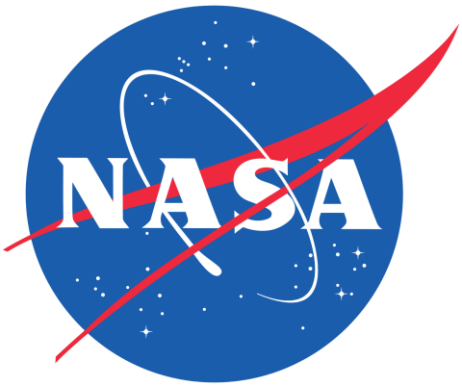

NASA's Space Exploration and Earth Based Mission's Funding Comparison Under the Obama Administration

by

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Abstract

This thesis will focus on how Congress's decisions influenced NASA's programs in Space exploration. The factors that will be examined are the budgetary process and bills. Another factor that will be examined is NASA's growing partnership with Commercial Space Industries due to Congress's push towards new forms of handling with space programs. A comparison will be made between Earth related/practical programs and exploration/discovery programs.

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Chapter 1: Introduction

"Earth is the cradle of humanity, but one cannot live in a cradle forever."
— Konstantin Tsiolkovsky

Thesis: NASA is more likely to undertake and fund Earth related/practical programs rather than exploration/discovery programs.

This paper will seek to demonstrate the validity of the above thesis. It must be noted that not all Congress members share the same interest in NASA's programs. There has been much debate in Congress over which programs should be funded whether they are Earth related/practical or exploration/discovery programs. On both sides of Congress there are mixed views of which programs take priority. There is a higher interest in space exploration for the Republicans but a severe lack for Earth related/practical programs. While in the Democratic side the Congress people are more focused on Earth related/practical programs with interest to space exploration.

This thesis will try to see which point of view has won the argument. There is a lot of back and forth between Democrats and Republicans on which program has higher priority and thesis is going to explore which point prevails.

Furthermore, this thesis will focus only on the years of the Obama Administration. The specific years' budgetary analysis will be 2011 to 2016. The reason why I will begin in 2011 and not 2009 is because the Obama Administration did not truly begin leaving their budgetary prints on NASA's programs until 2011. In 2009 and 2010 NASA's programs were still under the proposal and plans of the Bush Administration. Also, the analysis for the stand-alone bills will be analyzed from 2009 to 2016 because President Obama was able to direct the enactment of such bills once he was inaugurated President.

NASA Mission Statement:

NASA's mission statement begins with laying out its overall mission, which is to "reach for new heights and reveal the unknown for the benefit of humankind."[1] NASA lays out its four main focuses on how it will accomplish its mission. They are as follows:

1. *Aeronautics*: Focuses on managing "research and focuses on meeting global demand for air mobility in ways that are more environmentally friendly and sustainable, while also embracing revolutionary technology from outside aviation." [2]

2. *Human Exploration and Operations*: Focuses on managing the "International Space Station operations, development of commercial spaceflight capabilities and human exploration beyond low-Earth orbit."[3]

3. *Science*: Focuses on exploring the "Earth, our solar system and the universe beyond by charting the best route of discovery and reap the benefits of Earth and space exploration for society." [4]

4. *Space Technology*: Focuses on prospects to "rapidly develop, innovate, demonstrate, and infuse revolutionary, high-payoff technologies that enable NASA's future missions while providing economic benefit to the nation." [5]

Defining Earth Related/Practical and Exploration/Discovery Programs:

To test my thesis, I will be defining space exploration/discovery and Earth related/practical programs.

- Earth related/practical programs are defined as those which are primarily earth focused such as:
  - Building and launching of satellites around the Earth
  - Space tourism
  - Payload/human launches to the International Space Station (ISS)
  - Earth observation studies and Earth focused experimental programs.

- Space exploration/discovery programs are defined as those, which are primarily focused on investigating outer space using, manned and unmanned spacecraft's beyond low Earth orbit.

[1] Wilson, Jim. "What Does NASA Do?" NASA. NASA, 29 Jan. 2015. Web. 18 Mar. 2017.
[2] Wilson, Jim. "What Does NASA Do?" NASA. NASA, 29 Jan. 2015. Web. 18 Mar. 2017.
[3] Wilson, Jim. "What Does NASA Do?" NASA. NASA, 29 Jan. 2015. Web. 18 Mar. 2017.
[4] Wilson, Jim. "What Does NASA Do?" NASA. NASA, 29 Jan. 2015. Web. 18 Mar. 2017.
[5] Wilson, Jim. "What Does NASA Do?" NASA. NASA, 29 Jan. 2015. Web. 18 Mar. 2017.

Space exploration programs involve robotics, humans, and probes sent to other space bodies for the purposes of increasing knowledge of space and ensuring the survival of humanity.

My thesis will demonstrate that when we examine the definitions we will see the differences in the programs NASA undertakes and how there is a major difference in the priorities taken when Congress funds the programs. NASA began with a mission of discovery and exploration but in recent years they have been doing more Earth related/practical missions because it is cheaper and has quicker results than exploration/discovery programs.

Chapter 2: Explanation of NASA Programs

I will be examining the programs that NASA is funded for based on how Congress divides them in their Appropriations bills. The Appropriations bills are where NASA receives their budgeting every year.

The main programs cited under the appropriation bills are as follows:

- **Space Operations**: This program provides NASA with leadership and management related to human exploration in and beyond Low-Earth orbit. However, its primary focus has always been overseeing low-level requirements development, policy, and programmatic oversight. Another main focuses are in low-Earth orbit specially the Space Shuttle, International Space Station programs and space & flight support.[6]
    - *Space Shuttle:* The space shuttle had many functions. It could carry up to seven astronauts at a time and took satellites to space so they could orbit Earth. The space shuttle was also like a science lab where astronauts did experiments. The space shuttle has a total of 136 launches before its retirement in 2014.[7]
    - *International Space Station:* The International Space Station is a large spacecraft. It orbits around Earth as a science lab. Scientists study what happens to people when they live in space and other experiments that cannot be done on Earth.[8]
    - *Space and Flight Support:* This program handles the services including
        - Space Communications,
        - Launch Services
        - Rocket Propulsion Testing
        - Crew Health and Safety
        - Environmental.
        - Space and Flight Support includes the enabling capabilities required to conduct space exploration and expand scientific knowledge of the Earth and our universe. Each of these capabilities plays a critical support role in the success of NASA missions and goals.[9]
- **Education:** NASA's education program strives to "inspire and motivate students to pursue careers in science, technology, engineering, and mathematics" by supporting

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[6] Dunbar, Brian. "Space Operations." NASA. NASA, 24 Aug. 2011. Web. 18 Mar. 2017.

[7] Dunbar, Brian. "What Is the Space Shuttle?" NASA. NASA, 20 May 2015. Web. 18 Mar. 2017.

[8] Dunbar, Brian. "What Is the International Space Station?" NASA. NASA, 20 May 2015. Web. 18 Mar. 2017.

[9] "Space and Flight Support." NASA.gov. 2015. Web. <https://www.nasa.gov/pdf/55413main_30%20SFS.pdf>

education in the Nation's schools and to "engage the public in shaping and sharing the experience of exploration and discovery."[10]

- *Space Grant:* This program is a national network of colleges and universities. Its purpose is to expand opportunities in NASA's aeronautics and space projects. Grants, fellowships and scholarships are given to students pursuing careers in science, mathematics, engineering and technology, or STEM, as well as curriculum enhancement and faculty development.[11]

- *EPSCoR (The Experimental Program to Stimulate Competitive Research):* This program establishes partnerships with the government, higher education institutes and industries that are designed to effect lasting improvements in a state or region's research infrastructure by developing academic research.[12]

- *MUREP (Minority University Research and Education Project):* This program's focus is to enhance the capabilities of Historically Black Colleges and Universities', Hispanic Serving Institutions', and Tribal Colleges and Universities' contributions to the research needs of science and technology enterprises.[13]

- **Cross-agency Support (CAS):** This office is an administrative that enables NASA to carry out its functions and programs. CAS includes two themes which are the Center Management and Operations (CMO) and *Agency Management and Operations (AMO)*[14]:

  - *Center Management and Operations (CMO):* This office manages human capital, information technology, and facility assets. This office executes financial management and acquisition responsibilities, and ensures independent technical oversight of NASA's programs in support of safety and mission success.

  - *Agency Management and Operations (AMO):* This office provides policy and oversight to assure compliance with external and internal requirements, assure safety and mission success. Ensures that critical safety and mission success policies, procedures, and standards are in place for the safety and mission success of all NASA programs, projects and operations. AMO resolves the Agency's financial, acquisition, and business challenges.[15]

- **Aeronautics:** This program researches to develop and solve major challenges in Earth based aviation.

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[10] May, Sandra. "NASA Education Program: Overview." NASA. NASA, 28 Apr. 2015. Web. 18 Mar. 2017.

[11] May, Sandra. "About the Space Grant Program." NASA. NASA, 28 July 2015. Web. 18 Mar. 2017.

