# History of Rocketry and Astronautics

**Proceedings of the Forty-Fifth History Symposium of the International Academy of Astronautics**

**Cape Town, South Africa, 2011**

**Otfrid G. Liepack, Volume Editor**

**Rick W. Sturdevant, Series Editor**

## AAS History Series, Volume 42

**A Supplement to Advances in the Astronautical Sciences**

## IAA History Symposia, Volume 31

AAS Publications Office
P.O. Box 28130
San Diego, California 92198

Affiliated with the American Association for the Advancement of Science
Member of the International Astronautical Federation

*First Printing 2014*

ISSN 0730-3564

ISBN 978-0-87703-613-5 (Hard Cover)
ISBN 978-0-87703-614-2 (Soft Cover)

Published for the American Astronautical Society
by Univelt, Incorporated, P.O. Box 28130, San Diego, California 92198
Web Site: http://www.univelt.com

Printed and Bound in the U.S.A.

## Chapter 3

# The "Spiral" Project (1965–1978)— The First Attempt to Realize a "Real" Manned Spaceplane*

**Oleg A. Sokolov**†


### Abstract

The "Spiral" project, which was launched in the former Soviet Union (FSU) in 1965, foresaw the development of an orbital aerospace system that should include a small manned shuttle-type spacecraft and a specially developed supersonic (or hypersonic) carrier aircraft from which the spacecraft had to be launched. An assessment of this project is made from the point of view of its relevance to the concept of a "real" spaceplane. According to this concept, a "real" spaceplane is one which has to use the Earth's atmosphere both for ascent (for aerodynamic support and as a source of oxygen) and for descent (for aerodynamic braking and gliding flight before landing). The supposition is made that the "Spiral" system could correspond completely to this concept if the project had not been terminated for certain non-technological reasons. The proposed designs of the "Spiral" system's main components, the spaceplane itself and its carrier aircraft are briefly described. The process of this project realization included the creation of scaled demonstrators (BORs) and of a full-scale manned proto-


* Presented at the Forty-Fifth History Symposium of the International Academy of Astronautics, 3–7 October 2011, Cape Town, South Africa. Paper IAC-11.E4.1.03.

† Commercial Space Technologies Ltd., Moscow, Russia.

type for in-atmospheric tests. Their flight tests were carried out during the period of 1969–1978. The reminiscences of the author on his own participation in the BOR flight tests are presented. The supposed reasons for the project termination are mentioned.

## Introduction

This chapter is dedicated to the project of the "Spiral" reusable aerospace system that was being developed in the former Soviet Union (FSU) about forty years ago. This development had achieved a sufficiently high degree of readiness by the time the program was cancelled.

The "Spiral" project is known significantly less than other non-realized FSU space-relevant projects although certain publications have described it in sufficient details [Refs. 1 and 2]. This circumstance releases me from the necessity to describe these details once more and allows me to limit the project general description in this chapter with that which is required for establishing the special value of the "Spiral" project.

My own attitude to this project was formed not only by an acquaintance with the relevant information after the program's cancellation, but also with my personal participation in one of the project stages of realization. Of course, I cannot miss the opportunity to insert my corresponding reminiscences into this chapter.

So, I am beginning my chapter from a general description of the proposed "Spiral" system while mentioning my personal acquaintance with it and then I shall transfer to an assessment of this project role as a prototype for future space transportation systems for the routes "Earth—low Earth orbits (LEOs) and back."

## The "Spiral" Project, Its Development and Realization

I heard about the "Spiral" project for the first time in mid-1969 when I was working in the Flight Test Department of one of the Russian rocket engine-building enterprises. I was charged to take part in the flight tests of the BOR sub-orbital spaceplane that would be equipped with our enterprise's propulsion unit. In order to prepare myself for this job, I began to acquaint myself with all available information on the BOR and I got to know the flight test (more exactly, experimental) program of the BORs, the appellation of which meant "Bespilotnyi Orbitalnyi Raketoplan" = "Unmanned Orbital Rocketplane." It was a part of the vast "Spiral" project, which was targeted to the creation of a conceptually new space transportation system.

The "Spiral" project development was begun in the FSU in the early 1960s. This development was performed in the Soviet aviation industry, and it could be assumed that it had been an attempt of Russian aviation designers to pave their "own way into space" (because the main way had been occupied by adherents of "pure rocket" technology).

The initiator of this development was Dr. Gleb E. Lozino-Lozinsky (future General Designer of the "Buran" Orbiter), who was, at that time, Deputy General Designer of the famous MiG (Artem I. Mikoyan Experimental Design Bureau), and this enterprise was appointed as prime developer of the project. The preliminary program of the "Spiral" project was signed in 1965 and funding was provided.

The final goal of this project was to provide Soviet cosmonautics with a multipurpose aerospace system for manned LEO missions. Practically, it was a competitor to the "Soyuz" "pure rocket" space launch system, the development of which was also begun at approximately the same time.

The "Spiral" system was to consist of three main parts: the Hypersonic Airplane-Booster (the GSR, "Giperzvukovoy Samolyot-Rasgontshik") and the Orbital Plane (the OS, "Orbitalny Samolyot") with the Additional Booster (the DU, "Dopolnitelny Uskoritel"). An artistic general view of the "Spiral" system in a take- off configuration is shown in Figure 3–1.

