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The Future of the International Space Station

Introduction

The International Space Station (ISS) has been one of the prime examples of successful international cooperation in outer space. Amongst others, the station has been a major symbol of post-Cold War collaboration between the U.S. and Russia and a platform for exploration and scientific research insulated from tensions and conflicts on the ground. This changed in July 2022 when amid tensions between Moscow and the West over the Russo–Ukrainian war, the head of the Russian space agency Roscosmos declared that Russia would end its part in the programme after 2024.[2] While NASA, ESA, JAXA, and the Canadian Space Agency have all expressed interest in continuing with the programme until 2028 or preferably 2030,[3] the future of the ISS is now threatened by Russia's departure. This paper analyses the effects that Russia's potential departure from the ISS would have and the possible solutions to the challenges this would raise to the functioning of the station. In the first section of this paper, I analyse the inclusion of Russia in the ISS project in the early 1990s and explain what this meant for the future of the ISS project and for international cooperation in space as a whole. I then turn to an analysis of Russia's threats to disassociate from the space station after 2024 and assess whether they should be taken seriously. In the final section of this paper, I outline the possible options available to keep the station operational if Russia were to leave the ISS.

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[2] Sauer 2022.

[3] See for example NASA 2022a.

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Historical context

Beyond the physical and technological obstacles, one of the great challenges that space missions have to overcome is the geopolitical reality of sovereign states meeting in a neutral, unclaimed territory.[4] The principle of international co-operation underlies all space law. Amongst other it appears in the Declaration of Legal Principles[5] and the Outer Space Treaty.[6] The ISS can be considered one of the most significant examples of how this principle has been successfully applied in practice. Involving 15 countries and 5 different space agencies, the ISS was constructed over several years and is by far the largest construction project ever attempted in low Earth orbit (LEO).

The international framework governing the project was first established through the 1988 Intergovernmental Agreement[7] which was ratified by the Government of the United States of America, the Government of Japan, the Government of Canada and the Governments of Members States of the European Space Agency. The agreement set up a framework for a future manned space station called Freedom where each Partner would contribute proportionately to its level of technical expertise and development.[8]

The original proposal in the 1980s spearheaded by NASA to build a permanent international space station did not include Russia. However, following the fall of the Soviet Block in 1991, Russia was also invited to join the programme. The purpose of this was to incorporate Russian expertise and technologies as well as to allow for better international relations. Russia eventually became a full ISS partner in 1993 and has been instrumental in the success of the station ever since. This ushered a new era of international cooperation in outer space,

[4] Sharpe–Tronchetti 2015: 618.

[5] Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space, 1962.

[6] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, 1967.

[7] Agreement Among the Government of the United States of America, Governments of Member States of the European Space Agency, the Government of Japan, and the Government of Canada on Cooperation in the Detailed Design, Development, Operation, and Utilization of the Permanently Manned Civil Space Station, 1988.

[8] Sharpe–Tronchetti 2015: 619.

following the more competitive and militarily dominated era of the Cold War in which space was the ultimate frontier between the U.S. and the Soviet Union.[9]

The ISS was not the first instance of collaboration between Russia and the U.S. As the political landscape of the Cold War began to ease, a milestone was reached as early as 1975 when the U.S. and the Soviets worked together on the Apollo–Soyouz project – a mission which involved both nations docking their capsules together in space.[10] In the 1980, the U.S. Administration supported NASA to build a permanently manned space station.[11] The first partners joined the U.S. in the development of the ISS in 1985.[12] By the 1990s, the development of the ISS was well underway, when the Clinton Administration faced budget constraints, which also affected the amount of funding available to NASA projects. In an attempt to reduce costs and increase international involvement, NASA invited Russia to join the ISS programme.[13] This was a welcome opportunity for Russia as funds significantly decreased for the Russian space programme in the aftermath of the dissolution of the Soviet Union in the early 1990s.[14] The Russian Space Agency (Roscosmos) was formed in 1992 and the following years saw the golden age of Russian–American relations in the space sector.[15] The most notable cooperation between the two states was the Shuttle–Mir programme in which several American astronauts flew to the Mir space station between 1995 and 1998.[16] The programme laid the foundation for future collaboration between the U.S. and Russia. Eventually, Russian officials decided to de-orbit the ageing Mir and focus their resources on the ISS project.[17]