[12] May, Sandra. "About the Space Grant Program." NASA. NASA, 28 July 2015. Web. 18 Mar. 2017.

[13] Dunbar, Brian. "Minority University Research and Education Program." NASA. NASA, 10 Mar. 2015. Web. 18 Mar. 2017.

[14] NASA FY12 Budget Estimates for Cross-Agency Support. Nasa Office Of The Chief Financial Officer, 2012. Web.

[15] NASA FY12 Budget Estimates for Cross-Agency Support. Nasa Office Of The Chief Financial Officer, 2012. Web.

- **Exploration:** This program focuses on the exploration activities beyond low Earth orbit include the management of the following:
    - Commercial space transportation
    - Exploration systems development
    - Human Space Flight Capabilities
    - Advanced Exploration Systems
    - Space Life Sciences Research & Applications[16]

    - *Exploration Systems Development:* This program focuses on building a crew vehicle, evolvable rocket, and ground systems and operations that will enable NASA'S new missions to extend human existence beyond the moon, to an asteroid, to Mars and across the solar system.[17]

    - *Orion MPCV (Multi-Purpose Crew Vehicle):* This vehicle is designed to support human exploration missions to multiple destinations in deep space. It can support up to Six Humans.[18]

    - *Space Launch System*: NASA's most advanced launch vehicle (rocket). Its purpose is to launch the Orion spacecraft with humans into deep space.[19]

    - *Exploration Ground Systems:* This programs to develop and use equipment required to safely handling rockets and spacecraft during assembly, transport and launch. A key aspect of this program is its approach to long-term sustainability and affordability.[20]

    - *Commercial Spaceflight*: NASA and commercial space industry partnership to develop and operate new generation of spacecraft and launch systems capable of carrying crew to low Earth Orbit and the International Space Station.[21]

    - *Exploration R&D*: Develops long-range technologies to enable human exploration beyond Earth Orbit.[22]

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16 Pline, Alex. "About the Human Exploration and Operations Mission Directorate." NASA. NASA, 29 Apr. 2015. Web. 18 Mar. 2017.

17 "Exploration Systems Development." NASA.gov. 2015. Web.

18 "Orion/Multi-Purpose Crew Vehicle Program - Space Flight Systems." NASA. NASA, 16 Sept. 2016. Web. 18 Mar. 2017.

19 Mohon, Lee. "Space Launch System (SLS) Overview." NASA. NASA, 16 Mar. 2015. Web. 18 Mar. 2017.

20 "Ground System Development and Operations Program." NASAfacts. NASA.gov, n.d. Web.

21 Siceloff, Steven. "NASA Chooses American Companies to Transport U.S. Astronauts to Intern." NASA. NASA, 02 Mar. 2015. Web. 18 Mar. 2017.

22 Dunbar, Brian. "Exploration Technology Development Program (ETDP)." NASA. NASA, Apr. 2012. Web. 18 Mar. 2017.

- **Science:** This programs goals and objectives direct the exploration of the Earth, Moon, Mars, and beyond, as well as provide the context through which we formulate and define our science investigations and missions.[23]

    - *Planetary Science:* This programs studies our Inner Solar System, Outer Solar System, Small Bodies of the Solar System like asteroids, planets, and dwarf planets.[24]

    - *Astrophysics:* This program studies dark energy, dark matter, and black holes in the universe. Other parts of the universe that the Astrophysics program studies are galaxies, stars, exoplanets and the Big Bang.[25]

    - *James Webb Space Telescope (JWST*): The Successor of the Hubble telescope. JWST will look further back in time to see the first galaxies that formed in the early universe, and peer inside dust clouds where stars and planetary systems are forming today. [26]

    - *Heliophysics:* This program studies the Sun, space weather, magnetosphere and Heliosphere of the Sun.[27]

    - *Earth Science:* This programs objective is to understand the Earth's atmosphere, lithosphere, hydrosphere, cryosphere, and biosphere as a single connected system. A major component in Earth Science program is launching satellites and airborne missions for long-term global observations of the land surface, biosphere, solid Earth, atmosphere, and oceans.[28]

- **Space Technology:** The main objective of this program is to develop new technologies and capabilities needed to achieve future missions.[29]

- **Construction & Environmental Compliance & Restoration:** This program handles discrete and minor construction of facilities projects, facility demolition projects, and environmental compliance and restoration activities. [30]

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[23] Dunbar, Brian. "Science." NASA. 9 Mar. 2006. Web. 18 Mar. 2017.

[24] "NASA Planetary Science." NASA. Web. 18 Mar. 2017.

[25] "NASA Astrophysics." NASA. Web. 18 Mar. 2017.

[26] "What Is the James Webb Space Telescope?" NASA. NASA, Web. 18 Mar. 2017. <https://jwst.nasa.gov/faqLite.html>.

[27] "Heliosphere." NASA. Web. 18 Mar. 2017. <https://science.nasa.gov/heliophysics/focus-areas/heliosphere>.

[28] "NASA Earth Science." NASA.Web. 18 Mar. 2017. <https://science.nasa.gov/earth-science>.

[29] Hall, Loura. "About Us." NASA. NASA, 16 Mar. 2015. Web. 18 Mar. 2017. <https://www.nasa.gov/directorates/spacetech/about_us/index.html>.

[30] "Mission Directorate: Construction and Environmental Compliance and Restoration." NASA. N.p., 2011. Web. <https://www.nasa.gov/pdf/428353main_Construction_and_Env_Compliance.pdf>.

- *The Construction of Facilities*: This program ensures that the facilities critical to achieving NASA's space and aeronautics program are the right size and type, and that they are safe, secure, environmentally sound, and operated efficiently and effectively. [31]
    - *Environmental Compliance and Restoration:* The purpose of this program is to clean up chemicals released to the environment from past activates. [32]
- **Safety, Security and Mission Services:** This office provides oversight to reduce risk to life and mission for all NASA programs.[33] This office also handles the following:
    - *Travel expenses, passenger motor vehicles for employees and hardware.*
    - *Maintenance & operation of mission & Administrative Aircrafts.*

These programs are the main focuses of NASA and Congress. These categorizations are based upon the Appropriations of NASA. NASA undertakes multiple specific programs under each Program examined above. For instance, under Planetary Science the newest program deals with Europa, which is one of Jupiter's moons. Congress is interested in sending an orbiter and lander on one of Jupiter's Moons to discover if there is water within Europa's icy crust. NASA also has several sub divisions within the subdivisions that focus on extremely detailed aspects of certain programs. However, for the purpose of this paper the main programs that will be focused on are the ones that are mentioned in the appropriations of Congress. Each of the programs will be categorized under my definitions in chapter 3.

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31 "Mission Directorate: Construction and Environmental Compliance and Restoration." NASA. N.p., 2011. Web. <https://www.nasa.gov/pdf/428353main_Construction_and_Env_Compliance.pdf>.

32 "Mission Directorate: Construction and Environmental Compliance and Restoration." NASA. N.p., 2011. Web. <https://www.nasa.gov/pdf/428353main_Construction_and_Env_Compliance.pdf>.

33 Mochinski, Ron. "About Us." NASA. NASA, 12 Aug. 2015. Web. 18 Mar. 2017. <https://www.nasa.gov/msd/aboutus>.

Chapter 3 NASA: Practical v. Exploration

Part A: NASA'S Missions 2011-2011: Practical & Exploration

Chart 1

Earth Related/Practical	Exploration/Discovery
Space shuttle (retired 2014)	Planetary Science
International Space Station	Astrophysics
Space and Flight Support	Heliophysics
Space Grant	Exploration System Development
MUREP	Orion MPCV
EPSCoR	Space Launch System
Other (under Education program)	Exploration R&D
Earth Science	Space Technology
Commercial Spaceflight	James Webb Space Technology
Exploration Ground System	
Cross-agency	
Aeronautics	
Safety, Security & Mission Services	
Construction & Environmental Compliance &Restoration	

Chart 1 above shows my re-categorization of NASA'S programs. Each program will be analyzed under my definitions of Earth related/practical and exploration/discovery programs.

Earth Related Practical NASA Programs:

- *Earth related/practical programs are defined as those which are primarily earth focused such as:*
    - *Building and launching of satellites around the Earth*
    - *Space tourism*
    - *Payload/human launches to the International Space Station (ISS)*
    - Earth observation studies and Earth focused experimental programs

The list below is the programs that fall under Earth related/ Practical Programs:

- Space shuttle (retired 2014)
- International Space Station
- Space and Flight Support
- Space Grant
- MUREP
- EPSCoR
- Other (under Education program)
- Earth Science

- Commercial Spaceflight
- Exploration Ground System
- Cross-agency
- Aeronautics
- Construction & Environmental Compliance & Restoration
- Safety, Security & Mission Services

The Space shuttle's main focus was to send astronauts and cargo to the international space station. Also, the shuttle functioned as a laboratory in low Earth orbit. Its objectives were significantly practical based and like in my definition of Earth related/practical programs the spaces shuttle only stayed on low Earth orbit. One of the Space shuttles main experiments were studying lighting, which is considered to be Earth focused program.[34]

The International Space Station is a space laboratory in low Earth Orbit. Astronauts and scientist conducted a multiplied of experiments that they were not able to on Earth. One of those main experiments is studying long-term effects of space on the human body.

