International Space Station

by

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Abstract

The International Space Station has been a decade plus long endeavor culminating the union of international scientific communities and governments to create a low Earth orbiting research facility. The ISS is operated by five global space agencies. These international partners include National Aeronautics and Space Administration, the Russian Federal Space Agency, European Space Agency, Japan Aerospace Exploration Agency, and the Canadian Space Agency. With a modular construction approach since 1998, the ISS has been gradually expanding and is scheduled for completion by 2012. The arrival of the International Space Station has been greeted with both optimism for its technological advances in the study of biology, physics, astronomy, meteorology but also with skepticism due to the nature of its high cost.

This paper will explore the core Facts of Life with multiple in-depth examples for each. The major Facts of Life include the following: #1: politics, not technology, controls what technology is allowed to achieve, #2: cost rules, #3: a strong, coherent constituency is essential, #4: technical problems become political problems, and #5: the best engineering solutions are not necessarily the best political solutions. Additional Facts of Life will also be included such as the following: perception is often more important than the truth , politics prefer immediate, near-term gratification, and every presidential administration have its on vision, and before that vision can be completed, a new presidential administration has taken over and established their own newer vision. Detailed analysis of the Space Station's past history as an emerging complex scientific program engulfed in American politics will be provided to support each of the aforementioned Facts of Life.

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Introduction

The International Space Station low Earth orbit assembly began in 1998 with its first Russian built module. Named Zarya, this module was a foundational segment providing basic control, communications and power that will go on to support the addition of later modules in the years to come. The ISS program is the culmination of several predecessor space station programs including the United States Freedom, Japanese Kibo, European Columbus, and the Russian (Soviet) Mir-2 Space Station programs. [25] This International Space Station is scheduled to be fully completed by 2012. [25]

Being part of a multinational project, the International Space Station has been scrutinized on several fronts including high cost, ownership, and capabilities. Costs associated with building the International Space Station have sky rocketed since its inception in 1998 to a staggering sum upwards of $100 B. [27] Also ownership and usage of the International Space Station had to be clearly defined by the several nations involved in its development. The cancellation of certain modules such as the US Centrifuge Accommodations Module and the US Habitation Module from the original ISS design have set back certain previously envisioned space station capabilities that would no longer be available on International Space Station. [25]

However having warranted much criticism in the past decade plus, the International Space Station also continues to strive. The ISS is promoted for its scientific and political achievements. Scientific research can now be conducted in a safe and stable environment in low Earth orbit. Participating nations now share a bond of unity in the development and operation of the ISS. The International Space Station has survived several presidencies, each with a differing view for its purpose, because of the established voting constituency in each of the participating nations that is directly and indirectly employed by the International Space Station program.

The International Space Station serves not only as a beacon of scientific and technological break through but also as a global community achievement in which nations become politically entwined and are united with mutual benefits in creating a low Earth orbiting space station. This paper will explore the technological advances and the political process while employing the “Facts of Life” to provide a detailed analysis of the International Space Station program’s major events. The program growth of the International Space Station has been both arduous as it has been rewarding.

The Centrifuge Accommodations Module was intended as a very ambitious addition to the International Space Station in which the module would have added a controlled artificial gravity environment to the station's list of capabilities. This meant that experiments could have been conducted to observe the effects of microgravity exposed on a wide variety of different biological specimens. [13] This module would be built and paid for by Japan, instead of the U.S, to offset the cost of launching the Japanese Experiment Module aboard a U.S. NASA Space Shuttle. [13]

In February 2001, the Bush Administration announced possible cancelation or deferral of certain ISS components to stay within a Congress imposed $25 B cap. [11] In doing so, the International Space Station received its "core complete" design with President Bush's new "Vision for Space Exploration." This new vision was tailored in a manner that created a "U.S. Core Complete" design and an "International Partner Core Complete" design in an effort to mitigate increased expenses involving the development of the ISS. [11] President Bush's vision mandated U.S. research on the ISS to be restricted to this new "Vision for Space Exploration" in which NASA willingly complied thus cancelling the Japanese Centrifuge Accommodations Module in 2005. [11]

The following political factors were considered for the cancellation of the Centrifuge Accommodations Module: it was built by Japan and therefore considered a non U.S. module, Bush imposed a $25 B spending cap, and the new vision for space exploration redirected NASA.

Hope in advancing areas of gravitational biology research was to understand what "roles gravity has in the development of organisms from the cellular level up to that on an entire individual organism." [12] We were unable to achieve such technological breakthroughs on the International Space Station with its reduced capability.

