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# Multi-national cooperation in space operations

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# NAVAL POSTGRADUATE SCHOOL

**MONTEREY, CALIFORNIA**

# THESIS

**MULTI-NATIONAL COOPERATION IN SPACE OPERATIONS**

by

David R. Perry

June 2005

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| Second Reader: | Charles Racoosin |

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# MULTI-NATIONAL COOPERATION IN SPACE OPERATIONS

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Submitted in partial fulfillment of the
requirements for the degree of

**MASTER OF SCIENCE IN SPACE SYSTEMS OPERATIONS**

from the

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# ABSTRACT

This thesis discusses multi-national cooperation in space operations and its dependence on the human component. It includes a discussion of the history of U.S.-Russian cooperation, specifically the Apollo-Soyuz Test Project, the Shuttle-Mir Program and finally the origins of the International Space Station (ISS). This thesis goes into detail about the communication process between the International Space Station, the Mission Control Center – Houston (MCC-H) and the Mission Control Center – Moscow (MCC-M) with emphasis on the human component. This thesis further discusses the impact of personal relationships in the daily operation of the International Space Station. Finally, this thesis discusses lessons learned and additional applications where personal relationships can affect multi-national operations.

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# I. EARLY MULTINATIONAL COOPERATION IN SPACE

## A. INTRODUCTION

The U.S. began cooperating with Russia in the use of space shortly after the start of the space race itself with a limited exchange of weather-satellite data in 1962. However, it wasn't until the early 1970s that U.S.-Russian relations improved sufficiently to allow for what would become the Apollo-Soyuz Test Project (ASTP).[1]

Based on a successful ASTP flight a new agreement was signed in 1977 allowing for a U.S. Space Shuttle and Soviet *Salyut* space station rendezvous. However, due to concerns over technology transfers in 1978, the 1979 technical meetings were cancelled. With growing political concerns over the invasion of Afghanistan and martial law in Poland, the 1977 agreement was allowed to lapse in 1982 resulting in no rendezvous under this agreement.[2]

In 1984, President Reagan privately proposed to the Russians an idea of a space rescue mission involving the Space Shuttle and the Salyut 7 space station. Days later he proposed in his State of the Union speech the construction of a space station by the U.S. and her allies. It wasn't until three years later the U.S.S.R. agreed to President Reagan's proposal of a simulated space rescue mission.[3] Even though a few meetings took place over the next several years, an actual mission never happened due to the collapse of the Soviet Union.

On June 17, 1992, U.S. President George Bush and Russian President Boris Yeltsin signed a new agreement allowing greater cooperation in human space flight. The agreement specifically allowed for U.S. astronauts and Russian cosmonauts to participate in Space Shuttle and *Mir* space station missions.[4]

Today, the U.S. has intentionally placed Russian products and services in critical paths within NASA projects to promote economic and political stability, even over long

[1] U.S. Congress, Office of Technology Assessment, *U.S.-Russian Cooperation in Space,* OTA-ISS-618 (Washington, D.C., U.S. Government Printing Office, April 1995), 42.

[2] Ibid., 43.

[3] Ibid., 46.

[4] Ibid., 47.

time ally Canada. Initially, the primary reason was to keep Russian scientists from selling their expertise following the collapse of the Soviet Union.[5] Later, it was too late to change. Russia now has several aspects within the critical path of the International Space Station (ISS) Program. Examples of Russian aspects of the ISS Program that can no longer be undertaken by any other partner are: 1) guidance and navigation depends on the *Zvezda* Service Module, 2) station reboost depends on *Progress* vehicles, although this can also be done by the U.S. Shuttle when it is flying, 3) the crew lifeboat is provided by a *Soyuz* capsule, and 4) fuel resupply comes from the *Progress*.[6]

**B. APOLLO-SOYUZ TEST PROJECT**

On July 19, 1975, nearly two and a half years after the Apollo Program ended, an Apollo capsule joined with Soyuz 19 for the first ever multi-national rendezvous in space. This encounter was the result of more than four years of work. Both countries had to overcome an enormous distrust of each other.

NASA and the U.S.S.R. Academy of Science began meetings in 1970-71 to discuss a means to rendezvous spacecraft from different countries in space. This ultimately resulted in the Apollo-Soyuz Test Project and cooperation in satellite meteorology[7]. The ASTP had one seemingly simple objective: develop and demonstrate the capability to rendezvous a U.S. and Soviet spacecraft. But each country had other reasons for pursuing the ASTP. Russia wanted to regain lost prestige in the space community after recent failures with its lunar program, specifically the N1. America saw a gap between the planned end of the Apollo Program and the beginning of the Shuttle Program and the ASTP would allow NASA to retain engineers and other critical staff during the interim. In 1972, President Nixon and Prime Minister Alexei Kosygin signed the *Agreement on Cooperation in the Peaceful Exploration and Use of Outer Space*, which formalized the structure on implementing the ASTP.

The ASTP called for a new docking module to be built that would allow these two very different spacecraft to link. The Americans got the mission to launch the module

[5] U.S. Congress, 47.

[6] Ibid., 17.

[7] Ibid., 43.

into space. It wasn't a political decision, just physics. The Saturn used by the Americans had extra capacity that the Soyuz did not.

The success of the ASTP was not having three U.S. astronauts shake hands with two Soviet cosmonauts in space. The success actually was the cooperation between two adversaries. The cooperation was limited to the exchange of data, because of fears of technology transfers, but it was the basis for future endeavors. The Soviets were so concerned about spying, when astronaut Tom Stafford wanted to visit the Soviet launch facility at Baikonour to check on preparations, the Soviets flew him there and back in the middle of the night so he couldn't see anything. However, critics believed the entire project was a waste of valuable resources for a photo opportunity.[8]

The success of the ASTP led to further attempts at cooperation in space. In 1981, the space agencies from the U.S, U.S.S.R, Europe and Japan formed the Inter-Agency Consultative Group (IACG) to study Halley's Comet. NASA's Deep Space Network provided tracking for the ESA's *Giotto* and the U.S.S.R.'s *VEGA-1* and *2*. Additionally, several U.S. instruments flew on Soviet spacecraft.[9]

## C. INTERNATIONAL SPACE STATION – INCEPTION

### 1. Early ISS Agreements

The International Space Station has its roots back to President Reagan's January 1984 State of the Union Address, where he called for a permanently manned space station. The space station would have a crew of 8 astronauts and be used for continuous scientific research. Privately, the U.S. proposed to the Soviets, days before an extension of the ASTP, the notion of a space-rescue mission using the U.S. Space Shuttle and the Soviet space station, *Salyut-7*. Initially, the Soviets wanted to link this to a space arms control agreement.[10] However, in mid-1986 the Soviets dropped this requirement and in April, 1987, they signed an agreement to expand cooperation. Even though there were a couple of annual planning meetings, nothing really went forward as a result of this agreement.

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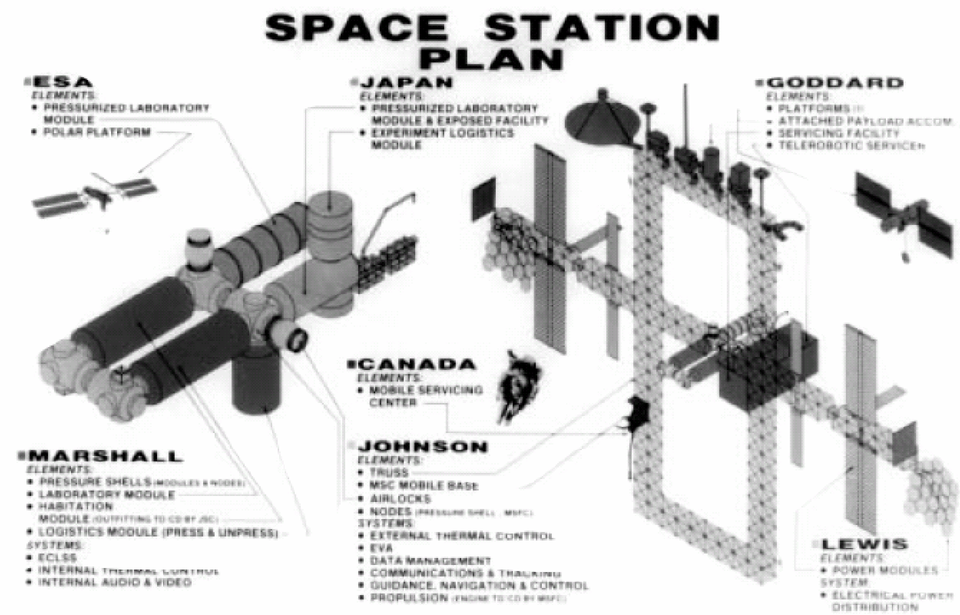
8 David M. Harland, *The MIR SPACE STATION: A Precursor to Space Colonization* (New York, NY: Wiley, 1997), 295.

