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Chapter 11

The Stabilizing Political Influence of Surveillance Satellites during the Cold War*

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Abstract

Fifty years ago the arms race in missiles and nuclear warheads between the United States and the Soviet Union escalated until the Strategic Arms Limitation Treaties (SALT) brought it to a halt—SALT I in 1972, SALT II in 1979. Surveillance satellites were critical in enabling these treaties to be negotiated, providing the basis for verification of many of their details. This chapter draws together recently declassified information from the U.S. and Russia to explain how surveillance satellites were a strong force for stabilizing a dangerously escalating military-political environment. It explains the main political context of the events, and the requirements on surveillance satellites driven by verification of arms limitation treaties. The key technical achievements in both countries are discussed, covering primarily the American CORONA and Gambit programs, and the Soviet Zenit program. The key similarities and differences in design decisions in the two countries are identified, and their implications explored. The chapter then looks at the role of surveillance satellites in the modern world in which there has been some proliferation of nuclear weapons and of long range missiles, and makes recommendations for stabilizing action by the nuclear powers.

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Sputnik and Its Effects

By the mid-1950s, both the Soviet Union and the United States had exploded nuclear weapons and fired long-range missiles. Both countries therefore felt exposed to an attack by the other, fueled by their recent history. The United States recalled the surprise Japanese attack at Pearl Harbor in December 1941 that triggered full-scale war in the Pacific. The entry of China into the Korean War in 1950 and the first Soviet atomic and hydrogen bomb tests (1949 and 1953) had also come as major surprises. On the Soviet side, Germany's surprise attack in the summer of 1941 was still fresh in the memory.

The United States initiated a program of high flying reconnaissance aircraft, commonly referred to as the U-2. Flights were made across the Soviet Union throughout the 1950s, safe in the knowledge that the Soviet Union did not possess an anti-aircraft weapon capable of reaching the 25+ kilometer altitude of the U-2. However the U.S. government realized that eventually the Soviet Union would develop such an anti-aircraft weapon, so in 1955 President Dwight D. Eisenhower initiated a reconnaissance satellite program aimed at replacing the U-2.

Soviet developments were focused on increasing the range of ballistic missiles, rather than on satellites. In 1955 the United States had wrongly believed that the Soviet Union was rapidly deploying a large fleet of long-range bombers. In retaliation the United States boosted the number of B-52 bombers, which the Soviet Union decided not to try to match. The Soviet Union chose instead to achieve superiority in missile reach.

By 1957 the Soviet long-range missile was being successfully tested, a fact that was known to the United States, thanks to its network of radar tracking stations ringing the Soviet Union. Somewhat reluctantly, the Soviet leadership gave the final go-ahead in the summer of 1957 for a payload to be carried on top of the long-range missile to be placed in orbit. The U.S. leadership had predicted such a step, since it was understood that an intercontinental ballistic missile (ICBM) was easily modified to reach orbit.

Sputnik's arrival in orbit on 4 October 1957 was therefore not intended by the Soviet Union as a major political coup nor seen as such by the U.S. government. The official communist newspaper, *Pravda*, carried the story as a small item on the front page without mentioning the name of the satellite. In the United States, President Dwight D. Eisenhower actually welcomed *Sputnik* as ensuring that the Soviet Union could not object when U.S. satellites started over-flying its territory before long.

Public reaction to *Sputnik* soon changed this reasoned official reaction. The media across the world hailed a great Soviet triumph. Public reaction was almost hysterical, especially in the United States—a small satellite today, a nuclear weapon tomorrow, was the fear. Opposition politicians quickly echoed these concerns—in apocalyptic language. For example, Senator Lyndon B. Johnson claimed that "control of space means control of the world." Two days after the small story in *Pravda*, *Sputnik* filled the whole of its front page—the Soviet leadership had realized the propaganda effect of the event.

For the next two years the Soviet Union continued to aim for publicity coups—for example: orbiting bigger and bigger satellites containing animals, and sending missions toward the Moon. The United States struggled to launch much smaller payloads, but these tended to be practical rather than for publicity. Furthermore U.S. launches took place in public, so the frequent failures were public knowledge, while Soviet failures were not made known until many years later. Thus in 1958, the United States had seven successful launches, the Soviet Union only one. But the media and the public focused on the 10 U.S. launch failures not the 7:1 U.S. lead. The five Soviet failures were hidden from view, and only the successful launch of *Sputnik 3* announced.[1]

By 1960, early U.S. weather satellites were sending back the first pictures of Earth from space. Despite the grainy quality of the images, they demonstrated the ability of satellites to observe any country over which they passed. This realization spurred the Soviet Union to initiate a surveillance satellite program.

