A success story for the
Federal career service

DEATH OF SPUTNIK IV:

Main Street, U.S.A.

The Russians hurled a 5-ton spacecraft into orbit in May 1960. Two weeks later they attempted reentry maneuvers. Something went wrong, and the wayward satellite swung into a higher orbit. Nearly 28 months later it plunged to earth over Wisconsin. Federal scientists of the Smithsonian Astrophysical Observatory, Cambridge, Mass., and volunteer Moonwatch teams were waiting for it, and retrieved what was left of the Russian prize.

The *Journal* presents here the story of their successful recovery and scientific analysis of the surviving fragment.

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ON SATURDAY, JANUARY 5, 1963, representatives of the Soviet Embassy in Washington formally accepted from the United States the last remains of Sputnik IV—a 14-pound chunk of blackened metal. The acceptance occurred only after a long series of negotiations following the initial American offer of the fragment at the United Nations.

Today the Sputnik fragment is undoubtedly back home in Russia, where by international agreement it rightfully belongs. It might even be on display in a Moscow museum—a disappointing thought to those who felt it should be turned over to one of our own museums, either to the Smithsonian or to the museum in Manitowoc, Wis. Why Manitowoc? Because the fragment, as part of the satellite, had whizzed through space for nearly 28 months and had crashed to earth in the middle of a Manitowoc street—practically in front of the community's own museum!

The Russians had hurled the 5-ton spacecraft into orbit on May 14, 1960, and had announced that this was to be a test of their life-support system. (This was before their successful Vostok flight.) The satellite, they said, carried a dummy cosmonaut in a pressurized cabin, and was programed for reentry maneuvers. Two weeks later, the retrorockets were fired to slow the spacecraft for reentry. However, something went wrong. The retrorockets obviously fired in the wrong direction, for the vehicle broke into several pieces and swung into a higher orbit that ended more than 2 years later on a Manitowoc street.

A disappointment to the Russians, yes. But the recovery and scientific analysis of the Sputnik fragment spelled high success to the Federal career scientists of the Astrophysical Observatory of the Smithsonian Institution (SAO), Cambridge, Mass., and to their volunteer Moonwatch teams scattered around the world.

THE STORY BEGINS . . .

Many people were involved in the recovery of the Sputnik IV fragment. In terms of numbers, the members of Moonwatch comprised the largest group.

"Boy Scouts to bankers" has often been used to describe the composition of Moonwatch teams—groups of volunteer citizens who have proved themselves valuable participants in the space age. Though they come from all walks of life and represent different age groups, they all have at least three things in common: some knowledge of astronomy, a deep interest in what's going on over-

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head, and a desire to participate in space adventures.

Moonwatchers, known as MW's, are scattered around the world. Today there are 94 registered teams (60 of them in the U.S.), averaging 10 members each. Their activities are directed by Richard C. Vanderburgh, Chief, Moonwatch Operations, Smithsonian Astrophysical Observatory.

The MW's put themselves on the map at the very beginning of the space age. Already organized and partially trained to help make visual observations during (and after) the International Geophysical Year, they were ready to respond when Russia caught the free world off-guard with the launching of Sputnik I on October 4, 1957. Our tracking stations were not yet fully operational, so the MW's headed for the fields and rooftops and provided our first direct information on the orbit and other characteristics of the satellite.

During the years since Sputnik I, the Moonwatchers have performed a variety of useful services. However, the growing sophistication of our electronic and camera tracking systems threatened to put them out of business. Dr. Fred L. Whipple, Director of SAO, had other ideas.

At the third annual MW Teamleaders Conference at SAO in May 1962, Dr. Whipple gave renewed emphasis to visual observations of reentering satellites as an MW project. Up to that time, the SAO-Moonwatch efforts to recover satellite fragments, supported in part by a NASA grant, had been unsuccessful. Dr. Whipple suggested an intensified effort, pointing out that with more and more satellites going up, and more and more coming down, the chances for success were getting better. He felt that MW observers would have a better chance for success than the Baker-Nunn camera stations, since skypatrols can continuously cover the entire sky. This point was strengthened by the fact that the final orbits of reentering satellites change very rapidly, making it difficult to know where and when to point the large cameras.

An all-out planned satellite recovery project seemed a natural enterprise for SAO to undertake, with their worldwide network of MW's, camera stations, and communications systems. Also, they had been engaged in recovery of meteorite fragments and had an excellent laboratory that was doing radioisotope analyses of the fragments.

Dr. Whipple's suggestion was adopted, but the MW's and SAO scientists who would work hand-in-hand on the project knew full well that the chances for early success were slim indeed.

