Congratulations and Good Luck from the Prime Launch Team

Astronauts, Technicians, Bureaucrats, and the Grumman Crew at Kennedy Space Center

By David Clow

The Mode and the Machine

Grumman Corporation of Bethpage, New York, built the Apollo lunar modules. They had no prior experience with spacecraft, but then, no one had experience with ships like these.

Grumman's story started with five entrepreneurial airplane designers on Long Island in 1929. In 1931 they created the XFF-1, the first Navy fighter with fully retractable landing gear and a fully enclosed cockpit. The company hit its stride during World War II, creating the Grumman Wildcat and the F6F Hellcat. Thereafter, its F9F Panther, Jaguar, A-6 Intruder, E-2A Hawkeye, and EA-6 Electric Intruder kept the Bethpage plants humming and made Grumman's name one of the most honored in American aviation history.[1]

The company's success actually worked against it when it first tried to enter the space race. Grumman's design for the Mercury spacecraft was the winner among 11 entries, beating the design submitted by McDonnell Aircraft, but its commitments to military aircraft suggested to NASA that Mercury would be more that Grumman could handle.[2] However, its new Space Sciences Group did succeed in winning NASA contracts for an orbital astronomical observatory, and when NASA gathered potential contractors for a preliminary long-range planning meeting in July 1960, Grumman was there.[3] NASA served notice that plenty of work and money was in play for a project called Apollo that would take the United States to the Moon.

What was not yet certain was how the United States was going to get there. President John F. Kennedy told his audience at Rice University that "we shall send to the Moon, 240,000 miles away from the control station in Houston, a giant rocket more than 300 feet tall, the length of this football field, made of new metal alloys, some of which have not yet been invented."[4] "*Some of which?*" Pretty much everything about this was not yet invented. The question of hardware was, to say the least, up in the air.

Designing vehicles involved with launch and reentry could make some use of precedent and common sense. NASA's Space Task Group, with the brilliant Max Faget leading its spacecraft design efforts, understood for example that the heat of reentry made blunt-body design and ablative heat shields more practical than the lifting bodies some contractors proposed at first.[5] But unknown this early in the planning was the so-called "mode," the actual technique for getting to, landing on, and coming back from the Moon. The mode was the final determinant of all hardware decisions and designs. Unknown along with the mode was what kind of vehicles would be required for it. Precedent was an option, and common sense was uncommon.

Dr. John Houbolt, the most vocal proponent of lunar orbit rendezvous (LOR), was still "a voice in the wilderness"[6] this early in the program, and so any hardware that might eventually be required for it was in dispute along with Houbolt's calculations and his reputation. Grumman committed resources to study Lunar Orbit Rendezvous before NASA finally selected it as the mode.[7] NASA issued a Request for Proposal for a Lunar Excursion Module in July 1962. Thomas J. Kelly, who served as Grumman's project engineer, engineering manager, and deputy program manager for the machine, and whom history would know as the "Father of the Lunar Module," said, "I was hungry for a win."[8] America, NASA, all its contractors, and the Soviet Union—they were hungry too.

The Rolling Process

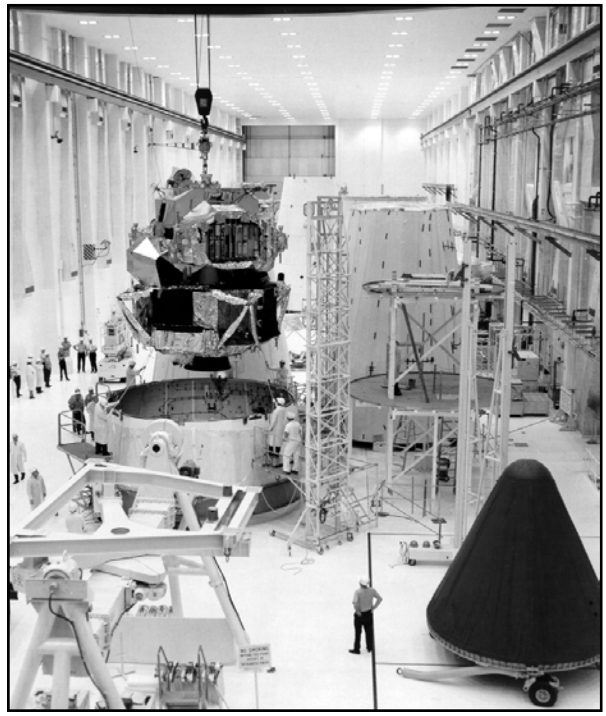
NASA announced on 7 November 1962, "Grumman Aircraft Engineering Corporation, New York, today was selected to build Project Apollo Lunar Excursion Module—a spacecraft in which Americans will land on the Moon and return to a Moon-orbiting mother craft for the journey back to Earth." Grumman was late the day it won the contract, as anyone would have been. In order to anticipate conditions no one had ever experienced, Grumman had to unlearn what it thought it knew.[9]

