Who mourns for Apollo?

By Colin Johnston, Science Communicator

Nearly thirty five years after the final Apollo mission, the Apollo Program is still probably NASA's best-known project. Although it also encompassed the almost forgotten Skylab and Apollo-Soyuz Test Project, the programme is remembered for the hugely successful moon landings. This article, one of several Apollo-related articles planned for this anniversary year, will describe the spacecraft, the scientific results and deeper cultural impact will be covered later in the year.

When it began in 1960, Apollo was a project to develop a versatile three seat spacecraft to succeed the single seat Mercury spacecraft (NASA's first manned spacecraft which itself was under development at the time). It was to be capable of missions in Earth and lunar orbit, possibly including landing on the Moon. This was very challenging, at that time no human had even flown in space. The requirement that the craft be able to operate in cislunar space would dominate the design as this meant it could be entering Earth's atmosphere at about 11 km/s on its return, enduring savage heating. Entirely new materials would have to be used in its construction. Several of the US's aviation companies proposed designs, many of which were completely unlike the spacecraft that was eventually built: General Electric suggested a vehicle strangely like the Soyuz craft then being developed in secret in the USSR. Other designs featured winged and aerodynamically-shaped re-entry vehicles which would land on a runway like the Shuttle decades later. Most unusual of all, but favoured by many in NASA was the Martin Corporation's lenticular design, a true flying saucer.

On May 25, 1961, President John F. Kennedy committed the US to the goal of landing Americans on the Moon before 1970. Apollo then became entirely a no expense crash spared, project to do just that (strictly speaking the Skylab and Apollo-Soyuz missions were not part of the Apollo project). By July 1961, the exotic layouts for the spacecraft 's re-entry vehicle had been rejected in favour of a squat conical design. In December that year, North American Aviation was selected for the coveted contract to build Apollo which then comprised the Command Module and a "second component", later called the Service Module, which would house the spacecraft's fuel, electrical power supply, propulsion system and lunar take-off gear (at this time it was still expected that the whole vehicle would touch down on the Moon, a third component, the "lunar landing module" would be attached to soft land all three components). North American had produced many successful and advanced military aircraft and anticipated building dozens or more Apollo spacecraft in the following decades but their Apollo experiences would not be happy. North American later became known as Rockwell and created the Space Shuttle Orbiter before being taken over by Boeing in the 1990s.

To send three men in an Apollo spacecraft to land on the Moon then take off for return to Earth required a huge launch vehicle. This would have been a titanic three stage rocket called Nova, there were several planned variants of this, the

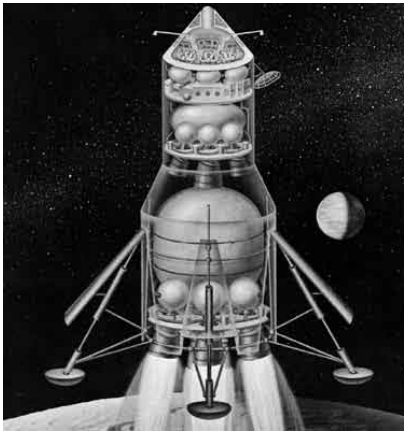

Image Credit: NASA

How it might have been 1: A painting of an early Apollo configuration which the whole spacecraft would have landed on the Moon.

'direct to the Moon and back again' model, the Nova C8, would have weighed about 4500 tonnes on the launch pad. Nova was still on the drawing board and would not be ready to test until the late 1960s at best. However, some NASA engineers were pushing a much simpler approach called Lunar Orbit Rendezvous (LOR), where only the landing module touched down (with one or two astronauts on board), leaving the Command and Service Module (the CSM) in lunar orbit. Since the heavy fuel load and engine for returning to Earth no longer needed to be transported to and from the Moon's surface, LOR had many advantages, in particular a (relatively) smaller rocket could be used, in the form of the Saturn 5 (3000 tonnes at launch) which was already in development. This revised mission plan rapidly gained support inside NASA. In July 1962 NASA invited tenders to design and build a "Lunar Excursion Module". The winning competitor was naval aircraft specialist Grumman who created the third component of the Apollo spacecraft, the Lunar Module. A spaceship in its own right (perhaps the only true spaceship to date), the LM will be covered in a later issue of Astronotes.

"the Martin Corporation's lenticular Apollo design was a true flying saucer "

The Apollo Command Module was 10.4 ft (3.18 m) high and measured 12.8 ft (3.9m). At the top was the vital docking adaptor encircled by the parachutes for descent to the splashdown in the ocean (the Command Module had to function as an acceptable boat too!) The rounded base was covered by a heatshield which during re-entry burned and disintegrated at a known rate, carrying heat away from the craft. The three crew, commander, CM pilot and LM pilot, sat in a pressurised cabin facing panels studded with 506 switches, 71 indicator lights and 40 dials and read outs. Five small windows allowed the crew to see outside. In diagrams the CM's interior seems horribly cramped, but the freedom to move all around it in micro-gravity made it seem relatively spacious to the crew. At launch, the CM was enclosed by the Boost Protective Cover surmounted by the Launch Escape System. A

