THE INTERNATIONAL SPACE STATION

AND ITS ROLE IN THE FUTURE OF

SPACE EXPLORATION

By

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Title of Study: THE INTERNATIONAL SPACE STATION AND ITS ROLE IN THE FUTURE OF SPACE EXPLORATION

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Abstract: The purpose of this study was to: (1) emphasize and evaluate the past and present scientific and societal contributions the International Space Station (ISS) has provided the United States, (2) determine support for NASA and their efforts to stimulate a new interest for future lunar, planetary and deep space exploration, and (3) decide if the continued benefits of U.S. space exploration, including new discoveries and successful research findings, justify the associated financial costs. The ISS plays an important role in human exploration in space and has made significant contributions to the scientific community through research. By taking an in depth look at how the ISS was used in the past, present, and is intended to be used in the future we determine how it has benefited and will continue to benefit the aerospace industry as well as the global population. This will also allow us to identify challenges faced and come up with possible solutions. Additionally, this study will take a look at the funding opportunities and how they can be addressed. This study will focus on the contributions the ISS has provided in the past, the partnerships of countries and opportunities for cooperation it offers, and what it can offer to the future of space exploration and research initiatives, by evaluating the influence and achievements and examining the effects the ISS has had on the aerospace industry, scientific community, and the population of the world.

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CHAPTER I

INTRODUCTION

In the beginning, the International Space Station (ISS) was intended to be used for conducting a broad range of NASA-funded experiments in numerous disciplines. These disciplines included: life sciences, combustion science, fluid physics, materials science, and technology demonstration. The ISS is the most complex international scientific and engineering project in the history of mankind and the largest structure to have ever been put into space. In 2005, Congress designated the ISS as a national laboratory and asked NASA to increase station research utilization by including other federal entities and the private sector. This increase in utilization could be accomplished through partnerships, cost sharing, and other arrangements that would supplement NASA funding of ISS research, as well as NASA entering into a contract with a nongovernmental agency to operate the ISS national laboratory, subject to all applicable federal laws and regulations (GAO, 2009).

The ISS was built by five different space agencies; representing 15 countries, all of who continue to operate it today. In the past, research was conducted on the effects of microgravity, as well as other factors that affect everyday lives. In fact, there have been significant research accomplishments achieved by astronauts and scientists on board the ISS, including: (1) bone loss minimization, (2) virulence of bacteria in space, (3) activities that inspire students about the values of STEM fields, (4) studies of dark matter in the universe, (5) manipulation of nanoparticles, and (6) improvements in robotics

(Robinson, 2013). From 2001-2010, more than 400 experiments had been conducted on the ISS. On a daily basis, ISS astronauts conduct science across a wide variety of fields, including human life sciences, biological science, human physiology, physical and materials science, and Earth and space science (NASA, 2011).

Statement of the Problem

There are many challenges affecting the ISS and its continued viability. The first challenge is the retirement of the Space Shuttle in 2011 which resulted in reduced launch capabilities and the question of when another United States (U.S.) space vehicle, capable of reaching the ISS, will be available after the shuttle's retirement. Another challenge is the high costs for launches and developing research hardware and a lack of dedicated funding streams for ISS research (GAO, 2009). Additionally, the ISS crew will be fixed in size and the time available for that crew to do research will be limited due to other requirements. The maintenance and cost as well as how to fund this global research facility will perhaps remain the greatest challenges.

With the ISS now fully assembled, astronauts are spending additional time on science. The U.S. and its partners have now entered a period of full exploitation of the ISS. However, the year of retirement for the ISS, 2024, is fast approaching and solutions need to be developed to keep this international asset operable. And yet the challenges the ISS faces are so significant that the future use of the ISS remains an uncertainty.

Unless the scheduled 2024 retirement date for the ISS is extended at the federal level, the scientific community will no longer consider the space station as a platform for fundamental research. In order for successful research to be completed, sufficient time is required to develop and conduct experiments. NASA has a vision for the ISS and the

role it will play in the future of space exploration; however, if an extension to the retirement date is not executed, NASA will have limited time to execute their robust research program before the ISS is deorbited (NASA, 2011). Even with the challenges facing the ISS, it offers the potential as a unique testing facility for new technologies and applications, for scientific breakthroughs, and a platform for increased international collaboration in research. As previously mentioned, a viable user base will not develop without sufficient launch opportunities, sufficient crew time to conduct research, and longevity of the ISS (GAO, 2009).

Lastly, the Review of Human Space Flight Plans Committee has proposed extension of the ISS until 2024 in three of its possible five scenarios and Congress has instructed NASA to take steps to ensure that it remains capable of being a viable and productive facility, but as of yet there is still not a commitment to continue operations (Foust, 2017). NASA has limited experience managing the type of diverse scientific research and technology demonstration portfolio that the ISS could eventually represent; therefore, it may become necessary for NASA to solicit assistance from an outside contractor or nonprofit organization to oversee the operations of this orbiting laboratory (GAO, 2009). Regardless, all viable opportunities of extending the ISS retirement date and additional funding initiatives for the ISS will need to be investigated to ensure that the 2024 retirement date does not bring an end to space exploration and the valuable research performed aboard the ISS.

Purpose of the Study

The purpose of this study was to: (1) emphasize and evaluate the past and present scientific and societal contributions the ISS has provided the United States, (2) determine

support for NASA and their efforts to stimulate a new interest for future lunar, planetary and deep space exploration, and (3) decide if the continued benefits of U.S. space exploration, including new discoveries and successful research findings, justify the associated financial costs.

Research Questions

According to NASA (2011), the ISS has conducted over 400 experiments and the most important knowledge gained from the ISS may still be unknown as amazing discoveries wait in the future. Several recent patents and partnerships have already demonstrated Earth benefits of the public's investment in ISS research (NASA, 2011). The following research questions have been developed to direct this quantitative study regarding the ISS:

RQ1: Do Americans fear that the U.S. will lose its dominance in space exploration and research to other countries that have further outlined robust plans for lunar and other space exploration?

RQ2: Do Americans believe that the U.S. space program, including the International Space Station, benefits the nation's economy by inspiring young people to consider an education in science, technology, engineering and mathematics (STEM) fields?

RQ3: Do Americans support increasing NASA's budget?

RQ4: Do Americans believe the benefits of space exploration and associated research outweigh the risks of human space flight?

RQ5: Do Americans believe that the benefits of space exploration justify the financial costs?

RQ6: Do Americans believe that additional funding for the ISS *will not* result in increased technological advances, endless research opportunities, and the continued growth of U.S. space exploration; therefore, NASA should not extend the ISS expectancy of use past the year 2024?

In addition, for comparative purposes, the researcher included participant data from a series of four research polls and focus groups conducted between 2005 and 2008 by The Gallup Organization. This series of studies, commissioned by The Space Foundation, were conducted to determine the magnitude of advocacy and public outlook towards America's space program, including the International Space Station. The sample population for this 2005-2008 study encompassed approximately 1,000 U.S. adult men and women aged 18 years and older. The survey questions used in the 2005-2008 studies included:

1. Do Americans believe that the space program benefits the nation's economy by inspiring young people to consider an education in science, technology, math or engineering fields?
2. Are Americans supportive of a new plan for space exploration?
3. Do you think the space program has brought enough benefits to this country to justify its costs, or don't you think so?
4. Do you think spending on the U.S. space program should be increased, kept at the present level, reduced, or ended altogether?

The research data analyzed from this study will be compared to the data that was collected over a decade ago by the Gallup Organization. By comparing the two sets of data, the researcher can determine if the perceptions of U.S. adults regarding the U.S.

space program, the significance of the ISS, and continued funding for space exploration has changed during the past ten to thirteen years.

Significance of the Study

Through the ISS program, the world has come together in a common goal for space exploration. Analyzing the past and present use of the ISS and the experiments conducted and how they benefit planet Earth and the global society will also provide insight into the future possibilities of the ISS.

Assumptions and Limitations

For the purpose of this study, the following assumptions and limitations were identified:

- It is assumed by the researcher that the sample population selected will have personal knowledge of the ISS and its objectives. The sample population are adults who live in the U.S. and the researcher assumed they have access to television, internet, or other means of information on past and present U.S, space exploration projects.
- It is assumed that the sample population will answer these questions honestly and to the best of their knowledge.
- Another assumption is that the sample population will be a representative sample of the American people interested in U.S. space exploration.
- This study will be limited based on the voluntary participation of U.S. adults asked to participate in this study.

CHAPTER II

REVIEW OF LITERATURE

This chapter provides an overview of the existing body of literature as it relates to: development of the International Space Station; research and experiments conducted onboard the ISS; social and environmental benefits; observation and remote sensing opportunities; commercial/private industry partnerships, and the Gallup studies commissioned by The Space Foundation. The conceptual framework for this study was built upon the historical and current understanding of the ISS and its numerous functions and benefits.

The ISS is a part of the global multimodal transportation system. Currently, there are 15 countries that fund and resupply the ISS: U.S., Russia, Canada, Japan, Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom. Collectively, the ISS brings together international flight crews, multiple launch vehicles, globally distributed launch operations, training, engineering and development facilities, communications networks, and the international scientific research community (NASA, 2011). The ISS was constructed by the countries involved.

Development of the ISS

The ISS is an unprecedented achievement in global human endeavors regarding conceiving, planning, building, operating, and utilizing a research platform in space (NASA, 2011). The ISS is relative to the size of a football field, including its large solar arrays. It weighs approximately 860,000 pounds, not including visiting vehicle weights.

It has more livable room than a conventional five-bedroom house and has two bathrooms, a gymnasium, and a 360-degree bay window (NASA, 2017). Through 2017, 161 spacewalks have been conducted in support of the ISS assembly, totaling more than 1,015 hours. The fifteenth anniversary of the ISS was on November 2, 2015. As of January 2018, the ISS has been visited by 230 individuals from 18 countries (Howell, 2018).

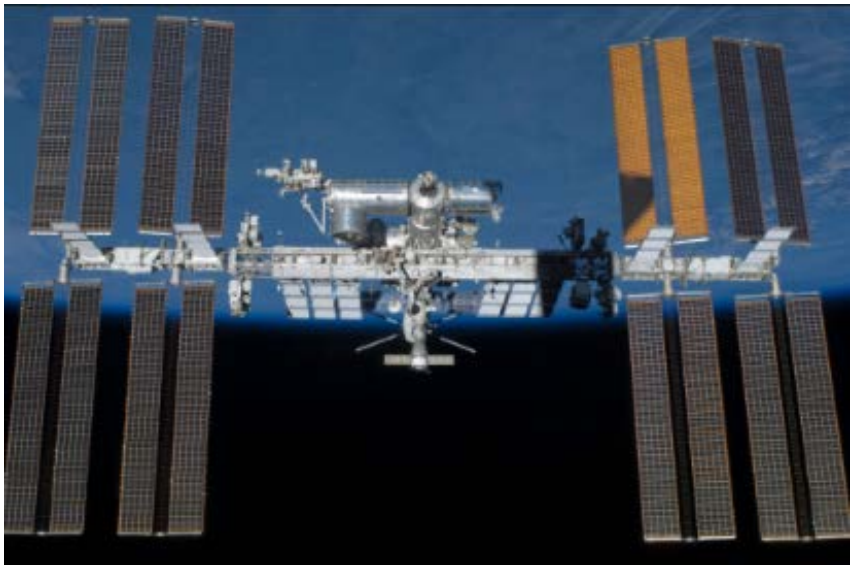

Figure 1. The fully assembled ISS. (Source: NASA)

Operating the ISS is more complex than other space flight endeavors because it is an international effort. Each partnering country is responsible for the hardware it provides in support of the ISS. NASA exercises management over the NASA Field Centers, establishes management policies, and analyzes all phases of the space station program (NASA, 2011). Roscosmos, the Russian Federal Space Agency oversees Russian flight activities. The Canadian Space Agency (CSA) provides the resources,

equipment, and expertise needed for the engineering and monitoring of the Mobile Servicing System (MSS) and also for crew training. The MSS is made up of a 17-meter long robotic arm, a two-armed robotic appendage, and a moveable work platform and storage facility (CSA, 2018).

