Today I'm Going to pick up on that first by outlining some of the history of activity in space and then I'm going to talk about issues facing further space development.Governments have traditionally played an important role in building up the infrastructure that supports more efficient transportation, such as roads, railways and ports, which support the movement of people and commercial goods.Infrequent launches also mean that rocket payloads tend to be larger, which requires rockets to be bigger and more powerful, again adding to the cost.Government funded launches are also burdened by the costs of government contracting practices.Farmers can monitor the effectiveness of irrigation through imagery of soil and leaf color, and fishing boats can use ocean surface color data to guide them to fish stocks more efficiently, so it's clear that satellites provide enormous amounts of big data just waiting for practical applications.Some important outcomes of the space race were the development of rockets that could be launched into Earth's orbit, the development and launch of low orbit satellites which could be used for both military and civilian purposes and most famously, the manned moon landings.Rare materials like earth metals such as platinum, Palladium and rodium are used in mobile phones and tablets, cancer treatments and spark plugs.These two missions were a great triumph for the Chinese National Space Administration because they fulfil the initial goals of achieving orbit, landing and return from space.Although it was also intended to be a staging base for future missions to the Moon, Mars and asteroids, it hasn't been used for this purpose.Although most of the research conducted on the space station is backed by government funding, increasingly private companies are conducting commercial research and development on the space station.This is partly because projects are costly long term ventures, for example achieving orbital flight and manned missions to the moon and other planets.Space offers plenty of possibilities for further uses which have commercial potential, for example.Tapping spaced based clean energy sources using low orbit space stations or lunar stations as space depots and launch spaces for travel into deeper space.finally in order for the private sector to operate in space it requires a number of functions that are taken for granted on earth but currently do not exist in space any government plan for encouraging a space infrastructure must include the establishment of a secure and dependable political and legal framework in which private activity can do its job.A key weakness of the government funded exploration approach is that space missions are relatively in frequent this means that each is treated as a customized launch, which adds complexity to the mission, which then in turn adds cost.Through sheer economics, frequency of launch improves structural efficiency and safety and reduces cost because successful commerce is based on cost per unit.To investigate the difference in commercial versus government funded space transport, a NASA study compared the cost of Space XS actual development of the Falcon 9 rocket with what it would have cost to build a similar rocket using NASA's practices.A considerable amount of the technology developed for or in space now has practical applications for us here on Earth, for example.Navigation relates to the GPS systems we use in our cars and phones, and Earth observations help scientists to track the effects of climate change.The development of reusable vehicles and the creation of operational and support facilities that can be reused again and again, all of these efficiencies bring down the cost per unit.Private companies have developed mass production methods for satellite production, and the availability of miniature satellites called Cubesats have been especially valuable in increasing access to broadband Internet.One proposal

is that governments and private entities should develop partnerships that use the best capabilities of each sector.Luckily, this is not new territory.In space, refueling depots, lunar facilities for resupply, and water and shuttles for travel to the lunar surface are just some of the essentials.In January 2019 the Chinese successfully completed a mission to land a robotic spacecraft on the dark side of the Moon.This mission was closely followed by another mission in November 2020 in this one the Chinese accomplished their first landing and return mission, which showed that China is now able to launch a spacecraft from the lunar surface.One of NASA's current goals is a return to the moon by 2024, with the aim of using it as a launchpad.To explore Mars.Today 5 countries plus a consortium of 22 European countries, which includes the UK, have official space agencies.NASA is interested in using ISS facilities to foster the development of a low Earth orbit economy.The closer consideration of the economics of space is increasingly leading to calls for space funding to move from government to private funding to support and encourage the commercialization of space.We can already see this happening with the global satellite market, where imaging and telecommunications developments have flourished under competitive private operation.And this also makes it possible for the Chinese to move forward with a new set of goals that include further exploration of the Moon and the building of an international lunar research space The Chinese also plan to complete the construction of a new space station in low Earth orbit by around 2022.As we can see with the Chinese space Program Historically, space exploration has been funded by governments.Space exploration began after the Second World War, when the US and USSR were competing for dominance in military power and world affairs.This competition extended to space and LED to what became called the Space race.Overtime, their activities have expanded to include interplanetary and deep space missions.They've also collaborated with NASA on important project such as the Hubble Space Telescope.It was initially Hanford by serious financial problems, but has since played a major role in manned space operations on the International Space Station.And from 2011 took on sole responsibility for crew transport to and from the space station.up to now government funding Have long been seen as the preferred method for supporting space exploration and research.However, when space funding is in the hands of governments, budgets for planning and projects can be threatened by changes in public and political opinions.In times where governments are expected to keep careful control over their budgets, funding for space agencies can be slashed.This means that the time and money that has been invested in projects is wasted when they are cancelled and expertise that has been gained may be lost.All space activity is dependent on satellites and other spacecraft being launched into orbit or towards a destination.However, more frequent launches are only likely to occur if there is a greater role for the private sector in space and we'll turn to this on the next few slides.Another is capturing space debris, such as old satellites, and reusing it to build new infrastructure in space.The presence of water on asteroids provides a key ingredient for rocket fuel, hydrogen.A key feature of the development of the three previous frontiers has been lowering the cost of transportation.Research such as studies into the effects of radiation on human health and deep space exploration are likely to remain the responsibility of government funded space agencies.Money saved in these areas would provide the funds to pay for infrastructure projects, military projects and deep space explorations.Scientists are especially excited about the new samples because they've been collected

