APPENDICES
ABBREVIATIONS

A7LB the spacesuit worn by Apollo astronauts
AFB Air Force Base
AGC Apollo Guidance Computer
AGS Abort Guidance System
ALM Augmented Lunar Module
APS Ascent Propulsion System
CDR Commander
CMP Command Module Pilot
CSI Coelliptic Sequence Initiation
CSM Command/Service Module
DEW Distant Early Warning
DPS Descent Propulsion System
DSKY Display and Keyboard for the AGC and LGC
EOI Earth Orbit Insertion
EVA Extra Vehicular Activity
LCG Liquid Cooling Garment
LEO Low Earth Orbit
LEVA Lunar Excursion Visor Assembly
LGC Lunar Module Guidance Computer
LM Lunar Module
LMP Lunar Module Pilot
LOS Loss Of Signal
LPD Landing Point Designator
LRV Lunar Roving Vehicle
MOL Manned Orbiting Laboratory
MORAD North American Aerospace Defence Command
PLSS Personal Life Support System
PNGS Primary Navigation and Guidance Section
RCS Reaction Control System
SAC Strategic Air Command
SAGE Semi Automatic Ground Environment
SALT Strategic Arms Limitation Talks
SPS Service Propulsion System
SRW Strategic Reconnaissance Wing
SST Supersonic Transport
TAC Tactical Air Command
TEI Trans Earth Injection
Tig Time to ignition
TLI Trans Lunar Injection
USAF United States Air Force
USAFE United States Air Force in Europe
USMC United States Marine Corps
USN United States Navy
VHF Very High Frequency
XO Executive officer
GLOSSARY

Apollo 1 Intended to be the first manned Apollo mission, it never left the launch-pad after a fire in the Command Module during a plugs-out test resulted in the deaths of all three crew. Crew: Virgil 'Gus' Grissom (CDR), Edward H White (senior pilot) and Roger Chaffee (pilot).

Apollo 4 to 6 These three launches were unmanned tests of the hardware: the Saturn V launch vehicle, Lunar Module and Command Module.

Apollo 7 This was the first manned Apollo mission, although it used a Saturn IB as a launch vehicle rather than the Saturn V needed for the lunar missions. The crew spent eleven days in LEO. Crew: Walter M Schirra (CDR), Walter Cunningham (LMP) and Donn Eisele (CMP). Command Module no callsign (CM-101). Launched 11 October 1968.

Apollo 8 Rumours of a possible Soviet attempt to send a cosmonaut round the Moon, and the delay of a Lunar Module for testing in LEO, prompted NASA to re-task Apollo 8 to orbit the Moon. This made its crew the first human beings to leave Earth orbit. Crew: Frank Borman (CDR), William Anders (LMP) and James Lovell (CMP). Command Module no callsign (CM-103). Launched 21 December 1968.

Apollo 9 The first Apollo mission with a Lunar Module, and so tasked with testing rendezvous and docking procedures between the two spacecraft in LEO. Crew: James McDivitt (CDR), Russell 'Rusty' Schweickart (LMP) and David Scott (CMP). Callsigns: Command Module Gumdrop (CM-


Apollo 13 This mission failed to complete after an explosion in an oxygen tank in the Service Module. The Lunar Module was successfully used as a lifeboat, and returned the crew to Earth. Crew: James A Lovell (CDR), Fred W Haise (LMP) and John 'Jack' Swigert (CMP). Callsigns: Command Module Odyssey (CM-109), Lunar Module Aquarius (LM-7). Launched 11 April 1970.

Apollo 15 The fourth lunar landing, and the first of the J-Class missions, which featured use of a LRV. It landed at Rima Hadley on Mare Imbrium. Crew: David Scott (CDR), James B Irwin (LMP) and Alfred M Worden (CMP). Callsigns: Command Module Endeavour (CM-112), Lunar Module Falcon (LM-10). Launched 26 July 1971, landed on Moon 30 July 1971. Duration on lunar surface 66h 54m 53s.