9 U.S. Congress, 44.

10 Ibid., 45.

A few months after President Reagan's announcement, the European Space Agency (ESA) agreed to add a laboratory module.[11] In 1989, Japan joined the partnership by agreeing to contribute a module of its own. Space Station *Freedom* had begun (Figure 1).




*The Space Station Plan, as proposed in 1986, at the time of the initial agreements for international participation. (NASA photo 86-H-324).*

**Monographs in Aerospace History**

Figure 1 Space Station *Freedom* Plan (From: Logsdon, 1998, 42)

The next milestone for the ISS was the June, 1992, *Agreement Between the United States of America and the Russian Federation Concerning Cooperation in the Exploration and Use of Outer Space for Peaceful Purposes*[12] signed by Presidents Bush and Yeltsin. This is the first agreement to raise the possibility of joint U.S.-Russian missions.

The 1992 agreement was followed by another on September 2, 1993, where U.S. Vice President Gore and Russian Prime Minister Chernomyrdin signed the Space Station Implementation Plan that effectively merged the U.S. Space Station *Alpha* with the next generation Russian *Mir-2*. The result was to be a space station at 51.6˚ inclination that

[11] Harland, 295.

[12] U.S. Congress, 85.

allowed for a Soyuz lifeboat.[13] This inclination was not optimal for either the U.S. or Russia, but it was especially disadvantageous for NASA. By changing inclinations from the original 28˚ to 51.6˚ for the space station, the lift capacity of the shuttle was severely restricted.

The subsequent addendum of 1 November set up three phases for implementation. Phase One called for seven to ten shuttle flights to *Mir* as well as five flights onboard *Mir* by U.S. astronauts. Phase Two called for basic assembly of the ISS, which would allow for a three man crew. Phase Three called for the completion of the ISS, including the European and Japanese modules.[14]

Russia wanted to use the *Mir-2* as a base for construction of the ISS. They argued the construction time would be reduced, since the *Mir* crew could be assembling the station while living on *Mir*. There would be no need to wait for shuttle flights. By adding modules to *Mir-2* to create the ISS, Russia would be seen as the basis for ISS instead of only a contributor. This was an attempt to save the *Mir* project, which had been highly successful but too costly to continue. Even though this proposal was rejected, the *Mir-2* did not truly go away. With a few modifications it came back as the service module to the ISS.

### 2. Merging Two Philosophies

In February 1986, the Soviet Union launched its next generation space station. The station would be called *Mir*, meaning "peace", rather than *Salyut-8*, because of General Secretary Mikhail Gorbachev's policies of *glasnost* and *perestroika*.[15] Unfortunately, depending on context, the word Mir in Russian could be translated as either "peace" or "world"; one could equally say "I want peace" or "I want the world". This type of linguistic dichotomy allowed for normally suspicious people to attribute nefarious intentions when they may not actually exist.

In 1986, the U.S. named its space station "Freedom", reflecting President Reagan's view of the Soviet Union as the Evil Empire.[16] Over the next seven years, both

[13] Harland, 299.

[14] U.S. Congress, 49.

[15] Brian Harvey, *Russia in Space: The Failed Frontier?* (Chichester,UK: Praxis, 2001), 23.

[16] Harland, 296.

Space Station *Freedom* and U.S.-Russian relations underwent various changes. In order to appear less provocative during an era of thawing relations, the name "Freedom" was dropped from the space station in January 1993.[17] Also by January 1993, the Space Station Program was getting too expensive. President Clinton directed NASA to reduce the cost of the project.

Over the next nine months, the space station underwent various design modifications. In September 1993, three plans were presented – Alpha, Bravo, and Charlie. Since Option Alpha was selected, the Space Station was referred to as Space Station Alpha.[18] Later, the term Alpha was dropped in favor of simply the International Space Station due to Russian sensitivity to the word Alpha. Alpha implied the first and to the Russians *Salyut-1* was the first space station.

As of 1995, the US believed there were five general benefits in cooperating with other countries in space operations and development: 1) reducing costs and sharing burdens, 2) broadening sources of know-how and expertise, 3) increasing effectiveness, 4) aggregating resources for large projects and 5) promoting foreign policy objectives.[19] To some degree, all of these benefits have been realized.

The Russian space design philosophy derives from its beginnings at the end of World War II. The U.S. and U.S.S.R. shared the spoils of German technology, namely the V-2, and their rocket scientists. In their effort to develop a delivery system for their H-bomb, the U.S.S.R. required a larger more powerful rocket, since their bomb design called for a much larger and heavier bomb than their American counterparts. The result was the R-7, the world's first intercontinental ballistic missile (ICBM).[20] The R-7 is such a powerful and reliable rocket it is still used today to launch the *Soyuz* capsules to the International Space Station.

One effect of their ability to produce reliable rockets with heavy lift capabilities is that the Russians do not have the same impetus to develop lighter payloads as the

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[17] Harland, 296.

[18] Ibid., 298.

[19] U.S. Congress, 8.

[20] Ibid., p. 26.

Americans. Furthermore, under the Soviet system labor was cheap. They could afford to use more workers to produce a less sophisticated product. This in no way implies the quality is inferior. To the contrary, the construction of the Functional Cargo Block (*Funkstionalii Gruzovoi Blok* or FGB) is an excellent example of the robustness of Russian systems. When American engineers found out the specifications the FGB was built to, specifically low temperatures (-50˚ C) and high *g* forces (50*g*), they were confused. The Russians then explained that the FGB had to survive the trip to Baikonour in an unheated Russian railcar and the drive on Russian roads; the conditions in space are much easier.[21]

A story about early space flight sums the difference in U.S.-Russian philosophies concerning technology:

"An American astronaut and a Russian cosmonaut are talking. The American tells the Russian, 'In America, we have developed something that will write in weightlessness; we call it a space pen'. The Russian replied, 'That is amazing. We have done the same thing in Russia, but we call ours a pencil'".

**D. MIR/SHUTTLE**

The Shuttle-Mir Program was actually Phase One of the ISS Implementation Plan. The program essentially paid Russia $400 million over a four year period for space hardware, services and 600 days of astronaut time on *Mir* over two years. It was a win-win situation for the Americans and the Russians. The Americans gained experience in living in space for long durations. Russia was able to extend the life of its aging space station with funds it no longer had after the collapse of the Soviet Union in 1991. The result actually exceeded expectations; 11 cosmonauts on eight shuttle missions and seven astronauts on *Mir* for 908 days.[22] Figure 2 illustrates how the Shuttle docked with *Mir*.[23]

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[21] Harvey, 89.

[22] Ibid., 88.

[23] http://spaceflight.nasa.gov/history/shuttle-mir/references/documents/jr-sec13.pdf accessed 1 April 2005.

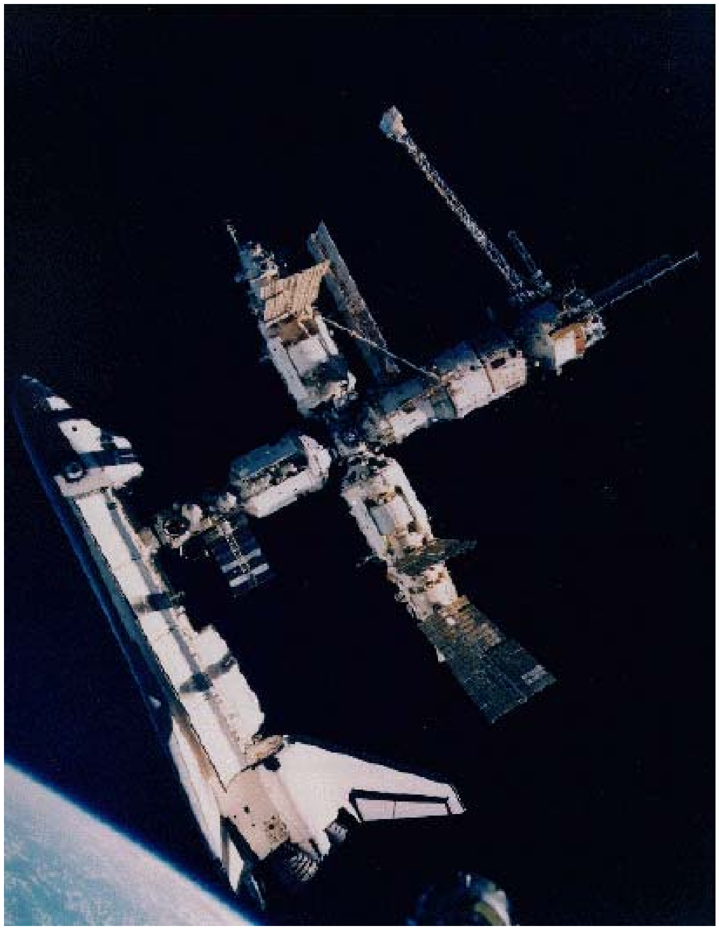

Figure 2 Atlantis docked to Mir during STS-71 (From: http://spaceflight.nasa.gov/history/shuttle-mir/references/documents/jr-sec13.pdf)

## E. COMMERCIAL COOPERATION

### 1. Sea Launch

U.S.-Russian cooperation in space exists beyond the governmental level. Sea Launch is a good example of how industry can cross cultural issues to successfully launch satellites. Although the program is not a manned mission, some lessons may still be drawn.

