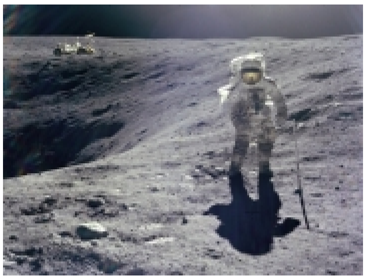
Year of the electric car also anniversary for out-of-this-world predecessor



Thursday, 17 February 2011

Dan McCue

With high-profile announcements about mass-produced electric vehicles seeming to come from the world's major automakers every day, and an increasing number of communities making significant investments in charging stations, 2011 is shaping up to be the year that clean energy vehicles finally come into their own.

Recently, for instance, the General Motors Co.'s Chevrolet division announced that it would accelerate the US rollout of its Volt, making it available in all 50 states by the end of the year, due to strong customer interest. Not to be out-done, the 100 miles-per-charge Nissan Leaf EV was just named Europe's Car of the Year, and Hyundai has unveiled a hydrogen fuel cell vehicle, dubbed the Tuscon iX FCEV, that will allow the automaker to explore another area of alternative fuel technology.

But 2011 is also a milestone year for electric and battery vehicles for an entirely different reason – it marks the 40th anniversary of the out-of-this-world debut of the lunar rover, the battery-powered "buggy" that first landed on the moon in 1971, and was used by US astronauts on the last three Apollo missions.

Prior to the rover, the astronauts making man's first foray onto another celestial body were limited in the range of their explorations to objects within walking distance of their lunar module.

The 480-pound (Earth weight) rover changed all that, not only extending how far astronauts could travel on the moon, but also greatly expanding what they could bring back with them.

Spare in appearance, the rover could carry more than twice its weight in passengers, scientific instruments and lunar soil samples. While on the lunar surface, the vehicle was powered by two silver zinc batteries driving electric motors on each of the four wire-mesh wheels, the vehicle had a top speed of eight miles per hour.

Astronaut recalls his lunar ride

Among those most familiar with the lunar rover was Apollo 16 astronaut Charles M. Duke, Jr., who not only participated in its design alongside his mission commander John W. Young, but also served as its navigator as Young drove the vehicle across the lunar surface.

"I was impressed with it," Duke said of the rover during an interview with Renewable Energy Magazine from his home in New Braunfels, Texas (US).

“Initially, John and I were scheduled to be the first crew that took the rover to the moon, and so we’d travel to Boeing and out to General Motors Delco Electronics Division laboratories in Santa Barbara, Calif., the contractors tasked with building it, and we got intimately involved with that process, making engineering suggestions, offering input on things like the seats and seat belts, simple stuff like that.”

Duke, the youngest of only twelve men to have walked on the moon, said he and Young also spent countless hours operating a rover simulator at the US National Aeronautic and Space Administration facility in Huntsville, Ala., and drove an Earth-bound model both on geological training missions in the field and on a “rover practice track” at the Kennedy Space Center in Florida.

“To me, at that time, it was the most advanced electrical vehicle I had ever seen or knew about,” Duke said.

The first operational lunar roving vehicle arrived at the Kennedy Space Centre in Florida in April 1971, with the remaining rovers arriving at the launch facility at three month intervals.

Then, NASA cancelled what would have been the last three moon landing missions, Apollo 18-20.

The rover’s debut was moved to the flight of Apollo 15, in July 1971, meaning Young, by then an experienced astronaut, having already flown three space missions, and Duke, a fighter pilot and MIT-trained engineer, would actually be the second crew to use the rover. Their mission occurred between 16 and 27 April 1972.

Three rovers actually made it to the moon, while the fourth and last to be built was used for spare parts. Final cost of the rover program was $38 million.

“It was an amazing little machine, very reliable, and very well-designed,” Duke said.

Rover powered by two silver-zinc batteries

For its journey to the surface of the moon, the rover was folded and tucked into a cargo bay in the descent stage of the lunar module.

To deploy it the astronauts on the surface would pull off a Mylar covering, release a series of pins, and then “jack” the vehicle out using a pair of cables on pulleys.

“Basically, you got it started, and then it unfolded like the landing gear of an airplane,” Duke said. “I was just amazed by the deployment mechanism. The ease with which it all worked, the scheme they had come up with for deployment.

“Once the rear wheels were on the ground, we unhooked the front, made sure all the chassis lugs were locked in place, then we carried it a distance away from the lunar module and put the seats and instrument panel up; John fired it up and we were on our way,” he continued.

