DOI: 10.6093/978-88-6887-296-0

INTEGRAL Observatory: Rescue at All Costs

Olga Dubrovina[1]

[1] Università di Padova, olga.dubrovina@unipd.it

Abstract: A heavy launch vehicle Proton carrying the International Gamma-Ray Astrophysics Laboratory (INTEGRAL) was launched from Baikonur Cosmodrome on October 17th, 2002. The project had been developed by the European Space Agency (ESA) for more than 10 years. Russians offered a free launch of Proton rocket in exchange for 25 percent observing time. This case study will be analysed from a geopolitical perspective by placing it in the broader context of Russian-European cooperation in space and of the political situation in Russia during the transition period.

Keywords: Russian Space Program, International Collaboration, Science Diplomacy

1. Introduction

A heavy launch vehicle Proton carrying the International Gamma-Ray Astrophysics Laboratory (INTEGRAL) was launched from Baikonur Cosmodrome on October 17th, 2002. The history of this project goes back to the mid-1980s. This is a story with a happy ending about how unforeseen circumstances can not only fail to thwart original plans but can lead to significant project improvements and the best possible outcome. However, the cost of this quantum leap was a decade of negotiations, patient waiting, diplomatic tact and an understanding of the complexity of the situation in which all parties involved in the project had been unwillingly placed.

INTEGRAL mission was seen as the direct successor to Soviet observatory Granat and U.S. Compton Gamma Ray Observatory (CGRO). Initially, it was expected that INTEGRAL would be launched by the European Ariane-5 rocket. The Russians offered their Proton rocket since their own observatories were nearing the end of their working life and there was no money to fund new missions. Rather than charge a launch fee for INTEGRAL, Russia offered a free launch in exchange for 25 percent observing time (Harvey 2021, p. 11).

In this paper the focus will be on the history of the development of this project: from the early years of its inception to the launch of the spacecraft. Since the first steps in Russian-European co-operation were made before the collapse of the USSR and under the conditions of existing Soviet space science and industry, it is interesting to trace the evolution of the project, which survived several stages of Russia’s internal history and the progress of international relations from the end of the Cold War to the late phase of the transition period in Russia. Thus, unlike many other projects, including international ones, INTEGRAL is an example of a “surviving” mission that has gone through all the difficulties of the ending of the USSR, its collapse, and the “roaring nineties” in the new Russia. All these “Russian” issues were superimposed on intra-Western difficulties relating to the development of both the ESA space program and its American partner. Below I will try to make sense of all these political, economic, scientific, organizational, and purely human factors.

2. Historical overview

The INTEGRAL is an observatory dedicated to the accurate imaging and fine spectroscopy of celestial gamma-ray sources in the energy range 15 KeV to 10 MeV. Before becoming the INTEGRAL spacecraft, the mission went through several stages of formation, that without exaggeration could be called symbols of the era in which they developed. Even before its transformation into a European project launched by a Russian rocket with American support from the ground, it went through the stages of the Italian-Soviet-British collaboration on Spektr-RG mission, the purely European GRASP, the European-American initial phase of INTEGRAL's creation, and the European-Russian-American co-operation in the late development phase.

The roots of the INTEGRAL project can be traced back to the late 1970's, when the first scientific contacts between the USSR and Italy began in the wake of the promising Soviet-American project Soyuz-Apollo in 1975 which opened the way, as it seemed to Italian scientists at the time, to rapprochement with the USSR in the field of space research.

The Soviet Spektr-RG with wide international participation began to develop in the USSR under leading astrophysicist, Rashid Sunyaev, in the early 1980s. It was the Italians who took responsibility for the design of one of the main instruments of the future international mission – the Hard-X-ray telescope. As Italian astrophysicist Pietro Ubertini PI of IBIS[1] points out, he had "an agreement with Sunyaev back in 1982 to supply the MART-LIME telescope, with support from IAS[2] " funded by the Italian space program (P. Ubertini, 6.11.23). As Ubertini claims, MART-LIME was a prototype for what was later extended to higher energies for INTEGRAL, "a kind of exercise costing over 10 billion of lire at the time that went up in smoke with the collapse of the USSR" (P. Ubertini, 6.11.23). The scientific Soviet-Italian links established during the work on Spektr-RG also played a major role.