Sea Launch is a joint effort between Boeing (U.S.), RSC Energia (Russia), SDO Yuzhnoye/PO Yuzhmash (Ukraine), and Kvaerner ASA (Norway). Boeing provides overall program management, payload fairing, analytical/physical spacecraft integration, mission operations, and home port management. RSC Energia provides the Block DM upper stage, launch vehicle integration, ground systems and launch operations. SDO Yuzhnoye/PO Yuzhmash provides two stages of the Zenit-3SL, vehicle integration support, and launch operations support. Kvaerner ASA crews both the *Odyssey* Launch Platform and the *Sea Launch Commander* (Assembly and Command Ship).[24]

Sea Launch is a mini example of the process the ISS has had to undergo. Like ISS, Sea Launch has brought components from around the world to one place for final assembly and operation (Figure 3).[25]

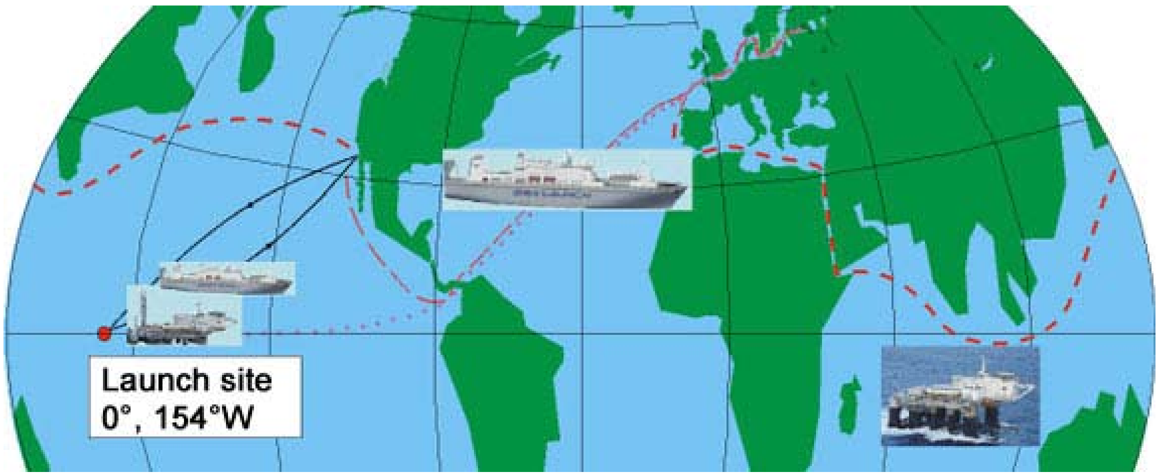


Figure 3 Sea Launch System (From: Energia)

The best example of cooperation was found with the construction of the command ship, *Odyssey*, itself. This command ship was built specifically around the needs of the different partners. The control center, in particular, was constructed to meet each of the partners' individual requirements, as opposed to forcing them to adapt to a standard layout. Aside from the two different missions of payload operations and booster operations, the control room that has two distinct layouts within the same room, each reflecting their country's perspective on operating a control room.

### 2. Other Commercial Cooperation

International Launch Services (ILS) is another corporate joint venture. This one is between Lockheed Martin (U.S.) and Khrunichev State Research and Production Space Center (Russia) to provide commercial launch services using the Atlas and Proton vehicles.

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24 Sea Launch Homepage. Accessed March 7, 2005. http://www.sea-launch.com/information.htm. Internet.

25 Energia. Assessed 11 April, 2005, http://www.energia.ru/english/energia/sea-launch/partner.html. Internet.

U.S. and Russian industry have also cooperated with respect to rocket engines. Both Pratt & Whitney and Aerojet have purchased Russian engines to use in American boosters. Although these and ILS reflect more of a business arrangement rather then a cooperative effort, cooperation begins with mutual benefit, which is the heart of business.

# II. INTERNATIONAL SPACE STATION

## A. INTRODUCTION

> The ISS was intended not only to serve as the next step in the exploration of space, but as a laboratory for microgravity research, a focus of education, and a demonstration of nations to work in a peaceful international endeavor.[26]

The International Space Station consists of two integrated segments. The prime contractor for the Americans is Boeing (U.S.), while for the Russians it is Energia (Russia). The International Space Station is a highly complex piece of equipment supported by an army of scientists and other staff from over 16 countries. Routinely, NASA has to deal with technological, logistical, political, cultural, and linguistic issues. While operating the ISS, even though safety is the number one concern, the specifics on how it is run are continuously discussed.

Communication between the Mission Control Centers (MCC) in Houston and Moscow and the ISS consists of three components: 1) the communication loops, 2) ground facilities and the ISS itself and 3) the people. These people include the console operators, astronauts, and translators, directly, as well as the administrators, engineers and other staff, indirectly.

## B. MISSION CONTROL CENTERS

### 1. Houston

NASA has numerous facilities around the country. Each facility has a different mission: research, administrative, or command and control. The Mission Control Center in Houston (MCC-H) at the Johnson Space Center (JSC) has the responsibility to manage the ISS and Space Shuttle while in orbit. They receive control of the shuttle shortly after liftoff from the Kennedy Space Center. However, for the ISS, this does not mean they control every aspect. For instance, if there is an issue with one of the experiments onboard, the Marshall Space Flight Center in Huntsville, Alabama addresses it.

NASA actually has two separate control rooms in the same building at JSC: the Blue Flight Control Room (FCR) is for ISS operations and the White FCR is for Space

[26] Dr. Laurie Zoloth. Meeting minutes for NASA Advisory Council, Washington DC, 6 December 2001.

Shuttle operations. The layout is similar in both FCRs, but physically the White FCR is twice the size of the Blue FCR. The room could be larger due to the faster pace required by shuttle missions and therefore there is a need for more experts to be immediately available. It could also be related to the fact the Space Shuttle is higher profile and a flashier control room shows off NASA at work to the general public. Or it could simply be that when ISS came onboard a smaller control room was required since they had learned to be more efficient since the Shuttle's control room was built. Regardless of the reason, this contributes to a perception of a "Shuttle first" attitude. When the Shuttle was up, people who were associated with the ISS felt as if they were of secondary importance. Their mission was equally important, but less flashy. This is an example of how even in ones own country there are perceptions and internal cultural issues that may have an impact on operations.

In addition to the control rooms themselves, this same building houses other useful parts of the Space Program; specifically the engineers. Although they do not work with the Russians as often as the control rooms do, they still need to have a certain degree of knowledge about the Russian systems. The U.S. experts need to know how those Russian systems will interact with the American components.

**2. Moscow**

Similar to the Americans, the Russians have two control rooms inside their MCC. The Mission Control Center in Moscow (MCC-M), known in Russian as the *Tsentr Upravleniya Polyotami* (*TsUP*), was built for *Buran*, the Russian Shuttle, and controls *Progress*, *Soyuz* and ISS activities. The other control room is no longer used. It was built and used for the *Apollo-Soyuz* mission. The control room's layout is very similar to NASA's version with consoles for Attitude, Direction and Control (ADCO), Life Support, Flight Director, etc. The functional areas the Russians required are the same as the functional areas the Americans use.

