AFD Ep 406 Links and Notes - Critical Space Theory: The Arc of Spaceflight Ambitions

- [Intro] In the first week of January 1972, 50 years ago, President Nixon officially kicked off the reusable, low-earth orbital Space Shuttle program to succeed the Apollo moon landings program and the upcoming short-term Apollo Skylab space station program. As we'll talk about later in the episode, the Shuttle would supposedly ferry crews and supplies back and forth to low-earth orbit projects such as space stations. While it might have been conceptualized as making a reality of mid-20th century science-fiction where human spaceflight to orbital platforms was routine, in reality it represented the indefinite end of human spaceflight beyond our own planet's orbit and it drew to a close humanity's vision from just over a century earlier in the 1860s, the dawn of both theoretical science for space rocketry and modern interplanetary science fiction. Today we'll be talking about that arc from its start during the Second Industrial Revolution to the height of the postwar Space Age and then the start of the descent into the 1970s and beyond.
- 1861: Although not widely read at the time and only emphasized in the past few years as having been startlingly prescient, Scottish-Canadian scientist and theologian William Leitch published an 1861 essay accurately scientifically describing how rockets could be made to work in space, not just as battlefield and siege artillery, and arguing that rockets were actually ideal for the vacuum of space. Unfortunately, through the various quirks of history and the publishing industry, he did not influence later rocket science researchers, despite having been correct ahead of his time. We will come back to this at the end of the episode today and we are linking in this episode's notes sheet to the book version of his essay*: https://books.google.com/books?id=vuAUAQAAMAAJ&vq=rocket&pg=PA1#v=onepage&q&f=false]*
- 1865: "From the Earth to the Moon: A Direct Route in 97 Hours, 20 Minutes" by French author Jules Verne, who imagined a near-future United States after the recently-ended American Civil War, where a society dedicated to the design of weapons attempts to build a massive cannon that can launch a manned capsule at the moon from central Florida. It seems notable that Verne selected the United States as the setting, instead of France, Britain, or Prussia. As one of the propellant components for the cannon blast, Verne chose newly patented and highly flammable Nitrocellulose, which we actually just recorded an episode on in the context of its use in movie film reels and newsreels. (At the time it was viewed primarily as a replacement for gunpowder and was called "gun cotton." https://en.wikipedia.org/wiki/Nitrocellulose) Our nitrocellulose episode also mentioned in passing the pioneering 1902 movie loosely adapted from Verne's book. At the time, both in the 1860s and start of the 1900s, it was not well understood how spaceflight could be achieved and – in his imagination and the imagination of many inspired by his work – cannons seemed to be the direction of things before the rocketry era began. There was also prominently an 1875 opera loosely based on Verne's 1865 book as well. https://en.wikipedia.org/wiki/Le_voyage_dans_la_lune_(opera-f%C3%A9erie)
    - Cannons vs rockets: Allegedly, the first liquid fuel propellant rocket might have been lab tested as early as 1895 but the person claiming to have done so did not publish any of his claims or research until 1927, which means he was either lying or at minimum had zero influence on the field until it was already in progress from other researchers publishing after World War I. https://ntrs.nasa.gov/citations/19770026106 And although a Russian school teacher had published some practical theories on the technology back in 1903, it also gained little traction until later presumably because of the chaotic situation inside Russia beginning in 1904 and because nobody apparently bothered to translate it and get it to a wider audience that understood the implications. The

field of research into this kind of rocket became serious just after WWI. More on that later. **The first known field test was in 1926 in Massachusetts**: https://en.wikipedia.org/wiki/Liquid-propellant_rocket#History