Space and Flight Support includes the enabling capabilities required to conduct space exploration and expand scientific knowledge of the Earth and our universe.[35] This program had some exploration aspects, however, it is a primarily Earth related/practical focused program because of its Earth based activities and focus on logistics.

Education and its subdivisions: space grant, MUREP, and EPSCoR all focus on awarding students and universities money to continue to purse STEM disciplines. These Education programs are heavily Earth based.

Under the sciences the majority of its divisions are focused on discovery and exploration of space. The only division under NASA's science program that does not focus on space is Earth

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[34] Boeck, W. L. "Space Research and Observations." NASA. Web. 19 Mar. 2017. <https://lightning.nsstc.nasa.gov/shuttle.html>.

[35] "Space and Flight Support." NASA.gov. 2015. Web. <https://www.nasa.gov/pdf/55413main_30%20SFS.pdf>

Science. Earth Science's purpose is to understand every aspect of Earth. Under my definition Earth Science is a primarily practical program due to the fact it's whole objective is Earth Based.

Under the Exploration program there are two divisions that are fall under a more practical standard. These two divisions are Commercial spaceflight and Exploration Ground Systems. The Commercial Spaceflight division's main function is to create a partnership between NASA and the commercial space industry to develop and operate new generation of spacecraft's and launch systems with capable of carrying crew only to low Earth orbit and the International Space Station, which are key pragmatic missions. Exploration Ground systems only focus on developing and using equipment to transport, assemble and launch rockets around the country and world which are all based on Earth. This division's functions are logistical and the purposes are practical. These programs have a primarily Earth based/practical objectives.

The next NASA programs that fall under the practical definition are Cross-agency Support. Cross-Agency basically handles the general operation of NASA and in a sense act like human resources department. Cross-Agency Support oversees 10 NASA centers and makes sure all departments and missions are operating smoothly.

Aeronautics another Earth related/practical program is which focuses on researching and developing new technologies in Earth based aviation.

The next Earth related/practical program under NASA is Construction & Environmental Compliance & Restoration. This program is broken down into two sub sections. The first sub section is the Construction of Facilities, which deals with ensuring facilities for NASA's missions are safe and operated efficiently and effectively. The second sub section is the Environmental Compliance and Restoration, which handles the cleanup of chemicals. These sub programs are all Earth based with programs and are considered to be practical because of their

functions, which are to clean up chemicals on Earth, keep all facilities safe and operational.

The last program that falls under practical missions is the Safety, Security and Mission Services**.** This program manages and operates NASA's centers and facilities by providing oversight. Other functions the Safety, Security and mission services handles are travel expenses, passenger motor vehicle and maintenance of missions. Once again this program perfectly fits the definition of being practical.

Exploration/Discovery NASA Programs:

- *Space exploration/discovery programs are defined as those, which are primarily focused on investigating outer space using, manned and unmanned spacecrafts beyond low Earth orbit. Space exploration programs involve robotics, humans, and probes sent to other space bodies for the purposes of increasing knowledge of space and ensuring the survival of humanity.*

The programs that fall under the definition of exploration/discovery programs are:

- Exploration Systems Development
- Orion MPCV
- Space Launch System
- Exploration R&D
- Planetary science
- Astrophysics
- Heliophysics
- James Webb Telescope
- Space Technology

Exploration Systems Development focuses on building vehicles that will directly enable NASA's new missions to extend human existence beyond the moon, to asteroids, to Mars and across the solar system.

The Orion MPCV is the capsule design to support human exploration missions to multiple destinations in deep space.

The Space Launch System (SLS) is NASA's most advanced launch vehicle (rocket) with the purpose to send humans into deep space. Exploration Systems Developments, Orion and SLS

are interconnected programs with the sole purpose of sending humans out beyond low Earth orbit and eventually to Mars. Exploration R&D focuses on Develops long-range technologies to enable human exploration beyond Earth Orbit. These main programs fall under exploration/discovery definition because their main purpose is to explore beyond Low-Earth orbit for the purpose of enhancing knowledge in space and human presence on other planetary bodies.

The next NASA mission that falls under the exploration/discovery definition are the science programs specifically Planetary Science, Astrophysics, and Heliophysics and the James Webb Telescope. Planetary science focuses on understanding planets, moons, asteroids and other planetary bodies within and outside our solar system by sending probes and orbiters to observe and gather data. Of the main purposes of Planetary science is to discover new worlds that humans are able to inhabit. Astrophysics focuses on the understanding universe for instance black holes, what and how was the universe created. Astrophysics missions are conducted by using satellites that look deep into the universe and understand how it works. Heliophysics is the study of the Sun and its effect on our solar system. These three science programs primarily have a discovery aspect than exploratory.

The James Webb Telescope (JWST) will be the successor of the Hubble Telescope in 2018. The JWST main purposes are to discovery new information on our universe and expand human knowledge. These Science sub-divisions focus on discovery of the universe, which falls under the exploration definition. Another aspect these program can fit in the exploration definition is the purpose of enhancing human knowledge.

The final program under NASA that follows in line with the definition of exploration is Space Technology, which focuses on developing new technologies and capabilities needed to

achieve future deep space missions. Space technology focuses on a variety of different advanced experimental technology that will help humans go to Mars and other planetary bodies faster than we can currently

Part B: Exploration/Discovery Budget v. Earth Related/ Practical Budget

NASA obtains its budget from Congress. This means all the missions NASA wishes to do must be approved and funded by Congress. The process of obtaining a budget NASA must go through several steps. The first step is to request the funding of their missions. Then President sends out a budget request to what he believes NASA should do. Afterwards, Congress authorizes the budget stating NASA's priority missions and what their expected funding is to be. It is important to note that authorization bills occur every three years. NASA'S authorization bill covers what the agency will be doing for the next 3 years. The last step is that Congress appropriates the funding and NASA is able to use to fund their missions. Unlike authorization bills appropriations occur every year.

Congressional appropriations from 2011 to 2016 are presented in the following charts.

Chart 2 presents the total budgetary appropriations for NASA. Chart 3 presents the budgetary appropriations under my definitions of Earth/related programs and exploration/discovery programs.

Chart 2

Totals NASA Budget	
2011	$18,413,900,000
2012	$18,183,700,000
2013	$16,775,000,000
2014	$17,609,000,000
2015	$18,710,463,000
2016	$18,579,100,000

As it can be seen in Chart 2 NASA's budget has stayed relativity consistent. The budget only slightly fluctuated throughout the years from roughly $17 billion to $18 billion. The only year NASA's budget drastically changed was in 2013 where it dropped to roughly $16 billion.

Practical & Exploration Mission Funding Under Obama Administration (2011-2016):

Chart 3

Year	Budget	Total $ Practical Programs	Practical Percentage	Total $ Exploration Programs	Exploration Percentage
2011	$18,413,900,000	$11,795,900,000	*64.05%*	$6,618,000,000	*35.95%*
2012	$18,183,700,000	$10,602,700,000	*58.30%*	$7,581,000,000	*41.70%*
2013	$16,775,000,000	$10,211,000,000	*60.87%*	$6,564,000,000	*39.13%*
2014	$17,609,000,000	$10,607,800,000	*60.24%*	$7,001,200,000	*39.76%*
2015	$18,710,463,000	$10,297,063,000	*55.03%*	$8,413,400,000	*44.97%*
2016	$18,579,100,000	$11,157,700,000	*60.06%*	$7,421,400,000	*39.94%*

It can be seen above in Chart 3 that appropriations for practical programs stay relatively constant under the Obama Administration. However, appropriations for the exploration programs budget showed greater fluctuations. The largest dip for exploration was in 2013 where it went down to roughly $6.5 Billion. While exploration suffered the practical budget stayed relatively the same at $10 Billion. Overall its very clear throughout the years the exploration is receiving less funding than practical.

Additionally, when observing the dips of programs Earth related/practical programs largest dip was 2011 to 2012, which went down by 10.1%. While the biggest dip in exploration were the years 2012 to 2013, which was 13.4%. It can be seen clearly that when the time comes to cut budgets Congress cuts the exploration/discovery program more severe than Earth related/practical programs.

The next observations in the budgets of the programs were in their increases. The biggest increase for Earth related/practical programs was in 2015 to 2016 is 8.4% the biggest increase for exploration was 2014 to 2015 which was a 20.2%. Even though exploration had a larger increase than practical it is important to note that practical programs stayed relatively consistent. While in exploration programs there is more fluctuation, with its yearly budget

ranging from roughly $6.6 Billion to $8.4 Billion, Earth related/practical programs had a relatively steady budget usually ranging from $10 Billion to $11Billion. The Programs under Earth related/practical program is typically hovered around 60% of NASA's budget while exploration/discovery programs typically hovered around 40%. Also, when Congress decided to increase exploration in 2014 to 2015 by 20.2% the large increase was due to the large cut in 2013. Overall its very clear throughout the years the exploration programs are getting a lot less than practical programs.