A difference shows up in how they man the control room – usually they don't. That isn't to say, they are not constantly sitting at a console monitoring what is happening. They are generally monitoring indirectly from their offices, unless a specific event, like docking or a ground pass, is occurring. At that time they would be at their console. This difference can be attributed to their work schedule. Unlike the American

9-hour shift, the Russians work a 24-hour shift and then get 72-hours off. During their 24 hours, they might be working an issue or sleeping in their office. Since their office is literally across the hall, if an issue arises they can simply be woken up to deal with it. Normally, their office doors would be open, but occasionally they would be closed. At these times they might be sleeping. They would answer the phone, but the unspoken rule is 'it had better be important if you are going to knock on the door'. The Russians believe the 24-hour shift is more efficient. They feel the greatest opportunity for error occurs at shift changeovers. A 24-hour rotation eliminates 2 shift changeovers and reduces the overall risk of errors. Additionally, Russia has very few *Pomoshchnik Rukovodutelya Polyota* (*PRP*), or Assistant Flight Directors. With an 8-hour shift they would have to work everyday. There would be no flexibility. Without a break they would get burned out.[27]

Like many of the American system experts, who actually work for Boeing, many of the Russian system experts do not work for the Russian Space Agency (RSA), but rather for Energia. However, unlike NASA whose administrators all work for NASA, some of the Russian Administrators are employees of Energia.

### 3. European Space Agency

The European Space Agency (ESA), like the U.S. and Russia, has two control centers: one for controlling the *Columbus* laboratory and one for operating Europe's Automated Transfer Vehicle (ATV).[28] The Columbus Control Center is located in the German Space Operations Center in the German Space Agency near Munich, Germany. It will control and operate the *Columbus* Laboratory as well as coordinate with the Marshall Space Flight Center, which is responsible for operating European experiments.

The ATV Control Center is located at the French Space Agency in Toulouse, France. This center will have the responsibility to operate the ATV. Neither of these control centers will be fully manned until their respective component goes into space.

[27] Maxim Matushin, interview by author, Korolev, Russia, 21 June 2004.

[28] ESA - Human Spaceflight – International Space Station Control Centers Homepage. Accessed 15 March 2005. http://www.esa.int/export/esaHS/ESAOYJ0VMOC_iss_0.html. Internet.

#### 4. Integration

The integration of all the control centers predominately falls to NASA. This is more of a practical decision rather than a political one, although there is probably a political aspect as well. Since every module connects to a U.S. module, it is logical for the U.S, that is to say NASA, to control the integration of it. MCC-H is able to integrate the control rooms from all of the partners through the use of liaisons. The Canadians, Japanese, Europeans and Russians each have liaisons assigned to JSC to act as a representative for both their equipment and their government. So even though the European Control Centers will not be fully functional prior to the launch of *Columbus*, the liaisons in Houston and Moscow are still providing input to the ISS.

### C. COMMUNICATION

#### 1. Communication Loops

There are 48 communication loops used for ISS operations (Table 1).[29] The most important one is MH 18. This is the primary communication loop between the MCC and the ISS. Generally, the only people who talk on this loop are the astronauts/cosmonauts, Flight Directors and the CAPCOMs (Capsule Commander) in Houston or *Glavnij*s (*Glavnij Operator*) in Moscow. All other discussions are held on other loops.

> There is only one official loop available. This is loop or channel 18 between Houston Flight Director and Moscow Flight Director. Officially, it means that whatever information goes through this channel is as good as written information.[30]

CAPCOMs have traditionally been astronauts only, since their primary function is to act as a liaison between the console operators on the ground and the astronauts in space. It was felt that only another astronaut would know how to translate the ground's intent to the crew in space. Additionally, a function of a CAPCOM is to help the crew stay relaxed. By knowing the astronaut and being able to relate to the situation in space, the CAPCOM can help reduce the tension. Recently, this changed to allow non-astronauts to fill this position.[31] There is an effort to shrink the number of astronauts on

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[29] NASA, *Operations Interface Procedures, Volume A: NASA/Rosaviakosmos, International Space Station, Mission Operations Directorate Basic*, (Houston, TX: Lyndon B. Johnson Space Center, June, 2003), A6-20.

[30] Konstantin Gregoriev, interview by author, Korolev, Russia, 26 June 2004.

[31] Ginger Kerrick. interview by author, Houston, TX, 13 February 2004.

staff, so by opening up CAPCOM positions to non-astronauts, the remaining astronauts are available for other missions.

Typically, the language spoken depends on the segment it relates to, the mission and who the audience is. Moscow will speak in Russian for issues related to the Russian segments, use of Russian equipment or for public affairs broadcasts intended for a Russian audience. Houston will speak in English for all other issues. Both astronauts and cosmonauts are fluent in English and Russian, so they can converse with whichever MCC calls.

| MH ## | Voice Loop Name | MH ## | Voice Loop Name | MH ## | Voice Loop Name |
|---|---|---|---|---|---|
| 01 | Trans ENG/RUS | 17 | ISS AFD 1 | 33 | ISS IST |
| 02 | CAPCOM Coord 1 | 18 | ISS OPS | 34 | IP CONF |
| 03 | IP/GC 1 | 19 | 1 S/G 1 | 35 | 2 S/G 1 |
| 04 | FD 1 | 20 | 1 S/G 2 | 36 | 2 S/G 2 |
| 05 | HSG/RIO Coord | 21 | RS ISS S/G 1 | 37 | OCA BFCR |
| 06 | Moscow Patch | 22 | ISS FD 1 | 38 | Moscow Patch |
| 07 | Moscow Support | 23 | RS FD | 39 | RT EXE Coord |
| 08 | Houston Support | 24 | RS ISS S/G 2 | 40 | ISS CMD Coord |
| 09 | 1 A/G 2 | 25 | ISO/RISS | 41 | OPS Plan 1 |
| 10 | Surgeon R/T | 26 | S/T PLN Coord | 42 | Moscow Patch |
| 11 | PAO Moscow | 27 | ISS SYS Coord 1 | 43 | FMT Coord 1 |
| 12 | Trans RUS to ENG | 28 | ISS SYS Coord 2 | 44 | OPS Plan SUPT 1 |
| 13 | 1 A/G 1 | 29 | ISS SYS Coord 3 | 45 | EVA PROCED ISS 1 |
| 14 | ISS Surgeon 1 | 30 | ISS SYS Coord 4 | 46 | Moscow Patch |
| 15 | ISS TN Coord | 31 | ISS MER 1 | 47 | Moscow Patch |
| 16 | ISS TLM Coord | 32 | ISS SIM Coord | 48 | ISS SYS Coord 5 |

Table 1 Voice Loops (After: NASA, 2003, A6-20)

The ground crew generally does not have the same bi-lingual skills as does the astronaut/cosmonaut. For this reason, there are two loops designated for simultaneous translation, MH 01 and MH 12. The console operator can individually configure which loops to listen in on. In most cases, the console operator is monitoring over four loops concurrently. So, as an example, an American ADCO can hear the translation of the conversation the MCC-M is having with the ISS, so as not to be caught unaware of ongoing events.

## 2. Ground Facilities

The Johnson Space Center, and in particular MCC-H, is the epitome of technology. The facilities are modern and well maintained. Computers and related software products are virtually everywhere. JSC enjoys access to numerous documents through their computer networks, while Moscow still heavily relies on paper copies.

MCC-M does not enjoy the same level of visual appeal, but this is in no way detracting from their ability to do their mission. The facilities in Russia reflect a culture striving to maintain its place in the space community with insufficient resources.

The condition of the American facilities is as much a part of resources as it is culture and regulations. Americans have to respond to OSHA, the EPA, and labor contracts, politics, and an era of risk aversion when considering work environments. This means money will be spent on facilities for appearance sake rather than merely for function.

Russia relies on six ground stations to send/receive their data (Figure 4).[32] They do not have a constellation of relay satellites, like the Tracking and Data Relay Satellite (TDRS), available to them. A further challenge to them is that only half of these are actually on Russian soil. Since the breakup of the Soviet Union three of the ground stations are in foreign countries.

