Testimony of

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For the hearing entitled

The Apollo Legacy

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Thank you for the opportunity to speak with you today about the technological legacy of Apollo. Many of the capabilities that we take for granted today had their roots in the technological investments made in the 1950s and 60s to put humans on the Moon. For example, high thrust yet fuel efficient rocket engines made it possible to place large satellites in orbit for worldwide data and voice communication networks, GPS navigation, television broadcasting, Earth monitoring for agriculture, and weather monitoring to enable accurate forecasts. Wireless handheld power tools, lightweight thermal insulation, foam materials to cushion against vibration and shock, advanced lightweight and high temperature materials, inertial guidance and navigation, integrated circuits and microchips, compact medical sensors, and many nutritional additives either found their start in, or their development was greatly accelerated by, Apollo. While the list goes on, I'd like to focus for a moment on computers which, in 2019, permeate our everyday lives.

Before Apollo, computers were used to perform large mathematical calculations. They filled large rooms in buildings. This required us to go to the computers in order to use them. Apollo changed all that. Apollo was the first time humans demonstrated that computers could come with us: in our cars, in our homes, in our trains, in our planes, even on our laps and in our pockets. By Apollo demonstrating that digital computers could assist us on humanity's furthest journey, we realized that computers could assist us on any journey. But this did not come easy. The Apollo scientists and engineers needed to miniaturize computers, that until then had only fit in rooms, to the size of one cubic foot. They coined the phrase “software engineering.” They invented the real-time operating system. Unlike the operating system in your laptop, which slows down as you ask it to do more, a real-time operating system maintains its speed by delaying lower priority tasks. The 1202 alarm during the descent of Apollo 11’s Lunar Module was not a sign of a problem. Instead, it was a sign that this new and innovative operating system could reliably continue to execute a critical task even when it was asked to do more than it could handle. This is why the basic principles of real-time operating systems are still at the core of the digital controllers in almost everything we use today: autopilots, cruise control, trains, environmental control systems, power grids, communications networks, phones, internet, just about everything that defines our technological world.

Apollo spacesuits were the first smart clothes with wearable technologies. They had wireless headsets, embedded medical sensors, and portable life support systems that now support firefighters and other hazardous career fields. Flight simulators for commercial and military aviation are safe and cost-effective tools for pilot training that came out of the Apollo simulator program. Apollo married digital computers with engineering design methods to spearhead the field of CAD, or computer aided design, which today spans all engineering disciplines and is essential in designing today’s complex systems.

But perhaps the most important technological legacy of Apollo is the inspiration it gave to several generations of scientists and engineers to pursue STEM education and careers. In turn, these generations have developed entirely new industries, made ground-breaking discoveries, and inspired and educated the subsequent generations not only in the field of space but many others. As an educator, I have first hand experience in the power of inspiration. When it comes to space, the United States is the greenest pasture and many of the brightest from around the world seek an education and follow-on career here. To borrow a quote from Plutarch, “The mind is not a vessel to be filled, but a fire to be kindled.” Apollo kindled the passion to take big strides, to not back away from a daunting challenge but to instead embrace and tackle that challenge.

This does not apply solely to space, it applies to all domains of intellectual effort. If we can put a human on the Moon, we can surely do anything we set our minds to.

While it is important to take pause and look back at all of the technological achievements gained through the original Apollo program, it is also important to consider the exciting next steps in lunar exploration and development which will be even more challenging than Apollo. The scale of technological advancement is directly correlated with the length of the stride we choose to make. The next generation of lunar missions will require larger habitats with closed-loop life support systems, long-term radiation protection, tele-medicine, autonomous operations and repair, the ability to independently generate consumables such as food and energy, the establishment of a routine logistics supply operation covering a distance of a quarter-million miles and do all this at a level of reliability, adaptability, and efficiency that will revolutionize what and how we do things right here on Earth. These requirements for operations on the Moon – and beyond – will drive a search for creative technical solutions, and their inevitable terrestrial applications, surpassing those that we've seen in the space age thus far. Just as Apollo brought about substantial technical advancements, we should be excited about the future technology that will emerge as a result of continued space exploration because, in the words of President Kennedy, that goal will serve to organize and measure the best of our energies and skills.

Thank you and I look forward to your questions.

DAVID W. MILLER
VICE PRESIDENT AND CHIEF TECHNOLOGY OFFICER

Dr. David W. (Dave) Miller is vice president and chief technology officer (CTO) at The Aerospace Corporation. He joined the company in January 2019. In this newly created role, Miller is responsible for providing vital leadership for the company's growing prototyping efforts through his supervision of Aerospace's Experiments Lab (the newly named "xLab"), previously called the Technology Demonstration Center. He will also oversee iLab (Aerospace's innovation laboratory, where staff collaborate in a creative space to develop ideas into game-changing technologies); the Engineering, Science & Technology Hubs; and the Tech Fellows program.

Prior to joining Aerospace, Miller was director of the Space Systems Laboratory and the Jerome C. Hunsaker Professor in the Department of Aeronautics and Astronautics at the Massachusetts Institute of Technology. Earlier in his career, he served five years—two as vice chair—on the Air Force Scientific Advisory Board, which is a Federal Advisory Committee that provides independent counsel on science and technology matters relating to the Air Force's mission. He also served as NASA's chief technologist at its headquarters in Washington, DC.

Miller has helped develop an extensive set of dynamics and controls technology laboratories on the space shuttle, the Mir space station, and the International Space Station. He is currently developing reconfigurable spacecraft concepts that permit a variety of capabilities through proximity operations and docking of modular satellites. Miller has also helped develop a technique to control satellite formations without the need for propellant.

Miller's comprehensive research experience, vast technical knowledge, investigative skills, and unique teaching abilities have prepared him to lead in the creation of agile space solutions for the most critical issues challenging Aerospace's customers.

Education

Miller earned his bachelor's and master's degrees and a Ph.D. in aeronautics and astronautics, all from the Massachusetts Institute of Technology.

Affiliations

Miller is a Fellow of the American Institute of Aeronautics and Astronautics.

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