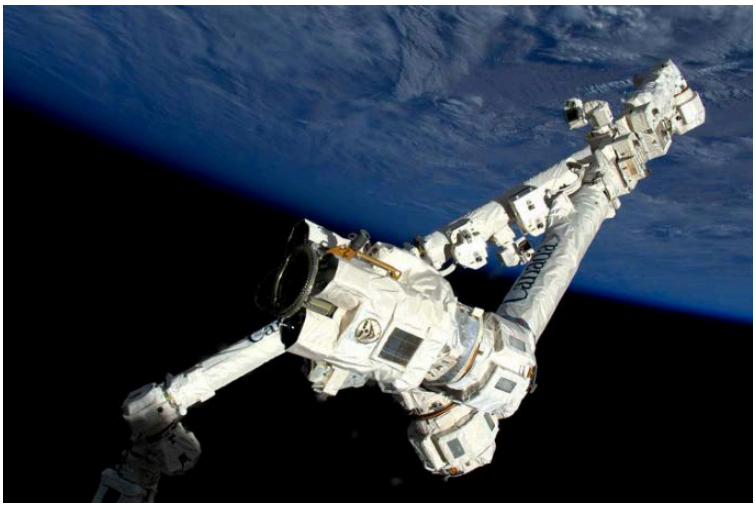

Figure 2. The Canadian MSS. (Source: NASA)

The European Space Agency (ESA) is exclusively responsible for two key Station elements: the European Columbus laboratory and the Automated Transfer Vehicle (ATV) (ESA, 2017). The ATV can carry up to seven tons of cargo including provisions, scientific payloads and propellant. Once docked, the craft uses its engines to boost the ISS to a higher orbit counteracting the faint drag of Earth's atmosphere. Since 2008, five expendable ATVs have been launched to the ISS. In 2012, the ESA stated that the ATV program would be terminated following the launch of the fifth ATV in July 2014 (Clark, 2012).

Figure 3. The European ATV. (Source: NASA)

Historically, the first segment of the ISS was launched in November 1998. However, the years leading up to the launch of that segment, a control module called Zarya, were quite bumpy. In Russia, the construction of the service module fell behind schedule due to lack of funds; however, this allowed NASA the additional time for on-ground testing of hardware which significantly reduced the risk of costly integration problems during the orbital assembly (Zak, 2018). The Russian delay meant that the original launch timeframe of November 1997 would not happen for another year.

In December of 1996, NASA initiated the development of the Interim Control Module (ICM) based on the propulsion module of a classified military satellite. The launch of the service module was scheduled for April 1999 but would be delayed for several months. In November 2000, the first resident crew of the station including U.S. astronaut Bill Shepard and Russian cosmonauts Yuri Gidzenko and Sergei Krikalev docked to the ISS aboard a Russian Soyuz spacecraft (Zak, 2017). In December 2000, the first U.S. Space Shuttle docked to the station and brought the first set of solar arrays and radiators to the station, making it the biggest orbital structure. On February 7, 2001,

the Shuttle Atlantis delivered Destiny, the U.S. laboratory module to the ISS. However, financial issues threatened the ISS project and as a result of the multi-billion-dollar cost overruns, NASA was forced to cancel the development of the U.S. habitation module and reusable rescue vehicle for the ISS.

In February 2003, the loss of Shuttle Columbia at the end of the STS-107 mission stalled the construction of the station and essentially grounded the U.S. manned space program for an indefinite period of time (Zak, 2018). In 2005, the U.S. Congress selected the U.S. portion of the ISS as the nation's newest national laboratory to maximize its use for other U.S. government agencies, as well as for academic and private institutions (CASIS, 2018). As anticipated in 2005, the U.S. cancelled the shuttle flight that was scheduled to deliver a Russian science and power platform that was to serve as a cornerstone of a future Russian space station.

Figure 4. The Russian science and power platform. (Source: NASA)

In March 2006, the global partners of the ISS project approved a new assembly sequence that dedicated 16 Space Shuttle flights. At this point, without any major delays or accidents in the Shuttle program it was expected that the ISS would be capable of sustaining a six-person crew by the year 2009 (Cowing, 2006).

Furthermore, the U.S. had to find a way to execute ISS missions without the use of the Space Shuttle program which was scheduled to conclude in 2011. The retirement of the shuttle program resulted in a four-year gap, between the years of 2010 and 2014 in which the U.S. turned to Russia to accomplish their ISS missions. During this same time frame, Russia had scheduled its own Soyuz flights to the ISS; aiding in the U.S missions would double Russian transport traffic to the ISS. To offset Russia's flight costs, NASA announced in April 2007 that it signed a contract with Russia for $719 million dollars. This contract was for the modification to the ISS and crew and cargo services through 2011. In addition, NASA purchased the capability for the Russian Docking Cargo Module to carry 1.4 metric tons of NASA cargo to the station in 2010 (Zak, 2018). Lastly, NASA purchased a flight opportunity to and from the ISS that would meet an obligation to its international partners. The flight would permit an astronaut from the global partners to spend roughly six months on board the ISS in 2009.

Figure 5. The Russian docking cargo module. (Source: NASA)

In September 2008, Congress extended a waiver to the Iran, North Korea and Syria Nonproliferation Act (INKSNA) that would allow NASA to purchase seats on Russian Soyuz spacecraft after a previous waiver was set to expire at the end of 2011 (Zak, 2018). The extension of this waiver provided a constant habitation of U.S. and European astronauts on the ISS at the same time of the projected Shuttle retirement. Prior to the decision being made by Congress, NASA Administrator announced to the media that there would be an interruption of U.S. and European manned space flight beginning in 2012.

Continuing efforts to develop alternative options extending the life span of the ISS were being considered during this time. Space officials were confident that the ISS would remain in orbit until at least 2020 even though the final decision on the expectancy and use was not anticipated until 2010. But when the Obama administration published a proposed budget in February 2010 that decreased funding for the Constellation program, the ISS would require a new charter for existence. The Constellation program was a

manned spaceflight program designed to complete construction of the ISS, as well as return to the Moon by 2020.

Research and Experiments Conducted Onboard the ISS

As of 2016, there have been 376 expeditions to the space station since the launch of the first module, Zarya, on November 20, 1998 (NASA, 2017). The ISS has had 221 visitors, 100 of which have resided on the ISS. The mission of the ISS is to conduct research and experiments. There have been 54 expeditions made to the ISS that have conducted experiments on a wide variety of disciplines. The research experiments conducted onboard the ISS are classified into six categories: biology and biotechnology, earth and space science, educational activities, human research, physical sciences, and technology. At any given time onboard the space station, a large array of different scientific experiments are underway within a wide range of disciplines (NASA, 2017).

In order to sustain life aboard the ISS, life support systems on the ISS remove carbon dioxide from the station atmosphere and supply oxygen. They also prevent gases like ammonia and acetone, which people emit in small amounts, from building up to dangerous levels. The environment of the ISS is a challenge for astronauts to both work and live. Astronauts are required to change their sleeping patterns, diets, sanitation, wear space suits, and conduct specially designed experiments. Crew members perform the daily functions of life in space using special products and procedures.

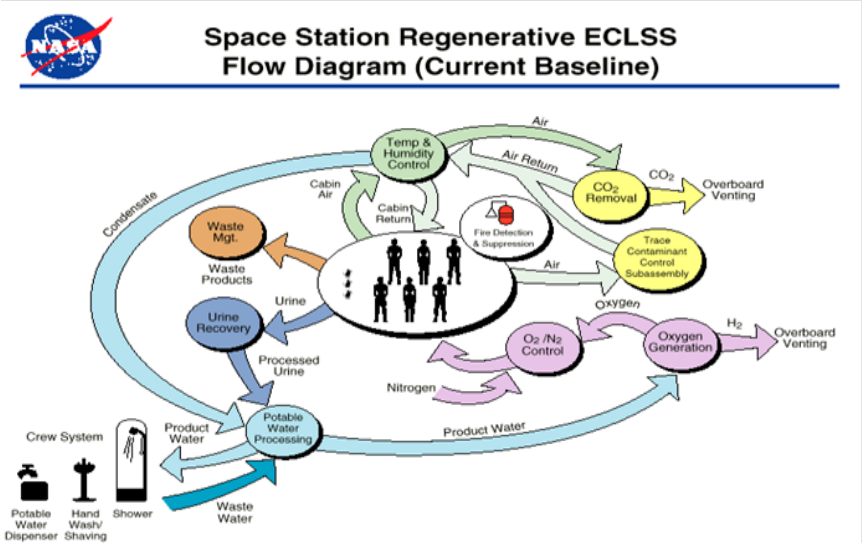

Figure 6. Life support system on the ISS. (Source: NASA)

Many of the experiments conducted in space have significantly benefited society. Onboard the ISS exists the ideal environment to grow and study high quality protein crystals. According to NASA research, there are more than 100,000 proteins in the human body and as many as 10 billion in nature; and every protein holds key information related to human health and each structure is dissimilar (NASA, 2015). Additionally, they are valuable to the global environment. The environment on board the ISS, specifically in space allows for optimal growth of the unique and complicated crystal structures of proteins leading to the development of medical treatments due to microgravity. An example of a protein that was successfully crystallized in space is hematopoietic prostaglandin D synthase (H-PGDS), which may be directly involved in developing useful drugs for treating muscular dystrophy (NASA, 2015).

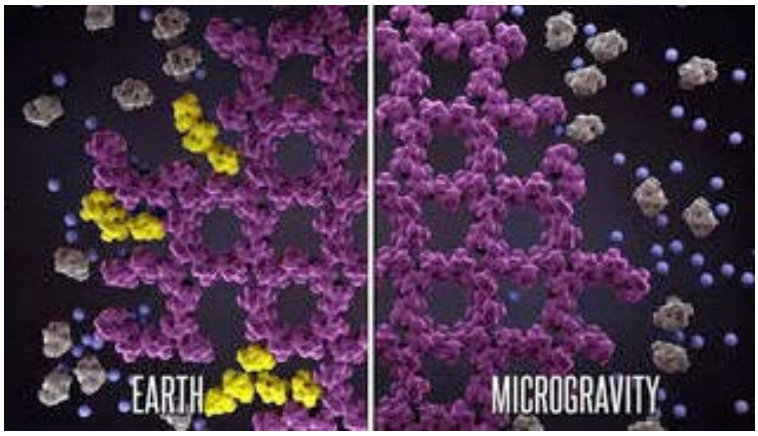

Figure 7. Protein differences between Earth and Space. (Source: NASA)

Basic human survival relies heavily on quick, adequate, and easily available medical attention when a health emergency occurs. When medical facilities are not easily accessible, it can mean the difference between life and death. On board the ISS, 250 miles above the Earth, that specific issue was examined through the Advanced Diagnostic Ultrasound in Microgravity (ADUM) investigation. In partnership with the World Interactive Network Focused on Critical Ultrasound (WINFO-CUS), the ADUM scientists took techniques originally developed for ISS astronauts and adapting them for use on Earth by developing protocols for performing complex procedures rapidly with remote expert guidance and training (NASA, 2017). The ultrasound technology and remote guidance techniques developed for astronauts living on board the ISS has enabled medical care to be readily available in remote locations on Earth that would otherwise not have the quick access to medical facilities and treatment.

