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Odyssey
Oxford Debates for Youths in Science Education

Space Exploration

Student's activities worksheets

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CENTER FOR THE PROMOTION OF SCIENCE

IRESE

ENERGIA AVASTUSKESKUS ENERGY DISCOVERY CENTRE

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Introduction

Topic

Space Exploration

Definitions

The basic glossary and key words, as well as your preexisting knowledge on the scientific concepts that will be used in the space exploration topic, are presented below.

Asteroid: Asteroids are small, rocky objects in the Solar System that travel around the Sun. The majority of asteroids gather around two Belts: the main asteroid and the Kuiper belt. It is estimated that millions of asteroids exist and are considered remnants left over from the early formation of our solar system.

Kessler syndrome: *A situation wherein the density of objects in the Low Earth Orbit grows so high that collisions between two objects could cause a massive cascade, which would prevent human space activities in the future.*

Terraforming: Terraforming of a planet, moon, or other body is the hypothetical process of deliberately modifying its atmosphere, temperature, surface topography or ecology to be similar to the environment of Earth to make it habitable by Earth-like life.

Colonization of the Moon: The far side of the Moon, also known as the "dark side of the Moon", remained unknown until *Luna 3*, a Soviet spacecraft, launched in 1959. The *far side's* terrain is rugged with a multitude of impact craters and relatively few flat *lunar maria* (dark, basaltic plains) and maritime areas, compared to the *near side. Given these facts, the far side of the moon is the only one that can be inhabited by human beings.*

International Space Station (ISS): The ISS is a joint project between the United States, Russia, Japan, Europe and Canada. Its construction was launched in November 1998 and its latest module was fitted in May 2011. The International Space Station has more than 820 cubic meters of pressurised space - enough room for its crew of six persons and provides the ground for scientific experiments to be carried out. Participation in the International Space Station gives the chance to thousands of Europe's brightest people at hundreds of universities and companies in ESA's Member States to work on the forefront of science and engineering.

UN Sustainable Development Goal: On September 25 2015, a Resolution was adopted by 193 Member States during the 70th General Assembly of the United Nations, known as the "2030 Agenda" for Sustainable Development. The 17 Sustainable Development Goals and as well as the 169 targets of this new Agenda, seek to deal with universal challenges that will lead to a more sustainable future for the society and the planet. (*European Commission, 2015; CSR Hellas; United Nations 2015). "The Sustainable Development Goals are our pathway toward a fairer, more peaceful and prosperous world on a healthy planet. They are also a summons to inter-generational solidarity. We have no greater duty than to invest in the well-*

being of young people so that they can realize their potential. (Antonio Guterres, IT UN)

Militarization of space: The militarization of space involves the use of weapons and military technology in outer space. The first space exploration began during the mid-20th century and had a military motive. Both the United States and the Soviet Union used it as a means of demonstrating ballistic-missile technology and other technologies, which had the potential of military application. Since 2019, the weapon systems that exist in space include only the Almaz space-station armament and pistols such as the TP-82 Cosmonaut survival pistol.

The UN Outer Space Treaty: The treaty entered into force in October 1967. It was the second of the so-called "nonarmament" treaties, following the Antarctic Treaty (1961). It prohibits any act of territorial expansion and economic exploitation as well as the use of nuclear weapons and prepares the ground for research and international cooperation which will benefit all mankind. The first three articles form the basis of international space law, while the others deal with international responsibility. Apart from the Outer Space Treaty of 1967, five more Treaties deal with space issues. Specifically:

a) The Partial Test Ban Treaty (1963): Prohibits the testing of nuclear weapons in outer space.

b) The Agreement on the Rescue of Astronauts (1968): Demands the safe return of astronauts and objects Launched into the outer space.

c) Space Liability Convention (1972): States bear international responsibility for all the damages caused to space objects of other states.

d) The Registration Convention (1976): Demands the registry of launchings into outer space.

e) The Moon Agreement (1984): Provides that the Moon and its natural resources can be exploited.

The Space Shuttle Challenger disaster: On the 28th of January 1986 approximately around 11:00 a.m. EST, the spacecraft Orbiter Challenger took off from the coast of Cape Canaveral in Florida. Just 73 minutes after it's liftoff it exploded, due to the failure of the rubber O-rings that sealed the joints of the shuttle's solid rocket boosters. The disaster shocked the world by bringing a devastating end to the spacecraft's mission and deprived the lives of all seven astronauts aboard, including Christa McAuliffe, a high school teacher from New Hampshire who would have been the first civilian and teacher in space. Later on, it was discovered that the unusually cold conditions together with a design flaw led to the accident. After the disaster it took NASA approximately 3 years to send astronauts into space again. (See "Challenger's liftoff https://www.youtube.com/watch?v=iHWMCoJF1-0&feature=youtu.be)

Science fiction (sci-fi or SF): It is a genre of fiction which explores possible futuristic concepts or alternative advances in science, technology and society. Dystopian or utopian scenarios deal with issues such as artificial intelligence, invisibility, buried civilizations etc. Some of its predictions that were characterized impossible in the past, unfold in front of our eyes (space exploration, 3D printing, wireless communication etc.)

Space debris: They are the leftovers of space explorations, such as nonfunctional spacecraft or fragments of satellite's erosion and collisions, which have been launched in the past in Earth orbit. Space debris travel at speeds up to 17.500 miles per hour.

Curiosity (2011): Curiosity is a robot vehicle (rover) which explores the crater Gale on Mars as part of NASA's Mars Science Laboratory mission (MLS). It was launched on the 26th of November 2011 from Cape Canaveral and landed on Aeolis Palus inside the crater Gale on the 6th of August 2012. After a 560 million km journey, Curiosity initially landed on a spot 2.4 km away from the initial target, called the Bradbury Landing. On December 2012 its mission was indefinitely extended.

The vehicle's main goals are to study the climate and geology of Mars and come to conclusions as to whether the chosen spot of the crater Gale could ever support microbial life including the examination of the water's role. The mission's greater goal, however, is to examine if the planet offers favorable circumstances for human exploration.

Curiosity has the size of a small car, with a mass of 899 kg, 3 m long by 2,7 wide and 2,2 m height. Its equipment allows chemical composition testing and analysis of samples. It consists of a mass spectrometer which serves for the identification of chemical elements and compounds, a gas chromatograph which separates the gases into various components for analysis and a tunable laser spectrometer which measures the abundance of carbon, hydrogen, and oxygen.

InSight (2018): It is a robotic lander which was launched on the 5th of May 2018 with Planet Mars as its destination. It successfully landed on Mars on 26 November 2018. The mission's objective was to place a seismometer on the surface of Mars, which would also bring a heat probe that would study Mar's geological evolution. This mission could possibly bring to light valuable information concerning the Solar System's terrestrial planets – Mercury, Venus, Earth, Mars – as well as the Moon.

Kepler-452b: Kepler-452b is an exoplanet orbiting the Sun-like star Kepler-452. The discovery was announced by NASA on 23 July 2015. It is the first planet that has ever been discovered which has an Earth-like size orbiting within the habitable zone of a star very similar to the Sun. The planet is 1.400 light-years away from our Solar System. If a spacecraft travelled at the speed similar to the New Horizons spacecraft, which was about 59.000 km/h, it would necessitate approximately 26 million years to get there.

Voyager 1: Voyager 1 is an unmanned spacecraft which was launched 16 days after Voyager 2 on the 5th of September 1977 from Cape Canaveral with a launch system known as the Titan III-Centaur. Despite being launched later, Voyager 1 reached Uranus sooner than its twin Voyager 2, following a shorter trajectory. Voyager 1 was initially planned as "Mariner 11" of the Mariner program. On 12 September 2013, NASA announced that Voyager 1 was the first human-made object that managed to enter the interstellar space. The 25th of August 2012 is been considered the official date of interstellar arrival. Scientists managed to identify Voyager's 1 location through the analysis of plasma's density.

Voyager 2*:* Voyager 2 is an unmanned spacecraft, which participated in the Voyager program and was launched on August 20, 1977, to study the outer planets of our Solar System. It is similar to its twin -Voyager 1-, which was launched a few days later. Both spacecrafts managed to reach Jupiter and Saturn with a few months difference. Voyager 1 provided an optimal flyby of Saturn's moon Titan, something that sent it out of the Solar System. However, Voyager 2 followed a different trajectory allowing it to remain within the ecliptic, continuing his journey to Uranus and Neptune. It has visited 4 planets by now, 2 of which have never been explored before, as well as most of their moons, providing us with a more

detailed image about this specific area of our Solar System. Voyager 2 has discovered five moons, four rings and a possible subsurface global ocean on the surface of one Jupiter's moons, Europa. Our understanding of the Solar System's structure and composition has changed radically due to its journey, which took advantage of an alignment of the outer planets that takes place only every 176 years and enables a spacecraft to visit all of them by using gravity assistance. At a distance of 122 AU (1.83×10^{10} km) from the Sun and moving at a velocity of (55,230 km/h), Voyager 2 is the fourth spacecraft to achieve the demanding Solar escape velocity, allowing it to leave the Solar System. On November 5, 2018 the spacecraft abandoned the heliosphere and became the second human-made object which reached the interstellar medium, providing direct measurements of the density and temperature of the interstellar plasma.

New Horizons: New Horizons is a NASA's spacecraft, which was launched to study the dwarf planet -Pluto- , its moons as well as one or more objects of the Kuiper belt. It was developed as a part of NASA's New Frontiers program that was authorized in 2001, after the cancelling of Pluto Fast Flyby and Pluto Kuiper Express missions. New Horizons was launched from Cape Canaveral on January 19, 2006 into a Solar System escape trajectory with a speed of 16.26 km/s in relation to Earth, making it the fastest man-made object that has ever launched. New Horizons reached Jupiter on the 14th of July 2015 and on January 1st of 2019, flew by the Kuiper Belt Object MU69, now nicknamed Ultima Thule (2014 MU69).

Cassini-Huygens: Cassini-Huygens was a shared space-research mission between NASA, ESA and the Italian ASI to send a probe to study the planet Saturn and its natural satellites. The spacecraft consisted of two components: NASA's Cassini probe, which was named after the Italian- French astronomer Giovanni Domenico Cassini, and ESA's Huygens lander, also named by the Dutch physicist, mathematician and astronomer, Christiaan Huygens. Cassini was the fourth spacecraft to visit planet Saturn and the first one to enter its orbit. It was launched on the 15th of October 1997 and after a long interstellar trip it managed to enter Saturn's orbit on July 1, 2004. On 25 December 2004, Huygens abandoned Cassini's main body and managed to land on Saturn's moon -Titan- returning data back to Earth. On the 18th of April 2008, NASA announced a two-year extension of the mission's funding which was renamed into Cassini Equinox. Its mission was to study the saturnian system during the Summer Solstice of 2009. The mission was extended on February 2010 and was finally completed on 15 September 2017.

Extra keywords and notions, used during the presentations or the videos should be noted below.

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Introductory questions

After the end, or throughout the 1st lesson, during which, the introduction to the argument topic has taken place (through the presentation and video material) you are being asked to answer the following indicative questions.

1. Have efforts been made to explore the Moon, the asteroids or even planets inside and beyond our solar system? Are there any space missions currently in progress? If so, which celestial bodies are they studying and which elements are they trying to collect?
2. What are the reasons that lead humanity to exploration and therefore to the attempt of colonizing planets suitable for sustaining **human** life? Does the technology developed by space agencies (NASA, ESA) have real life applications?
3. Is there the right technology and capital to continue our space exploration missions and perhaps in the near future exploit the Moon, Mars or other planets in our solar system, as well as some economically worthwhile asteroids?
4. How much does a space mission cost? Could those funds be exploited to improve our planet's health? Are commercial activities, including space tourism, well-received acts? How do you judge the non-peaceful exploitation of the near space by certain states?
5. How dangerous can space travel be? Could it be detrimental to the health of the space mission's crew?

Students' answers

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Worksheet

Topic
Space Exploration
Debate topics
• Space exploration benefits future generations. • Bad management of the issue constitutes a threat to humanity.

Activity 1

During your preparation for resolving the space exploration argument, prepare a series of arguments, classifying them into three categories: the ones in favor of the resolution, the ones against the resolution and the arguments that can be used by both cases. The questions asked by your teacher during the "Introduction" phase, will support the development of your arguments.

FOR	GREY AREA	AGAINST

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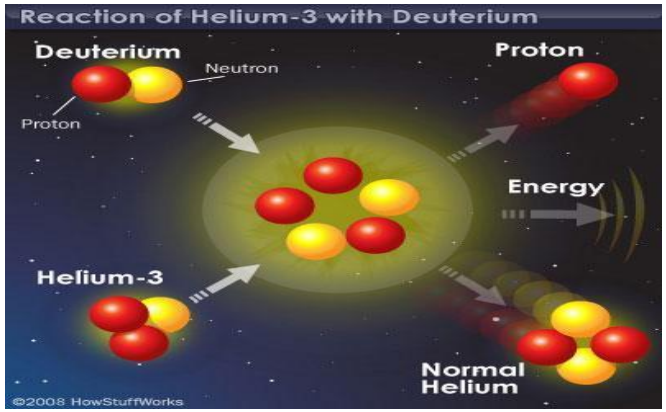
REAL-LIFE EVENTS

Below you will find the Information, Story and Question Cards. Read them carefully so as to develop arguments for the conversation that will follow.

INFO CARD 1	INFO CARD 2
50 years since the first moon landing. 2019 marks the 50th anniversary of Apollo 11's giant leap to the moon. Lunar exploration is no longer the domain of NASA alone. Several governmental agencies- such as ESA(Europe), JAXA(Japan), CNSA(China), FSA(India)- are already "on the run". Commercial agencies (such as Space X, Amazon, Virgin etc.) have big plans for the future. Those plans include missions to the moon, to Mars and the exploitation of asteroids. **Source: David L., (2014), *Mining the Moon? Space Property Rights Still Unclear, Experts Say*, @ space.com, http://bit.ly/2L1g9nX (Photo NASA)** 	***The NASA Twins Study: Researchers looked at the effects of space travel on the human body*** The former astronauts and twins, Scott and Mark Kelly, participated into NASA's research in 2015 and 2016. Scott Kelly began a 340 days mission in space on the International Space Station, while Mark remained on Earth. NASA's researchers studied several factors such as alterations in gene regulation, immune response and the cognitive performance. The study discovered that space travel affects and results to aging. Researchers also noticed a slew of changes in Scott's genes expression, especially in the ones that were related to immune response and DNA construct. Those gene instructions were read and carried out differently in space. Then, within six months of returning to Earth, about 90% of Scott's affected genes returned to their normal expression levels. However, a few genes changed permanently after his stay in space. We should also mention that the ISS missions, called expeditions, usually last about six months e.g. Scott twins remained in space for 340 days.  **Source: Garrett- Bakelman F. et al., (2019), *The NASA Twins Study: A multidimensional analysis of a year-long human spaceflight*, Science, Vol. 364, Issue 6436, DOI: 10.1126/science.aau8650, &Torbet G., (2019), *NASA's twin study reveals effects of time spent in space on the human body*@ digitaltrends.com (NASA's Photo)&ESA (2019d) *Frequently Asked Questions – ESA Astronauts* @ esa.int**

