NEWMARKET U3A: WINGS, WHEELS & WATER GROUP

April 2020

Due to the Coronavirus pandemic restrictions this is a brief, light, but hopefully enlightening presentation for home study

Space and Lunar Surface Travel:

From thoughts in 1969 to the Lunar Rover and Beyond

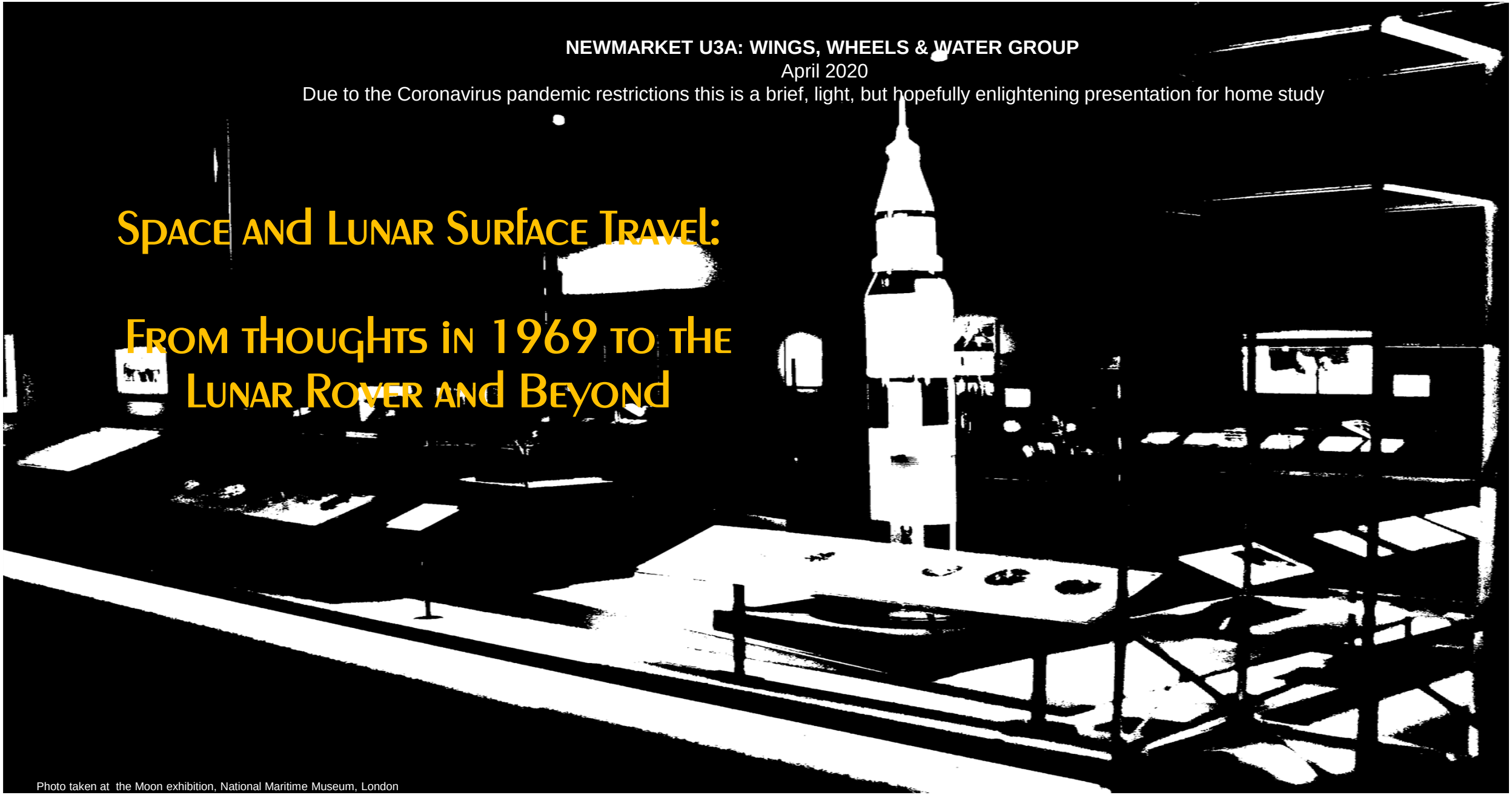


Photo taken at the Moon exhibition, National Maritime Museum, London

Space and Lunar Surface Travel:

From Thoughts in 1969 to the Lunar Rover and Beyond

As always, Tim's April presentation for the WWW Group, about Apollo 13, bought back memories and set me thinking.