Another experiment that has been developed on the ISS and used on Earthly is the eye tracking device. Laser surgery on the human eye has become more common and enhancing eye surgery using space hardware has played a key role in the success of laser surgery. The use of tracking technology that was initially developed for use in space is

now being used to track a patient's eye and accurately manage the laser scalpel. According to NASA, (2017), the eye tracking device experiment gave researchers insight into how a human's frames of reference, balance and the overall control of eye movement are affected by weightlessness; concluding that the device could be significantly beneficial to society.

Another societal contribution that originated from the ISS is making inoperable tumors operable with the use of a robotic arm. In fact, since 2008, this technology has been used extensively in clinical experiences with patients who were considered otherwise inoperable. Paige Nickason had an egg-shaped brain tumor successfully removed with the aid of a gentle touch and a world-famous arm, not a surgeon's arm but a robotic arm.

> "The technology that went into developing neuroArm, the world's first robot capable of performing surgery inside magnetic resonance machines was born of the Canadarm, developed for the U.S. Space Shuttle Program; as well as Canadarm2, the robotic arm that performs the heavy lifting and maintenance aboard the International Space Station" (NASA, 2012, pg. 1).

Research on board the ISS has also led to development of improved vaccines. Ground research determined that bacteria, especially Salmonella, has the potential to become more able to cause disease during spaceflight. In the U.S. alone, Salmonella is responsible for thousands of hospitalizations and hundreds of annual deaths. During analysis in space, scientists found a pathway for bacterial pathogens to become virulent, by identifying the genetic pathway activating in Salmonella, and allowing the increased likelihood to spread in microgravity (NASA, 2017).

Furthermore, improving air quality is another experiment that has benefited the astronauts on the ISS and society on Earth. The solutions that allowed for growth of crops in space now enables solutions for mold prevention in wine cellars, homes, medical facilities, and other industries on Earth. Looking to the future, NASA is monitoring the crop growth on the ISS to establish the ability for astronauts to grow their own food as part of the agency's journey to Mars.

Lastly, through research and analysis came the Advanced Astro-culture or ADVASC, which is an ethylene removal system in space. It aided in keeping plants alive by discarding bacteria, viruses, and mold from the plant growth chamber. Scientists adjusted the ADVASC system for application in air purification. This technology is now able to prolong the shelf-life of fruits and vegetables. Additionally, winemakers are utilizing it in their storage cellars.

Figure 8. The ADVASC plant growth experiment. (Source: NASA)

Social and Environmental Benefits

The ISS is an extensive part of the commercialization of space research. Aboard the ISS, selected industries have participated in research by conducting experiments and studies aimed at developing new products and services. The results of these experiments have greatly benefited those on Earth; not only by providing innovative new products, but also by creating new jobs to manufacture and market these new products.

Environmental aspects of the ISS include both onboard effects on the crew from prolonged space exposure, as well as the observations of the Earth from orbit that will help the study of large-scale, long-term changes in the environment. These studies assist in understanding the effects of volcanoes, meteorite impacts, hurricanes, typhoons, forest, oceans, and mountains. In addition, changes to the Earth that are caused by the human race can be observed from the ISS. The effects of: (1) air pollution, (2) deforestation, and (3) water pollution are visible from space and can be captured in images that provide a global perspective unavailable from the ground (Shuttle Press Kit, 1999).

One system in particular captures photographs of Earth from space for application in developing countries affected by natural disasters. That system is known as the Environmental Research and Visualization System (ISERV). Additionally, another shared effort by NASA and the U.S. Agency for International Development, known as SERVIR, collaborates with developing nations to involve satellites as a means of making decisions related to the environment. The ISS passes over more than 90 percent of the Earth's populated areas daily, allowing the ISERV system to provide imagery to developing nations quickly, collecting up to 1,000 images per day, these images in turn can aid in a quick response to efforts for floods, fires, volcanic eruptions, deforestation,

harmful algal blooms and other types of natural events (NASA, 2017). The ISS continues to confirm its contribution to the planet as a priceless platform for observation of the Earth.

Figure 9. ISERV image of Mt. Etna. (Source: NASA)

When the first astronauts went to the ISS, they were losing almost two percent of their total bone mass density each month. Using diet and an exercise regimen, scientists have developed a way to reduce bone loss. These scientists discovered that high-intensity resistive exercise, as well as dietary supplementation for vitamin D and specific caloric intake can minimize the loss of bone mass in space (NASA, 2017). These types of scientific discoveries will continue to provide a huge benefit for the support of astronauts and crew on the ISS; the future of deep space exploration and incorporating the possibility of a journey to Mars or an orbiting asteroid.

Pharmaceutical companies have benefited from ISS research focusing on the mechanisms of osteoporosis. By using model organisms, such as mice, scientists

conducted a study in orbit to understand mechanisms of osteoporosis. Model organisms are non-human species with specific characteristics that allow them easily to be reproduced and studied in a confined laboratory (NASA, 2017). This study that involved mice onboard the ISS led to the availability of a pharmaceutical medication called Prolia, which helps treat humans with osteoporosis.

Observation and Remote Sensing Opportunities

The ISS provides a unique opportunity to capture a variety of sites on Earth by providing repeated overflight passes of the Earth with different lighting and viewing angles (NASA, 2017). The crew on the ISS conducts Crew Earth Observations (CEO) defined as photographing human-made and natural events on Earth. The photographs record the Earth's surface changes over time, along with dynamic events such as storms, floods, fires and volcanic eruptions (NASA, 2017). These images offer researchers data from a perspective on the ISS, allowing them to understand the planet from that vantage point. Earth observations from space serves as a unique record of environmental change on Earth and the destructive impact caused by humans; such as city growth, agricultural expansion, and reservoir construction. Short- and long-term events documented by CEOs have included hurricanes, floods, fires, volcanic eruptions, climate change, forest fires, urban sprawl, and pollution (NASA, 2017).

The ISS crewmembers use commercial and professional handheld cameras with a suite of lenses (from wide angle to an 800mm lens equivalent) to take the Earth observation photographs that support research in a wide variety of Earth Science sub-disciplines. The crew is also provided with a daily list of targets of the greatest scientific interest; ranging from educational and research tools, as well as historical records of

global environmental change, special geological and weather events, and the growth and change of human-made features (NASA, 2017).

Commercial/Private Industry Partnerships

As the future continues to unfold for NASA and the longevity of the ISS, the commercial/private industry will play a vital role in the success of the U.S. space exploration. To accomplish the goals of the National Space Policy and achieve NASA's strategic plan for future space exploration, NASA is maintaining its efforts to promote the development of advanced industrial space-related capabilities towards new space markets. According to NASA, (2017), the Human Exploration and Operations Mission Directorate was initiated to allow authorization of the Commercial Space Capabilities Office to solicit and manage Space Act Agreements with U.S. private sector enterprises that wish to collaborate with NASA on the development of new space-related capabilities.

> "The purpose of the Space Act Agreements (SAAs) is to advance commercial space-related efforts by facilitating access to NASA's vast spaceflight resources including technical expertise, assessments, lessons learned, and data so that the emerging products or services are commercially available to government and non-government customers within approximately the next five years (NASA, 2017, pg. 2)."

In 2017, NASA released its list of the 1,200 active SAAs the space agency had with commercial companies, non-profit entities, and state and local governments. Included in this list are the thirty-one SAAs that NASA has signed with SpaceX (Messier, 2017). NASA's decade-long collaboration with SpaceX, a private U.S.

aerospace manufacturer and space transportation company, has resulted in numerous successful funding, organization, and research initiatives for NASA.

> "Space X is involved in the development of space transportation capabilities for unmanned science, crew missions, deep space communication and navigation, Mars entry, descent and landing, methane-oxygen propulsion, propellant management, and large scale in situ resource utilization systems (NASA, 2017, pg. 2)."

Since the NASA and SpaceX partnership, SpaceX has flown thirteen missions to the ISS, delivering various payloads. The most recent NASA-contracted ISS mission launched from a Florida Air Force station on April 2, 2018, delivering 6,000 pounds of supplies and science equipment to the ISS. The astronauts onboard the ISS docked the SpaceX cargo capsule to the ISS by using the Canadaarm2 robotic arm. The SpaceX capsule will remain docked to the ISS for a month while the ISS crew packs the capsule with 4,000 pounds of cargo that the ISS no longer needs in space.

The science equipment will be used to support 50 of the 250 science experiments that are currently being conducted onboard the space station (Weitering, 2018). Two of the research studies involve the optimization of plant growth in space, as well as the production of red blood cells by bone marrow in a microgravity environment (Wall, 2018). In addition to the cargo contract with NASA; in 2014, NASA and SpaceX had also partnered to develop a manned launch vehicle capable of transporting astronauts to the ISS and return them to Earth (NASA, 2017). SpaceX has projected that it will be able to conduct a manned test flight in December 2018. This test flight will be one step closer the NASA's goal of launching its astronauts to the ISS from U.S. soil. Ever since 2011

when the U.S. Space Shuttle program retired, the U.S. has relied on the Russia's space program to launch U.S. crews to the ISS.

Figure 10. ISS astronauts docking the SpaceX capsule with the Canadarm2. (Source: NASA)

The Gallup Studies

The Gallup World Poll tracks the most important issues worldwide. One of those topics is the space program and space exploration. Gallup uses telephone surveys in countries where telephone coverage represents at least 80% of the population (Gallup, 2018). The Gallup organization uses a random-digit-dial (RDD) method or a nationally representative list of phone numbers. The list of phone numbers used are contacted up to three times by Gallup. The results of the Gallup polls used for comparison in this study were based on telephone interviews with randomly selected national samples of approximately 1,000 adults, aged 18 years or older (Gallup, 2018).

A series of four polls commissioned by The Space Foundation in an effort to determine the extent of support and public attitudes toward America's space program

were conducted by the Gallup Organization. The polls were conducted in June 2005, March 2006, August 2006 and May 2008. The results from the polls revealed that in the midst of a varying world and national circumstances and uncertainties, Americans still strongly supported U.S. space exploration and were willing to support its funding at current levels or even slightly increased levels, according to Mary Engola, chairwoman of the Coalition for Space Exploration's Public Affairs Team (Gallup, 2009).

CHAPTER III

METHODOLOGY

This chapter describes the methodology used in this research study, to include: purpose of the study, selection of the research population, description of the research instrument, quantitative data collection, quantitative data analysis, and ethical issues and assurances.

Purpose of the Study

The purpose of this study was to: (1) emphasize and evaluate the past and present scientific and societal contributions the ISS has provided the United States, (2) determine support for NASA and their efforts to stimulate a new interest for future lunar, planetary and deep space exploration, and (3) decide if the continued benefits of U.S. space exploration, including new discoveries and successful research findings, justify the associated financial costs.

Selection of the Research Population

The research population for this national study was determined by convenience sampling and snowball sampling. Convenience sampling is a nonrandom sampling technique where representatives of the target population that meet certain criteria, established by the researcher, are included for the purpose of the study (Etikan, Musa, and Alkassim, 2016). The primary objective of convenience sampling is to collect information from participants who are easily accessible to the researcher. In addition, nonrandom sampling is useful when randomization is impossible, for instance when the

population is extremely large. Lastly, this sampling technique can be useful when the researcher has limited resources, including time, workforce and monetary funds (Explorable, 2018). Convenience sampling was used for the participants who responded to the survey via email responses.