INFO CARD 3	INFO CARD 4
Helium-3 Helium-3 (3He) is a rare isotope of the Sun, located on the surface of the Moon and has the potential to be used in many different ways e.g. the research of low temperature applications, nuclear fusion etc. In comparison with other fuels, the use of 2He-3He and 3He-3He "fuel" is preferred, since it produces less radioactivity.  **Source: Badescu V. (Ed.), (2012), *Moon - Prospective Energy and Material Resources*, ISBN 978-3-642-27969-0, DOI 10.1007/978-3-642-27969-0, Springer**	***Militarization of space & The Global Positioning System (GPS)*** "The Global Positioning System is technically a military construction, which the army shares with the rest of the world", stated the vice-president of the United States. Not only the military uses data and services provided by commercial / governmental satellites, but also both companies and states use data and services provided by military satellites.  **Source: BartelsM, (2018). Space Has Always Been Militarized, Just Not Weaponized — Not Yet, Anyway, @ Space.com (2002), *Interaction of Human and inner space- thesis*, AUTH (Photo, Almaz weapon, Wikipedia)**

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INFO CARD 5	INFO CARD 6
Biological Consequences Space weather, as well as the lunar surface, are a major and constant threat to cosmonauts. Space weather describes the effects of cosmic rays (at 100MeV-10GeV), of the solar wind (solar energy particles/SEP accelerated to 1-100MeV) and they are capable of implanting up to 1 centimeter deep) and of the exposure to ultraviolet (UV) radiation. Due to microgravity ⇒ muscle atrophy, deterioration of the skeleton, slowing of cardiovascular system functions, eye disorders. Due to limited space⇒ isolation, confinement, low air quality.  **Source: Garrett- Bakelman F. et al., (2019), *The NASA Twins Study: A multidimensional analysis of a year-long human spaceflight*, Science, Vol. 364, Issue 6436, DOI: 10.1126/science.aau8650&Badescu V. (Ed.), (2012), *Moon - Prospective Energy and Material Resources*, ISBN 978-3-642-27969-0, DOI 10.1007/978-3-642-27969-0, Springer&NASA (2019) The Human Body in Space @ nasa.gov**	***Asteroids, treasures and risks*** Asteroids within the asteroid belt (which orbits between Mars and Jupiter) are estimated to be worth: - Asteroid Davida: 20 x 10^{18} $ - Asteroid Diotima: 10 x 10^{18} $ - Asteroid Alauda: 50 x 10^{18} $ - Asteroid Palma: 50 x 10^{18} $ The above as well as other asteroids contain numerous metals, including: nickel, cobalt and more valuable metals such as gold, platinum and rhodium. **Source : Armstrong M., (2019) *The Colossal Untapped Value Of Asteroids* @ statista.com,http://www.asterank.com/ , *https://www.space.com/15391-asteroid-mining-space-planetary-resources-infographic.html*** ***The moon is another source of raw materials*** https://www.space.com/moon-mining-space-exploration-report.html , https://www.space.com/41164-mining-moon-water-plans-take-shape.html , https://www.jpl.nasa.gov/infographics/infographic.view.php?id=11272 Asteroid mining, spells danger for the artificial satellites of Earth! Asteroids are really close to Earth and in worst case scenario they can enter into Earth's orbit and collide with the artificial satellites, creating huge disasters e.g. GPS, telecommunications etc. **Source: Scoles S., (2015), *Dust from asteroid mining spells danger for satellites* @ newscientist.com *http://bit.ly/2XXqncR*** odyssey.igf.edu.pl

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INFO CARD 7	INFO CARD 8
Space Debris The latest data (Jan. 2019) concerning the existence of (man-made) objects and debris in the near space since the start of the space age in 1957 are: ▪ Number of successful rocket launches ~5450, ▪Number of satellites orbiting Earth ~ 8950, ▪Number of satellites which are still in space: ~ 5000, ▪ Number of satellites which are still in use: ~ 1950 ▪ Total mass of all space objects in Earth orbit: > than 8400 tons ▪Number of fragmentation debris which are regularly examined by the Space Surveillance Network and are kept under their running catalog of artificial space objects: ~ 22 300 ▪Estimated number of explosions, collisions, or abnormal events resulting in fragmentation> from 500, ▪Number of debris objects estimated by statistical models to be in orbit: 34 000 objects >10 cm, ▪ 900 000 objects from greater than 1 cm to 10 cm, 128 million objects from greater than 1 mm to 1 cm. Europe, recognizing the problem of space debris, is embarking on one of the most important projects. It is a mission called **Remove DEBRIS**, with the participation of 10 partners and with the cost of approximately 15 million euros. Solutions developed as 'countermeasures' against space pollution use 'small' space devices which either collect space junk or drag them down to Earth's atmosphere, where they will burn up. Source: ESA, (2019a), *Image: Visualization of orbital space debris* @ phys.org&ESA (2019b), Space Debris By The Numbers @ esa.int & Wei-Haas M., (2019), *Space junk is a huge problem—and it's only getting bigger* @ nationalgeografic.org & PultarovaT. (2019), *Watch a Satellite Fire a Harpoonin Space inWildDebris-CatchingTest (Video)* @ space.com&ESA (2019c) Active Debris Removal @ esa.int (2002), Interaction of Human and Interstellar Environment,Thesis, AUTH, https://www.huffingtonpost.gr/entry/diethnes-taxidi-australiani-erimos-coober-pedy_gr_14412180	***Hazards of Human Spaceflight I*** > Dangers during the launch process (burning fuels and trying to escape Earth's gravity). > Cosmic and solar radiation (extremely dangerous for human health). > Collisions with space or man-made objects. > Protection from radiation and from the cold. > Spaceflight accident and entrapment in space. > Fossil fuel depletion. > Earth reentry procedure (Atmospheric entry = friction burn and ground collision). > Handling of machinery and applications. > A spacesuit is essential, while travelling in space.  **Source : NASA (2019a),*5 Hazards of Human Spaceflight* @ nasa.gov &ESA, (2018), *The Toxic Side Of The Moon* @ esa.int &ESA, (2004), *Surviving Extreme Conditions In Space* @ esa.int**

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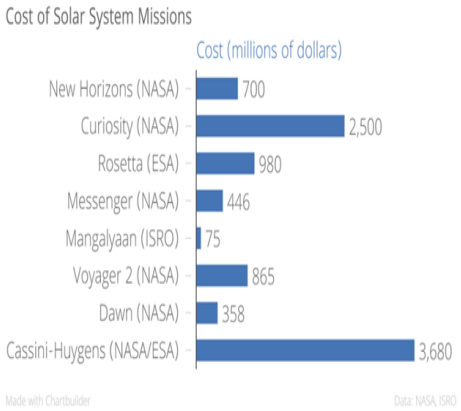
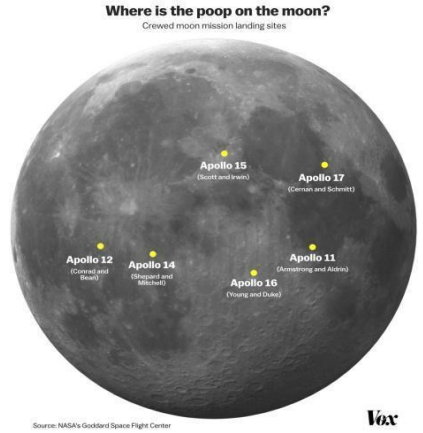
INFO CARD 9	INFO CARD 10	INFO CARD 11
Hazards of Human Spaceflight II > Waste management (CO2 removal). > Filtration of microorganisms, air and dirt separation. >Air Quality. > Biological waste management. > Protection from the vacuum of space. > Fire and leak detector, detection of dangers (e.g. meteorites)  **Source : NASA (2019a),*5 Hazards of Human Spaceflight* @ nasa.gov &ESA, (2018), *The Toxic Side Of The Moon* @ esa.int &ESA, (2004), *Surviving Extreme Conditions In Space* @ esa.int**	***The Cost of Space Exploration*** NASA has signed a contract with both Space X and Orbital ATK, which were valued at $1.6 billion and $1.9 billion respectively, for a total of 20 round-trip launches to the International Space Station (ISS). Thus, the average estimated shipping cost per kilo is ~ $ 50,000 for SpaceX and ~ $ 80,000 for Orbital ATK  **Source: NASA (2018), Audit Of Commercial Resupply Services To The International Space Station, Office of Inspector General - Office of Audits, Report No. IG-18-016 & Foust J. (2018), NASA will pay more for less ISS cargo under new commercial contracts @ spacenews.com /Source: Knapp A., (2015), *How Do New Horizons Costs Compare To Other Space Missions?* @ fordes.com**	***Moon exploration and human pollution*** Since the beginning of moon missions in 1959, more than 800 pounds of Moon rocks and lunar soil had been brought back to Earth. But some things were intentionally or by accident left behind.  **Lunar resources** **Source: NASA (2019c), *Catalogue of Manmade Material on the Moon NASA History Program Office 7-05-12* @ nasa.gov & Zafra & Gómez (2019), *The Incredible Inventory of Things We've Put on the Moon*@ wsj.com &Resnick B. (2019), *Apollo astronauts left their poop on the moon. We gotta go back for that shit. What 50-year-old dirty diapers can teach us about the potential origins of life on Earth* @vox.com**

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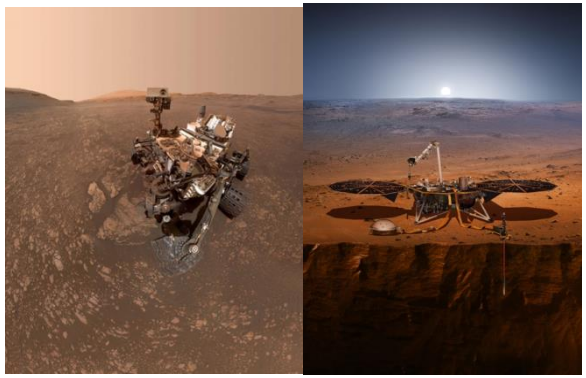
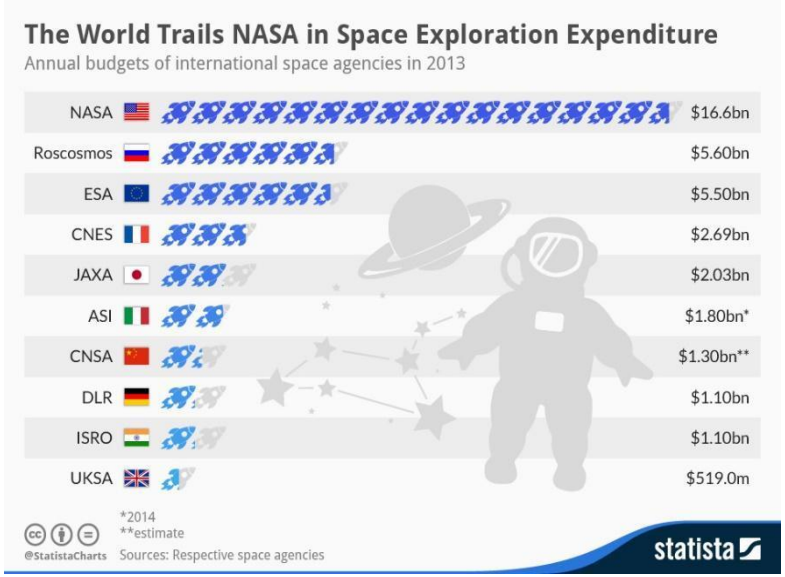
INFO CARD 12	INFO CARD 13
Mission to Mars Mars is one of the most promising planets within our solar system that can be used for future colonization. (NASA missions, *Curiosity 2011* and *Insight 2018*). It is located within the habitable zone, while its gravity is similar to that of Earth (a huge advantage for human beings) and the current studies indicate water existence and a life development possibility. Australia's space analog is currently Mars, which despite being barren and inhabitable, could eventually become suitable for human settlement through the long and complex process of terraforming.  **Sources:** **https://mars.nasa.gov/msl/home/,** **https://mars.nasa.gov/insight/,** https://www.huffingtonpost.gr/entry/diethnes-taxidi-australiani-erimos-coober-pedy_gr_14412180	***The Cost of Space Exploration*** In the following bar graph, the annual budget of international space agencies in 2013, is presented:  **Source: McCarthy N., (2014) *The World Trails NASA in Space Exploration Expenditure* @ statista.com**

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INFO CARD 14

Is space tourism the first step towards space colonization?


Spacex, Virgin Galactic, Blue Origin, RosCosmos, Boeing, Orion Span are some of the companies that are already organizing, advertising and implementing space travels. However, few people have the budget for such a trip, since the cost of a trip with SpaceX at the International Space Station is $ 52 million.

Sources: https://www.blueorigin.com/, http://en.roscosmos.ru/, https://www.spacex.com/, https://www.virgingalactic.com/, https://www.boeing.com/space/, https://www.orionspan.com/, *https://www.cnbc.com/2019/06/11/tourist-cost-to-visit-international-space-station-with-spacex-is-52m.html,*

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INFO CARD 15	INFO CARD 16
Have we considered all the alternative solutions our planet has to offer?	***Problems which seek a solution***
 	 
The scientific knowledge we can derive from the planet itself, especially from organisms that survive in areas with extreme conditions (deserts, Antarctica, abyssal plains, etc.), can provide valuable and essential information that humanity can immediately use, comparing to the space exploration process. There are many areas of the Earth that still remain unexplored, such as the sea bed and especially areas next to undersea volcanoes which can provide useful information concerning new forms of life or natural resources. Part of the huge sums invested in space exploration, could also be used to explore such areas. ***https://www.athensvoice.gr/world/598422_santorini-arhise-i-apostoli-tis-nasa-sto-ypothalassio-ifaisteio*** ▪ ***https://www.the-ies.org/analysis/exploring-submarine-volcanoes*** ***A big part of the Antarctic remains unexplored as well.*** ***https://www.tanea.gr/2019/01/21/science-technology/zoi-kato-apo-ena-xiliometro-pagon-stin-antarktiki/***	Global warming and the consequent shrinking of Antarctica's sea ice, are causing the problem of climate change that has major impacts to both our planet and humanity in general. It seems advisable to invest money so as to solve these major problems, and consequently prevent a potential catastrophe, improve our planet's living conditions and enable the preservation of many species, rather than investing billions of dollars in something like space exploration. ***https://energypress.gr/news/oie-lysi-gia-tin-yperthermansi-toy-planiti-i-strofi-stis-ape*** ***https://www.nationalgeographic.com/environment/global-warming/global-warming-solutions/***

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STORY CARD 1	STORY CARD 2
 ***Neil Armstrong (Astronaut)*** "There was great uncertainty about how well we would be able to walk in our cumbersome pressurized suit. My colleague demonstrated a variety of techniques in view of the television camera that I had installed in a position predetermined to be in the optimum spot for coverage of all of our activities. Preflight planners wanted us to stay in TV range so that they could learn from our results how they could best plan for future missions. I candidly admit that I knowingly and deliberately left the planned working area out of TV coverage to examine and photograph the interior crater walls for possible bedrock exposure or other useful information. I felt that the potential gain was worth the risk." **Source : KrulwichR., (2010), *NeilArmstrongTalksAboutTheFirstMoonWalk, December 8*, Letter @ npr.org (*https://n.pr/2ITV1gJ*)**	***About Galileo*** Galileo is the European Union's Global Satellite Navigation System (GNSS). Galileo will provide users from all around the world with the chance to be acquainted with radio signals for position, navigation and timing purposes. When completed, it will consist of 24 nominal Medium Earth Orbit satellites and a ground segment for tracking position, navigation and timing purposes. The Galileo program is funded and owned by the EU. The European Commission has the overall responsibility for the program, managing and overseeing the implementation of all program activities. Galileo's deployment, the design and development of the new generation of systems and the technical development of infrastructure are entrusted to ESA. The definition, development and in-orbit validation phases were carried out by ESA, and co-funded by ESA and the European Commission. The European Global Navigation Satellite System Agency (GSA) is ensuring the uptake and security of Galileo. Galileo operations and provision of services has been entrusted to the GSA from July 2017.  ***Source:* ESA, (2017), Galileo's launch brings the navigation network close to completion@*esa.int***

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STORY CARD 3

SpaceX: Musk's achievements and his vision of Mars colonization.