The Habitation Module would have served as an integral piece of technology which created an environment with the sole purpose of providing living quarters for humans in space. Serving as the main living quarters for the ISS, this module would have provided basic necessities that we on Earth take advantage of such as a toilet, shower, galley, sleep stations, and medical facilities. [13] The technology, although seemingly basic and resoundingly simple was of great importance to the human space exploration because of the fact that this module would have turned the space station into more of a "home in outer space" for its astronauts.

However, once again politics came into play from the Columbia Accident Investigation Board which mandated 15 recommendations be completed before the space shuttles return to operational status. [11] Space shuttle flight operations were delayed for 2 years ultimately delaying construction of the ISS and forcing the program to slide. Already behind schedule with budget limitations, NASA was forced to cut back further on spending by reducing certain ISS capabilities one of which included the Habitation Module.

Each module on the International Space Station has a certain life span for basic operations. For example, the Russian Zarya module has a rated life span in orbit for about 15 years. [28] This means the first module on the International Space Station according to its technical lifetime will be required to be retired and de orbited from low Earth orbit by 2013 since it launched back in 1998. [28]

However, the Obama Administration has changed the vision of the International Space Station to operate well into 2020, many years beyond the Russian Zarya module's technical life span. The Russian Zarya module will need to be refurbished or replaced for further use of the International Space Station.

The International Space Station had to understate the cost and overstate its benefits to get the program started. The cost estimated for the International Space Station for FY1994 was determined to be $ 17.4B. [11] However this figure grossly understated the true cost of the ISS. This estimate failed to include other budget absorbing factors such as launch costs, operational cost after final assembly, and civil service costs. [11] From FY1994 to FY2001 this cost grew to a perfect number of $25 B, the same amount of spending cap placed on the development of the International Space Station by the Bush Administration.

In January 2001, NASA announced the cost of the ISS will now rise to $30 B, which was 72% more than it originally estimated in 1993 and $5 B more than the current spending cap imposed by President Bush. [11] Programs often understate the true cost of a program to receive the initial funding required to get things started. Once the initial funding has been appropriated, the true funding required begins to surface as the program gets underway.

NASA's International Space Station program was no different then most other programs vying for financial aid from the U.S. government. NASA actually came forth and explained to Congress that their own program managers for the International Space Station had actually "underestimated the complexity of building and operating" the International Space Station. [11] Even with NASA admitting the initial cost of the program was grossly underestimated, the Bush administration did not allow for additional funding above the mandated $25 B spending cap.

The International Space Station budget has to be re won every year even though funding has been previously appropriated to the program. In section 501 of the NASA Authorization Act of 2010, the government will appropriate funding for the International Space Station through at least 2020. However NASA has to be able to sustain and support a structurally sound and operating International Space Station through out that period of time. [15] Every year is a struggle for large programs to maintain or improve their government funding.

In a budget compromise that was reached by the White House and Congress on April 8, 2011, NASA alone was appropriated $18.485 B which was 1.3% less than the 2010 NASA budget of $18.724 B of last year. The ISS and Space Shuttle received an

estimated $600 M less than the previous year [20] The Obama Administration was forced to cut spending due to budget crunches while facing a possible government shutdown. With President Obama at the helm, NASA changed their directions of no longer needing to get back to the moon thus cutting the Constellation Program. A 2012 spending bill draft released from the House appropriations panel overseeing NASA on July 6, 2011, cuts a total of $1.6 B of available funds. The additional budget cut terminates the much anticipated James Webb Space Telescope. [21]

It is pertinent for long lead programs such as the International Space Station that is capable of spanning several decades be able to win enough funding to keep the program alive. Budget fluctuations vary from differing visions from each presidential administration greatly affecting the outcome of a program.

In order to be a successful program, the program itself has to address multiple agendas in which governments dictate multiple mission systems. For example, the International Space Station Intergovernmental Agreement was signed on Jan. 29, 1998 by a total of fifteen governments involved in the space station program which warranted peaceful civilian use amongst its participants. This constituency comprised of the following nations: United States of America, Russia, Japan, Canada, Belgium, Denmark, France, Germany, Italy, The Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom. [4] [5] The International Space Station program likelihood of survival became more formidable and secure with a multinational constituency of supporters because the International Space Station represented a great achievement in unifying these nations for one common purpose of establishing a low-Earth orbiting Space Station for peaceful purposes.

