we'd set out to do," he said.

McWhorter continued with his data analysis role until 1973, when he moved to JSC Engineering, which had just started working on crew displays and interfaces for the space shuttle. He worked on the re-entry flight controls for the shuttle and managed the flight simulations activities, basically the "man-in-the-loop" testing of the controls.

In 1979, McWhorter got his first taste of life as a contractor when he and his family moved to Los Angeles where he worked as the on-site NASA representative at a Rockwell facility at Downey Air Force Base where they were doing formal testing of entry systems on shuttle flight hardware.

"Being a NASA guy working directly with Rockwell engineers in their facility was a learning experience," McWhorter said. "I was able to go to a lot of the contractor meetings and I got to see first-hand how contractors do business." But McWhorter wouldn't join the ranks of NASA contractors for another two decades.

Over the next 20 years, McWhorter moved back to Houston and continued to work on space shuttle, take on special assignments on start-up programs, and finally support the International Space Station. There were many landmark events during that time, he said, including his having the privilege of signing the certification of flight readiness for the entry flight control system (the auto-pilot, for the space shuttle) and having International Space Station telecons at 2 a.m. to best accommodate the international team, which included Italians, Russians, Canadian, Japanese and European Space Agency representatives as well as American companies.

In 2002, after 35 years with the agency, McWhorter retired from NASA and joined The Boeing Company. He first supported Boeing's ISS program, and worked return-to-flight activities for about a year following the Columbia accident in 2003. After that assignment, McWhorter's career became very future-looking, supporting Boeing's proposal for the Orbital Space Plane, which was ultimately cancelled, as well as the Crew Exploration Vehicle, which Boeing lost to Lockheed Martin.

McWhorter returned to the chief engineer's office, but soon was pulled into supporting Boeing's proposal activity for the Ares I instrument unit avionics (IUA), which will provide guidance, navigation and control for the Ares I rocket until it reaches orbit.

"My wife says proposals are four-letter words – during the IUA proposal activity, I stayed about 105 nights in hotels in Huntsville over the span of about a year," McWhorter said.

NASA awarded Boeing the contracts for upper stage production and the IUA in 2007, and McWhorter now spends his day managing the day-to-day activities of the avionics and software group for Ares I.

McWhorter said he's had some great times in his career – Apollo 8, Apollo 11, STS-1, return to flight after the 1986 Challenge disaster, and getting ISS running on-orbit, to name a few – but he notes that the venture of human space flight is different now than when he started.

"I see a lot of the same issues and problems we went through in the early days, but the biggest difference is that when we started shuttle, everybody was working on shuttle. Today, we have several programs competing for the same resources," he said. "Also, during Apollo we were very focused on JFK's 'decade' commitment. Today there's no real competition pushing us to move forward."

Perhaps one of the greatest challenges for human space flight, McWhorter said, is our ability to transition from the current working generation to the new group that will take humans beyond earth orbit to live and work on a permanent basis. "We've got to continue to keep our students interested to ensure we have the skills to carry out our vision of going back to the moon and beyond."

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Edward Mokslaveskas, known as Ed Moke to the people he worked with at North American-Rockwell for nearly four decades, earned his chops in the space business as a lead engineer on a forerunner to the Mercury Program.

"I worked in the North American Aviation Advanced design section," he says. "After Sputnik we made a proposal where we'd put an X-15 on top of three Atlas boosters and launch it into orbit. That never materialized. But, in early spring 1958 we received a Request For Proposal from the U.S. Air Force Aero-Medical Lab to perform a program that would simulate all the things an astronaut would experience going into space and orbiting the Earth.

They wanted us to look at the total program, and Gene Salvay, the Proposal Manager put me in charge of everything on the ground. This included all the handling and testing of the missile and space vehicle. We designed a mockup, identified where we would locate the tracking stations around the world and how to handle the space vehicle recovery, even the instrumentation and testing of primates in a launch mode. We talked about where we were going to launch from, Cape Canaveral or maybe Dry Tortuga in the Caribbean, where it would take less energy to get into orbit. I was thrilled to work on this program and it was very exciting," he says.