Apollo 18 The fourth J-Class mission to land on the Moon, at Copernicus. Crew: Richard F Gordon (CDR), Joe Engle (LMP) and Vance D Brand (CMP). Callsigns: Command Module Discovery (CM-116), Lunar Module Atlantis (LM-


**Apollo 21A/B** After the successful completion of Apollo 20's visit to Tycho in April 1974, NASA instituted its programme of Apollo Extensions Series missions, intended to further explore the Moon and lead towards an eventual mission to Mars in the early 1980s. Each AES mission was supported by two launches. The first, A, launched an automated LM Taxi to the Moon, an augmented LM which contained sufficient supplies for a two-week stay. A week later, B, carrying the crew and LM, followed. Apollo 21A/B landed at Censorinus crater, the planned destination of Apollo 15 until Apollo 13's failure. Crew: Charles 'Pete' Conrad (CDR), Edward Gibson (LMP) and Joseph P Kerwin (CMP). Callsigns: Command Module *Shenandoah* (CM-119), Lunar Module *Whope* (LM-16), LM Taxi no callsign (LMT-1). B launched 15 July 1975, landed on Moon 20 July 1975. Duration on lunar surface 281h 46m 11s.
Apollo 22A/B  The second AES mission to the Moon, landing on the dark side at Tsiolkovskiy Crater. Crew: Al Worden (CDR), Don L Lind (LMP) and Bruce McCandless (CMP). Callsigns: Command Module Lewis (CM-120), Lunar Module Clark (LM-17), LM Taxi no callsign (LMT-2). B launched 3 December 1975, landed on Moon 7 December 1975. Duration on lunar surface 283h 16m 9s.


Apollo 24A/B  The second ALSS mission, which landed at Schröter's Valley. The scientist-astronauts had now taken over the Apollo programme, and though some military astronauts remained in command positions most had transferred across to the military's own astronaut corps or retired. Unfortunately, the focus on science only exacerbated dwindling public interest in the programme, and by the time the astronauts returned only one more planned Moon mission was left and all remaining hardware had been transferred to the Space Station Freedom project. Crew: Ronald E Evans (CDR), F Story Musgrave (LMP) and Robert L Crippen (CMP). Callsigns: Command Module Ticonderoga (CM-121), Lunar Module Soarer (LM-18), LM Taxi no callsign (LMT-5). B
launched 24 November 1977, landed on Moon 28 November 1977. Duration on lunar surface 689h 43m 31s.

Apollo 25A/B  The third ALSS mission and the final civilian Apollo mission to the Moon, which landed at Aristarchus crater. It had been intended that the ALSS missions would lead to Lunar Exploration System Apollo, LESA, missions capable of up to 90 days stay on the lunar surface. Continued lack of public interest and subsequent budget cuts, however, brought the programme to a close. Although the Apollo missions put twenty-eight men on the Moon — no women ever qualified as astronauts until the 1980s — without a single death or injury, concerns closer to home eventually took precedence. The first modules for Space Station Freedom were boosted into Low Earth Orbit, with military involvement contributing to the cost of the Saturn launch vehicles, and the planned mission to Mars was quietly shelved. By the end of the decade, the US's civilian space presence was confined to LEO and unlikely to travel further. Crew: Jack R Lousma (CDR), Brian O'Leary (LMP) and Robert Parker (CMP). Callsigns: Command Module Goddard (CM-121), Lunar Module Tombaugh (LM-18), LM Taxi no callsign (LMT-5). B launched 4 July 1979, landed on Moon 7 July 1979. Duration on lunar surface 687h 51m 42s.

Augmented Lunar Module  A development of the Grumman Lunar Module, used exclusively by the Phoebus programme, which could carry four men to and from the lunar surface. The ALM was not designed for a lunar stay and carried only sufficient consumables for the journey to and from lunar orbit.
The Bell

Discovered in an underground facility in Nazi Germany, near Wenceslaus in Silesia, and transported secretly to the US after the end of WWII, it was many years before American scientists determined its actual function. The Bell was nine feet in diameter and twelve feet high, and constructed of metal and ceramics. Within it, two beryllium peroxide cylinders were suspended in a bath of a violet mercury-like substance known as “Xerum-525”. The two cylinders were spun at tens of thousands of revolutions per second, and thorium ions at high voltage were then fired into the vortex they generated. The precise nature of “Xerum-525” remained a mystery, as did the nature of the effect generated by the Bell. After inconclusive experiments had been performed on it at Los Alamos, the Bell was moved to Montauk, where it remained for several decades.

