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Acta Astronautica 65 (2009) 603–612

ACTA
ASTRONAUTICA

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REVIEW

Space medicine policy development for the International Space Station

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Received 23 December 2008; received in revised form 23 February 2009; accepted 3 March 2009

Available online 8 April 2009

Abstract

Providing medical care capability in a multinational setting in space is a daunting challenge. As the International Space Station (ISS) has taken shape over the last decade the space medicine community of the ISS partners has established a foundation with which to govern medical policy, medical processes, and medical care during the ISS Program. This foundation was predicated on a rich history of bilateral and multilateral cooperation among space faring nations. Three key organizations were established, they include the agency or senior level Multilateral Medical Policy Board (MMPB), the Multilateral Space Medicine Board (MSMB), and the Multilateral Medical Operations Panel (MMOP). All three are staffed by senior medical personnel within each of the partner organizations of the ISS and each has specific roles and responsibilities. These three entities strive to protect the human element of spaceflight through highly effective interaction in a multilingual, multicultural program. This paper reviews the creation of this tripartite approach to the development of medical policy for ISS.

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Keywords: Medical care; Medicine; Multilateral; Multinational; International medical policy; ISS

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1. Introduction

The early 1990s saw an openness in human exploration of space on a grand scale. Former adversaries became staunch partners in developing a permanent outpost in space. The Union of Soviet Socialist Republics (USSR) had garnered significant experience in building and maintaining space stations in low earth orbit and the United States of America (US) had established preeminence in building and maintaining a reusable spacecraft, the US Space Shuttle. The US program, under the National Aeronautics and Space Administration (NASA), had embarked on the building of the Space Station Freedom program in the 1980s. This program was international in nature and included a wide variety of nations, each providing elements for the construction of a permanent International Space Station (ISS). Freedom was in the initial stages of a major redesign in the early 1990s as geopolitical changes were occurring in the Soviet Union.

As the USSR dissolved into the Commonwealth of Independent States in 1991, Russia maintained its leadership role in space exploration among the former Soviet states. There was interest by both the government of Russia and the US to further develop mutual collaboration in human spaceflight. This included bringing Russia into the Space Station Freedom program. On June 17, 1992, US President George H.W. Bush and Russian Federation (RF) President Boris Yeltsin signed the “Agreement between the United States of America and the Russian Federation Concerning Cooperation in the Exploration and Use of Outer Space for Peaceful

Purposes.” This bilateral agreement set the stage for mutually beneficial cooperation in space, including full partnership in an International Space Station, exchange of crews on the Space Shuttle and the Mir Space Station, and further collaboration in space exploration. The agreement specifically mentioned cooperation in the areas of microgravity sciences, engineering, biotechnology, space physics, space medicine, biology, and Earth observation. It also addressed overall space flight safety issues and potential future cooperation in planning for exploration missions of Mars.

This agreement defined three distinct phases. Phase 1—cooperative flights and exchange of US astronauts and Russian cosmonauts on the Space Shuttle and Mir Space Station. The second phase (Phase 2)—early construction of the redesigned International Space Station (ISS)—required NASA to launch and mate in orbit the Zarya (Sunrise) Functional Cargo Block (FGB) built by Khrunichev State Research and Production Center (KhSC) for Rosaviakosmos also known as the Russian Space Agency (RSA) and the main docking node, Unity, which was built by Boeing Aerospace for NASA. The current program, known as Phase 3, includes full deployment and operations of the research laboratories from all the international partners (IP) on the ISS.

2. Authority

Cooperation for the construction and operation of the ISS is defined by the agreement among the Governments of Canada; Member States of the European Space Agency (ESA) (Belgium, Denmark, Norway, The

Netherlands, Spain, Sweden, Great Britain and Northern Ireland, France, Germany, Italy, and Switzerland), Japan, the RF, and the US [1]. This agreement stipulates that the US has the lead role for overall ISS management and coordination, and that detailed provisions for implementation of the agreement are contained in the four Memoranda of Understanding (MOU), which were signed in 1998, as bilateral agreements between NASA and each individual ISS partner [2].