Moke was a design supervisor and later the Project Engineer on the SII-6, the second stage of the Saturn V rocket that launched Apollo 11. "My duties were to resolve all of the engineering problems that arose from the design, construction, and testing of the SII-6" he says. "I worked on the this Stage all the way through design, manufacturing and subsequent testing at the NASA Test Facility in Mississippi, where the engines were tested before being shipped to Florida to be added to the Apollo 11 booster."

He says that in the development of any new product, problems in design, construction and testing will occur that require resolution. "We called them squawks. That was my task, to resolve squawks, to make sure everything worked perfectly.

"After the Apollo fire," Moke says, referring to the 1967 accident that killed three astronauts training for the first crewed Apollo mission, "NASA and Rockwell were concerned about how things were wired and plumbed on the SII. The lower part of the SII was a complete maze of electric devices, wires and plumbing. We were determined we wouldn't have the same kind of a problem. So, we inspected the whole vehicle and made all the changes necessary to secure the plumbing and the wires. That was an interesting program, and it was a last-minute effort before completion of the stage. We worked literally day and night for a month.

"One problem arising from manufacturing that we had to resolve was concerned with the potential of excess heat from the interaction of the flumes of two adjacent outboard engines bouncing back and burning through the heat shield for the electrical equipment. This was a major concern because it could cause a total Apollo 11 mission abort or even an explosion of the S-II. But we resolved the threat and the S-II 6 performed perfectly on the Apollo 11 launch."

Mokslaveskas says the Apollo 11 mission that landed humans on the moon was a career highlight. "I felt wonderfully when the Saturn-II booster performed exactly as designed as part of launching a man to the Moon. I watched it with a group of workers from the North American-Rockwell space division. It was a real thrill to see it liftoff and rise toward space," he says. "An outstanding achievement."

Retired since 1990, Mokslaveskas lives in the San Fernando Valley in California. He is Chairman of the Bald Eagles, a non-profit organization consisting of North American-Rockwell retirees and employees, which holds an annual reunion.

"I miss the people I worked with," he says of his time on the space program.

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When Boeing Constellation Chief Engineer **Leonard Nicholson** joined NASA in April 1963, he did so to try something different from what he was doing for a local mining company in West Virginia.

"I grew up in a town surrounded by coal mines and when I was going to college in West Virginia University, I had spent my summers working in a coal mine machinery business. I was required to go down and test some of the hardware in a mine and that was when I decided I wanted to look for another job after graduation."

When he graduated, Mercury had just started flying and he interviewed with a bunch of different companies, including NASA. "NASA made me an offer that was about 30 percent less than the others, but I figured I'd go try it for a maximum of about five years. It sounded like exciting work and something different. I ended up leaving NASA 37 years later."

When he joined NASA, the Johnson Space Center in Houston had not yet been built. "I ended working in an apartment complex and my office was on the second floor and overlooked a swimming pool."

He added the environment was very hectic and everyone was trying to learn as much as they could. "You never had time to take a breath and were running at full speed. Most of the people working on the Apollo program were experienced designers that had come from aircraft industries and I was one of the learners at the time. It was a very aggressive and dynamic time period and the concern was that someone else would get ahead of us."

The Lunar Module contract was awarded in late 1962 and after coming on board in 1963, one of the first things that he was asked to do was to look at possible landing gear designs for the lunar module. "I felt I could handle the task and so when I asked folks about what was the lunar surface like, what was the density of the soil, what was it made of, etc. so I can make this gear right. They told me they did not have any idea."

Nicholson also worked on putting a science bay into the Apollo Service Module. Nicholson later went on to work on the Apollo-Soyuz project after the lunar missions and then onto the space shuttle and station programs before eventually becoming the Director of Engineering.

The NASA team was extremely busy during this period. "Everyone was totally involved and excited about going to the moon. It was just a go do it atmosphere. It was a total blast. Everyone worked so hard so the astronauts could get there safely and back," said Nicholson.

"The community was very supportive of our teams on Apollo. You almost felt like a hero and people seemed to bend over backwards to make sure we got what we needed," he said.

