History of Rocketry and Astronautics

Proceedings of the Thirty-Fifth History Symposium of
the International Academy of Astronautics

Toulouse, France, 2001

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AAS History Series, Volume 32

A Supplement to Advances in the Astronautical Sciences

IAA History Symposia, Volume 21

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 2010

ISSN 0730-3564

ISBN 978-0-87703-555-8 (Hard Cover)
ISBN 978-0-87703-556-5 (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 17

Initial Stage of the Development of Space Medicine in the USSR: Dedicated to the 40th Anniversary of Spaceflight*

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Abstract

USSR space medicine made its first steps in the middle of the 1930s, when all the premises to start the practical work on the research of biomedical problems of the spaceflights on rockets were defined. During the 1950s life support, data collection, and transfer systems were being tested; experimental material on the effects of rocket flight factors (mainly microgravity) on living organism were accumulated; hypotheses of mechanisms and peculiarities of the effects of harmful factors of flight were checked and specified; and necessary infrastructures of space industry were created. Space medicine was still not an independent field science (all works were carried out by aviation medicine specialists). The main outcome of space medicine of that period was that the supposed biological human limits on the participation of humans in spaceflight were removed.

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* Presented at the Thirty-Fifth History Symposium of the International Academy of Astronautics, 1–5 October 2001, Toulouse, France.

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In order to practically achieve the task of human spaceflight, the following conditions were required:

1. The idea of human spaceflight must be rated as a real-world scientific problem.
2. There are necessary technical and financial means.
3. Absence of the evidences of fundamental impossibility for humans to survive in this environment.

The idea of human spaceflight had existed from time immemorial and had its followers among specialists in the rocketry field. The works of first spaceflight enthusiasts (K. Tsiolkovsky, F. Hoefft, H. Noordung, H. Oberth, R. Esnault-Pelterie, R. Goddard, and F. Tsander) created the initial theoretical foundation for it. The USSR's space medicine made its first steps in the middle of the 1930s, when all the premises to start the practical work on the research of biomedical problems of the spaceflights on rockets were defined. But practically all the members of the "Soviet rocketry team" were subjected to repression because of the internal political situation in the USSR at the end of the 1930s, and all the works in this direction were stopped.

During World War II Germany created, mass-produced, and launched up to 1,400 A-4 rockets and unveiled the tremendous potential of large rockets. The development of rocket military equipment that could bear a nuclear weapon was "task number one" for the Soviet government under "cold war" conditions. For this task, solving special conditions (unlimited financing, priority material and technical provision, and enrollment of personnel) was crucial.

A special group was formed in the USSR to study the German rocket experience. A new "Soviet rocket team" included V. Barmin, V. Glushko, S. Korolev, V. Kuznetsov, A. Isaev, M. Ryasansky, and others, some of whom worked in this field before the war. At the same time military missiles could be used as an instrument for upper atmosphere exploration. For members of the Soviet rocket team, it was a perfect possibility to realize their long-standing dream—human spaceflight. The study of the German rocket experience, production of missing units and equipment, and reassembling of some rockets (A-4) required a lot of time (almost two years).

In 1947–1949 six launches of A-4 rockets were conducted from the Kapustin Yar range. During these flights rocket launching technologies were worked on, the dynamics and ballistics of rocket flight were studied, and the upper atmosphere was explored. As a result the first scientific information about physical conditions of the upper atmosphere (gas composition, meteoric matters allocation, and temperature) was taken.

In 1949, the government resolved to develop rockets for research, and the first research on biological effects of rocket flight began in the Institute of Aviation Medicine of the USSR Aviation Force (IAM). The chief of the laboratory of environmental suits and pressurized cabins of IAM, V. Yazdovsky, headed the medical part of the project. He and the team of investigators from his laboratory (B. Builov, V. Popov, and A. Seryapin) had two main tasks: to substantiate a possibility for humans to fly on a rocket and to elaborate a complex of measures guaranteeing their safety in the flight. Since this time space medicine turned from scientific fiction to science.