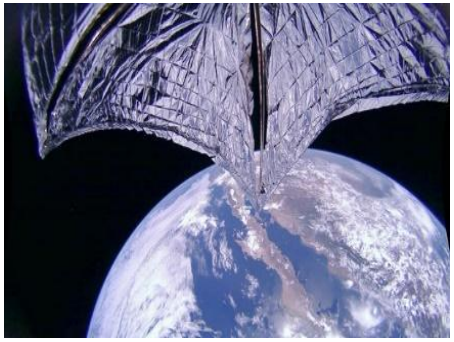
In September 2016, Elon Musk presented his vision which was to colonize Mars with the resources and spacecrafts of SpaceX company. He plans to transfer 1 million people to the so called "red planet", something that would cost around $ 100.000 to $ 200.000 per person. […] Musk also revealed the creation of an enormous carbon-fiber fuel tank, that will be essential for making the ITS spaceship work. The tank, which is designed completely from carbon-fiber, passed the "pressure test" on November 2016 and is ready to face real-life challenges. SpaceX's skilled stuff is constantly increasing since the company has hired more than 500 scientists and researchers. In general, the company strives to make Musk's vision come true: A trip with no return to Mars.

Source: Musk E. (2018), *Making Humans a Multi-Planetary Species*, New Space Vol. 5, No. 2, https://doi.org/10.1089/space.2017.29009.emu&Mosher D. (2017), *Elon Musk has published an updated plan to colonize Mars with 1 million people* @ businessinsider.com *http://bit.ly/32Do01l*&NASA (2019b), *SpaceX Dragon en Route to Space Station with NASA*, Release 19-058 @ nasa.gov

"SpaceX has begun to get the hang of the landings / launches of the reusable Falcon 9 rockets. The truth is that we didn't expect to witness its technology being used so soon for real-life applications, but it has proved us all wrong. SpaceX recently used a Falcon 9 rocket so as to boost a classified spy satellite of the NRO (National Reconnaissance Office) into orbit for the U.S. military and landed it with safety to Florida's Cape Canaveral for future use. It is the first out of five missions for which Elon Musk's company has come to an agreement with the U.S. government." **(Source: Elpidis C., 2017)**

"The three reusable parts of SpaceX's Falcon Heavy rocket are returning to Earth after the commercial launch of the world's largest rocket (11 April 2019). All three parts of the rocket have successfully returned to Earth: the two outer cores landed together, while its central part was the only one to land at the unmanned SpaceX ship, "I StillLoveYou" on the Atlantic. "

Source: CNN Greece, (2019), *FalconHeavy: SpaceX's rocket has returned to Earth but its main part disappeared … on the Atlantic* @ *cnn.gr3* . "In July 2019, LightSail 2 became the first spacecraft to modify its orbit using sunlight." "LightSail 2 spacecraft is successfully raising its orbit solely on the power of sunlight, *opening the door to a new, cost-effective way to propel small craft." Source: Haynes K. (2019) @ astronomy.com (Photo of LightSail 2)*



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STORY CARD 4

Stamatis Krimigis "Attempts to conquer Mars will not guarantee the crew's survival before 2050" **(an interview by Kostas Deligiannis@ naftemporiki.gr)**

After several successful attempts of space exploration, the crash of the European Space Agency's (ESA), MarsLander, reminded us that the slightest mistake "out there" carries massive liability. How much anxiety do scientists and engineers experience while coordinating a space mission?

The anxiety is huge, given the fact that there is always a huge risk. Especially in the case of Mars, about 50% of the spaceships that have attempted to land have been destroyed. [...].

Given this specific context, how do you explain the fact that we are reading recently about missions that attempt to send humans further from the Earth's orbit?

I believe that the reasons are either economic or scientific. The main motivation is that human crew missions are far more imaginative than robotic spaceships. On the other hand, exploration has always been a part of human nature – whether it's about unknown regions on Earth, as it happened centuries ago, or about space.

Apart from NASA, Mars "conquest" is also the goal of many private companies. Do you believe that a private business can develop the appropriate technologies?

Although SpaceX has already agreed to get all the technical assistance it needs from NASA for free, I personally believe that is extremely difficult. The main reason is that there are certain issues that no one has managed to solve, not even the US space agency. One of the most important issues has to do with the crew's safety and, specifically, its protection from cosmic rays and solar flares. Imagine that in one flare the sun fires up protons in such a high speed that they penetrate 2cm thick walls. [...] In September I attended Musk's speech [...]. I would say that some of his milestones, such as the creation of a permanent base of 200,000 people by 2100, belong to the realm of science fiction

Regarding the first trip to Mars, SpaceX's founder has said that it could even start in 2022. On the other hand, Boeing's CEO Dennis Muilenburg is convinced that the first astronaut that will walk on Mars will travel with a rocket of his own company. NASA is planning the first manned mission to the Red Planet in the mid2030s. Who do you believe that will be the first to make his vision come true and when?

I personally agree with the most recent assessment by the American Academy of Sciences, according to which, the first astronaut mission to Mars will take place from 2050 and onwards. In fact, I'm sure that it will come true with all space agencies working together. I believe this because no governmental agency would send people to Mars, unless it could guarantee their safe return. On the other hand, however, a private company could take the risk earlier, by searching for volunteers that are willing to risk the lives. However, it's not that unlikely to find people who would want to risk their lives, if the prize was to remain in history as Mar's first explorers.

It has been argued that the ultimate goal of conquering Mars is that mankind must have a "spare" Earth in the future to survive. Do you think Mars will have to play this role? I do not agree. In my opinion, our species can be better protected on Earth than on any other planet. [...].

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STORY CARD 5	STORY CARD 6
	
Navstar: GPS Satellite Network	**The case for protecting the Apollo landing areas as heritage sites**
The U.S. Navy developed the first operational satellite navigation system – called Transit – in the 1960s. These "spin-stabilized" spacecraft – meaning that their spin kept the spacecraft pointing in the same direction – were first used for navigation in 1964 by Polaris submarines. Nowadays, there is Navstar, a network of U.S. satellites that provide global positioning system (GPS) services. They are used for navigation by both the military and civilians. These 24 main GPS satellites orbit Earth every 12 hours, sending a synchronized signal from each individual satellite. Because the satellites are moving in different directions, a user on the ground receives the signals at slightly different times. When at least four satellites get in touch with the receiver, the receiver can calculate where the user is – often to a precision of just a few feet, for civilian use.	A professor of Space Law argues that the Apollo landing areas must be listed on the World's Heritage List. "Nearly 50 years ago, Neil Armstrong also took a few small steps. On the Moon. His boot prints, along with those of fellow astronaut Buzz Aldrin, are preserved in the lunar soil, called regolith, on what Aldrin described as the "magnificent desolation" of the Moon's surface. These prints, too, bear witness to an evolutionary milestone, as well as humankind's greatest technological achievement. What's more, they remind the work of many individuals who worked to unlock the secrets of space and sent humans there. And those small steps pay homage to the daring men and women who have dedicated – and those who lost – their lives to space exploration". Prof. Michelle L.D. Hanlon, University of Mississippi.
Source: Howell E., (2018), Navstar: GPS Satellite Network @ space.com	**Source: Hanlon M., (2019), *The case for protecting the Apollo landing areas as heritage sites* @ Astronomy.com**

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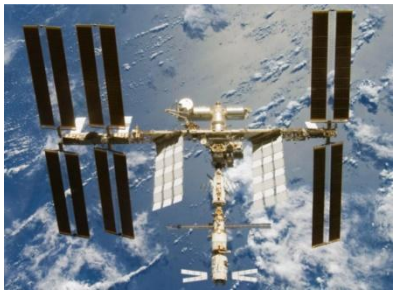
STORY CARD 7

Microgravity in ISS, a tool for industrial research

The launch of the Columbus laboratory in February 2008, followed by the launch of the ATV in March 2008, marks the beginning of a truly continuous European utilization of the International Space Station. With the addition of Columbus, the science capacity of the International Space Station was nearly doubled and a new era has begun for ESA's activities onboard the Station, which from now on offers a permanent opportunity for space-based research. The weightless environment of the International Space Station represents a tool for application-oriented and industrial research. From biotechnology and material science to fluid physics, the facilities and resources available on board allow scientists to carry out unique research. They also offer companies the opportunity to increase their competitive advantage by using the space environment as a platform for developing and testing new products and innovative technologies. For example, weightlessness is a non-invasive tool in which to investigate cellular functions. This is essential for the better understanding of biological and physiological processes with potential applications ranging from drug development to tissue engineering. Studying how the human body adapts to the lack of gravity can contribute to a better understanding of many physiological processes, thus supporting the development of effective countermeasures, from pharmaceuticals to fitness equipment. Research under conditions of weightlessness allows more precise measurement of thermophysical properties, which can be applied in numerical models to optimize material-forming processes and leading to the improvement of production methods or materials. Nowadays (2019) in Mission 60 on the ISS, a 3D space bioprinting is explored (Projet Biofabrication)-which was become a vital source for human organ construction in the future. Research on thermophysical properties of heated materials in microgravity and of samples on Electrostatic Levitation Furnace, as well as the Cell Science-02 research on bone healing and tissue regeneration are ongoing.



Source: ESA (1998), *Microgravity*, http://www.esa.int/esapub/br/br136/br136.pdf, ISBN: 92-9092-605-8 & ESA, *Microgravity, A Tool For Industrial Research*, http://bit.ly/esa-2GivwoN& Pettigrew et al. (2003). *Design features and capabilities of the First Materials Science Research Rack (MSRR-1)*, IEEE Aerospace Conference, Big Sky, MT. 2003 155-63 & Krasowski et al. *CIB: An improved communication architecture for real-time monitoring of aerospace materials, instruments, and sensors on the ISS*. The Scientific World Journal. 2013 2013(185769): 12 pp. DOI: 10.1155/2013/185769) & Moran. N., (2019), 3-D Bioprinting, Grip Studies on Station May Benefit Earth and Space Systems @ nasa.gov&NRC, (2003). *Factors Affecting the Utilization of the International Space Station for Research in the Biological and Physical Sciences*. Washington, DC: The National Academies Press. https://doi.org/10.17226/10614.

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STORY CARD 8

Inventions developed thanks to space exploration

> Photovoltaic panels: silicon monocrystalline cells were originally developed for aerospace engineering and are now widely available at low cost.

> Magnetic Resonance Imaging MRI: the non-invasive imaging method that saves millions of lives each year, may not have been invented by NASA scientists, but incorporates technologies developed in its own laboratories, such as digital image processing and image amplification.

> LEDs: tiny light-emitting diodes with applications in medicine and particularly in the treatment of cancer tumors, such as breast cancer.

>Digital camera sensors (CMOS), which are also used in smartphones. The first of these were developed at NASA to withstand harmful radiation during interplanetary travel, and were 100 times less demanding in energy.

> Water Filtration: NASA engineers have invented at times various water filtration systems even for the most difficult water sources, so as to convert any liquid element into a potable one.

> Programmable pacemakers: In the 1970s, three programs which were under NASA supervision, led to the creation of the first permanent pacemaker, which could be remotely programmed with telemetry data eliminating the need for surgery.

> Image / Video Analysis: many of the image and video analysis programs, used today for any kind of demanding application have evolved as algorithms which were originally written to improve images from space.

Source: P. Bozèlos (2014) 8 useful applications you may not know that they were invented thanks to space exploration – Examples concerning the way space exploration has changed our lives. @ lifo.gr

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STORY CARD 9

From 1967 to the future

In 1967, the UN Outer Space Treaty was signed. Developments since then have made discussions on Space Law necessary. For example, discussions about the legality of space mining, space transport management or the involvement of the private sector in space. Environmental issues are also a matter of priority. When the UN Outer Space Treaty (1967) was drawn up, the aim was to avoid an irrational space competition or any other kind of military conflict. Another key debate is how to maintain peace in an environment that has resources and strategically important space infrastructures (which already exist or will exist in the future). Having in mind the plans for human settlement in space in the near future, the Treaty should also take into consideration these future settlements in other celestial bodies. We should note that the Treaty's primary concern was to avoid the possibility of claiming resources, as this can be considered a source of conflict. In addition, it is both interesting and useful to see how the Treaty affects the rights and responsibilities of humans and robots in current law, but also how this can affect and cause changes in international regulation. Finally, the Treaty is also expected to balance the ambitions of the private sector as well as the sovereignty of nations in both space and resources. In addition, the Treaty should provide the possibility to establish a specialized transnational judicial body, which will facilitate the adaptation of the Treaty to developments in space technologies and activities.

UNISPACE+50 UNITED NATIONS Office for Outer Space Affairs UNOOSA

Source: Froehlich A., (Edt.), (2018*), A Fresh View on the Outer Space Treaty, Studies in Space Policy*, Volume 13, ISBN 978-3-319-70434-0, https://doi.org/10.1007/978-3-319-70434-0, Springer, Abeyratne R., (2011), *Space Security Law*, ISBN 978-3-642-16701-0, DOI 10.1007/978-3-642-16702-7, Springer

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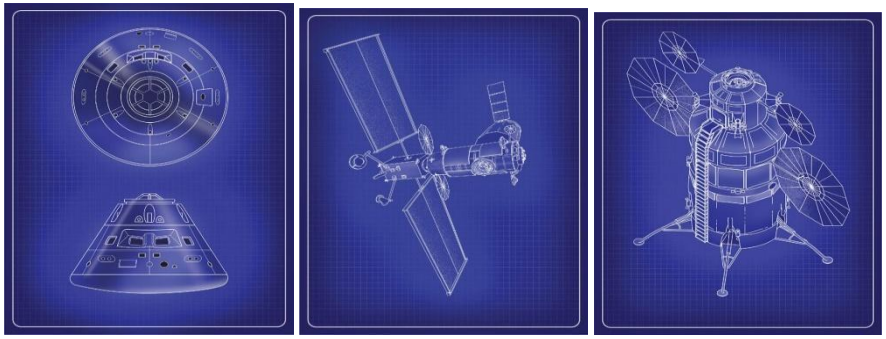
STORY CARD 10

Artemis program. Are there any plans for moon colonization?

NASA is sending a mobile robot to the South Pole of the Moon to get a close-up view of the location and concentration of water ice in the region. About the size of a golf cart, the Volatiles Investigating Polar Exploration Rover, or VIPER, will roam several miles, using its four science instruments — including a 1-meter drill — to sample various soil environments. Planned for delivery to the lunar surface in December 2022, VIPER will collect about 100 days of data that will be used to inform the first global water resource maps of the Moon. Its goal is to discover data that will confirm water ice existence in the Moon's south pole. In 2009, NASA crashed a rocket into a large crater near the South Pole and directly detected the presence of water ice. Since then other spacecrafts have managed to survive from the same findings. Scientists consider that the Moon has reservoirs of water ice, potentially amounting to millions of tons. Water discovery will bring us a significant step closer towards NASA's ultimate goal of a sustainable, long-term presence on the Moon – making it possible to eventually explore Mars and beyond.



Several nations and international organizations are interested in Artemis program..

The first unmanned mission of the program ("Artemis 1") is scheduled for 2020 and will be the "maiden" use of the new Large Space Launch System (SLS) to launch the unmanned Orion spacecraft, which will go to the moon and it will return to Earth. A similar human-made flight ("Artemis 2") will follow, with the "Artemis 3" mission scheduled in 2024, to send a pair of astronauts to the Moon.

