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Determination of the flight trajectory of Gagarin's space vehicle

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This paper is devoted to works performed at the Institute of Applied Mathematics of USSR Academy of Sciences on Determination of Flight Trajectory of Space Vehicle with Yu.A. Gagarin on Board and recollections of eye-witnesses.

Keywords: Keldysh Institute of Applied Mathematics RAS, trajectory of Gagarin's flight

Presentations devoted to Yu.A. Gagarin were given in many sections of the annual Gagarin's Readings, an important international scientific and technical conference. Various aspects of Gagarin's life and activity, his character and passions were discussed; it seems that no gap has been left unfilled. Already 33 conferences have been held, and at each of these conferences reporters introduced new unknown facts connected with the flight of Yu.A. Gagarin. However, to the best of my knowledge, the following important questions have never been discussed: the choice of the orbit of Gagarin's flight, the author of methods and programs, computers used for calculations of the flight trajectory, i.e., the problems of ballistics, a separate science without which a flight of a rocket is impossible. A large group from different organizations is engaged in this problem. These organizations include the M.V. Keldysh (Fig. 1) Institute of Applied Mathematics (IAM) RAS as one of the leading computing centers in the large coordination-computer center.

The aim of this report is the presentation of the facts known from those IAM employees who participated directly in calculation of the trajectory of Gagarin's flight. Among those who provided information in private talks are the head of Programming Department of the Institute Mikhail Romanovich Shura-Bura (Fig. 2); Eduard Zinov'evich Lyubimskii (Fig. 3) who was in charge of calculation of deceleration; Galina Nikolaevna Ezerova (Fig. 4) responsible for the passive section flight of the space vehicle, and the chief of calculations performed at IAS and Chief Scientific Advisor of all Computer Centers which took part in this project Academician Timur Magometovich Eneev (Fig. 5).

To our deep regret a number of colleagues who participated in those events have already passed away: head of Department no. 5 Academician Dmitrii Evgen'evich Okhotsimskii (Fig. 6) who was the leader of the space topics at the Institute; head

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Figure 1



Figure 2

of Department Doctor of Physical and Mathematical Sciences Vsevolod Serafimovich Shtarkman (Fig. 7); and senior scientist Igor Borisovich Zadykhailo (Fig. 8); they were responsible for calculation of the active section.

Our institute was created as a separate organization in 1953 by a special resolution of the government for the calculation of problems related to the development of the nuclear shield in the country. Academician M.V. Keldysh was appointed the Director.



Figure 3



Figure 4

The Institute received the status of a PB ("post box"). However, according to T.M. Eneev, there was an addition made by the Central Committee which allowed Mstislav Vsevolodovich to have a department for the determination of rocket flight dynamics.

The Computer Center was not legalized in the framework of our Institute yet but, according to the agreement with S.P. Korolev, we had to repeat all calculations made by OKB-1 and NII-4 and provide real-time tracking of all rocket launches.



Figure 5



Figure 6

The work on the calculation of the trajectory of Gagarin's flight at our Institute was headed by Timur Magometovich Eneev who derived formulas for programming at "Strela-1" computer (in those years, our Institute had advanced domestic computing technique). The program of calculations included the calculation of the active section with strict program of engine operation and rocket stage separation, calculations of the passive section of the trajectory, and the deceleration section with account of the atmosphere model.



Figure 7



Figure 8

The obligatory procedure was the matching of flight trajectories with NII-4 and flight mission with OKB-1. Once, a curious case happened when S.P. Korolev asked M.V. Keldysh to direct D.E. Okhotsimskii and T.M. Eneev to OKB-1 to verify the flight mission formulated by experts in ballistics under the leadership of S.S. Lavrov. It should be mentioned that we had the closest cooperation with Svet Sergeevich Lavrov and his colleagues. Timur Magometovich told: "If we come as inspectors, it would be awkward. However, Mstislav Vsevolodovich said that he understood



Figure 9

everything, but the matter was serious, the request of Sergei Pavlovich. We went to OKB-1, feeling embarrassed: 'Guys, we were told to check the flight mission.' They laughed, brought all the materials, and the prepared mission. We checked everything accurately, signed the draft, then had some tea and left."

It should be recalled that the following factors played the decisive role in the field of flight of a manned space vehicle:

(1) Already in 1953 T.M. Eneev proposed ballistic descent of a man along a flat trajectory (earlier descent on wings was planned, but such a vehicle would not be ready soon). Timur Magometovich managed to calculate that at ballistic descent overload would not exceed 9, which is below the overload margin. Timur Magometovich showed his results to Yazdovskii and he said: "Pilots undergo higher overloads". Keldysh did not sign the report during the whole year. It was checked at Belka and Strelka. The priority of Timur Magometovich, among others, in proposing ballistic descent of a man was noted in Demidov Prize.

(2) Timur Magometovich was the first to calculate the burn of the space vehicle in the case of ballistic descent. The cone (the preliminary variant of spherical space vehicle was proposed by K.P. Feoktistov) had a double coating: an upper layer, silicon carbide, and a lower layer, asbestos-reinforced laminate (less refractory material with lower heat conduction). When the sphere was manufactured at OKB-1, the asbestos-reinforced laminate coating with increased thickness was left. Part of the burn was carried off during descent, and the remaining part prevented the iron frame of the space vehicle from overheating. The result was shown to physicians and they said that everything was normal. Roshchin who worked at OKB-1 calculated the size of the coating. Before the launch of Gagarin our Institute had the long-term experience of calculating flight ballistics of military rockets and flights to the Moon and planets. But in the case of a manned flight additional resources were necessary for everything to be

done accurately, and the programming department headed by M.R. Shura-Bura was engaged in the calculations. Efraim Lazarevich Akim (Fig. 9), now the Correspondent Member of RAS, Deputy Director of our Institute, worked in this department at that time. Before the launch of a man, he and other scientists of the department calculated ballistic trajectories of "number seven", the famous "semerka".

It is interesting that not many people knew about the launch of Gagarin beforehand: Eneev, Okhotsimskii, Shura-Bura, Platonov. Other colleagues considered this calculation as a regular launch of either a dog, or a dummy. The space vehicle with Gagarin was brought to the nominal trajectory. And in the morning the announcer Levitan informed everyone of this historical event. Calculations of flight trajectories of space vehicles with the cosmonauts Titov, Nikolaev, Bykovskii, Tereshkova, etc. followed. Pavel Efimovich El'yasberg carried out great and important work at NII-4. At the beginning of space rocket technology when NII-4 still had no computers, the graphic-analytical method for calculation of a satellite motion using optical observations was created by him; this method provided good precision. At present, all works on the calculation of flight trajectories of manned space vehicles and design works for future flights to planets and comets are performed at M.V. Keldysh IAM.



Figure 10 The cosmonaut G.S. Titov in the Institute of Applied Mathematics RAS.

The following curious story of recent time is told: when the electricity at our computer center was switched off we could not perform calculations in parallel with TsNIIMASh to back them up. Then Utkin sent a government telegram stating that he freed himself from responsibility for military operation and the launch of the cosmonaut. The electricity was switched on immediately. The authorities were frightened.

T.M. Eneev thinks that at present there are two topical problems in space:

(i) the main problem is to understand the Earth's structure and find the relic matter;



Figure 11 The 20 year jubilee of IAM.

(ii) the second problem is the asteroid danger.

In conclusion I would like to note the immeasurable importance of our Director, Academician, "chief theoretician of cosmonautics", AS USSR President Mstislav Vsevolodovich Keldysh in the field of development of space science and technique; no space undertaking was held without his approval.