These agreements serve as the foundation for establishing the ISS and building the necessary processes for operating every aspect of this multinational program.

2.1. Historical context

Although space exploration was highly competitive and a matter of national prestige to the US and USSR from the late 1950s, there was a significant amount of interaction between these two countries as well as significant interaction with other nations involved in space exploration. These collaborations covered many disciplines but they set the stage for the issue of medical care.

In 1971, the Joint US/USSR Working Group (JWG) on Space Biology and Medicine was established by Dr. Oleg G. Gazenko (USSR) and Dr. Charles A. Berry (US). The JWG performed a number of important activities, including a review of reports on space biology and medicine from both countries, discussion on the biomedical research and operational methodologies; and the conduct of research projects such as the bed rest study in 1977 and the highly successful international biomedical project on the Russian BION satellites [3].

From 1972 through 1975, the first international joint flight, the Apollo-Soyuz Test Project (ASTP), was developed and implemented under an intergovernmental agreement between the US and the USSR. The ASTP was the first activity to integrate the technologies and designs of space systems from two different nations and the first significant international cooperative effort in space medicine. A joint document, describing the medical support requirements for the ASTP, was developed and has served as a prototype for subsequent agreements on the standardization of medical support of joint missions [4–6].

Since that time, NASA has worked extensively with ESA, the Japanese Aerospace Exploration Agency (JAXA) (formerly National Aeronautics and Space Development Agency (NASDA) of Japan), and the Canadian Space Agency (CSA) on numerous Space Shuttle flights. Similarly, the USSR and subsequently the RF

have conducted cooperative programs with European countries and China.

During each of these collaborations, medical care was provided by the host country (either US or USSR/RF). To this point, there had been limited or no cooperation on medical support for long duration missions. However, this historical work laid a strong foundation with which to build upon.

The evolution and implementation of space medicine policies that currently govern the medical support of ISS represents a valuable archetype for future international cooperation in the area of space medicine or operational medical systems of other specializations.

2.2. Creating a platform for interaction

Planning for medical care for the ISS involved complex policy development by medical representatives of the five original IP's—NASA, RSA, CSA, ESA, and NASDA. This initial process was bilateral (NASA/RSA) but has evolved into a multilateral activity as the program has matured.

In the summer of 1992, Russian and American officials met in Washington, DC, to participate in the Space Station Freedom redesign review. The Russian delegation, led by general designer Yuri P. Semyonov, included experts in space medicine (Dr. Valery V. Bogomolov from the Institute for Biomedical Problems (IBMP)) and life support systems (Eduard Grigorov from Energia). Dr. Arnauld Nicogossian represented space research, life support, and space medicine for NASA. During bilateral meetings between the Russian and US delegations, the US side, supported by the other IPs, indicated a willingness to consider joint endeavors in human spaceflight. The Russian side offered the US an opportunity to participate in long duration space missions on the Mir Space Station to conduct joint research, fly international crews of astronauts and cosmonauts on Mir and Shuttle, and to begin familiarization with the engineering infrastructure of the human space flight programs of both countries. The Russian proposal was incorporated into the overall strategy, accelerating the space infrastructure capability development. The orbiting Mir station was recognized as the first phase (Phase 1) and the precursor to the ISS.

On October 5, 1992, RSA Administrator Yuri Koptev and NASA Administrator Daniel Goldin signed a bilateral agreement committing the two agencies to exchange crew-astronauts on Mir and cosmonauts on the Shuttle. Russia would redesign the existing docking adapter for the Shuttle to dock to Mir.

In 1993, the US–Russian Joint Commission on Economic and Technical Cooperation negotiated by US Vice President Albert Gore and Russian Prime Minister Viktor Chernomyrdin (Gore–Chernomyrdin Commission) was chartered. In October 1993, organizational procedures and principles of medical support were defined for the Shuttle/Mir and NASA/Mir Joint Space Flight Programs. Dr. Nicogossian was responsible for the oversight of a multifaceted research, development, and operational program, including the funding of the Russian research and engineering community led by the Academician Vladimir Utkin. Dr. Carolyn Leach Huntoon and Dr. Anatoly Grigoriev were responsible for the development and implementation of the research and space medicine programs in support of the NASA/Mir project. Dr. Bogomolov and NASA's Dr. Sam Pool were responsible for the development of the space medicine programs for all phases of ISS. This created the Medical Operations Working Group (MOWG), which reported to the technical program managers, Mr. Valery V. Ryumin of RSA and Tommy W. Holloway of NASA.