As Thierry Courvoisier, director of ISDC[3] and responsible for the data analysis for INTEGRAL, testifies, "the project INTEGRAL was developed between 1988 and 1991 from the U.K. GRASP project" (Th. Courvoisier, 27.07.2023). The GRASP mission – Gamma-Ray Astronomy with Spectroscopy and Positioning – was originally proposed by U.K. and Italian astrophysicists as a prospective European astronomy mission and was selected by ESA for a detailed assessment study. It was one of the candidates for selection of the first medium-size Scientific Project (M1) within the framework of Horizon 2000. The strong side of the project was the fact that GRASP could use an unmodified XMM[4] platform and so achieve an important reduction in costs. It was the first real case in ESA's Science Programme where one platform would be used for two distinct missions (ESA-12524 1988). Despite this important advantage, international Cassini-Huygens mission was selected over GRASP. Regardless of this failure, the researchers of the project did not give up and decided to unite their efforts with scientists from NASA laying the foundations for the future ESA INTEGRAL mission.

The INTEGRAL project was originally proposed jointly by Jim Mattheson from UCSD[5] and NASA's Goddard Space flight, and a European consortium, more interested in Gamma Space Survey (P. Ubertini, 6.11.23). The main role in the European part of the project was played by British scientist Tony (Antony J.) Dean from Phys. Lab. University of Southampton and Pietro Ubertini from the IAS along with Rüdiger Staubert from the University of Tübingen with strong Nanni (Giovanni Fabrizio) Bignami's support from IFCTR-CNR.[6] As Guido Di Cocco from INAF IASF[7] Bologna recalls, "our British colleague went to great political lengths to help realise the project" (G. Di Cocco, 2.10.23).

INTEGRAL was the second medium-size mission of ESA's Horizon 2000 Space Science Plan. Out of twenty-two proposals received, six were chosen by the Agency's Space Science Advisory

[1] Imager on Board the *Integral* Satellite, one of the main instruments of the INTEGRAL observatory.
[2] Institute of Space Astrophysics.
[3] International Scientific Data Center of the INTEGRAL observatory, Geneva, Switzerland.
[4] X-ray Multi-Mirror Mission.
[5] University of California San Diego.
[6] The Institute for Research in Cosmic Physics and Relative Technologies of the National Research Council in Milan.
[7] The Institute for Research in Cosmic Physics in Bologna

Committee (SSAC) for study at assessment level. In 1993 the INTEGRAL won the competition as a joint project between ESA, the Russian Academy of Sciences and NASA (Krige, Russo & Sebesta 2000, p. 222). For the space community INTEGRAL represented a remarkable breakthrough: it was the first space mission to involve all three of the top space powers: EU, U.S., and Russia.

Apart from the pooling of different knowledge and competences, there were also purely material reasons behind the international co-operation on the project: "Although fully justified on scientific grounds, the proposed collaboration was also motivated by the financial limitation imposed on the M2 mission, which was 265 MAU[8] (1988 e.c.)" (ESA-16579 1993, p.1). Moreover, INTEGRAL was considered a mission focused on fundamental scientific research. It consisted exclusively of scientific organizations, which found funding for the project from their own national financial institutions.

Shortly after INTEGRAL was selected according to Courvoisier's recollection, the U.S. and U.K. sides refused to finance their instruments and withdrew from the project. For ESA, which was interested in the mission, "this was a huge disaster" (Th. Courvoisier, 27.07.23). After the withdrawal of the British and Americans, Roger Bonnet, ESA's scientific director, had to take matters into his own hands and take steps to save the project. As Ubertini remembers, "Bonnet tried to save the mission by asking us Italians to take over from the U.K., going from spending dozens of times more than the originally agreed-upon amount to build IBIS, and the Germans and French to do the same to replace NAE[9] " (P. Ubertini, 6.11.23).

The probable reasons for U.S. withdrawal from the mission were described by an astronomical journalist Daniel Clery in his article published before their dramatic decision. He highlighted the ESA coherence as attractive to U.S. researchers in the light of their frustrations with NASA. As he sustained, these included "a complex, multi-tiered, long-term planning process, an arcane proposal procedure that is often bewildering to outsiders, and a budget that must be approved by Congress every year, leaving projects prone to delays – or even cancellation – caused by unanticipated budget squeezes" (Clery 1993, p. 540). Apparently, despite the opportunities provided by ESA, internal dynamics at NASA prevented, as in the case of the U.K., the active participation of American scientists.