In 1969 I was a 12-year-old boy, clearly excited by the Apollo Moon landing and wanting to collect anything and everything. My store of newspaper cuttings and magazines has survived.

Last year, on the 50th anniversary of the event I re-read all these documents, and particularly enjoyed a magazine called "Moonslaught, the full story of man's race to the moon". It was a Purnell History of the 20th Century magazine, carrying an image of the Apollo 9 Lunar Module ("spider") in a lunar landing conformation, and cost 4/-. The author was Reginal Turnill. (A copy of the magazine is held in the National Space Centre, in Leicester)

An obvious connection of this magazine with Tim's talk is the Apollo missions, but less obvious is that Reginald Turnill was also the journalist to first report on the Apollo 13 disaster, via the BBC World Service.

The Apollo 9 Lunar Module

By NASA David Scott - Great Images in NASA Description, Public Domain, https://commons.wikimedia.org/w/index.php?curid=6449740

Reginald Turnill (1915–2013)

Reginald Turnill's career with the Press Association began when he was 15, after an interruption for military service it continued until 1956 when he joined the BBC as an industrial correspondent.

1958 brought a change to become the BBC's Air and Space Correspondent, dealing with the development of passenger jets from Comet VI through to Concorde, for which he reported on the maiden flight at Toulouse-Blagnac Airport in 1969.

1969 also brought him an assignment at NASA's Cape Canaveral site in Florida and Mission Control in Houston, Texas, reporting on the Apollo 11 mission, and man's first landing on the Moon.

His most memorable story however probably came in 1970. On the 13th of April after completing commentary on the Apollo 13 mission he was about to leave when a message came through saying "OK, Houston, hey, we've got a problem here".

He spent the next four days covering the unfolding drama, and the eventual safe return of the astronauts to earth. (See Tim's April WWW Group presentation)

In his 1969 Moonslaught publication Reginald Turnill described visions of what people thought lay ahead for space exploration. I thought that reviewing these may help distract us from thoughts about Coronavirus.

Apollo 13 launch: 11th April 1970

By NASA - http://history.nasa.gov/alsj/a13/images13.html (direct link), Public Domain, https://commons.wikimedia.org/w/index.php?curid=5795251

1969: What lies ahead? - Space Stations

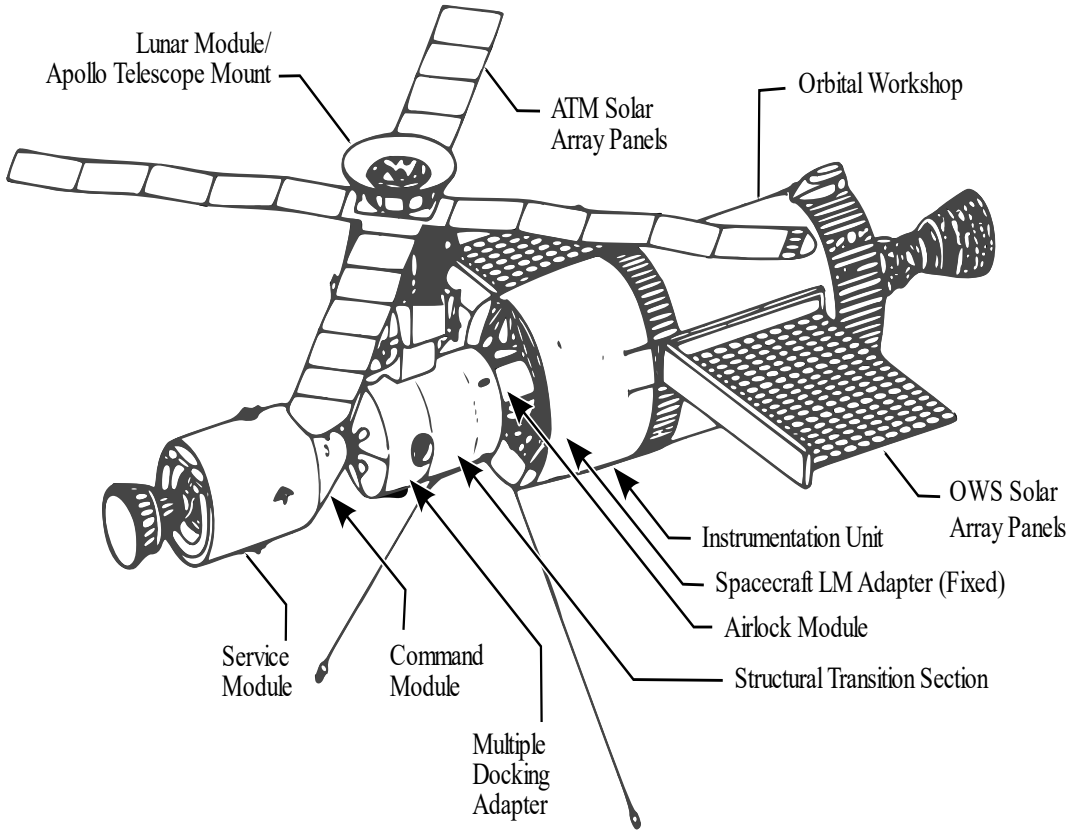
At the time of his writing the general thought was that after reaching the Moon the next challenge would be heading for the planets, although this would be some years away. More pressing seemed to be the desire of America and Russia to establish space stations, also referred to as workshops and laboratories, postulating that the first one would be launched in 1971.