Nicholson has noticed that engineers today have much better tools to use than he did. "I have done some work on the new lunar lander and getting ready for some of the proposals. I am amazed at how much quicker you can produce a design product than we could in those days. When I started on Apollo, we were using slide rules and we had some central computers but they were off in another building and you had to enter everything manually and program it. Now everybody can just do it at their desk and can create all the data that used to take us months to create in about an hour and half. "

Nicholson remembers watching the Apollo 11 landing at a big NASA party in a downtown Houston hotel. "I was blown away by the landing when we saw it," he said. He and several hundred NASA employees watched the landing.

With NASA plans to return to moon again, Nicholson sees the same level of excitement among Boeing engineers. "I see our teams have no problem getting excited about working on something new such as the lander. It is just really fun stuff and the productivity is orders of magnitude higher and there is still a strong sense of teamwork. I see many of the same environmental factors except the productivity is orders of magnitude higher."

"The basic concept of using a capsule is sound if you are going to return from the moon. It is going to be a totally different ballgame this time around. People will get excited about them living on the moon and some of the scientific discoveries." According to Nicholson, our technology today will allow people to better experience the moon in a way never before and the astronauts will get to interact with the public. The excitement is experiencing what the astronauts are doing, he says, not in the machines that get you there.

Today, Nicholson provides support to Boeing's efforts on NASA Constellation program which includes a variety of vehicles to return to the moon again, but this time to stay. "When I first got to work on the Boeing lunar lander design, it was déjà vu all over again. It is going to be interesting what the new administration comes up and their strategy. I think we will keep exploring space and the discussion is about the architecture for doing that. I have no issues with the basic design of any of the systems for NASA's Constellation program."

Nicholson recalls seeing a Saturn V launch, but remembers that the launch is not what excites him most. "It is not the launch that excites me, but rather where are we going? It is building the capability to sustain people on the moon for an extended period of time and doing that elsewhere in this universe. I think putting people on the moon for an extended period of time to do some research and exploration will help us to understand what it will take us to take people to mars and back. The moon is a step on our way to Mars."

Why do we need to go? There are two reasons, according to Nicholson, for going to the moon. "First, the technology we develop to go there will be beneficial to all of us and that has been proven with the space program. Second, the things you learn that you didn't know. You never know how a new set of knowledge can be applied to other areas."

If the first step on the moon was the defining moment, what do you see as the moment when we go back? "We are good at the transportation aspects but we do need to figure out how we are going to take care of the people for extended periods of time and how we are going to accommodate them on one of these remote places for an extended period."

Nicholson is convinced that the nation will continue to explore. "I am convinced that it is going to keep going and the only question is the pace at which it goes that is driven by the budget that becomes available." Nicholson has no plans to retire anytime soon and says that his criteria for retiring will be when it stops being fun or he ceases to be productive.

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Enjoying his retirement in Palm Springs, Calif., **Jack Parker** nevertheless remembers exciting times supporting Apollo missions for Rockwell, now part of Boeing, which built the Apollo Command and Service Module. "You'd be there in the test rooms, staffed with technical support, you'd feel a part of it. We weren't in Houston or Florida," says the California-based engineer, "but you're plugged into everything that's happening. We were there on call if NASA needed technical support. That part was fascinating."

Parker was a mechanical systems engineer on Apollo, charged with making sure the Command and Service module worked as planned. "I had transferred from the B-70 flight test effort at Edwards Air Force base to Apollo in 1965. My first effort for the space program was to

design a test for the Apollo docking system, which was used to attach the command module to the lunar module.

"I then transferred to the test and operations department, checking out the Command and Service Modules before they were shipped out. We got to do fit and function checks with the astronauts themselves, and educated them to all of the 'goodies' in the interior of the command module."

In addition to the triumph of Apollo 11, Parker recalls working around some of the missions that, tragically, didn't go as planned. "I had an early experience working in test and operations on the crew compartment, when we interfaced with the astronauts. I got to know some of them, not on a super-personal basis, but…. I am sad to say that one of the groups I worked with was the ill-fated [Apollo 1] crew. We worked with them quite a bit. You get to know them pretty well.