The year 1960 was also a watershed for the United States. On 1 May, the Soviet Union finally shot down a U-2 spy plane deep inside its territory. The pilot was captured and put on trial and the wreckage of the plane put on display. The priority given to the U.S. surveillance satellite program was immediately increased.

The series of Soviet space spectaculars was seen by many U.S. commentators as proof of a large Soviet lead in ICBMs. This apparent "missile gap" contributed to the victory of John F. Kennedy in the 1960 U.S. presidential election.

The U.S. CORONA Program[2]

The initial U.S. concept was for a satellite that developed the film onboard and radioed the images to ground. By the time of *Sputnik,* this project had encountered a variety of problems, delaying its completion and increasing its costs. Spurred on by the Soviet missile successes, an interim concept was initiated in which the film would be returned to Earth in a recovery capsule and developed on the ground. This "interim" system, called CORONA, ended up as the mainstay of the U.S. strategic surveillance program for more than 10 years.

Being an interim program, CORONA looked to existing solutions where possible. The platform was the upper stage of the Agena rocket. The camera was adapted from that flown in the U-2 aircraft. Despite avoiding unnecessary developments, CORONA was plagued by failures. All nine attempts to launch a CORONA in 1959 failed, involving most of the elements of the system—the first and second stages of the rocket, the camera, and the capsule ejection system.

There was not enough time between launches to fully evaluate each flight, but because of the urgent need to observe Soviet missile developments, the pace continued unabated. A new film was developed that retained its resilience in the full vacuum of space, and new ejection rockets were installed. Still the failures continued—four in the first half of 1960.

Finally in August 1960 two capsules were successfully recovered. The first was just an instrumented test but contained a U.S. flag, which was duly presented to President Eisenhower. The second included 1,400 photographic frames of many Soviet airfields, missile launch sites, and radar facilities (Figure 11–1). The resolution of the imagery was poorer than expected, at about 15 meters. Nevertheless the wide area covered exceeded that of all previous U-2 flights combined, and detected 20 new SA-2 antiaircraft sites with 6 more under construction, 64 previously unknown airfields, and many new urban areas.

There were a further seven failures and only one successful flight (in mid-winter, when much of the Soviet Union is dark and cloud covered) before CORONA imagery became reliably available from the summer of 1962 onward.

The mid-1961 flights provided sufficient evidence to prove that the "missile gap," which helped President Kennedy win election was in fact in America's favor not the Soviet Union's. The Soviet Union had just six ICBMs, and they were of a design that made them difficult to deploy rapidly—the previous year, the U.S. Air Force was predicting that the Soviet Union would have 700 ICBMs deployed by 1963. CORONA therefore had the immediate effect of undermining those "hawks" in the U.S. administration who were calling for preemptive attacks on the Soviet Union before all of its missiles were ready for use.

Once a CORONA had exposed all of its film, its mission was over—and this typically occurred within a few days for the early flights. A new satellite had to be launched to continue the surveillance, and the frequency with which this was done seems astonishing by today's standards. A new CORONA was launched on average every six weeks. Over the 10 years of the program, a total of 145 were launched, of which more than 120 were successful. The frequent launches had the advantage that improvements could be introduced incrementally.