Convair F-106 Delta Dart An all-weather missile-armed interceptor aircraft operated by USAF between 1959 and 1988. Until 1981, it remained the primary interceptor and served both at continental US air bases and abroad in Europe and South Korea. It was powered by a single Pratt & Whitney J75-17 turbojet, and could reach a maximum speed of Mach 2.3.

Falcon Base

After no more than a year of operation, the Pentagon deemed the Sentinel modules attached to Space Station Freedom too vulnerable to attack by the Soviets. Yet they were still determined to control the high ground of space. As a result, they turned to 1950s Army Ballistic Missile Agency studies for a planned base on the Moon. Eventually adopting a modified plan drawn up by NASA during the 1970s, in early 1983 USAF began adopting modules destined for Space Station
Freedom so they could be used on the lunar surface. A number of locations were considered, but one necessity limited the Pentagon's choices: the moon base had to be located at a site that had been mapped by astronauts. After much study, Apollo 15's landing site was chosen, as Rima Hadley, a nearby trench system, provided a ready-made place in which the moon base could be buried. As a result, the base was named for the Apollo 15 lunar module, Falcon. Five modules for Space Station Freedom were modified for Falcon Base, and launched from Vandenberg in early 1984. A secret military manned mission followed two weeks later and, using a LRV similar to that carried by the ALSS missions, the modules were dragged from the LM Trucks which had carried them to the Moon into Rima Hadley, mated together and then part-buried. A series of supply missions, again landed on the lunar surface using LM Trucks, provided the SP-100 nuclear reactor and the oxygen, food and other consumables necessary for the base to function. The four astronauts who had built Falcon Base moved in and became its first crew. They were joined by a further eight members of the astronaut corps, and a rolling schedule of six months duty implemented.

**LM Truck** A development of the Grumman Lunar Module in which the ascent stage cabin and its APS was replaced by a platform capable of carrying up to 10,000 lbs of payload no more than 10 feet tall and 15 feet in diameter. LM Trucks were entirely automated and flown using guidance data transmitted to them from Mission Control Center computers.

**Lockheed Martin SR-71 Blackbird** A reconnaissance aircraft capable of flying at speeds in excess of Mach 3 and
altitudes of 80,000 feet, the SR-71 was flown by the USAF between 1966 and 1977, before being phased out in favour of the SR-91 Aurora. The SR-71 was known by its crew as the "Habu", a type of snake. It was powered by twin Pratt & Whitney J58-P4 engines, developing 32,500 pounds of thrust each. It had a crew of two, both of which had to wear full pressure suits.

**Lockheed Martin SR-71 Aurora** A hypersonic reconnaissance aircraft which replaced the Lockheed Martin SR-71 Blackbird. The Aurora was capable of speeds of up to Mach 7 and altitudes of 200,000 feet. It had a crew of two, a pilot and a reconnaissance systems operator, and was powered by liquid hydrogen-fuelled pulse detonation wave engines. All details regarding the construction and operation of the Aurora were top secret, and the existence of the aircraft has never been officially acknowledged by the US government. Only a single wing of Auroras exists, flying out of Groom Lake at Nellis AFB, Nevada.

**North American B-70 Valkyrie** A long-range supersonic deep penetration bomber operated by USAF from 1973, the B-70 was powered by six YJ93 turbojets, giving it a maximum speed of 2,065 mph (Mach 3.1), a ceiling of 77,350 feet, and a range of 4,200 miles. It had a crew of two and could carry both nuclear bombs and missiles.

**North American F-108 Rapier** A long-range supersonic interceptor, which entered service with USAF in 1968 after more than a decade of development. Armed primarily with three AAM missiles, the Rapier was capable of reaching speeds of 1,980 mph (Mach 3 approx) and an altitude of 80,000 feet. It had a range of 1,270 miles, a crew of two, and was powered by a pair of YJ93
turbojets, each delivering an afterburning thrust of 29,300 lbs each.

