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Chapter 5

A *Sputnik 4* Saga*

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Abstract

The *Sputnik 4* launch occurred on 15 May 1960. On 19 May, an attempt to deorbit a "space cabin" failed and the cabin went into a higher orbit. The orbit of the cabin was monitored and Moonwatch volunteer satellite tracking teams were alerted to watch for the vehicle demise. On 5 September 1962, several team members from Milwaukee, Wisconsin made observations starting at 4:49 a.m. of a fireball following the predicted orbit of *Sputnik 4*. Requests went out to report any objects found under the fireball path. An early morning police patrol in Manitowoc had noticed a metal object on a street and had moved it to the curb. Later the officers recovered the object and had it dropped off at the *Milwaukee Journal*. The Moonwatch team got the object and reported the situation to Moonwatch Headquarters at the Smithsonian Astrophysical Observatory. A team member flew to Cambridge with the object. It was a solid, 9.49 kg piece of steel with a slag-like layer attached to it. Subsequent analyses showed that it contained radioactive nuclei produced by cosmic ray exposure in space. The scientists at the Observatory quickly recognized that measurements of its induced radioactivity could serve as a calibration for similar measurements of recently fallen nickel-

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iron meteorites. Concurrently, the Observatory directorate informed government agencies that a fragment from *Sputnik 4* had been recovered. Coincidently, a debate in the United Nations Committee on Peaceful Uses of Outer Space involved the issue of liability for damage caused by falling satellite fragments. On 12 September, the Observatory delivered the bulk of the fragment to the U.S. Delegation to the United Nations. Two days later, the fragment was used by U.S. Ambassador Francis Plimpton as an exhibit that the time had come to agree on liability for damage from satellite debris. He offered the *Sputnik 4* fragment to USSR* Ambassador P. D. Morozov, who refused the offer. On 23 October, Drs. Alla Massevitch and E. K. Federov of the USSR visited the Observatory. They were shown the *Sputnik 4* fragment. Measurements on the fragment were reported at the American Geophysical Union meeting on 28 December 1962. Early in January, 1963, the Soviet Embassy told the State Department that the USSR wished to accept the remaining fragment. On 5 January 1963 it was picked up by the Soviet Embassy. This four-month saga dramatically illustrated the need for international agreements on satellite debris issues.

Background Circumstances

With the launch of *Sputnik I* and the opening of the space age, a new phenomenon confronted mankind—namely the return of orbiting objects into the atmosphere and the impact of surviving fragments onto the surface of Earth. No international laws or agreements specifically addressed such events. Hence this situation was one of the topics brought before the United Nations Committee on Peaceful Uses of Space when it was established in 1959.[1]

There were, however, technological precedents for artificial satellite plunges into the atmosphere. The meteor and meteorite phenomena are natural occurrences similar to satellite demise events. Also the technology of ballistic missiles involves warheads entering the atmosphere after suborbital flights.

Another new enterprise spawned by the space age was tracking objects in orbit and monitoring the parameters of their individual orbits. In the United States, the Smithsonian Astrophysical Observatory (SAO), under its director, Fred L. Whipple, was given the task of employing optical techniques to track the satellites launched for the International Geophysical Year.[2, 3] Concurrently, SAO also had very active meteor and meteorite research programs.[4] Having these meteor, meteorite, and satellite tracking programs, it was natural for the scientists at SAO to wish to study the related phenomena of satellite entry, starting with *Sput-*

* Union of Soviet Socialist Republics, or Soviet Union.

nik 2.[5] Another historic opportunity to do so resulted from the entry of objects from the *Sputnik 4* mission.[6]

The *Sputnik 4* Demise

The Soviet Union launched *Sputnik 4* on 15 May 1960 from Tyuratam. The mission was announced as a test of life support systems to be used later for cosmonaut missions.[7] On 19 May, an attempt to deorbit a "space cabin" failed, and the cabin (designated 1960 epsilon 1) went into a higher orbit.[8] The launch vehicle (1960 epsilon 2) remained in the original orbit. Additionally, seven small objects resulting from the deorbit attempt went into individual orbits. The orbit of 1960 epsilon 1 was one of several monitored by SAO. In late August 1962, the orbit parameters indicated that its demise was imminent.