The ISS partners joined with Russia entered into the 1998 Intergovernmental Agreement[18] (the IGA) which superseded the previous agreement signed between the parties over the building and development of the space station. The Russian contribution was critical already in the development phase as the Russians brought the expertise they had gained from operating Mir which was the first

9 Sharpe–Tronchetti 2015: 618.
10 NASA 2020.
11 Sharpe–Tronchetti 2015: 623.
12 Sharpe–Tronchetti 2015: 623.
13 Sharpe–Tronchetti 2015: 623.
14 Howell 2018.
15 U.S. Embassy and Consulates in Russia 2022.
16 Howell 2018.
17 Howell 2018.
18 1998 Intergovernmental Agreement.

modular space station to be assembled in orbit. The actual construction of the ISS began with Russia launching the Zarya control module in 1998 and was gradually completed over the next years with the final module being attached to the station in 2011.[19] At first NASA was concerned that Russia would use the opportunity to transfer advanced technology for their own military use. But after the U.S. decided to suspend the Space Shuttle programme following the Columbia disaster in 2003, NASA had no choice but to rely on Russia to transport to and from the space station.[20] The ISS project not least because of Russia's contributions has been considered a major success in international cooperation and the IGA has been taken as a model for future cooperative endeavours.[21] The operational programme was originally designed to end in 2015 but was gradually extended to 2024.[22]

Russia's potential departure from the ISS

The success story of the ISS took dramatic turns when in July 2022 amid tensions between Moscow and the West over the Russo–Ukrainian war, the head of the Russian space agency Roscosmos, Yuri Borisov declared that Russia would end its part in the programme after 2024 when the IGA is currently set to end.[23] The declaration did not come wholly by surprise as Russia raised concerns over high maintenance costs and ageing infrastructure already in 2021, citing potentially irreparable failures due to outdated equipment and hardware. [24] The recent declaration came as a response to the sanctions imposed by Western countries following Russia's latest invasion of Ukraine on 24 February 2022. On the day of the invasion, the Biden Administration announced the introduction of export sanctions on Russia, cutting more than half of Russia's high-tech imports. In a White House address, Biden said the sanctions would degrade Russia's "aerospace industry, including their space program".[25] Russia quickly retaliated

19 Howell 2018.
20 Sharpe–Tronchetti 2015: 625.
21 Sharpe–Tronchetti 2015: 659.
22 NASA 2014.
23 Sauer 2022.
24 Mishanec 2022.
25 Berger–Foust 2022.

by putting an embargo on the supply of rocket engines used in U.S. spacecraft.[26] Other Western countries responded similarly to the U.S. The European Space Agency also suspended its cooperation with Russia on the ExoMars mission[27] as well as its discontinuing its cooperative activities with Russia on several lunar missions.[28] It was in this context that in March 2022 former head of Roscosmos Dmitry Rogozin threatened that the sanctions could disrupt the operation of Russian spacecraft servicing the ISS, causing the structure to "fall down into the sea or onto land".[29] Rogozin also stated that the restoration of normal relations was only possible if the "illegal sanctions" were to be lifted.[30]

The tension over the sanctions culminated in the July 2022 statement of the newly appointed head of Roscosmos Yuri Borisov who stated that Russia would leave the ISS after 2024 and focus its efforts on building its own space station (the Russian Orbital Service Station set to be launched in 2028).[31] This would end decades of partnership between Russia and the West.[32] And while NASA, ESA, JAXA and the Canadian Space Agency have all expressed interest in continuing with the programme until 2028 or preferably 2030,[33] the future of the ISS is now threatened by Russia's departure. The harshness of Borisov's claims were somewhat softened by his statement that Russia would continue to fulfil its obligations to its partners on the ISS before leaving the project.[34] In the following week after the statement was made, Borisov also clarified that there may have been a mistranslation regarding his claims, as the country's intent to leave the ISS was after 2024, not in 2024, as some translations suggested.[35] The Roscosmos chief also recalled the one-year withdrawal notice period required by Article 28 point 1 of the IGA which was included precisely to prevent sudden withdrawals where partners are left unable to react.[36]

[26] Reuters 2022.
[27] ESA 2022a.
[28] ESA 2022b.
[29] France 24 2022.
[30] France 24 2022.
[31] Howell 2018.
[32] Sauer 2022.
[33] See for example, NASA 2022a.
[34] Sauer 2022.
[35] Dinner 2022.
[36] Dinner 2022; see also 1998 Intergovernmental Agreement, Article 28, point 1.