A concept was that the third section of a Saturn V rocket, known as Saturn 4B, which is normally jettisoned as an empty shell, after using its fuel, could be converted into living quarters by docking with another Apollo spacecraft. Astronauts would enter the Saturn 4B shell and use pre-packed materials to establish the living quarters, such as bedrooms and even a proper toilet.

It was envisaged that up to two visiting Apollo craft could dock, and wing-like solar panels would generate power.

How this compares with what actually happened is perhaps the subject for another WWW Group presentation.

Proposal for wet workshop derived from an S-4B upper stage



By Own work - This file was derived from: Wet Workshop.jpg, Public Domain, https://commons.wikimedia.org/w/index.php?curid=4875611

1969: What lies ahead? - Space Planes

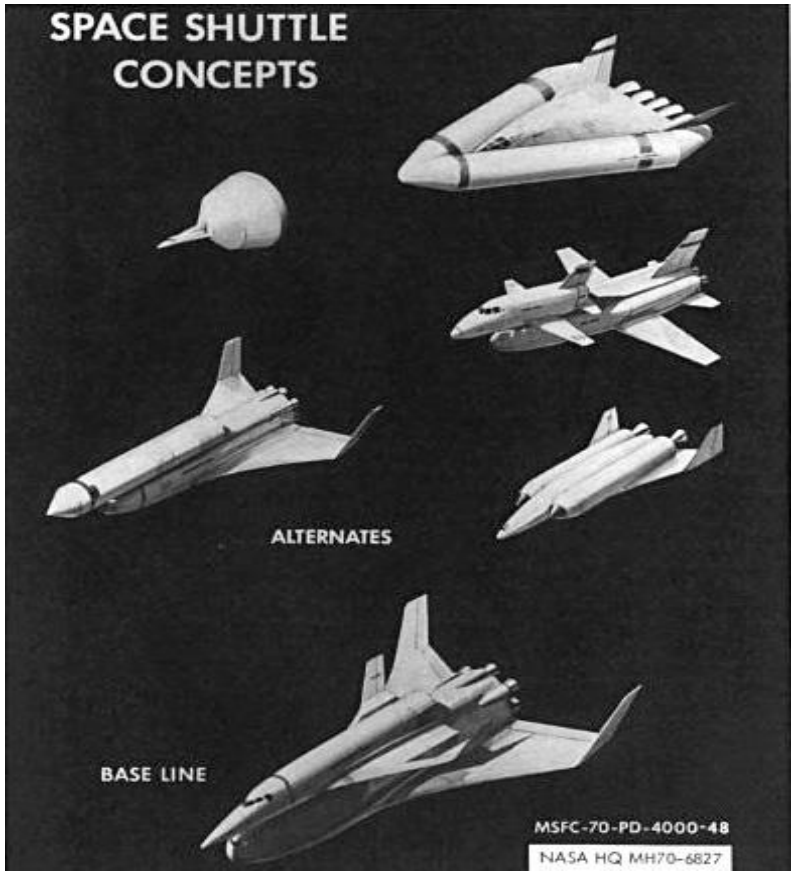
Another concept that was considered as being actively pursued was the idea of a reusable space plane, called a “Space Shuttle”, a vehicle somewhere between a conventional aircraft and a space craft.

It was hoped that such craft would bring down the cost of space flight to something more like jet flights, with estimates of a 50,000-fold reduction in costs.