"Apollo 13, where they had the problem and were running out of oxygen, that got to be pretty exciting for everybody in the country. Our portion was standby to help support mission control in Houston. We found that to be 'overly exciting.'"

Despite the challenges, Parker looks back on his work on the Apollo program with fondness. "Probably what I have missed is the camaraderie and teamwork environment that existed. It's kind of like playing on a winning football team – as long as you're winning it's great. Each mission was spectacular as long as it was successful.

"It was pretty exciting, and the fact that we as a country and a company were able to accomplish that – it was amazing. And it can be done again.

"I still have a lot of good friends from the Apollo days, and we get together from time to time. We're all very proud to have contributed what we could," he says.

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Leo "Dusty" Rhodes made his career as a design engineer working on latches during the Apollo Program, but it was a "fly-on-the-wall" moment that counts among his most significant memories.

"I was in a meeting at NASA to show them how to disassemble these latches if there was a problem during the flight. There were about a dozen astronauts in this meeting. Suddenly, someone came in and whispered something, and it was whispered on down the line. The decision had been made: the first man on the moon was going to be… guess who!"

Rhodes worked on the latches that connected the Apollo Lunar Excursion Module – or LEM – to the Command and Service Module. "Another engineer and I accumulated 12 patents working on this latch. Twelve latches circled the transfer tunnel that the astronauts crawled through to get to the LEM," he says. "They were such a specialized design.

"The astronauts had to release all 12 latches manually. This was a lot of work for them, but it was important that the latches were powerful. We worried a lot about them coming loose due to all the vibrations of launch. It was like two-gallon jugs joined together at the neck.

"The first time that they worked all the latches and they unlocked – we breathed easy," he says.

"The latches had to be redesigned after the Apollo 1 fire [which killed three astronauts in training in 1967.] We had one year to redesign the latches. NASA insisted they had to be more powerful, but the requirements were almost impossible! Still, we managed to design, test and build these latches in 12 months."

Once, Rhodes says, he got an opportunity to truly appreciate the size and power of Apollo. “I got a trip to the very top of the stack,” he says of the Saturn V-Apollo structure waiting on the launch pad. “This was in the middle of the night. You looked down and there were some little white specks, barely moving. Those were guys walking around with their hardhats on. It was impressive how tall this thing was.”

Rhodes marvels not only at the achievement of landing humans on the moon, but of the broader strategy of the Apollo Program. “It was a smart move on JFK’s part: all these technical achievements, economic development, without going to war. It accomplished a lot,” he says.

Rhodes lives in Southern California, where he’s been retired since 1978.

“I think it’s great that NASA’s working to go to the moon again,” he says. “The moon is a great service station out there. After you escape gravity on the earth and burn up your fuel, it would be nice to stop at a service station and refuel. We’re lucky to have a moon like that,” he adds. “We should take advantage of it.”

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Boeing International Space Station systems engineer **Larry Tosto** can claim that his name was taken along with others on a microfilm that travelled to the moon and back. His name was part of a list of key contributors who had worked on the Apollo program’s lunar lander for the Grumman Aerospace Company in Bethpage, Long Island.

“One day they asked all the engineers and test personnel who worked on the Lunar Excursion Module (LEM) to sign our names on a piece of paper and did not tell us what they were going to do with the signatures. When the astronauts came back from the first landing on the moon, they came to Grumman to personally thank all of us. They held up a picture that contained about 300 names and had pictures of the landing on the moon. At the top it said, " for all of you that helped get us to the moon and back safely, your name landed on the Moon".

When Neil Armstrong stepped on the moon for the first time, he carried that microfilm in his pocket with everyone’s name on it. “I have a copy of this picture at home and am very proud of it,” Tosto said.

Having left a teaching career, Tosto began as a test engineer working for Grumman Aerospace on the Apollo Program in 1961 in the structural test department. “I did the development test to ensure that the LEM would be stable when it touched down on the moon. In addition, at the same time, I helped developed the aluminum honeycomb cartridges that would be inserted into the LEM landing gear struts and used as shock absorbers to take the place of hydraulic fluid,” he explained. “We could not use hydraulic fluids because of the extreme temperatures in space.” He added they tested a wide variety of honeycomb cartridges with different diameters that had different absorption rates.