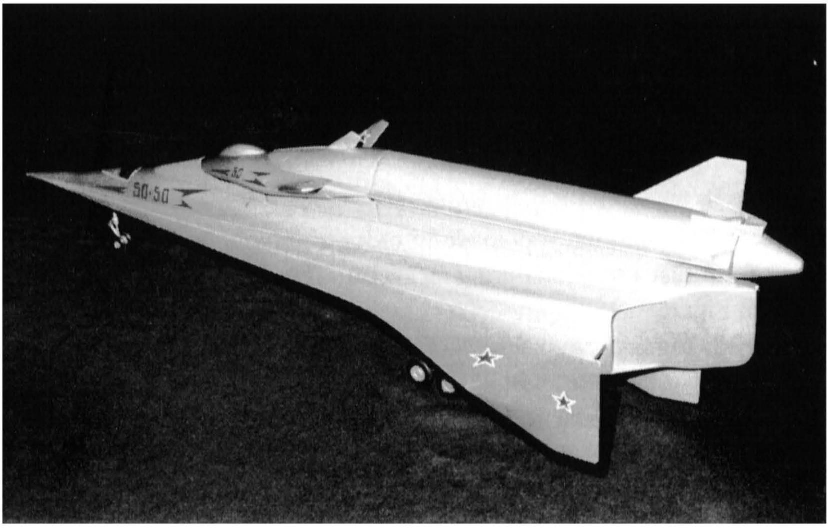


**Figure 3–1**: The "Spiral" aerospace system in the take-off configuration. Credit: V. P. Lukashenko and I. B. Afanasiev, *Kosmicheskie Krylia*, Moscow, 2009.

The OS had to be a real airplane having a lifting body with two short folding wings. Its mass should to be about 10 tons, with a length of 8 meters and a wingspan of 7.4 meters. For orbital maneuvering, the OS had to have main and spare liquid bipropellant (nitric tetroxide plus unsymmetrical dimethylhydrazine, UDMH) rocket engines and a set of thrusters with their own propellant supply. An onboard computer should be used in the OS guidance and control system, which was an advanced solution at that time. The OS could have a small turbojet engine for powered atmospheric flight during landing. An artistic general view of the OS in a flight configuration is shown in Figure 3–2.


**Figure 3–2**: The "Spiral" system's Orbital Plane (OS) in flight configuration. Credit: V. P. Lukashenko and I. B. Afanasiev, *Kosmicheskie Krylia*, Moscow, 2009.

The design of the GSR, Hypersonic Airplane Booster, was proposed as a delta-wing manned hypersonic tail-less airplane having four multi-mode turbojets under its body, using either kerosene or liquid hydrogen fuel. (An artistic general view of the GSR in a flight configuration is shown in Figure 3–3.) It was interesting that the engines had to be installed in vertical pairs in the GSP tail with their exhaust onto a mutual nozzle of external expansion. (Currently, this type of nozzle is being called as of the "aerospike type," although the U.S. "Aerospike" rocket engine with the same concept's nozzle was developed later than the "Spiral" project.) This solution was made in order to provide a partial altitude compensation for thrust alteration during an ascent. This feature of the GSP design is well seen in Figure 3–4.

The OS, together with the DU (Additional Booster), was to be installed onto the "back" of the GSR, with their front and rear ends closed by fairings. The separation of the OS orbiter with DU from the GSR should be carried out at the altitude of 22–24 kilometers and at the flight speed of Mach 4 (for the option using the kerosene fuel), or 28–30 km and Mach 6 (for the option using the liquid hydrogen fuel) accordingly.

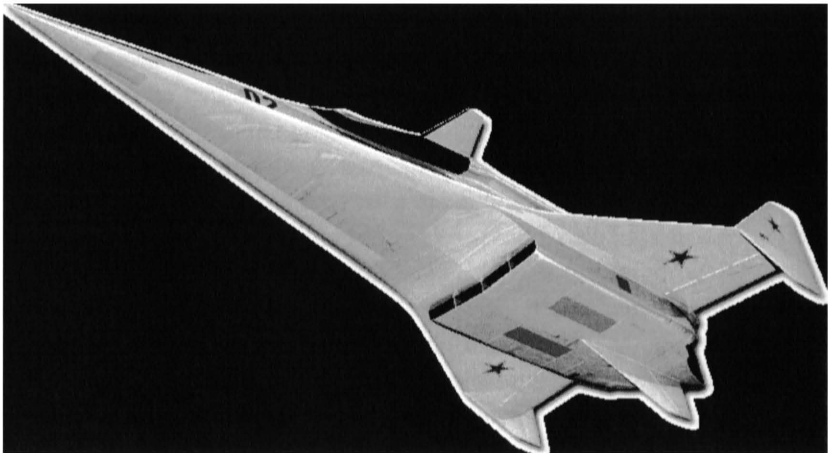


**Figure 3–3**: The "Spiral" system's Hypersonic Airplane Booster (GSP) in flight configuration. Credit: V. P. Lukashenko and I. B. Afanasiev, *Kosmicheskie Krylia*, Moscow, 2009.