Source : ***https://www.nasa.gov/specials/artemis/***

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QUESTION CARD 1	QUESTION CARD 2	QUESTION CARD 3	QUESTION CARD 4
Has space technology contributed to real life applications?	Does space travel have an impact on astronauts' health?	Could there be consequences from the increased spaceflight - at a time when we are even seeing reusable rockets?	Could unpredictable consequences (e.g. from crashes or inactive space devices) be caused by the existence of artificial satellites, which would be disastrous for our planet in the long run - threatening mankind's future?

QUESTION CARD 5	QUESTION CARD 6	QUESTION CARD 7	QUESTION CARD 8
Are there any 'countermeasures' for the confrontation of space debris?	Can space militarization have a positive impact?	Does space exploration have a high cost after all?	Can the creation of a legal framework supporting international cooperation in the near space, be considered an immediate goal?
QUESTION CARD 9	**QUESTION CARD 10**	**QUESTION CARD 11**	**QUESTION CARD 12**
Which planets are considered potential destinations for the creation of the first human colonies?	What benefits can humanity derive from space exploration?	Which is the future of space tourism and where can it lead?	Are there any plans for moon colonization?

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Oxford Debates for Youths in Science Education

Controversy Plan

Follow your teacher's instructions and complete the following Argument Table.

Write down information, your questions or anything else you need.

ARGUMENT nº 1

Argument	Foreseen rebuttals from the other team	Response to rebuttals

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ARGUMENT n°2

Argument	Foreseen rebuttals from the other team	Response to rebuttals

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ARGUMENT nº 3

Argument	Foreseen rebuttals from the other team	Response to rebuttals

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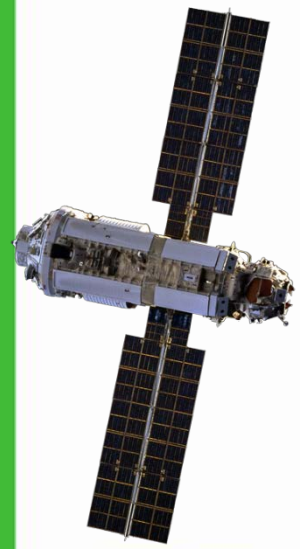
“Space Exploration”



Zois Asimakopoulos, member of HIRCS, Geologist, M.Ed. In Digital Technologies in Education , UoA.

Institute of Geophysics
Polish Academy of Sciences

CENTER FOR THE PROMOTION OF SCIENCE

IRESE

ENERGIA
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ENERGY DISCOVERY CENTRE

21st century, the century of space exploration

- According to many scientists, mankind's future depends on space exploration.
- Does the constant population growth create the need for new, hospitable areas as well as the need for natural resources, space travel and research in general?
- Serious concerns are raised concerning the possible risks that are related to the high cost of space exploration, the intense competition for sovereignty in space, the space debris existing in orbit as well as the health risks astronauts face, etc.
- **Future of space exploration (video)**

The milestones of space exploration presented in stamps

In 1942 the German V2 was the first rocket to reach 100km from the Earth's surface (the boundary of space). The rocket was designed by Wernher Von Braun, who later worked with NASA as the creator of the rockets that went to the moon.

Albert II, was the first monkey in space. He was a Rhesus monkey, a type of monkey that originally comes from Asia. Albert went into space on 14th June, 1949 in a specially adapted American V2 rocket, that flew to a height of 83 miles from earth.

On 4th October 1957, Russia launched the first satellite into space; Sputnik 1.
The space age had properly begun!

.

In November 1957, the Russian space dog Laika became the first animal to orbit the earth. Laika travelled in a spacecraft known as Sputnik 2. Her mission helped scientists understand whether people could survive in space.

The milestones of space exploration presented in stamps

On 12th April 1961, Russian Cosmonaut Yuri Gagarin became the first man in space. Gagarin's spacecraft, Vostok 1, completed one orbit of the earth, and landed about two hours after its launch. Gagarin had to bail out and land using his parachute, because the Vostok 1 was designed to crash!

On January 28th 1986, Space Shuttle Challenger exploded shortly after launch, because of a fuel system failure. All seven astronauts on board were killed, and all shuttles were grounded for nearly three years.

In 2000 the first permanent crew moved into the International Space Station (ISS), where crews of astronauts have been living ever since. The ISS is a huge space station for research and space exploration. Its construction began in 1986 and was completed in 2010.

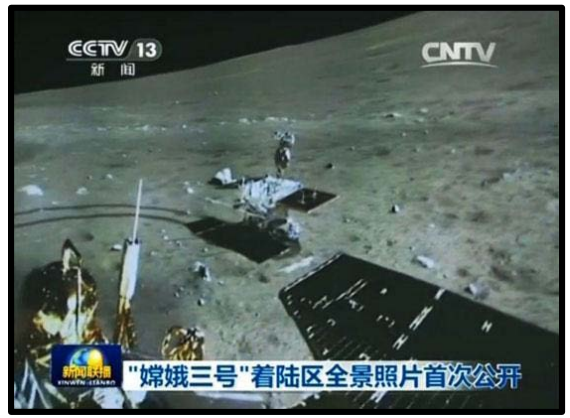
On October 25th 2003, China sent her first astronaut (Yang Liwei) to space.

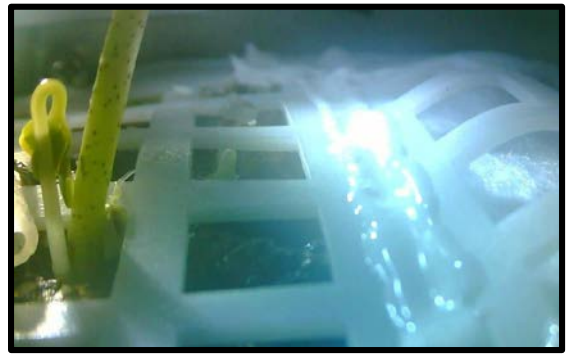
Man and Space

- Using his imagination, man created the concept of space travel (*From the Earth to the Moon* - July Verne, *The Odyssey of Space* - Stanley Kubrick, Arthur Clark, etc.) and initially envisioned a trip to the moon.
- This vision came true 50 years ago, with the landing of Apollo mission to the moon.
- Space exploration is no longer considered NASA's privileged field. Many governmental agencies, as well as commercial organizations (e.g. SpaceX, Amazon, Virgin) have plans to organize missions to space, to the moon, to asteroids, even to Mars.

- The recent Chinese landing on the *far side* of the moon (where cotton was planted!) reopens the debate about:

  - the exploitation of lunar resources
  - the new, manned space missions
  - the lunar bases.

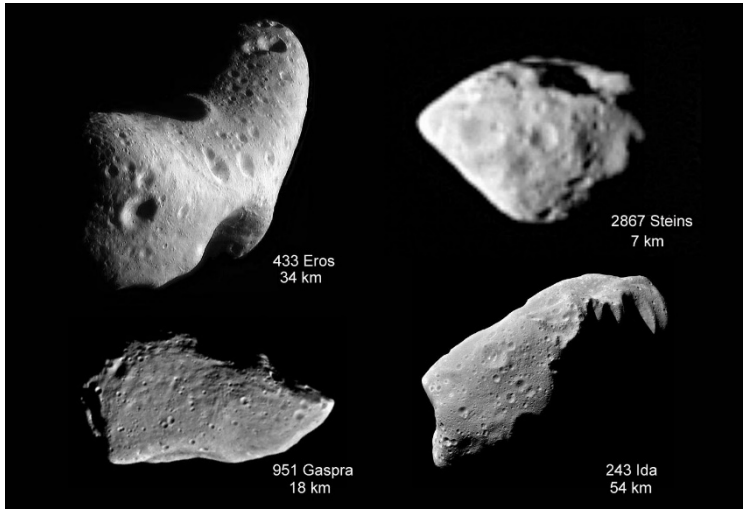


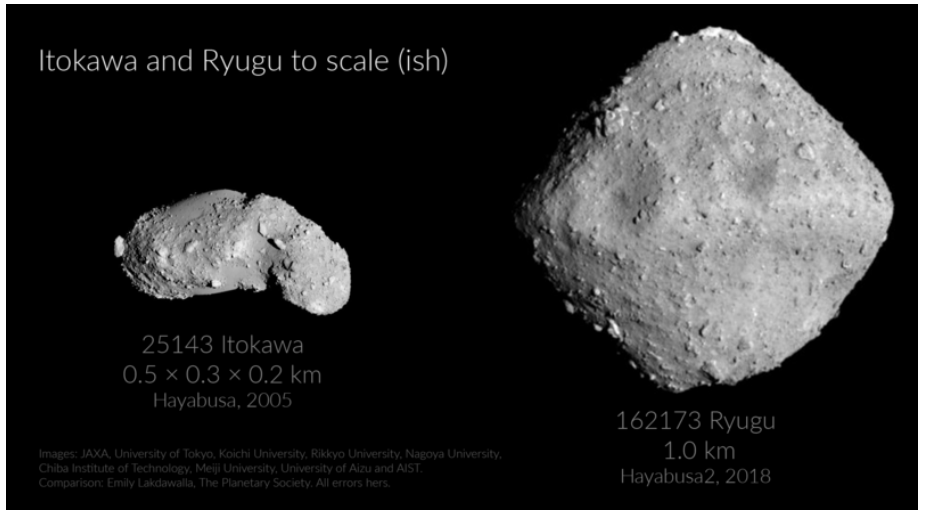


- [Colonization of the Moon (video)]

From the Moon to Asteroids

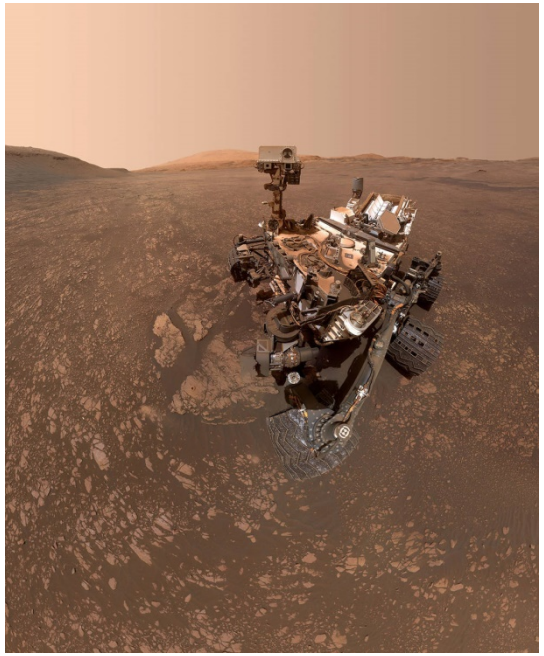
- The Moon will be an important base for the scientific and commercial space activities as well as for the asteroid mining process. (von der Dunk 2017 & 2018).
- **Mining the Moon (Video)**
- **How close are we to mining the space? (Video)**
- **https://www.jpl.nasa.gov/infographics/infographic.view.php?id=11272**

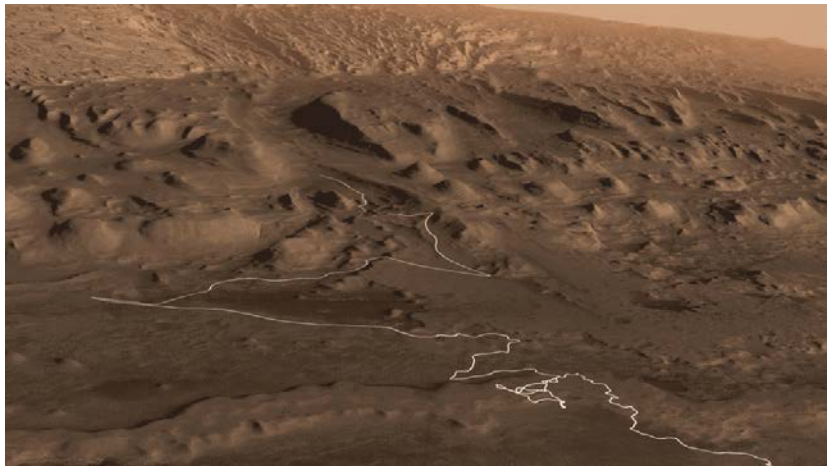




Missions to Mars / NASA

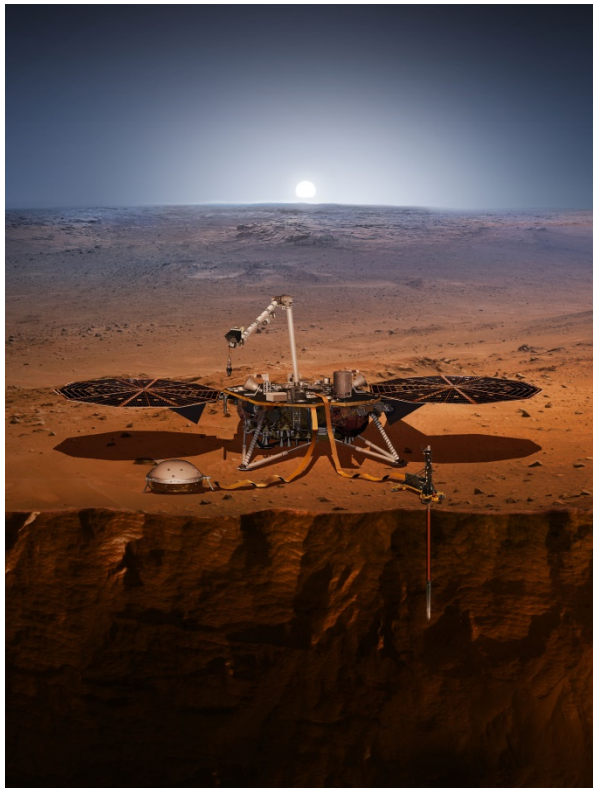
- **Curiosity Mars rover 2011**

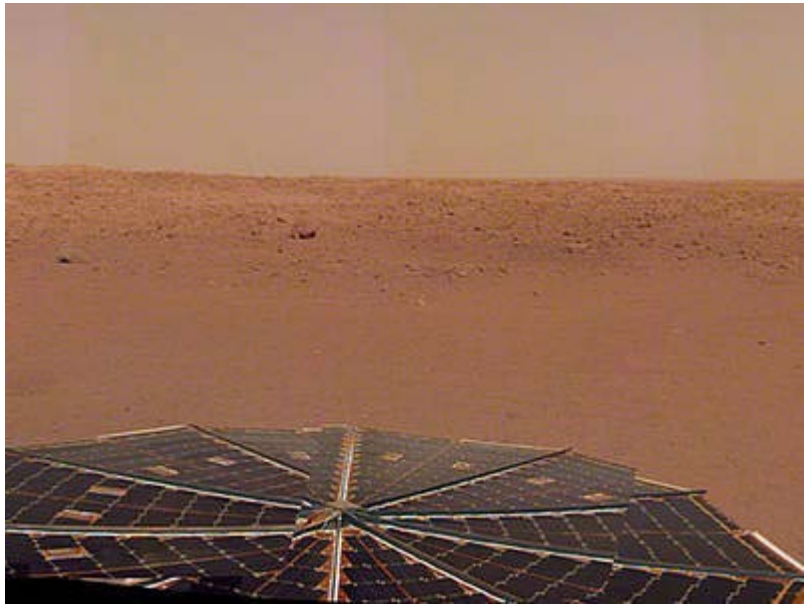




Missions to Mars/ NASA

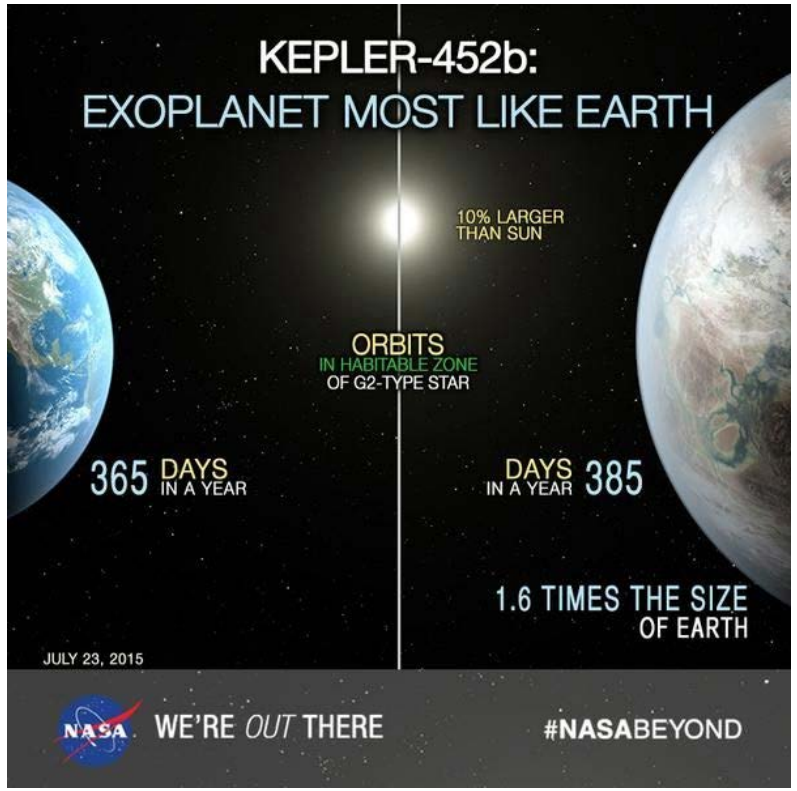
- **Insight 2018**
- [Watch Elon Musk Reveal SpaceX's Most Detailed Plans To Colonize Mars (Video)]