Vertical take-off from a launch pad and a normal gliding runway return landing was perceived. There was however concern about wings being a problem, due to potential damage during re-entry, and a sledge shaped craft was considered as a potential alternative.

In the figure opposite, the bottom, baseline image combines a variety of ideas which met the basic design specifications, while the images above represent ideas from various companies, with those at the top being the most radical.

How these concepts developed into the eventual space shuttle could again be the subject of a future WWW Group presentation.

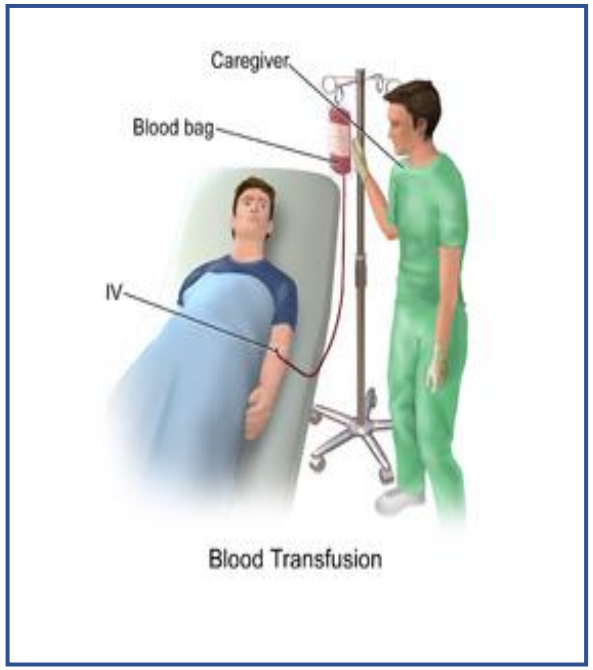


By NASA - NASA-Website, Public Domain, https://commons.wikimedia.org/w/index.php?curid=3807274

1969: What lies ahead? – Orbiting Hospitals and Treating Trauma

Another perhaps slightly less obvious idea was for turning a space station into an orbiting hospital. It was thought that reduced gravity might be beneficial for some surgical procedures, and would certainly reduce the problem of bed-sores!

Although I am unaware of progress being made with these concepts, thoughts about treating accidental injury are still in the minds of those concerned with space travel and exploration.



In October 2019 the scientific journal of the AABB, an American organisation active in the field of blood transfusion, published a paper called “Blood transfusion for deep space exploration”. The authors came from multiple organisations, including NASA, and considered options for dealing with blood loss following accidents during space missions. Extra-vehicular activities were thought to present particular risks for events like crush injuries or exposure to micrometeorites.

The authors considered factors such as weight, volume and power requirements, whilst also remembering complication of donating and receiving blood in microgravity.

Overall, they concluded that the most viable means of providing blood would be by the use of a “floating” blood bank, whereby astronauts would act as donors for each other. Thus, astronaut selection and training would need to include medical knowledge, while crew selection criteria would include blood group compatibility with each other.

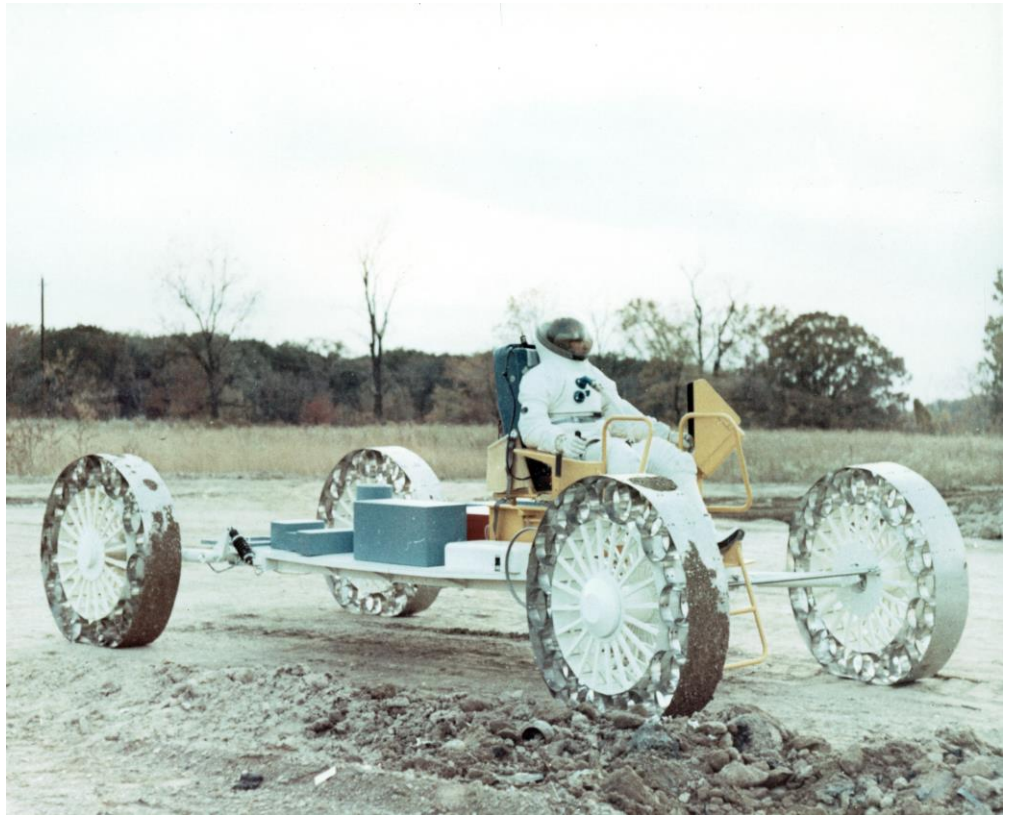
1969: What lies ahead? – Lunar Surface Travel