- 1900-01: HG Wells - “The First Men in the Moon” - This one just imagines a fictional anti-gravity material, handwaving away pretenses to hard sciences in favor of a more fantastical narrative.
- 1930: https://en.wikipedia.org/wiki/American_Rocket_Society - began as the American Interplanetary Society. Founded in 1930 by science fiction authors. Members conducted their own rocket launches in New York and New Jersey in the 1930s, using liquid-fueled rocket engines, powered by liquid oxygen and gasoline propellants. The ARS pioneered this type of engine, adapted from the German Mirak rocket. http://www.astronautix.com/m/mirak.html In 1936, the American Rocket Society and its member Alfred Africano were awarded the Prix d'Astronautique by the Société astronomique de France (French Astronomical Society) in recognition of their pioneering tests with liquid fueled rockets. In 1963, they ARS merged with the Institute of the Aerospace Sciences to become the American Institute of Aeronautics and Astronautics (AIAA).
- The 1940s-1960s: [not to get too detailed]: https://en.wikipedia.org/wiki/Operation_Paperclip https://en.wikipedia.org/wiki/Wernher_von_Braun Operation Paperclip is the secret program in which German scientists and engineers - some high-ranking Nazi party members - were brought into the US post-WWII to bolster the US government’s side in the US-Soviet Cold War and the Space Race. One prominent rocket engineer who was a major part of US aeronautics was Wernher von Braun. He was a leading figure in rocket development in Nazi Germany - he co-developed the V-2 rocket - and he became a major innovator in rocket and space technology in the US. He was the chief architect for the Saturn V super heavy-lift launch vehicle that propelled the Apollo spacecraft to the Moon. He was also a major proponent for manned space flight, and he advocated for a manned expedition to Mars. This wasn’t the direction that NASA ultimately pursued, which led to his retirement from NASA in 1972, which we’ll get into later.
    - 1962 Kennedy’s “We Choose to Go the Moon” Speech The Kennedy Moonshot exemplified the optimism and vision of what man can do together in the vein of the Interwar aeronautic and Interplanetary societies. He even proposed making the moon landing mission a joint US/Soviet effort, but that was abandoned after Kennedy’s death.
    - Aerospace industry, which basically grew out of early 20th century airplane companies (e.g. North American Aviation, Douglas Aircraft, Glenn L. Martin, Boeing, Grumman) and automakers (e.g. Chrysler) plus a submarine company (General Dynamics) and General Electric, virtually all of which had been doing manufacturing and design for war materiel in WW2 https://www.britannica.com/technology/aerospace-industry/The-space-age *NASA conducted many in-house research-and-development projects at its numerous space centres. The final development and production of flight hardware for the subsequent Apollo program, however, was carried out by a few prime contractors and elaborate networks of subcontractors and suppliers in virtually every part of the United States. For example, Grumman Aircraft produced the Lunar Modules, the actual vehicles to land on the Moon, and North American Aviation built the Command and Service modules, which remained in lunar orbit during the landings. Boeing, North American, and McDonnell Douglas each served as a contractor for one of the three stages of the Saturn V launcher, while the main engines for all stages were supplied by Rocketdyne, then a*

division of North American Rockwell. The number of personnel involved in the U.S. space program reflected intense activity in the industry, increasing from 36,000 in 1960 to 377,000 by 1965.