In Chart 4 (further down) it shows all the specific programs under Earth related/ practical and exploration/discovery programs. When Earth related/practical programs dropped in 2012 we can see how specific programs were affected.

Earth related/Practical Programs dip by comparing 2011 and 2012:

The three main programs that will be observed under the budget cut are the space shuttle, space grant and commercial spaceflight. The space shuttle program in 2011 was $1,593,000,000 and 2012 dropped to $573,000,000, which was roughly a $1billion difference. Another Earth related/practical program that was affected by budget cuts was the Space Grant. In 2011 the space grant was 46,000,000, and in 2012 it dropped to $40,000,000, which is a $6,000,000 difference. The last example of a drop in Earth related/practical is Commercial Spaceflight, which was $607,000,000 in 2011 and in 2012 it dropped to $406,000,000 this was also a $6,000,000 difference. Most of the Earth related programs had a $6 Million drop except for the space shuttle since it was nearing its retirement.

Exploration/Discovery Programs dip by comparing 2012 and 2013:

The three main programs that will be observed in 2012 and 2013 are the Space Launch System (SLS), Exploration R&D, and Astrophysics. In 2012 the SLS was $1,860,000,000 and it

dropped to $1,415,000,000 in 2013, which is a $445 Million difference. In 2012 Exploration R&D was $304,800,000 and dropped to $297,000,0000 in 2013, which was a $7million difference. The last program that will analyze is Astrophysics, which $672,000,000 in 2012 and 617,000,000 in 2013, which was a $55 million.

It can be seen that Earth related/practical might have suffered severe budget cuts, however most of the programs stayed relativity the same and some budgets increased which is why overall the budget cut which was 8% roughly was not as severe as Explorations roughly 13% budget cut

Note: Some totals may not add up because of rounding.
Chart 4[36]

NASA Appropriations 2011-2016	
NASA Appropriations 2011: $18,413,900,000	
Practical 2011	**Exploration/Discovery 2011**
Space Shuttle: $1,593,000,000	Planetary Science: $1,451,000,000
International Space Station: $2,714,000,000	Astrophysics: $631,000,000
Space and Flight Support: $840,000,000	James Webb Space Telescope: $477,000,000
Earth Science: $1,722,000,000	Heliophysics: $639,000,000
Space Grant: $46,000,000	Orion MPCV: $1,196,000,000
EPSCoR: $25,000,000	Space Launch System: $1,536,000,000
MUREP: $29,000,000	Exploration R&D: $232,000,000
Other: $47,000,000	Space Technology: $456,000,000
Commercial Spaceflight: $607,000,000	
Exploration Ground Systems: $250,000,000	
Cross-agency: $2,956,000,000	
Aeronautics: $533,900,000	
Construction and EC&R: $433,000,000	
Total: $11,795,900,000	**Total: $6,618,000,000**
NASA Appropriations 2012: $18,183,700,000	
Practical 2012	**Exploration/Discovery 2012**
Space Shuttle: $573,000,000	Planetary Science: $1,500,100,000
International Space Station (ISS): $2,830,000,000	Astrophysics: $672,000,000
Satellite servicing: $50,000,000	James Webb Space Telescope: $529,600,000

36 Morgan, Daniel. "NASA Appropriations and Authorizations: A Fact Sheet." N.p., 16 Dec. 2016. Web. <https://fas.org/sgp/crs/space/R43419.pdf>.

Earth Science: $1,765,700,000	Heliophysics: $622,300,000
Experimental Program to Stimulate Competitive Research: $18,400,000	Orion multipurpose crew vehicle: $1,200,000,000
National Space Grant College program: $40,000,000	Space Launch System (SLS): $1,860,000,000
Commercial spaceflight activities: $406,000,000	SLS Ground Operations: $316,500,000
Cross Agency Support: $2,994,000,000	Exploration R&D: $304,800,000
Aeronautics: $569,900,000	Space technology: $575,000,000
Construction and EC&R 495,000,000	
Total: $10,602,700,000	**Total: $7,581,000,000**
NASA Appropriations 2013: $16,880,400,000	
Practical 2013	**Exploration/Discovery 2013**
Aeronautics: $530,000,000	Astrophysics $617,000,000
Earth Science $1,659,000,000	James Webb Space Telescope $628,000,000
Space Shuttle $39,000,000	Heliophysics: $603,000,000
International Space Station: $2,776,000,000	Space technology: $615,000,000
Space and Flight Support: 910,000,000	Orion Multi-Purpose Crew Vehicle: $1,114,000,000
Experimental Program to Stimulate Competitive Research: $18,000,000	Space Launch System: $1,415,000,000
National Space Grant College: $27,000,000	Exploration R&D: $297,000,0000
Cross Agency Support: $2,711,000,000	Planetary Science 1,275,000,000
Exploration Ground Systems: $355,000,000	
Commercial Spaceflight Activities: $525,000,000	
Construction and environmental compliance and Restoration: $661,000,000	
Total: $10,211,000,000	**Total: $6,564,000,000**
NASA Appropriations 2014: $17,647,000,000	
Practical 2014	**Exploration/Discovery 2014**
Aeronautics: $566,000,000	Astrophysics: $678,000,000
Earth Science: $1,825,000,000	James Webb Space Telescope: $658,000,000
International Space Station: 2,964,000,000	Heliophysics: $641,000,000
Space and Flight Support: 810,000,000	Space technology: $576,000,000
Experimental Program to Stimulate Competitive Research:	Orion Multi-Purpose Crew Vehicle: $1,197,000,000
National Space Grant College program: $40,000,000	Space Launch System: $1,918,200,000
Exploration Ground Systems: $318,200,000	Launch Vehicle Development: $1,600,000,000
Commercial Spaceflight Activities: $696,000,000	Commercial Crew Program: $171,000,000
Cross agency support: $2,793,000,000	Exploration R&D: $302,000,000
Independent verification and validation activities: $39,100,000	Planetary Science: $1,346,000,000
Construction and environmental compliance and restoration: $515,000,000	
Total: $10,607,800,000	**Total: $7,001,200,000**
NASA Appropriations 2015: 18,010,000,000	
Practical 2015	**Exploration/Discovery 2015**
Aeronautics: $651,000,000	Astrophysics: $731,000,000
Earth Science: $1,784,000,000	James Webb Space Telescope: $645,000,000
Space Shuttle: $8,000,000	Heliophysics: $636,000,000
International Space Station: $1,525,000,000	Space Technology: $596,000,000

Space Transportation: $2,254,000,000	Orion Multi-Purpose Crew Vehicle: $1,194,000,000
Space and Flight Support: $839,000,000	Space Launch System: $2,051,300,000
Experimental Program to Stimulate Competitive Research: $18,000,000	Launch Vehicle Development: $1,700,000,000
National Space Grant College Program: $40,000,000	Exploration R&D: $306,400,000
Travel expenses, passenger motor vehicles: $63,000,	Planetary Science: $1,447,000,000
Maintenance & operation of mission & Administrative Aircraft, $2,758,900,000	
Exploration Ground Systems: $351,300,000	
Commercial Spaceflight Activities: $805,000,000	
Total: $10,297,063,000	**Total: $8,413,400,000**
NASA Appropriations 2016: $18,579,100,000	
Practical 2016	**Exploration/discovery 2016**
Aeronautics: $640,000,000	Astrophysics: 731,000,000
Earth Science: 1,921,000,000	James Webb Space Telescope: 620,000,000
Space operations: $5,029,200,000	Heliophysics: 650,000,000
Experimental Program to Stimulate Competitive Research:	Space Technology: $133,000,000
National Space Grant College program: $40,000,000	Orion Multi-Purpose Crew Vehicle: $1,270,000,000
Safety, security & mission services: $2,768,600,000	Space Launch System (SLS): $2,000,000,000
Exploration Ground Systems: $410,000,000	Enhanced upper stage development: $85,000,000
Construction & Environmental Compliance & Restoration: $388,900,000	Exploration R&D: $350,000,000
	Planetary Science: $1,63,000,000
Total: $11,157,700,000	**Total: $ 7,421,400,000**

An important factor to note in the budgeting of practical and exploration missions is that there more practical programs unlike exploration where there are three large programs. Space exploration/discovery programs have roughly nine major programs with sub divisions. While Earth related/practical programs are roughly 14 in total.

By researching the budgeting of NASA and categorizing its missions under what I define as practical and exploration I find that exploration receives less funding than practical missions. An important factor to note is the lack of amount of exploration programs compared to practical. There is a heavier focus on practical programs than exploration. The main programs under exploratory are the construction of the Orion, SLS, which will eventually launch humans to Mars. Another major exploration/discovery program is the James Webb Telescope, which will see farther into the universe than the Hubble Telescope. Under the Science programs planetary

science receives the most usually around at least $1billion per year while Heliophysics, Astrophysics stayed under the $7Million. The reason behind Planetary Science receiving more funding is because of its more complex missions like landing probes and orbiters to Mars and other planetary objects. There is a vast difference in how Earth related/practical and exploration/discovery programs are funded by Congress.