In the first years of the space age, analytical tools to predict the place and time for a satellite's final plunge into the atmosphere were the subject of serious development efforts, for example.[9, 10] In 1962, such predictions were quite uncertain. Hence, SAO Headquarters on 28 August 1962 alerted the stations in its international tracking networks to be prepared on 6 September (plus or minus one day) to observe the demise of 1960 epsilon 1 whenever the satellite orbital plane was visible from the station.[11]

On Wednesday, 5 September, starting at 4:49 a.m. local time, members Gale Highsmith, Leonard Schaefer, and Raymond Zit of the Milwaukee, Wisconsin, Moonwatch satellite tracking team saw a "bright reddish-orange star-like thing" cross the sky from the northwest to the southeast.[11] It appeared to split up into several pieces, moving along the predicted *Sputnik 4* path. The glowing pieces vanished before reaching the horizon. Many other early risers in the region saw the same spectacular sight, which was promptly featured in the media. The Moonwatch members immediately reported their observations to SAO Headquarters and communicated with local officials and media personnel, requesting to be notified if any suspicious fragments were found on the ground.

The Fragments

That afternoon, Wednesday, 5 September, *Milwaukee Journal* personnel informed Ed Halback, the Milwaukee Moonwatch team leader, that a suspicious fragment had been delivered to them. Halbach at once picked up the object at the newspaper and learned of its history.[11]

At about 5:30 a.m., two Manitowoc, Wisconsin, policemen on routine driving patrol saw what looked like a piece of cardboard in the street in front of the local museum. They passed the site again at about 7:00 a.m. and stopped to examine the object. It was a piece of metal embedded some 2 or 3 cm into the asphalt. They are quoted as saying it was hot. To remove the hazard to traffic, they moved it to the curbside.

Later Wednesday, the officers heard news accounts of the possible *Sputnik 4* breakup and the request that suspicious objects should be recovered. They returned to the curbside by the museum and moved the metal object to police headquarters. A motorist carried it to the *Milwaukee Journal*, where Halbach picked it up.

Late in the day, Wednesday, Ed Halbach called SAO Headquarters in Cambridge, Massachusetts, to report and discuss the situation. The object seemed on casual examination to be a heavy disk-like piece of solid iron nearly 20 cm in diameter and about 8 cm thick. This was hardly the sort of material used in constructing weight-critical U.S. satellites, and hence the initial reaction of SAO personnel was doubt that this was a satellite fragment. Nevertheless, a member of the Moonwatch team was authorized to fly from Milwaukee to Cambridge with the object.

At 3:15 on Thursday, 6 September, Gale Highsmith arrived at SAO Headquarters with the object. Drs. Ed Fireman, Dave Tilles, and Dick McCrosky, meteorite experts, met with Moonwatch Director Dick Vanderburg and the author to plan its detailed examination.[12] It was weighed (9.49 kg), measured, and extensively photographed before a first, pie-shaped specimen was sawed from it for analysis (Figure 5–1). The original specimen was further divided into segments to be sent to various laboratories. Most of the resulting analyses took some time and were reported only later, but rudimentary tests suggested that the unmelted body was a common steel. Also the saw cut exposed a bolt in the slag-like material on one side. The bolt had one thread per millimeter, a standard metric dimension not common in the United States at the time. A bolt hole in the middle layer had a 0.75 cm diameter. These and other exact metric dimensions suggested that this was not a common piece of U.S. junk that had fallen off a passing truck. At a meeting with Dr. Whipple later in the day, all participants agreed that in spite of strong circumstantial evidence, definitive proof was needed that the object had been in space.[12]