Power on the moon was provided by two 36-volt silver-zinc potassium hydroxide non-rechargeable batteries with a capacity of 121 amp-hr.

These were used to power the drive and steering motors and also a 36-volt utility outlet mounted on front of the rover to power the communications relay unit or the TV camera.

Passive thermal controls kept the batteries within an optimal temperature range, but the composition of the lunar soil required the astronauts to keep dusting the unit off so that it wouldn’t overheat.

The rover itself measured 10 feet, 2 inches in length, was slightly more than 6 feet wide, and had a 7 ½ foot wheelbase.

Reliability was obtained through simplicity in design and operation and through redundancy. For example, there were two complete battery systems, each sufficient for powering the vehicle. The vehicle was normally steered by both the front and rear wheels; however, if one steering mechanism failed, it could be disconnected and the remaining steering system would do the job. Each wheel was powered by a separate electric motor which had a sealed drive to prevent problems of lunar dust. Even if two wheel motors failed, the rover could continue to be driven by simply decoupling the failed motor to free the wheel.

“John and I were both pretty pleased with the way it behaved, although once on the moon we discovered that the simulator on Earth wasn’t quite right in terms of the bounciness,” Duke said. “On the moon, it bounced a lot more than we expected, but I that was byproduct, I think, of the great difference on the weight of the rover.

“On Earth, it was a few hundred pounds, while the whole vehicle must have weighed just 80 pounds on the moon, maybe a little over that,” he said. “And if you watch the films of us driving across the moon, you can see how bouncy it was.”

The other thing the astronauts quickly discovered in the Descartes region of the rugged lunar highlands was that steering on the lunar rover was extremely sensitive.

“As a result, we tended to fish tail a lot, but the thing is, it was still a very stable vehicle,” Duke said. “Despite the bouncing and occasional fish-tails, you never felt like it was going to turn over… and a case in point was when we wound up spinning out inside of a crater. “We had driven into the crater and skidded, and John over-corrected, causing us to spin. Still,” he continued, “we never felt in danger of turning over.

“The other thing I was very, very impressed with was the rover’s power,” Duke said.

The rover had a rated capacity of climbing a 25-degree slope. But Duke said that was likely exceeded on a lunar feature dubbed Stone Mountain.

“We drove up the mountain and I can remember looking at this little incline meter that we had and seeing that it was off the scale,” he said. “At that point, I’d say we both felt like we were going to fall out the back of the seat, but even more impressive was when we near the top and looked back and saw how steep it looked.

“No question, it was quite an experience riding it,” Duke said.

What a ride

Born in Charlotte, North Carolina in October, 1953, Duke attended high school in Lancaster, South Carolina and graduated as valedictorian from the Admiral Farragut Academy in St. Petersburg, Florida in 1953. He is also an Eagle Scout.

He received a Bachelor of Science degree in Naval Sciences from the United States Naval Academy in 1957 and a Master's degree in Aeronautics from the Massachusetts Institute of Technology in 1964.

After graduating from the Aerospace Research Pilot School in September 1965, Duke stayed on as an instructor teaching control systems and flying in a number of high performance aircraft. In April 1966 he was one of the 19 selected for NASA's fifth group of astronauts.

Although he was a member of the astronaut support crew for Apollo 10, he first became widely known to most Americans during the flight of Apollo 11, the first lunar landing mission.

Although now a largely forgotten aspect of Apollo 11's historic voyage, Neil Armstrong had to make last minute adjustments in the last lunar landing, adjustments that led to expending almost all of the module's fuel and a prolonged period of radio silence.

When Armstrong announced "the Eagle has landed", it was Duke who famously exclaimed, "Roger Tranquility Base [the name of the landing site], we copy you on the ground. You got a bunch of guys about to turn blue. We're breathing again. Thanks a lot!"

Reflecting on his own experience heading for the lunar surface in the lunar module, Duke compared the ride to being in a helicopter.

"It had a rocket engine rather than a rotor blade, of course, but in terms of maneuvering it was actually very much like a helicopter," he said. "You could roll, you could yawl – spinning the module a full 360 degrees around – and you could go up and down, right and left, back and forward.

"As for the systems in the module, I found them fairly straight-forward and easy to learn," he said. "In fact, once you mastered the hover part, it was very easy to fly."

Duke said the only time the module felt like flying in an airplane was immediately after lift-off from the moon, when the ascent stage of the module would race back into space, leaving the heavy descent stage behind.