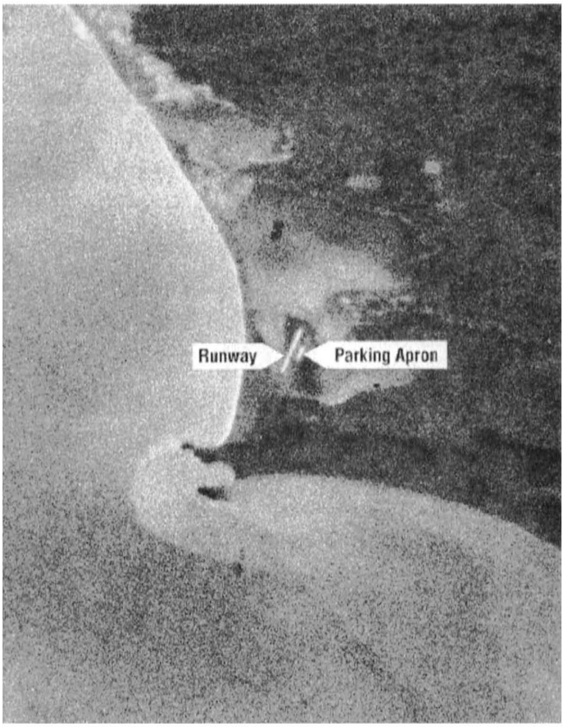

Figure 11–1: Mys Schmidta airfield in the eastern Soviet Union photographed by the first successful CORONA mission in August 1960. Credit: National Reconnaissance Office.

Several improvements in the image motion compensation system were introduced that gradually improved the resolution to reach the design goal of 2 meters. The system also eventually accommodated elliptical orbits, thus allowing the satellites to vary their orbit, for example occasionally dropping the perigee below 130 kilometers for close-up images of important targets.

The control of the image sequence also became more flexible. Initially a very simple electro-mechanical system that could not be varied from Earth triggered the opening of the camera shutter. Later versions allowed radio control of the shutter sequence, for example to take account of the actual orbit differing from that predicted or of information provided by weather satellites—initially 50 percent of the returned images were of clouds.

The cameras were gradually improved too. The swath width of the images increased from 190 kilometers to 290 kilometers. From 1962, stereo images were introduced—a major improvement in allowing the analysts to identify objects, as anyone who has viewed a high resolution black-and-white space image will know.

Another major improvement from about 1963 was the addition of a second recovery capsule (Figure 11–2). The second capsule meant that images could be returned to Earth before the film was finished. The remainder of the film could be exposed over the course of several more days before being returned in the second capsule. Longer film reels were carried, to take advantage of the longer mission duration.

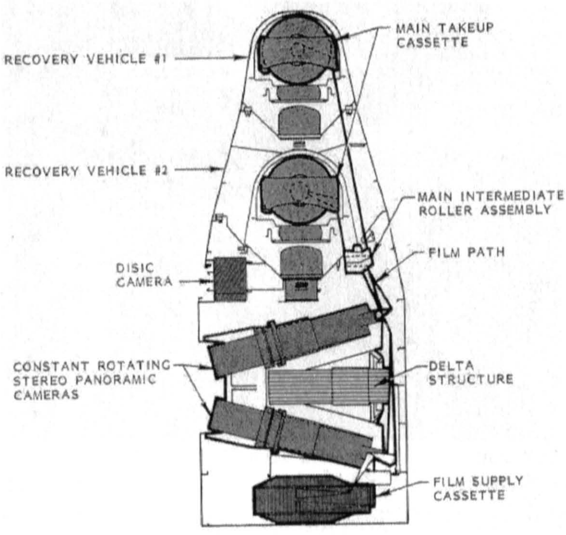

Figure 11–2: Schematic of one of the later CORONA satellites (after 1963) showing, from bottom to top, the film cassette, the twin stereo cameras, and the two recovery capsules. Credit: National Reconnaissance Office.

One of the features of CORONA that worked well was the recovery procedure, whereby the capsule descended by parachute over the ocean and was caught by an aircraft. Extra fuel was carried onboard the later flights to allow the perigee to be adjusted for optimum imaging of priority targets. All of these changes resulted in a gradual increase in the weight of CORONA from 1.75 tons to 1.9 tons.

The Soviet Zenit Satellite[3]

The Soviet Union, too, had many failures before their surveillance satellite became operational in August 1962—two years after CORONA. Like the United States, it initially intended to have a real-time, read-out scheme. And like the

United States, it found that too difficult to implement with the required image resolution and reverted to a capsule recovery scheme.

The Soviet Zenit-2 satellite, as it was called, was based on the Vostok manned capsule, a design choice that was intended to reduce the need for new developments, for example, in the area of attitude stabilization. However the stability required by Zenit-2 proved much more demanding than for Vostok, and significant development was needed. At 4.8 tons, Zenit-2 was more than double the mass of CORONA. The main design difference was that the Zenit-2 camera was housed in a pressurized capsule, thus avoiding the vacuum-induced film problems experienced by CORONA.