Chapter 4: Stand-Alone NASA Bills

During Obama's Administration there were 15 bills that have been passed that dealt with Space and NASA. Six of those bills are considered to be Honorific, which is honoring fallen Astronauts and celebrating their accomplishments. Nine bills were Earth related/practical and zero bills involving exploratory/discovery bills were passed.

To begin with an example of an Honorific bill is H.*R. 2726 (114th): Apollo 11 50th Anniversary Commemorative Coin Act,* which was enacted to require the Secretary of the Treasury to mint commemorative coins in recognition of the 50th anniversary of the first manned landing on the moon.[37]

The bills that involved discovery and exploration were the generals funding bills. The main bills that will be focused on in this chapter are the three most substantive practical bills, and three major exploration/discovery bills that were introduced in multiple Congressional terms.

<u>Earth Related/Practical Space related Bills:</u>

- *Earth related/practical programs are defined as those which are primarily earth focused such as:*
    - *Building and launching of satellites around the Earth*
    - *Space tourism*
    - *Payload/human launches to the International Space Station (ISS)*
    - *Earth observation studies and Earth focused experimental programs.*

The major substantive practical bills were as follows:

- H.R. 3819 (111th): To extend the commercial space transportation liability regime 2009
- H.R. 6586 (112th) Space Exploration Sustainability Act 2013
- H.R.2262 (114th) U.S. Commercial Space Launch Competitiveness Act 2015

[37] "H.R. 2726 — 114th Congress: Apollo 11 50th Anniversary Commemorative Coin Act." www.GovTrack.us. 2015. February 9, 2017 <https://www.govtrack.us/congress/bills/114/hr2726>

H.R. 3819 (111th): To extend the commercial space transportation liability regime 2009:

The bill *H.R. 3819 (111th): To extend the commercial space transportation liability regime 2009*[38] (hereinafter referred to *H.R 3819*) was first introduced in 2000 under *the Commercial Space Transportation Competitiveness Act of 2000* in the liability risk-sharing regime for commercial space transportation activities. The purpose of *H.R 3819* is to enable the private space industry. The basic overview of this bill began as an encouraging the privatization of commercial launch services. This financial responsibility is usually through the purchase of liability insurance that protects private launch participants, and the U.S government, its contractors, subcontractors, and personnel.

The second aspect of the act covers cross-waivers of liability among- launch participants, and a promise by the U.S government to pay third claims in amounts up to $1.5 Billion above the insurance requirement, subject to congressional appropriations. Under this act, U.S government employees are treated as third parties, as well as government launch participants, which allows them to make claims for damages in case of injury of loss, while also being covered by the licensee's third party liability insurance.[39] *H.R. 3819* follows the definition of Earth related/Practical based programs because it's primary objective is to ensure that commercial industries are able to thrive. The Act focuses on handling the logistics of the partnership of commercial space industries and the government. These activities mentioned in *H.R. 3819* are all Earth based.

[38] "H.R. 3819 — 111th Congress: To extend the commercial space transportation liability regime." www.GovTrack.us. 2009. January 28, 2017 <https://www.govtrack.us/congress/bills/111/hr3819>

[39] "H.R. 3819 — 111th Congress: To extend the commercial space transportation liability regime." www.GovTrack.us. 2009. January 28, 2017 <https://www.govtrack.us/congress/bills/111/hr3819>

H.R. 6586 (112th) Space Exploration Sustainability Act 2013:

The next major bill is *H.R. 6586 (112th) Space Exploration Sustainability Act 2013*[40] (hereinafter referred to *H.R 6568*). H.R 6586 overview is to maintain the space infrastructure the commercial companies' involvement with NASA and other governmental organization. This Act does not focus directly on NASA but on the private Space industry structure. *H.R 6586* specifically details the commercial space industries involvement in the International Space Station (ISS), technology development, and follow-on transportation systems including the space launch system and the multipurpose crew vehicle. The Act stresses the importance of balancing the development, sustainment, and use of each of these capabilities, which are of critical importance to the viability and sustainability of the U.S. space program. The Secretary of Transportation (DOT) handles the payment compensation for claims in excess of a commercial space launcher's required insurance coverage.[41] *H.R 6586* objective is to enhance commercial space industry's relationship with NASA and its programs. The programs that *H.R 6586* mentions are all Earth related/practical programs. The Act also includes space launch system and the multipurpose crew vehicle, which are exploration/discovery-focused programs. However, *H.R 6586* maintains a primarily practical approach to the Commercial space industries partnership with NASA.

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40 "H.R. 6586 — 112th Congress: Space Exploration Sustainability Act." www.GovTrack.us. 2012. March 19, 2017 <https://www.govtrack.us/congress/bills/112/hr6586>

41 "H.R. 6586 — 112th Congress: Space Exploration Sustainability Act." www.GovTrack.us. 2012. March 19, 2017 <https://www.govtrack.us/congress/bills/112/hr6586>

H.R.2262 U.S. Commercial Space Launch Competitiveness Act 2015:

The third and arguably the most significant bill is *H.R.2262 U.S. Commercial Space Launch Competitiveness Act 2015*[42] (Hereinafter referred to *H.R 2262)* the overview of the bill is to continue the enhancement of commercial space industries. This Act has multiple sections including:

- The encouragement of safety protocols in commercial space industry.
- The Department of Transportation (DOT) and Department of Defense's (DOD) roles in:
    - Space sector
    - Exploitation of space resources
    - The Space Launch System

H.R 2262 includes the extension of compensation of US launch providers for catastrophic third-party losses of a failed launch through 2025. The Act also extends, through 2025, the "learning period" restrictions, which limit the ability of the Federal Aviation Administration (FAA) to enact regulations regarding the safety of spaceflight participants.

The Department of Transportation's function under *H.R 2262* is to evaluate, develop a plan to update, and to calculate the maximum probable loss from commercial space launch liability claims. Under this act designs of rockets and reusable launch vehicles and also their launches will be covered. DOT has been given the power to issue an experimental permit for reusable suborbital rockets or reusable launch vehicles that will be launched into a suborbital trajectory (testing technologies).[43]

An issue *H.R 2262* brings up is Congress's concern of space traffic management of federal assets and U.S. private assets in outer space and orbital debris mitigation. This act gives

[42] "H.R. 2262 — 114th Congress: U.S. Commercial Space Launch Competitiveness Act." www.GovTrack.us. 2015. January 5, 2017 <https://www.govtrack.us/congress/bills/114/hr2262>
[43] "H.R. 2262 — 114th Congress: U.S. Commercial Space Launch Competitiveness Act." www.GovTrack.us. 2015. January 5, 2017 <https://www.govtrack.us/congress/bills/114/hr2262>

NASA the ability to arrange with an independent systems engineering and technical assistance organization to study alternate frameworks for the management of space traffic and orbital activities.[44]

A small section of *H.R 2262* focuses on human space exploration pertaining to the Space Launch System payloads and missions that contributes to extending human presence beyond low-Earth orbit and substantially benefit from the System's unique capabilities. [45]

Section 402 of the *H.R 2262* includes the *Space Resource Exploration and Utilization Act of 2015,*[46] which directs the President to facilitate the commercial exploration for and commercial recovery of space resources by U.S. citizens. Another aspect of *H.R 2262* is to discourage government barriers to the development of economically viable, safe, and stable industries for the commercial exploration for and commercial recovery of space resources in manners consistent with U.S. international obligations.[47]

H.R. 2262 had multiple sections that dealt with different aspects of space. Even though this act has a section of space exploration it was a primarily Earth related/Practical act. The majority of activates the act encourages are Earth based and in low Earth orbit.

Exploratory/Discovery Bills:

- *Space exploration/discovery programs are defined as those, which are primarily focused on investigating outer space using, manned and unmanned spacecraft's beyond low Earth orbit. Space exploration programs involve robotics, humans, and probes sent to other space bodies for the purposes of increasing knowledge of space and ensuring the survival of humanity.*

[44] "H.R. 2262 — 114th Congress: U.S. Commercial Space Launch Competitiveness Act." www.GovTrack.us. 2015. January 5, 2017 <https://www.govtrack.us/congress/bills/114/hr2262>
[45] "H.R. 2262 — 114th Congress: U.S. Commercial Space Launch Competitiveness Act." www.GovTrack.us. 2015. January 5, 2017 <https://www.govtrack.us/congress/bills/114/hr2262>
[46] "H.R. 2262 — 114th Congress: U.S. Commercial Space Launch Competitiveness Act." www.GovTrack.us. 2015. January 5, 2017 <https://www.govtrack.us/congress/bills/114/hr2262>
[47] "H.R. 2262 — 114th Congress: U.S. Commercial Space Launch Competitiveness Act." www.GovTrack.us. 2015. January 5, 2017 <https://www.govtrack.us/congress/bills/114/hr2262>

Unlike the Earth related/practical based acts that were passed no exploratory/discovery bills made it to the President to be enacted. There were several factors and reasoning behind why no Exploratory/Discovery bill was passed. I will be analyzing three bills that were heavily focused on exploration and discovery.