Snowball sampling refers to a non-probability sampling technique in which a researcher begins with a small population of individuals and through the course of the research, the population expands as those initial participants recruit others to participate in the study. In other words, the sample population starts small but snowballs into a larger sample (Lewis-Beck, Bryman & Liao, 2004). Snowball sampling was used by the researcher when the social media links were created and posted; asking for participants to complete the research survey. Snowball sampling is often used by researchers who are working with a population that is difficult to identify or locate, because it allows for additional discovery of characteristics about a population that may not otherwise be identifiable (Spreen, 1992). However, a disadvantage of this sampling technique is that it becomes more difficult to determine the sampling error.

The U.S. adult men and women participating in this study remained anonymous as a result of the researcher using the following methods: (1) the research questionnaire did not ask for the participants' names, (2) the data provided by the participants could not be linked back to an identifiable email or social media account, (3) the data submitted by the participants were anonymously coded and electronically sent to an Excel spreadsheet, and (4) the spreadsheet was electronically entered by the researcher into a statistical software program, Statistical Package for the Social Sciences (SPSS), for analysis. In addition, all participants were notified in the introductory section of the research

questionnaire that the information they provided would be kept confidential and would be anonymously coded for statistical analysis. The participants were also notified in the cover letter (Appendix A), that contributing to this research study was strictly voluntary.

Description of the Research Instrument

Guided by descriptive methodology, this research study used a research instrument (survey), *The International Space Station and its Role in the Future of Space Exploration* (Appendix B) authored by the researcher. The instrument was developed by the researcher to quantitatively investigate the perceptions of U.S. adult men and women age 18 and older, as well as obtain demographic data and personal comments from each participant related to their perceptions on U.S. space exploration and the International Space Station.

The research survey consisted of three parts: demographic information, closed-end questions, and a personal comment section. The first part of the instrument prompted demographic (personal) information characterizing each adult man and woman participating in the study. The personal information sought by the researcher included the participant's age and level of completed education. The second part administered a series of closed-end questions; requiring a yes or no response from the participant. The list of questions were considered with the intension to gain insight into the participating adults' perceptions of the International Space Station, its future in U.S. space exploration, and the financial costs of U.S. space exploration including the continuous operation and maintenance of the ISS. The third and final part of the research questionnaire presented a text box providing the participant an opportunity to provide their own personal remarks

regarding the historical significance of the ISS, as well as its future role in space exploration and research initiatives.

Quantitative Data Collection

A research instrument (survey) was chosen to collect the necessary data for this study; that is to determine if American adults continue to: (1) support the purpose of the ISS, (2) support further funding of the ISS for research experimentation, and (3) support U.S. deep space exploration. The survey method was chosen because surveys are comparatively cost-effective. Related to cost effectiveness is a survey's potential for generalizability. Of all the known data-collection methods, survey research is one of the best methods to use when the researcher wants to obtain a representative picture of the attitudes and characteristics of a large population group (Blackstone, 2012).

The survey developed for this study was distributed using Qualtrics, a web-based academic survey platform that allows for easy distribution of the survey to the participants and creation of a data analysis report after the submission of all completed surveys. The survey was distributed and administered electronically via email and social media using a secure password-protected web link from Qualtrics.

Prior to completing the survey, the participants were presented a cover letter that provided a brief background of the ISS, as well as the researcher's purpose of the study (Appendix A). The participants then completed the survey (Appendix B). In addition, the participants were required to read a consent form (Appendix C) before completing the survey and electronically submitting it back to the researcher. After the survey was initially sent to participants, two weeks later the researcher sent reminder emails and social media messages encouraging potential participants to complete and submit a

completed survey (Appendices D & E). The distribution of the research instrument through social media (snowball sampling) and email (convenience sampling) allowed for a date stamp of the initial post or sending of the survey and provided an opportunity for the researcher to repost or send an additional email reminder after two weeks. After thirty days, the researcher confidentially coded and analyzed the data from each completed survey electronically returned to the researcher. The researcher collected, coded, and analyzed all of the survey data by the end of January 2018. The researcher was the only individual who had access to the password-protected, private, and encrypted website to receive and analyze the participants' data.

Quantitative Data Analysis

Following the data collection, all participant information from the surveys were categorized in terms of quantitative data. The demographic data and the perceptions of the U.S. adult men and women were examined and explained by the researcher through descriptive statistics. Descriptive statistics are commonly used to present quantitative descriptions in a manageable form; simplifying a large amount of data in a more practical way (Social Research Methods, 2006).

A benefit of using descriptive statistics is to allow the researcher to effectively describe and communicate patterns that might emerge from the data. Descriptive statistics helps define and summarize data through the use of percentages, rates, graphs, and frequency distributions (Laerd Statistics.com, 2015). The results and interpretation of this statistical analysis of data is discussed by the researcher in Chapter IV.

Ethical Issues and Assurances

Human subjects were an integral part of this study; therefore, this research study was conducted in accordance with Institutional Review Board (IRB) requirements established by the OSU Office of University Research Compliance (URC). The researcher obtained IRB approval (IRB Application Number: ED17129, December 2017) from the URC before conducting any research and collecting data from participants.

Potential ethical issues discussed include personal disclosure of information from the participants, perception of involuntary participation in the study, confidentiality issues involved with coding and analyzing the data provided by the participants. Each issue was discussed, and ways were identified to alleviate each issue. Prior to completing the survey, each participant read and reviewed a cover letter explaining that participation in this research study is strictly voluntary. The letter also stated that the responses to each survey question will remain confidential and will be used solely for statistical analysis. The statement detailing that it will be understood by the researcher if a participant completes the survey and submits their responses to the researcher meant that the participant had agreed and given consent to participate in this study which was also included in the cover letter.

The participants who volunteered to provide their own information all chose to do so by clicking on the "I choose to participate and consent to begin" button. The researcher clearly explained that the study had been approved by the IRB (Appendix F) and met all requirements to begin distributing the data, prior to forwarding the survey to participants.

The established IRB protocol has been systematically followed and complied with by the researcher. All quantitative data collection regarding the participants has been

protected and secured through all IRB requirements, and all confidential information and issues have been maintained through IRB standards and consent forms. All appropriate citations and references have been included in the final draft of the dissertation study.

CHAPTER IV

FINDINGS

The purpose of this research study was to: (1) emphasize and evaluate the past and present scientific and societal contributions the ISS has provided the United States, (2) determine support for NASA and their efforts to stimulate a new interest for future lunar, planetary and deep space exploration, and (3) decide if the continued benefits of U.S. space exploration, including new discoveries and successful research findings, justify the associated financial costs.

In addition, for comparative purposes with the participant perception data collected for this study, the researcher included selected participant data from a series of four research polls and focus groups conducted between 2005 and 2008 by The Gallup Organization. This series of studies were conducted to determine the magnitude of advocacy and public outlook towards America's space program, including the International Space Station during the time span of 2005 - 2008. The sample population for this 2005-2008 study encompassed approximately 1,000 U.S. adult men and women aged 18 years and older. The survey questions used in the 2005-2008 studies to collect the perception data included:

5. Do you think America's space program benefits the nation's economy by inspiring students to pursue careers in technical fields?
6. This year, a new plan or goal for space exploration was announced. The plan includes a stepping stone approach to return the space shuttle to flight, complete

assembly of the space station, build a replacement for the shuttle, go back to the moon, and then on to Mars and beyond. If NASA's budget did not exceed 1% of the federal budget, to what extent would you support or oppose this new plan for space exploration? Would you strongly support it, support it, oppose it, or strongly oppose it?

7. Do you think spending on the U.S. space program should be increased, kept at the present level, reduced, or ended altogether?
8. It is now 40 years since the United States first landed men on the moon. Do you think the space program has brought enough benefits to this country to justify its costs, or don't you think so?

Data Summary

In December of 2017, the researcher posted the survey through social media; posting the survey in four distinct groups to help facilitate participation. Additionally, the researcher emailed the survey to 950 co-workers, college students, and professional colleagues. It is impossible to calculate how many potential participants saw the survey posted through social media due to the snowball sampling discussed earlier; however, the researcher received 294 completed surveys as a result of the social media post. In addition, the researcher received 201 completed survey that were emailed to the 950 co-workers, college students, and professional colleagues. The surveys from the email responses yielded a response rate of 21% (201/950). At the end of the time allotted for collection, 495 completed surveys from the social media post and the emails were received by the researcher.

The research survey had a total of eight questions, seven questions were closed-end questions and one question was open-end. There were two questions related to demographic information regarding the participant, five questions related to the participant's perceptions regarding U.S. space exploration and the International Space Station, and one personal comment box allowing for any additional participant comments regarding the International Space Station and its role in the future of space exploration.

The first survey question asked participants about their age. Table 1 indicated different age ranges for each of the participants. The findings for this first question show that the majority of the adult participants (74%) were under the age of 35 years old. In addition, only 4% of the participating U.S. adults were 55 years old or older.

Survey Question One

1. What is your age?
   [ ] 18-24 [ ] 25-34 [ ] 35-44
   [ ] 45-54 [ ] 55-64 [ ] 65 or older

Table 1
Age of Participant

Range of Age	Responses	Percentage of Responses
18-24	113 out of 495	23%
25-34	253 out of 495	51%
34-44	80 out of 495	16%
45-54	29 out of 495	6%
55-64	11 out of 495	2%
65 or older	9 out of 495	2%

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The remaining demographic question identified the participant's completed level of education. The majority of the participants (37%) had earned a Bachelor's degree; and

an overwhelming percentage of participants (98%) had earned college credits. Lastly, 150 participants (30%) had earned a graduate degree or a professional degree.

Survey Question Two

2. What is the highest degree or level of school you have completed?
   [ ] High School Diploma or GED
   [ ] Some College Credit, No Degree
   [ ] Associate Degree
   [ ] Bachelor's Degree
   [ ] Master's Degree
   [ ] Doctorate or Professional Degree

Table 2
Completion of Highest Degree or Level of School

Level of Degree or School	Responses	Percentage of Responses
High School Diploma/GED	9 out of 495	2%
College Credit, No Degree	75 out of 495	15%
Associate Degree	76 out of 495	16%
Bachelor Degree	185 out of 495	37%
Master's Degree	135 out of 495	27%
Doctoral/Professional Degree	15 out of 495	3%

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In Table 3, the findings for survey question three show that most U.S. adults (79%) responding to the survey believe that U.S. space program, including the International Space Station, benefits the economy by inspiring young people to consider an education in STEM (science, technology, engineering and mathematics) fields.