He worked with a 1/6 scale model of the ascent and decent stage of the LEM. A team of structural test engineers designed a test fixture (pendulum) that would release the LEM model at various combinations of horizontal and vertical velocities. The model had struts on it, similar to actual descent stage of the LEM. “We released the model and allowed it to fall into various surfaces to test the stability and crush rate of the cartridges. At first, the landing gear struts ends were spikes and then we went to Teflon pads.”

For about two years, the team dropped the model on different types of surfaces at various velocities. “We were trying to make sure the vehicle was stable and that it would not tip over. We needed the descent stage to remain upright so that the ascent stage could fire and you could return.” He would provide the data from these tests to a mechanical engineering group who

would do the analysis. He added they dropped it on a wide variety of surfaces because they did not really know at the time what the surface of the moon was like. Eventually, they went to a full scale test model later in the program.

Following the completion of the scale model testing, he was transferred to the Cold Flow Test Facility. In this facility, they pressurized the LEM Propulsion System and checked out all the systems under pressure. "They were large test chambers that they put the LEM in there and hooked up nitrogen and pressurized the tanks to make sure there were no leaks. I worked on the consoles when we pressurized those tanks and none of the valves, lines and other areas would leak. "

He said it was common to work 12 hour shifts, 7 days a week during those days because of schedule pressure.

The LEM had a sensor on the pads so that when it touched down on the surface of the moon, a light would turn on letting the astronauts know that they had landed safely. "Grumman distributed a landing light pin to kids at the time. I was at home watching the landing when my kids wanted to know why their pin had not lit up after the LEM had landed on the moon."

"In those days, when you worked on structural test, you designed the test fixtures and ran the test from beginning to end," he said. "It was interesting to see all the spinoffs from the space program and that's where Teflon had been developed. People forget about the many advances that came out of the Apollo program."

Tosto worked for General Electric in Cincinnati in their jet engine division when he graduated from college. He worked in the stress and weigh analysis group and was working on an atomic engine for a bomber for the Air Force. After the program was cancelled, he returned to New York as an instructor in physics, aerodynamics and strength and materials.

"After two years of teaching, I saw an advertisement that Grumman was looking for engineers and they put me onto work right away in structural and environmental test. One day, while I was in the lab, I met Werner Von Braun (famous NASA rocket designer) and was able to talk with him for a while. He was a very pleasant person to speak with."

Tosto worked on the International Space Station when Grumman had the support contract with NASA. He had moved to Reston, Va. and worked for Grumman for another six years before retiring after 31 years. "At the time, I knew Fred Haise (a NASA astronaut) while he was the president of that program. When that program ended and Boeing won it, I was part of a group of 60 people that were picked up by Boeing as a subcontractor and moved to Houston." He joined the Boeing ISS program about 13 years ago following his retirement from Grumman. During his time with Boeing from 2003 to 2006, he spent two years working on the Future Combat Systems program.

"I am also a licensed aircraft mechanic and I had a chance to work on the F-14 following the end of the Apollo program for about eight to nine years as a test engineer in Long Island. During that time, I did a lot of testing on fuels systems and engines and provided training and taught people how to fix the planes. But eventually I wanted to get back into space program."

Today, he works on setting and verifying space station requirements that were used to set up the initial test teams, but he no longer gets the hands on work like he did during the Apollo program. "My work is to write requirements on the station as well as the various specifications. A good requirement has to be verifiable and be written simply so it can be understood."

As a kid, Tosto always had an interest in aerospace, especially aircraft. He graduated from Brooklyn Tech's aerospace curriculum at the age of 16 and went on to the academy of aeronautics and then on to C.W. Post College. "I was working on the Apollo program when I

got my Bachelor of Science degree. I was able to get an autograph from astronaut Scott Carpenter when he visited us and met many others when they came through the test facilities. As a kid, we looked up at the moon and wondered about it and then here I was working on a program to send people to the moon. It was a very exciting time and you were very close to the people that you worked with in those days. My family is very proud of my Apollo work."