. . . WITH A STACKED DECK

What were the chances for recovering a satellite fragment? Better than ever before, but not good enough to warrant hopes for an early recovery.

Four-fifths of the earth's surface is water. Of the one-fifth that is land, a large proportion is behind the Iron Curtain. Then, too, a large part of Free World land is uninhabited, forested, mountainous, etc. All of which means, of course, that for a successful recovery, a satellite (or fragments) would have to survive the flaming plunge through the earth's atmosphere and would have to fall on inhabited Free World land. The reentry would have to be observed; the point of impact calculated; and the surviving fragments located. This would surely happen, the SAO scientists reasoned, sooner or later—probably within 1 to 10 years. Undaunted by such poor odds, they knew that a successful recovery would have great scientific value in the fields of radiation and meteoritic studies, especially since the amount of time the fragment had spent in space would be known precisely.

The U.S. had previously recovered some fragments from space, mostly pieces of rocket casings that had been up for only a few orbits, but we had never recovered any satellite fragment that had been exposed to the space environment for any length of time. It was this latter condition that interested the SAO people.

A TRIAL RUN

As an experiment, the Moonwatch Division made plans to conduct an organized skypatrol in an attempt to observe the next large reentering satellite—which happened to be Sputnik IV. The U.S. Space Detection and Tracking Center (SPADATS) had predicted reentry of this satellite to occur on or about September 6, 1962. Exact time and place of reentry: unknown.

Using their own approach to the problem, plus basic information provided by SPADATS, the Moonwatch Division outlined for the IBM–7090 computer a basic program that would produce detailed information as to when a given observation station would pass beneath

REENTRY FACTS

As an orbiting satellite begins to lose its energy, each successive orbit brings it closer and closer to earth. As this happens, atmospheric resistance removes more and more energy during each orbit. Ultimately it will reach a point where its velocity cannot offset the pull of earth's gravity, and reentry begins.

Reentering at a speed of around 5 miles-per-second, the body begins to experience sufficient air friction about 60 miles up to cause it to heat up and glow—and thus to be visible from the ground. The final, uncontrolled plunge to earth creates destructive temperatures that can vaporize the hardest steel. The distance from the first glow-point to the point where surviving fragments (if any) strike the ground can be several thousand miles.

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the satellite's orbit during its final revolutions. From the computer output, a table showing such information (called a "prediction ephemeris") was carefully prepared.

On August 29, 1962, MW headquarters airmailed instruction packets to about 750 addresses, including those of MW teams, phototrack members, observatories, colleges, universities, and other interested groups throughout the world. MW had decided to scan the skies around the clock on September 5, 6, and 7—or until it was known that Sputnik IV was down.

The prediction ephemeris was sent to all MW teams with instructions to set up shifts to monitor each pass of the satellite over their stations. A covering letter said, in part: "Our main purpose will be to try out techniques and procedures for determination of the region of impact by the pieces of the satellite which survive the plunge through the atmosphere. . . ."

A trial run, the attempt was to be. Nothing more.

DEATHWATCH AND A FIERY PLUNGE

ON TUESDAY NIGHT, September 4, Milwaukee MW team leader Ed Halbach and his assistant, Gale V. Highsmith (both industrial engineers), held a brief training session at the observatory of the Milwaukee Astronomical Society (an amateur group) to prepare their team for effective reentry sky patrol. Similar sessions were the order of the day at other MW locations around the world. The ephemeris indicated that the orbital plane of Sputnik IV would be over Milwaukee at 8:25 that night. The team monitored the pass, but nothing happened.

Observers Leonard Schaefer and Raymond Zit planned to continue the Milwaukee patrol from the observatory at the next orbital pass predicted for 4:58 the next morning. Highsmith would observe independently 20 miles away from a small hill near his home in downtown Milwaukee. The MW's went home, set their alarm clocks, and were back at their stations by 4:00 a.m.

At 4:49 a.m., Wednesday, the incredible happened. Highsmith saw just what he was looking for: coming from the northwest was a bright reddish-orange starlike fireball. It appeared to split into several pieces—exactly as a disintegrating satellite might behave. The pieces streaked to the southeast—along the predicted Sputnik path—and Highsmith was able to get a compass fix on them before they vanished.

Schaefer and Zit saw much the same thing (but got no fixes), and so did Wisconsin policemen, farmers, and other early risers. Most witnesses reported seeing as many as 24 pieces, and some reported a "thunderlike noise." Still, no one reported seeing any surviving fragment hit the earth. Nevertheless, reentry had been observed and Highsmith had been able to get the compass heading of the fiery display.