There were theoretical reasons for believing a person could survive the conditions of spaceflight, but there were no practical proofs of it, because the majority of the flight factors could only be simulated in ground conditions, and protection from the space environment in the strict sense of the word did not exist.

Nothing was known about the existence of near-Earth radiation belts or the increased intensity of space radiation connected with solar activity. Therefore, space radiation was considered as an improbable source of genetic danger for future flights. Problems of acceleration effects during flights on airplanes were investigated, and the first methods of counteracting the unfavorable effects were developed. The matter of high-altitude hypoxia was sufficiently investigated in physiology and aviation medicine, and there was some experience with creation of artificial environments in hermetically closed volumes in underwater medicine.

There was no information on the problem of weightlessness, but moreover, there was no clear understanding of the term among doctors. In a condition close to weightlessness, pilots collided during acrobatic maneuvers (for example, return closed loop). The first publication about short-term weightlessness per capita in aircraft was made by G. Ferry in 1918.[1] Nevertheless, in the beginning, this problem had minor significance in aviation medicine. Since pilots experienced the condition for only several seconds during specific maneuvers, it was a rare phenomenon.

The efficiency of a person in near-weightless conditions was actively studied in Germany only in connection with the needs of the German Aviation Force. In 1934, H. von Diringshofen created a condition of weightlessness for seven to eight seconds on a special airplane, "Junkers-87," equipped with instrumentation for registering physiological functions and X rays. Von Diringshofen dove in an abrupt spiral from a light altitude, using the engine only to overcome frontal resistance. It was the first aviation physiological laboratory in the world. In these researches the long duration of weightlessness on airplanes was achieved.[2] The first non-experimental situation in which a person could execute various tasks during weightlessness also occurred in Germany during World War II, when German fighter pilots dove from great height to catch Allied bombers below. At the end of this maneuver, they executed a return closed loop, during which gravitational force was counterbalanced by centrifugal force. The rich experimental data accumulated by German aviation doctors (G. Strughold, U. Luft, O. Gauer, and S. Gerathewohl) during the war years was published in a two-volume manual, *German Aviation Medicine in World War II.*[3]

With these initial scientific data, Soviet scientists began development of a methodology of planning investigations. As a starting point, the methodology of aviation medicine was accepted. It assumed the analysis of an organism's response to an extreme factor would enable the development of preventive measures to protect the organism from that factor's unfavorable effects. During the preparation of experiments, team members devised techniques for simulating separate spaceflight factors on the ground, selected animals most likely to be stable in these conditions, and trained them preliminarily for flight conditions.

Systems-analysis methodology also was involved. It allowed dismembering a complex system of elements or a complex problem (or a combination of simple ones) to express them quantitatively, with a greater degree of accuracy, and to apply existing methods to solve a new problem. Well-spent units and equipment from aviation practice, for example, were incorporated in systems intended to fulfill essentially new functions—maintenance of a person during orbital flight. This approach was exact and also was used in space medicine, both for engineering life-support systems and for extrapolating facts and regularities obtained in other problem areas, certainly, with their verification in practice.

Investigators decided to study the effect of all factors directly in flight by a biological testing method and to conduct safe, complex activities. It was decided in discussions with S. Korolev, Chief Designer of rockets, and S. Vavilov, President of the Academy of Sciences of the USSR, that to go by separate, gradual learning from available problems (inductive path of knowledge), required improbable financial and temporary costs that made the design completely unreal. Investigators, therefore, selected the deductive approach, which proved fast and effective. On the basis of surveys conducted, the investigators developed the scheme of experiments, and the research was approved at a joint meeting of the Presidium of the Academy of Sciences of the USSR and the Academy of Medical Sciences of the USSR.

The first series of experiments involved vertical launches of R-1V rockets with an animal up to altitudes of 100 kilometers. This program included the choice of a suitable biological object, the development of the life-support system for a small hermetic cabin, and instrumentation and methods to study animal physiological functions in flight. The purpose was to learn the effects of a complex set of factors associated with suborbital flight, beginning with how weightlessness affected animals' main vital signs. The first rocket with dogs, Tsygan and Dezik, was launched on 22 July 1951 from the Kapustin Yar range. It reached an altitude of 100.8 kilometers and successfully landed. It was a priority of Soviet space medicine to have the first successful return of animals from a rocket flight into space. The United States began a similar biological research program in 1948 but did not return animals to Earth successfully until 20 September 1951.