Survey Question Three

3. Do Americans believe that the U.S. space program, including the ISS, benefits the nation's economy by inspiring young people to consider an education in science, technology, engineering and mathematics (STEM) fields?
   [ ] Yes
   [ ] No

Table 3
U.S. Space Program Inspires Young People

Space Program Inspiration	Responses	Percentage of Responses
Yes	392 out of 495	79%
No	103 out of 495	21%

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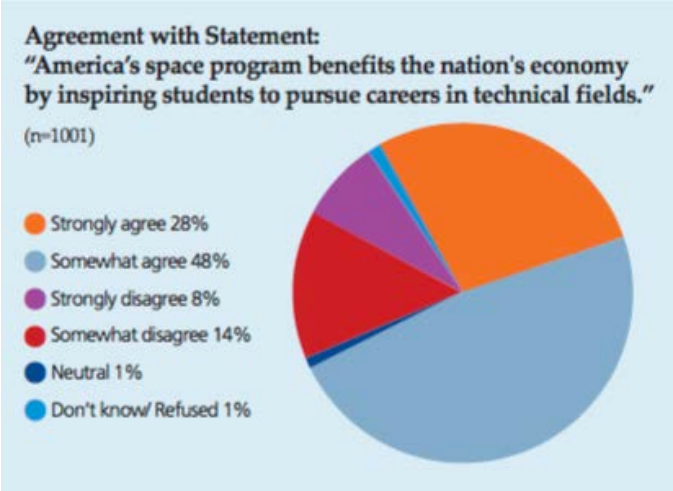
In comparison, the results from The Gallup Organization studies conducted between 2005 and 2008 studies (Figure 11) also showed that the majority (76%) of U.S. adults participating in these studies agreed with the following Gallup statement, "America's space program benefits the nation's economy by inspiring students to pursue careers in technical fields."

Figure 11. Space program inspires students (Gallup study).

When asked the question, "Do Americans fear that without public support and



further funding, the U.S. will lose its dominance in space exploration and research to other countries that have outlined robust plans for lunar/solar system exploration?", the majority (80%) of participants agreed that as a nation it is important to support, as well as fund U.S. space exploration; otherwise, the nation could lose its dominance to competing countries who have outlined their own plans for lunar and deep space exploration.

Survey Question Four

4. Do Americans fear that without public support and further funding, the U.S. will lose its dominance in space exploration and research to other countries that have outlined robust plans for lunar/solar system exploration?
   [ ] Yes
   [ ] No

Table 4
U.S. Space Will Lose Dominance without Support and Funding

Will Lose Dominance	Responses	Percentage of Responses
Yes	397 out of 495	80%
No	98 out of 495	20%

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A similar question regarding public support and further funding for space exploration was asked during the Gallup studies, "This year, a new plan or goal for space exploration was announced. The plan includes a stepping stone approach to return the space shuttle to flight, complete assembly of the space station, build a replacement for the shuttle, go back to the moon, and then on to Mars and beyond. If NASA's budget did not exceed 1% of the federal budget, to what extent would you support or oppose this new

plan for space exploration? Would you strongly support it, support it, oppose it, or strongly oppose it?"

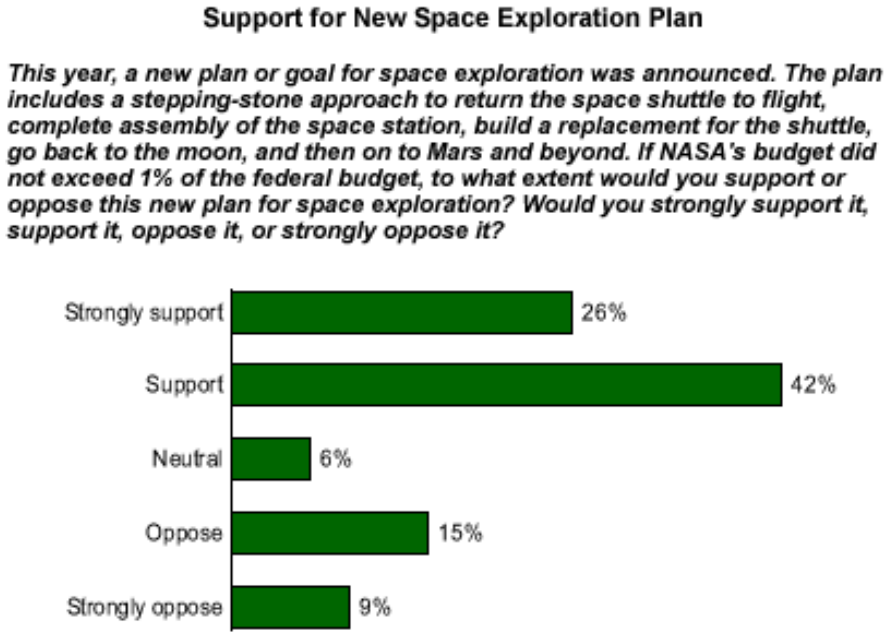

Figure 12. Support for a new U.S. space exploration plan (Gallup study).

The participants' responses to this Gallup study (Figure 12) indicate that more than half (68%) of the participating U.S. adults strongly agreed or agreed in support of a new plan for space exploration that would include a stepping-stone approach to return the space shuttle to flight, complete the assembly of the ISS, build a replacement for the shuttle, go back to the Moon, and then on to Mars or beyond.

Table 5 identified that 406 participants (82%) agree the overall benefits of U.S. space exploration and associated scientific research discoveries outweighs the risks of human space flight; even though 17 NASA astronauts have been killed in either a training exercise (Apollo 1) or actual Space Shuttle flights (Challenger and Columbia).

Survey Question Five

5. Do Americans believe the benefits of space exploration and associated scientific research outweigh the risks of human space flight?
   [ ] Yes
   [ ] No

Table 5
U.S. Space Exploration Outweighs the Risks

Exploration Outweighs Risks	Responses	Percentage of Responses
Yes	406 out of 495	82%
No	89 out of 495	18%

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Question six in the survey specifically asked if Americans support increasing the NASA budget. Most of the U.S. adults (58%) participating in the study indicated that Americans support increasing NASA's budget; while less than half (42%) of participants did not believe that Americans would support increasing NASA's budget.

Survey Question Six

6. Do Americans support increasing NASA's budget?
   [ ] Yes
   [ ] No

Table 6
Americans Support Increasing NASA Budget

Increase NASA Budget	Responses	Percentage of Responses
Yes	286 out of 495	58%
No	209 out of 495	42%

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During the Gallup studies, participating U.S. adults were asked the question, “Do you think spending on the U.S. space program should be increased, kept at the present level, reduced, or ended altogether?” The results (Figure 13) indicated that the majority of the participants (60-70%) stated that space program spending should be increased or at least kept at the current spending level.

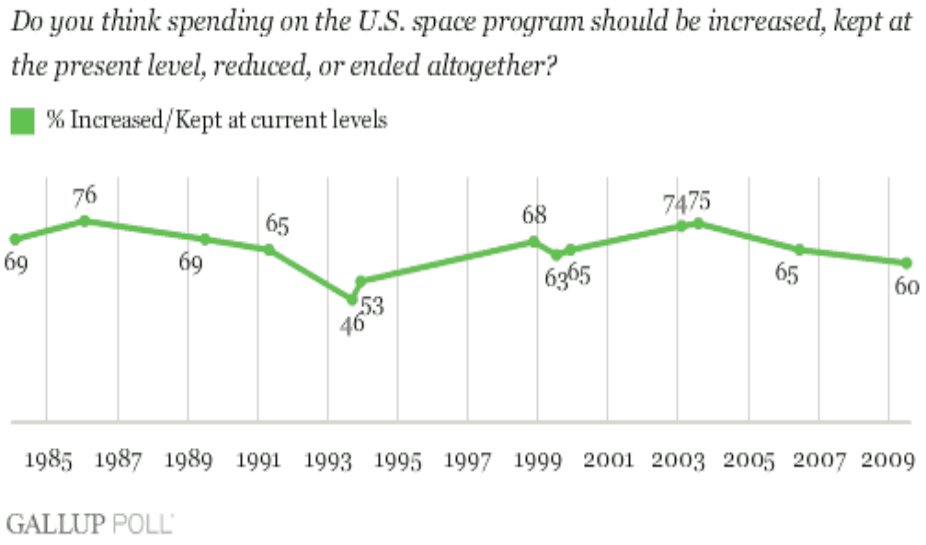

Figure 13. Spending on the U.S. space program (Gallup study).

Table 7 displays the results of the research question, “Do Americans believe that the benefits of U.S. space exploration, including the ISS, justify the financial costs?” Approximately two-thirds (67%) of the participants believe that the benefits of the U.S. space program justify the financial costs.

Survey Question Seven

7. Do Americans believe that the benefits of U.S. space exploration, including the ISS, justify the financial costs?
   [ ] Yes
   [ ] No

Table 7
U.S. Space Exploration Justifies the Financial Costs

Exploration Justifies Costs	Responses	Percentage of Responses
Yes	329 out of 495	66%
No	166 out of 495	34%

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A comparative research question, "It is now 40 years since the United States first landed men on the moon. Do you think the space program has brought enough benefits to this country to justify its costs, or don't you think so?", was included in the Gallup studies (Figure 14). The results showed that most (63%) of participating adults (ages 18 to 49) agreed that the benefits of the U.S. space program have justified the overall costs, and about half (54%) of participating adults (age 50 or older) agreed as well that the benefits of the U.S. space program have justified the overall costs.

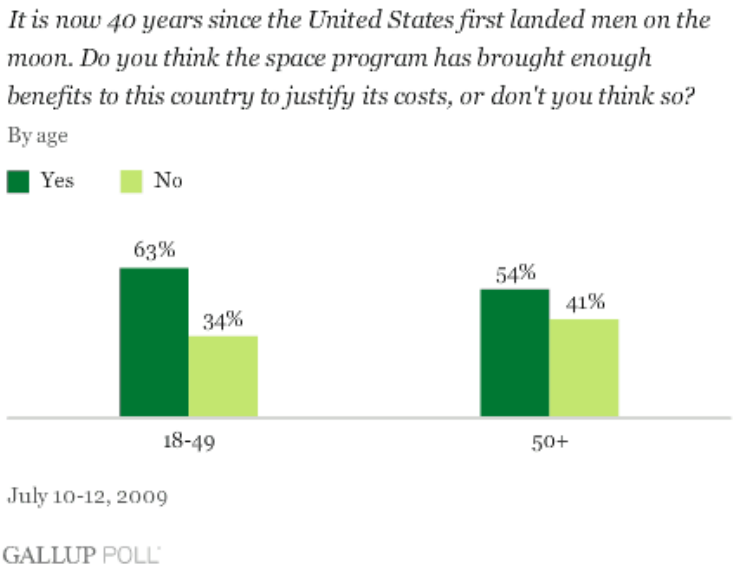

Figure 14. Space program benefits justify the costs (Gallup study).

In Table 8, only a small amount (26%) of participants believe that additional funding for the ISS will not result in increased technological advances, endless research opportunities, and the continued growth of U.S. space exploration; so therefore, NASA

should not extend the ISS expectancy of use past the year 2024. The support to extend the ISS and that additional funding will result in increased technological advances, endless research opportunities, and continued growth in the realm of space exploration was represented by the majority (74%) of the participants. In addition, these participants agree that NASA should continue to operate and maintain the ISS past the year 2024.

Survey Question Eight

8. Do Americans believe that additional funding for the ISS *will not* result in increased technological advances, endless research opportunities, and the continued growth of U.S. space exploration; therefore, NASA should not extend the ISS expectancy of use past the year 2024?
   [ ] Yes
   [ ] No

Table 8
NASA should not extend the ISS expectancy of use past the year 2024

Should Not Extend ISS Use	Responses	Percentage of Responses
Yes	130 out of 495	26%
No	365 out of 495	74%

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The last section of the questionnaire asked the participants to add any additional comments regarding the International Space Station and its role in the future of space exploration. The survey information showed that 71 participants (14%) left personal comments. Thirty participants (42%) specifically commented on the ISS and/or the U.S. space program. There were seven participants that provided their personal opinions of the ISS. Two of these participants commented, "The ISS is our chance at great scientific breakthroughs" and "I believe the ISS is extremely important for the future of the world, not just our country." Another participant stated that not enough people knew about the

benefits of the ISS or its function in space. There were 16 participants that discussed how most Americans do not understand government budgets and offered suggestions on how private institution(s) could replace NASA. These comments provided good insight on how to incorporate the private sector to assist in financial responsibility, but still provide opportunities for growth in space exploration. Lastly, seven participants shared information regarding their academic backgrounds and/or professional experiences related to the U.S. space program; or left their contact information to further discuss the study with the researcher.