A different explanation was given by Igor Mitrofanov, Head of the Department of Nuclear Planetology at IKI[10] and a member of the INTEGRAL Scientific Evaluation Committee. Comparing the controversial decision of the Russians to participate in the European project on the terms of delivery of a launch vehicle in exchange for scientific data, he emphasizes the choice of the Americans aimed at the development of domestic science: "unlike us, they decided to withdraw from INTEGRAL and develop their national scientific space with international participation" (I. Mitrofanov, 23.10.23).

3. Why Proton?

ESA specialists conducted a detailed analysis of the technical characteristics of three possible rockets (Titan, Proton and Ariane-5) and their compliance with the project requirements. Based on this study, crucial scientific information was expected from the orbit guaranteed by the Proton launcher. Thanks to the higher perigee no trapped proton radiation was presumed, while the higher inclination helped to avoid contamination due to radiation belts. The Proton launcher could deliver the satellite into an orbit consistently above 40000 km, which would offer certain benefits for scientific operations. This contrasted with the Titan orbit when approximately 8 hours per 48-hour orbit were spent below 40000 km where no science observations could be performed. As the authors of the project argued, by using Proton orbit, one could gain at least 15% of science data in any given period (ESA-16579 1993, p. 2).

[8] Million Accounting Units; 1 AU= ± 1 US $.

[9] Nuclear Astrophysics Explorer.

[10] Space Research Institute of the Russian Academy of Sciences.

Even in technical terms the use of Proton launcher was more favorable. The Proton launcher could deliver INTEGRAL into its orbit with a very comfortable margin. The total spacecraft launch mass was 3643 kg while the Proton capability for INTEGRAL was 4060 kg, leaving a 417 kg margin. The spacecraft was conjectured to be delivered close to its operation orbit so that only a small amount of spacecraft on-board propulsion was required for orbital maintenance.

There were, however, at least two negative points which the European specialists paid particular attention to, but which, at the time, decided not to emphasize. First, it was pointed out that the best interface of the spacecraft would be combined with Ariane-5, because “a key feature of INTEGRAL was its commonality with the ESA X-ray mission (XMM), the second cornerstone of Horizon 2000” (ESA-16579 1993, p. 3).

The second negative point of the “Russian choice” was the unpredictability of Russian social, economic, and political reality. In the case of Proton, this meant the possibility of a governmental situation where it would no longer be possible to launch the rocket. As the authors of the launcher analysis put it, “at the foreseen launch date for INTEGRAL, the Proton might no longer be available at the same conditions if the political context were to change” (ESA-16579 1993, p. 2).

In addition to assessing if Proton met the requirements for a successful INTEGRAL mission, the European’s final decision could not but be influenced by the overall success rate of the rocket. According to estimates quoted in the open press the success rate of the Proton rocket, used in 1996 to launch the famous Inmarsat 3-F2 satellite, had been 96%, extremely high by international standards and better than Ariane at 93% (*Financial Times* 1996, p. 13).

However, since Proton was chosen as the primary launch option for INTEGRAL until its launch, the rocket had crashed four times (Proton archive.org). And the most notable and high-profile failure was the launch of the international scientific mission on the Russian Mars-96 spacecraft in 1996. Obviously, this failed launch caused consternation for the European partners. At a meeting at ESTEC in January 1997, ESA representatives asked the Khrunichev State Research and Production Space Centre’s (hereinafter Khrunichev) managers to provide an update of the Proton launch history as given in the ILS[11] user manual to cover the year 1996. In addition, Alain Fournier-Sicre, Head of Permanent ESA Mission in Moscow, requested the investigation reports from RKA[12] for the two launch failures occurring in 1996.

At the end of the 1990s ESA leadership was still uncertain that the Russian Government would agree to launch the rocket in the interests of the European scientific community. The political and, to an even greater extent, the economic situation of the country also cast doubt on the reliability of the Russian partner. Sunyaev and Albert Galeev, Director of the IKI (1988-2002), did not hide the alarming news about problems with financing the construction of the rocket for INTEGRAL from their European colleagues. Even by the autumn of 1998, the status quo had not changed, and ESA continued to exert pressure on the IKI using all possible channels of influence the Russian political leadership.

In this period the problem of financing the launch of INTEGRAL by the Russian Proton had clearly emerged. Behind the delay in the decision to fund the rocket was a complex internal state of affairs relating to scientific space for Russia during the transition period. With a shortage of funding, a whole struggle for implementation was unleashed within the Academy of Sciences.