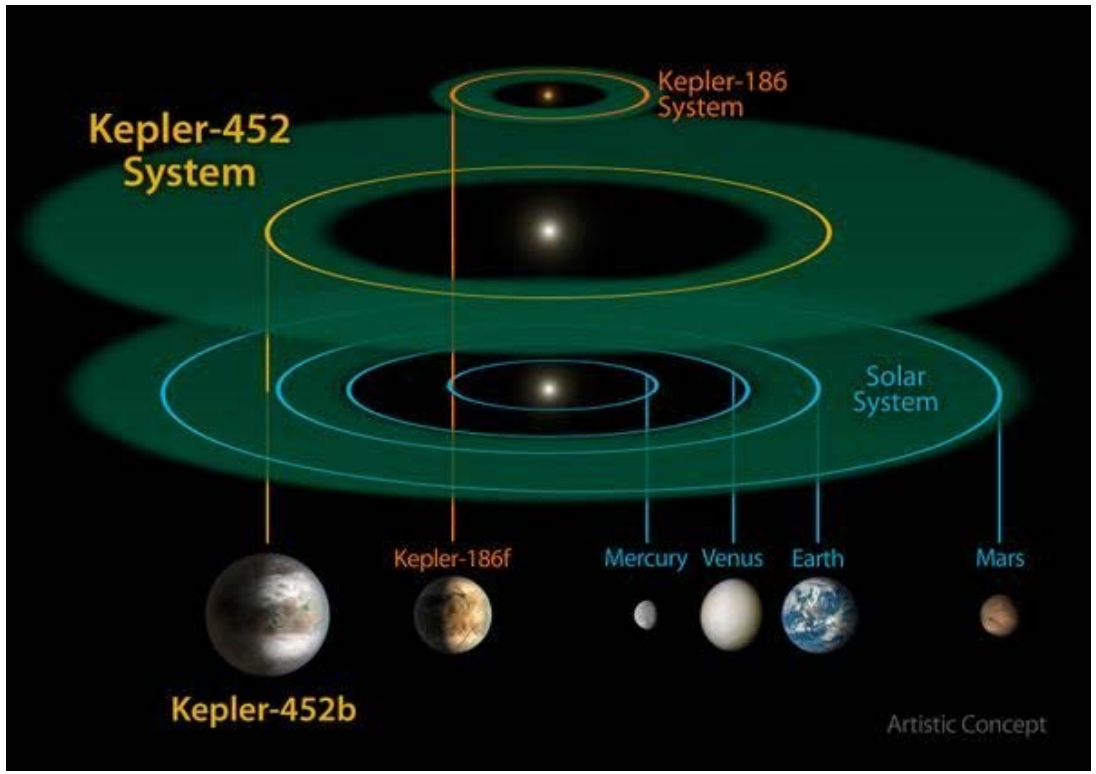




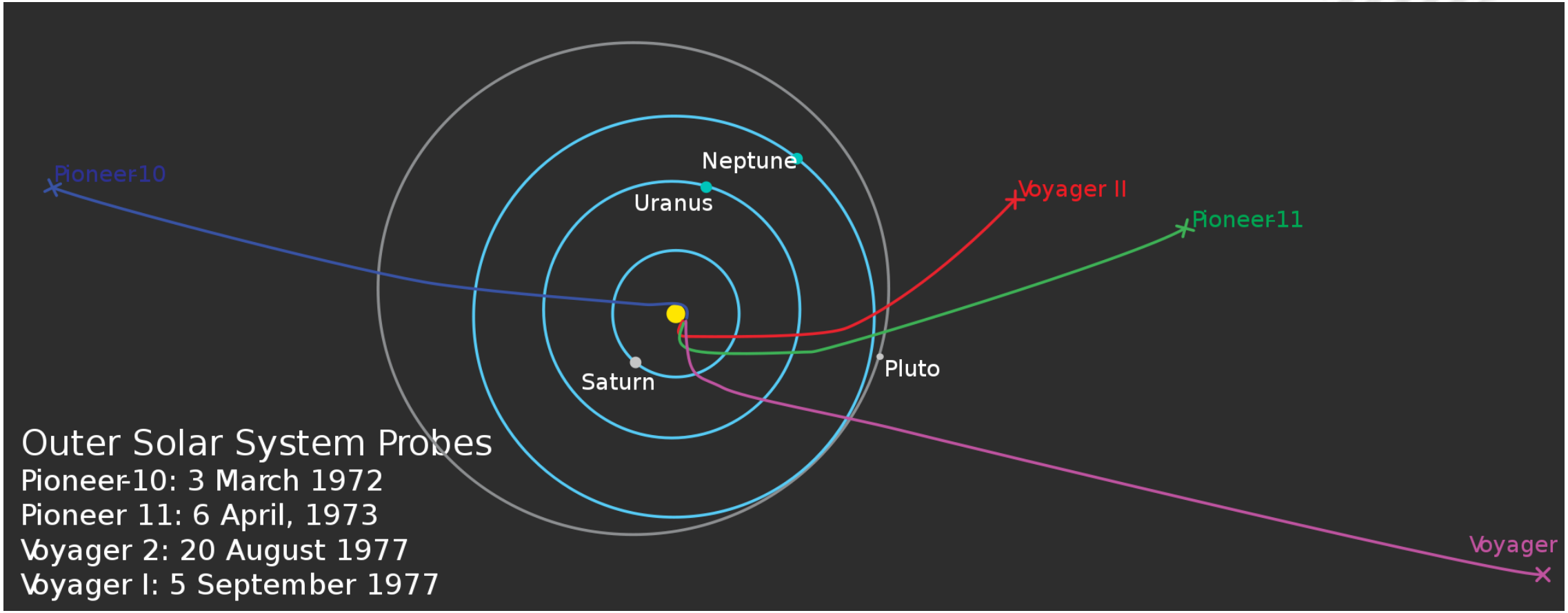
Other destinations…

- **Kepler 452b**
- https://www.youtube.com/watch?v=KmFfNLHjt6Q





Voyager I & II


Pioneer-10
Neptune
Uranus
Voyager II
Pioneer-11
Saturn
Pluto
Voyager
Outer Solar System Probes
Pioneer-10: 3 March 1972
Pioneer 11: 6 April, 1973
Voyager 2: 20 August 1977
Voyager I: 5 September 1977

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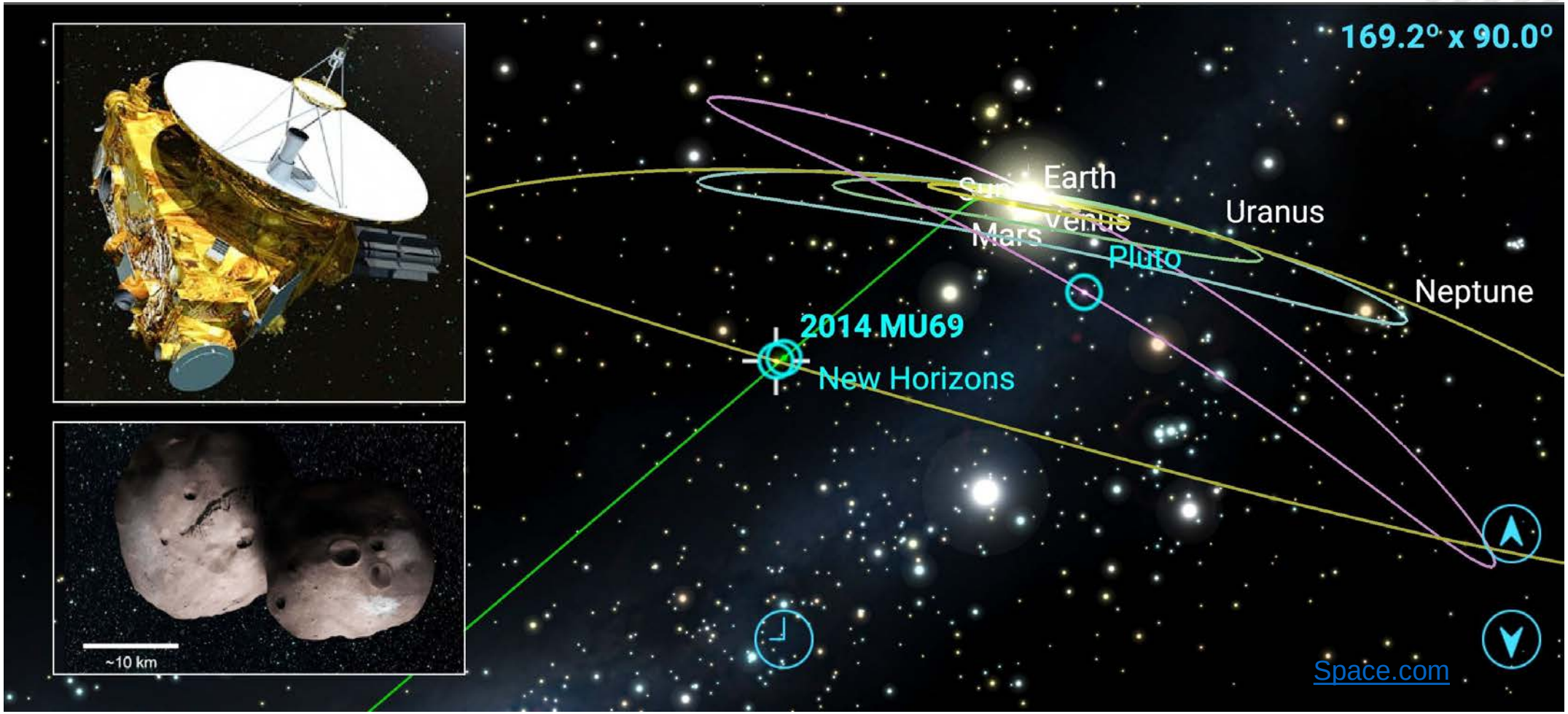
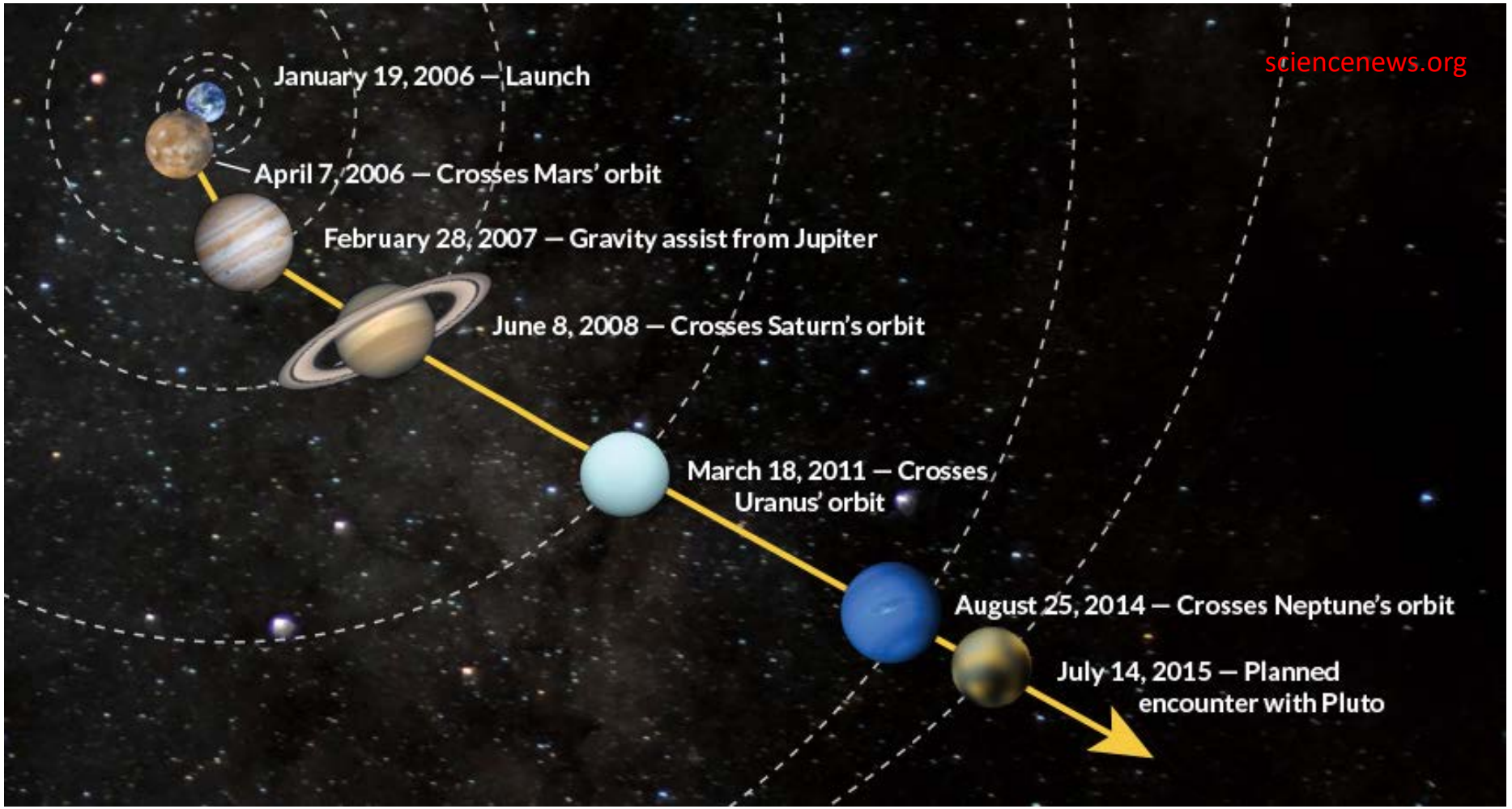
New Horizons (Moons of Pluto)




January 19, 2006 — Launch
April 7, 2006 — Crosses Mars' orbit
February 28, 2007 — Gravity assist from Jupiter
June 8, 2008 — Crosses Saturn's orbit
March 18, 2011 — Crosses Uranus' orbit
August 25, 2014 — Crosses Neptune's orbit
July 14, 2015 — Planned encounter with Pluto
sciencenews.org