The remaining 41 participants (58%) provided comments that were not specifically-related to the ISS and its future role in U.S. space exploration. Fourteen of the participants stated that most Americans do not have an educated opinion on U.S. space exploration and/or the ISS due to their lack of knowledge. There were eight participants who were confused by the survey questions, believing they could not give their perception on what Americans as a whole thought. Contradicting the participants who said the survey questions were confusing and could not provide an overall American perception; 19 participants stated they answered the questions with what they believed would be the average American's perception instead of providing their own opinion to the questions.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

There have been many challenges affecting the International Space Station and its continued viability. A major challenge was the retirement of the Space Shuttle program in 2011; resulting in the reduction of launch capabilities to the ISS, as well as identifying and building another manned U.S. space vehicle capable of reaching the ISS. Another challenge has been the increasing expense of space launches and required research hardware; occurring at the same time there was a general lack of funding and political support for the U.S. human space program (Powell, 2016). Additionally, the astronaut crew will remain fixed in size and the time available for the crew to do research will be limited due to other requirements onboard the ISS. Even though the ISS is now fully assembled, the required maintenance of the station and the financial whereabouts to fund the ISS past its predetermined retirement date of 2024 will remain constant challenges.

Even with the challenges the ISS has faced or is continuing to face, it remains a unique test bed for new technologies and applications, for scientific discoveries, and a platform for increased international collaboration in research and space exploration. But regardless how much public support still exists today for U.S. space exploration, as evidenced in this study; unless the scheduled 2024 retirement date for the ISS is extended at the federal level, or can transition to a fully-qualified private enterprise - the global scientific community will no longer be able to rely on the station for fundamental

research and exploration. If an extension to the retirement date is not granted or a seamless transition is not completed, the ISS could likely be deorbited by NASA (NASA, 2011).

Summary of Findings

This research study was designed to evaluate the past and present scientific and societal contributions the ISS has provided the United States; determine public support for U.S. space exploration and its efforts to stimulate a new interest for future lunar, planetary and deep space exploration; and decide if the continued benefits of U.S. space exploration, including new discoveries and successful research initiatives, justify the associated financial costs.

In addition, for comparative purposes with the participant perception data collected for this study, the researcher included selected participant data from a series of research polls and focus groups conducted between 2005 and 2008 by The Gallup Organization. This series of studies were conducted to determine the level of advocacy and public support towards America's space program, including the International Space Station. The purpose of comparing the previous Gallup studies with this study was to determine if the perceptions of U.S. adults regarding space exploration have changed since 2008; especially after it was confirmed in 2015 that Congress would only extend NASA's operations of the International Space Station through 2024.

In reference to the five research questions directing this study and one of the survey questions, the following findings emerged after the researcher analyzed the data collected from the participating 495 U.S. adults:

1. The first research question asked if Americans fear that without public support and further funding, the U.S. will lose its dominance in space exploration to other countries that have outlined robust plans for lunar/solar system exploration. Eighty percent of the adult participants were concerned that the U.S. will, at some point, lose their dominance in space exploration once Congress removes NASA funding from the federal budget after 2024. A similar question regarding public support and further funding for space exploration was asked during the Gallup studies, "This year, a new plan or goal for space exploration was announced. The plan includes a stepping stone approach to return the space shuttle to flight, complete assembly of the space station, build a replacement for the shuttle, go back to the moon, and then on to Mars and beyond. If NASA's budget did not exceed 1% of the federal budget, to what extent would you support or oppose this new plan for space exploration?" Sixty eight percent of participants that answered this Gallup question agreed they would support a new plan for U.S. space exploration.
2. Overall, approximately 80% of the U.S. adults that participated in the survey agreed that Americans believe that the space program, including the ISS, benefits the economy by inspiring young people to consider an education in STEM fields. This percentage was slightly higher than the percent of U.S. adults (76%) asked a similar question a decade ago, "Does America's space program benefit the nation's economy by inspiring students to pursue careers in technical fields?"
3. One of the survey questions specifically asked if Americans support increasing NASA's budget. Even though the federal price tag to annually fund NASA has

only been about $19 billion dollars, equating to 0.5 percent of a $4-trillion-dollar federal budget (Anapol, 2018), only 58% of participants would support a NASA budget increase. During the Gallup studies, a larger percentage of the participants (60-70%) indicated that space program spending should be increased or at least kept at the current spending level.

4. Even though 17 U.S. astronauts have lost their lives since NASA was founded in 1968, 82% of participants believed the benefits of U.S. space exploration and associated scientific discoveries outweigh the risks of human space flight.
5. When asked the question, "Do Americans believe that the benefits of U.S. space exploration, including the ISS, justify the financial costs?" approximately two-thirds (66%) of participants agreed with the question. In 2008, U.S. adults were asked a similar question, "It is now 40 years since the United States first landed men on the moon. Do you think the space program has brought enough benefits to this country to justify its costs, or don't you think so?" The results indicated that 63% of participating adults (ages 18-49) agreed the U.S. space program brought enough benefits to justify its costs; but only 54% of participants (age 50 or older) agreed with the question.
6. The final question asked, "Do Americans believe that additional funding for the ISS will not result in increased technological advances, endless research opportunities, and the continued growth of U.S. space exploration; therefore, NASA should not extend the ISS expectancy of use past the year 2024?" Almost three-fourths of the participants (74%) believed that additional funding for the ISS will, indeed, result in an increase in technological advances, research

opportunities, and continued growth in space exploration. Additionally, these participants agreed that NASA should continue to operate and maintain the ISS past 2024.

Conclusions

Since the construction of the ISS began in November 1998, the space station has been involved in bringing together: (1) international flight crews; (2) multiple launch vehicles; (3) globally distributed launch, operations, engineering, and development facilities; (4) communications networks; and (5) a global scientific research community (NASA, 2011). Operating the ISS for the past twenty years has been more complex than any other space flight endeavor, primarily because it has always been an international effort. Perhaps one of the most impactful benefits of the ISS has been the opportunity for different nations to come together and collaboratively work on common goals and objectives. For each international partner to set aside political differences and cooperate with NASA and other space organizations demonstrates how unifying space exploration can adapt and provide solutions to life-changing global issues.

There have been numerous research technologies and scientific discoveries that have been successfully tested, developed and perfected; providing significant societal benefits to the global population. In addition, the ISS has provided an abundance of environmental benefits over the past two decades.

ISS crew members have been living and working in space for extended periods of time and examining each crew after long-duration missions provides the necessary information for physicians and scientists to determine exactly what the human limitations are in this type of environment. Peggy Whitson, a biochemistry researcher and NASA

astronaut has accrued 665 days in space over the course of her career. This is more time in space than any other U.S. astronaut (Held, 2017). During her time aboard the ISS, she contributed to hundreds of scientific experiments, including research on antibodies that will increase the effectiveness of chemotherapy drugs and the changes that an astronaut's eyes undergo in environment with very little gravity (Held, 2017). Whitson's remarkable career alone supports the finding that two-thirds of the participants in this study agreed that the benefits of U.S. space exploration, including the ISS, justify the financial costs.

The continued research conducted on human endurance onboard the ISS has greatly improved the knowledge of long-term space exposure and its effects on the human body. Understanding an astronaut's physiological, chemical, and behavioral changes while working in space will be critical in the years to come as astronauts continue to explore deeper and deeper in space. The future of U.S. space exploration is dependent on the research performed onboard the ISS to determine if interplanetary space travel and further exploration of the vast universe will ever be possible.

In February 2018, President Trump's 2019 federal budget proposal sought to end U.S. government funding for the International Space Station (ISS) at the end of 2024; even though the federal price tag to annually fund NASA equates to 0.5% of a $4-trillion-dollar federal budget. Instead, the Trump administration would allot millions of dollars of funding to pursue privatization of the ISS and return U.S. astronauts to the lunar surface. But many of these emerging private space companies have already made it clear that they are not yet prepared to be fully involved with the ISS by the time federal funding ends in 2024 and are cautious of accepting the risks of the ISS without any administrative and financial support from the U.S. government (Anapol, 2018).

Regardless when these commercial companies will be able to fully support the ISS and other U.S. space initiatives, they will be forced to play a key role in the future of the U.S. space program, including the ISS. Even though federal funding of the ISS will terminate in 2024, the 2019 budget proposal will provide: (1) robotic missions to the moon, (2) development of the Space Launch System and Orion spacecraft, (3) momentum to lead astronauts back to the moon in 2023, (4) funding for the next Mars rover launch in 2020, and (5) a step towards more ambitious deep space exploratory goals (Rivera, 2018).

According to the findings from this study and the previous Gallup studies, U.S. adult perceptions regarding past, present and future space exploration including the evolvement of the ISS has remained consistently positive for the past twenty years. But the future of space discovery and experimentation will primarily depend on the emerging role of the private space companies; however, NASA has strongly urged Congress to plan a smooth and seamless transition with budding commercial space companies (Klotz, 2017).

At a March 2017 hearing on the future of the ISS, the President of the Commercial Spaceflight Federation commented, "The commercial sector is moving in the right direction but to fully privatize the ISS it would be difficult, you would need that expertise that NASA offers, fifty-fifty would be a great starting off point (Fernholz, 2017, pg. 1)." A U.S. representative expressed concern stating, "Another reason to delay the closure of the ISS might be increasing concern over other countries' space ambitions, as a fear of turning over human presence in low-Earth orbit to China (Fernholz, 2017, pg. 1)." This opinion was similar to participant responses in this study, referring to the question

that the U.S. can lose its dominance in space exploration and research to other countries. The desire and support for the U.S. to continue to lead in space exploration and discovery is still present; however, the ISS (with or without federal funding) will be required to play a vital role in preserving U.S. leadership in future space initiatives. This echoes some of the personal comments from the participants in this study, "The ISS is our chance at great scientific breakthroughs" and "I believe the ISS is extremely important for the future of the world not just our country."

Final Remarks

By evaluating the influential achievements and examining the overall effects the ISS has had on the perceptions of a sample of U.S. adults; the researcher focused on the exploratory contributions and research benefits the ISS has provided to the global population during the past twenty years; the international collaboration of space partnerships centered around the ISS; and what the ISS, as a long-duration space platform, can continue to offer to the future of U.S. space exploration and research initiatives.

The mission of the International Space Station (ISS) was to enable long-term exploration of space and provide benefits to people on Earth. During the past two decades, the scientific studies conducted onboard the ISS have successfully tested a variety of technologies, systems, and materials that have proven beneficial to society, as well as future long-duration space exploration missions (NASA, 2017). Furthermore, the research accomplishments onboard the ISS have significantly improved technology in aiding future space exploration. But as 2024 nears, all of these new private space companies must continue to unite in their goals and objectives as they apply their own

knowledge gained through space station research in human physiology, radiation, materials science, engineering, biology, fluid physics, and technology to enable the future of exploratory missions beyond the space station.