The three examples of Exploratory/Discovery Bills that were not passed were as follows:

- H.R. 2036: REAL Space Act
- S.2617: 114th Congress: MANIFEST for Human Spaceflight Act of 2016
- H.R.4752 - Space Exploration, Development, and Settlement Act of 2016

H.R. 2036: REAL Space Act:

Out of all the bills that were introduced during the Obama years on NASA with the intent of research and discovery no bill has been passed. For instance, the bill, *H.R. 2036: REAL Space Act*[48] (hereinafter referred to H.R 2036) has been proposed three times in the 112th, 113th, and 114th Congress and has yet to survive past the committee hearings. *H.R 2036* has three sections, the first section is the full title, the second are the findings and the third is the mission of the bill. The main findings of the bill propose to direct NASA to plan to return to the Moon and develop a sustained human presence.

The three main objectives in the findings are:

- Sustaining a human presence on the Moon
- Enhancing United States economy
- Enhancing United Stated security

The findings in *H.R 2036* have two major sections that explain the bills purpose.

[48] "H.R. 2036 — 114th Congress: REAL Space Act." www.GovTrack.us. 2015. January 5, 2017 <https://www.govtrack.us/congress/bills/114/hr2036>

Section 1 focus on a sustained Human Presence on the Moon by stating:

Having a sustained human presence on the Moon will allow astronauts and researchers the opportunity to test new technologies in addressing the challenges of sustaining life on another celestial body. A sustained human presence on the Moon would continue to develop technologies that will enhance American exploration programs but can also be applied across all disciplines of science. The bills specify the technologies developed and sustained by NASA for the purposed Moon mission:

- Liquid and solid rocket propulsion
- Environmental and life support systems
- Communications
- Navigation
- Control systems

Section 2: Commercial Space Industries and U.S Security:

The second section of the bills findings involves a commercial space industry aspect in which it has billions of dollars in economic impact.[49] Section 2 goes on to state the importance of enhancing US security. The bill explains how space is considered to be the world's ultimate high ground, and returning to the Moon will enhance human spaceflight program, which is considered to be a matter of national security.[50] The case of U.S security objective makes it apparent that China and Russia understand the economic and strategic importance of human space flight and have declared their intentions of colonizing the Moon and are advancing their lunar exploration plans. The last objective of section 2 notes how it is strategically important that the United States possesses and maintains the capabilities of a

[49] "H.R. 2036 — 114th Congress: REAL Space Act." www.GovTrack.us. 2015. January 5, 2017 <https://www.govtrack.us/congress/bills/114/hr2036>

[50] "H.R. 2036 — 114th Congress: REAL Space Act." www.GovTrack.us. 2015. January 5, 2017 <https://www.govtrack.us/ congress/bills/114/hr2036>

powerful operation in the cislunar space domain, and not let this domain be taken over by other nations.

The last part of *H.R. 2036* showcases NASA's mission focus is "To develop a sustained human presence on the Moon . . . To promote exploration, commerce, science, and the United States preeminence in space as a stepping stone for the future exploration of Mars and other destinations" which was stated in NASA authorization Act of 2005 and later restated in the Authorization Act of 2008.[51] *H.R 2036* has an almost practical purpose to its intended mission.

For instance, the case of U.S security and economy are practical and Earth based, however, the bills underlining foundation is on human space exploration on another planetary body. This bill shows many important findings that are beneficial to the United States. Unfortunately, *H.R 2036* does not purpose a solid structure to how the mission will be accomplished making it into a weak bill.

S.2617: 114th Congress: MANIFEST for Human Spaceflight Act of 2016:

The *S.2617: 114th Congress: MANIFEST for Human Spaceflight Act of 2016*[52] (hereinafter will be referred to *S.2617*) is another space exploration based bill that never made it out of a committee hearing. The overview of the bill is make it a key U.S. objective to achieve human exploration of Mars, including the establishment of a capability to extend human presence to the surface of Mars. The bill states that the rationale for these missions is for the following:

- Economic benefits
- National security
- National prestige,
- Inspiring students & other citizens

[51] "S.1281 - 109th Congress (2005-2006): National Aeronautics and Space Administration Authorization Act of 2005." | Congress.gov | Library of Congress. Web.
[52] "S.2617 - 114th Congress (2015-2016): MANIFEST for Human Spaceflight Act of 2016."| *Congress.gov | Library of Congress*. Web

- Scientific discovery
- Human survival
- Sense of shared destiny

The bill lists of the strategy requirements to achieve the mission is to have Administrator of NASA to include first utility of an expanded human presence in cis-lunar space toward enabling missions in the following:

- Lunar orbits
- Lunar surface
- Asteroids
- Mars
- Moons of Mars and,
- Other destinations of interest for future human exploration and development.[53]

The term ``cis-lunar space'' means the region of space from the Earth out to and including the region around the surface of the Moon.[54] The bill cites the opportunities for collaboration for the missions with international partners, private industry, and other Federal agencies, including missions relevant to national security or scientific needs.

To ensure the safety of the crew, the bill includes a description of training needs and capabilities with space suits and life support systems, which are necessary to support the conduct of missions. *S. 2617* may at first seem to be practical due to its focus on enhancing American national security and economy. However, the fact it is a mission to another planetary body makes it an exploration mission. Even though the case of national security and economic growth are practical goals the concept of going out farther than Earth Low Orbit is extremely difficult to get passed through Congress and the President.

[53] "S.2617 - 114th Congress (2015-2016): MANIFEST for Human Spaceflight Act of 2016."| *Congress.gov* | *Library of Congress*. Web
[54] "Text - S.3729 - 111th Congress (2009-2010): National Aeronautics and Space Administration Authorization Act of 2010." | *Congress.gov* | *Library of Congress*.Web.

H.R.4752 - Space Exploration, Development, and Settlement Act of 2016:

The last bill that will be analyzed was focusing on Human Spaceflight that never made it passed the committee hearing is the *H.R.4752 - Space Exploration, Development, and Settlement Act of 2016*[55] (hereinafter referred to *H.R 4752*). The bill starts with how in Section 217 of the *National Aeronautics and Space Administration Authorization Act*, in the Fiscal Year of 1989 states, "The Congress declares that the extension of human life beyond Earth's atmosphere, leading ultimately to the establishment of space settlements, will fulfill the purposes of advancing science, exploration, and development and will enhance the general welfare." The term space settlement means "any community of humans living beyond Earth's atmosphere that can economically sustain its population through a neutral or positive balance of trade of goods and services, and can expand its habitable real estate as need and desire of the community may warrant and international law permits."[56]

The bill has three sections. The first section is the full title of the bill the second involves Policy and Findings and the third section are the Human Exploration strategy. Under the policy and findings section the bill states that "Congress reaffirms that the long-term goal of the human space flight and exploration efforts of NASA shall be to expand permanent human presence beyond low-Earth orbit and to do so, where practical, in a manner involving international partners, as stated in section 202(a) of the National Aeronautics and Space Administration Authorization Act of 2010."[57]

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55 "H.R.4752 - 114th Congress (2015-2016): Space Exploration, Development, and Settlement Act of 2016."*Congress.gov | Library of Congress*. Web.

56 "H.R.4752 - 114th Congress (2015-2016): Space Exploration, Development, and Settlement Act of 2016."*Congress.gov | Library of Congress*. Web.

57 H.R.4752 - 114th Congress (2015-2016): Space Exploration, Development, and Settlement Act of 2016."*Congress.gov | Library of Congress*. Web.

Under the Human Exploration Strategy section, it lists all of the strategies of the Mars mission. The general overview of the strategy is to first have human presence in cis-lunar space toward enabling missions to the following:

- Various lunar orbits
- The lunar surface
- Asteroids
- Mars
- The moons of Mars
- Other destinations of interest for future human exploration and development.[58]

The strategies section cites multiple beneficial outcomes. Some of the main outcomes of human presence outside of Earth are the following:

- The creation new jobs
- Emergence of new industries
- Accelerating innovation and new technologies
- Enable America to tap vast new resources that will generate new wealth
- Enhance national security
- Provide Americans with new and limitless opportunities.[59]

The second part of the Human Exploration Strategy shows the expected activities that will be occurring in the Space Settlements. For instance, NASA should be in close cooperation with the following:

- Other appropriate agencies
- The private sector
- Academia
- The international communities, which will obtain, produce, and provide information relating to all issues important for the development of a thriving space economy and the development and establishment of human space settlements. [60]

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[58] "H.R.4752 - 114th Congress (2015-2016): Space Exploration, Development, and Settlement Act of 2016."*Congress.gov | Library of Congress*. Web.

[59] "H.R.4752 - 114th Congress (2015-2016): Space Exploration, Development, and Settlement Act of 2016."*Congress.gov | Library of Congress*. Web

[60] "H.R.4752 - 114th Congress (2015-2016): Space Exploration, Development, and Settlement Act of 2016."*Congress.gov | Library of Congress*. Web

H.R.4752 This bill gave more detailed in the kinds of activities that could occur on the Moon than the previous bills. However, his bill was never enacted due to the fact it was a purely discovery mission. These three exploratory/discovery bills never made it out of the committee's hearings. One of the main reasoning's why these bills were never enacted was the lack of a solid plan to their purpose. The bills are practically "fluff" there is nothing to back strengthen and hold the bill through committee hearings.