"At that point the module was very light and the roll rates were very rapid, and you can hear it in my voice on the audio recordings, where I'm saying, 'What a ride! What a ride!,'" Duke laughed. "It was like a jet fighter doing aileron roles and stuff. We didn't spin all the way around, but it was an exciting 7 ½ minutes until we got back into lunar orbit."

According to Duke, pre-flight simulations of the mission were accurate down to the smallest detail.

"As a result, when we pitched over and saw our landing spot for the first time, we recognized the major craters and realized that we were almost exactly on track. In a sense, we found ourselves heading into a very familiar place, a place we'd stayed at and walked through many times in the simulator."

But that's not to say the astronauts were immune to human emotions. Duke said that despite all the training and preparation, there's still a part of you that says 'that's the moon… and it's right there!' as the surface beckons.

"Oh yeah," he said, "That certainly happens."

"I mean, the dynamic and emotional high of living through that experience is -- Real. It's not a simulation," Duke said. "So you're coming into the moon and it's very, very exciting and you are very, very focused on landing this vehicle because you want to find a place that's level and you want to find a place where you can walk around and do your work.

"My commander, John Young, was actually piloting the module; I was more of the systems guy, keeping it operating and talking him down, giving him the altitude and rate of descent, the lateral and forward velocities, things like that," he said.

Like the rover, the Lunar module was battery powered and had multiple redundancies built into its power scheme. Also like the rover, its systems were built to work together or as separate units, a measure intended to give the astronauts a multitude of options should an emergency arise.

Power on board the lunar module was initially to be produced by fuel cells built by Pratt and Whitney similar to those employed in the command module which would ferry the astronauts to and from the Earth, but in March 1965 these were discarded in favor of an all-battery design. The ascent stage of the lunar module was powered by two 28–32 volt, 296 ampere-hour silver-zinc batteries, each weighing 125 pounds (57 kg); the descent stage was powered by five 28–32 volt, 415 A•h silver-zinc batteries, weighing 135 pounds (61 kg) each.

“One thing I clearly remember is how the whole system would just come alive as you powered the module up,” Duke said. “The lights came on, the guidance and navigation systems sprang to life, the pressurization and environmental control, all of that stuff.

“And, because the module had ample power, we actually powered down a lot of stuff once we landed on the moon, the flight and operational systems and so forth. After all, we needed those batteries to last three-plus days,” he said.

“Those batteries were really state of the art for those days,” he added. “They had plenty of power.”

Lunar module no luxury vehicle

After inclusion of the rover in the mission, the batteries, in fact, were among the most significant change in the program between the early lunar landing missions, Apollo 11, 12 and 14, and the final three, Apollo 15, 16 and 17.

“Basically, we got bigger batteries,” Duke said matter-of-factly in his soft Texas drawl. “The first three landings on the moon were designed for 30 to 40 hours, while the last three, what we called the J missions, were planned to last at least 72 hours.

“So you had bigger batteries, bigger oxygen tanks, more fuel, the rover – it was certainly a heavier vehicle – but the basic systems were all the same,” he said. “If you climbed into the Apollo 11 lunar module and the Apollo 16 module, you couldn’t tell the difference.” Which means, if various astronaut memoires are to be believed, that there wasn’t a lot of luxury in living on the moon?

“Well, no,” Duke said. “It didn’t have any seats. But you’re 1/6th gravity and you don’t really need a seat. I mean, I weighed 25 pounds up on the moon. And you just never got tired.

“The other thing is, I had the environmental control system right behind me, so I could lean against that,” he said. “Also, you know, we took off suits off inside the module, and that process was much easier than it had been in training on earth, because of the lack of gravity. “Now, that’s not to say it wasn’t crowded,” Duke added. “The module wasn’t very big in terms of overall volume, so once you suited up and had your backpack on, you couldn’t stand up straight; you had to kind of move toward the center. But we had practiced, and we had mastered that process. We helped each other with our connections and stuff like that. We worked together as a team, so we never felt like it was uncomfortable.

“We had hammocks when we went to sleep,” he said. “We put out some hammocks and sleeping was – well, the first night wasn’t so good for me because I was so excited and it was hard to calm down, but the second two rest periods we had, we slept like babies because we were so tired. It was hard working in a space suit out on the moon. So you were really tired. And we slept really well. It was very comfortable, actually.”

Smart people come up with unique ways to do things

Reflecting on lessons learned from manned space flight and those that particularly pertain to renewable energy, Duke said the main thing is “as we got smarter, the systems got more efficient”. “For instance, in terms of the batteries, the rover and the lunar module were pushing the state of the art in those days,” he said. “Now we’ve got remote control rovers used by both NASA and the military that use batteries that can be recharged with solar power – something we didn’t do during the Apollo program.