Consequently, Borisov's claims give reassurance that Russia would honour its legal obligations under the IGA and any previous claims of suddenly dropping the ISS into the ocean or on land were merely empty threats. As per Article 28 point 2 of the IGA, any withdrawal notice would trigger a series of negotiations whereby the parties would try to reach an agreement concerning the terms and conditions of the withdrawal with a view towards ensuring the continuation of the overall programme.[37] Also, under Article 23 on Consultations any partner is required to inform the other partners of any significant flight element changes that would impact on the other partners at the earliest opportunity,[38] and there are built-in provisions regarding dispute resolution mechanisms under the same article if the partners cannot resolve their issues through consultations.[39] To date, NASA has not received a formal withdrawal notice from Russia, so no exit process has been initiated.

Can Russia be replaced?

However, if Russia would indeed leave the Station, the question arises whether it can be replaced. This requires a closer examination of Russia's contribution to the ISS project. The Russian components are essential to the functioning of the space station. They include the Zvezda and the Zarya modules which comprise most of the thermal control systems, the life support systems, the flight control systems and the propulsion systems that provide station-keeping and manoeuvrability in outer space.[40] The Zvezda module also provides communication systems that include remote command capabilities from ground flight controllers, and a docking port for the Soyuz and the Progress spacecraft.[41] The Soyuz provides regular crew transfers, while the Progress spacecraft provides regular cargo flights as well as periodic reboosting for the station.[42] While there are other means of transportation to the ISS, for example, SpaceX's Dragon spacecraft,[43] the station relies entirely on the Zvezda service module thrusters and the Progress

37 1998 Intergovernmental Agreement, Article 28, point 2.
38 1998 Intergovernmental Agreement, Article 23.
39 1998 Intergovernmental Agreement, Article 23.
40 NASA 2018a; NASA 2018b.
41 NASA 2018a.
42 NASA 2018c.
43 NASA 2022b.

spacecraft to keep the ISS in orbit as well as to provide a controlled re-entry at the end of the station's lifetime. Therefore, in the worst possible scenario, if no action is taken and Russia decides to detach their modules and leave the ISS, the station would gradually lose altitude before re-entering the atmosphere where it would break up into pieces and fall into the ocean in an uncontrolled manner.

To avoid the aforementioned scenario and keep the ISS operational, the critical functionalities of the Russian modules would need to be replaced. One option would be to design and launch new modules that would recreate the functions of the Russian segment and attach them before the Russians leave. With the current timelines (2024 being less than two years from now), this option is not practical, because it would take years to build and test new modules, not to mention the amount of resources this would require.

Providing station-keeping via spacecraft propulsion is a more viable option, however, this also faces many challenges. NASA has confirmed that they have been working on contingency plans with multiple space companies to keep the ISS in orbit if Russia were to leave the station.[44] For example, in June 2022 Northrop Grunman successfully boosted the station using an updated version of its Cygnus cargo spacecraft, demonstrating a potential alternative to Russian thrusters.[45] Boeing and SpaceX have also been looking into alternative ways of controlling the station using spacecraft propulsion. In May 2022, Boeing's Starliner spacecraft successfully docked to the ISS for the first time.[46] And while it does have the boost capability required to support the space station, it launches on Atlas V rockets that fly on Russian engines (RD-180 engine) that are currently unavailable due to the embargo introduced by Russia.[47] SpaceX, on the other hand, has been supplying cargo deliveries with its Cargo Dragon capsules since 2012, and the company started providing crew transportation using their Crew Dragon capsules under NASA's Commercial Crew Program in 2020.[48] The problem, however, with Dragon capsules is that their engines do not have the manoeuvrability and the power required to provide station-keeping for the ISS.[49] SpaceX has also been developing Starship which will be the most