Tosto works out everyday and has a healthy lifestyle and hopes to keep working on the space program for many more years. "I enjoy the people and I really like working. I believe we should go back to the moon and that can be a stepping off point for wherever else we want to go in space. Despite the challenges, I believe our engineers can do it and are up to the task. It is fascinating what we do. It took real teamwork to be successful in Apollo and that will be important when we go back."

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Retired NASA and Boeing senior manager **Chet Vaughan** worked many years on the programs leading up to Apollo. His last job at Boeing was as the chief engineer for the International Space Station before retiring in 2006. Today, he is enjoying retirement in Seabrook, Texas.

During the Apollo 11 mission, Vaughan was the NASA section head of the Reaction Control Section: Aux. Propulsion Branch: Propulsion and Power Division: Engineering and Development Directorate at the Johnson Space Center. During this period, he had about 19 engineers working for him. His team's primary responsibility was to provide technical support for the Reaction Control System (RCS) for the Apollo Command Module, Service Module and Lunar Module, to include requirements definition, design, development, flight hardware checkout and mission support to the Operations Directorate.

The Apollo system had three basic modules and two of them always flew together, which was the service module and the command module. The command module stayed with the service module until ready to reenter the Earth's atmosphere. "We were looking at a tremendous amount of impulses with the new RCS. Gemini tested the first time use of hypergolic RCS thrusters for the first time. During the Gemini orbital mission, we wound up with some thrust decay on some of the thrusters on almost all of the Gemini missions," he said. Thruster decay is an abrupt change in output.

"During the early days, we did not have very good instrumentation and the Gemini vehicle had two levels of thrust." But, he added that they were able to judge the performance of the thrusters from the way the vehicle moved. Use of improved instrumentation in Apollo allowed better tracking of the spacecraft movements in real time.

"On Apollo 11, I was the Prop and Power Division rep. at the Flight Readiness Review for the CM, SM and LM RCS systems. During Apollo 11, I spent a lot of time in the Mission Evaluation Room supporting my personnel, but was not an official console operator," he said. The MER rooms in those days had only access to tables on a computer screen, but not all of the data and they had limited access to a few communication loops.

Vaughan had a long and distinguished career working for NASA. His career began in 1955 when he was hired as a co-op at the Langley Research Center of the National Advisory Committee for Aeronautics. "Under the co-op program, I was rotated through a number of different organizations at NASA so I got a good rundown of how things worked," he

said. He added the experience convinced him to pursue a career in the space program. Following graduation from Virginia Tech in 1959, he worked in the Space Vehicle Group at Langley until Sept. 1961 when he moved to the Space Task Group which had the responsibility for the Manned Space Program. He moved to Houston in Feb. 1962 and worked in various positions with the Propulsion and Power Division until 1992.

"I can remember two or three of us sitting in the office trying to decide what kind of thrust levels we needed to have for the Apollo RCS," he said. He explained that the Gemini and Apollo programs had been closely designed on top of one another at the time. "I had helped define what kind of system we needed for the escape towers too. At that time, we needed to do an abort on the launch pad and had to be able to escape anywhere up to a certain altitude."

"We had a lot of confidence on our systems during the Apollo flights and had tested them pretty good," he remembered. Extensive tests were conducted at the contractor facilities as well as the government facilities, he says. "We learned a lot from our system level tests and we were not as impacted as much as others following the Apollo one fire."

Vaughan also worked on numerous special assignments and failure investigation boards and even served as an acting deputy center director for the Marshall Space Flight Center. In 1992, he was selected as the deputy director of the Engineering Directorate at JSC and served as a member of the ISS redesign team in 1993 before becoming the chief engineer for the ISS program in 1995. He retired from NASA in 1996 and was hired by The Boeing Company.

Vaughan grew up on a tobacco farm and had decided he did not want to spend the rest of his life on a farm, but had an early interest in aviation when he used to see military planes fly by. He watched the Apollo 10 launch at the cape where he was participating in the flight readiness review for Apollo 11. "All of the subsystem managers felt obligated to review all the of the checkout data during the entire checkout process," he said. Vaughan watched the Apollo 11 landing on TV with his wife and two girls (ages 3 and 6) at the time. "I am sure that I also turned blue when Armstrong seemed to take so long for the landing. I was concerned that the RCS systems might have a problem and cause a mission problem. I was always proud when the missions were successfully completed," he said. "We never lost a thruster on any of the Apollo flights and none of the Apollo missions had a significant issue with the RCS."