In early 1994, at a joint meeting, MOWG #8, led by Drs. Bogomolov and Valeri Morgun (Russia) and Drs. Pool and Roger Billica (US), was chartered. This group provided the foundation for working on medical care issue for the Phase 1 program [7,8].

On March 29, 1995, a Space Medicine Cooperation Agreement was signed as part of the Shuttle/Mir Bilateral Cooperation Agreement. This document concluded lengthy negotiations undertaken over the previous year that defined preflight, inflight, and postflight medical care and established roles and responsibilities for crew surgeons. The Shuttle/Mir program became the NASA/Mir program, with seven US crewmembers to fly on Mir and 11 Shuttle flights to Mir.

In 1995, the first NASA/Mir crewmember exchange occurred under an MOU defining NASA and RSA's interim approach to medical policy supporting human spaceflight, signed on November 20, 1996. Under the interim agreement, both sides agreed that the US medical requirements, defined in the ISS Medical Operations Requirements Document (MORD) would serve as a basis for the development of detailed medical requirements, which were subsequently formulated. This flight experience provided valuable lessons on bilateral collaboration—addressing the challenges of providing medical care in a bilateral and bilingual environment [7,8].

While the Phase 1 program was operational, negotiations were underway with all the IPs to finalize the MOU. This resulted in detailed discussions with leaders

in space medicine from each partner. They developed and proposed the governing principles for the medical support of the ISS, which were defined in Article 11.4 of each ISS MOU [2,9,10]. This Article authorized three multilateral forums of ISS medical authority: (a) the Multilateral Medical Policy Board (MMPB), (b) the Multilateral Space Medicine Board (MSMB), and (c) the Multilateral Medical Operations Panel (MMOP). The consensus on the establishment of these medical forums and on their responsibilities provided a framework for further consensus building.

3. Establishment of current structure

In 1996, the IPs agreed that the MMPB would be the highest level ISS medical forum for medical policy. The other two forums, staffed by senior level physicians, include the MSMB for clinical medicine and the MMOP for medical operations. The sides agreed to develop requirements for training and eligibility for flight surgeons on console at each of the mission control centers, including an exchange of flight surgeons for training and operations support.

The MMPB was formally chartered on April 16, 1998. RSA's Dr. Grigoriev (IBMP) and NASA's Lt. Col. James Collier, MC, USAF served as the first co-chairs; Dr. Gary Gray (CSA), Dr. Heinz Oser (ESA) and Dr. Chiharu Sekiguchi (NASDA) were the other MMPB members.

Since those early days of multilateral cooperation and experience from the NASA/Mir program, a robust ISS medical operations and clinical decision making infrastructure evolved that is supported by medical policy and influenced by events and lessons learned. Table 1 lists those individuals who have participated in each of these groups. These three groups of experts and their major responsibilities are highlighted in Table 2. The MMPB served an important function during this formative period by providing a forum for all the IPs to present and discuss medical issues.

3.1. MMPB roles and responsibilities

The MMPB is responsible for overarching policy formulation and promulgation and oversight of all crew health matters, and exercises its medical decision making responsibility independent of the ISS Multilateral Coordination Board (MCB) and other ISS management forums. It is comprised of a single representative from each IP and is co-chaired by NASA and the RSA members during the ISS assembly phase. Once ISS

assembly is complete, the chair rotates among the partners annually. The MMPB considers issues that need coordination with similar-level organizations, or agency-level decision making, and ensures that medical input is fully recognized in the general decision-making system in the ISS Program. The MMPB provides policy direction to the working-level medical organizations in maintaining adequate medical management structure, prioritizing their responsibilities and areas of activity. The MMPB provides guidance in further international efforts in development and refinement of the clinical practices of space medicine.