It can be seen that there is a sizeable difference in the way Earth related/practical and space exploration/discovery bills are constructed and handled by Congress. While the bills that focused on Earth related/practical programs were constructed in a solid detailed format with a clear understanding of the activities being purposed. We have the complete opposite in the space exploration/discovery based bills. There seems to be no substantial structure them. There was a lot of writing on what will occur after a space settlement is establishment but on how to establish one.

Another note to make is that all the Earth related/practical bills were on enhancing commercial space industry. The practical bills were not focuses on specific NASA programs. These bills on Commercial industry show a push toward the government interests in privatization the space sector.

Chapter 5: Collaboration between NASA and Commercial Companies

Background on NASA and Commercial Space Industry Partnerships:

Since the enactment of the Space Act Agreement NASA has been able to partner with businesses and other outside sources. The Space Agreement was established as The National Aeronautics and Space Act of 1958. This act authorizes NASA "to enter into and perform such contracts, leases, cooperative agreements, or other transactions as may be necessary for the conduct of its work..."[61] with domestic and foreign entities. Under this authority, NASA has been able to enter into a significant number of agreements with various public and private sector organizations. With NASA being able to enter into contracts they can meet wide-ranging missions and program requirements. The entities that can be contracted by NASA under the Space Act "can be a U.S. or foreign person or entity, and academic institution, a Federal, state, or local governmental unit, a foreign government, or an international organization, for profit, or not for profit."[62]

NASA has worked with commercial industries since the 1960's. However, they were only satellite based, and the government contracted them. Starting from the early 2000's NASA has been contracting with businesses that build actual space ships with realistic launch capabilities that will implement into NASA's Orion and SLS.

Most of the companies that are contracted by NASA lean towards the practical categories. SpaceX is the only main company contracted by NASA that has a heavy focus on space exploration. In Chart 5 above I have calculated the total contracts based on their categorization of Earth related/practical contracts and exploration/discovery and there is a vast difference between the number. I calculated the sum of all the practical contracts from 2011 to

[61] Dunbar, Brian. "NASA Space Act Agreements." *NASA*. Ed. Veronica Phillips. NASA, 31 July 2015. Web.
[62] Dunbar, Brian. "NASA Space Act Agreements." *NASA*. Ed. Veronica Phillips. NASA, 31 July 2015. Web.

2016 to be roughly to be $19,796,900,000 and exploration/discovery-based contracts were calculated to be $1,665,000,000. When comparing the contracts there is an $18, 131,900,000 difference between the two. It is important to note that commercial space industries are a new addition to the space sector and NASA is still wary in sending astronauts in commercial vehicles at the moment. (Chart 6 on Commercial industries contracts attached in the last page.)

Main Commercial Space Industries Partnered with NASA

The leading companies that have been contracted by NASA so far are the following:

- Orbital ATK Space Systems
- Final Frontier Design
- SpaceX
- United Launch Alliance (Joint Venture by Boeing and Lockheed Martin Space Systems also known as LMSS)
- Blue Origin
- Sierra Nevada.

Each Company has its own specific focus on what they are building to enhance America's ability to go further into space.

- *Orbital ATK:*
    - Orbital ATK focuses on Development of space logistics, hosted payload and other space transportation capabilities.[63]
- Final Frontier Design (FFD):
    - Handles the development of a new generation, lighter weight, inexpensive, and reliable IVA (intravehicular activity) space suit for high altitude and space flight.[64]

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[63] Webb, Carlyle. "Collaborations for Commercial Space Capabilities (CCSC)." NASA. NASA, 15 June 2015. Web. 03 Apr. 2017. <https://www.nasa.gov/content/collaborations-for-commercial-space-capabilities-ccsc/>.

[64] Webb, Carlyle. "Collaborations for Commercial Space Capabilities (CCSC)." NASA. NASA, 15 June 2015. Web. 03 Apr. 2017. <https://www.nasa.gov/content/collaborations-for-commercial-space-capabilities-ccsc/>.

- *SpaceX:*
    - SpaceX focuses in development of space transportation capabilities to and from deep space for the following:
    - Unmanned science missions
    - Crew missions
    - Deep space communication and navigation
    - Mars entry
    - Launch Vehicle descent and landing
    - Methane-oxygen propulsion
    - Propellant management[65]

- *United Launch Alliance (ULA):*

ULA Focuses on launch vehicle technologies development and demonstrations that enable new capabilities while substantially reducing cost of:

- H2/O2 Thruster
- Integrated Vehicle Fluids
- Fuel Cell
- Low Cost Propulsion
- Cryo Storage and Handling
- Upper Stage Mission Kits
- Advanced Avionics
- Advanced Welding
- Additive Manufacturing, Modeling.[66]

- *Sierra Nevada:*

This Company a multiple sectors including but not all:

- Navigation Surveillance/Air Traffic Management
- Intelligence
- Surveillance, and Reconnaissance
- Information and Sensor Solutions
- Space Systems

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[65] Webb, Carlyle. "Collaborations for Commercial Space Capabilities (CCSC)." NASA. NASA, 15 June 2015. Web. 03 Apr. 2017. <https://www.nasa.gov/content/collaborations-for-commercial-space-capabilities-ccsc/>.

[66] "Collaborations for Commercial Space Capabilities (CCSC)." *NASA*. Ed. Carlyle Webb. NASA, 27 Apr. 2016. Web.

- Main vehicle in the Space Systems sector is the Dream Chaser (space vehicle), which will eventually be used for space tourism. [67]

- *Bigelow Aerospace:*
  - This company's main mission is to assist human exploration and the discovery of beneficial resources, whether in Low Earth Orbit (LEO), on the moon, in deep space or on Mars.[68]

Earth Related/Practical contracts:

- *Earth related/practical programs are defined as those which are primarily earth focused such as:*
  - *Building and launching of satellites around the Earth*
  - *Space tourism*
  - *Payload/human launches to the International Space Station (ISS)*
  - *Earth observation studies and Earth focused experimental programs.*

Orbital ATK: Earth Related/Practical Contracts:

- Landsat 9 remote sensing satellite (5 year) (2016)
- Commercial Resupply services (CRS-2) to ISS (2016)

NASA has awarded the Landsat 9 remote sensing satellite contract to Orbital ATK. This contract is worth $129.9 Million and will last for five years, which will require the company to design and manufacture the spacecraft (Landsat 9). Orbital ATK will also be conducting satellite-level testing, in-orbit satellite checkout, and mission operations support. The Landsat 9's main purpose is to provide imagery to researchers in fields such as agriculture, forestry, education, regional planning and global change.[69]

Another Contract Orbital ATK is under since 2008 was the Commercial Resupply se8rvices (CRS). The CRS is a commercial space program with the purpose of contracting

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[67] *Sierra Nevada Corporation.* Mergent, Fort Mill, 2017, *Business Market Research Collection*, http://library.saintpeters.edu/login?url=http://search.proquest.com/docview/1860774037?accountid=28700.

[68] "Bigelow Aerospace." Bigelow Aerospace. Web. 20 Mar. 2017. <https://bigelowaerospace.com/>.

[69] Henry, Caleb. "NASA Awards $130 Million Landsat 9 Contract to Orbital ATK - Via Satellite -."Via Satellite. 26 Oct. 2016. Web.

commercial space industries to resupply the International Space Station. Orbital ATK was contracted once again in 2016 for the next installment of CRS now called CRS-2. Orbital ATK is estimated to receive roughly $4 Billion.

All these projects in which Orbital ATK follow in line with my definition of practical missions. Practical missions involve launching satellites, cargo resupplies to the international space station and low Earth Orbit missions.

Blue Origin: Earth Related/Practical Contracts:

- *Suborbital Reusable Launch Vehicle Flight and Payload Integration Services project (2014)*

Blue Origin is currently building its reusable rocket, primarily for space tourism in low-earth orbit. However, a large-scale version, called New Glenn, is currently under development. Blue Origin has been contracted $45 million by NASA for its Suborbital Reusable Launch Vehicle Flight and Payload Integration Services project, which is part of NASA's Flight Opportunities Program. Blue Origin's contract is to provide the suborbital flights on which researchers and scientists will test technologies that NASA has selected for inclusion in the program. Blue Origin's New Shepard is a reusable rocket that launches into suborbital space (just out of the atmosphere) and comes down to Earth to be used again. The New Shepard space capsule, which rests on top of the rocket, is supposed to hold six crew members for its first manned test flight next year. The goal is to welcome paying space tourists by 2018.[70]
Blue Origins contracts fall under Earth related/practical definitions because everything is focused on Earth and low Earth orbit contracts.

[70] Yakowicz, Will. "Jeff Bezos' Blue Origin Lands NASA Contract." Inc.com. Inc., 07 June 2016. Web. 20 Feb. 2017.