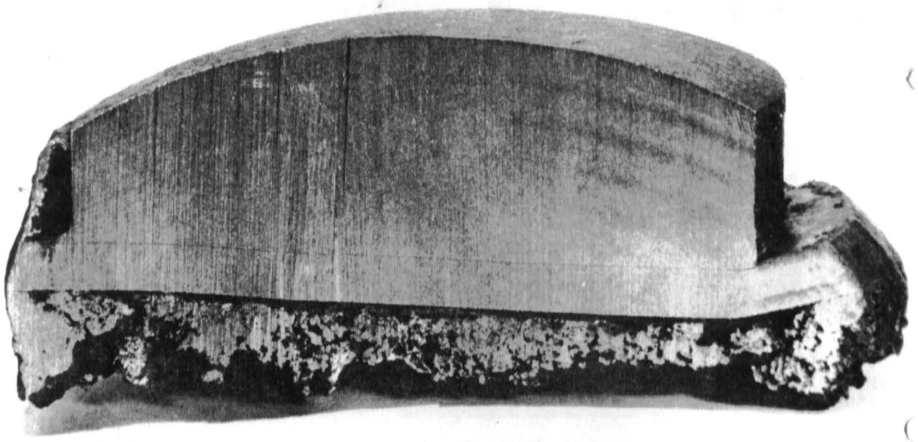

Figure 5–1: The fragment found in the street in Manitowoc, Wisconsin, after slices have been sawed off to obtain specimens to be distributed for analysis. In this view, the upper unit is a cylinder with a rounded top. It is welded to a circular plate of larger diameter. Below the plate in this view is a mass of material that was melted and resolidified. This is the fragment as returned to the Soviet Union. Credit: SAO.

The definitive proof that a body has been in space for an extended period can be provided by measurements of slight, specific radioactivity induced in the body by exposure to cosmic radiation. Bodies on the Earth surface are shielded by the atmosphere from virtually all such cosmic radiation and do not have induced radioactivity. The meteorite laboratories at SAO were prepared to make these measurements, because the laboratories routinely made similar measurements on nickel–iron meteorites.

While the study of the Manitowoc fragment was in process in Cambridge, SAO dispatched Walter Munn from its meteorite team to seek other fragments.[13] He found a number of small metal objects that were candidates for *Sputnik 4* fragments (Figure 5–2). For example, he collected tiny melted iron pellets on the flat roof of a church in Manitowoc. He also noted reports of the sonic booms associated with the satellite entry.

In Cambridge, after a couple days of laboratory analysis, vaporized specimens of the Manitowoc fragment showed traces of argon-37 and manganese-54, which are distinctive induced radioactive isotopes. This was the first time that such radioisotope measurements were employed to prove that a recovered body had indeed been in space. The circumstances of its discovery showed that it must have been part of *Sputnik 4*.

Figure 5–2: Gale Highsmith, left; Dick Vanderburgh, center; and Ed Halbach, right; examine some of the smaller fragments recovered by Walter Munn. Credit: SAO.

Washington D.C.

Following the Moonwatch observations of the fireball over Wisconsin and during the subsequent developments, SAO had, of course, transmitted timely messages to the Washington headquarters of the Smithsonian Institution and the National Aeronautics and Space Administration (NASA), giving the progress of the investigations. On Tuesday, 11 September, after the definitive radioactivity results were known, Carlton Tillinghast (SAO Assistant Director for Administration) and the author (then SAO Assistant Director for Science) visited Washington, where they gave a briefing to NASA officials, G. A. Vacca and Leo Abernathy.[14]

These NASA officials related that the United Nations Committee on Peaceful Uses of Outer Space was currently meeting in New York, and that at some time before the current series of meetings ended, the United States desired to offer the remaining *Sputnik 4* fragment to the USSR. Later, Tuesday evening, Vacca informed the author that a larger briefing was wanted in Washington the next afternoon, and that the fragment, less the specimens removed for analysis, needed to be at the offices of the U.S. delegation to the United Nations by "tomorrow night."[14]

At 4:00 p.m. on Wednesday, 12 September, a meeting on the *Sputnik 4* status convened in NASA Headquarters, chaired by G. A. Vacca.[15] After an introduction by him, the SAO attendees, Dr. Richard McCrosky, Dr. David Tilles, and the author, presented the SAO observations and results. The *Sputnik 4* fragment was available for examination. Also attending the meeting were representa-

tives from many government agencies. The SAO delegation answered questions from the other attendees and left a set of informal notes with Mr. Vacca. Before the meeting ended, a representative from the Department of State read a proposed press release.