"I do miss those day's, but I always had new challenges and was lucky enough to love all my job assignments. Work was always more like my hobby rather than work. I can't understand how people can work in a job that they do not love to do."

Vaughan thinks we should go back to the moon again, but it should not be a repeat of what was accomplished on the Apollo missions - it should be more ambitious. "We need to have enough human presence there to really advance the technology and capability to live and work in space. I would tell the President and Congress to be sure we have the correct mission goals and objectives defined and then fund the program sufficiently without forcing so many redesigns. No progress can be made if the program is in a redesign mode every year or so."

One of the biggest lessons learned from the Apollo program, according to Vaughan, was to always pay attention to detail and to remember that the "devil is always in the detail." He adds that the program should not be hardware poor. "I am not aware of anyone ever knowingly designed hardware/software with problems, but it is almost impossible to be problem free. These problems are identified and corrected by various design reviews and more importantly during development testing."

Throughout a long and distinguished career with NASA and Boeing, Vaughan has seen a lot of innovation in the space hardware and engineering practices. "The biggest changes are in

the area of technology development and computer aided designs. The hypergolic propellants and associated hardware was very new when we started and is quite mature today. However, they still have the same energy potential and things can go south in a hurry if attention to detail is not maintained. The computer aided design technology is both a blessing and a curse. It provides pretty looking designs even when the detailed information may be incorrect."

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Boeing's **Edward Volick**, now 88, had a long and distinguished career supporting NASA during the Apollo program. His last job for Boeing was in the late 1970s as a flight engineer in Downey, Calif., and eventually at Johnson Space Center. After retiring from Boeing, he went on to work for Singer Link as a mechanical engineer on the Space Shuttle simulator. His last job related to the space program was for Hernandez Engineering providing consulting on Crew Astronaut Support Systems in 2000.

Before joining Boeing in 1965, he was the President of the San Fernando Valley chapter of the California Society of Professional Engineers when he was employed by Atomics International as a senior engineer in Canoga Park, Ca. He is a graduate of the Detroit Institute of Technology and has been registered professional engineer his entire career. Born in Windsor, Ontario, Canada and lived there until 1956 when he moved to California and became a US Citizen. He served as a flight engineer with the Royal Canadian Air Force during World War II.

He started working with Boeing in Downey California as a flight engineer for the Apollo program in crew systems and eventually transferred to Huntsville, Ala. for a period of time before being transferred back again to Downey to work on Apollo Flight Engineering.

Volick was a Resident Apollo Systems Program Office Subsystem Manager and he worked specifically as a NASA/Downey MSC Subsystem Interface and worked closely with the Dynamics group, as well as with the test laboratories, reliability and design groups in Downey, Calif. His areas of work were mainly in the component and system vibration and acoustic qualification programs, the transient dynamics and deployment testing of lunar orbit experiments and the pyrotechnic shock certification testing of subsystems and vehicle modules. During this time, he worked with many of the astronauts.

"I worked with my NASA counterpart Bill Slattery in the Crew Compartment Fit and Function. This was a very interesting time, I worked with many different astronauts. We worked with the captains of each Apollo flight from Apollo 7 through Apollo 13. We provided the preliminary final design OK for the Crew Compartment Fit and Function. These were exciting times. "

During this time period, Volick got to know many of the Apollo astronauts personally and developed a close friendship with Alan Bean. "We worked closely with the Apollo crews on the finalization of Crew Systems," he said.

Today, Volick is retired and living in Lakeway, Texas near his son's family, but the space industry was an area of interest for most of his career. "I was very interested in the possibility of traveling in space as a young man. I was a flight engineer in the Royal Canadian Air Force during WWII and had developed an interest in air travel," he said. "When I relocated to Los Angles, Calif. and worked as an engineer, I developed a further interest in the space program after our Chapter of Professional Engineers was asked by the Smithsonian Institution to track the Sputnik orbits over the U.S. in October of 1957." His local engineering chapter in the San Fernando Valley rotated nightly shifts to track Sputnik's orbits.