SpaceX: Earth Related/Practical Contracts:

- *Commercial Crew Transportation Capability (CCtCap) (2014)*
- *Surface Water and Ocean Topography (SWOT) (2016) satellite (launch date 2021)*
- *Cargo-Supply mission (2016)*
- *Commercial resupply Cargo (CRS-2) (2016)*

The Crew Transportation Capability (CCtCap) contracts purpose is to development of spacecraft capable of transporting NASA astronauts to and from the International Space Station as early as 2017. SpaceX will receive $2.6 billion to build its Dragon V2 spacecraft, an upgraded version of the Dragon spacecraft currently used to transport cargo to and from the ISS.[71]

NASA awarded a contract to SpaceX for the Falcon 9 launch of an Earth science satellite in 2021. The award, with a total cost to NASA of $112 million, is for the launch of the Surface Water and Ocean Topography (SWOT) spacecraft, scheduled for April 2021. The contract, NASA said in a statement, includes the launch service itself as well as spacecraft processing, payload integration, and tracking, data and telemetry support.

NASA has awarded five additional space station cargo-supply missions to SpaceX in a Late-December contract with an undisclosed value that industry official's estimate at around $700 million. [72]

In 2016 under the CRS-2 NASA contracted Sierra Nevada, Orbital ATK and SpaceX with a maximum budget for the contracts of $14 billion However, NASA had noted that it

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[71] Foust, Jeff. "NASA Selects Boeing and SpaceX for Commercial Crew Contracts."SpaceNews.com. Space News, 06 Aug. 2015. Web. 20 Mar. 2017. <http://spacenews.com/41891nasa-selects-boeing-and-spacex-for-commercial-crew-contracts/>.

[72] De Selding, Peter B. "SpaceX Wins 5 New Space Station Cargo Missions in NASA Contract Estimated at $700 Million." SpaceNews.com. 24 Feb. 2016. Web. 20 Mar. 2017. <http://spacenews.com/spacex-wins-5-new-space-station-cargo-missions-in-nasa-contract-estimated-at-700-million/>.

doesn't expect to spend all of it on CRS-2.[73] It is roughly estimated that SpaceX might receive up to $4 Billion for the CRS-2 contract.

The contracts that SpaceX has with NASA pertain to Earth based and low Earth orbit contracts. The majority of the contracts are Cargo runs to the International Space Station.

Sierra Nevada: Earth Related/Practical Contracts:

- *Commercial Resupply services (CRS-2) to ISS (2016)*

Sierra Nevada like SpaceX and Orbital ATK has been awarded the CRS-2 with an awarded roughly $4 Billion. This currently the most recent contract by NASA that Sierra Nevada has attained and it is a low Earth Orbit based contact. This is a cargo resupply program to the International Space Station.[74]

The Boeing Company: Earth Related/Practical Contracts:

- *Commercial Crew Transportation Capability (CCtCap) (2014)*

Boeing received $4.2 billion of the NASA CCtCap contract. Their plan under the contract is to send astronauts into Earth orbit with their CST-100 *Starliner* spacecraft using *United Launch Alliance's* Atlas 5 rockets. *Starliner* should return from each of its missions with landings in the Southwestern United States utilizing a system of parachutes and airbags.[75]

Space Exploration/Discovery Based Contracts:

- *Space exploration/discovery programs are defined as those, which are primarily focused on investigating outer space using, manned and unmanned spacecrafts beyond low Earth orbit. Space exploration programs involve robotics, humans, and probes sent to other*

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[73] "NASA Awards International Space Station Cargo Transport Contracts." NASA. Ed. Karen Northon. NASA, 14 Jan. 2016. Web.

[74] De Selding, Peter B. "SpaceX Wins 5 New Space Station Cargo Missions in NASA Contract Estimated at $700 Million." SpaceNews.com. 24 Feb. 2016. Web. 04 Apr. 2017. <http://spacenews.com/spacex-wins-5-new-space-station-cargo-missions-in-nasa-contract-estimated-at-700-million/>.

[75] Klaes, Larry. "Boeing, SpaceX Update Progress on Commercial Crew Spacecraft."SpaceFlight Insider. 08 June 2016. Web. 20 Mar. 2017. <http://www.spaceflightinsider.com/missions/human-spaceflight/boeing-spacex-update-progress-crewed-spacecraft/>.

space bodies for the purposes of increasing knowledge of space and ensuring the survival of humanity.

United Launch Alliance (ULA): Space Exploration/Discovery Contracts:

- *NASA's Mars 2020 rover (2016)*

United Launch Alliance has won a $243 million contract to launch NASA's Mars 2020 rover on its trip to the Red Planet in four years.[76] The Mars 2020 rover mission presents new opportunities to learn how future human explorers could use natural resources available on the surface of the Red Planet. An ability to live off the land could reduce costs and engineering challenges posed by Mars exploration.[77]

NextSTEP-2:

The next major component of human space exploration beyond Low-Earth orbit is building deep space habitats. NASA is soliciting proposals for the development of prototypes for deep space habitats that will give astronauts a place to call home during long-duration missions supporting the agency's Journey to Mars. This solicitation is called the Next Space Technologies for Exploration Partnerships-2 (NextSTEP-2). NextSTEP is a public-private partnership model that seeks commercial development of deep space exploration capabilities to support more extensive human spaceflight missions in the proving ground of space around the moon, known as cislunar space, and to enable transit to Mars. This partnership model enables NASA to obtain innovative concepts and support private industry commercialization plans for low-Earth orbit.[78]

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[76] "NASA Awards Launch Services Contract for Mars 2020 Rover Mission." NASA. Ed. Karen Northon. NASA, 25 Aug. 2016. Web.

[77] Northon, Karen. "NASA Awards Launch Services Contract for Mars 2020 Rover Mission."NASA. NASA, 25 Aug. 2016. Web. 20 Mar. 2017. <https://www.nasa.gov/press-release/nasa-awards-launch-services-contract-for-mars-2020-rover-mission>.

[78] "Next Space Technologies for Exploration Partnerships." NASA. NASA, 05 May 2015. Web.

NASA has selected six U.S. companies to help advance the Journey to Mars by developing ground prototypes and concepts for deep space habitats. The selected companies are:

1. Bigelow Aerospace
2. Boeing
3. Lockheed Martin
4. Orbital ATK
5. Sierra Nevada Corporation's Space Systems
6. NanoRacks

These six companies will develop the next human exploration capabilities needed beyond the Space Launch System (SLS) rocket and Orion capsule are deep space, long duration habitation and in-space propulsion. NASA is now adding focus and specifics on the deep space habitats where humans will live and work independently for months or years at a time, without cargo supply deliveries from Earth.

The companies will have up to approximately 2 years to develop ground prototypes and/or conduct concept studies for deep space habitats. The contract award amounts are dependent on contract negotiations, and NASA has estimated the combined total of all the awards, covering work in 2016 and 2017, will be approximately $65 million, with additional efforts and funding continuing into 2018. Selected companies are required to contribute at least 30 percent of the cost of the overall proposed effort.

Chart 5

Total Earth Related/Practical Contracts	Total Exploration/Discovery Contracts
$19,796,900,000	$ 1,665,000,000

Chart 5 shows the total amount of contracts in the Earth related/practical and Exploration/discovery. It can be seen that Earth related/practical contracts are much larger in money amount than the exploration/discovery contracts. The difference between them is a roughly 18 billion difference.

The reason why the majority of the space companies contracted by NASA focus on practical programs is because it is currently much cheaper and less risky. When a company focuses on a smaller aspect of space technology like rocket fuel, satellites, and space suits there is less risk in losing assets.

Chapter 6: Conclusion

In final analysis of my thesis I have concluded that Earth related/practical programs do in fact get funded more than exploration/discovery programs.

In every chapter there is a difference between the funding and focus on Earth related/practical programs and exploration/discovery programs. When looking at NASA's budget it can be seen how there is a difference between the funding of the programs. Every year Earth related/practical program received significantly more funding than exploration/discovery program. Also, when it comes to Congress and the President passing and enacting bills Exploration/discovery programs never make it out of committee hearings, while Earth related/practical programs usually went through committing hearings and were enacted. Additionally, as concerns contacts with commercial space industries, the majority of contracts were Earth related/practical. These totaled roughly $19 billion while exploration/discovery contracts totaled $1 billion.

Currently NASA's exploration/discovery programs are vastly underfunded and constantly being contested every fiscal year. It is not to say that NASA's budget will always be the way it was the past six years since it is subject to drastic changes every time a new administration enters. One last note to make is that I do not disregard Earth related/practical programs as unimportant. I believe both programs are equally significant in enhancing human sustainability. However, there does seem to be an unbalanced funding between the two types of programs. Unfortunately, due to limited time I am unable to delve further into research of the factors of budgeting and bills passed in Congress.

"Since, in the long run, every planetary civilization will be endangered will be endangered by impacts from space, every surviving civilization is obliged to become spacefaring—not because of exploratory or romantic zeal, but for the most practical reason imaginable: staying alive… If our long-term survival is at stake, we have a basic responsibility to our species to venture to other worlds."
-Carl Sagan

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