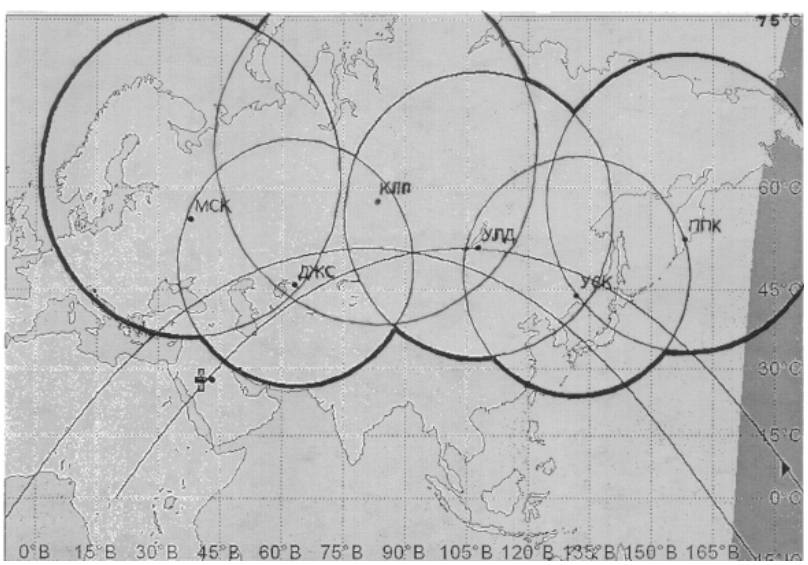


Figure 4 Primary Russian Ground Site Coverage (From: NASA/JSC, 2003)

32 NASA/JSC, *RGS_Capabilities_05_2003*, Houston, TX, 11 April 2003.

The lack of a relay system and the shortage of personnel in the *TsUP* mean that some of the tracking data Moscow gets is actually relayed to them from the U.S. This even includes telemetry data originating from the Russian segments.[33] There have been times when Moscow received warning of a problem from the crew itself before any of their systems alerted them to the problem, primarily because of the coverage.

### 3. The Big Picture

The greatest success to date for the ISS has been the fact it even happened at all. "No one had ever done this on a national scale before."[34] Components built in different countries actually fit together for the first time while in orbit.

Management of the ISS is a joint operation between Russia and the United States. It is a seemingly complex organization (Figure 5), which has well defined roles within it. The International Space Station Mission Management Team (IMMT) handles the overarching control, while the day-to-day operation is left to various subgroups.[35] For each group on the U.S. side there is a corresponding group on the Russian side, whether it is the Mission Operations Director or the Mission Evaluation Room (MER). Additionally, there is also vertical integration, besides the horizontal ones.

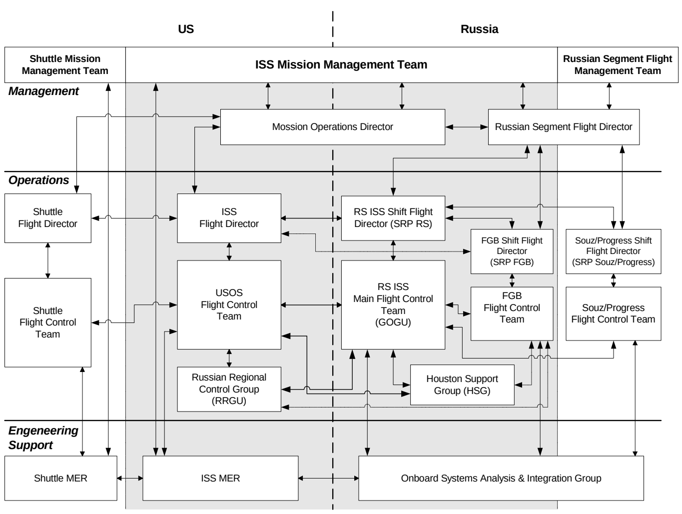


Figure 5 ISS Real-time Operational Interfaces (From: NASA, Operations Interface Procedures, Generic, International Space Station, 2003, 2-1.)

33 Dimitri Churkin, interview by author, Korolev, Russia, 29 June 2004.

34 Chirold EPP, interview by author, Monterey, CA, 18 May 2004.

35 NASA, *Operations Interface Procedures, Generic, International Space Station*, (Houston, TX: Lyndon B. Johnson Space Center, June, 2003), 2-1.

## D. THE PERSONAL TOUCH

### 1. Houston Support Group/Russian Support Group

Early in the 1990's U.S. astronauts were on the *Mir* space station. This created a need for a group of liaison officers between NASA and the Russian Space Agency. Two groups that were subsequently established later became the Houston Support Group (HSG) and the Russian Support Group (RSG). The HSG was a group of NASA representatives that would work either out of Houston or Moscow to facilitate the communication between the two space agencies. The RSG did the same mission but from the Russian's perspective. Coincidently, two weeks after it was decided to create these groups the need for such groups were demonstrated when a fire occurred on *Mir*, even though they did not have a direct impact at the time.

When Russia's role in the ISS increased with the launching of the first module, NASA identified a similar need for liaison and various translational services. NASA took on the responsibility for translating, because of a desire to make the process run smoother. Translations into Russian or English are provided more as a courtesy than a regulatory requirement. These missions, consequently, fall into the domain of the HSG. The HSG sees its purpose as the last refuge to solve cultural issues.[36] Basically, to ensure the U.S. and Russian control centers work together smoothly.

The HSG has primarily two assets: their small staff and their contracted interpreters/translators. There are between 9 and 15 translators in Houston and up to 25 in Moscow, which are paid for out of NASA's budget. The missions of these interpreters/translators range from translating Operating Interface Procedures (OIP) to interpreting conversations over the various loops.

HSG's organic staff is primarily based out of JSC. Because of the need for liaison presence in Russia, these people will rotate for usually six months to Moscow. This rotation is seen as the best scheduling solution, given the limited number of people they have. Although, the disadvantage of this rotation plan is that developing deep personal relationships is difficult. The Russians feel that the Americans come and go too quickly to get to know them. Even the senior management, who stay in Russia over a year, is

[36] Timothy E. Baum, interview by author, Houston, Texas, 11 February 2004.

seen as transient. On the other hand, since the group is small they rotate fairly frequently, so the relationships are forming, only slower.

The linguists NASA hires routinely go through a certification program to ensure they stay proficient. Unfortunately, as with linguists everywhere, their skills range from moderately proficient to very proficient. Most are proficient in routine conversation; however, the difficulty for the linguist is the specialized terminology. There is currently an effort to develop a lexicon of agreed upon definitions for the commonly used words and phrases.[37]

The RSG has a much different mission. The RSG in Houston is a small group of console operators, who provide the Russian perspective and expertise when Houston is monitoring or controlling the ISS. Ironically, the RSG is not funded by the RSA. NASA pays for these representatives to come to the U.S.

**2. Clash of Cultures**

One large source of tension within the ISS Program comes from the different views of who has authority over the station. The U.S. believes it has the ultimate authority, but Russia believes it has authority over the Russian segments.

As far back as the February 1997 fire onboard *Mir*, there have been similar issues concerning roles of authority. The Russians did not feel any need to inform NASA that there was anything going wrong onboard *Mir*. After all, the space station was under their control and they didn't want NASA to interfere. On the other hand, NASA, who had only found out about the fire when a console operator heard several times *pozhar*, the Russian word meaning fire, felt it was being side-lined.[38]

Similarly, in November 2003, there was a leak in a vent tube for a lab window on the ISS. The NASA safety community had a procedure to address it. Since NASA feels it has the controlling authority over safety issues, they sent a message about the procedure to Moscow for informational purposes only, not for approval. Russian safety representatives felt differently. They felt there were insufficient safety precautions and required NASA to prove there were, in this case, two barriers to space. At first glance,

[37] Rob Landis, interview by author. Moscow, Russia, 22 June 2004.

[38] Harvey, 49.

this seemed a logical concern, until you added two facts: first, on a previous Russian procedure they were content with only one barrier to space and second, NASA had three barriers to space for this particular procedure. Fortunately, the issue was resolved to a great extent from people who had personal relationships with each other talking the issue over.

A reason for this apparent disconnect can be traced back to how information is passed in general. Americans feel anyone who needs the information should have access to it. For the Russians, they tend more to tell you only what they think you need to know. The Russian attitude can probably be linked to either their tracking system or to their history of being in a closed society for so long. If they can only communicate with something in space when it passes over a ground station, they have time to look into any problems that may arise, but only have a limited amount of time to pass the most important information. Likewise, from the perspective of a closed society, you may be unsure if the people you are talking to actually need the information they are requesting or if it is some means of testing your reliability. Either way, the flow of information isn't very efficient and is usually guarded.

For example, a difference in how the systems work can be seen during any U.S.-Russian meeting. Americans, in general, feel they need to have every person that might have an interest in the topic of discussion attend a meeting. At a typical IMMT meeting there would be 40 people in a large conference room that is linked via a conference call to Moscow. Although, usually only two or three people plus the interpreter talk, the others are there just in case a question comes up in their field of expertise. This may be a by-product of the shuttle mentality of only having a limited amount of time to get the mission done or a feeling of needing to be involved. In Moscow, however, this same meeting would be attended by two or three people in a small room that doubles as a break room. The Russians take a more relaxed view that most things can be taken care of later. Issues brought up at the IMMT meeting that can't be addressed immediately are discussed with the appropriate experts after the meeting and the answer would be forwarded later.