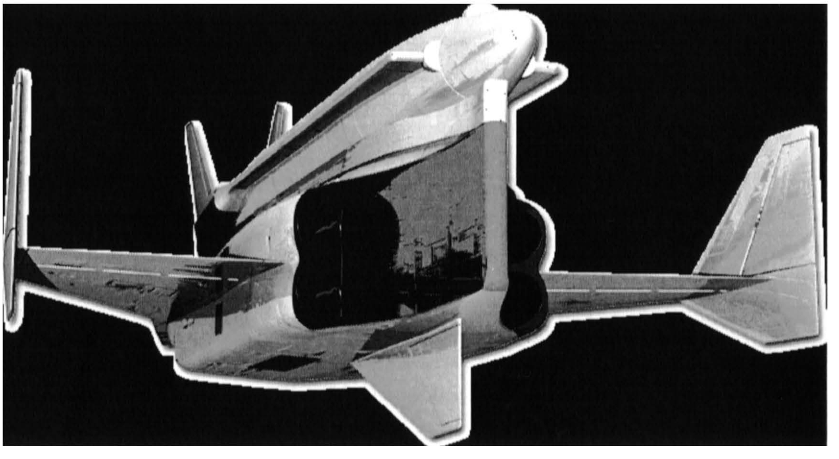


**Figure 3–4**: A view to the GPS rear. Credit: V. P. Lukashenko and I. B. Afanasiev, *Kosmicheskie Krylia*, Moscow, 2009.

The DU was to be a two-stage liquid bipropellant (liquid oxygen plus kerosene, or liquid oxygen plus liquid hydrogen) booster.

The whole system should have a total mass of about 140 tons; it could inject the OS orbiter with a crew of three cosmonauts into LEOs with altitudes of about 130 km in which the OS would perform two or three revolutions with the possibility to alter its altitude and orbital plane. The OS would be able to perform an "aviation" landing onto common airfields.

All the system's components, excluding the DU, should be reusable.

The program foresaw the development of two manned aircraft-demonstrators ("analogues") of the OS, they should be dropped from a carrier aircraft—the Tu-95 heavy bomber (the "Bear" by Western designation) for aerodynamic testing in Earth's atmosphere. One of these aircraft was intended for subsonic tests, while the second analogue should achieve the maximum speed up to Mach 6–8. According to the schedule of the program, the development of these two aircraft analogues would be begun in 1967 and 1968, accordingly. The work beginning on the GSR was scheduled for 1970.

After testing the atmospheric demonstrators, a sub-scale unmanned experimental version of the OS would be launched into an orbit by the "Soyuz" launch vehicle. By that time, presumably in 1972, the GSR manufacturing would be begun and the first manned orbital flight of the "Spiral" system would be performed in 1977.

The contribution of the enterprise in which I was working was the development of the propulsion unit for the OS. Our designers began to develop this propulsion unit. It was based on using a pressurized propellant supply system that had an interesting feature. Usually, the high-pressure gas for the pressurized propellant supply was stored in special onboard bottles or containers that provided the pressurization of the propellant tanks through a pressure regulator in order to maintain a constant level of propellant supply during burning. But in the OS propulsion unit's design, the gas for the propellant supply was to be pumped under pressure directly into cylindrical propellant tanks having bellows separators. Because the combustion chambers and thrusters were burning under a decreasing propellant pressure, there should be a gradual decrease of their thrusts. (Such a method of supply, for us, had the "pig" nickname because the diagram of the supply pressure changing actually resembled a pig's snout.)

Such a solution provided simpler servicing during fueling and, mainly, eliminated the mass of heavy high-pressure gas containers while the relatively short time of orbital flight would permit some decrease of the thrust level.

By the spring of 1969, the preliminary project of the OS propulsion unit had been approved and—was put aside. The "Spiral" program required the other, more urgent work.

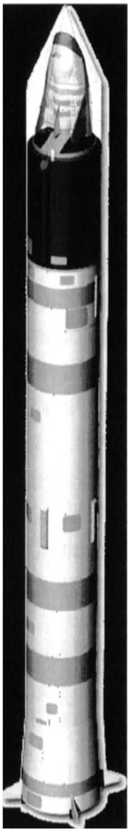
It was recognized that the problems of the OS entering into the Earth's atmosphere with a following controlled descent required additional experimental investigations of this process by using special vehicles that had to be similar aerodynamically to the OS. A series of these experimental vehicles, which had the mutual BOR designation, was designed under the management of the omnipresent Lozino-Lozinsky in the MiG's filial in the Flight Test Institute (LII) in the town of Zhukovski in the Moscow Region. I am describing the BOR subprogram in somewhat more details since that was the field of my direct participation in the "Spiral" project. (Certain episodes of that participation were already described by me in [Ref. 3.)

By the time of my involvement in this field, the BOR-1 had been just manufactured and, when I visited the MiG filial in the LII for a first time, I saw it with own eyes in a somewhat interesting situation. When I opened the door of the LII assembly workshop, I nearly trod upon a wooden structure in the shape of a great galosh. "What do you make of it? It is our flight example!" workers cried out to me. Indeed, the BOR-1 had a wooden structure!