Mission control centers for the development of the International Space Station are spread across the entire globe, some of which include the following: The Program Management and Mission Control for the ISS located in Houston, United States. Mobile Servicing System Control and Training located in Saint-Hubert, Canada. ESA European Space Research and Technology Center in Noordwijk, Netherlands and the Gagarin Cosmonaut Training center in Russia. [6] These centers not only technically advance the technology but also politically generate revenue in terms of jobs which equate to votes for their respective nations. These governments are involved as builders, suppliers, and financers through whom their respective space agencies acted as their nation's primary representative to create the International Space Station.

Also influential is the constituency of different space agencies participating on the International Space Station. Four Memoranda of Understandings was written between the United States National Aeronautics and Space Administration (NASA), the Russian Federal Space Agency (Roscosmos), Canadian Space Agency (CSA), Japan Aerospace Exploration Agency (JAXA), and European Space Agency (ESA). [4] The union of these different space agencies brought forth a pool of invaluable knowledge and technical know how to benefit the development, construction, and operation of the International Space Station.

Roscosmos launched Zarya in November 20, 1998, the first ISS module which provided capabilities such as electrical power and storage for initial assembly of the International Space Station. This module was Russian built but American financed. [7] NASA provided such modules as the Destiny module launched on February 7, 2001 for the ISS which contributed as a primary research facilities used for various general researches. During the activation of the Destiny module, Astronaut Tom Jones conducted 3 spacewalks which was hailed as a "major milestone for human space flight." [8] JAXA contributed its first human space facility designated as the Kibo Experiment Logistics Module on March 11, 2008, which is use to conduct biotechnology, space medicine, and communications research capabilities. [9] ESA provided the ISS with additional modules including the Columbus module, launched in February 7, 2008, which housed a generic laboratory designed to conduct biology, fluid, and biomedical research. [10]. These are some modules that comprise the ISS.

The International Space Station has been able to maintain appropriate funding for a decade plus due to the strength of combining support from multinational governments and space agencies to comprise its constituency. The governments achieved in creating jobs and establishing multinational relationships while the space agencies were able to advance the technology and share knowledge and ideas with their respective foreign counterparts.

The Space Shuttle Columbia's demise started during the February 2003 launch in which the left shuttle wing became damaged by a rouge piece of foam debris the size of a briefcase that struck the leading edge of the wing thus damaging the shuttle's thermal protection system capabilities required for atmospheric re entry. [14] Without the ability to properly shield itself from heat generated during re entry, the Space Shuttle Columbia disintegrated during re entry into the Earth's atmosphere.

The technical problem that occurred on Space Shuttle Columbia would resonate throughout the other NASA programs including the International Space Station fueled by public outcry for the tragic loss of the shuttle and crew. In direct response, President Bush directs NASA in a January 14, 2004 space policy address to focus on returning humans to the Moon and Mars, a commitment that crucially re affirms public belief in NASA's capability. [11] In this "Vision for Space Exploration" the President outlined key major events including the retirement of the space shuttle and restructuring of the ISS development schedule. In doing so, President Bush essentially created a political problem for NASA and the International Space Station in the ensuing years.

The following investigations into the Space Shuttle Colombia tragedy prompted a 2 year delay of Space Shuttle activity that lasted until 2006. [11] The Columbia Accident Investigation Board found the accident to be a technical problem on the Space Shuttle and insisted NASA comply with 29 of their recommendations, in which 15 were required to be completed before any space shuttle flight activity resumed. Then NASA administrator, Sean O'Keefe, eagerly agreed to comply with the Columbia Accident Investigation Board recommendations. [11] However the delay prompted by this Space Shuttle investigation became a political problem for the International Space Station,

greatly affecting the development of the International Space Station resulting in redesign and increased cost.

Retirement of the NASA Space Shuttle is a problem because the fleet of aging Space Shuttles will enter retirement in end of 2011 without a proper vehicle replacement from the United States until the then slated but now defunct Orion future space shuttle becomes available. [2] The United States of America will have to depend on Russia, the only nation with current capabilities, to send American astronauts and equipment to the International Space Station. Trips are undoubtedly expensive and require payment but the problem now is how to pay the Russians when President Clinton signed an Iran Nonproliferation Act of 2000 that doesn't allow the United States to pay Russia to shuttle American astronauts and equipment up to the International Space Station.