An example that directly relates to the ISS is how much information Houston and Moscow give to the crew in space. MCC-M will put out a single page document outlining the day's events for that day only and give the crew only limited perspective on future activities. MCC-H, on the other hand, will put all the information it can muster on the web and flood the Russians with information. Anything the crew wants to know, Houston will tell them.[39] How much information the crew gets and what form that information is disseminated is a source of friction between the two space agencies.

The primary language on the ISS officially is English, according to Article 13 of the agreement signed by NASA and the RSA.[40] However, when MCC-H talks, it is in English and when MCC-M talks, it is in Russian. The U.S. has never pressed the issue, so it has spent millions in translation services. At one time, there was an effort to label all the equipment in English, but that was never followed through. Over time it has been accepted that the Russian equipment will be labeled in Cyrillic.

Originally, MCC-M was supposed to have the lead for the ISS until the U.S. segment was added, and then it was supposed to transfer to MCC-H. However, things got fuzzy. The first segment, the FGB, was launched as planned on a Russian *Proton* rocket. Then the Space Shuttle brought up Node 1 to connect to it. That was when the issue of 'lead' MCC really came to the forefront of the Russians mind. The Russians balked at the turnover citing the U.S. did not have the experience in long term space operations. But that wasn't the real reason.

The Russians have a fierce pride in their accomplishments in space. And soon politics and pride overshadowed agreements. They could hardly believe that someone else was 'lead' MCC and they would just be reporting to them. For the Russians, it was totally unacceptable.[41] NASA sent a letter formally stating it was in charge of everything shortly after the Russians balked at transfer of control. The Russians summarily ignored the letter, which in effect made it meaningless. No follow-on agreement to date has been reached. What has happened, though, is a quasi-cooperative agreement where no one is in charge and everybody works together. The only acknowledged exception is in the case

[39] Greg Smith, interview by author, Houston, TX, 11 February 2004.

[40] U.S. Congress, 102.

[41] Dimitri Churkin, interview by author, Korolev, Russia, 29 June 2004.

of an emergency, and then Houston has the lead. This undefined leadership role that seems to work for the ISS will later become an issue as more multi-national missions are planned in the future.

### 3. Effects Associated with Personal Relationships

Personal relationships have an effect on the efficiency of the manned space program. It is difficult to isolate a specific instance of something that occurs everyday. Experts from both sides of the Atlantic talk routinely. This makes it difficult to distinguish at what point a personal relationship comes into a communication and affects it. Efficiency in this case refers to smoother communication, which in turn reduces ambiguity, misconceptions and increases the flow of information.

From the November 2003 leak onboard the ISS, two specific examples of the effects of personal relationships can be drawn. These are separate from the procedural issue mentioned earlier.

The first example is from a CAPCOM's perspective. NASA scientists could not identify the source of the leak. The CAPCOM, while talking to a *Glavnij* in Russia, whom she knew, found out that *Mir* had a similar problem years before that turned out to be the air scrubber. The *Glavnij* further told the CAPCOM how they fixed the problem. NASA, previously, had not known about this particular problem. As it turned out, that was not the problem for the ISS, but it still had exposed an area to look into.[42]

The second example is from a *Smennij Rukovoditel Polyota* (SRP), or Shift Flight Controller, perspective. MCC-M was going to close the hatch between the U.S. and Russian segments in an effort to further isolate the location of the leak. The Flight Director in Houston noticed a procedural problem and stopped the hatch from closing. After two hours of discussions over the various loops a new procedure was developed and the hatch was closed.[43] The ability to talk to someone they knew over these loops is what allowed this issue to be resolved quickly and at a low level. Typically, such an issue would have delayed the implementation of the procedure, while experts discussed the pros and cons and came to a consensus.

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[42] Ginger Kerrick. interview by author, Houston, TX, 13 February 2004.

[43] Dimitri Churkin, interview by author, Korolev, Russia, 29 June 2004.

### 4. Personal Relationships versus National Interests

Personal relationships are critical in Russian culture. But no matter what relationship exists, few people would go against their national interests. As long as there is no direct conflict, both Americans and Russians will do what they can to help each other. The challenge will be to find common interests at a national level. National interests are expressed predominately by senior government officials. But what exactly defines the national interest can vary, based on political, economic, technological or even personal input. Pride, for example, is a form of personal input that can have a strong effect on individual actions. At a national level, pride at the accomplishments of fellow countrymen can be used to leverage funding for the program involved.

## E. BALANCE OF CONTRIBUTIONS

NASA has a long history of international cooperation. The standard practice in dealing with other countries is to use a "balance of contribution" basis instead of any exchange of funds. However, when *Columbia*'s accident grounded the shuttle fleet, the U.S. had to rely solely on Russia for ISS support. This meant the U.S. now had to trade crew hours to offset the increased Russian contribution. Each side does get "credit" for other partners' items stored in their module, but this is a relatively insignificant amount in terms of the balance of contributions. The greatest impact of this occurs when determining priorities of space allocation, especially onboard the returning *Progress* capsule.

NASA is restricted in how it can manage its resources in trying to fulfill national priorities. Over concerns of technology transfers to Iran, Congress passed the Iranian Non-proliferation Act (INA). This Act specifically prohibits NASA from paying Russia cash for ISS services.[44] Although, there are exceptions allowed for things like safety. Whether intended or not, the INA has had an adverse effect on NASA's ability to function efficiently. As early as 2006, Russia will no longer be bound by previously negotiated balance of contribution agreements and will not be required to bring any U.S. astronauts to the ISS. So, even though the U.S. bore the largest share of the cost to build the ISS we may not have a presence.

[44] Sharon Squassoni and Marcia S. Smith, *The Iran Nonproliferation Act and the International Space Station: Issues and Options.* Congressional Research Service, 2 March 2005. Available at Http://www.spaceref.com/news/viewsr.html?pid=15775. Accessed 21 March 2005.

The balance of contributions, however, does not take into account the numerous interactions at all levels. For instance, even though English is the official language for the ISS, NASA has spent millions to ensure translation service is available. Documents are translated into Russian and a staff of interpreters is contracted by NASA to facilitate communication between the U.S. and Russia. There is no price tag on cooperation achieved between two console operators and a cosmonaut.

The INA has had an impact on the manner in which NASA deals with Russia, specifically with respect to the ISS. There was a study on the impact of the INA conducted in 2005. However, with the grounding of the Shuttle, there has been a great imbalance with the balance of contributions of the partners. The Russian Space Program needs money. If they can't get it from the Americans through bona fide requirements, like the ISS, they might look for funding from sources not aligned with U.S. interests. If the U.S. is truly interested in U.S.-Russian joint efforts in space, a new analysis of the INA should be conducted to determine both the effects on the ISS Program and future space related missions with Russia.

**F. REQUIRED SKILLS**

There are many skills that are important for astronauts/cosmonauts. There is no doubt that technical knowledge is a mandatory pre-requisite. However, the amount of time man will spend in space will only increase in the future. NASA has been given the objectives of completing the ISS and then returning men to the Moon and eventually using the Moon as a launching point to further space exploration.[45]

Doctors and scientists will use data collected from ISS missions to better understand the physical and psychological effects of living in space. However, it is obvious an individual will not be in space alone. Whether the astronauts are from the same country or from different countries, the issue is the same. They need to be able to interact on a personal level with their crewmates.

The Russians believe technical skills are not enough for crews on long duration missions. They know an ability to communicate and to have mutual understanding

[45] NASA, *The Vision for Space Exploration*. (Washington DC, NASA HQ, February, 2004), iv.

within a crew is vital.[46,47] The ability to communicate goes beyond mere linguistics. True, crew members need to be able to speak each others language. But, crew members must also be able to sense what is important to each other, whether that is being alone or everybody eating together.[48]

The ability to be able to carve out some personal time in a schedule that is dictated will continue to be a challenge. Astronauts/cosmonauts are a valuable resource on which millions of dollars have been spent in order to put them where they are. Naturally, the people footing the bill want to maximize their use. A typical daily plan, *detalnij plan polyota* (DPP), used by the Russians is nearly identical to the American planning tool. It accounts for literally every minute of the day. Therefore, the ability to manage time available is essential.