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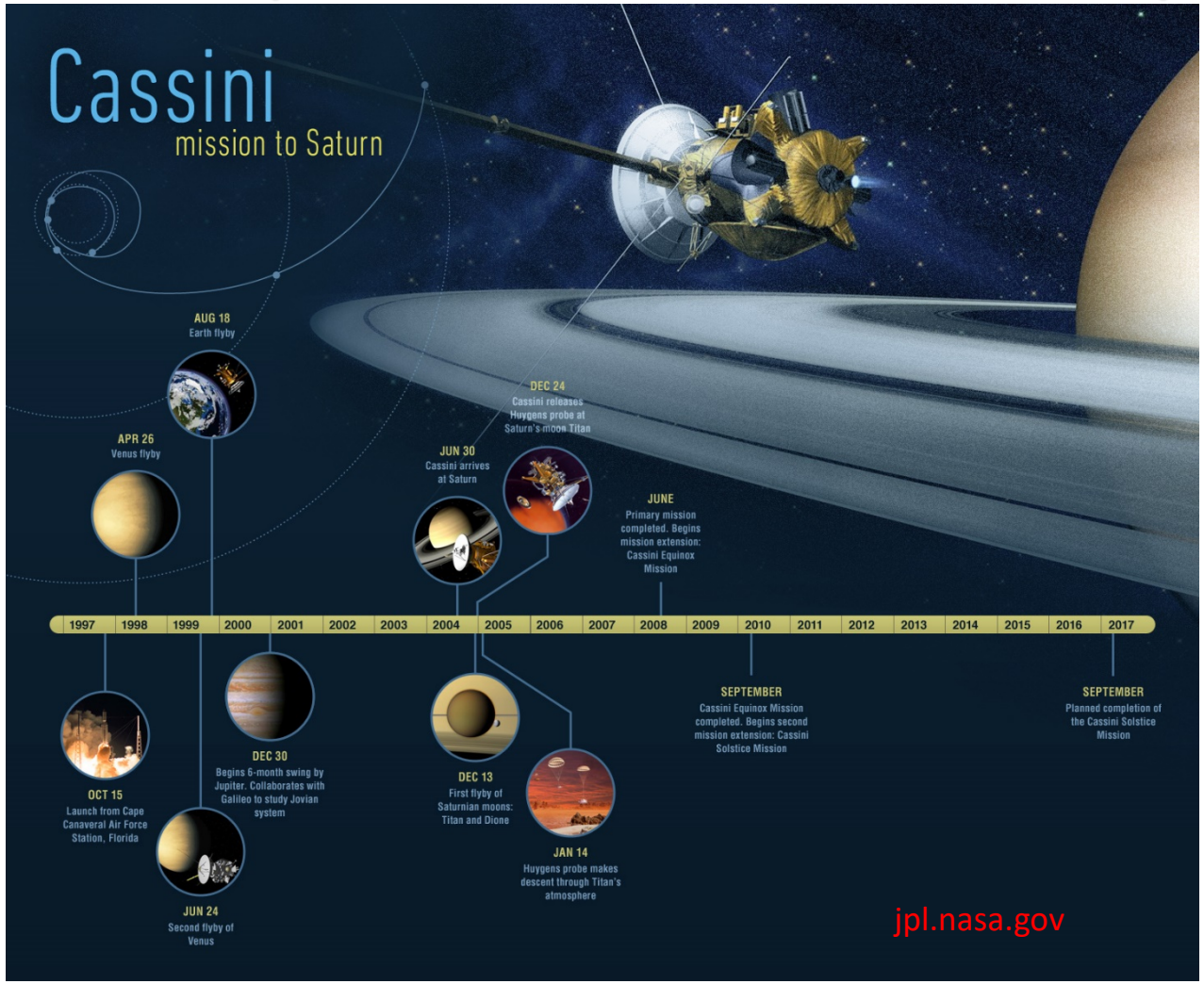
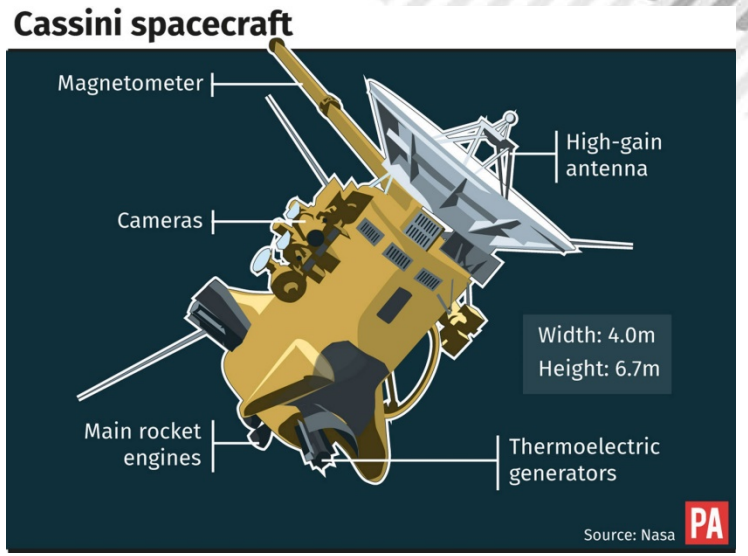
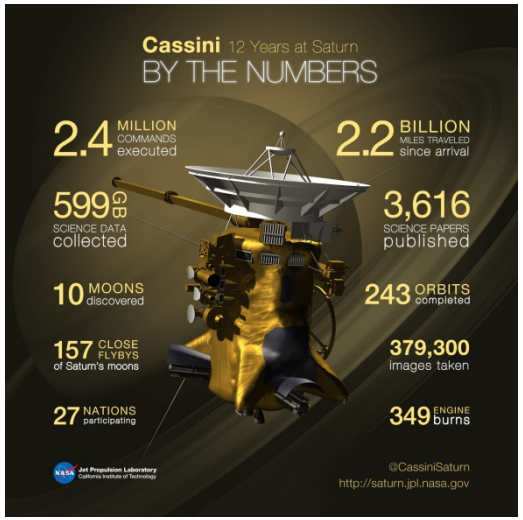
Cassini (Nasa/ESA/ASI - Saturn)

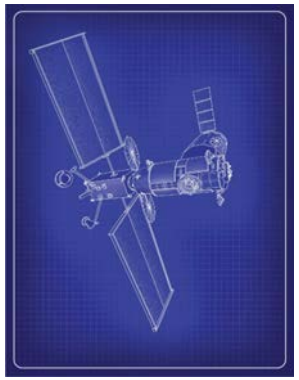






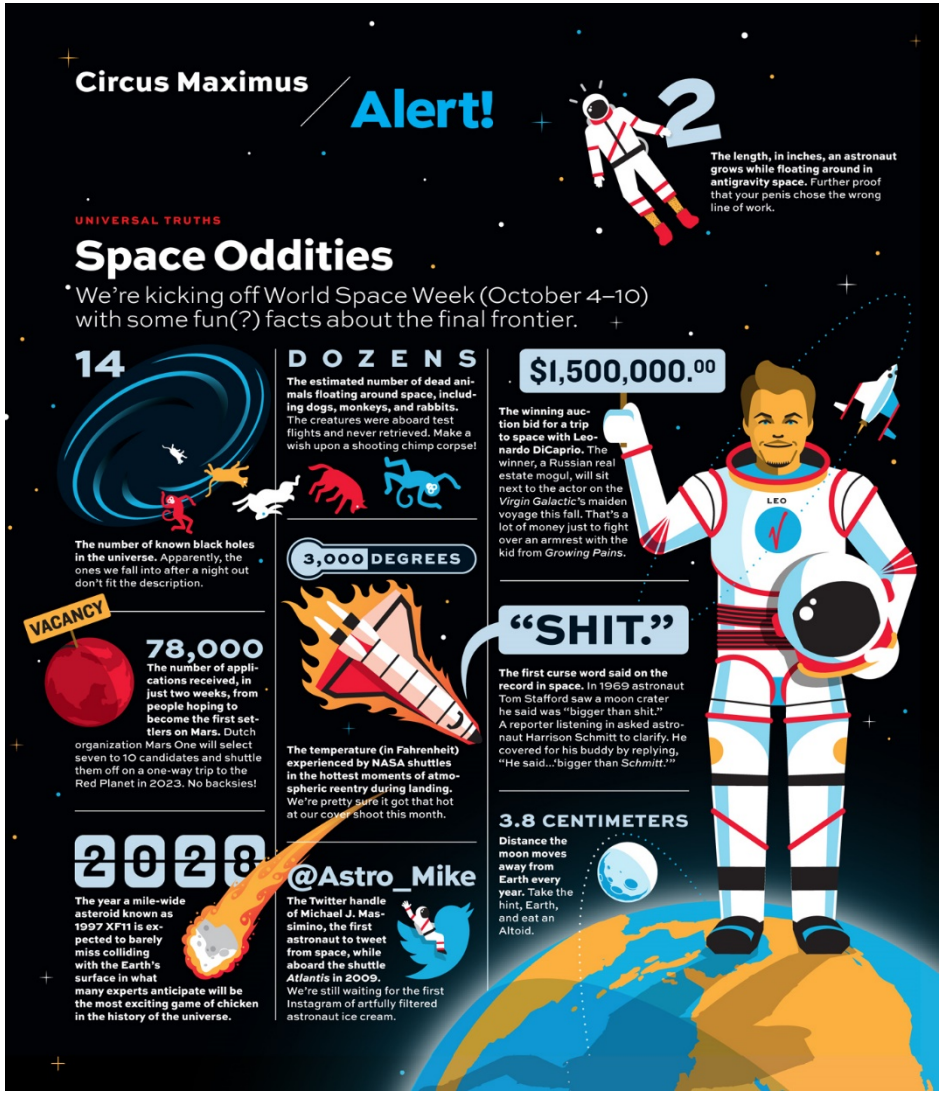
Future missions

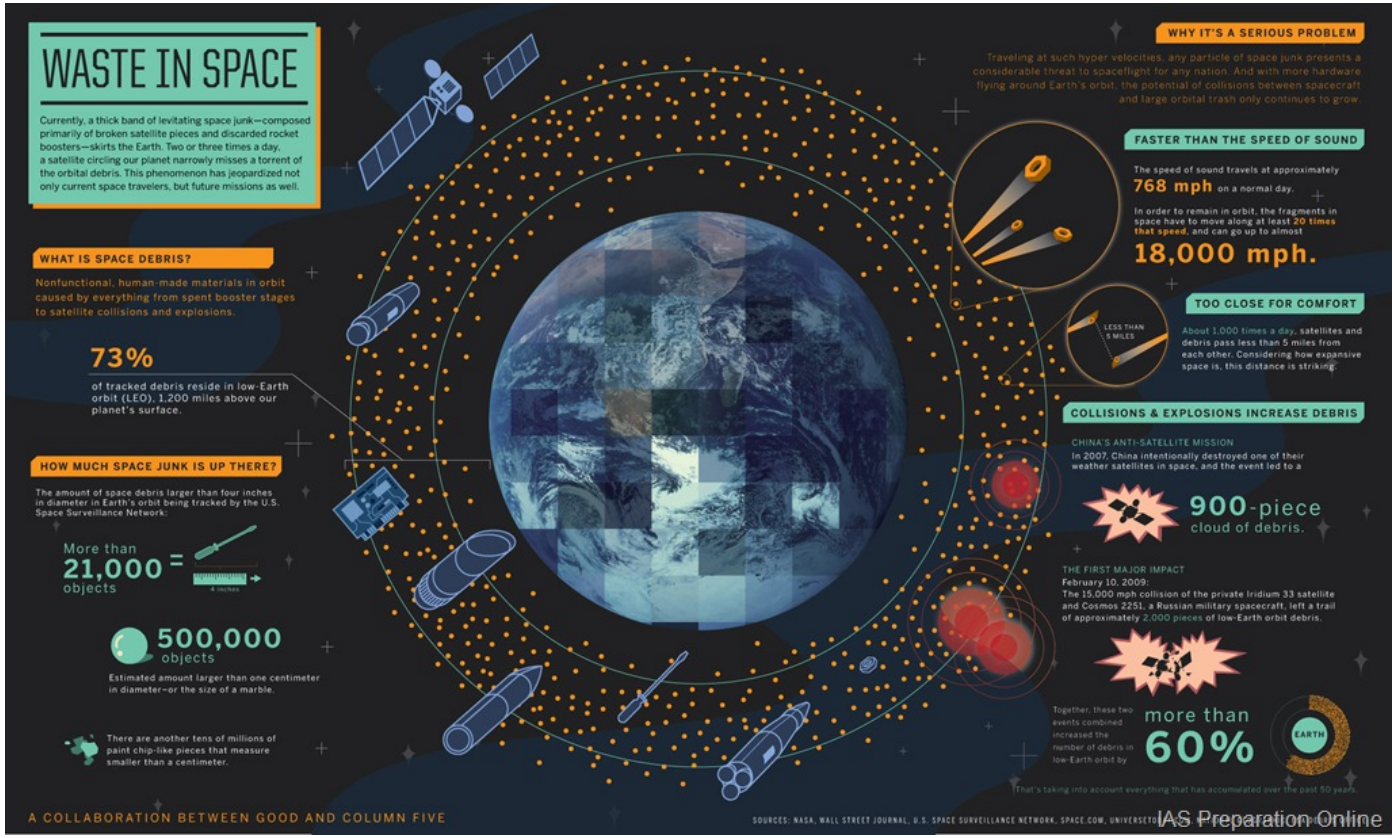
- The *Artemis program*, with which NASA plans to create a lunar base. This base will be the starting point from which missions will launch, so as to explore Mars or other planets.
- https://www.nasa.gov/specials/artemis/



Concerns / Space Debris

- Space exploration has been and will always be a great motivation for humanity. Technological advances, which have significantly changed our lives, were developed thanks to the knowledge space exploration has provided (e.g. advances in the domain of safety (collision avoidance system), to the domain of health-CAT scan, to the domain of energy and to the environment-solar energy etc.).
- However, the (large) amount of space debris on the Earth's orbit has increased. This can be considered a result of the deliberate destruction of space objects - such as the collision of the Russian Cosmos 2251 and of the Iridium 33 satellite, as well as the destruction of a Chinese weather satellite.





- The only thing we know at the time being, is that there are plans to launch many more "smallsats“ in the future. This plethora of small satellites, which are deployed at a particularly low orbit, raises concerns about the orbital congestion and the existence of space debris. In addition, the theoretical scenario of “**Kessler syndrome**” is likely to occur.
- A brief description of the scenario mentioned above is the situation wherein the density of objects in the Low Earth Orbit grows so high that collisions between two objects could cause a massive cascade, which would prevent human space activities in the future!

- In order to prevent the creation of new space debris, the active removal of the existing ones appears to be increasingly important.

- However, the removal of space debris faces numerous challenges, not only economic, but also technical and “regulatory”.

Dangers of space travel

- Dangers during the launch process (burning fuels and trying to escape Earth's gravity).
- Cosmic and solar radiation (extremely dangerous for human health).
- Collisions with space or man-made objects.
- Spaceflight accidents and entrapment in space.
- Fossil fuel depletion.
- Earth reentry procedure (Atmospheric entry = friction burn and ground collision).