According to NASA documents, it was not until 2000 that Rosaviakosmos finally confirmed that a Proton rocket had been designated to launch INTEGRAL. During a meeting held at NASA on September 28th, 2000 with representatives of Rosaviakosmos and IKI to discuss current projects, Georgy Polishchuk, Deputy Director General and Deputy Head of Rosaviakosmos, reported that “a

[11] International Launch Services.
[12] Russian space agency.

Proton had now been designated for INTEGRAL. Integration was now underway" (NASA-Rosaviakosmos, 2000).

4. Reasons of collaboration

Discussions on the participation of the Soviet Union in INTEGRAL started before the collapse of the USSR. There were several reasons on both sides to enter into close co-operation on the project. By the beginning of 1990s Soviet scientists knew that their sources of original scientific data were drying up taking into account the lifetime of Granat and Gamma observatories. INTEGRAL was a clear case of the disintegrating USSR spotting the opportunity to keep a source of data flowing and keep their share of observation time in exchange for expensive Proton launcher (Harvey 2021, p. 147).

In addition to the scientific continuity and professional links in astrophysics already established through the Spektr-RG project, another important event preceded the start of the INTEGRAL collaboration: the appearance in 1987 of the Energya launch vehicle on the international market of launchers. Discussions on payloads for the latest Energya rocket started as soon as it became operational and dated back to the late 1980s. Initially Energya was proposed by the Soviets to launch European gamma-ray observatory, subsequently the gamma-ray observatory mission was transformed into the INTEGRAL mission of ESA and launched by Proton, more suitable for the European scientific payload (IKI 1999, p. 35).

With the withdrawal of U.S. participants from the project, ESA could no longer cover the launch costs (both Ariane and Titan were provided on a commercial basis) forcing them to look for the best way out of the situation, which the Russians could provide. Whilst earlier their proposal for a Proton launch had not aroused much enthusiasm, now, left with serious holes in the project's budget, ESA returned to reconsidering the Russian proposal.

It is very likely that the decision to pay more attention to the Russian offer was influenced not only by the purely economic factor, but also by a fundamental change in the international situation. After Boris Yeltsin came to power in Russia and Bill Clinton to the Presidency of the United States, the new Russia and the U.S. were actively approaching each other.

There was also another factor that was possible to have influenced ESA management's decision to start effective co-operation with the Proton manufacturers. As early as 1987, following the entrepreneurial spirit of Perestroika and, simultaneously, trying to stay afloat in difficult economic conditions, Khrunichev centre, one of the leading manufacturers of the Soviet space rockets, started diversifying. After 1991 Russia's space industry launched itself on a new mission of discovery: into the world's satellite market. In 1995 Khrunichev formed a joint venture with Lockheed Martin, the U.S. aviation group, to sell their launch services. The new company, ILS, aimed at winning 50% of the international commercial launch market by the end of the century using both Russian Proton and U.S. Atlas rockets. The most dramatic sign of Russian's arrival on the world launching scene came in September 1996 when a Proton rocket blasted off from Baikonur with the Inmarsat-3 telecommunications satellite and successfully deployed it in geo-stationary orbit (Financial Times, 1996, p. 13).

5. Story of Arrangement

The first draft of Arrangement was ready on July 21st, 1994. After a whole series of harmonizations of the texts in Russian and English, the final version was produced in early 1995. In March of the same year the ESA Ministerial Council unanimously approved the draft Arrangement and therefore authorized ESA Director General to sign (ESA-28053).

However, while on the European side the process to draw up and approve the Arrangement did not encounter any notable difficulties or lengthy bureaucratic delays, the same cannot be said for the Russian partners. The Russian Ministry of Foreign Affairs (MID) was delaying reaction to the signing of the INTEGRAL Arrangement, and the Customs Committee had identified various problems that needed to be sorted out beforehand. The new text modified by the Russian MID and informally sent to ESA by RKA then put European officials in a quandary. The points already agreed with the Russians had been fundamentally revised by the Russian Ministry, which inevitably led to a new round of negotiations and the start of another approval procedure by the ESA Ministerial Council.