The Moonslaught story didn't comment in great detail on vehicles designed for lunar surface travel. There was however mention of a British engineer, Dr Ian Dodds, working for Rockwell, designing rocket-powered scooters for exploring the moon.

In addition, there were two images, one, of what looked like a totally enclosed vehicle carrying the name of Grumman. This was a US producer of military and civilian aircraft which had worked on designs for pressurized-cabin lunar vehicles, with electric motors for each wheel. They were also a major contractor for the Apollo Lunar Modules, and were subsequently involved in development of the Space Shuttle.

The other image simply had a comment about the need for flexible wheels to help sustain contact with the ground in low gravity. It was similar to the vehicle in the picture on the right, also produced by Grumman.

A potential Lunar Roving Vehicle built by Grumman Industries



By NASA - http://mix.msfc.nasa.gov, Public Domain, https://commons.wikimedia.org/w/index.php?curid=25467982

Development of Lunar Rovers

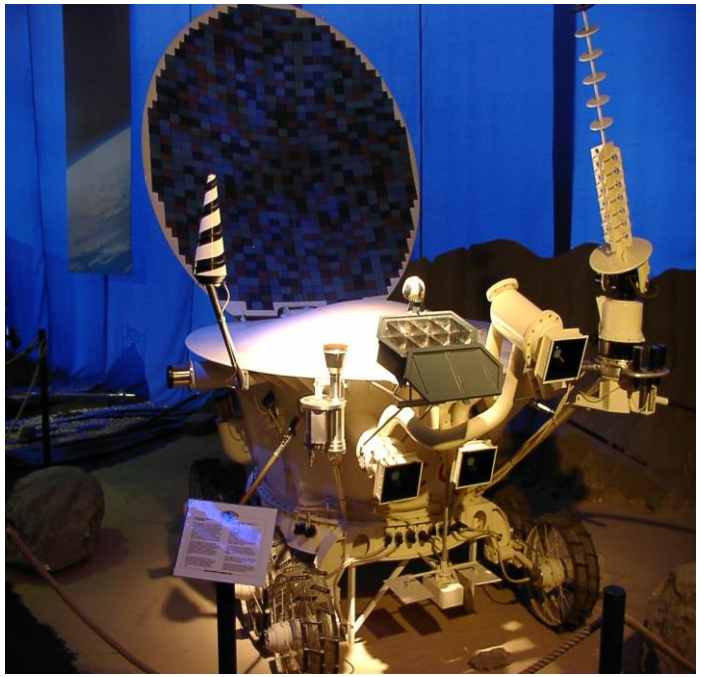
The first rover to land on the Moon was Lunokhod 1, part of the Soviet Union's Lunokhod program. Although initially intended to support the Soviet's manned Moon missions, the Lunokhod vehicles became remote-controlled robots for studying the Moon's surface.

The rover's mechanical parts were maintained with a special lubricant, able to function in a vacuum, and electric motors, in each wheel hub, were enclosed in pressurised containers.