A further difference was that the whole camera was returned in the re-entry capsule, not just a film reel as used by CORONA. The Soviets could reuse the Zenit-2 cameras, thus saving money, but the design meant that they couldn't add a second recovery capsule. It wasn't until the 1970s that they changed the design so that multiple recovery capsules could be accommodated. Like the manned Soyuz capsules, Zenit-2 descended on land.

Zenit-2 exposed its film onto two square frames rather than a film roll, simplifying the interpretation on the ground. Stereo imagery was therefore a natural feature of the design from the outset. The larger size of Zenit also allowed it to carry a high-resolution camera as well as the wide-area surveillance camera. The United States, in contrast, had to put the high-resolution camera on a separate satellite called Gambit, since CORONA only had room for the wide-area instrument.

Why the Information Was Important

The super powers relied on three main forms of detection to assess their adversary's ICBM capability. First, radar stations on land or at sea could detect the launch of test missiles and observe their trajectory, especially the end phase—for example, to detect end-stage guidance, multiple warheads, and overall accuracy. Second, radio listening stations on land, at sea, in the air, and eventually in space, monitored the radio transmissions of telemetry between test missiles and ground. And third, satellites counted the number of deployed missiles and monitored their manufacture and transportation, and that of their nuclear warheads.

Figure 11–3 illustrates the type of information provided by CORONA and Zenit. Two images of the same area taken a year apart show clearly the construction of an SS-7 ICBM site in the interregnum. Each type of missile involved a set pattern of facilities (antiaircraft batteries, storage sheds, fuel tanks, et cetera) and roads, making it straightforward for analysts to identify the weapon concerned.

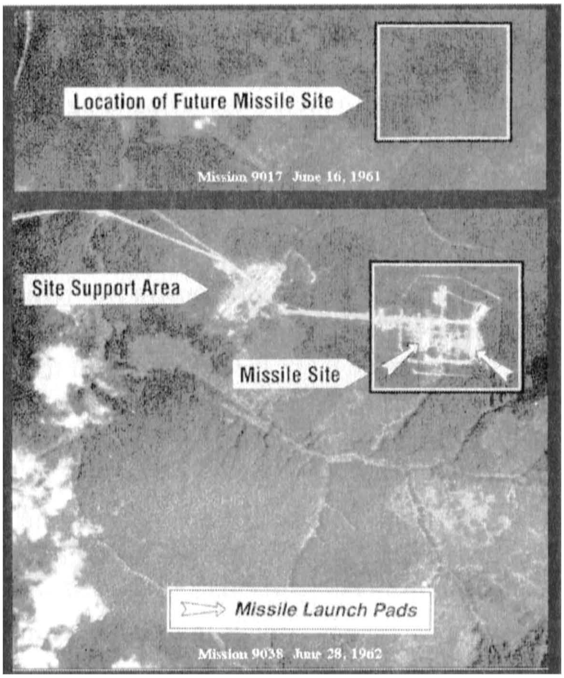

Figure 11–3: Annotated CORONA images of SS-7 ICBM site at Yur'ya June 1961 and June 1962. Credit: National Reconnaissance Office.

The early CORONA satellites in 1961 identified not only the absence of ICBM sites, but the presence of more than 300 medium-range ballistic missiles (MRBM) in the western Soviet Union with a range of 1,000 to 2,000 kilometers. Another 50 Soviet MRBM sites were detected east of the Urals, and early phases of the deployment of 3,000 kilometer range intermediate-range ballistic missiles (IRBM) were spotted.[4]

Submarine-launched ballistic missiles (SLBM) were also monitored. Although SLBMs had a much shorter range than ICBMs, they could reach the heartland of the adversary by virtue of the on-station position of the submarine close to the enemy's shore. SLBMs were therefore treated as strategic weapons, similar in their effect to ICBMs. By contrast MRBMs and IRBMs were considered less provocative, since they couldn't reach from one adversary's homeland to the other's.

Satellites were the key to monitoring SLBMs. The submarines could be monitored during their lengthy fabrication in the few bases able to host them—

there were just two shipyards building these submarines in the Soviet Union—Figure 11–4.