The United Nations

After the Washington meeting ended, the SAO party flew to New York and reached the offices of the U.S. delegation to the United Nations at 9:00 p.m.[15] Arnold Frutkin, Peter Thacher, Leonard Meeker, and Robert Packard were present from NASA and the Department of State. Dr. McCrosky, Dr. Tilles, and the author presented an abbreviated version of the afternoon briefing. The residual *Sputnik 4* fragment (6.4 kg) was left with the delegation officials.

The next morning, Thursday, 13 September, the SAO representatives met again with the staff of the U.S. delegation. The SAO personnel clarified and expanded on aspects of the briefings on the previous day. At mid-day, they returned to Cambridge.

On taking office, President John F. Kennedy appointed Adlai Stevenson to be the U.S. Ambassador to the United Nations. Ambassador Stevenson in turn, recruited Francis T. P. Plimpton to be the number-two man at the U.S. delegation, also with the rank of ambassador. Aldai Stevenson and Francis Plimpton were former Harvard Law School roommates and had been close friends since then. Stevenson went into politics and Plimpton was a prominent New York attorney when recruited by Stevenson.[16] Thus, in September 1962, Ambassador Plimpton was the senior U.S. diplomat representing the United States in the United Nations Committee on Peaceful Uses of Outer Space.

At that time, the USSR senior representative for this committee was Ambassador P. D. Morozov, who had been at the United Nations for many years. He was later a member of the International Court of Justice from 1970 to 1985.[17]

At 10:30 a.m., Friday, 14 September 1962, Chairman Matsch of Austria convened the Committee on Peaceful Uses of Outer Space to continue general debate. After some other speakers, A. A. Blagonravov from the USSR spoke.[18] He emphasized eloquently that "the peaceful conquest of space is essentially scientific . . ." and concluded with the statement "during the launching of the first artificial satellite in 1957, if anyone said that in less than four years a Soviet man would conduct a space flight, he would have been deemed raving or at least an extreme optimist. Now a month ago, thanks to the creative work of Soviet scientists and engineers, a strikingly accurate cosmic flight of two cosmonauts took place."

Subsequently, Ambassador Plimpton spoke.[19] After first commenting on the general principles of previous Soviet remarks, he continued "But I should like to say something about the importance of practical constructive steps to develop the law of outer space. I should like to give you tangible evidence of what the United States believes is the need for early consideration of the practical problems of space law. Very early on the morning of 5 September, a metal object weighing approximately twenty pounds landed on a street in Manitowoc, Wisconsin."

He then recounted the SAO observation of the entry of *Sputnik 4* and the analysis of the recovered fragment. Ambassador Plimpton then continued "I have here today the remaining fourteen pound portion of the steel object found in Manitowoc." After offering a written report on the analysis, he continued "We are prepared to turn over the fragment to Soviet representatives and will be glad to deliver it to Mr. Morozov now or at any time of his choosing . . . What we have on this table is tangible evidence of the practical need to work out agreed rules and procedures for dealing with damage caused by objects launched into outer space."

In reply, Ambassador Morozov spoke.[20] "There is no need, with such dramatic stage setting, to put a piece of metal on the table to show that the penetration of satellites can be damaging to humanity, as described here by Mr. Plimpton. I do not know to whom this piece of metal belongs, whether it belongs to the United States, to the Soviet Union or to any other state . . . If these dramatic means are utilized here, we can only express our regret that they are used in order to divert our attention from important and great issues."

After further speakers and debate, the *Sputnik 4* fragment remained on the table at the end of the day. It was retrieved by staff members of the U.S. delegation.