When the Russians put the first satellite into orbit, it ignited the space race and eventually led to President John F. Kennedy setting the ambitious goal of putting a person on the moon before the end of the decade. "After this experience I became very interested in the race for space and went to work for Boeing a few years later. I was always very interested in space, but when I graduated from college we were in WW II and there was not much time to ponder conquering space."

Volick was on the flight engineering team in Downey when Apollo 11 landed. "The excitement and the success of the mission penetrated through the whole facility! Because we had so much hands-on experience with the crew it was even more rewarding. I was with my family in Placentia, California when Neil Armstrong stepped on the moon. Those were very good times."

There were many lessons learned from the Apollo program, but one of the greatest benefits according to Volick was some of the new technologies that were developed. "The space program was a primary force driving many technology disciplines ahead of their time. Going back to the moon again would inspire new solutions and businesses."

One of his most memorable experiences was receiving the top spaceflight achievement award called the Silver Snoopy Award following the Apollo 12 mission. The tradition of presenting those awards by astronauts continues today. "I miss those years of the Apollo program and joint efforts made to get a man on the moon. The fondest memory I have is when astronauts Alan Bean and Dick Gordon presented me with the Snoopy award at the general meeting after Apollo 12. Shortly after, Alan Bean gave me his moon landing patch."

Volick hopes the nation continues to explore the universe and the moon. "It would be a very good launching off point for other exploration in our solar system and the Galaxy. I would tell the President and Congress that the technology gained from the space program had pushed America forward in the area of technology, and we should continue in this direction. I was proud to be part of the Apollo Program and believe there is so much ahead for us in space exploration."

He says our country's engineers are up to the task of returning to the moon. "The basics of engineering are the same but implementations and processes have changed immensely. I believe today's younger engineers are up to the task."

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Boeing engineer **Freddie Wallace** spent the Apollo years working on one of the most enduring pieces of hardware in America's human space flight program: the crawler transporter, that massive and slow-moving land-barge that moves spacecraft to the launch pad. Then, as now, the crawler transporter's trip to the pad was one of the most exciting pre-flight activities, especially for the astronauts assigned to the mission. "The Apollo 11 crew came aboard the crawler transporter while we were delivering their vehicle to the launch pad," Wallace says. "We were able to shake the hand of each of them and also wish them a safe flight."

"As a matter of fact," Wallace adds, "the Apollo crew members from all the missions rode the transporters with their flight vehicles for a mile or two, on the way to the launch pad. We were able to meet them all."

Getting the enviable opportunity to personally bid moon-bound astronauts "godspeed" was just one perk in a long aerospace career that began in the U.S. Navy of the 1950s and continues today. Wallace is still working for Boeing, as a systems engineer on the space shuttle environment and life support systems. Wallace says he always wanted to work on the space

program. “The experiences of working in Naval aviation, then missile programs with the Army and Air Force, led me into the manned space program,” he says.

Reflecting on the achievement of Apollo 11, forty years ago this summer, Wallace believes the moon is something the U.S. space program should pursue once again.

“During the actual landing on the moon, I was home with my wife Beckey and my two daughters April and Melanie. We were glued to the television. At the actual touchdown, everyone stood up, threw their hands in the air and shouted!” he says.

“It was very exciting for everyone in our family for having been a part of this effort and also for all the people in our country – and many other countries as well.

“I remember how very exciting it was and how proud and elated I was that the United States was the first to set foot on the moon,” he says. “A magnificent achievement!

“Man can accomplish great things through perseverance,” he says. “The same applies now to the return to the moon. At the end of the Apollo missions, I felt that we should have continued on with more flights to expand on our achievements.

“Right now, we should continue to fly the shuttle in support of the International Space Station, and also press on with the moon landing program.” He says, “There’s no rush to get to the moon again, just continue the endeavor at a steady safe pace.

“The engineers of today are very capable and up to the task of returning us to the moon,” he says. “They only need to know they have full government and public support to achieve this task.”