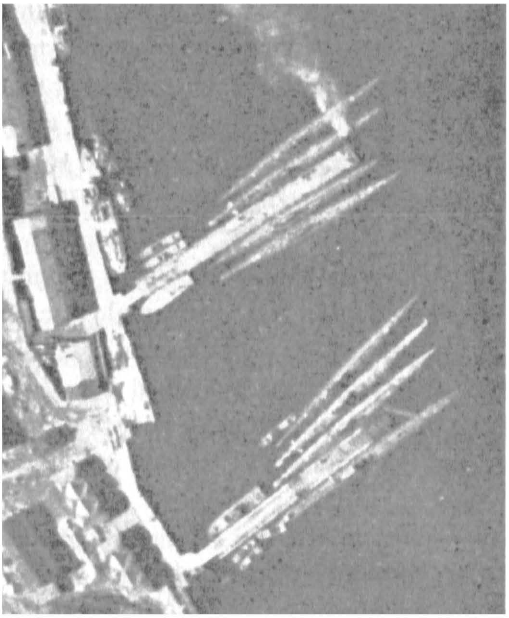

Figure 11–4: Gambit image of submarine pens at Polyarny near Murmansk, 9 June 1966. Credit: U.S. Geological Survey.

By the end of the 1960s, both super powers had an accurate count of the other's strategic weapons. Henry Kissinger illustrates this fact with an amusing anecdote.[5] The Soviet Union was a police state in which information on strategic weapons was withheld from even senior politicians. In the negotiations to limit strategic weapons, the Soviet military lead negotiator became extremely agitated when Kissinger trotted out details of the number of Soviet missiles, submarines, bombers, and nuclear warheads.

Kissinger was unsure whether the concern was about the level of U.S. knowledge or the fact that he was giving the information to Soviet diplomats not normally privy to these details. In any case it was clear that the U.S. information was uncannily accurate—and the Soviet Union had the same level of information on U.S. weaponry.

The SALT-I and SALT-II Agreements

By the late 1960s, the U.S. tallies of Soviet ICBMs and SLBMs were tending to be under-estimates rather than the over-estimates at the start of the decade. The cause of this change was the massive deployment of strategic missiles by the Soviet Union, triggered in part by the determination never to be humiliated by the United States as it was during the 1962 Cuban Missile Crisis. The Cuban "humiliation" is now-a-days seen as a much more balanced outcome. The Soviet Union persuaded the United States to withdraw its MRBMs from Turkey and to promise not to invade Cuba.

The United States persuaded the Soviet Union to remove nuclear missiles from Cuba. Modern commentators note, for example, the failure by the United States to extract an agreement for Cuba to be neutralized, like Finland or Austria. Nevertheless, at the time, the crisis was perceived as a U.S. victory not only in the West but also in the Soviet Union. Premier Nikita Khrushchev lost his position shortly afterward and the rapid Soviet buildup of missiles and warheads began.

By 1972, the two super-powers had reached rough strategic equality. The Soviets had 1,600 ICBMs and SLBMs, compared to 1,050 for the United States, but the United States had fitted many of its missiles with multiple independently-targetable re-entry vehicles (MIRV) each of which effectively was a separate weapon capable of hitting widely separated targets. So in terms of warheads the United States led with about 4,000—double that of the Soviet Union.

Even before the Cuban crisis, President Kennedy had specified that future arms treaties be negotiated in such a way that their provisions could be verified—there had to be externally observable features detectable by "national technical means," such as satellites. If you couldn't verify it, you excluded it from the agreement, and this approach was to prove workable for the next 20 years.[6]

The first Strategic Arms Limitation Treaty (SALT-I) in 1972 froze the number of strategic weapons of the super powers at their existing levels. The details of the treaty were controversial, such as, for example, the agreement not to "significantly" change any of the missiles. Both sides agreed that "significant" meant a 15 percent increase in the size of the missile silo, but the United States stated this meant in either diameter or depth, while the Soviet Union took it to mean both—and 15 percent greater depth and diameter represents an increase of a third in volume. The liberal Soviet interpretation of "significant" resulted in an across-the-board enhancement of Soviet ICBMs over the next few years. The United States, meanwhile, continued to outfit its missiles with MIRV warheads.

By 1979 when SALT-II was initialed by the Soviet and U.S. leaders, the Soviet Union had increased its warhead count by 50 percent to 3,000, while the United States had about 9,000. Both of these arsenals were of course grotesque over-kill, capable of wiping all human life off the planet several times over.