In retrospect, Ambassador Plimpton relates his memory of the debate with Ambassador Morozov:[21] "I produced this thing the size of a football at a time when the United States was pressing for an international agreement on liability for accidents originating in outer space. I asked my Soviet counterpart to come and get it. He looked at it as though it were a viper." Richard Gardner, Plimpton's deputy at the time, describes the event as one of Plimpton's finest hours.[21]

American Geophysical Union

While the political implications of the *Sputnik 4* demise were being debated, scientific analysis based on the Manitowoc fragment continued vigorously. During the first days after the fragment reached Cambridge, SAO had distributed

a number of specimens to various laboratories and organizations for analysis. During a period after the United Nations debate, while the remaining bulk of the Manitowoc fragment was in NASA custody, it was loaned to other laboratories. On 22 October, the fragment returned to SAO to be available for still further studies.

The scientific interest in the *Sputnik 4* specimens arose largely from their similarity to nickel–iron meteorites. The study of trace radioactivity, produced in such meteorites by exposure to particle radiation in space, was a relatively recent topic, which was actively being pursued at several laboratories. The *Sputnik* fragment had similar chemical composition to metal meteorites, and it had been exposed to the radiation in space for a known length of time. Hence it was a baseline sample that could be measured to validate the interpretation of comparable meteorite measurements.

Drs. Ed Fireman and Dave Tilles of SAO monitored the various laboratories' results. They proposed and planned a group of papers in a special late results session at the Western National Meeting of the American Geophysical Union in December 1962.[22] This group of seven presentations was organized to provide an opportunity for various investigators to present their findings and to compare their results with other investigators. The session began at 9:00 a.m. on Friday, 28 December. It is not appropriate here to attempt an interpretation of the presentations, but the range of topics and participants is instructive.

The first paper was by Bill C. Giessen and Nicholas J. Grant of the Massachusetts Institute of Technology. They presented a metallurgical investigation of the *Sputnik 4* fragment and reported that the smaller diameter unit was 0.32 percent carbon steel and the larger diameter plate was hot-rolled 0.21 percent carbon steel. The melted, irregular material consisted of decarburized iron with spheroidal oxide inclusions and nitride needles. The steels were common materials.

A second paper was by Ursula B. Marvin of SAO, who studied the mineralogy of the melted material. Among the several minerals found, wüstite (FeO) was a surprise, because it was expected to be an unstable compound below 570° C. Wüstite was previously unknown as a natural mineral in terrestrial rocks or in meteorites. This *Sputnik 4* finding motivated a search for wüstite in the melted crusts of a number of meteorites, and it was indeed identified in a few.

Another paper from SAO, by D. Tilles, E. L. Fireman, and J. DeFelice, reported on the Hydrogen 3 (tritium, or ^{3}H) and the Argon 37 (^{37}Ar) activities in the *Sputnik 4* specimens. The observed amount of radioactive ^{37}Ar can be explained by the radiation environment to which the fragment was exposed. The measures of ^{3}H were less than might have been expected. The ^{3}H was presumably lost due to heating during entry into the atmosphere.

A paper by J. P. Shedlovsky and J. H. Kaye of the Carnegie Institute of Technology, discussed other radioactive nuclides produced in *Sputnik 4* by cosmic rays. They reported nuclides such as Cobalt 56 (^{56}Co) and Cobalt 57 (^{57}Co).

Ernest C. Anderson and M. A. VanDilla from Los Alamos Scientific Laboratory, performed gamma-ray spectrometry of the residual fragment of *Sputnik 4*. They identified a number of cosmic-ray induced spallation products, including Manganese 54 (^{54}Mn), Vanadium 48 (^{48}V), and Scandium 46 (^{46}Sc).

A measurement of positron decays in the fragment was made by John T. Wasson of Air Force Cambridge Laboratories. Much of the positron activity reduced over time with a half-life of about one week. This is attributable to short-lived nuclides, such as Manganese 52 (^{52}Mn).