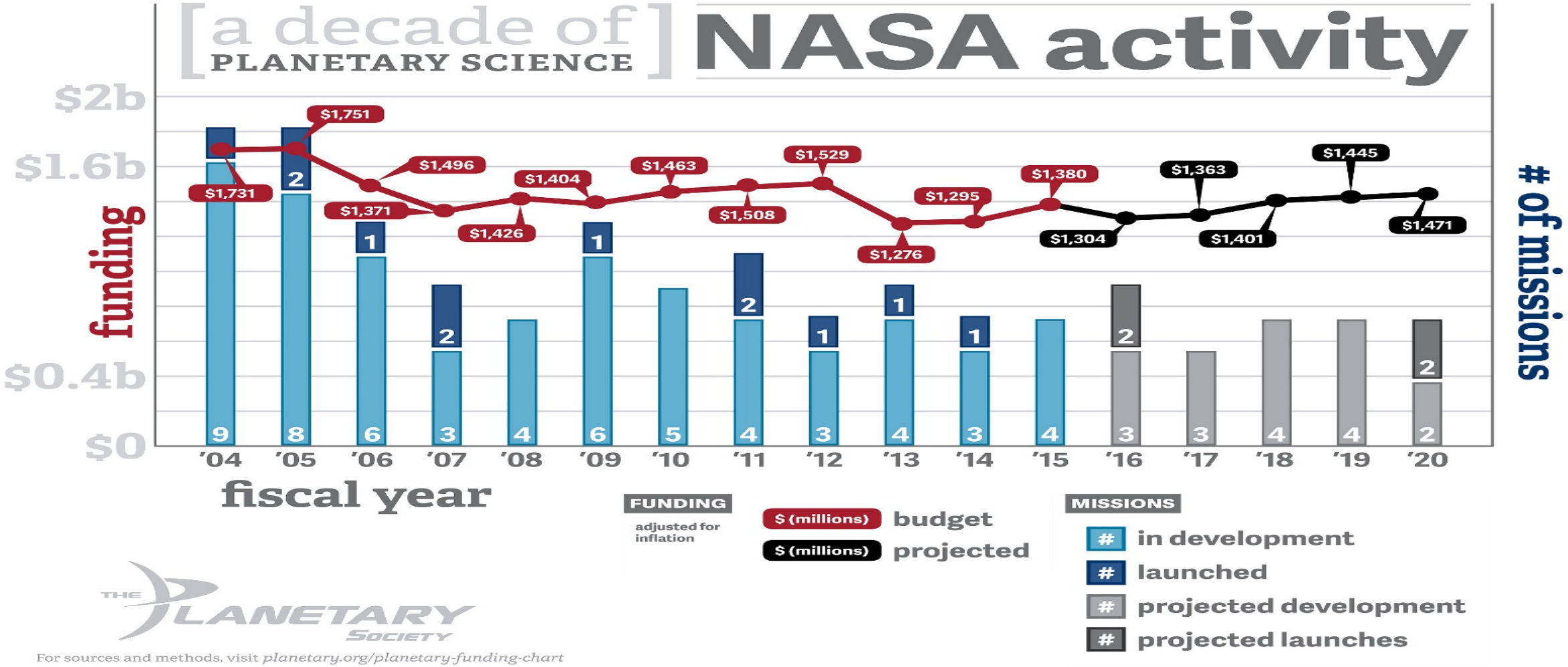
Physical and mental signs of stress

- Due to microgravity
  - Muscle atrophy
  - Deterioration of the skeleton
  - Slowing of cardiovascular system functions
  - Eyesight disorders

- Due to limited space
  - Isolation and confinement
  - Limited company
  - Air quality.

The Human Body in Space

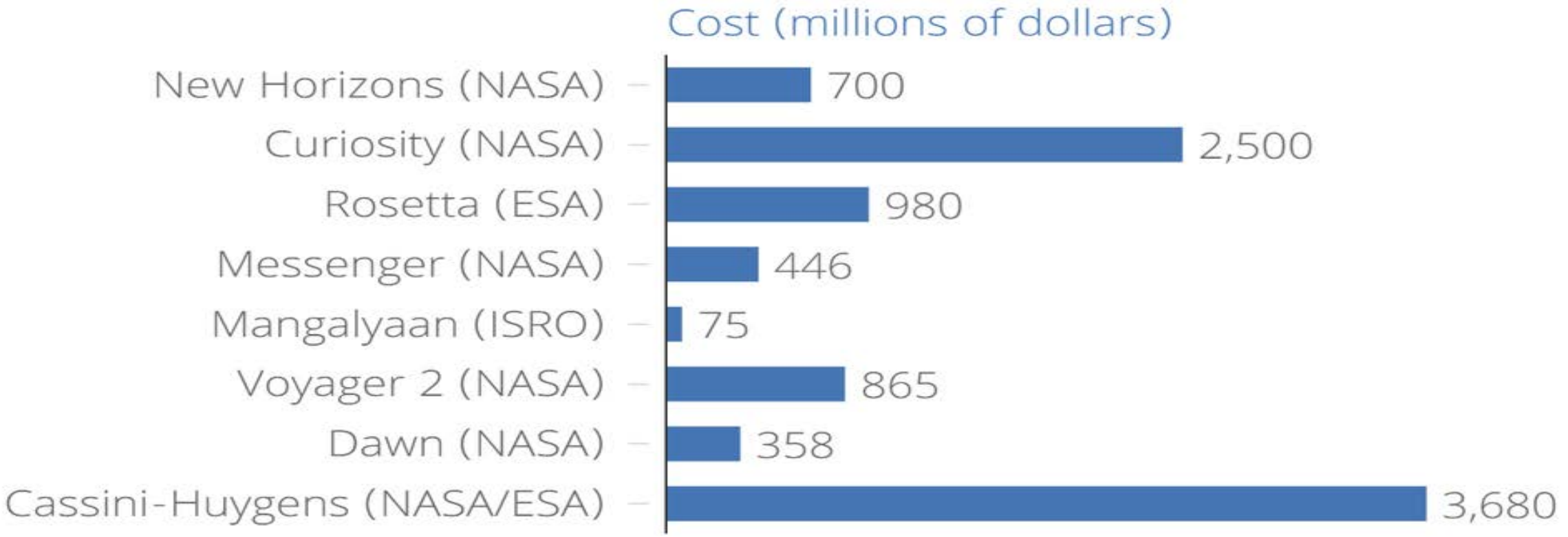
The cost…



THE PLANETARY SOCIETY

For sources and methods, visit *planetary.org/planetary-funding-chart*

Cost of Solar System Missions



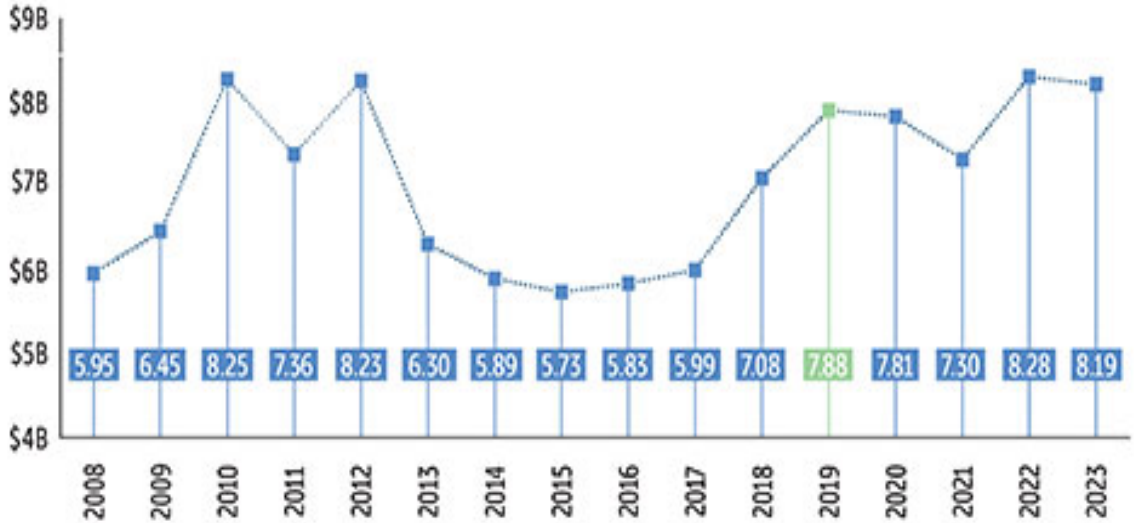
Made with Chartbuilder

Data: NASA, ISRO

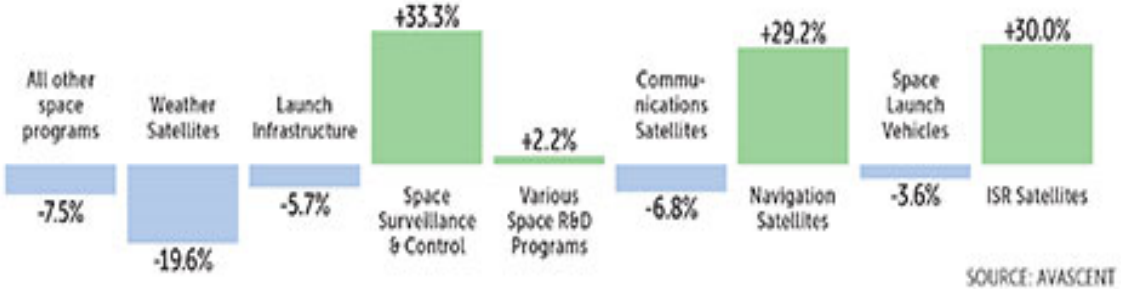
DoD SPACE BUDGET

The U.S. Defense Department's 2019 budget request includes an estimated $7.88 billion for unclassified space programs, according to Jacques & Associates. Space, according to Avascent, likely receives the biggest share of DoD's estimated $43 billion classified budget.

Total unclassified DoD space budget for FY-19: **$7.88B**



COMPOUND ANNUAL GROWTH RATE, 2017–2023 PER TECHNOLOGY



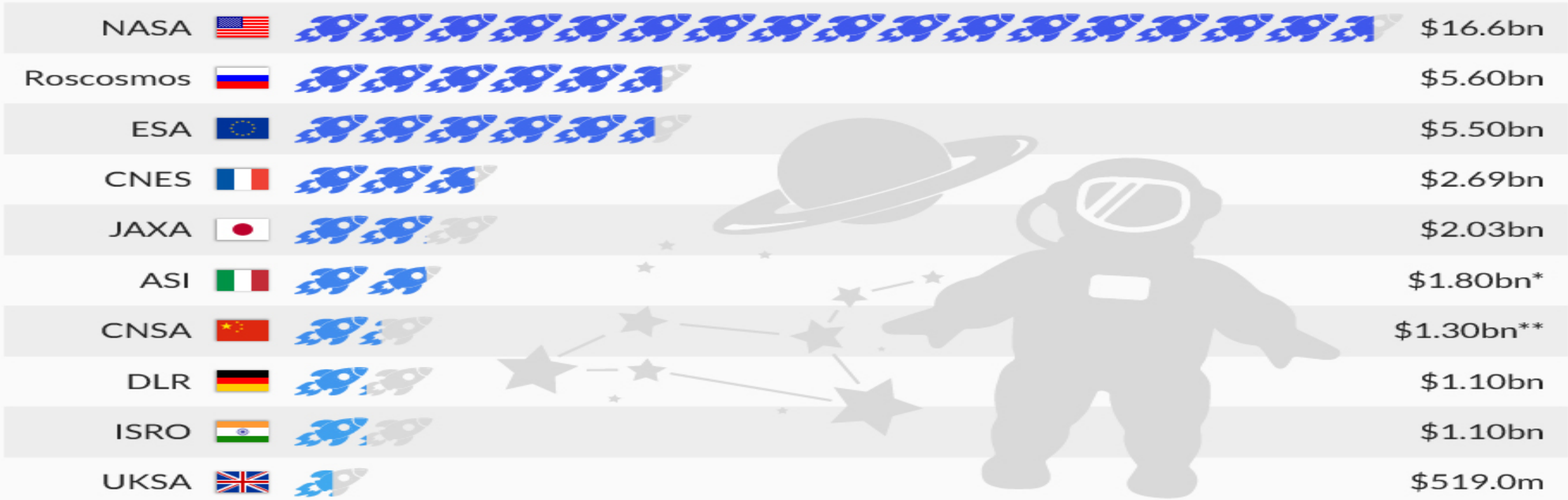
SOURCE: AVASCENT

BUDGET BY MILITARY DEPARTMENT

SOURCE: JACQUES & ASSOCIATES

The World Trails NASA in Space Exploration Expenditure

Annual budgets of international space agencies in 2013



*2014
**estimate

Sources: Respective space agencies

The project has been funded with the support of European Commission within ERASMUS+ program

„Space exploration”

Material for teachers
With methodological guidelines, a lesson plan and an answer key to worksheets

The educational package " Space exploration " was developed within "Oxford debates for the education of young people in the field of mathematics and science" project.
It is a key material, facilitating the achievement of primary project goals, including increasing reasoning skills and interest in STEM, which in the future may result in taking up a scientific career.
When preparing students for the debate, one should not neglect the development of such skills as: communication excellence, argumentation or public speaking. Students should improve their ability to persuade effectively, argue properly, reason accordingly and speak out correctly. Composition of texts, using rhetorical means in oral statements, speaking in accordance with the rules of language culture, text interpretation, public speaking and presentation of texts, discussions and negotiations are of equally high importance.
In order to achieve the abovementioned goals, the implementation of thematic educational packages should be preceded by classes dedicated to preparation for debating as such. This can be accomplished in consultation with teachers of other subjects and the class teacher. The development of basic communication skills can be included in the class teacher's work plan, and the prepared lesson plans can be used during regular classes. Auxiliary materials can be found in the following documents:

1. **Warm up practice** – Annex No 2 to National frameworks for implementation of Oxford debates in STEM in school practice ;
   This document includes the following exercises: active listening, public speaking and debating skills.

2. **Lesson plans aimed at general development of debating skills** – Annex No 2 do National frameworks for implementation of Oxford debates in STEM in school practice ;

   This material consists of 7 lesson plans prepared by Dr. Foteini Englezou, president of the Hellenic Institute for Rhetorical and Communication Research. Scenarios are a guide to work. It is not necessary to follow all the lessons. The teacher can decide which scenarios (or their selected fragments) are most useful for working with a specific group of students. The document offers the following lesson plans:

   1. Communication skills
   2. Express your scientific argument, not your opinion
   3. Build a valid scientific argument
   4. Searching for evidence
   5. Enhancing students’ linguistic skills
   6. Rebuttal and refutation
   7. Fallacies

3. Methodological Guide for Teachers. ODYSSEY: Oxford Debates for Youths in Science Education

The final stage of preparation for debates based on specific packages is to familiarize students with the principles of debating, described in detail in the abovementioned document.

Space Exploration

The "Space Exploration" educational package consists of the following elements:

- Multimedia presentation;
- Video- recording based on the presentation;
https://www.youtube.com/watch?v=r2c7lrSPN7Y&list=PLfqrEdpFjt1d_463n3BVM5TtwmyFSmIkz&index=7
- Educational package "Space exploration" - material for students;
- Worksheets (the same for all packages);
- "Space Exploration" - material for the teacher (with answer key).

It is recommended to implement the package during a minimum of three lesson units.

2019 marks the 50th anniversary of Apollo 11's giant leap to the moon. Lunar exploration is no longer the domain of NASA alone. Several governmental agencies, such as ESA (Europe), JAXA (Japan), CNSA (China), FSA (India), are already “on the run”. Commercial agencies (such as Space X, Amazon, Virgin etc.) have big plans for the future. Those plans include missions to the moon, to Mars and the exploitation of asteroids. In the upcoming decades we will experience the building of a robotic village, new manned missions to the Moon. In the upcoming decades we will see the construction of a global robotic village, new manned missions to the Moon, greater development of near-space applications (research on the International Space Station/ISS) and the development of small satellites (nanosatellites' constellation, etc.). At the same time Mars as well other planets able to support human life, will probably be colonized. The Space Services Department and the stakeholders have arleady begun to collaborate on the filed of research (e.g. on the history of the solar system well as on the human adaptation to the conditions of space), on innovative technical applications (e.g. robotics and 3D printing), promoting the concept of global cooperation.