Table 1
Individuals involved as co-chairs of the tripartite boards.

MMPB		
Lt Col James Collier, MC, USAF	Co-chair (orig)	NASA
Anatoly I. Grigoriev, MD	Co-chair (orig)	RSA
Richard S. Williams, MD, MPH	Co-chair	NASA
Charles R. Doarn, MBA	Executive secretary (orig)	NASA
Ashot E. Sargsyan, MD	Executive secretary	NASA
MSMB		
Jeffrey R. Davis, MD	Co-chair	NASA
Valeri Morgun, MD	Co-chair (orig)	RSA
Sam L Pool, MD	Co-chair (orig)	NASA
Vladimir Pochuev, MD	Co-chair	RSA
MMOP		
Roger D. Billica, MD	Co-chair (orig)	NASA
Valery V. Bogomolov, MD	Co-chair (orig)	RSA
Terrance A. Taddeo, MD	Co-chair	NASA

3.2. MSMB roles and responsibilities

The MSMB is primarily clinical in nature and is responsible for medical certification for training and flight in the ISS Program, reviews and approves space medicine standards and certifies physicians for practice of space medicine in support of the ISS. The MSMB is co-chaired by NASA and the RSA during ISS assembly, with the chair rotating annually among the IPs once assembly is complete.

The MSMB forwards recommendations and decisions concerning crew medical certification to the MMPB and ISS Multilateral Crew Operations Panel (MCOP). The MSMB operates on the principle of consensus. Should the MSMB fail to reach consensus on a matter of medical eligibility of a crewmember, or on other issues involving oversight of medical operations, those issues are referred to the MMPB for resolution and policy definition.

3.3. MMOP roles and responsibilities

The MMOP is comprised of representatives from each IP and is responsible for developing and executing ISS medical operations requirements, standards, guidelines, and implementation plans. The MMOP is the workhorse of the three forums, interacting on a regular basis. It is co-chaired during ISS assembly by NASA and the RSA. The primary tasks of the MMOP and its subgroups are to develop and implement requirements for medical support of the international ISS crews preflight, inflight, and postflight. The MMOP develops health standards, real-time flight and ground

Table 2
Tripartite medical support forums for the ISS.

Board	Responsibilities	Membership
MMPB	Top-level medical policy and oversight	One representative from each IP
MSMB	Crew medical certification for ISS mission increment training and flight Approve mission-assigned flight surgeons endorsed by the MMOP Certifies physicians for practice of space medicine in support of the ISS.	A designated physician from each IP with ad hoc, non-voting consultative members as required
MMOP	Establishes processes for medical training and certification of ISS crewmembers, medical selection and certification standards, requirements for hardware and ground support, requirements for human behavior and performance support, requirements for the monitoring of the environment, requirements for the EMS, and certification guidelines for ISS IP flight surgeons Defines and implements medical monitoring and countermeasures and response capability for in-flight medical events	Medical representatives from all IPs

Table 3
Select MMOP tasks.

MMOP tasks
Development and implementation of the ISS medical operations requirement document (MORD)
Development of ISS crewmember medical selection standards
Development of medical evaluation and care standards
Development of training requirements and guidelines for ISS crewmembers and flight surgeons, and endorsement of these physicians to the MSMB for approval
Assignment of expedition crew surgeon
Evaluation of medical hardware and medical and environmental monitoring capability

medical documentation, and supports the work of integrated medical organizations for controlling flight operations on board the ISS. Table 3 outlines a number of important MMOP tasks.

The MMOP established and is supported by specialized working groups in each area related to crew health, which are highlighted in Table 4.

The MMOP reports to the ISS Program Office through the ISS Multilateral Mission Integration and Operations Control Board (MMIOCB). It also provides periodic reports and responds to tasks assigned by the MMPB.