The final meeting was held on 18-19 January 1996 in Moscow with MID, RKA, ESA and Academy of Sciences representatives all present. The result was a finalized version of the Arrangement, ready for the approval of the respective authorities: ESA Council and Russian government (ESA-28052 1996). With these conclusions the Russians committed to obtain the necessary governmental approvals within the February/March 1996 timeframe.

It is worthwhile remembering that this interval of consideration for the Arrangement in Russia coincided with the presidential elections of June 16th, 1996. It becomes evident (from internal correspondence of ESA officials) that the unstable political circumstances had a significant impact on the process of review and approval of the Russian-European Arrangement on INTEGRAL project (ESA-28052 1996).

This is how Serghey Grebenev, Russian astrophysicist from IKI, explains the reason for the bureaucratic delay in signing on the Russian side: “During the Boris Yeltsin era, governments changed so frequently that the co-operation Arrangement simply did not have time to be signed. The documents had to be prepared for signing five times, starting from the moment when Viktor Chernomyrdin was the Chairman of the Government of the Russian Federation” (S. Grebenev, 10.9.23).

And here we finally come to the end of the match – the final decision to use the rocket in the INTEGRAL project on the Russian side was approved by Vladimir Putin on September 17th, 1999, just one month after he became Chairman of the Government. Despite a wide array of rehearsals relating to the signing of the Arrangement, the results of the successful launch fulfilled the calculations and expectations of ESA scientists.

6. Scientific collaboration

In parallel with the negotiations on the use of Proton, we should look at the promotion of the scientific cooperation and the inclusion of the Russians preparing the scientific components of the mission, or more precisely, the IKI researchers.

A key issue was the distribution of the data obtained from INTEGRAL which arrived from the telescopes at the INTEGRAL Science Data Centre (ISDC). This primary processing by specialists from the Astronomy Department of the University of Geneva was under the direction of Thierry Courvoisier. All data became publicly available one year after their receipt and processing, as stated in the ESA Science Management Plan. However, during the first year it could normally be used only by the Principal Investigators responsible of the delivery to ESA of the four instruments on board in return of the national space agency investment. By Courvoisier’s definition: “We had to share the skies we observed. Like an Oriental bazaar, ESA and Russian scientists shared the observing time of INTEGRAL telescopes, trying to “bargain” for more time in quantity and also in quality”. As Courvoisier remembers, “Sunyaev had a strong position because ESA could not pay for the use of Ariane, for the launch of which a very high price was offered” (Th. Courvoisier, 27.07.23).

One more important fact is worth highlighting here – in case of the INTEGRAL launch by Proton, the observation time was increased. This also gave weight to Sunyaev’s negotiating position. In Grebenev’s opinion, “the share of observation time and data processed and analyzed by Russian scientists was comparable to observation time obtained when launching a satellite into orbit of Proton compared to a possible Ariane-5 orbit" (S. Grebenev, 10.9.23). This notion was also confirmed by Ubertini: "The 'business' was in the fact of giving 25% more of the data obtainable from the Proton's better orbit to Russian colleagues" (P. Ubertini, 6.11.23).

Once the allocation of observation time was finalized, routine work began between European and Russian scientists, characterized by official appointments, exchanges of delegations, project discussions, etc. Summarizing the initial phase of the development of joint actions on the INTEGRAL project, Grebenev emphasizes that "Although the first agreements with the ESA management were reached in heated debates, on the whole it was always a constructive and mutually beneficial co-operation" (S. Grebenev, 10.9.23), that is still ongoing after 20 years of scientific observations.

7. Conclusions

Summarizing this article and trying to avoid the obvious conclusions about the complexity and sometimes tragic nature of mutual relations between politicians, engineers, and scientists, which fully depend on specific foreign and domestic political conditions, three key points should be emphasized. They are united by the positive outcome of Russian-European co-operation and although the collaboration was fruitful for both, the focus here is on the significant intangible assets gained by Russia.

The first is that ESA managed to convey to its Russian colleagues a very concrete "good practice" of democracy, about which so much was said in the 1990s and so little was done to transfer and establish it on Russian soil. According to Article 5.6 of the Arrangement the Russian side was obliged to "establish with the Russian Academy of Sciences the Russian Scientific Data Center (RSDC) to support the preparation of Russian observation proposals and the processing of the scientific data return" (ESA-19466 1996). All the scientific data obtained within the Russian observation time quota were (and still are) transferred to the ISDC and then become available for Russian scientists via the RSDC of the INTEGRAL observatory established in the High Energy Astrophysics Department (IKI).