- 1970: In January, a year into Nixon's presidency and already under budgetary pressure to shift course, NASA announces that the planned final Apollo moon landing mission will be replaced instead by the launch of an Apollo-based space station called Skylab. In April, the near-disaster with Apollo 13 occurs and no more launches happen until January of the following year. In September, two more missions are canceled, either for budgetary reasons or for fear of losing astronauts in failures. This leaves the program with two lunar missions planned for 1971 and two final lunar missions planned for 1972. https://en.wikipedia.org/wiki/Canceled_Apollo_missions
- 1971: During the August 1971 crisis that we alluded to on our 1971 recap episode and which we are preparing to cover in a separate episode, Nixon contemplates canceling the last two moon missions altogether but is talked out of it. Aerospace and defense contractors are still lobbying, as they have been since 1966, to repurpose the designs and components of the Apollo program for other uses so that they don't have to close huge divisions with mass layoffs. They are mostly unsuccessful in this appeal. https://en.wikipedia.org/wiki/Apollo_Applications_Program
- Jan 5, 1972: Space Shuttle Program officially begins, promising a reusable "space truck" to take as-yet hypothetical space station construction materials into orbit beginning in the 1980s…and surely it would be replaced in the 1990s by something better (which didn't end up happening and the program simply carried on until it ended in 2011)
    - There were a lot of valid technical criticisms of the shuttle program, as well as more philosophical criticisms about the narrowed horizons. But perhaps it also represents an inevitable rollback of American government aspirations amid the emerging crisis of the 1970s that was the beginning of the long decline to present. That's something we'll talk about in a separate episode to come. And if nothing else, the moonshot had been closely associated politically with Kennedy and Johnson, and Republicans had been trying to cut NASA spending for years before Nixon made the decision to go with the shuttle. The 1972 shuttle decision came in the midst of a 3 year reduction of federal budget deficits relative to GDP and during the decades-long run of fairly steady reduction in the federal debt-to-GDP ratio since the end of WWII that did not come to an end till Reagan. (The numbers today would make us laugh but at the time the deficit stuff was a fixation… We'll circle back to this in a separate episode.)
        - The decision also came amid the Nixon-Brezhnev détente negotiations that followed the US winning the moon race in mid-1969. Strategic Arms Limitation Talks began in November 1969 and would conclude a first treaty in May 1972. (In April 1972, as a side effort, the US and USSR agreed to an Apollo-Soyuz link-up mission in orbit around Earth, which did take place in 1975 under President Ford: https://en.wikipedia.org/wiki/Apollo%E2%80%93Soyuz) In both the US and USSR, the moon race had always been kind of a publicity flourish on the development of increasingly sophisticated, deadly, and costly intercontinental ballistic missile systems. https://en.wikipedia.org/wiki/Strategic_Arms_Limitation_Talks https://en.wikipedia.org/wiki/Intercontinental_ballistic_missile#Cold_War
    - Leading directly to May 26 retirement of Wernher von Braun from NASA (Not because he disagreed with low-earth orbit work itself, since he had always advocated it, but because it was to be instead of manned interplanetary missions)

    - Not to downplay von Braun's role in Nazi Germany, but it is important to note that Weimar Germany (before Hitler came to power) was at the forefront of manned rocketry technology in the late 1920s. More specifically, von Braun was directly following up on the work of Robert H. Goddard in 1919 on the practical potential of liquid fuel rockets for manned off-planet rocketry. Goddard in turn had been inspired as a teenager to get into rocketry after reading the newly published "War of the Worlds" by H.G. Wells. We tend to think of modern rocketry from its wartime applications and the Cold War space race but this is partially because of the immense public ridicule and abuse heaped on the small number of scientists and researchers from the interwar period who were actually mapping out most of the technology that would indeed come into widespread use just a few decades later.
        - https://www.nytimes.com/1982/10/05/science/a-salute-to-long-neglected-father-of-american-rocketry.html
          https://en.wikipedia.org/wiki/Robert_H._Goddard#A_Method_of_Reaching_Extreme_Altitudes
          https://en.wikipedia.org/wiki/The_War_of_the_Worlds
- What were some of the criticisms of the reusable shuttle program from a technical standpoint?
  https://en.wikipedia.org/wiki/Criticism_of_the_Space_Shuttle_program
    - Was originally planned to launch once a week, leading to lower per-launch costs from amortization, so R+D costs were recouped through increased access to space. It greatly failed in this mission, only achieving 135 launches (including 2 major failures) from 1972-2011. Launch rates reached a peak of 9 per year in 1985 but averaged 4.5 for the entire program
    - Maintenance costs were exorbitant, with ~35,000 thermal protection tiles needing inspection after each launch, and the tiles were designed to fit in one particular slot on the Shuttle
    - To make the program more attractive to Congress, contracts were awarded to companies spread across states, leading to higher operational costs.
    - Pressure to launch frequently led to less focus on safety, called "go fever" by engineers. This aggressive launch schedule arose in the Reagan years to rehabilitate our post-Vietnam image.
    - The Challenger disaster of January 28, 1986 resulted from this "go fever" and a lack of communication between engineers and upper management. *The physicist Richard Feynman, who was appointed to the official inquiry on the Challenger disaster, wrote in his report that working NASA engineers estimated the risk of mission failure to be "on the order of a percent", adding, "Official management, on the other hand, claims to believe the probability of failure is a thousand times less. One reason for this may be an attempt to assure the government of NASA perfection and success in order to ensure the supply of funds. The other may be that they sincerely believed it to be true, demonstrating an almost incredible lack of communication between themselves and their working engineers.*"
    - The Columbia disaster of February 1, 2003 was another example of this disregard for safety, with downplaying the risk from small foam chunk breakage at launch. The bureaucracy and lack of communication between engineers who oversaw the day-to-day operations and management was

a chronic issue, even when there were serious systems diagnostic warnings.