The rover ran during the lunar day, deriving power from its solar panels, and hibernated at night. Lunokhod 1 remained active for 11 months and consequently held the space rover durability record for more than 30 years.

For the USA, the early 1960s saw NASA's recognition of the need for surface vehicles to support its lunar exploration programme. Each mission would involve two Saturn V rockets. One to transport the crew to the Moon and back, and other to carry the transport vehicle and supplies for the astronauts while on the lunar surface.

Model Of Lunokhod vehicle



By de:Benutzer:HPH - photo taken and edited by de:Benutzer:HPH on "Russia in Space" exhibition (Airport of Frankfurt, Germany, 2002), CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=176704
de:Benutzer:HPH / CC BY-SA (http://creativecommons.org/licenses/by-sa/3.0/)

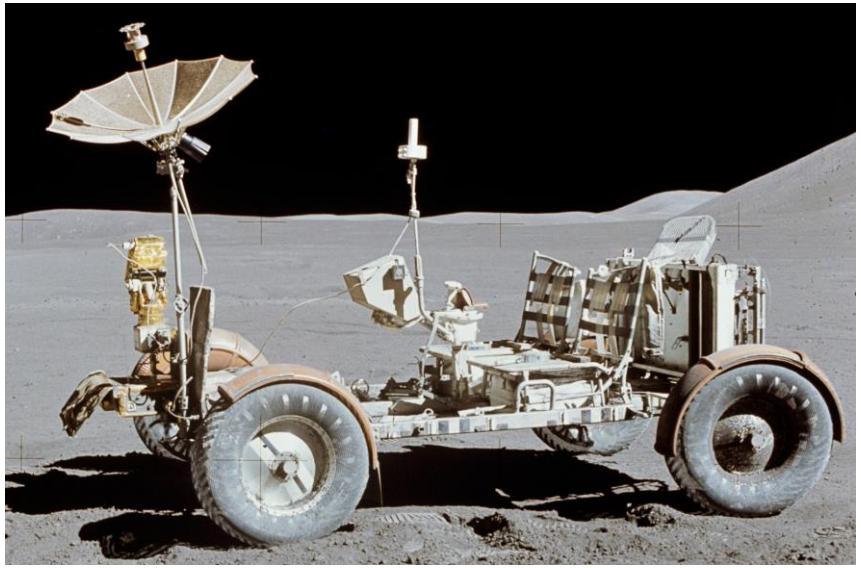
Political pressure to hold down Apollo costs however meant that rocket production was reduced, enabling only a single launch per mission. Consequently, surface vehicles had to be accommodated in the same lunar module as the astronauts.

The Apollo Lunar Roving Vehicle (LRV)

Numerous companies worked with NASA on the development of lunar vehicles. A team at Brown Engineering used early studies to develop a small rover able to meet the new single Saturn V launch system and incorporated existing available components where possible. They paid particular attention to the wheels due to the lack of information about the lunar surface. Boeing were eventually selected as the main contractor for the LRV, and only 17 months later they delivered the first vehicle.

Although looking like a golf cart, it was great engineering achievement, reaching a speed of 11.2 mph on its last Apollo 17 mission. It was of course left-hand drive. Using woven piano-wire mesh-like wheels it crossed the lunar surface carrying four times its own weight, equipped with a colour television camera for sending images back to Earth.

The Apollo 15 LRV



By NASA/Dave Scott; cropped by User:Bubba73 - http://www.hq.nasa.gov/office/pao/History/alsj/a15/images15.html (direct link), Public Domain, https://commons.wikimedia.org/w/index.php?curid=6057491

The frame of the LRV was hinged at the centre so that it could be folded and carried in the descent stage of the lunar module, in a section known as the quadrant 1 bay.

The LRV was removed using a system of pulleys, reels, ropes and cloth tapes. One astronaut would climb a ladder on the Lunar Module and release the LRV. Assembly was mostly automatic, with the rear wheels folding out and locking in place. On reaching the ground, the front of the rover could be unfolded, the wheels deployed, and the entire frame let down to the surface by pulleys. Many components locked into place upon opening, while other equipment was removed and assembled before turning on the power and driving away.

Apollo LRV Activities

John Young at the LRV near the LM on the Apollo 16 mission

Public Domain, https://commons.wikimedia.org/w/index.php?curid=525451

The LRV was used in the Apollo 15, 16 and 17 missions, during 1971 and 1972. It was generally considered to be faultless, safe, flexible and reliable, and able to operate in temperatures between -128^{0}C and +93^{0}C. It was used on three occasions for each mission, giving a total of 9 excursions, covering approximately 56 miles.