**Project Phoebus** With the original order of fifteen Saturn V launch vehicles assigned, NASA needed additional ones in order to meet its published mission schedule. But at $6.5 billion for those fifteen, and interest already waning in missions to the Moon, Congress was unwilling to sign off on the budget. The Pentagon, however, annoyed at having had both its X-20 Dyna-Soar and MOL programmes cancelled, stepped in and offered a deal: in return for access to Apollo technology, they would pay for additional Saturn Vs and 1Bs. By 1975, USAF had already spent almost $600 million on the SLC-6 launch facility at Vandenberg AFB and was looking to launch manned missions from there. As a result, a second order of ten Saturn Vs was placed, paid for entirely out of the Defence budget and with six of them going to USAF. Additional Saturn 1B's were also ordered, chiefly in order to service Space Station Freedom (and the Sentinel modules). The militarized version of Apollo was soon dubbed "Phoebus", and the name stuck. By 1982, Vandenberg boasted three launch complexes, and was running four missions a year, these culminating in the supply runs to Falcon Base on the Moon. The Phoebus spacecraft were identical in all respects to the Apollo spacecraft, although some improvements were added over time, leading to the Block-V CSM capable of carrying five crew and the Augmented LM which could carry a crew of four to and from the lunar surface.

**Saturn 1B** A launch vehicle commissioned and operated by NASA, it first flew in February 1966 and was capable of lifting 46,000 lb into LEO. The Saturn 1B was a two-stage rocket, standing 141.6 ft tall and weighing
1,300,220 lb without payload. The first stage was powered by eight H-1 engines, developing a total thrust of 1,600,000 lbf. The second stage comprised a single J-2 engine with a thrust of 200,000 lbf.

**Saturn V** The most powerful human-rated launch vehicle ever built and flown, capable of lifting 262,000 lb to LEO or 100,000 lb to the Moon. The Saturn V had three stages, stood 363 ft tall, and weighed 6,699,000 lb. The first stage was powered by five F-1 engines developing a combined thrust of 7,648,000 lbf, the second stage had five J-2 rocket engines for a total of 1,000,000 lbf, and the third stage comprised a single J-2 of 225,000 lbf thrust. The Saturn V first launched in 1967, and flew without accident or mishap throughout the following two decades.

**Space Station Freedom** In 1978, President Carter announced plans to build a space station in Low Earth Orbit, stating, "We can follow our dreams to distant stars, living and working in space for peaceful economic and scientific gain". Despite the achievements of exploration further afield, it was the need for a permanently-manned foothold in orbit which prompted the desire for a space station. The Soviets had no presence in LEO, and the US was determined to take and keep the high ground. It was not until 1980 that the first modules in what became Space Station Freedom were launched. Maintaining an impressive schedule of alternating Saturn 1B and Saturn V launches every eight weeks, NASA managed to have the basic configuration of the station in place by mid-1981. During the rest of the decade, Freedom was extended overtly by NASA and covertly by USAF. A typical tour on Space Station Freedom lasted approximately six months, with a
permanent crew of four (plus two "undeclared" in Sentinel), and room for an additional four short-stay visitors. Despite the expense of the station, it did not prove as scientifically useful as had been hoped, and once NASA plans for a mission to Mars had been scrapped its military role began to expand.

**Sentinel** Plans for a space station partly funded and built by international partners were never going to be politically acceptable, and so NASA was forced to compromise and accept funds – and an agenda – from the US military. As a result, an additional two modules, referred to as Project Sentinel, were built and added to Space Station Freedom. The Sentinel modules did little that a satellite could not have done, but the Pentagon saw them more as an excuse for a military presence in LEO than having any significant early warning capacity.

**Soyuz** A Soviet spacecraft, it replaced the Voskhod in 1967. It comprised three modules: a spherical re-entry module, a cylindrical service module, and between them a spheroid orbital module. It initially carried a crew of two, but a new model introduced in 1980 increased this to three cosmonauts. A typical Soyuz could provide life support for its crew for 30 days.

**Sukhoi T-4 'Blowtorch'** A supersonic strategic bomber built by the USSR in direct response to the USA's North American B-70 Valkyrie. The T-4, given the reporting name 'Blowtorch' by NATO, was capable of Mach 3, altitudes of 65,000 feet and had a range of 4,300 miles. It carried a crew of two and was powered by four Kolesov RD-36-41 turbofans, generating an afterburning thrust of 35,000 lbs each.
TKS A Soviet military spacecraft designed to fly alongside Soyuz, it used a conical capsule similar in shape to the Apollo Command Module. It comprised two modules: a manned crew return capsule and a functional cargo block. The TKS carried a crew of three, although the crew return capsule was only occupied during launch and re-entry.
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