In addition to this experience in democracy, my second point is that the Russians received an even greater bonus from the Europeans and that was trust. A trust built, among other things, on the personal and professional ties of the scientists. Almost twenty years after the described events, one of their participants, Lev Zeleny, drew special attention to the exclusivity and value. "Thanks to our joint efforts, in September 1999 the Russian government issued a decree on the launch of INTEGRAL. We would like to recall with a kind word Roger Bonnet, our great friend, an activist of co-operation with Russia, thanks to whom this difficult period was overcome. […] The experience of the INTEGRAL project proved to be very important. Colleagues from Europe began to trust us. Since then, Russian scientists have participated in other ESA projects. The Mars Express, Cluster, Venus Express, and ExoMars-2016 were successfully launched into space by our Soyuz-Fregat rockets. So, the co-operation ended up being beneficial not only for scientists, but also for our rocket industry" (Integral Observatory).

Thirdly and finally, scientists contributed, to the best of their ability, to the creation of a positive international climate in which their co-operation had developed. With common scientific and technical goals, independent of the political situation and taking advantage of the freedom in communication of the 1990s, scientists made joint efforts for achievement, simultaneously contributing to the formation of new Russian-European relations. The scientists played a "stabilizing" role in that period, contributing to the construction of new West-East relations. Thus, three key concepts characteristic of the Russian-European cooperation on INTEGRAL can be identified: scientific democracy, professional trust, and space diplomacy. All three went far beyond the scope of a single project creating a broader perspective for further joint efforts.

Acknowledgments

Sincere thanks to Thierry Courvoisier, Guido Di Cocco, Serghey Grebenev, Leonid Gurvits, Igor Mitrofanov, Pietro Ubertini and Lev Zeleny for their time and willingness to share their memories and suggestions with me. And Gherardo Bonini (HAEU) and Sarah Jenkins (NASA HQ Archives) for their help with archival sources.

Bibliography

Clery, D. (1993). "U.S. Space Scientists Look to Europe", *Science*, 261(5121), pp. 540-542. doi: 10.1126/science.261.5121.540.

Financial Times, 22 November 1996.

Harvey, B. (2021). *European-Russian Space Cooperation: From De Gaulle to Exomars*. Chichester: Springer.

IKI (1999). "Department for High Energy Astrophysics", in Galeev, A. (ed.), *Space Research Institute of the Russian Academy of Sciences. 35 years*. Moscow: IKI RAN, pp. 36-37.

Integral Observatory. Available at: https://prof-ras.ru/index.php?option=com_k2&view=item&id=933:observatoriya-integral-nedremannoe-oko-na-zemnoj-orbite (Accessed: 17 July 2024).

Krige, J., Russo, A. & Sebesta, L. (2000). *A History of the European Space Agency, 1973-1987*, vol. 2. Noordwijk: ESA Publications Division.

Proton (archive.org). Available at: https://web.archive.org/web/20080913224630/astronautix.com/lvs/proton.htm (Accessed: 17 July 2024).

Archival Sources

Barbance K. (1996). Letter to V. Nicolae, HAEU, *Collection ESA*, 28052.

ESA-12524 (1988). Selection of the Next Scientific Project (M1). Historical Archives of the European Union (HAEU), *Collection ESA*, 12524.

ESA-16579 (1993). Launcher for INTEGRAL. HAEU, Florence, *Collection ESA*, 16579.

ESA-19466 (1996). Article 5 of Arrangement between the ESA and the RKA concerning cooperation in the INTEGRAL, *Collection ESA*, 19466.

ESA-28052 (1996). Protocol of a meeting on INTEGRAL space cooperation, HAEU, *Collection ESA*, 28052.

Lafferranderie G. (1995). Letter to A. Medvedchikov, HAEU, *Collection ESA*, 28053.

NASA-Rosaviakosmos (2000). NASA-Rosaviakosmos Esecutive Joint Working Group. NASA HQ Archives, *Marc Allen Strategic and International planning collection*, Box 4.

Interviews

Interview with Thierry Courvoisier, 27th July 2023.

Interview with Serghey Grebenev, 10th September 2023.

Interview with Guido Di Cocco, 2nd October 2023.

Interview with Igor Mitrofanov, 23d October 2023.

Interview with Pietro Ubertini, 6th November 2023.