Astronauts/cosmonauts are not the only people who need special skills. A CAPCOM, and to a lesser extent a *Glavnij*, needs to have strong interpersonal skills. Since, culturally speaking, Americans don't place a high emphasis on personal relationships in the work environment; this would be a skill that would have to be actively sought out. As the interface between the crew in space and the controllers on the ground, they have to not only be technically proficient, but also be able to know the crew well enough to sense when there might be a personal issue. However, the downside with the CAPCOM/*Glavnij* to astronaut/cosmonaut link is the CAPCOM doesn't generally feel comfortable talking with the cosmonaut and the *Glavnij* is not comfortable talking with the astronaut.[49]

The *Glavnij*'s lesser demand for interpersonal skills is more a factor of culture and individual history than anything else. A *Glavnij* is going to be hired from within their system. This means he has been involved in the manned space program for years, knows how the system works and personally knows all the cosmonauts. In one instance, for example, a particular *Glavnij* worked for 15 years training crews at the *Gagarin* Cosmonaut Training Center (GCTC) in communicating and then was selected to be a

46 Dimitri Churkin, interview by author, Korolev, Russia, 29 June 2004.

47 Konstantin Gregoriev, interview by author, Korolev, Russia, 26 June 2004.

48 Daniel Bursch, interview by author, Monterey, CA, 23 March, 2005.

49 Molly Meyer, interview by author, Houston, TX, 12 February 2004.

*Glavnij*.[50] A Russian, as in this case, would have had the opportunity to develop personal relationships with cosmonauts and ground controllers, but would also have the cultural background of placing a high importance on personal relationships.

**G. SHORTFALLS AND FIXES IN THE PROGRAM**

There have been several items that have been identified as either a requirement not yet filled or "nice to have" items that would make working the ISS Program easier:

- Better management tool for propellant use on ISS.[51]
- Funding commensurate with the level of importance each country places on it.
- Improved technology interfaces in Russia.
- Improved visa policies.[52]

There currently is not a tool for managing propellant use onboard the Space Station. The Russians are responsible for fuel resupply. Without knowing precisely how much fuel is left, engineers may be in a situation where they will need to do a burn, believing there is sufficient fuel available, only to find out there isn't. This will indirectly affect safety.

Financing large projects will always be an issue. The ISS Program is no exception. The scope of the U.S. Space Station itself was changed due to funding requirements. NASA is continuously trying to do more with less. Russia is in a similar situation. They are constantly struggling with an economy that is hard pressed to support a space program.

Russia needs to improve its computerized networks and databases. MCC-M still relies on printed worksheets to manage daily activity. This is in part due to finances, but it is as much an issue of culture. The Russian society was a closed society for 70 years. Knowledge was power. That is a difficult barrier to breakdown, but it is happening slowly.

The issuance of visas, both American and Russian, has an impact on the operation of the ISS. In establishing the ISS Program, both countries agrees to "use its best efforts

[50] Konstantine Glukhov, interview by author, Korolev, Russia, 28 June 2004.

[51] Molly Meyer, interview by author, Houston, TX, 12 February 2004.

[52] Dimitri Churkin, interview by author, Korolev, Russia, 29 June 2004.

to facilitate the movement of personnel and goods necessary to implement”[53]the program.  Visas are processed, but sometimes due to the fluid nature of the space program, travel is required on short notice.  There are no procedures in place for processing short-notice visa applications, particularly for personnel who have previously traveled for the ISS Program.  One potential method of handling this issue would be to create/maintain a fast track list of NASA/Russian personnel who would require minimal lead time for a visa.

53 U.S. Congress, 101.

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# III. CONCLUSION

## A. JOINT INTEROPERABILITY IN SPACE

### 1. Introduction

Mankind is getting more and more dependent on each other in its efforts to go beyond the bounds of near Earth space. The Space Race began as two countries competed against each other to gain the ultimate means of looking into the other's territory. From satellites to manned programs, technology and the desire to do just a little more pushed these competing programs closer together. These programs never merged, merely intersected at a common point of interest.

The partnership that was formed 13 years ago has survived the tragedy of *Columbia* and economic turmoil of a developing democracy. It has done what few people thought possible. It created a joint scientific research environment from components built in different parts of the world and assembled for the first time in the harshest and most remote place possible.

The International Space Station is successful not only because of the will of the International Partners to succeed, but also because of the individuals working with each other to achieve a common goal. A key feature to this program and other successful programs in the past has been the inclusion of liaisons and the understanding that comes with it.

The International Space Station has become the best example of how different countries can work together in a joint environment. There are still problems that the ISS will have to work out in the future, but this program has made tremendous strides forward since the days of *Apollo-Soyuz*. Despite these problems, the lessons learned from the ISS Program will be used as a basis to grow from, when man once again leaves near-Earth orbit.

### 2. Technology

With mankind's goal of going deeper into space, the requirement for countries to work together continuously increases. Countries have fewer and fewer resources to devote to exploring space. It is not yet cost effective for industry to do it without governments. This need for cooperation at a national level brings up the specter of politics and technology.

As was mentioned, politics has a tremendous effect on multi-national endeavors. Politics changed the American Space Station Freedom several times until it ended up as the multi-national International Space Station. Politics still haunt the ISS Program. The U.S, for example, is using the ISS as a lever to coerce Russia to modify to whom it sells missile technology, specifically through the use of the INA. This political decision ultimately affects the technology, and finance, that is available to the ISS Program. On one hand the U.S. has a stated goal of international cooperation with regard to the space station, but at the same time hampers the effectiveness of the project by restricting how the ISS Program spends its funding because of something unrelated to the ISS.

### 3. Human Interaction

Technology can only assist mankind in fulfilling its desire for knowledge, but it cannot discover the unknown alone. Manned space flight will continue. Even though some technological challenges remain for long duration space flight, other challenges including how people from different countries and cultures can thrive in the harsh environment of space also must be over come. Simply surviving to make the journey is insufficient.

Countries may set goals, but it is the interactions at a personal level that actually accomplish those goals. The U.S. will eventually a need shift from its more clinical view of “mission first” to one that encompasses more personal relationships. NASA does an excellent job technically getting a mission done. However, they are battling against the American culture of mobility. In general, Americans are less of a social animal than Russians. An American will strike up a temporary relationship at the drop of a hat and then move on to another when the job is done, while the Russian will maintain that relationship.

Russia has a long rich history in space. They have managed a program using, in some cases, very unsophisticated equipment. To their credit, they take advantage of their cultural predisposition to develop personal relationships with the people they work with by learning on a personal level about their coworkers. This allows the PRP, for example, to better understand the strengths and weaknesses of the *Glavnij* or the cosmonaut and therefore anticipate and counter potential conflicts before they become serious.

## B. EFFECTS IN OTHER AREAS

### 1. Multi-National Cooperation on Earth

The lessons that are being learned by the ISS Program can be applied to any multi-national effort on Earth. Whether it is a military operation or a commercial business venture there are similar requirements and issues. The partners need to understand how each other works and how their own actions will be interpreted. They need to use liaisons at all levels to facilitate that understanding. Personal relationships need to be encouraged, but with a clear understanding of potential national security issues.

The lessons learned from the ISS Program can be applied to current and future military operations. The U.S. military will continue to conduct more joint multi-national operations. The Global War on Terrorism is only the latest example of the modern era of cooperation. NASA, for example, is mindful of its role and responsibility within the world space community. It has taken upon itself the responsibility for all translation into Russian or English and for the extensive use of liaisons to promote understanding and facilitate communication.

The U.S. military already uses liaisons at higher echelons to better integrate foreign equipment and methods. Perhaps, though, the lesson they can take away from the ISS is the integration at lower levels. Junior officers and to some degree junior NCOs of today will be the senior leadership of tomorrow. By incorporating junior leaders early into multi-national operations and encouraging a certain degree of personal relationship development, the military will benefit through increased awareness and understanding of not only other nations' military, but also their thought process. When these junior leaders advance through the ranks they will bring with them that knowledge and will help improve future multi-national operations.

### 2. Future Manned Space Missions

Man will not stop searching among the stars. The Americans have a vision to return to the moon and eventually go to Mars in the relative near future. It is highly unlikely they will go alone. The make up of how other countries will participate will probably be different from what they are currently using with the ISS. NASA has realized the wisdom of working with experts other than their own, but they also recognize the difficulties of not having a clear chain of command.

The Russians have the greatest source of experience in long duration space flight. Through the ISS Program Russia has become both a teacher and student. Russia is sharing with the U.S. its experience, while at the same time it is learning procedures and techniques to improve its ground control operations.

