

*History of Space*

Part 4 Notes

\* Please note, the following notes concerning the slides within Part 4 are ‘additional’ notes to those found to be on the slides as they already exist. The following simply helps compile the slides chronology and associations as well as adding additional info for pertinent slides.

**Slide 1:** a simple graphic ‘genealogy’ to help show how tech transfer influenced concepts and designs for ‘to follow’ vehicles. You should be able to show the students what vehicles have been discussed to date so they can see where they are in America’s space efforts.

**Slides 2:** Family of R-7 vehicle…from Sputnik; through one manned vehicle, Vostok; through two-manned vehicle, Voskhod; to ‘yet to be discussed’ three-manned vehicle, Soyuz.

**Slide 3:** Graphic showing flight plan of Russian effort to put man on moon.

**Slides 4-8:** Shows the Russian Soyuz capsule and vehicle. Note the enlarged upper stage of the Soyuz to loft 3-manned capsule. Again, same R-7 booster that dates back to sputnik – still used today.

**Slides 9-13:** These slides show the Russian N-1 ‘moon’ vehicle. Yes, the Russians did attempt to beat us to the moon; however, due to Korolev’s inability to develop the critical components needed, such as large booster motors, he had to work with Glushko to cluster their best motors. Design was unable to endure the ‘harmonics’ developed from the 30 motors firing at the same time and, in most tests, the vehicle shook itself apart.

**Slide 14:** This graphic shows the flight plan for our Apollo program. Each of the programs, Mercury, Gemini, and Apollo can be seen within the clockwise images.

**Slides 15-17:** Slides 15/16 show the Redstone and Atlas of Mercury program. 17 shows the moon flight plan where you can see how important Mercury program was to flight plan – review Mercury goals/objectives to see how they relate to flight plan.

**Slides 18-19:** Shows the Titan missile supporting the Gemini launches. Again, on slide 19 you can look and see that without Gemini, the moon flight plan would not be possible – two weeks in space, rendezvous and docking, etc.

**Slides 20-22:** Shows the 3-man Apollo capsule compared to Mercury and Gemini capsules.

**Slides 23&24:** Shows the Apollo capsule with the Command Service Module (CSM). Also shows proportional imagery of Apollo compared to Merc/Gemini capsules. Also shows comparison of launch vehicles between Saturn V, Titan missile, and Atlas.

**Slide 25:** Introduces the Saturn ‘family’ – Sat I, Sat IB, and Sat V. Also denotes variation of motors used within the vehicles. Make sure students become familiar with H-1, J-2, and F-1 motors over the next few slides.

**Slides 26-28:** These slides show the Saturn I. The Saturn I’s booster was actually a cluster of eight Redstone rockets; however, each Redstone vessel either carried kerosene or Lox. The white tanks carried lox and the black painted tanks carried kerosene. All engines were H-1’s. Slide 28 shows a comparison of the Sat 1 with the original grandfather – the Redstone. The main purpose of the Sat 1 was to begin testing of the S-IV upper stage…the upper stage that will take CSM and Apollo capsule to the moon.

**Slides 29-31:** These slides show the Saturn IB. The Saturn IB was pretty similar to the Saturn I in design and performance, with some major upgrades. As noted in image, the IB possessed the ‘real’ S-IVB upper stage (compare the S-IVB ‘stack’ as what is seen on the Sat V vehicle). The ‘upgrade’ included the new J-2 motor that performed above the original six RL10 motors on the Sat I. The J-2 is still used today. NASA’s Stennis Space Center recently completed testing of the new J-2X motor. The new J-2X performs at nearly 35% more thrust, nearly 300,000-lbf of thrust, than the original J-2. (note: the testing was supported by a SystemsGo student – Justin Junell)

**Slides 32-42:** These slides show the Saturn V. Slide 32 is a previous slide allowing the students to see a comparison of the Sat family vehicles. Note the Saturn V has the same S-IVB upper stage, consisting of the Apollo capsule, CSM, and S-IVB upper stage of one J-2 motor. This S-IVB upper stage J-2 was responsible for getting the men/equipment from earth orbit to the moon and putting them in lunar orbit. The S-IVB could also be called the ‘third’ stage of the Sat V. The S-II consisted of five J-2 motors. This was the Sat V’s ‘second stage’ and was responsible for placing the S-IVB into earth’s orbit. And finally, the third stage – or the S-IC. The S-IC possessed five F-1 motors. Each motor produced 1.5 million pounds of thrust – totaling 7.5 million pounds of thrust. This was needed to loft the other half of the vehicle above the atmosphere and to get it traveling at a velocity where the second stage could accelerate it to orbital velocity. The F-1’s were truly amazing motors. Lox/Kerosene, they were cooled via regenerative cooling – as was Goddard’s and the VI – and they were gimbaled (as were all the J-2’s). Still, today, the most powerful motors ever developed. Slides within this group show images to compare the sizes of the boosters/motors; as well as, testing facilities at NASA’s MSFC and Stennis. The F-1 motors are what won the moon for the U.S. Korolev, and the Russian space initiative, never had the time to develop the technologies to win the moon as they were always pushing to be the ‘first’ for political reasons.