Grumman's announcement continued, "LEM will look something like the cab of a two-man helicopter, measuring 10 feet in diameter and standing about 15 feet tall on its skid-type legs."[10] Precedent in this case was wrong: Grumman was already trying to fit the square peg they understood—Earth-based flight, Earth-like conditions—into the round hole of space. A helicopter? That was two men, side by side, sitting, flying in the air. The lunar module (LM) was going where air did not exist. Skids? Suitable for Earth, but as the LM was being designed, no one could be certain just what there was to land on on the Moon. Piloting the two would be very different as well, and it was dangerous to assume transferring skills between them. "The helicopter wasn't a good simulation of the lunar module control at all," Neil Armstrong reflected. "Had it been, we would have configured a helicopter such that it could duplicate lunar flying…the natural requirements of helicopter aerodynamics preclude you from duplicating the lunar module characteristics." Bill Anders, who, like Armstrong, endured the dangers of the bizarre Lunar Landing Training Vehicle, said that a pilot's entire understanding of mass, weight, and lift in a helicopter didn't apply at all to lunar flight, and that any assumptions to the contrary were "in a sense, bad training." "Flying on the Moon," he said, "was literally a different world."[11]

NASA evaluated contractor proposals to build the LM based less on prior experience than on the contractor's grasp of the whole theory, tenuous as it was, of going to the Moon and getting back, including every shaky sub-theory in between. No one really even knew what the Moon was—rock? dust? The United States and the Soviet Union had been flinging unmanned probes at the Moon since 1958, Most of their attempts from the Luna, Sputnik, Cosmos, Pioneer, and Ranger programs failed. Not until *Ranger 7* in 1964 did America succeed in both hitting the Moon and taking pictures until the moment of impact.[12] Kelly and his team were an estimated year behind by spring 1965,[13] and while Kelly's 3,000 people in Bethpage were working flat-out, they still did not know what conditions they were designing this machine to meet. It was January 1966 before anyone successfully soft-landed (it was the Soviets' *Luna 9*), and May of that year when the Americans put *Surveyor 1* down safely. Until then, no one was certain about the nature of the lunar surface, whether it was hard and would support weight, or soft drifts of dust that would swallow the LM.

Grumman could not wait for the questions to be settled. Their design changed rapidly, starting with a sleek egg-shaped helicopter cabin with big windows, seats, and a round snout hatch on five legs. From there it devolved into a four-legged thing with an octagonal base, and then into something lumpy and asymmetrical like a boys' treehouse made from scrap plywood and tar paper, with a jack-o'-lantern face, a ladder up the front leg, and a hatch they could shut to keep girls out. The engineers finally understood its uniqueness. The lunar module did not need to be aerodynamic or even symmetrical. They could defy precedent and reimagine common sense, forget Grumman's history of elegance, indulge in "a very, very free form of engineering," make something "ridiculous"—and it would work.[14]

Meanwhile, the missions it would fly were not finalized; indeed, they were barely guessed at in the detail Grumman really needed to know. Tom Kelly called the LM "my baby,"[15] and it was: it kept him awake nights worrying what would happen if it grew up. It did the same with 3,000 of his colleagues in Bethpage and New Mexico, where engines were tested.[16] It kept all of Grumman's contractors up late, too; and likewise NASA, which seemed never to sleep. Joe Shea, NASA's manager for the Apollo Spacecraft Program, spotted problems early on with Grumman's ground support equipment (GSE) capabilities—Grumman had not only to build the flight item but to create the hardware that would test it as well, and falling behind there would cause delays in the whole process. Shea unleashed a GSE overseer on Grumman and North American Aviation (NAA), the company building the command module. This inquisitor would visit both of them weekly, roasting NAA about the command module in Downey all day, then taking a red-eye flight to Long Island and doing the same the next day with Grumman and the LM. His meetings started at 7:00 AM and typically ran 12–14 hours. No breaks. On the table, he'd put his whole day's sustenance: an apple and a glass of water. If you had fine dining in one of Bethpage's delis in mind for your own meals that day, tough luck.[17]



LM-1 being prepared for launch (note the absence of landing gear) Credit: The Project Apollo Image Gallery

Into the Homestretch

With both contenders heading for the homestretch, the United States pushed its people and its machines to the limit in 1966: five Gemini flights; *Lunar Orbiter 1* and *2*; NASA's contract with Bendix to develop the Apollo Lunar Surface Experiments Package (ALSEP);[18] Congressional funding for the lunar receiving laboratory.[19] The crawler-transporter, the world's largest self-powered vehicle, first rolled its six million pounds from the Vehicle Assembly Building in May.[20] Nineteen new astronaut candidates were hired (including four men who soon become lunar module pilots, and two whose life the LM would help to save).[21] Joe Shea convened 75 NASA contractors in Houston in June to make sure everyone understood the goals and requirements of lunar orbit rendezvous, and ask what they still needed to consider.[22] Apollo spacecraft 012, the command module from North American Aviation that was slated to carry *Apollo 1*, arrived at Kennedy Space Center (KSC) just before Labor Day.[23] The Soviets' *Luna 10*, meanwhile, scored another first: first spacecraft to enter lunar orbit. It circled