Lastly, the International Space Station must remain a critical asset for U.S. space exploration as new leadership champions the continued exploration and research that is still needed to fully understand and overcome the challenges of long-duration spaceflight required for deep space exploration missions. The U.S. space program has the support of the American people, but without the ISS, the future of U.S. space exploration could easily be in jeopardy.

Recommendations

Based on the conclusions and findings of this study, the researcher offers the following recommendations.

1. After reading and reviewing the participants' personal comments, a large percentage of the American population is not knowledgeable of the ISS; including its past, present and possible future contributions to American and global societies. Even though a tremendous amount of factual information regarding U.S. space exploration and NASA is readily available, Americans seem to have lost interest in the ISS. Perhaps it is simply old news because the ISS had been operational for twenty years. This is a similar result of the Space Shuttle program which lost public interest because it was a successful twenty-year human spaceflight program. There needs to be a public reawakening of the U.S. space program, especially as future space exploratory plans are being discussed with private industry. Public educational systems need to continue to demand STEM

curriculum and funding initiatives with private partners to provide the necessary K-12 classroom technology. Even though the results from this study showed that U.S. adults support increasing NASA's budget, and that the benefits of U.S. space exploration and scientific discovery outweigh the risks of human spaceflight; the American population and media outlets must continue to be more responsible for obtaining and sharing knowledge of U.S. space exploration.

2. This study was conducted during the timeframe of a successful Space X rocket launch that was livestreamed to the American population. It was clearly observed through reactions on news stations, social media, and in person that this privately-funded launch created a resurgence of excitement and interest in the U.S. space industry among Americans. In 2018, the Space X rocket company has already completed seven successful launch missions including missions for NASA to send supplies and experiments to the ISS (CNBC, 2018). As the federal government begins to transition the U.S. space program toward privatization; these private space companies like SpaceX, Orbital ATK, and Sierra Nevada Corporation will need to take the initiative to develop and implement marketing and advertising campaigns to reintroduce the benefits of U.S. space exploration to younger generations of Americans who may not have received the same public exposure of the Space Shuttle and ISS successes as their parents and grandparents.
3. The findings from this study were very similar to the results from the Gallup studies conducted from 2005 to 2009. The overall findings of support for continued funding, belief in benefits, and increase in motivation for STEM career provided encouragement to the researcher. During the twelve-year difference in

time between these two studies, Americans witnessed the successes, and some failures, of the Space Shuttle program, the ISS, the rover launches to Mars, and the Hubble telescope. It is recommended that additional studies regarding perceptions of U.S. space exploration be conducted with the hope that Americans will stay as fascinated and supportive in the future as they witness manned spaceflight back to the Moon, deep space exploration to Mars, photographs of a vast universe we have yet to visualize, and the possibility of affordable spaceflight opportunities for the American citizen.

REFERENCES

Anapol, A. (2018, February). Trump budget ends US funding for international space station by 2025. The Hill.com. Retrieved from http://thehill.com/homenews/administration/373597-trump-budget-ends-us-funding-for-international-space-station-by-2025

Blackstone, A. (2012). *Principles of Sociological Inquiry: Qualitative and Quantitative Methods.* Irvington, NY: Flat World Knowledge.

Carlson, D. K. (2004). Space: To infinity and beyond on a budget. Retrieved from http://news.gallup.com/poll/12727/space-infinity-beyond-budget.aspx

CASIS. (2018). History and timeline of the ISS. Retrieved from https://www.iss-casis.org/about/iss-timeline/

Clark, S. (2012, April). ATV production terminated as decision on follow-on nears. Spaceflight Now.com. Retrieved from https://spaceflightnow.com/news/n1204/02atvfuture/

Cowing, K. (2006, March). March 2006 archives. NASA Watch.com. Retrieved from http://nasawatch.com/archives/2006/03/

Canadian Space Agency. (2018). The International Space Station. Retrieved from http://www.asc-csa.gc.ca/eng/iss/default.asp

European Space Agency. (2017). About the international space station. Retrieved from http://www.esa.int/Our_Activities/Human_Spaceflight/International_Space_Statio

n/About_the_International_Space_Station

Etikan, I., Musa, S.A., and Alkassim, S.A. (2016). Comparison of Convenience Sampling and Purposive Sampling. *American Journal of Theoretical and Applied Statistics. Vol. 5*, No. 1, pp. 1-4. doi: 10.11648/j.ajtas.20160501.11

Explorable. (2018). Convenience sampling. Explorable,com. Retrieved from https://explorable.com/convenience-sampling

Fernholz, T. (2017, March). The US is facing a choice between the International Space Station and a new deep space rocket. Quartz.com. Retrieved from https://qz.com/942983/the-us-is-facing-a-choice-between-the-international-space-station-and-a-new-deep-space-rocket/

Friedman, L. (2011). The case for international cooperation in space exploration. Retrieved from http://thespacereview.com/article/1782/1

Foust, J. (2017, June). Pondering the future of the International Space Station. The Space Review. Retrieved from http://www.thespacereview.com/article/3297/1

Gallup, A. M. & Newport, F. (2009). Majority of Americans say space program costs justified. In J. Jones (Ed), *The Gallup Poll: Public Opinion 2009. 249-250.* Retrieved from https://books.google.com/books?id=tfdsJPV9w4MC&pg=PA250&lpg=PA250&dq=americans+views+on+space+exploration+gallup+poll+results&source=bl&ots=5YIz3dh3QW&sig=HZlk8OWmrEyQpTcI3S_jn72fSuQ&hl=en&sa=X&ved=0ahUKEwi_oPHxsZnZAhVC92MKHV2DDGMQ6AEITDAH#v=onepage&q=americans%20views%20on%20space%20exploration%20gallup%20poll%20results&f=false

Gallup. (2018). How does the Gallup world poll work? Retrieved from http://www.gallup.com/178667/gallup-world-poll-work.aspx

GAO. (2009). International space station: Significant challenges may limit onboard research. *Report to Congressional Requesters.* Retrieved from http://www.gao.gov/new.items/d109.pdf

Howell, E. (2018, February). International Space Station: Facts, history & tracking. Space.com. Retrieved from https://www.space.com/16748-international-space-station.html

Hunt, A. (2017, September). American space ninja back on Earth after record-breaking flight. NPR.org. Retrieved from https://www.npr.org/sections/thetwo-way/2017/09/03/548295156/-american-space-ninja-peggy-whitson-back-on-earth-after-record-breaking-flight

Klotz, I. (2017, March). Congress mulls options for space station beyond 2024. Commercial Spaceflight.org. Retrieved from http://www.commercialspaceflight.org/2017/03/congress-mulls-options-space-station-beyond-2024/

Laerd Statistics. (2015). Understanding descriptive and inferential statistics. Retrieved from https://statistics.laerd.com/statistical-guides/descriptive-inferential-statistics.php

Lewis-Beck, M.S., Bryman, A., and Liao, T.F. (2004). Snowball sampling. In The SAGE Encyclopedia of Social Science Research Methods. DOI: http://dx.doi.org/10.4135/9781412950589.n931

Longnecker, D.E. (2014). NASA advisory council meeting of the human exploration and operations committee research subcommittee. Retrieved from https://www.nasa.gov/sites/default/files/files/Research_Subcommittee_Minutes_22414.pdf

Messier, D. (2017, August). NASA's Space Act Agreements with SpaceX, Boeing, ULA & Sierra Nevada. Parabolic Arc. Retrieved from http://www.parabolicarc.com/2017/08/31/nasas-space-act-agreements-spacex-boeing-ula-sierra-nevada/

NASA. (2018). International Space Station: Browse experiments by category. NASA.gov. Retrieved from https://www.nasa.gov/mission_pages/station/research/experiments_category.html

NASA. (2017). International Space Station. NASA.gov. Retrieved from http://www.nasa.gov/mission_pages/station/research/index.html

NASA. (2015). 15 ways the international space station is benefiting earth. NASA.gov. Retrieved from https://www.nasa.gov/mission_pages/station/research/news/15_ways_iss_benefits_earth

NASA. (2012, February). neuroArm: Robotic arms lend a healing touch. NASA.gov. Retrieved from https://www.nasa.gov/mission_pages/station/research/benefits/neuro_Arm.html

Orbital ATK. (2017). Mission page: OA-7 space station cargo resupply. Retrieved from https://www.orbitalatk.com/news-room/feature-stories/OA7-Mission Page/default.aspx?prid=180

Powell, C. (2016, August). Is NASA worth the money we spend on it? Fobres.com. Retrieved from https://www.forbes.com/sites/quora/2016/08/19/is-nasa-worth-the-money-we-spend-on-it/#7587ee7c6447

Rivera, M. (2018). NASA doubles down on deep space exploration, but uncertain future for international space station. Hoholok.com. Retrieved from https://hoholok.com/nasa-doubles-down-on-deep-space-exploration-but-uncertain-future-for-the-international-space-station/

Robinson, J. (2013, October). International Space Station's Top 10 science accomplishments. ExploreDeepSpace.com. Retrieved from http://exploredeepspace.com/international-space-stations-top-10-science-accomplishments/

Savage, S. (2008). New Gallup poll reveals Americans strongly support space exploration, believe it inspires younger generation. Retrieved from http://www.foxnews.com/tech/2018/02/21/nasa-doubles-down-on-deep-space-exploration-but-uncertain-future-for-international-space-station.html http://www.redorbit.com/news/space/1436984/new_gallup_poll_reveals_america\ns_strongly_support_space_exploration_believe/

Shuttle Press Kit. (1999). International space station. Retrieved from http://www.shuttlepresskit.com/ISS_OVR/index.htm

Social Research Methods. (2006). Descriptive Statistics. Retrieved from https://www.socialresearchmethods.net/kb/statdesc.htm

Space.com. (2005). Shuttle's retirement may affect ISS construction, NASA chief says. Retrieved from https://www.space.com/1065-shuttle-retirement-affect-iss-

construction-nasa-chief.html

Space Foundation. (2006). The case for space exploration: Failure is not an option. Retrieved from http://astro.cornell.edu/~randerson/TheCaseForSpace.pdf

Space Foundation Press Release. (2004). Gallup survey shows Americans support new plan for space exploration. Retrieved from https://www.spacefoundation.org/news/gallup-survey-shows-americans-support-new-plan-space-exploration

Spreen, M. (1992, September). Rare populations, hidden populations, and link-tracing designs: What and why? *Bulletin de Methodologie Sociologique N.36,* pp. 34-58.

Wall, M. (2018, April). SpaceX cargo capsule arrives at space station with tons of supplies. Space.com. Retrieved from https://www.space.com/40193-spacex-dragon-cargo-capsule-arrives-iss.html

Weitering, H. (2018, April). Used SpaceX Dragon launches NASA cargo to space station on pre-flown rocket. Space.com. Retrieved from https://www.space.com/40172-space-used-dragon-cargo-launch-success-crs14.html

Zak, A. (2018). Spacecraft: manned ISS chronology. Retrieved from http://www.russianspaceweb.com/iss_chronology.html

APPENDICES

APPENDIX A
COVER LETTER

The International Space Station and Its Role in The Future of Space Exploration

The International Space Station (ISS) is a large spacecraft in orbit around Earth. The ISS serves as a unique science laboratory and consists of modules/parts that were assembled in space by astronauts. It orbits Earth at an average altitude of 220 miles and travels at 17,500 mph; orbiting the Earth every 90 minutes. NASA is using the space station to learn more about living and working in space. These lessons will make it possible to send humans farther into space than ever before. The first piece of the International Space Station was launched in November 1998. The first crew arrived on November 2, 2000 and astronauts and cosmonauts have lived and worked on the ISS ever since. NASA and its global space partners completed final construction of the space station in 2011.