[44] Roulette 2022.
[45] Roulette 2022.
[46] Wall 2022.
[47] Reuters 2022.
[48] SpaceX 2023a.
[49] Dragon capsules use Draco thrusters for manoeuevring. These have thrust power of around 90 lbf (400 newtons), which is too little to provide station-keeping for the ISS. The Super Draco Engines

powerful launch vehicle ever developed,[50] designed amongst other for voyages to the surface of the Moon under the Artemis program.[51] Currently the Federal Aviation Administration (FAA) is conducting an environmental review of the launch vehicle as a part of the license application process that will allow SpaceX to carry out test launching.[52] However, even if they obtain the FAA approval, the Starship is years from becoming a dependable launch vehicle capable of launching modules that would fit into the ISS. So the question remains whether NASA and its partners can find a long-term solution to keep the station in orbit as currently there is a lack in reliable U.S. capacity to boost the station.

Of course, the best possible alternative scenario would be if the Russian modules were left in place and kept operational until at least 2028, whilst recognising that a change of ownership may be required for this. The withdrawal provisions of the IGA also require the leaving member to "expeditiously provide hardware, drawings, documentation, software, spares, tooling, special test equipment, and/or any other necessary items requested by the United States",[53] however, this clause only applies to Canada. The Russians are unlikely to entertain such a transfer of equipment. First, at the moment only the Russians have the expertise to operate the Russian components. Secondly, they made the claim already back in 2016 that they intend to detach and reuse their modules for the new Russian space station.[54] That being said, the most ideal scenario would be if Russia stayed on the ISS and continued to contribute towards maintaining the ISS beyond 2024 until the partners decide to retire the ISS. The partners would then have the challenging task of removing the world's largest man-made object from outer space. The most likely solution is to deorbit the space station into an area of the Pacific Ocean called Point Nemo, which is where Mir was deorbited in 2001.[55]

on Dragon V2 is significantly more powerful with a thrust of 16,400 lbf (72,950 newtons) of thrust, but are fuel-constrained as they are designed for powered landings which is a fuel-intensive process. By comparison, the engines on the Progress Spacecraft have a thrust power of approximately 660,000 lbf (2942 kN).

50 SpaceX 2023b.

51 NASA 2021.

52 Federal Aviation Administration 2022.

53 1998 Intergovernmental Agreement, Article 28, point 3 (a).

54 Smith 2022.

55 Shepherd 2021.

Conclusion

In summary, the Russian contributions are essential to the functioning of the space station. Most importantly, they include the flight control and propulsion systems that keep the ISS in orbit. So if Russia decides to quit the programme after 2024, the critical functionalities of their modules would need to be replaced potentially with commercial involvement. The biggest problem is that currently there is a lack in reliable U.S. capacity to boost the station and keep it in orbit, and the timelines are very tight for coming up with alternative solutions to Russian thrusters. This all begs the question of course whether it is really worth maintaining something beyond its life expectancy. The station was originally designed to operate until 2015, and while the programme has been gradually extended by the ISS partners, the station has started experiencing irreparable failures that will multiply in the next few years due to the ageing equipment and hardware.[56] The ISS is roughly the same age as Mir was when they decided to end its operation, and there are other exciting projects around the corner that the ISS partners could focus on such as the Lunar gateway and other deep space projects.[57] At the same time, there are ongoing commercial developments in LEO. For example, Axiom Space is developing the world's first commercial space station and states could use these on a timeshare basis to carry out scientific research.[58] However, until these projects materialise, the ISS partners should operate the station as long as they can so there will be no gap in mankind's capacity to carry out research in an orbital laboratory such as the ISS. To date the partners have not received a formal withdrawal notice from Russia. Recent developments also give rise to hope regarding the future of the station as Roscosmos official struck a more conciliatory tone regarding U.S.–Russian cooperation in outer space after NASA successfully sent two American astronauts, a Japanese astronaut and a Russian cosmonaut to the ISS in October 2022.[59] Roscosmos's head of human space flight programs Sergei Krikalev said that Russia is looking into the technical possibility of keeping the station operational as long as they can.[60] So we can hope that the partners will negotiate an agreement that will see that this major symbol of post-Cold War collaboration continue beyond 2024.

[56] Cuthbertson 2021.
[57] ESA 2022c.
[58] Axiom Space 2022.
[59] Davenport 2022
[60] Foust 2022.

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