Within minutes the Milwaukee *Journal* and local radio and TV stations swung into action, informing the public that pieces of the satellite might be down in that area. Residents finding suspicious pieces of metal were asked to rush them to the *Journal*. Needless to say, a strange assortment of just plain junk was collected.

DISCOVERY IN MANITOWOC

Seventy-five miles north of Milwaukee, the Lake Michigan port city of Manitowoc was beginning to stir in the early morning. Unaware of what had been seen in other sections of Wisconsin, patrolmen Ronald Rusboldt and Marvin Bausch were cruising the streets in their squad car. At 5:30 a.m. they noticed in the middle of the street a small object resembling an irregularly shaped piece of cardboard. When they passed again at about 7:00 a.m., they saw that the object was definitely metallic, so they stopped to remove it as a hazard to traffic. They were surprised to find the object imbedded in the asphalt and too hot to handle, but managed to move it to the side of the street.

There it lay until the afternoon when the same two patrolmen, having heard the news reports, went back to take another look. The object was still lying by the curb, so they took it to Inspector Francis J. Lallansach at police headquarters. Personnel from two local foundries and a shipyard were called in to inspect the object, but they could not identify it. Lallansach asked a visiting salesman, on his way to Milwaukee, to drop it off at the Milwaukee *Journal*.

Upon receiving the object, the *Journal* notified Moonwatcher Halbach of the Manitowoc discovery, and Halbach quickly called MW headquarters at SAO. Observer Highsmith was commissioned to fly the object to Cambridge, as local examination indicated a possibility that this 20-pound piece of metal might well be a satellite fragment.

HOAX, JUNK . . . OR FOR REAL?

Highsmith, with his mysterious cargo, arrived at SAO on Thursday afternoon, the day after Sputnik IV was known to be down, as was verified by space radars. Dr. Charles A. Lundquist, SAO's Assistant Director, and a group of SAO people were on deck to meet him.

The object was laid bare on a table in Lundquist's office, and the group gathered around. The blackened hunk of metal was obviously manmade, they could tell, but it appeared to be solid steel—far thicker than that ordinarily used in satellite construction. On the other hand, it appeared to have been subjected to great heat and a considerable amount of melting.

The initial reaction, according to Dr. Lundquist, was one of "skepticism that the fragment was authentic." The whole atmosphere, he related, was one of "amuse-

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ment and curiosity." The first step was to photograph the object completely from every angle. Then careful measurements were taken—still in Lundquist's office. Suddenly hopes began to mount. All measurements figured out in the metric system—a system not used by American manufacturers but used throughout Europe (including Russia).

The object was crudely disk-shaped, approximately 20 centimeters in diameter and 8 centimeters high. It weighed 9.49 kilograms, or about 20 pounds, and the top cylinder was welded to a circular plate precisely 1 centimeter thick.

The SAO career scientists then took the object downstairs to their machine shop and cut a pie-shaped section from it. Again, luck was very much with them. The cut exposed an embedded bolt in an irregular layer of metal that had melted and resolidified. The threads on the bolt were measured: 1 thread per millimeter—again, the standard European size.

As Dr. Lundquist said, "We then knew that if this was a piece of junk, it was a strange piece to be found on a Wisconsin street." Concluding only that the fragment was "probably authentic," Lundquist reached for his phone and called Arnold Frutkin, Director of NASA's Office of International Programs, to give him as much lead time as possible with regard to international implications of the recovery.

Proof was still needed that the object had been exposed to the radiations of space. SAO's Dr. Edward L. Fireman and his associates spent the next two days looking for proof. They melted down a fragment of the object in a vacuum chamber to release radioactive gaseous isotopes (if any) that might have formed and been trapped in the metal. They found traces of argon 37 and manganese 54 which could have been formed only by sustained bombardment by cosmic rays and trapped particles in the Van Allen belts.

THE "CATCH" in a king-sized ball game that stretched around the world was the above 20-pound Sputnik IV fragment that survived the reentry plunge and crashed to earth on a Manitowoc, Wis., street. *(SAO photo)*

This was indeed part of Sputnik IV!

FOLLOW-UP AND FURTHER ANALYSIS

The day after the fragment arrived in Cambridge, SAO sent Walter A. Munn, assistant supervisor of their Photographic Meteorite Recovery Project, to Wisconsin to make further inquiries and to search for additional specimens. Many smaller fragments were found, but none exceeded an inch in length.