A final paper by O. F. Kammerer, R. Davis, H. L. Finston, and J. Sandofsky of Brookhaven National Laboratory gave further detailed chemical and metallographic analyses of the fragment.

Written versions of several of these talks at the American Geophysical Union meeting, and other related papers, have been published in the standard scientific literature.

Massevitch and Fedorov

Two Soviet space program officials, Alla Massevitch and E. K. Fedorov, visited SAO on 23 October 1962 (Figure 5–3).[23] Dr. Massevitch, an astronomer by education, had been asked to organize the Soviet optical satellite tracking program[24] in much the same way as Dr. Whipple had been asked to organize the U.S. program. The two satellite tracking programs maintained communications and exchanged data. Her visit to SAO was in part for coordination discussions. E. K. Fedorov was one of the Soviet officials quoted by writer Evert Clark in his article on the mission of the *Sputnik 4* satellite.[7]

During their visit they were given a briefing and documentation on the *Sputnik 4* events. They were told of the plans for the December session at the American Geophysical Union meeting. Also they were shown the major recovered fragment (Figure 5-1) and told of Plimpton's offer. They exhibited appreciable interest in these matters.

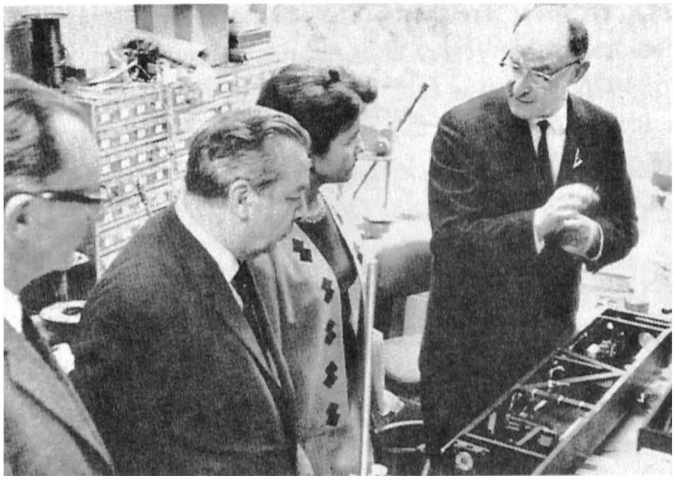

Figure 5–3: SAO Director Fred L. Whipple (left) and Harvard College Observatory Director Leo Goldberg (right) brief E. K. Fedorov and Alla Massevitch at their visit in Cambridge. Credit: SAO.

Finale

In a 31 December phone conversation with Leo Abernathy, NASA Headquarters, the author was informed that the Soviet Embassy had recently requested that the U.S. Department of State return the residual *Sputnik 4* fragment, as offered by Ambassador Plimpton.[25] The author suspects, but cannot confirm, that this change of Soviet attitude was a consequence of the Massevitch and Fedorov visit to SAO.

On 2 January 1963, the author delivered the *Sputnik 4* fragment to Mr. Abernathy at NASA Headquarters.[26] Mr. Abernathy then transferred it to the Department of State. A representative from the Soviet Embassy picked it up at the Department of State on 5 January, exactly four months after it fell to Earth.

The sequence of events following the entry of the 1960 epsilon 1 component of *Sputnik 4*, of course, received widespread press attention. A *New York Times* article by the renowned space journalist, Walter Sullivan, is an excellent example of many such accounts.[27] Satellite entry events were press-worthy features of the new space age. They motivated consideration of the new legal issues.

Debate continued in the United Nations Committee on the Peaceful Uses of Outer Space. As related by Nandasiri Jasentuliyana,[27] "The first significant step in the development of space law was made in 1963 when the U.N. General Assembly adopted the 'Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space.'" This resolution formed a

basis for the Outer Space Treaty of 1967. The 40th anniversary of this treaty is being commemorated this year. Other treaties followed, including the Liability Convention of 1976. Now it is established who is liable for damage from falling space debris. It is also accepted that items recovered on Earth are to be returned to the satellite-owner state.

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