This initial vehicle had not only the wooden structure, but its attitude control before entering into Earth's atmosphere in order to direct it into the necessary position (nose forward) and under the required angle of attack had to be provided by a constantly burning solid-propellant gas-generator with a hot gas supply through a kit of ejectors (nozzles) equipped with control valves. Initially, it had been considered that this system would be sufficient; however, more precise calculations showed that liquid bipropellant thrusters would be necessary. Because of that, our enterprise received an urgent order to develop and manufacture this propulsion unit for the next versions, BOR-2/3 and BOR-4.


**Figure 3–5**: An external view of the BOR-2 suborbital xperimental vehicle. Credit: "Apparaty BOR," http://www/buran.ru/htm/bord.htm.

The BOR-2, in contrast to the BOR-1, had an all-metallic structure (its external view is shown in Figure 3–5 and its upper external surface, which is seemed to be a wooden coating, was thermal insulation in reality). Its BOR-3 option had certain alterations but was actually the same vehicle. These vehicles had a single bipropellant propulsion unit with a spherical bipropellant tank pressurized from a separate high-pressure gas bottle and a kit of 10-kg thrusters on the vehicle's flat rear end. This propulsion unit had to provide attitude control only, without any braking, correction or boosting functions. The orbital BOR-4 could have the same propulsion unit, but the kit of its thrusters was to be supplemented with a single 40-kg thruster that had to provide a braking impulse for deorbiting.



Both the BOR-1 and BOR-2/3 versions had the OS aerodynamic shape but their dimensions were in the scale of 1:3. These were intended for launches along a suborbital (ballistic) trajectory by the "Cosmos-3M" launch vehicle's suborbital option, 8K63MR from the Kapustin Yar missile test range (the delta of Volga River) to the area of the Sary-Shagan test range nearby to the Balkhash Lake in Kazakhstan. (The accommodation of the BOR in the launch vehicle is shown in Figure 3–6.) The BOR-4 (of the same shape but in the 1:2 scale of the OS) was intended for the same sort of experiments, but within the frame of orbital missions.

**Figure 3–6**: The accommodation of the BOR in the "Cosmos-3M" launch vehicle. Credit: *Novosti Kosmonavtiki* magazine.

The single BOR-1 was launched from Kapustin Yar on 15 July 1969. Before its complete burning-up at an altitude of about 70 km during descent (due to its wooden airframe), it transferred certain useful information on the parameters of the vehicle entering into the atmosphere and confirmed the supposition of the lack of efficiency of the solid-propellant attitude control system.

The propulsion unit for the first BOR-2 was manufactured very quickly. The launch was scheduled for December 1969.

All the BORs were designed in such a manner that they should have a soft landing by using a parachute at the final leg of descent. This was done in order to rescue the recordings of the data on the vehicle's descent parameters, including aerodynamic and thermal indices. This data could not be transmitted to the Earth in the process of passing through the top layers of the atmosphere and they had to be recorded onboard. In order to provide for the safety of those people who should remove the memory device with data records from the landed vehicle, a preliminary inspection of this vehicle at the spot of landing was necessary, since a certain quantity of dangerous propellant would remain in the propulsion unit's tanks and pipelines. The existence of propellant leakages, for example, through possible cracks should be defined and, in this case, the propellant residues should be neutralized before permitting access of the vehicle developer's experts to the vehicle. This job within the frame of the BOR-2 first mission was charged to me.

After my arrival in the town of Priozersk, the Sary-Shagan test range's center, I was included in the special search/rescue team of the BOR developers plus me and one–two especially allotted military experts. On the day of the launch, 6 December, one of the developers, one military expert and I were on duty in the lightweight Mi-1 helicopter together with its pilot. We were waiting for when the BOR would have entered into the Earth's atmosphere's dense layers. (This moment should be defined by a disappearance of the telemetry data transmission from it.) Initially, we received the message that the BOR had been just launched from Kapustin Yar. Then we were waiting for more than half an hour until the moment when the test range's on-ground tracking service informed us about the supposed spot of the vehicle landing. After this information was received, our direct work was begun.

The most difficult part of this work was not an accurate survey of the landed charred BOR with a danger of the harmful propellant probable leakages, as one might think. It was to find this BOR on the real spot of its landing. Although the BOR-2 was equipped with a radio beacon that had to transmit signals after the vehicle's decrease of speed at the leg of descent, this equipment failed, apparently, due to the enhanced temperature inside the vehicle's body when aerodynamic heating was acting. The BOR released its parachute before landing, but the vehicle's speed at that moment was still sufficiently high and the parachute was broken. (As it was found later, the control/guidance system had a malfunction on the roll channel and the vehicle transferred to a ballistic descent at an altitude of 25 km.) The vehicle still covered a certain distance at low altitude where it could not be tracked by the test range's radars and then performed a "hard" landing. Therefore, we knew this landing spot only very approximately, with an accuracy of 5–10 kilometers.