from a much younger area of the moon and can help them to better understand both the age and the formation of the Moon.On the slide, you can also see the size of each agency's budget.In terms of space activities, India has focused on the development of satellites that can be used for telecommunications and Earth observations.They've also had mixed success with attempts at interplanetary missions.In December 2020, the Japanese completed a second successful mission to land a spacecraft on a near Earth asteroid and return it with samples.Like India and Japan, the European Space Agency's early focus was on launching satellites.Russia's space program emerged from the Soviet space program following the collapse of the Soviet Union in 1991.This occurred in the US after the moon landing showed that the space race had been won, public and political interest in space began to decrease, and the final planned moon missions after Apollo 17 were cancelled.However, competing national agendas can lead to duplication of effort and we can argue that a failure to pool resources slows the rate at which space technology moves forward.The infrequency of launches also means that space agencies have to bring together a new team of skilled personnel for each.Launch.More regular launches will encourage standardization of launch vehicles.Private companies, on the other hand, would provide launch vehicles and other spacecraft and also space and Luna stations.In the meantime, be sure that you listen to the podcast I've uploaded on the Learning Portal.This mission was also noticeable because it was the first to bring back rock and soil samples from the moon since the US And Soviet Union moon mission stopped in the mid 1970s.Back then, the US Congress allocated $89,000,000 to fund NASA activities.I just want to know that although I've used the EU flag on the slide, the European Space Agency is separate from the European Union.Japan Space Program has had a wider focus in addition to satellite development and launch with a focus on astronomy.An Earth observation.In 2001, the Russians carried the first private fee paying passengers to the International Space Station.the US, Russian, Japanese and European Space agencies, along with the Canadian Space Agency are all partners in the ISS.The primary purpose of the ISS is to carry out research in microgravity and the space environment.It has also provided opportunities to conduct long term research on the effects of space on human health.In this case that means the number of launches efficiency is mandatory.This would save on the cost of sending new materials into space.Of particular interest is the possibility of asteroid mining.As you can see in the next slide, asteroids contain a range of raw materials which are in short supply on Earth.In fact, we can find plenty of parallels between space exploration and the opening of frontiers on Earth.The provision of this infrastructure is necessary for other commercial efficiencies to be made possible.Governments could enter into contracts with private companies for use of these facilities.Although moon landings are not new, the mission was notable because this was the first time any country had landed on the far side of the moon.Because all of this development was spurred on by the competition between the two countries.the US established the first national space agency.NASA in 1958.This was equal to 0.1% of the national budget.For 2021, Congress has allocated $25.2 billion to NASA, or 0.5% of the national budget.which means that they're unlikely to ever turn a profit and therefore not attractive to investors.Even more costly is the fact that each orbital launch vehicle is thrown away after its first and only flight.In contrast, the main driver of the commercial approach is frequency of launch.They could be mined and returned to earth for use in manufacturing and medicine.Other asteroids have materials that

could support both building in space and launch in space.Practical uses of space are most likely to be driven by private sector technology for the purpose of commerce.All of the funding came from government.Humans have not returned to the moon since then.Politics also leads to concerns about managing costs.Still interesting space has never completely disappeared and a new space race appears to have broken out in Asia.This also adds to the cost.Here we can see that activity in space has moved beyond space exploration.The commercialization of space has already begun, So what role does that leave for government?Unfortunately, we don't have time to discuss these points today, so I'll pick up on them in next week's class.Let's just focus on the international space station for a moment.So let's take a look at this in relation to launch.As you can see on the slide, the cost of the commercial vehicle is 1/3 the cost of the government vehicle.With the growth of satellite technology, we're now able to view and map our world.Thank you so much for your time today.