Towards the end of President Clinton's administration, the Iran Nonproliferation Act of 2000 was signed into law on March 14, 2000. [3] This act authorizes the President of the United States to take punitive actions against nations known to be providing materials to create weapons of mass destruction in Iran. Such punitive actions taken included the United States House Of Representatives 1883 substantially cutting U.S. funding to Russian Space Agencies responsible for the U.S. and Russian Space Station Project because Russia did not display "sustained commitment to seek out and prevent aid to Iran's weapons programs." [3] This Act banned U.S. payments to Russia involving the International Space Station unless Russia halted supply of nuclear missiles and weapons technology to Iran. [11]

Because this Iran Nonproliferation Act of 2000 was signed by then President Clinton, the United States was placed into a political dilemma. The International Space Station now faced a technical problem that has become a political problem: how to make payment to Russia for use of their Soyuz Shuttles during a technical capabilities gap as a result of the NASA upcoming Space Shuttle retirement? The answer to this political problem came from the International Space Station Payments Act of 2008.

The Congressional Budget office Cost Estimate S.3103 International Space Station Payments Act of 2008 was reported by the Senate Committee on Foreign Relations on September 23, 2008. [2] This Act grants NASA authority to make payments to Russia for transporting U.S. astronauts to the International Space Station until the NASA Space Shuttle replacement vehicle named Orion enters service. The budget granted for 2012 and 2013 was determined to be $330 million, by Assistant Director for Budget Analysis Peter Fontaine, to transport six astronauts each year which falls within budget function 250, Science, Space and Technology. [2]

Differing module life spans are a challenge, as the multinational consortium of nations and space agencies plan to spread the development costs of the International Space Station through the development of separate modules that comprise the International Space Station. These modules will be provided separately by the differing nations. In doing so, each module design maintains a unique life span after entering service during separate launches in a decade plus time frame.

The resulting political problem occurs when the Obama Administration mandates that the International Space Station operations continue beyond 2015 well into 2020. [28] Since modules have already begun to reach their retirement age such as the Russian Zarya module in 2013, will there be additional funding appropriated to refurbish the aging modules to comply with the ISS operation mandate into 2020? [28] How major are the refurbish of these modules when considering that the large cargo lift capacity of the US Space Shuttle will no longer be available for use and that the temporary Russian Soyuz cargo capacity is much less than that of the retired US Space Shuttle.

Another issue is the technical complexity of knowledge and capabilities sharing amongst the different space agencies to fully develop a low Earth orbiting space station. The best engineering solution in this example is to have several prominent space agencies combine their technical knowledge and capabilities in a unified effort to realize a worthy space station, however the best political solution would be to have just one space agency developing the space station to avoid financial and legal obligations concerning space station module ownership, resupply, and use.

Concerns of managing the cost and use of the International Space Station was outlined in the Space Station Intergovernmental Agreement on January 29, 1998 which dictated which nation owned which module, how modules are used, and how the International Space Station was paid for. [5] In doing so at the start, the multinational project avoided unnecessary internal strife and conflict amongst its core constituency.

The Government Accountability Office functional availability assessment was used to evaluate NASA's analytical techniques for International Space Station capability up until 2020. In this example, NASA's engineering solution for overall ISS health is that "23 percent of space station functions are within 5 percent" of their intended goal. [16] However the Government Accountability Office, GAO, views this differently as politically meeting a functional target at "94 percent confidence." [16] In other words, the GAO perspective with NASA's assessment is stated as a "failure to meet a functional target one time in 20 versus one time in 100." [16]

NASA's statement that some of their capabilities are within 5 percent was an acceptable engineering assessment however it was simply not politically adequate for the GAO, which read the percentage description as failing to meet the target one in 20 as opposed to the preferred one in 100. Although NASA's statement is technically acceptable and considered a best technical analysis, it is not politically acceptable by the GAO and cannot be considered the best political analysis.

Potential collisions with micrometeoroid and orbital debris that lead to major loss of cabin pressure have been a major safety concern for the International Space Station. Such debris capable of impacting the ISS in its assembly complete configuration is "55% with a 9% catastrophic result over a 10 year period." [18] However these figures can be greatly reduced to "29% chance of impact with 5% catastrophic result by adding additional shielding to minimize the severity of any debris impact on the International

Space Station. [18] However plans were delayed to fly protective shielding for the Russian Service Module on the ISS due to a decision to ground the Space Shuttle fleet after the Columbia investigation. [19] One solution is to provide the outer shielding to the Russian Service Module on the ISS for added protection. However the politically-motivated choice for the International Space Station is to continue its current state without the extra shielding.