The purpose and objectives of the present lesson plan follow the Curriculum Planning Principles of secondary education. They are essential for the overall development of students' personality and their evolution to active citizens of tomorrow, since they focus on the cultivation of basic knowledge, attitudes and skills. The school’s role is important for the cultivation of such skills, since they contribute to the development of critical thinking as well as the interpretation and processing of data. That way students will have an active role in decision making, concerning not only their future life quality, but also the concept of sustainable development. Students’ education should not be limited to the passive transmission of knowledge, but instead, it should be focused to their active participation and to the application of the knowledge acquired, in real life problems

Lesson 1. An Introduction to Space Exploration

1. The introduction that takes place during the first didactic hour emphasizes the importance of Space Exploration and presents the reasons why one should decide to invest in this perspective. In which of the problems that mankind already faces (or future generations will be expected to face) does space exploration have the answers to? The need for additional natural and energy resources (which are not renewed as quickly as they are consumed by human beings), the need for additional habitable zones due to the rapid growth of population as well as the need for greater food production, are emphasized. In addition, the dangers both astronauts and their missions face while being in space and the cost of space exploration should also be mentioned.

Lesson 2. Should mankind invest in the exploration of space? Constructing arguments for and against the resolution

The aim of the second lesson is to formulate as many arguments as possible (both for and against the resolution) that will be used by students during the debate, summarizing the work with the package.

Lesson plan

1. Organizational issues, checking the attendance list, familiarizing with the topic and objectives of the lesson **[5 minutes].**
2. Preparation of arguments: The teacher divides the class into teams of two. Each team receives **12 question cards** available in the educational package (materials for the student) and 2 copies of worksheet No. 1 (one for each student individually). Based on the questions, students formulate arguments for the presented thesis, against the thesis and those that are debatable and can be used in the discussion by both parties. Students work together, but each student individually completes his/her worksheet. There are examples of selected arguments for worksheet 1 are in the answer key. **[25 minutes]**
3. **Teams: proposition and opposition are formed [10 minutes].**

Team selection may be executed in 2 forms, each of them having both advantages and disadvantages.

A) Students declare which arguments are closer to their beliefs. The teacher divides the class into teams (each with a similar number of students) in the manner reflecting their convictions.

B) The second method assumes a division similar to the one above, with the difference that ultimately the team consisting of the supporters of a given resolution becomes the "opposition" team, while the opponents of the thesis become “proposition” team. The supporters of such a division assume that it teaches the participants of the debate to a greater extent to use arguments supported by facts and is less based on emotions. Alternatively, division into teams can also be done randomly.

Finally, team selection can also be made by the teacher in a subjective way, ensuring that each team has both leaders and students who require more help, so that both teams have similar “winning potential”. In order to save time for division, the teacher can do it at the beginning of the lesson, for

example by distributing worksheets number 1 to the students, printed on sheets of different colour or marked in some other manner.

1. The teacher distributes worksheets number 2 to the students (one for each student) and explains the homework. An example of a filled-out worksheet is available in the answer key.
2. Students in each team read prepared arguments in accordance with the assignment to a given group. Each student receives 1 argument, which he/she will develop (as homework) according to the guidelines in worksheet No.2.
3. Each team also appoints 3 people who will present the arguments prepared by the entire group. Students decide the order of their speeches. During the debate, other team members who are not directly involved in the debate, fill out worksheet
4. Summary of the lesson, evaluation of students' work **[5 minutes].**

Lesson 3. Debate

During the final lesson, the teams conduct a debate according to the guidelines contained in the " Methodological Guide for Teachers. ODYSSEY: Oxford Debates for Youths in Science Education".

It takes 45 minutes in total to conduct a full debate. During the debate, the teacher does not comment on the arguments or indicate the fallacies made by the students on an ongoing basis.

An exercise-based debate should be structured as follows:

1. Opening of the debate by the moderator/chairperson [3 minutes].
2. Initial vote by the audience [2 minutes].
3. 1 st Researcher-Debater of the A research-team: Constructive Speech [4 minutes].
4. 1 st Researcher-Debater of the B research-team: Constructive Speech [4 minutes].
5. Cross-fire between the researchers-debaters (1) of both research teams [3 minutes].
6. 2 nd Researcher-Debater of the A research-team: Rebuttal Speech [4 minutes].
7. 2 nd Researcher-Debater of the B research-team: Rebuttal Speech [4 minutes]
8. Cross-fire between the researchers-debaters (2) of both research teams [3 minutes].
9. Preparation time for the Summary and Final Rebuttal by both research teams [2 minutes].
10. 3 rd Researcher-Debater of the A research-team: Summary Rebuttal [2 minutes].
11. 3 rd Researcher-Debater of the B research-team: Summary Rebuttal [2 minutes].
12. Grand Cross-fire between the researchers-debaters (1 & 2) of both research-teams [3 minutes].
13. 3 rd Researcher-Debater of the A research-team: Final Focus Rebuttal [2 minutes].
14. 3 rd Researcher-Debater of the B research-team: Final Focus Rebuttal [2 minutes].
15. Final vote by the audience / Short written feedback [3 minutes].
16. Presentation of the results by the moderator [2 minutes].

If the debate takes place during extra-curricular activities, then it is recommended to devote, for example, 90 minutes for this part. This will allow you to prepare the room for the debate, recall the rules, conduct the debate and discuss its course and finally evaluate the work of students.

In terms of classroom conditions, it would be ideal to allocate two adjoining lesson units to the debate. Taking into account the school circumstances, organizational difficulties and the inability to devote too many lessons to content extending the core curriculum, the debate can be conducted in one lesson, while maintaining high discipline in time. In this case, it is recommended that during the next lesson with the class additional 10 minutes are spent discussing the debate, pointing to strengths and mistakes made by the participants of the debate.

In this format, 6 students (3 from each team) actively participate in the debate. The teacher may also appoint a moderator from among the students and a time keeper. The rest of the students will receive worksheet number 3. Their task will be to listen carefully to the debate and to note the opposing team's strengths and areas for improvement, and to justify their choice. Completed worksheet no. 3 may be the basis for issuing a grade for activity in the lesson for students who did not take part in the debate directly, but participated in its preparation and were active observers of its course.

The projest has been funded with the support of European Commission within ERASMUS+ program

Worksheet No 1 – Questions and indicative answers

The educational package contains a set of questions to help prepare arguments for discussion on the resolution. On their basis, prepare a set of arguments and group them into those that are clearly in favor of the resolution, against the resolution, and those arguments that can be used by both teams. Write them down in the appropriate parts of the table.

FOR	„GREY AREA"	AGAINST
Has space technology contributed to real life applications? Yes, in many domains: GPS system development, Galileo system development, new materials, 3D printing, power generation (photovoltaics), recycling and water purification technologies etc. (see SC 2,5,7,8). Research on microgravity (in ISS) is also underway, searching for new applications in technology, medicine, etc. (See IC.2, KI.7) **Does space exploration have a high cost after all?** Indeed. The amounts are huge. However, the benefits are expected to be equally huge. Colonies, raw material extraction, energy production etc. are some of the benefits. After all, huge amounts are spent each year on research and production of military material. (See IC. 6,10,12,13) **What benefits derive from space exploration for the humanity?** The extraction of raw materials, especially minerals which are not easily found on Earth, motivates many companies so as to invest. The moon as well as many	**Are there any 'counter-measures' for the confrontation of space debris?** Although this is an age-old problem, nowadays technologies and solutions, which are both cheap and applicable, are being developed and tested. The basic idea of these applications is either to collect the fragments with nets and / or to propel the fragments into the earth's atmosphere (so that they will burn upon the re-entry procedure due to friction). (See IC7) **Can the creation of a legal framework supporting international cooperation in the near space, be considered an immediate goal?** The status quo of the 1967 International Convention, concerning the Moon and its minerals, supports that those are common heritage of mankind. The spirit of the Treaty lies in the so-called 'nonarmament', but, given the challenges of our times, it must be updated / supplemented, while efforts are being made towards this direction (See SC 9). **Which is the future of space tourism and where can it lead?**	**Does space travel have an impact on astronauts' health?** Yes, and in fact a negative one. Space travel affects both physical / biological functions (e.g. deterioration of the skeleton and muscle atrophy) and psychological ones. (astronauts living 'in isolation' for ~ 6 months. (See IC 2,5,8,9) **Could unpredictable consequences (e.g. from crashes or inactive space devices) be caused by the existence of artificial satellites, which would be disastrous for our planet in the long run - threatening mankind's future?** There are way many space debris and from sheer luck catastrophic events haven't yet happened. A typical example is the uncontrolled decline of the Chinese space station Tiangong-1 in April 2018 - where it fortunately fell into the sea, given the fact that its fall was uncontrollable. (See IC. 7,8, SC 4)

asteroids are the main focus of many companies which are investing in this domain. (See IC 6)	Spacex, Virgin Galactic, Blue Origin, RosCosmos, Boeing, OrionSpan are some of the companies which are already organizing, advertising and implementing space travel. However, the cost is really high for the time being. (See IC 14) **Can space militarization have a positive impact?** Military research has led to the creation of GPS, which has revolutionized the 'fixed and independent' identification of any spot and position on the Earth's surface. (See IC4) **Which planets are considered potential destinations for the creation of the first human colonies?** Mars has been the main focus of international space research for many years. It can be used as an alternative to our solar system. Australia's Coober City is currently the space analogue of Mars (See IC.12) **Are there any plans for moon colonization?** Water discovery on the south pole of the moon in 2009 changed all data. NASA, through the Artemis program is preparing the rover Viper in 2020 to conduct investigations. In 2024 it is expected to send the first woman and one more man to the moon. (See SC 10)	**Could there be consequences from the increased spaceflight - at a time when we are even seeing reusable rockets?** Indeed, the existence and the devastating effects of space debris can 'ban' human access to space (Kessler Syndrome). Studies are being carried out by the international organization in order to collect them. (See IC 7.8, SC 4)

Worksheet No 2 – examples of argument

Based on the materials provided by the teacher, prepare arguments for discussion. One group of students prepares arguments supporting the resolution, the other one - opposing arguments. Use the proposed template.

ARGUMENT nº 1

Argument with reasoning	Foreseen rebuttals of the other group	Answers to rebuttals
Space research (while a space mission is being designed and prepared) has enabled the invention of certain applications, such as the advanced prosthetic technology and has led to better and more efficient magnetic resonance imaging (fMRI). (See IC 8)	The negative effects of space travel conceal serious dangers. We know that space travel leads to the muscle atrophy of astronauts staying on the ISS for 6 months while their immune system is "suffering". In addition, they live in isolation, something that has a serious impact on their psychology. Furthermore, the danger of an accident - such as the Challenger disaster- is always lurking. (See IC 2,5). Many investigations have been funded with secret funds for military applications. War systems (such as Almaz) are a constant threat to the citizens security across the Earth. Once they go up, they stay there! (See IC 4).	Astronauts stay in space for a short time, and changes in their muscles or DNA are reversible. However, the results of their research, under the ISS microgravity, are truly innovative, enabling the potential to immediately apply this new knowledge: e.g. production of new ceramic materials, new semiconductors (See IC 5, SC 7) Military research, however, has led to the development of applications, such as the GPS, that have definitely contributed to the creation a better and safer world. We should also not forget that every state has its inalienable right to defense and protection. (See IC4, S.2,5)

ARGUMENT nº 2

Argument with reasoning	Foreseen rebuttals of the other group	Answers to rebuttals
Despite the fact that space missions are expensive, the (economic) balance of space research is positive. However, thanks to of the creation and findings of those missions, technologies, which have reduced the cost of producing materials and have improved the life quality of many citizens, are now available. Photovoltaic panels, water purification systems and 3D object printing are some of the examples. (See IC 12,13, SC 8)	However, space missions and satellite systems have created an enormous amount of space debris. The countermeasures that are developed for the collection or destruction of space debris can be considered equally expensive space missions. We pay (at least) twice for each mission. (See IC7)	Yes, there are programs destructing and / or collecting space debris that are much 'cheaper', since the size / weight of space devices (something that also determines the mission's cost) is much smaller. In fact, when those programs will be fully implemented, a single mission will be able to send dozens of such space devices, operating continuously. The amount of space debris will be reduced very quickly in the near future (See IC 7).
	We are also seeing space services partner up with private sector companies, which promise many things at a low cost. This can lead to an economic disaster in the future. (See IC 3,4,9).	Certain companies have provided many opportunities by developing innovative technologies and by having a clear vision. Space X for example, has built the Falcon 9 rocket, which can be reused even in the time being (2019). In fact, some companies have also prepared a solar-powered mission (something which was discussed a few years ago only as a sci-fi scenario). In addition, international laws define their involvement and cooperation boundaries, in the near future (See IC 3,9).

ARGUMENT nº 3

Argument with reasoning	Foreseen rebuttals of the other group	Answers to rebuttals
The constant growth of the earth's population as well as the current technological evolution, have improved the individual's living conditions. If medicine achievements carry on, two major accomplishments will take place: the reduction of mortality rate and the increase of the average life expectancy. These undoubtedly positive achievements will eventually lead to overpopulation. Consequently, individuals will have to deal with dwelling and nutrition problems. Space exploration is about to come up with the solution to each and every one of those problems. Space colonization is related to the prementioned facts. Water discovery on the south pole of the Moon, the Artemis program development as well as the unmanned Curiosity and Insight missions which aim at exploring Mars, indicate that humanity is looking at space exploration with the ultimate goal of space colonization for resolving the problems on Earth (See SC 10).	The cost of all those ventures is really high and the results are uncertain. Part of those funds could be used to solve certain environmental problems that our planet is currently facing or to increase food production. Global warming and the consequent shrinking of Antarctica's sea ice, are causing the problem of climate change that has major impacts to both our planet and humanity in general. It seems advisable to invest money so as to solve these major problems, and consequently prevent a potential catastrophe, improve our planet's living conditions and enable the preservation of many species, rather than investing billions of dollars in something like space exploration (See IC 12). The scientific knowledge we can derive from the planet itself, especially from organisms that survive in areas with extreme conditions (deserts, Antarctica, abyssal plains, etc.), can provide valuable and essential information that humanity	The natural resources of earth that can cover the needs and demands of the constantly growing population are of a finite number. Soon enough arable lands will not suffice for food production. Consequently, in order to optimize production, we will focus on genetically modified products, pesticide use, etc. All the above will have severe consequences for both the individual and the environment. As a result, the space exploration and the achievement of space colonization seems to be, probably, the only solution for the humanity in the future.

	can immediately use, comparing to the ones coming from the space exploration process. https://www.the-ies.org/analysis/exploring-submarine-volcanoes	

The projest has been funded with the support of European Commission within ERASMUS+ program

Worksheet no. 3

Name and surname: ……. Class……. Team: Proposition/Opposition

During the debate, hear and observe carefully the speeches of the debates from the other team. Then, evaluate which speech convinced you the most and which areas of your opponents' speech should be improved.

---

1. In terms of **argumentation (**e.g. the quality of the arguments presented, credibility of the data and scientific evidence) in the rival team I was most convinced by the speaker No. .....

Reason:

……

……

……

……

……

2. In terms of **the style of presentation and communication with the audience** (e.g. confident, persuasive, authentic and dynamic posture, moderate gestures, assertive voice variety, good eye contact with the audience, use of moderate humor, friendly and professional approach to all participants, effective use of body language) in the rival team I was most convinced by the speaker No. .....

Reason:

……

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Indicate the element of the rival team's performance that requires improvement. Justify your answer.

.....

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Reason:

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