From July until September 1951, a total of five USSR launches carried nine dogs (one dog was launched twice); two launches were unsuccessful (see table). The in-flight frequencies of breathing, pulse, systolic and diastolic arterial pressure, and the animal's temperature were registered. As a result of this series of experiments, researchers concluded that the effects of acceleration, space radiation, partial weightlessness, and other flight factors of flight cause practically no changes in a number of physiological and behavioral functions of animals. Furthermore, the experiments substantiated that the recording instrumentation developed was capable of obtaining scientific information in flight.

Date of Launch	**Rocket**	**Dogs**	**Result**
22 July 1951	R-1V	Tsygan and Dezik	Successful return
29 July 1951	R-1V	Lisa and Dezik	Crashed on return
August 1951	R-1V	Mishka and Chyznik	Crashed on return
August 1951	R-1V	Smelyi and Ryishik	Successful return
3 September 1951	R-1V	Neputevyi and Zib	Successful return

Before this time, some scientists said short-term weightlessness should not cause any serious changes in an organism's cardiovascular and respiratory activities. However, these statements were only theoretical reasoning based on certain assumptions. The duration of partial and full weightlessness in these experiments totaled about 220 seconds. To prolong this condition, it was necessary to increase the height of the experimental rocket flights or to leave the orbit of Earth.

In 1954, S. Korolev sent the government an offer to begin practical activities to create an artificial satellite of Earth. The offer was accepted. In parallel with vertical launches of rockets, theoretical and practical study began to determine the possibility of using unrecoverable satellites for biological experiments.

The positive results of rocket flights carrying animals enabled S. Korolev, in 1956, to propose a suborbital human flight. Planning included a role for doctors who had participated in biomedical maintenance of animals during rocket flights and, consequently, were familiar with the influence of spaceflight on an organism. There were five volunteers (A. Genin, I. Kasyan, A. Pokrovsky, A. Seryapin, and E. Yuganov) for this flight. A bit later, however, in connection with successful development activity of the orbital rocket, economies of time and means led to a decision to concentrate at once on preparation of an orbital flight.

So, during the 1950s life support, data collection, and transfer systems were being tested. Experimental material on the effects of rocket flight (mainly microgravity) on living organisms was accumulated. Hypotheses regarding the mechanisms and peculiar effects of harmful flight factors were checked and specified, and the necessary space-industrial infrastructure was created. Space medicine was still not an independent field science (all works being carried out by aviation medicine specialists).

Space medicine became a separate branch of medical science and practice during 1959–1961, when corresponding organizations were created, normative documents and a system of medical evaluation for preparation of cosmonauts were established, and finally Yuri A. Gagarin's flight took place. The main outcome of space medicine in that period was that the supposed biological limits on human spaceflight were removed.

Thus, the initial stage of development in space medicine happened during 1934–1961. The main content of this stage was proof of the absence of biological limits on human spaceflight and creation of the needed technical means. Work in this field was carried out as a purposeful program using the resources of aviation medicine and a series of other existing scientific, medical directions. During implementation of this work, space medicine was becoming a separate scientific branch.

Space medicine was formed as a means of implementing the main task of the state—to launch a human into space. In the following years there would be many different problems encountered as the duration of human orbital flights and the volume of activities there gradually increased, but breaking the main barrier of the unknown in the spring of 1961 turned space medicine into an independent science and a branch of medical practice.

Reference Notes

[1] G. Ferry, L'aptitude a l'aviation; le vol en hauteur et le mal des aviateurs (Paris: Balliere, 1918).

[2] H. von Diringhshofen, Wie wird sich der menschliche Organismus voraussichtlich im schwerefreien Raum verhalten (Weltraumfahrt, 1951).

[3] *German Aviation Medicine in World War II* (Washington, 1950).