The distances travelled for each expedition were limited by the need to be able to walk back to their base, the Lunar Module, should there be an LRV failure.

Operationally this meant that astronauts would travel the maximum limit away from the Lunar Module, and then work their way back to it. By the final mission of Apollo 17 the reliability of the LRV and spacesuits had been demonstrated and enabled travel and time restriction to be relaxed a little.

The LRV did experience some minor problems, although these seem to have been mainly a result of accidents. Part of a wheel protector (fender) was lost during the Apollo 16 mission when an astronaut bumped into it, resulting in dust covering the crew and equipment, causing increased battery temperatures and power consumption. Similarly, a fender was accidently bumped with a hammer during the Apollo 17 mission.

(*I wonder if these incidents occurring outside of the LM were in the minds of the authors of the scientific paper I mentioned earlier, "Blood transfusion for deep space exploration", published in 2019, which considered activities outside the main craft as presenting particular risks for accidents*)

A criticism of space missions is that the money might have been better spent on alternative projects. To counter this argument, technical "spin-offs that have entered our every-day lives are mentioned.

During my reading for this WWW Group exercise I learnt of a benefit I was previously unaware of. The technology in the LRV which enabled lunar travel, has subsequently evolved into motorised wheelchairs that help travel on this world.

More Recent Rovers

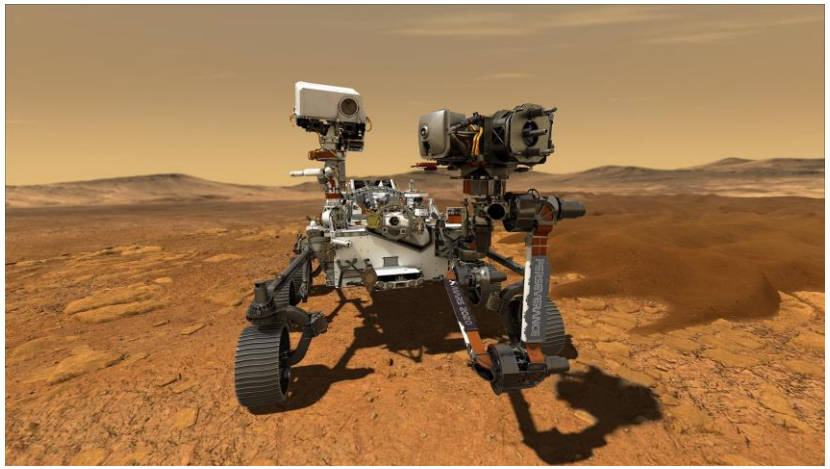
On looking for more developments of the lunar rover concept I came across the ATHLETE vehicle (All-Terrain Hex-Limbed Extra-Terrestrial Explorer) developed at the Jet Propulsion Laboratory.

The vehicle had six wheels at the ends of six multi-degree-of-freedom limbs. This conformation aimed to provide mobility over stable gently rolling landscapes. The ability to lock the wheels however, combined with the limb's flexibility meant that it could "walk" on soft surfaces, avoid obstacles and generally manage difficult terrains. It was envisaged as a utility vehicle to support exploration of Moon or Martian surfaces. Although going through two stages of development and participating in studies in the Arizona desert in 2010, I was unable to find more recent information.

The ATHLETE carrying it's cargo

https://athlete.jpl.nasa.gov/

The Perseverance Rover



"Courtesy NASA/JPL-Caltech."

To go beyond Lunar Rovers, but reflect current developments we can go to the Perseverance Rover, designed for exploration of Mars, and due to be launched during the summer of 2020, reaching the planet in 2021.

The mission's aim is to collect and store rock and soil samples to further our knowledge of Martian geology and look for evidence of previous life.

Acknowledgements and Further Reading

Under normal circumstances I like to base a presentation around personal visits, my own photos, and multiple sources of information. This presentation however has been a desk-based exercise using internet sources, including Wikipedia, due to the Coronavirus induced travel restriction.

Two magazines from 1969 and a visit to the Moon exhibition at the National Maritime Museum in December 2019 inspired my interest. Unfortunately the paper about “Blood transfusion for deep space exploration” isn’t freely available.