On the face of it, it seemed relatively simple to find from the air the 3-meter long, metallic vehicle in the desert steppe in an area with a radius of 10 kilometers. However, it was found that to find a needle in a haystack could have been a simpler task. Indeed, you could find this needle using a magnet or magnetometer, or even radar while, in our case, the haystack itself contained iron hay. The BORs were being targeted (during their deorbiting) for their landing to that area of the Sary-Shagan test range (that was testing, mostly, antiaircraft systems) over which the intercepts of drones were being carried out and, due to this, this area's surface was filled with the metallic debris of these drones and missiles. A visual survey from a short distance was the sole tool that could be used. One can image how much in-flight time was lost in the determination of whether any pieces of burned hardware were the BOR debris or not.

When the landed BOR, in a significantly damaged condition, had been found, we surrounded it smelling the air. (The vapors of propellant's components after their possible leakages could be simply exposed by their specific smells.)

Then (since these smells were not detected), I opened the hatch over the propulsion unit's propellant tank (this hatch was made in the shape of a bulb that simulated the future OS cockpit), put on a gas mask and stuck myself partially inside, carrying out a visual survey of this tank. After this, another hatch in the vehicle's rear part was opened and I checked out the propellant pipelines. These pipelines were slightly deformed during the landing but evident signs of leakage (drops) were absent. I said OK and the team's developer went for the ill-fated BOR, which could make no resistance, as a dog for a half-dead cat. He investigated mostly the condition of and damages to the body's thermal protection coating that was the main subject of the testing within the frame of the BOR program. Then he checked up the condition of the container with the recording device after its drawing out through a hatch. (The military expert's role was to assist me if a propellant leakage had been found. Fortunately, this assistance was not required.) Last, we flew back to Priozersk taking the removed recording device with us. The found BOR should be still neutralized from propellant residues by military personnel (with my presence), inspected in detail by representatives of its developer-enterprise and delivered later to Moscow for a following investigation.

This relatively happy ending had been preceded by several long flights searching for the BOR. These repeated flights (since we were not lucky to find the BOR during the first flight), were carried out in the conditions of frosty winter weather while the Mi-1 helicopter's cockpit had insufficient heating for these conditions. As a result, we got out of the helicopter like frozen broilers from a refrigerator despite being dressed in fur suits. This discomfort forced us to dream of the time when the following BOR-2 launch would be carried out (it had been scheduled for the following summer).

This second launch (of the BOR-2) was, really, realized on 31 July 1970, with complete success. However, I did not participate in this realization since I had been returned earlier to a continuation of my regular work on the provision of our enterprise's propulsion units for the preparation for the FSU lunar programs. Nevertheless, I was continuing to keep abreast (via contacts with my newly found friends among the "Spiral" project developers) of the following development of the project realization. (I was maintaining a hope to take part some day in the preflight preparation of the OS propulsion unit for a spaceflight.)

The BOR sub-program was really continued: one more BOR-2 and two BOR-3s were launched from Kapustin Yar to Sary-Shagan during 1971–1974, then the turn of the orbital BOR-4 came (three launches in 1980–1984, one of which failed). However, the BOR-4 missions were carried out actually outside the frame of the "Spiral" project realization. This project was cancelled by 1980 in favor of the new huge "Buran-Energia" project. Nevertheless, the remaining hardware and gained experience were used in the interests of this new project: thus, for example, samples of the advanced thermal insulation for the future "Buran" were tested in the flights of the BOR-4s (Figure 3–7). Moreover, the next BOR version, BOR-5 was especially designed for the "Buran" Orbiter's aerodynamic configuration verification and had this Orbiter's shape in the scale of 1:8 (Figure 3–8).

A complete description of the BOR sub-program can be found in [Ref. 4].

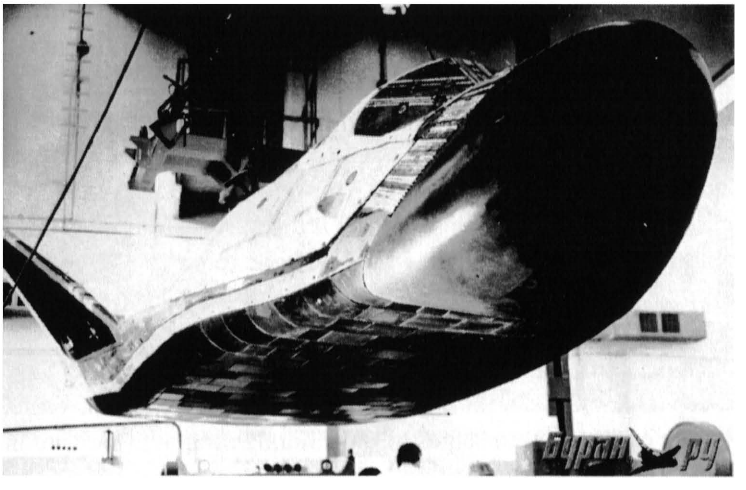


**Figure 3–7**: The orbital BOR-4 that was used for the in-flight testing of the thermal insulation for the "Buran" Orbiter. Credit: Advertising materials of "Molniya" NPO.