**Slides 43:** Shows the Sat V configuration – basically 363 feet tall and 6.3 million pounds in initial mass.

**Slides 44:** Shows a comparison of the Russian’s N-1 vehicle with the Saturn V.

**Slides 45-49:** Images of the enormous Sat V going to the pad on the ‘crawler’. Slide 48 shows Werner Von Braun in front of Apollo 11. He was the director of NASA’s MSFC, the center that built the Sat V, at the time of reaching for the moon.

**Slides 50-54:** These slides show the tragic incident when the entire Apollo 1 team, consisting of one of the ‘original eight’ Gus Grissom, and White and Chaffee, were lost when testing the vehicle on the pad and a fire broke out within the capsule. The testing was on ‘unplugged’ test where the vehicle was on the pad, unplugged from all external support, and was being checked out while still sitting at the pad. The capsule was pressurized with pure oxygen as it would have been if it had been in space. Due to the oxygen, and the rush to complete the Apollo capsule on time before the Russians beat us to the moon, mistakes were made. An electrical short under the seats of the astronauts ignited strongly with the oxygen atmosphere – there was no ability to remove the astronauts from the fire before they were lost. Slide 54 shows the metal storage facility up at NASA’s Goddard Center in Ohio where the Apollo 1 capsule, etc. are stored. After nearly a decade of design, development, and testing…it looked like the U.S. would lose the moon to the Russians. However, western civilization was not aware to the problems Russia was having with their N-1 rocket.

**Slides 55-57:** After nearly a year of investigations and studies into the fire that caused the loss of Apollo 1 and its flight team, NASA was ready to begin new testing after many, many modifications and redesigns of the Apollo capsule. Testing began with unmanned flights for Apollo’s 2-7…man-rating the entire vehicle configuration.

**Slides 58-65:** With the first six Apollo’s scheduled for unmanned flight testing, Apollo 7 was the first manned flight and was simply a Low Earth Orbit (LEO) testing of the Apollo capsule and CSM while in orbit. Apollo 8 was to be first to be manned. It’s original flight plan was to orbit the earth and test out the Lunar Excursion Module (LEM) along with the CSM. Rendezvous and docking between the two were scheduled. However, the LEM was a very difficult vehicle to design. It was the first, true space vehicle. It would only fly in the vacuum of space. In addition, it had to be able to provide propulsion, life support, and flight capability for two men working on the moon – all within a constrained mass envelope. The LEM’s walls were actually as thick as only a few sheets of aluminum foil. In addition, since there would be no gravity, all seats/etc. had been removed. With all the redesigns, the first LEM was not ready to join the Apollo 8 configuration for testing. So, instead of waiting, and falling behind the race with the Russians, Apollo 8 was given the flight plan of Apollo 9 – to orbit the moon. The first manned flight of the Apollo configuration was decided, by NASA, to go to the moon. Slides 59 shows the lunar flight plan, with specific aspects of how the LEM/CSM will have to rendezvous and dock while in transit to the moon. Slide 60 shows a comparison of the U.S. LEM/CSM and the Russian equivalent. Slides 61-65 show the LEM trainers used to help train the astronauts to live/fly the LEM. Included in the last two slides it the famous ‘flying bed’ simulator that helped astronaut Neil Armstrong, the Captain of Apollo 8, learn how to fly the LEM. Note the hypergolic motor located center of mass below the vehicle….while the astronaut is forward of the center. The vehicle was very difficult to fly ‘by the seat of the pants’. In fact, multiple crashes occurred with the ‘flying bed’ tester. (hypergolic notes that there were two elements that, when brought together, combusted automatically. This would allow the LEM to ignite on its own in the event there was any trouble with the propulsion system. The astronauts could actually open two valves within the floor of the LEM to provide propulsion if needed…since there was no ‘launch crew’ on the moon to support their leaving.)