SALT-II grappled with several difficult problems. Long-range bombers, MIRV warheads, and some types of cruise missiles were included. Limits were set for 1979 and lower targets for 1981 of both missiles and warheads. Although the Soviet invasion of Afghanistan prevented SALT-II from being approved in the United States, it provided an informal limit on strategic weapons while a further round of negotiations began.

Satellites were central to the verification regime for SALT-II. Congressman (later Defense Secretary) Les Aspin reviewed how each of the elements of SALT-II would be monitored,[7] showing how satellites were required for almost every important and difficult limit set by the treaty. Weapon types that satellites couldn't verify were excluded from SALT-II, such as long-range cruise missiles and mobile ICBMs.

Lessons for the Future

International tensions involving nuclear powers continue today, albeit primarily regional rather than global. In some cases the two parties both possess nuclear weapons, in other cases only one does. Without adequate visibility of the strategic forces of the adversary, a nuclear power may feel threatened due to rumor or speculation, and may feel compelled to use its nuclear weapons.

Surveillance satellites are a mechanism for reducing tension by ensuring that decisions on the use of strategic weapons are taken based on hard evidence. Satellites do not see everything, but what they see is unbiased—and with experienced interpretation is relatively immune to spoofing. Human intelligence is biased, or as former United Nations Weapons Inspector Hans Blix put it: "defectors don't want inspection, they want invasion."[8]

This chapter hasn't covered many of the other ways in which surveillance satellites can verify strategic weapons—for example to monitor the manufacture and testing of nuclear weapons themselves—Figure 11–5 shows the preparations for China's first nuclear test, which gave the United States the information needed to announce the test's likely occurrence before the event, thereby blunting its propaganda impact. A more complete survey of the roles of such satellites[9] shows that they have a crucial role to play in monitoring a wide range of activities central to arms control and nonproliferation.

Figure 11–5: Schematic of one of the later CORONA satellites (after 1963) showing, from bottom to top, the film cassette, the twin stereo cameras, and the two recovery capsules. Credit: National Reconnaissance Office.

During the Cold War, surveillance satellites rapidly became the reference source of information on strategic missiles and weapons—providing unambiguous, authoritative, and surprisingly comprehensive details of developments around the world. They allowed the super powers to engage in debate about how to limit their heavily overstocked nuclear arsenals, with the confidence that any violation of an agreement would be detected. The need for confidence led to the resulting treaties being formulated so that satellites could verify their terms—they put limits on silos not on missiles, on bombers not on bombs, and on tested systems not on theoretical ones.

Most of the major powers have access to high-resolution satellite imagery of areas that they designate (they have "shutter control"), and commercial satellites now offer images of the quality that CORONA provided in the 1960s to anyone willing to pay. Is it then time to think of a service to provide strategic imagery for developing countries?

The service would avoid images with tactical significance but would cover strategic targets such as airports, harbors, power stations, railroad complexes, industrial plants, and the like. In practice it might be easier to say what is excluded than included. As a starter, the only areas excluded would be United Nations-sanctioned forces. This definition would have avoided images of the Desert Shield formations massing in the Saudi Arabia desert in 1991 that attacked Saddam Hussein's forces from an unexpected direction.

It need not cost very much. Through the World Meteorological Organization (a United Nations agency) several countries make weather satellite data available to the world's weather forecasters. The United Nations doesn't own any satellites or facilities; it just provides a legal umbrella under which individual countries can agree on the types of data they will provide in the future, the formats and standards for exchanging data, and so on.

Another smaller scale example of the collaborative way to provide a global service is the Disaster Monitoring Constellation created by Surrey Satellite of the United Kingdom—satellites are purchased and operated by individual countries, and their imagery is made available as required to respond to emergencies, such as earthquakes, tidal waves, and famines. Another concept to consider is Google Earth where images from various satellites are amalgamated and made available to all comers.

For this service to work, an organization would be needed to decide which targets should not be imaged, and the United Nation's International Atomic Energy Agency (IAEA) is an example of a possible owner of that task. As a start, a regional body such as the European Union could initiate this kind of service as a pilot exercise—to see if there is a demand for it, to explore the technical and political difficulties involved and to see how much it would cost.

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