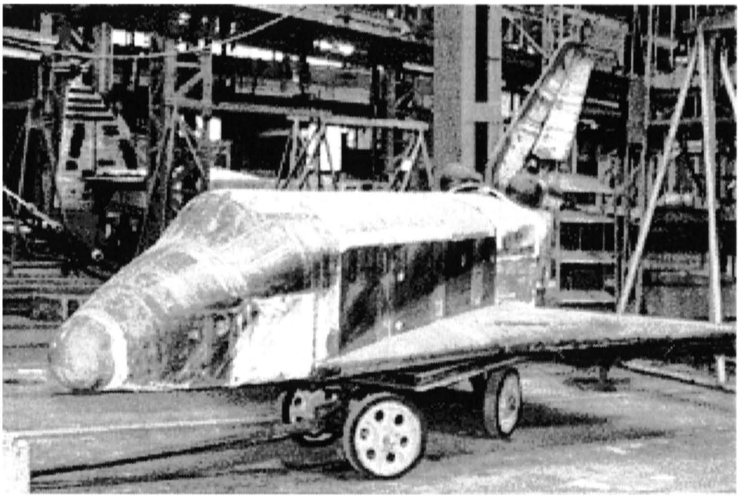


**Figure 3–8**: BOR-5 had the "Buran" Orbiter's external configuration. Credit: Advertising materials of "Molniya" NPO.

However, the last works were actually a rational use of the "Spiral's" heritage but not a continuation of its realization. Meanwhile, the other initially planned stage of that realization was led up to a sufficiently high level. We are talking about the manned aircraft-demonstrator ("analogue") of the OS that was officially called the "Experimental Manned Orbital Aircraft" (EPOS by the Russian acronym).

This appellation reflected the change that had appeared in the main goal of the "Spiral" program by that time. Due to the growing negative attitude of the FSU top leadership to this program, it was redirected from a creation of a real aerospace system to the creation of the OS orbital spaceplane only for the purpose to gain experience for future developments of this type of spacecraft. The EPOS in its final version should be launched by the "Soyuz" expendable launch vehicle. In this way, the "Spiral" developers were trying to save the project for a probable continuation in the future. Indeed, if the OS would provide a real orbital mission in the EPOS version, there would be hope to convince the leadership to continue the program in the development of the system's remaining components, GSR and DU.

With this approach, a realization of the EPOS in two demonstrators, subsonic and supersonic ones, with a following transfer to the orbital vehicle should be actually the early foreseen stages of the "Spiral" program (they are mentioned above) while the single difference with the early planned process of the "Spiral" realization should be the postponed development of the GSR and DU.

The EPOS-subsonic demonstrator was built and its flight tests with its dropping from the Tu-95K carrier aircraft were carried out successfully during 1977–1978 (six flights). The airframe of the supersonic demonstrator was also manufactured. However, the EPOS program was finally cancelled by 1980, although the flight tests of the subsonic demonstrator as well as the earlier tests of the BOR-2/3 confirmed the OS feasibility with verification of its capability to provide a controlled flight both at the leg of entering into the Earth's atmosphere and at the leg of return to an airfield. Currently, the subsonic EPOS, which was confirming this feasibility more than thirty years ago, is an exhibit of the Russian Air Force Museum in Monino near Moscow as a reminder of the former "Spiral" project (Figure 3–9).

Although neither the GSR nor DU was built, the involved designers had no doubts about their feasibility; at least in those options that foresaw the use of oxygen-kerosene propellant. (The Russian rocket engine developers did not have a serious experience of oxygen-hydrogen engine developments at that time.) Indeed, the MiG Design Bureau had already developed the MiG-25 heavy fighter with the take-off mass of 40 tons and with the maximum speed up to Mach 3.

This aircraft could have been used as a prototype for the GSP (in the area of basic technologies) while its turbojet engine R15-300 with a maximum thrust of 11,200 kg could have been used as a prototype for the creation of an engine for the GSP [Ref. 5].

**Figure 3–9**: The EPOS, a manned "analogue" (demonstrator) of the OS, which was being used for in-atmospheric subsonic flights, in the Russian Air Force Museum. Credit: Photo by the author.

The creation of the two-stage Additional Booster (DU) to be equipped with oxygen-kerosene rocket engines did not raise any problems for the FSU missile-space industry, which had great experience of similar product developments.

So, the cancellation of the "Spiral" project realization was initiated not by technological problems and not even by the necessity to invest great monies into developments of expensive quite advanced technologies (as, for example, the developments of reusable thermal insulation for the "Buran" Orbiter and of a powerful oxygen-hydrogen rocket engine for the "Energia" launch vehicle) but by certain other reasons. Let us try to briefly analyze these reasons and let us see what the "Spiral" system would provide if it had been realized nevertheless.

## The Roles of the "Spiral" Project for the Past and for the Future

As mentioned above, the "Spiral" project development was carried out by the FSU aviation but not the missile/space industry. However, it was not only the initiative of the Ministry of Aviation Industry (MAP)—rather, this initiative was inspired by certain top officers of the Air Force who would like to include "space squadrons" into a composition of their arm of the service (not for nothing, the project foresaw to create the OS in the options of photo-intelligence spacecraft, satellite interceptor and space-to-surface bomber [See Ref. 1]). Actually, the MAP was really paving its "own way into space" but not for the purpose of competition against the Ministry of General Machine-building (MOM, which was the FSU Ministry of missile-space industry) in the field of space exploration, which was an esteemed and profitable business in that time's Soviet Union. Instead, the MAP would have liked to receive large profitable contracts from its traditional customer, the Air Force, which had its own specific requirements for space systems.