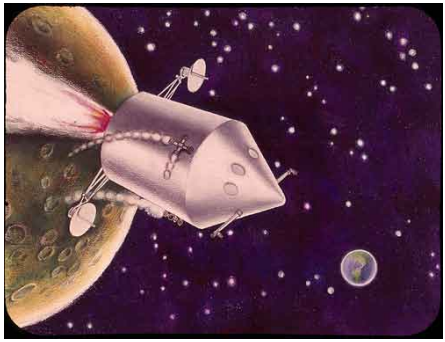

Image Credit: NASA

How it might have been 2: An early concept of the Apollo CSM rounding the Moon.

hefty rocket in its own right, the LES would have pulled the CM to safety should the Saturn rocket fail on ascent. Thankfully no Apollo crew ever had to rely on this device. Both the Boost Protective Cover and the LES were discarded once the spacecraft was clear of the atmosphere.

"the Command Module had to function as an acceptable boat "

Throughout the flight the CM's base was attached to the Service Module (SM), a 24 feet 7 inches (7.5 m) long cylinder which contained an AJ10 rocket engine and its propellants, fuel cells to generate power for the mission, tanks of water and air and the spacecraft's S-band antenna for communications with Earth. Later missions also carried scientific instruments in the SM including a deployable sub-satellite and a mapping camera (based on a camera developed for spy satellites although no one mentioned this at the time). The crew could not access the SM, so a spacewalk was needed to retrieve the mapping camera's film cartridges. Every SM was discarded shortly before the CM reentered the Earth's atmosphere.

Developing the Apollo spacecraft was far from straightforward (although to today's eyes it seems to have been remarkably fast), but at the start of 1967, Apollo 1 was being prepared for a test flight in Earth orbit. But hope turned to horror when astronauts Grissom, White and Chaffee were killed by a fire during a ground test of the capsule. The project was halted by

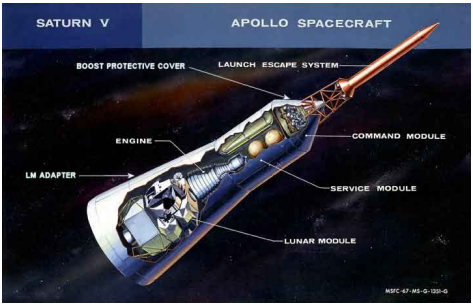

Image Credit: NASA

Apollo cutaway The Apollo modules are shown in launch configuration in this 1960s NASA artwork.

this tragedy. A review board was unable to find the exact cause of the fire which spread faster and burned more intensely than it should have been thanks to the extensive use of flammable materials and the 100% oxygen atmosphere in the cabin. The board compiled a shockingly long list of design flaws and poor workmanship on the spacecraft and lambasted North America for its poor quality control.

"the Apollo project ... successfully enabled the first phase of human exploration of the Moon"

By the Autumn of 1968, an enormously improved version of the CSM (the Block II) was ready for flight. Thousands of technical defects had been eliminated in the redesign and the crew breathed air rather than pure oxygen. The first crewed flight was Apollo 7 in October 1968, and this successfully demonstrated the vehicle was spaceworthy. In the next four years the Apollo project made history as it successfully enabled the first phase of human exploration of the Moon, ending with Apollo 17 in December 1972 (individual missions will be discussed in future Astronotes). Three further moon landings, Apollos 18, 19 and 20 were cancelled. Shrinking budgets and a sharp decline in public and political interest in space exploration were among the reasons for the project's waning.

It was not, however, meant to be like this. In the mid-60s NASA foresaw increasingly ambitious Apollo Moon missions throughout the 1970s. Ideas such as simultaneous landings by pairs of Lunar Modules and astronauts establishing lunar bases were planned for. There were more grandiose plans still including manned flybys of Mars and even Venus using Apollo Spacecraft. The Venus flight was considered in detail in 1967 and would have been launched in 1973. At the very least there was the Apollo Applications Program, which foresaw thirty or more missions for Apollo CSMs including visits to a series of space stations based on modified Saturn 5 upper stages. These space stations were to be placed in orbit around the Earth and Moon, but only one, Skylab, was actually launched to become the first American space station in Earth orbit. The last Apollo CSM carried three astronauts to a docking with a Soviet Soyuz spacecraft in 1975. Apollo was retired in favour of the Shuttle as America's manned space vehicle. Now in 2009, the Shuttle is soon to be retired itself, to be replaced by the Orion CEV, a sort of "Apollo on Steroids".

The Apollo project cost the US $25.5 billion by 1969 (more than $145 billion in today's money). It developed a flexible space transportation system that enabled twelve men to walk on the Moon, returning thousands of photographs and scientific measurements and 382 kg (842 lb) of lunar rocks and soil. Further missions would have been feasible but were not performed and the spacecraft could have been developed further still. Even today many wonder at this loss of vision.

Image Credit: NASA

How it was Apollo 15's CSM Endeavour as seen by from the Lunar Module Falcon. Note a section of the Service Module's skin has been jettisoned to expose the scientific instruments.