The participants for this research study will consist of approximately 500 U.S. adult men and women aged 18 years and older. This research study is designed to examine America's perception of U.S. space exploration, including the role of the ISS. Are Americans still supportive of the U.S. space program and space exploration and are Americans supportive of using more tax dollars to pay for space exploration including the maintenance of the ISS. The useful life for the ISS is expected to end in 2020 and at that time the ISS could be de-orbited.

The researcher, *Mrs. Jessica Devett, Oklahoma State University doctoral candidate* strongly believes the information obtained in this research initiative can be a springboard to facilitate discussion and offer a way for the nation's collegiate aviation community to proceed proactively in addressing emerging areas of concern.

Your participation in this research study is **strictly voluntary**. Your response to each survey question will remain confidential and will be used solely for statistical analysis. It will be understood by the researchers if you complete this survey and submit your responses back to the researchers, you have agreed and given your consent to participate in this study.

The researcher of this research study personally *thank you* for your feedback and support of this research. The final research report will be presented at a professional aviation or educational conference and published in a peer-reviewed aviation or educational journal.

If you have questions regarding this study, please contact Jessica Devett at jessmdevett@yahoo.com or Dr. Hugh Crethar, Chair – Institutional Review Board, Oklahoma State University at crethar@okstate.edu.

APPENDIX B
RESEARCH INSTRUMENT

The International Space Station and Its Role in The Future of Space Exploration

Please provide all requested information. Your responses will be kept confidential.

I. Demographics

1. What is your age?

[ ] 18-24 [ ] 25-34 [ ] 35-44
[ ] 45-54 [ ] 55-64 [ ] 65 or older

2. What is the highest degree or level of school you have completed?

[ ] High School Diploma or GED [ ] Bachelor's Degree
[ ] Some College Credit, No Degree [ ] Master's Degree
[ ] Associate Degree [ ] Doctorate or Professional Degree

II. Perceptions on U.S. Space Exploration and the International Space Station

3. Do Americans believe that the U.S. space program, including the ISS, benefits the nation's economy by inspiring young people to consider an education in science, technology, engineering and math (STEM) fields?

[ ] Yes
[ ] No

4. Do Americans fear that without public support and further funding, the U.S. will lose its dominance in space exploration and research to other countries that have outlined robust plans for lunar/solar system exploration?

[ ] Yes
[ ] No

5. Do Americans believe the benefits of space exploration and associated scientific research outweigh the risks of human space flight?

[ ] Yes
[ ] No

6. Do Americans support increasing NASA's budget?

[ ] Yes
[ ] No

9. Do Americans believe that the benefits of U.S. space exploration, including the ISS, justify the financial costs?

[ ] Yes
[ ] No

10. Do Americans believe that additional funding for the ISS *will not* result in increased technological advances, endless research opportunities, and the continued growth of U.S. space exploration; therefore, NASA should not extend the ISS expectancy of use past the year 2024?

[ ] Yes
[ ] No

III. Personal Comments

Please indicate any additional comments you may have regarding the International Space Station and its role in the future of space exploration.

APPENDIX C
PARTICIPANT CONSENT FORM

OKLAHOMA STATE UNIVERSITY
COLLEGE OF EDUCATION, HEALTH, AND AVIATION
PARTICIPANT INFORMATION AND CONSENT FORM

Title: The International Space Station and Its Role in the Future of Space Exploration

Investigator: Mrs. Jessica M. Devett

Purpose: The purpose of this study is to focus on the contributions the ISS has provided in the past, the partnerships of countries and opportunities for cooperation it offers, and what it can offer to the future of space exploration and research initiatives, by evaluating the influence and achievements and examining the effects the ISS has had on the aerospace industry, scientific community, and the population of the world.. You must be 18 years or older to participate.

What to Expect: This research study is administered online via Qualtrics. Participation in this research will involve completion of a questionnaire. The questionnaire has three sections, the first section is demographic information. The second has questions on your perceptions on U.S. space exploration and the International Space Station. The third asks for any personal comments. You will be expected to complete the questionnaire once. It should take you about five minutes to complete.

Risks: There are no risks associated with this project which are expected to be greater than those ordinarily encountered in daily life.

Benefits: There are no direct benefits to you. However, you may gain an appreciation and understanding of how research is conducted.

Your Rights and Confidentiality: Your participation in this research is voluntary. There is no penalty for refusal to participate, and you are free to withdraw your consent and participation in this project at any time. The records of this study will be kept private. Any written results will discuss group findings and will not include information that will identify you. Research records will be stored on a password protected computer in a locked office and only researchers and individuals responsible for research oversight will have access to the records. Data will be destroyed three years after the study has been completed.

Contacts: Should you desire to discuss your participation in the study and/or request information about the results of the study: please contact Jessica Devett at jessmdevett@yahoo.com or Dr. Hugh Crethar, Chair – Institutional Review Board, Oklahoma State University at crethar@okstate.edu. If you have questions about your rights as a research volunteer, you may contact the IRB Office at 223 Scott Hall, Stillwater, OK 74078, 405-744-3377 or irb@okstate.edu

If you choose to participate: Please, click NEXT if you choose to participate. By clicking NEXT, you are indicating that you freely and voluntarily and agree to participate in this study and you also acknowledge that you are at least 18 years of age. It is recommended that you print a copy of this consent page for your records before you begin the study by clicking below.

APPENDIX D
EMAIL MESSAGE FORMAT

Email to Previous University TAMUCC Professors

Dear Faculty and Staff,

I am an Oklahoma State University doctoral candidate (Aviation & Space) currently conducting research for my dissertation study: *The International Space Station and the Future of Space Exploration*. Would you please consider distributing the online survey (Qualtrics) to your students on my behalf if they wish to participate? It should take no more than three or four minutes. Thank you.

Very Respectfully,
Jessica M. Devett, Capt, USAF
Instructor Combat Systems Officer/451 Flying Training Squadron
Naval Air Station Pensacola, FL

Dear Islanders,

I am an Oklahoma State University doctoral candidate (Aviation & Space) currently conducting research for my dissertation study: *The International Space Station and the Future of Space Exploration*. Would you please consider taking a short online survey (Qualtrics) to assist in my research? It should take no more than three or four minutes. Thank you. Please use the link below if you wish to participate. Thank you.

Very Respectfully,
Jessica M. Devett, Capt, USAF
Instructor Combat Systems Officer/451 Flying Training Squadron
Naval Air Station Pensacola, FL

https://okstatecoe.az1.qualtrics.com/jfe/form/SV_1z6jOwyqnd7DE2N

Email to OSU Faculty and Advisors

Dear Faculty and Staff,

I am an Oklahoma State University doctoral candidate (Aviation & Space) currently conducting research for my dissertation study: *The International Space Station and the Future of Space Exploration*. Would you please consider distributing the online survey (Qualtrics) to your students on my behalf if they wish to participate? It should take no more than three or four minutes. Thank you.

Very Respectfully,
Jessica M. Devett, Capt, USAF
Instructor Combat Systems Officer/451 Flying Training Squadron

Naval Air Station Pensacola, FL

Dear Fellow Cowboys,

I am a doctoral candidate (Aviation & Space) currently conducting research for my dissertation on *The International Space Station and the Future of Space Exploration*. Would you please consider taking a short online survey (Qualtrics) to assist in my research? It should take no more than three or four minutes. Please use the link below if you wish to participate. Thank you.

Very Respectfully,
Jessica M. Devett, Capt, USAF
Instructor Combat Systems Officer/451 Flying Training Squadron
Naval Air Station Pensacola, FL

https://okstatecoe.az1.qualtrics.com/jfe/form/SV_1z6jOwyqnd7DE2N

Email to Squadron/Colleagues

Good Morning Golden Eagles,

I am an Oklahoma State University doctoral candidate (Aviation & Space) currently conducting research for my dissertation on *The International Space Station and the Future of Space Exploration*. Would you please consider taking a short online survey (Qualtrics) to assist in my research? It should take no more than three or four minutes. Please use the link below if you wish to participate. Thank you.

Very Respectfully,
Jessica M. Devett, Capt, USAF
Instructor Combat Systems Officer/451 Flying Training Squadron
Naval Air Station Pensacola, FL

https://okstatecoe.az1.qualtrics.com/jfe/form/SV_1z6jOwyqnd7DE2N

APPENDIX E
SOCIAL MEDIA MESSAGE FORMAT

Posted on Social Media Homepage/Group Pages/Shared by Others

I am an Oklahoma State University doctoral candidate (Aviation & Space) currently conducting research for my dissertation on *The International Space Station and the Future of Space Exploration*. Would you please consider taking a short online survey (Qualtrics) to assist in my research? It should take no more than three or four minutes. Please use the link below if you wish to participate. Thank you.

Updated Post 1 Month after Initial Post

Still gathering data for my dissertation. I am an Oklahoma State University doctoral candidate (Aviation & Space) currently conducting research for my dissertation on *The International Space Station and the Future of Space Exploration*. Would you please consider taking a short online survey (Qualtrics) to assist in my research? It should take no more than three or four minutes. If you haven't already please consider taking the survey to assist in my research.

APPENDIX F
INSTITUTIONAL REVIEW BOARD APPROVAL

Oklahoma State University Institutional Review Board

Date: Monday, December 4, 2017

IRB Application No ED17129

Proposal Title: THE INTERNATIONAL SPACE STATION AND ITS' ROLE IN THE FUTURE OF SPACE EXPLORATION

Reviewed and Processed as: Exempt

Status Recommended by Reviewer(s): Approved

Protocol Expires: 12/3/2020

Principal Investigator(s):

Jessica Devett
Stillwater, OK 74078

Timm Bliss
318 Willard
Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1.Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval. Protocol modifications requiring approval may include changes to the title, PI advisor, funding status or sponsor, subject population composition or size, recruitment, inclusion/exclusion criteria, research site, research procedures and consent/assent process or forms.

2.Submit a request for continuation if the study extends beyond the approval period. This continuation must receive IRB review and approval before the research can continue. 3.Report any adverse events to the IRB Chair promptly.

Adverse events are those which are unanticipated and impact the subjects during the course of the research; and

4.Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Dawnett Watkins 219 Scott Hall (phone: 405-744-5700, dawnett.watkins@okstate.edu).

Sincerely,

Hugh Crethar, Chair
Institutional Review Board

VITA

Jessica Marie Devett

Candidate for the Degree of

Doctor of Education

Thesis: THE INTERNATIONAL SPACE STATION AND ITS ROLE IN THE FUTURE OF SPACE EXPLORATION

Major Field: Applied Educational Studies, Aviation and Space Education

Biographical:

Education: Completed the requirements for the Doctor of Education in Applied Educational Studies in Aviation and Space Education at Oklahoma State University, Stillwater, Oklahoma in May, 2018.

Completed the requirements for the Master of Aeronautical Science in Space Studies at Embry Riddle Aeronautical University, Daytona Beach, Florida/USA in 2012.

Completed the requirements for the Bachelor of Arts in English at Texas A&M University Corpus Christi, Corpus Christi, Texas/USA in 2008.

Completed the requirements for Associates in Airway Science at Community College of the Air Force at Maxwell Air Force Base, Alabama/USA in 2010.

Experience: United States Air Force, 2008 to Present

Professional Memberships: Phi Kappa Phi and Society for Collegiate Leadership & Achievement Honor Society; Women in Aviation, Company Grade Officers Club, and Military Officers Association