With the Space Shuttle retirement, the alternate means to transport astronauts and equipment to the ISS became the Russian Soyuz. However, the Soyuz has far less cargo capability then the previously retired Space Shuttle. The International Space Station has little choice in its ability to provide itself crucial logistics due to the political choice of retiring the Space Shuttles without having an adequate replacement in place.

In his statement on February 1, 2010 during a NASA budget press conference, Bolden exudes great confidence in mans ability to venture deep into outer space, across the solar system, to visit mars, and the moon. [24] In this perception, Bolden's words are very reminiscing of what Hollywood movies are made of. However as grand his tale may be of space adventure, does the general public realize the truth behind such a tall tale? Most likely no.

How long has it been since Neil Armstrong stepped foot on the moon? This event occurred July 20, 1969, in which nearly four decades have passed by. [22] American astronaut Eugene Cernan was the last man on the moon in 1972 and we haven't been back since. [23] Not because our technology was no longer there but because of the impacts of politics and how it can hinder great technological achievements.

Thus when NASA Administrator Bolden sells his big idea to the general public he makes it very awe inspiring. He must demonstrate to the American Public a grand scheme of perception that we not only will reach out to lower Earth orbit but back to the moon and far beyond the reaches of our galaxy. The perception is far more important as it is far from the truth that we were only able to reach the moon. Since truth is often overlooked, Bolden will garner support for his new direction for NASA.

The International Space Station began construction in 1998 with its first Russian module, Zarya, launched on November 20, 1998 followed by the first American module, Unity, launched on December 4, 1998. [7] [25] The modules fulfilled the immediate near-term gratification which was preferred by politics. Subsequent modules including the Zvezda, Destiny, Quest, and Pirs began launching within the following years. [25] Until the launch of the Columbus module on February 7, 2008 which provides ISS capability for fluid physics and biomedical research and a generic laboratory, critics have called the International Space Station a "job-creation scheme for aerospace companies rather than a productive scientific platform." [25] [26] However, with jobs being created meant votes being created for member of Congress in those districts.

Both job creation and the scientific platform were and still remain the primary intentions for creating the International Space Station. Job creation in the Aerospace

Industry provides a much needed boost to state economies while advancing the degrees of science and technology. Simply put, basic research alone does not have the capability of creating as many jobs as if there was a deliverable such as a module from the International Space Station.

Until 2010, NASA participation in the ISS program would have concluded in 2015. However with the current Obama Presidential Administration, the current participation of NASA and the ISS extended until 2020. [16] In comparison, under the original time line for the International Space Station, full completion would have been in 2002 and operations of the ISS would have lasted until 2012. [11] President Bush's 2004 "Vision for Space Exploration" detailed that NASA will complete its use of the International Space Station by 2016. [11]

Differing Presidential Administrations allowed for great variation in a completion date for the development, construction, and operation of the International Space Station. Since the Presidential term is 4 years, changes to a large complex program are inevitable because the program will depend on several presidencies with which each president will have differing new visions then their predecessors. Of course with each new vision, the new President will feel that this vision is best suited for the U.S then the old vision that will soon be replaced.

The Bush Administration promoted a new "Vision for Space Exploration" in 2004 which included the Space Shuttle Retirement in 2010, replaced by Orion, and a "core completion" strategy for the ISS greatly changing its original configuration. [11] President Obama's current initiative on the International Space Station shuts down the Constellation program which wipes out the intended Space Shuttle Replacement Orion that is desperately needed to ship critical supplies, modules and astronauts with a large enough payload to the International Space Station. [17] Instead, the current Obama's Administration change in direction plans on developing multiple types of space shuttle replacements within the private sector calling for $6 B to be spend over 5 years to develop. [17] In doing so, the International Space Station is once again found waiting for a viable means similar to the unmatched Space Shuttle payload capacity for ferrying critical equipment and astronauts into low Earth orbit.

Once again, different Presidents call for different visions that shape the future of large complex programs such as the International Space Station. The ISS will eventually finish its construction but it will differ greatly from its original concept with each presidential administration it encounters.

Conclusion

This paper has provided detailed analyses to explore the Political Process and its involvement in the development of the International Space Station.

In closing, the fate of the International Space Station rests upon the leadership of the current Presidential Administration and Congress to be able to work together to provide sufficient funding and a realistic timeline. This International Space Station has been a decade plus in the making symbolizing not only great technical achievement but also great political achievement in intergovernmental politics as well.

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