Although the integration of different space programs into one has created a working space station, the model may be difficult to copy exactly for future manned missions, for instance exploration of the Moon or Mars. Neither America nor Russia can afford to go alone and neither wants to be in a subservient role, but there clearly needs to be one entity in charge to make the final decision. However, there may be a means to give various partners a sense of importance without giving command authority. Perhaps one alternative may be subdividing a Lunar Base mission into transportation and base operations. One country would have the responsibility for all aspects of their particular subdivision. For example, Russia would have the responsibility of developing and managing the base itself due to their expertise in long term space operations, while the U.S. would take advantage of its strengths of technology and command and control by managing the transportation aspect. While the U.S. would have overall authority of the program, Russia, for example, would have sole responsibility for the base. Unlike the ISS, the Lunar Base would not be an amalgamation of different procedures and ambiguous chain of command. Although, even this method has issues that would have to be overcome; one might ask, for example, would any country allow another country to be exclusively responsible for their own citizen's security?

The ISS Program uses a backup for everything from launch systems to command centers. Lunar or Martian missions would make duplicate launch systems at a minimum impractical, but more than likely impossible. Clearly, there are reasons for some duplication of effort in various areas, but launch systems should not be one of those efforts. Just from a cost perspective, a manned Martian mission would probably not launch more than once a year. Two distinct production lines for one launch a year seems excessive. A single line with an extra launch vehicle could alleviate any concern about a need for a quick launch.

## C. FUTURE RESEARCH

### 1. Future MCC Structure

Currently, every International Partner has its own Control Center. This system requires liaisons for each control center. It also provides a focal point of national pride for each nation's space program as well as a source for jobs and economic development. This system works well enough for countries going into space alone, but is it efficient enough for missions involving three, four, or more countries for long duration missions or even permanent occupation of space? For example, will national control centers have any effect on the perception of ownership when dealing with a lunar base? Research needs to be conducted to determine the most effective method of controlling multi-national long duration missions. Issues that would need to be addressed include: cost, economic implications to national economies, technological feasibility to implement, effect on existing or future operations, political/legal ramifications in a changing global environment, and the will to change to a new system by each of the partners.

### 2. Conduct Trend Analysis of Station Anomaly Tool

NASA has a front end interface tool listing anomalies in a Microsoft Excel/Access type format known as the Station Anomaly Tool (SAT). The SAT is available to anyone in the NASA internal network. The SAT has the capability of sorting anomalies by any criteria the user wants. However, the tool doesn't appear to have the ability to do any kind of trend analysis. Only institutional knowledge allows the organization to know what anomalies have occurred with respect to some other anomaly. Future development of this tool might provide a more efficient use of the data NASA collects to predict, prevent, or minimize the effects of future anomalies.

The SAT does not include historical data from the Russians. They would benefit from being included in this database because the analysis would have a greater pool of information to draw upon. The difficulties, however, would be the Russians may not have an accurate historical record of their own anomalies and they may not be willing to share the information even if they did. The Russians are generally receptive to new tools that are provided by the Americans, but for financial reasons don't want to pay for those tools themselves. If NASA provided the improved SAT to MCC-M and paid for the data to be collected and entered into the database, they might do it. Unfortunately, the Russians may be hesitant to use the SAT even if a trend analysis was available to them. NASA would use the data, because it is used to gathering enormous amounts of data. The Russians, on the other hand, feel they are being inundated with so much information they can not process it all properly.

With an analysis that includes Russian anomaly data, a more precise trend could be determined for all equipment on the ISS. Since similar equipment onboard the ISS will probably be used on Lunar/Martian missions, the results will have a lasting impact.

**D. SUMMARY**

The International Space Station has been a source of pride and accomplishment for many nations. From President Reagan's call for its development to President Bush's vision to go beyond the bound of Earth, the International Space Station Program has undergone several evolutions. Space Station Freedom was an American project with a few other countries contributing to it. Space Station Alpha was a multi-national program that had to overcome the merging of two space station programs. The ISS is truly a multi-national program at all levels.

A station, which was designed and built around the world, has been assembled in orbit. The majority of the credit doesn't belong to the politicians who had the foresight to undertake this program, but to the individuals who make it work. People from 16 different cultures have been able to find common ground to achieve this technological marvel. Even with minor problems, these partners in space were able to overcome them through cooperation and understanding. The astronauts and cosmonauts have the awesome responsibility of putting a face to the ISS for the world to see. But unseen are the hundreds of engineers, technicians, administrators and console operators whose daily interactions make the program a success.

The personal relationships that are crucial for the Russian culture have turned out to be vital for the ISS Program. These relationships have facilitated conflict resolution among the International Partners. They have fostered a mutual learning environment instead of a superior-subordinate relationship. Personal relationships will not resolve every issue that arises.  They are merely one more tool that improves the overall success of the program.

Perhaps, a new culture will develop as mankind's reach extends beyond its home world, a culture not based on any of the Earth-focused issues of nationality or even language, but something completely different.  Only time will tell what effect the International Space Station Program will have on future manned missions to the Moon or beyond.  The issues of command and control, cost and authority are of significant concern today and will continue to be in the future.

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# BIBLIOGRAPHY


Baum, Timothy E. interview by author. Houston, TX, 11 February 2004.

Baum, Timothy E. interview by author, tape recording. Houston, TX, 25 February 2005.

Buchilin, Alexei. interview by author, tape recording. Korolev, Russia, 28 June 2004.

Bursch, Daniel. Interview by author, tape recording. Monterey, CA, 23 March 2005.

Churkin, Dmitri. interview by author, tape recording. Korolev, Russia, 29 June 2004.

Energia Homepage. Available from http://www.energia.ru/english/index.html; internet; accessed 11 April 2005.

Epp, Chirold. interview by author. Monterey, CA, 18 May 2004.

ESA – Human Spaceflight – International Space Station Homepage. Available from http://www.esa.int/export/esaHS/ESAOYJ0VMOC_iss_0.html : internet, accessed 15 March 2005.

Glukhov, Konstantine. interview by author, tape recording. Korolev, Russia, 28 June 2004.

Gregoriev, Konstantine. interview by author, tape recording. Korolev, Russia, 26 June 2004.

Harland, David M. *The Mir Space Station: A Precursor to Space Colonization*. New York, NY: John Wiley & Sons, 1997.

Harvey, Brian. *Russia in Space: The Failed Frontier?*. Chichester, UK: Praxis, 2001.

Kerrick, Ginger. interview by author. Houston, TX, 13 February 2004.

Landis, Rob. interview by author. Moscow, Russia, 22 June 2004.

Logsdon, John M. *Together in Orbit: The Origins of International Participation in the Space Station*. Washington DC: NASA Headquarters, November 1998.

Matushin, Maxim. interview by author. Korolev, Russia, 21 June 2004.

Meyer, Molly. interview by author. Houston, TX, 12 February 2004.

Montalbano, Joel. interview by author. Houston, TX, 12 February 2004.

NASA, *Fiscal Year 1996 Estimates, Analysis of NASA/Russian Cooperative Mir Program*. Available from http://www.hq.nasa.gov/office/budget/fy96/si-1.html: internet, accessed 5 April 2005.

NASA. *Operations Interface Procedures, Generic, International Space Station*, Houston, TX: Lyndon B. Johnson Space Center, June 2003.

NASA. *Operations Interface Procedures, Volume A: NASA/Rosaviakosmos, International Space Station, Mission Operations Directorate Basic*, Houston, TX: Lyndon B. Johnson Space Center, June 2003.

NASA. *Station Program Implementation Plan, Volume 1: Station Program Management Plan, International Space Station Program, Baseline*, Houston, TX: Lyndon B. Johnson Space Center, January 1998.

NASA. *The Vision for Space Exploration*, Washington DC: NASA Headquarters, February 2004.

NASA/JSC, *RGS_Capabilities_05_2003*, Houston, TX, 11 April 2003

Newman, James. interview by author, tape recording. Moscow, Russia, 1 July 2004.

Sea Launch Homepage. Available from http://www.sea-launch.com/information.htm.; internet; accessed 7 March 2005.

Smith, Greg. interview by author. Houston, TX, 11 February 2004.

Squassoni, Sharon and Marcia S. Smith, *The Iran Nonproliferation Act and the International Space Station: Issues and Options.* Congressional Research Service, 2 March 2005. Available from http://www.spaceref.com/news/viewsr.html?pid=15775, internet. Accessed 21 March 2005.

Suffredini, Michael. interview by author. Houston, TX, 13 February 2004.

TsUP Homepage. Available from http://www.mcc.rsa.ru; internet; accessed 11 April 2005.

U.S. Congress, Office of Technology Assessment. *U.S.-Russian Cooperation in Space*. Washington, D.C.: U.S. Government Printing Office, April 1995.

Zoloth, Laurie. Meeting minutes for NASA Advisory Council. Washington DC: NASA Headquarters, 6 December 2001.

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