**Slides 66-80:** Shows images related to Apollo 8 as it circumnavigated the moon.

**Slides 81-86:** Shows images related to Apollo 9 and its flight plans for testing CSM/LEM in LEO.

**Slides 87-98:**  Shows images related to Apollo 10 as it orbited the moon with fully configured LEM.

**Slides 99-142:** Shows images related to Apollo 11 – the first lunar landing – as well as some subsequent missions. On descent, Neil Armstrong and Buzz Aldrin were having a little trouble with the MIT flight control computers as the antique computers were attempting to keep up with data input and flight control. A couple of minutes from touch down, Neil Armstrong took over control of the LEM – named Eagle One – and began flying low over the lunar landscape toward a safe landing site. With less than a minute of fuel remaining for flight, Neil Armstrong set down the LEM and stated: “Houston, Tranquility Base here….the Eagle has landed”. With a successful landing of the Apollo 11 LEM within the Sea of Tranquility, the U.S. had beat the Russians to the moon. Just two weeks prior, with recon images showing an N-1 moon rocket sitting on a pad in Russia, the U. S. believed they had actually lost the race. It wasn’t until the following day, when additional images were developed, when the scorched earth at the Russian launch site indicated that Russia had experienced a catastrophic failure – and the U.S. would finally surpass Russia. Slides 106 through 131 show different mission events across several Apollo missions; such as – slide 106 shows one of the early Surveyor Lunar probes that had been sent to the moon prior to the lunar landing to send data concerning the moon’s surface and atmosphere. Landing the LEM so close to the Surveyor was a pretty amazing accomplishment considering most the math, physics, and orbital mechanics was done with a slide rule. Slide 110, for the conspirators in the classroom that want to mention that the flag is ‘flying’, please note the top horizontal bar that keeps the flag in its horizontal position. There is no atmosphere to ‘fly’ the flag. (If anyone is interested in the design/development of the flag/pole, we can get them in contact with Tom Moser – he was the Head of the Engineering Directorate at JSC when Apollo 11 first landed and was the designer of the flag pole. He’s also a good friend of SystemsGO.) Slide 111 shows the infamous ‘diamond reflector’ that was place on the moon and has allowed lasers to be shot to the moon and reflected back to allow accurate distance between the moon and earth down to the hundredth of an inch….and still used today. Slide 114 shows the electric lunar rover – this vehicle allowed astronauts to travel greater distances to accomplish more science while on the moon. Slides 122&123 show the site location of the ‘Genesis rock’. A rock sample that allowed scientist/geologist to discover how the moon was formed. Slides 132 through 135 show what a hypergolic propulsion system looks like during ignition and full burn in a non-atmospheric environment. Note how there are no ‘flames’ as might be depicted in a Hollywood movie. 136 through 142 shows the LEM cap arising from the lunar surface to come rendezvous and dock with the CSM – which has been in lunar orbit with the third Apollo astronaut – before the thrusting maneuver to head back to earth. As some anti-government conspirators have noted, the lunar images don’t show any stars – students should be able to answer that on their own. Consider sunlight, on a reflective soil, without an atmosphere to reduce its intensity. In fact, during one of the later Apollo missions, one of the astronauts accidentally pointed the color video camera toward the sun and immediately burned out its’ lenses. [Anyone that feels the U.S. didn’t go to the moon should make contact with Vladamir Putin. Since we were in a race with Russia, they would be the first to adamantly deny that we were successful. Which, they never had – they’ve simply congratulated us.]

**Slides 143-153:** These slides show the Apollo 13 incident. Slides 143 thru 145 shows the CSM after the Apollo 13 capsule has jettisoned away. Note the absence of the external panel – revealing the internal plumbing of the CSM where the LOX tank exploded. Slides 146 and 147 show the 12volt thermostat associated with the LOX tank…a tank that had been converted to a 36volt system prior to the launch of Apollo 13. Slide 147 shows a ‘root cause’ testing of a similar LOX tank recreating the explosion that occurred when the LOX tank was ‘stirred’ to keep LOX from freezing solid. Slide 148 shows a telescope image of Apollo 13 CSM on the way to the moon, with the surrounding O2 cloud, followed by the S-IVB upper stage that had been previously jettisoned. [Again, for the conspiracy students – telescopes were not the only ways to watch man go to the moon; radio telemetry also proved Americans walked on the moon. Slides 149 and 150 shows some of the unique problem solving that occurred during the Apollo 13 rescue – all of which had to occur quickly as the vehicle was moving at over 25,000 miles per hour away from the earth. This is where the square CO2 scrubbers from the CSM had to be adapted to fit into round scrubber ports on the LEM to help the three astronauts use the LEM as a lifeboat for the eight day journey to the moon and back. Slides 152 through 153 show the Apollo capsule successfully under parachute returning to the pacific ocean; celebration occurring at NASA’s JSC Mission Control; and finally, Flight Director Gene Kranz as he lights up the infamous cigar, as did everyone, to denote the completion of a successful mission. Yes, Apollo 13 was considered a ‘successful failure’.

**Slides 154-156:** These slides show a completion of the Apollo flights to the moon. 20 flights were scheduled; however, congress cancelled the last three. The final three Saturn V ‘flight ready’ vehicles are located for exhibit at NASA’s JSC in Houston, Kennedy Space Center, and Marshall Space Flight Center’s Visitor Center in Huntsville, AL. In conclusion, the last two slides compare the successes of the U.S. Apollo program and Russia’s Soyuz/N-1 program. Students should realize that by the U.S. deciding on a far reaching goal, and by investing time and money into the design, development and testing of needed components and skills, the U.S. was able to finally surpass Russia for that access of space. And in doing so, was able to be noted around the world as the country that possessed the strongest technological capacities. This was important because, when it came to individuals around the world wanting to purchase a car, radio, or washing machine, they bought American. And because of this, we became a very wealthy country. Compare that to the economics of today where nearly seven other countries are outcompeting us within the global market – over the last decade and a half, when was the last time we didn’t have to borrow monies? It is extremely important that American classrooms are developing the most valued engineers in the world to compete in the global market.