3.4. Summary of MMPB activities

The first formal meeting of the MMPB took place in April 1998. Following this meeting, the MMPB has interacted through meetings and correspondence. It has established and managed ISS medical policy through consultations with experts and by reviewing activities performed by MMOP and MSMB. As the ISS Program matured, the importance and frequency of the MMPB meetings increased to address policy-level issues brought to Board's attention by the ISS Program, the MSMB, the MMOP, or partner agencies through their representatives. Table 5 summarizes the MMPB meetings and key policy discussions in support of the ISS.

The MMPB provides the leadership necessary to generate a viable medical policy framework for the complex and sophisticated medical infrastructure of the ISS. MMPB decisions have enabled the practice of space medicine in the ISS environment while adhering to and integrating overarching principles of medical care in order to successfully direct the MSMB and MMOP through the complicated challenges of joint medical operations.

Table 4
Select MMOP specialized subgroups.

MMOP specialized subgroups
Biomedical training
Medical informatics and technology
In-flight clinical medicine
Postflight activities and rehabilitation
Environmental health
Nutrition
Medical standards and health evaluation
Radiation health
Spaceflight human behavior and performance
Extravehicular activity
Countermeasures

Medical policy decisions of MMPB have been issued in a number of ways, including standalone MMPB policy directives, statements in MMPB meeting minutes, MMPB letters, and review and eventual approval of high-level ISS documents, such as charters, standards, and requirements. ISS medical policies are shaped by the MMPB with changes that result from recommendations of the MSMB and MMOP.

4. Integrated approach to medical policy

Since the Shuttle/Mir program, an integrated approach to ISS medical policy has been adopted and followed by all ISS partners. The expedition crew surgeon leads the Integrated Medical Group (IMG), composed of international flight surgeons and medical support specialists who are located at the mission control centers in Houston (MCC-H) and Moscow (MCC-M) or MCC-IP. Consultants and specialists in medicine and psychology are members of the IMG and are available to participate as required. Decisions are coordinated among all ISS medical counterparts and joint procedures are integrated into the common Station Operations Data file books and ground documentation, such as the ISS Medical Hardware Catalog.

4.1. Evidence-based scientific approach to the development and operation of the ISS medical support system

As previously described, the MMPB establishes health and medical policy and standards for medical care and training. Policy and standards are derived from and incorporate experience gained from previous missions. Operational experience and the results of research and technology advances drive policy and standards as they evolve. The medical support system

Table 5
Summary of MMPB policy meetings.

MMPB meeting #	Meeting date and location	Main agenda items	Main products of the meeting
Founding meeting	April 16, 1998, Washington, DC	Formal establishment of the MMPB and acceptance of the initial version of its charter	Initial version of the MMPB charter
1	March 15–16, 2001, Houston, TX	ISS MMOP and MSMB reports. Review of ISS-1 and ISS-2 medical support. Review of ISS medical standards and concepts of nominal and contingency medical response. Policies for transition from bilateral to multilateral operations	Meeting summary with actions and conclusions
2	May 10, 2002, Videoconference	MMOP and MSMB reports, MMPB charter update	Meeting summary, draft charter
3	December 04, 2003, Moscow, Russia	Periodic reports and updates. Review of progress made towards full integration of crew medical support. Review of the ISS medical support in the current medical policy framework	Meeting summary; MMPB policy directive #1 (PD#1)
4	April 5–7, 2004, Washington, DC	Periodic reports and updates. Update to PD#1. Review and approval of the MSMB charter	Meeting summary; PD#1
5	July 15, 2004, Videoconference	Periodic reports and updates. Increment duration limits and medical/health risks of duration extensions	Meeting summary
6	October 28, 2004, Videoconference	Periodic reports and updates. MMPB conflict resolution methodology, NASA return to flight status, ISS mission status review	Meeting summary
7	March 14–15, 2005, Tsukuba, Japan	Periodic reports and updates. Review of ISS medical support with special emphasis on the activities of the JAXA medical organization. MMPB conflict resolution	Meeting summary; MMPB PD#2
8	November 9–11, 2005, Cologne Germany	Periodic reports and updates. Development of medical risk assessment methodology, enhancement of cardiac screening algorithms for ISS crewmembers. Review and approval of ISS medical standards, including those for space flight participants	Meeting summary
9	April 24–25, 2006, Washington DC	Periodic reports and updates. Future developments of national space programs of ISS partners. NASA information briefings, including NASA's occupational health approach to human health protection in space flight.	Meeting summary
10	November 03, 2006, Cologne, Germany	Periodic reports and updates. Biomedical review of ISS Expeditions 1–12. Approval of ISS medical standards updates. Medical data sharing policy discussions	Meeting summary
11	May 11, 2007, Johnson Space Center	Periodic reports and updates. Medical data sharing policy approval (PD#3). Public release of the ISS medical standards for Space Flight Participants	Meeting summary; MMPB PD#3
12	November 12, 2007, Tokyo, Japan Videoconference	Discussions focused on future cooperative space-flight activities using MMPB as a foundation. Strategic directions of the MMPB were discussed. Recommendations for future discussion points at future MMPB meetings	Meeting summary