Indeed, the "Spiral" system's laid-down features reflected directly its similarity with battle aircraft: it had to be manned and reusable with a relatively short inter-flight period. It was also well understood that this system could be created by the aviation industry, due to this similarity.

True, any space system had its own features that were not present in aviation systems. However, the broad scope of the capabilities of the Ministry of Aviation Industry provided an opportunity to meet these specific requirements since this Ministry's numerous enterprises were involved in the provision of the FSU space-relevant programs: thus, for instance, certain of them were developing and manufacturing rocket engines for spacecraft and launch vehicles. (In a contrast, the MOM could not develop and build aviation structures without the MAP participation.)

So, as it seemed, the launch of the "Spiral" project was well grounded both from the point of view of its future practical application and from the point of view of its executor choice. Why, in this case, did the FSU top political and economic leadership not support this project over the period that would have been sufficient for its realization? In other words, why did a complete disappointment come after almost fifteen years of work?

I am thinking that a combination of reasons took place. The first reason was connected with economic difficulties. The Ministry of Aviation Industry was financing the "Spiral" project development with its own funds from the item for R&D works; then the Ministry's top management began to understand that these funds would be insufficient and it appealed to the government for financial support. However, the government could only allot special funding for the project realization at the expense of the Ministry of General Machine-building (MOM) which, in its turn, was providing a number of space programs including the Moon-relevant missions and the development of manned orbital stations.

If the "Spiral" had been tested successfully in a complete composition by 1977 as was initially planned, it was possible that the system could be added to the FSU Air Force armory. However, the lack of funding had led to significant delays and the time was just missed. By then, two other reasons were apparent. First, the promised performance of the "Spiral" system was too low for solving a majority of the required space tasks: indeed, even the expected maximum available altitude of the provided orbits was evidently insufficient (130 km only) while it was evident that the GSR in any feasible (at that time) configuration would not provide better performance as the system's first stage. Second, it became clear by the late 1970s that almost all the missions, which were supposed for this system, could be carried out by unmanned satellites.

These shortcomings stipulated a transfer to the concept of the OS launching by common expendable launch vehicles. In this case, the opportunity to receive a reusable manned spacecraft (but not a reusable whole space transportation system!) remained nevertheless. However, when the decision to develop an analogue of the U.S. "Space Shuttle" was made, that is, a similar concept of a space transportation system with a drastically higher payload capability, the destiny of this "bit" of the "Spiral" project was finally determined.

However, the conceptual promise of the "Spiral" system was not taken into account. This system in its complete configuration would be a real aerospace system which should use the Earth atmosphere both at the lower leg of ascent into the space, where the GSP had to use the atmospheric air for breathing its engines and for a provision of lifting capacity by aerodynamic support, and in a final phase of the mission when the atmosphere had to be used by the OS for an aerodynamic braking and the following gliding to a landing spot.

As I remarked in [Ref. 3], a real aerospace system, intended for the injection of a payload into an LEO and for its return back to Earth, had to use Earth's atmosphere as much as possible. The atmosphere would provide aerodynamic support both at the leg of ascent and at the leg of descent and could provide an oxidizer, atmospheric oxygen for use in the system's propulsion during its boosting up to the atmosphere's top layers during the ascent. From this point of view, such "aerospace" systems as the realized "Space Shuttle," "Energia"/"Buran" and even the small class "Pegasus" can be considered "quasi-aerospace" systems (this term was introduced and defined in [Ref. 6]) because they are only using Earth's atmosphere either at the leg of descent (for aerodynamic support during the gliding of both the "Shuttle" Orbiter and the "Buran"), or at the initial leg of ascent for the boosting of the "Pegasus" launch vehicle by the carrier aircraft.

The first example of a quasi-aerospace system, which was developed up to the level that allowed the start of its realization, was, undoubtedly, the U.S.

"Dyna-Soar" which foresaw the launch of the winged manned spacecraft by a common expendable launch vehicle with a gliding descent of this spacecraft for returning to Earth (Figure 3–10). Both the "Dyna-Soar" and "Spiral" projects were actually contemporaries but, as one can see, the proposed "Spiral" system was a real aerospace system with all its characteristic features: Earth's atmosphere should be used by it at the legs of both ascent and descent, it should use common airfields instead of a special launch site, it was manned and all of its main components were reusable. (True, it had to have a sole expendable component, the Additional Booster, DU, but what of it? Aircraft were using expendable take-off boosters as well!) In a word, the "Spiral" could be a pathfinder for the way to space for aviation-like transportation systems and a realization of this way would return astronautics to the general concept of its development as a further evolution of aviation.