“As a result we have an unmanned rover on Mars that was supposed to last for four months and it has lasted for years on the Martian surface, and you know, that same approach to power generation and recharging batteries is also in use on the International Space Station,” Duke said.

“So you build on those kinds of successes. You get smarter people and engineers and different materials and then we start building batteries with a different composition than what we had,” he said. “In that sense, I think when you talk about advances in technology; it’s just a process of evolution.

That said, Duke believes manned space flight gave energy and other technologies a “push” it wouldn’t have otherwise had.

“In our case, the push to create the technology we needed came from the space program and I think that’s probably still true today in some respects,” he said.

Speaking of solar, Duke said the efficiency of solar cells has gone up “by quantum leaps” from the earliest days of the space program, and that solar is becoming ever more practical in other settings.

“I mean, not far from where I live, the San Antonio (Texas) Public Service System has a huge solar panel farm in operation,” he said. “Still, I don’t think solar will ever be the dominate replacement for fossil fuels, mainly because of the expense.

“But, you know, it’s just like anything else,” Duke quickly added. “It was expensive to send a letter across the country back in 1900, when it cost all of two cents.”

So will future space exploration lead us to entirely new renewable sources of energy? “It’s possible,” Duke said. “But it is hard to predict those kinds of things.”

“Personally, I think as far as electrical generation is concerned nuclear systems are going to replace a lot of fossil fuels, natural gas plants and the coal-fired stuff. And that technology has been around for some time, though it continues to develop and evolve,” he said.

“We had a radioactive thermal generator on our experiments package on the moon, using a little plutonium rod and that proved to be both efficient and much longer-lasting that was expected at the time,” Duke continued.

“So space technology certainly motivates advancement, not only in areas of electrical power generation, but in communications and computers and stuff like that. My cell phone has 100,000 times the memory of my Apollo computer,” he laughs.

Although Duke conceded that today’s technology is far more efficient than that he took to the moon, he was far from ready to wave a white flag.

“Our technology was good,” he said. “For what we were working with and the state of space flight back in those days, I think Apollo was a tremendous accomplishment. Of course, it was first generation stuff, but it was well made and it was good and it performed as advertised.” Simply put, Duke believes the story of renewable energy and any technological advancement is the story of “smart people coming up with very unique ways of doing things”.

Later this year, after several delays, the US will launch its last space shuttle mission, putting an end, for a time, to America’s manned spaceflight efforts.

Given his long association with the program, it was not surprising to hear Duke express his disappointment in the current situation, particularly cancellation of the planned Orion and Constellation projects, which would have continued manned missions to low Earth orbit, the moon, and ultimately, Mars.

“I think it was a mistake to sort of place the man in space program into a situation where it is dead in the water,” he said.”Back in the 1970s, we had a six year break between the [joint US and Soviet Union] Apollo Soyuz mission and the shuttle, but it was different then. We didn’t have a program that required people to be in orbit at that point. We didn’t have an International Space Station. We were just building toward something to get us back in space. “Now, we do have a need to get people back and forth to the space station, and there’s no way we are going to be able to do that, save having to depend on the Russians to take our astronauts to the station,” Duke said.

“There are some private companies that are working on it, but…”

With that, Duke’s voice trailed off momentarily.

“I’m just disappointed. I’d like to see us return to the moon. [Apollo 11 astronaut and second man on the moon] Buzz Aldrin would like us to go to Mars, and not go to the moon, but I think we have good reasons to go back. I think establishing a scientific base on the moon would advance science and technology significantly, including giving us a chance to develop long duration systems for living out in deep space for weeks and months at a time – something we’ll need before we go to Mars.”

“So, there’s a slight debate amongst the astronauts about where the future of manned flight should go, but there should be manned flights,” he said.

With that Duke was asked to answer one question more: When you look up at the moon at night, what do you think about?

For a moment, his words came haltingly.

“I think the main thing is a sense of pride,” he said. “I feel this sense of pride in country, pride in team and pride in NASA, that we did it and that I had the opportunity to be involved in that great program. And it was just a thrilling adventure for me.

“Of course, if I just take a quick glance, you know, I might think, ‘Well that’s a pretty moon.’ But if I just look at it, especially when it’s a half moon, which was what the phase was when we landed, and I start thinking about it, I can see the general area of our landing site, and I experience this flood of memories of a very exciting, wonder and fun time of my life,” Duke said.

For additional information:

Charles Duke’s web site