development is enhanced using the best available scientific and clinical evidence. The evidence-base is derived from research findings from flight and analog environments, lessons learned from operational experience, and recommendations from consultant subject matter experts. This approach assures that medical policies are reviewed and may be updated as new evidence emerges.

4.2. Common space medicine standards

Recognizing the prime responsibility of protecting the health and safety of the ISS crew, the MMPB has directed the MMOP and MSMB to develop common space medicine standards. These standards include not only medical certification standards for space flight

crewmembers, but also requirements for training and certification of flight surgeons and other medical support personnel, diagnostic protocols, countermeasures, treatment protocols, environmental standards, post flight rehabilitation, and radiation standards for the ISS. In those areas not addressed by commonly agreed to standards, the standards of each partner are recognized as valid until common standards are developed. The MMPB has emphasized the need for continuous amendment and improvement of the ISS space medicine standards.

4.3. Principles of ongoing integrated medical support

The MMPB defined integrated medical support and responsibility for ISS crews for nominal ongoing operations, in degraded support capability, and in medical contingency situations. Medical control of the ISS, similar to overall control of the ISS, is implemented from an integrated control center that includes MCC-M and MCC-H. IPs, CSA, ESA and JAXA have their own control centers for their ISS components. Some of the partners have medical control organization and these interact with other IPs. The role of the lead MCC may change, depending on the specific flight operations. Medical support teams are comprised of the crew surgeon, deputy crew surgeon, flight surgeons of the IPs whose crewmembers are working on orbit, and flight bioengineers. When the flight and medical operations are performed on Russian vehicles or per the Russian program, the primary medical responsibility falls on the Russian medical organizations. When flight and medical operations are performed on US vehicles or per the US program, medical responsibility falls on the medical organizations of MCC-H. It is very important that the cooperation between the medical organizations of MCC-H and MCC-M with regard to planning and implementing medical operations takes place within the IMG [11,13]. The lead role can and has changed due to planned activities and emergency procedures such as weather.

In nominal operations, the ISS MCC-H is the controlling center, with the ISS MCC-H crew surgeon responsible for the medical care of all individuals on the ISS in cooperation with the designated crew surgeons assigned to a given ISS Increment. The ISS crew surgeon consults with the crew surgeons of any docked vehicles on any critical matter of crew health prior to taking action, if doing so will not endanger the health of the crew due to time constraints. When ISS control is passed to another MCC, medical responsibility is assumed by that center. For example, when flight operations are performed using Russian vehicles

(Soyuz-TMA or Progress) or an EVA is performed in Russian Orlan spacesuits, MCC-M is the lead control center.

The MCC-M was given control of ISS support during September 2005 evacuation of the MCC-H personnel due to a tropical hurricane and medical control of the mission was transferred to MCC-M.

Non-emergency medical or health contingencies on the ISS, including the care of illness or injury, are addressed by the Space Medicine Operations Team (SMOT). SMOT meets weekly via telecomm with all IP's medical representatives including crew surgeons. Every week, SMOT reviews the planning and implementation of current medical operations on board the ISS and, when necessary, makes corrections to the ISS crew health medical support program, assesses the medical services readiness for performing the missions, and develops recommendations for flight controllers in MCC-H and MCC-M. The SMOT reviews matters relating to the medical status of ISS operations and, if necessary, refers it to the MSMB. If consensus on the response cannot be achieved, the matter will be referred to the MMPB.