At SAO a mineralogical analysis was made of the oxidation products (crust) that formed on the fragment during reentry. Civil servant mineralogist Ursula Mar-

MOONWATCH CHIEF Dick Vanderburgh (center) on September 19 personally delivered commendations from SAO's Director, Dr. Fred Whipple, to Milwaukee's MW team and other Wisconsinites who helped in the recovery of Sputnik IV fragments. Here team member Gale Highsmith (left) and leader Ed Halbach join in looking at chunks of still unidentified metal. *(SAO photo)*

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vin found two minerals that are extremely rare in the earth's crust. By X-ray diffraction analysis she found wüstite, a black iron oxide that is unstable and almost nonexistent at room temperature. When wüstite is produced industrially (as a trace byproduct in steel smelting), it decomposes rapidly as the molten mass cools. Mrs. Marvin had expected the black crust to consist mainly of the stable iron oxide, magnetite.

"Luckily wüstite appeared on my first film," she related to the *Civil Service Journal*, "because I probably wouldn't have made a second." She also found akaganeite, another rare and unstable mineral.

After identifying these two minerals on the fragment, Mrs. Marvin reasoned that they might also occur in the crust of iron meteorites. Having been working on the meteorite recovery and analysis project, and having meteorite specimens at hand, she checked—and found both wüstite and akaganeite. These occurrences on meteorites had never before been noted. On both the Sputnik fragment and iron meteorites, Mrs. Marvin concluded, the two rare minerals were created by the extreme heating (and oxidation) conditions of reentry.

In addition to the continuing SAO analysis, specimens of the fragment were sent for metallurgical examination to the Massachusetts Institute of Technology and to the Brookhaven National Laboratory. The fragment was found to be made primarily of ordinary steel. Specimens were also sent for radioactive analysis to the Los Alamos Scientific Laboratory, the Air Force Cambridge Research Laboratories, the Carnegie Institute of Technology chemistry department, and to Brookhaven. All findings corroborated those of SAO.

FRAGMENT AT THE U.N.

By a remarkable coincidence, at the very time that the Manitowoc fragment was undergoing SAO's tests for authenticity, a not-unrelated debate was going on in the United Nations Committee on Peaceful Uses of Outer Space. An impasse had been reached—the Russians wanted to take up one thing on the agenda, the Americans another. The American position was that the committee should be considering specific questions on the legal side of space exploration—questions such as: Who would be liable if a reentering satellite fragment caused damage or personal injury? Who could claim ownership of fragments that survived the death plunge—the country that launched the satellite, or was it to be finders-keepers? The Russians did not agree with the U.S. position, and wanted the group to consider general principles rather than specific practical matters.

On September 12—just 6 days after the Manitowoc fragment had been unwrapped on his desk—Dr. Lundquist was directed to deliver the remains of Sputnik IV to the U.S. Mission to the United Nations. He did so that very night.

STARTLING DISCOVERY

SAO scientists are accustomed to making important discoveries. Here is one of their most dramatic recent findings.

For nearly 100 years astronomers have figured that the spectacular rings of Saturn are about 45,000 miles wide and around 10 miles thick. SAO astronomers Allan Cook and Fred Franklin, after 5 years of ring research—including 6 months at two South African observatories—have calculated that the rings are "probably less than 8 inches thick"! This incredible width-thickness ratio of 356,400,000 to 1 is not known to be paralleled anywhere else in nature. It may be, Cook and Franklin are now thinking, that those glorious rings, composed of dust, snow, and ice particles, are less than *four* inches thick.

On September 14, Francis Plimpton, American delegate to the UN Committee on Peaceful Uses of Outer Space, made a speech defending the American position. Then he produced the Sputnik fragment and offered it to Russia in the name of the United States.

P. D. Morozov, the Soviet delegate to the committee, declined to accept the fragment for his government.

The offer was left open. The Soviet refusal stuck, and the unclaimed fragment was returned to SAO for further analysis. However, early in January of this year the Soviets decided to accept the fragment, and on January 5, 1963, representatives of the Soviet Embassy in Washington formally accepted what was left (14 pounds) of their 5-ton spacecraft.

CONCLUSION

The Sputnik IV story is more than a chronology of exciting events. The scientific results were of such importance that a special session was held at the American Geophysical Union meeting last December at Menlo Park, Stanford, Calif. At the session, chaired by SAO's Dr. David D. Tilles, representatives from Federal and non-Federal organizations that had analyzed the fragment presented their findings to the scientific community.

Such success is no newcomer to SAO. This was but another in a long series of discoveries and contributions—many of which by far outrank the Manitowoc recovery in terms of pure scientific value.

Nonetheless, the Sputnik achievement did establish an important "first" in the annals of American space exploits. We can be sure there will be many more, and sure also that SAO will be in there pitching—as well as catching.