- On the other hand, plenty of people argue that sophisticated robotics and other technological improvements mean that unmanned missions make more sense, even if they are less inspiring, than the incredibly demanding constraints and dangers of manned missions to other parts of the solar system and beyond…
- Concluding discussion
- Closing abridged quotation from astronomer and theologian William Leitch in the 1860s, arguing in favor of human space travel by rocket, shortly after the Great Comet of 1861 passed visibly by the Earth so close that its tail plume reached our planet:
    - *We are accustomed to survey the universe from the stand point of our globe, and, consequently, as far as the mere evidence of sense is concerned, all else appears little compared to man's abode; and so great is the mastery of sense over reason, that, for ages, man resisted the conclusive force of the latter. It was an agreeable delusion, that the whole universe centred in man; and when Galileo was persecuted by papal authority, the motive may perhaps as much be traced to human pride, as to orthodox zeal. The whole subsequent history of astronomy is, simply, the record of the way in which man has been brought to his level as far, at least, as his dignity depends on the abode in which he dwells. But the grand lesson of astronomy is, that man's true dignity does not consist in the mere outward and physical. The more that the discoveries of astronomy make this world shrink into insignificance, the more amazing is the view we obtain of man's spiritual dignity. It is the immensity of the universe contrasted with the humble abode of man that brings out most strikingly the value of the human soul [...] When you attempt to plumb the depths of space, or number the orbs of heaven, your feeling is, How little is man! And, yet, how great when measured by the price of his redemption! [...] There is something that urges us to find some use or adaptation for all God's works, but we too often restrict the nature of the use; and unless we find some physical adaptation, we think that we have failed. Is it not use enough for the innumerable hosts of heaven to be the silent teachers of immortal spirits, emphasising the great redemptive act, and proclaiming that, in the estimate of heaven, there is nothing greater than the soul of man? The deeper we penetrate into the abyss of space, the more will we comprehend the significance of the inquiry, "What shall it profit a man though he gain the whole world and lose his own soul? or what shall a man give in exchange for his soul?" Though the facts and deductions of astronomy sufficiently bring out the immensity of the universe, as contrasted with our world, still it is difficult to realise the truth our thoughts will obstinately cling to our globe, and the images of grandeur will still be our terrestrial seas and mountains. Let us, however, attempt to escape from the narrow confines of our globe, and see it, as others see it, from a different point of view. Let us take a nearer survey of other orbs and systems, and see what impressions they produce as compared with that received from the platform of the earth.*
    - *But what vehicle can we avail ourselves of for our excursion? Must we be altogether dependent on the fairy wings of imagination, or can we derive aid from some less ethereal agencies? It was long the fond wish of man to soar above this terrestrial scene, and visit other planets. In the infancy*

of physical science, it was hoped that some discovery might be made that would enable us to emancipate ourselves from the bondage of gravity, and, at least, pay a visit to our neighbour the moon. The poor attempts of the aeronaut have shewn the hoplessness of the enterprise. The success of his achievement depends on the buoyant power of the atmosphere, but the atmosphere extends only a few miles above the earth, and its action cannot reach beyond its own limits. The only machine, independent of the atmosphere, we can conceive of, would be one on the principle of the rocket. The rocket rises in the air, not from the resistance offered by the atmosphere to its fiery stream, but from the internal reaction. The velocity would, indeed, be greater in a vacuum than in the atmosphere, and could we dispense with the comfort of breathing air, we might, with such a machine transcend the boundaries of our globe. and visit other orbs.

- *[...]*
- *The drawback of our own globe is, that it always keeps at the same distance, or nearly so, from all the bodies of the system; so that, although it is constantly moving onwards, we are kept at such a distance, that we see but little change in the celestial scenery. It is like an excursion steamer constantly sailing, in a narrow circuit, round a buoy moored in the middle of a wide lake. The view of the surrounding scenery never changes, and the minute objects of the landscape are never seen.*