In all operational situations where the capability of one or more ISS health support systems is degraded, the combined resources of all partners are considered in determining the ability of the remaining ISS systems to support the health and safety of the ISS crew. To facilitate this process, the MMPB members have made a commitment to share all necessary information in a timely fashion. Furthermore, MMPB members cooperate to make on-orbit ISS crew health support capabilities available to all partners as appropriate, and to cooperate in the analysis of samples and data. Non-emergency medical situations with potential major operational impacts, such as situations requiring return of the crew from ISS for a medical reason, are to be reported to the MMPB for review. In such cases, any resulting decisions and/or recommendations of the MMPB would be transmitted to the ISS Mission Management Team (MMT), which has authority over operational implementation of decisions. In the event of a medical or health emergency on board the ISS in which there is insufficient time to consult with the IMG/SMOT, MMOP, and the MMPB, the crew surgeon at the controlling MCC has the authority to decide the appropriate medical response and communicate it to the ISS Increment Flight Director.

4.4. Consensus and issue resolution

When formulating policy directives, the MMPB makes every effort to achieve consensus in medical and

health decisions to best support the health of the crew. The principle of consensus is used by the ISS MCB, as well as by the MSMB, and MMOP. To achieve consistency across ISS boards, the MMPB uses consensus adopting the following process for dispute resolution:

In the event that consensus cannot be achieved on any specific issue within the available time, the NASA and RSA co-chairs would attempt to reach a joint decision. If a joint decision is not achieved, and only as a last resort, the MMPB would articulate a decision consistent with the majority opinion. The minority opinion would also be fully reflected in the MMPB minutes. However, any partner would retain their full right to use the consultation and settlement of disputes provisions of Article 18 of the ISS MOU's. Pending resolution of any issues through consultations, and in accordance with the mechanism established in that article, a partner may choose not to proceed with implementation of an MMPB decision with respect to its elements, assuming responsibility for the outcome of that choice. The MMPB has also expressed its consensus position that medical and health decisions must always remain the responsibility of physicians, and should always be deliberated upon and finalized by physicians. MMPB is therefore determined to make every effort to achieve final and satisfactory conflict resolution at its level, and to avoid referral of medical decisions to higher management authorities.

5. Conclusion

The first four decades of human space flight were led by two diverse nations, the US and USSR; each doing things differently with regard to operational activities, management and processes related to maintaining human presence in space. The Soviets had a permanent presence and the Americans had a reusable spacecraft. The fundamental operational activities were different, yet when combined they were complementary. The ISS Program has become a platform where nations of different culture, different language, and different styles are working together to build a large integrated complex research facility in space.

This effort could not have been accomplished without the legendary work by each space faring nation [12–15]. Human presence in space is now dependent upon multiple partners. Achieving the goals of today has been accomplished by people of all walks of life. The ability to provide medical care to those living on the ISS has been created out of multinational

collaboration and an understanding of how best to achieve it. The chief medical officials of each of the IPs serve on the MMPB; they have substantially influenced the planning and development of all aspects of ISS crew healthcare. These same individuals, in the multilateral setting of the MMPB, have overcome the often profound differences and conflicting approaches to achieve a multilateral, medical authority structure. The medical policy framework, founded on a number of core principles, has proven its viability. The validity of these policies is evidenced by the consistently high quality of crew medical support, the multilateral decision-making at all levels of ISS medical status and readiness review, the stability and high level of engagement of every IP's medical organization, and the continued compatibility of the medical policies with the overall ISS policies and management principles. Based on these outcomes, the ISS medical policy framework and the resulting medical support system will serve as a successful, validated model of a multinational cooperative structure of long-term nature with a high degree of medical, technical, and organizational integration. The expertise of developing and maintaining such a viable model will be valuable in planning of other international endeavors of comparable proportions and complexity.

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