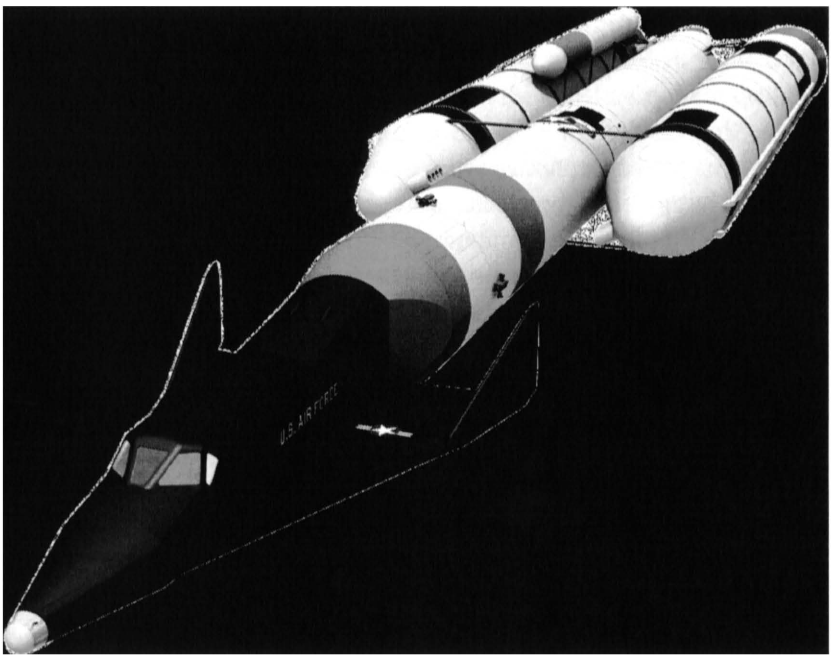



**Figure 3–10:** The U.S. "Dyna-Soar" system that would use the Earth's atmosphere on its descent leg only. Credit: V. P. Lukashenko and I. B. Afanasiev, *Kosmicheskie Krylia*, Moscow, 2009.

This concept was being proposed by certain pioneers of astronautics (for instance, by Russians F. Tsander and N. Kondratyuk) in the late 1920s of the past century: they believed that manned altitude aircraft equipped with additional (!)

rocket engines would become the first orbital spacecraft [Ref. 6]. The following successes in the developments of experimental rocket airplanes (for example, the U.S. post–World War II X-1/X-2), as it seemed, showed a beginning of this concept realization. Why, in this case, did the practical beginning of the world's astronautics use "pure rocket" technology for the delivering of any payloads into space?

A possible explanation was given in [Ref. 3]: since mankind is often selecting shorter, büt less expedient, ways to achieve its aims, that is, it always select the shortest way if it has the means for its realization in existence, and only some time later will it understand two things: first, that the selected way has some unforeseen consequences, and, second, there was another, "evolutionary" way that would have been rational, but the realization of which would require more time.

Indeed, when the means for payload launches into space (military ballistic missiles) had appeared, their designers used them for achieving this great goal. Under the thunder of triumph, it was forgotten, somehow, that these means had been intended for a quite different purpose, and that their feature of passing quickly through Earth's atmosphere at initial and end legs of flight was only a requirement for military operation (the quickness of striking a blow, and passing through an antimissile defense).

So, a completion of the "Spiral" realization (in its initial configuration) could have returned the FSU and, perhaps, the world's astronautics to this initially supposed way that could be a more rational one and promised certain significant benefits (for instance, in the economic regard, due to the system reusability). However, that did not become a reality.

The interest in aviation-like aerospace systems was and is never disappearing, but the developments of these systems projects have not achieved the level of realization that was achieved in the "Spiral" program (a description of one of most recent Russian projects of this sort can be found in [Ref. 7]). Meanwhile, the experimental results of this program and even certain laid-down "Spiral" design solutions would be useful for the realization of a similar concept when the space market demand will force this to be done.

Indeed, the current circumstances are requiring us to enhance the efficiency of space transportation systems in all regards and a realization of the above described concept would be one of the suitable methods for that.

In any case, this concept of using the atmosphere most completely should be better than the recent attempts to use rocket engines for braking a returning spacecraft in the atmosphere and even during a landing (the "Delta Clipper" and certain other more recent projects). The intention to get along without any aerodynamic support for these purposes is very suitable for the Moon, but we are living on Earth, thank God!

If this probable change of the current common approach to the provision of access into space from a "rocket break through the atmosphere" to the "aviation" approach, in which this "breakthrough" should be substituted with a real flight, will be realized, I think that the role of "Spiral" as the first-in-the-world, reusable, space transportation system of "aviation" type would be appreciated more than it has been.

## References


[1] http://www.buran.ru/htm/aviaspi2.htm.

[2] V. P. Lukashevich, I. B. Afanasiev, *Kosmitcheskie Krylia* (Moscow: 2009).

[3] O. Sokolov, "By Aerospace Plane into Space and Back," *Executive Intelligence Review*, Vol. 23, No. 21, 17 May 1996.

[4] http://www.buran.ru/htm/bors.htm.

[5] O. Lazutchenko, A. Borisov, "30 Let Nesostoyavshemusya Poletu," *Novosti Kosmonavtiki*, Vol. 13, No. 10 (249), 2003.

[6] Russian Developments in the Creation of True Spaceplanes and Their Propulsion Units, *CST Report*, 1998.

[7] The "Ajax" Project: an Attempt to Run Ahead, *CST Report*, 2001.