In case you wish to learn more about any of the subjects, some related links, which I have used, are below and opposite:

National Space Centre

https://spacecentre.co.uk/

https://en.wikipedia.org/wiki/National_Space_Centre

Reginald Turnill:

hthttps://www.theguardian.com/media/2013/feb/12/reginald-turnill-obituary

https://en.wikipedia.org/wiki/Reginald_Turnill

https://collections.spacecentre.co.uk/object-2018-21

Space Stations:

https://en.wikipedia.org/wiki/Wet_workshop

Space Shuttles:

https://en.wikipedia.org/wiki/Space_Shuttle_design_process

Lunar and Martian Rovers:

https://en.wikipedia.org/wiki/Lunokhod_programme

https://en.wikipedia.org/wiki/Lunar_rover

https://en.wikipedia.org/wiki/Lunar_Roving_Vehicle

https://www.boeing.com/history/products/lunar-roving-vehicle.page

https://athlete.jpl.nasa.gov/

https://www.jpl.nasa.gov/

https://commons.wikimedia.org/wiki/File:Lunar_Roving_Vehicle_Mobility_Test_Article_Dress_Test.jpg

https://en.wikipedia.org/wiki/Marshall_Space_Flight_Center

Apollo 13

https://en.wikipedia.org/wiki/Apollo_13

Grumman

https://en.wikipedia.org/wiki/Grumman

Apollo 9

https://en.wikipedia.org/wiki/Apollo_9

Final Thoughts

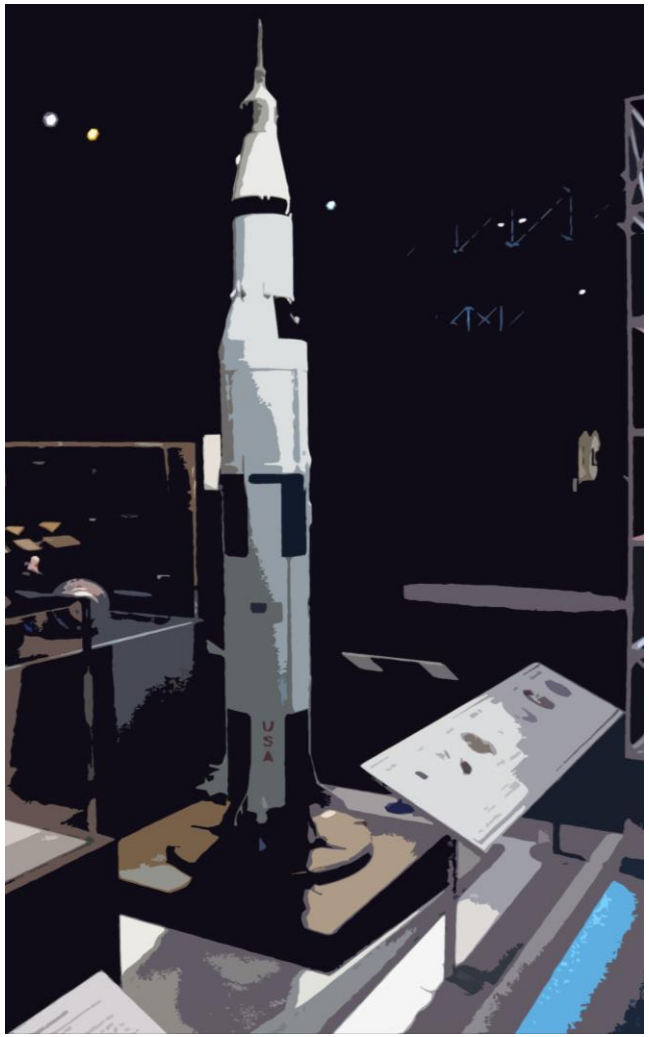


Photo taken at the Moon exhibition, National Maritime Museum, London. December 2019

I hope you have enjoyed this presentation and learned at least one thing.

When the WWW Group re-convenes I will help us look nostalgically back to what we were reading and thinking in 1969. I hope to bring my copy of “Moonslaught”, and also a magazine called “Man on the Moon, Your Guide To The Greatest Adventure Since The Start Of Time”, a Daily Mirror publication for the wonderful price of 3/6.

The reading behind getting this presentation together has given me “itchy feet”, and when we are all allowed to go out and play again I hope to visit the National Space Centre in Leicester. If I do, a WWW Group presentation will follow.

The National Space Centre Leicester

By Ned Trifle - Ned Trifle's flickr account, CC BY-SA 2.0, https://commons.wikimedia.org/w/index.php?curid=1371877