Spying on the Sky

A few months after Sputnik 2 was launched in 1957, U.S. scientists knew, without ever seeing it, what it looked like and why it was there, thanks to the 'black art' of 'radar signature analysis'

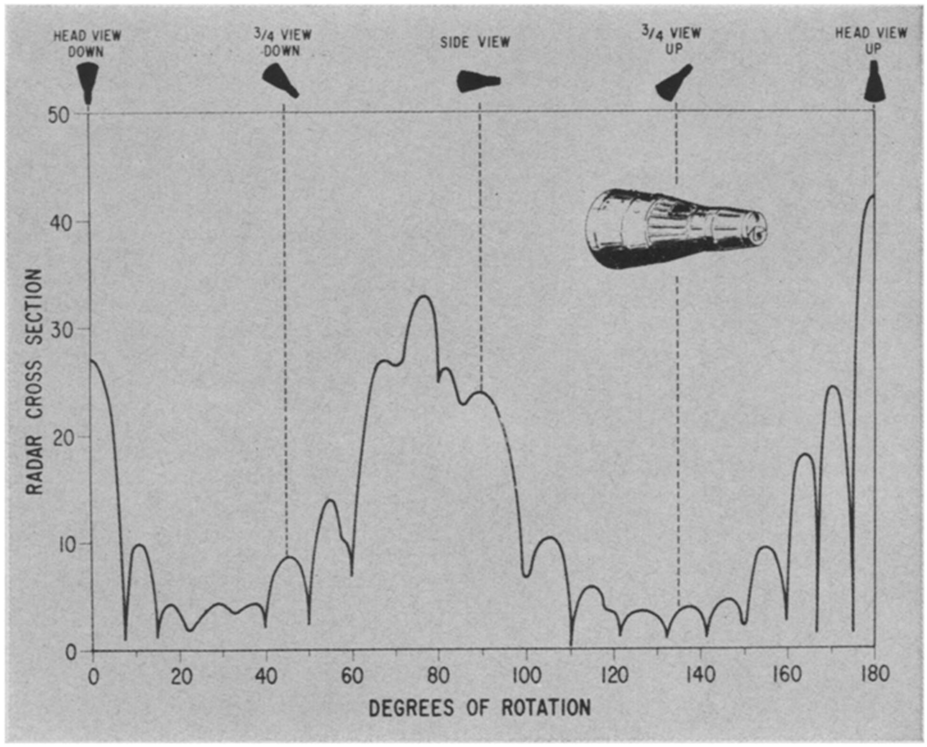
By Jonathan Eberhart

➤ GRAND BAHAMA Island is certainly one of the pearls of the Atlantic. Inland from the ring of tourist-filled hotels are miles of semi-tropical greenery and myriad brightly colored birds. One hundred miles northeast of Miami, 100 miles southeast of Cape Kennedy, the Island is an oasis of escapism, of carefree relaxation and isolation from the world's problems.

On the surface.

There is another side, however. Ever since the earliest whisperings of the coming space age, the United States has used Grand Bahama as one of its most vital electronic "keyholes," through which it peers constantly at events unfolding in the once-empty skies. The Air Force, the Navy, the National Aeronautics and Space Administration and who knows, perhaps even the Central Intelligence Agency, all have their hands in with various strange buildings built under, around or near even stranger structures devoted to tracking any man-made object that passes overhead.

On Feb. 4, 1958, just such an object appeared. It crossed almost directly over Grand Bahama Island through the first light of dawn, moving at slightly more than 16,772 miles per hour. The object appeared again two days later.



RCA

GEMINI'S 'HANCOCK'—Radar experts have developed a method of identifying space objects by the radar reflections, or echoes, received back on earth. The ability to make such identifications is based on the fact that the radar cross section—the amplitude of the signal reflected from the target—changes according to the satellite's shape and motion, among other factors.

Cone Noted Passing

Down below, on an iron-railinged platform, a small cone made of metal tubes and chicken wire noted the object's passing. The cone was a Navy tracking antenna called an X/FPS-16. The object was Sputnik 2, launched almost exactly three months before, carrying a young female husky named Laika.

No alarms went off at Sputnik's passing, no worldwide defense networks swung into operation. Yet those two sightings marked the beginning of a strange, almost occult art known as Radar Signature Analysis (RSA).

Without once seeing the satellite or knowing anything about it other than the information from the radar tracks, scientists were able not only to tell what it looked like, but also to deduce some vital facts about the Russian tracking network.

In particular, they determined that the Soviet radar net included a number of low-powered units dating back more than a decade. "It can be assumed," said Radio Corporation of America radar expert David K. Barton at the time, "that the Soviet tracking network would include microwave radars such as the S- and X-band sets widely used in World War II."

Before the Sputnik 2 incident, RSA had been nothing but a relatively obscure laboratory technique about which nothing had even been written except a few references in the Massachusetts Institute of Technology Radiation Laboratory Series, 10 years before. The discovery, however, that it was a useful, perhaps vital tool "touched off a rigorous consideration of the problem.

Complicated Formulas

In its beginnings, RSA consisted of a lot of rambling, complicated formulas for converting radar information into a "picture" of the target. With virtually no background of research to rely on (and since the Sputniks were classified there was no way of checking back the results), the radar analysts were forced to resort to a combination of textbook theories, educated guesswork and intuition.

More than three years were required to boil the vast calculations down to the first workable general equation. Almost 70 satellites had been placed in orbit by that time, more than 50 of them belonging to the U.S. In addition, tests had been made to establish the characteristic radar pattern, or signature, of certain standard shapes, such as a disk, sphere, cone or cylinder.

Shapes were at least recognizable, long before the tests simplified the problem. The deduction that there were old, low-powered radar transmitters in the Russian tracking net followed the signature analysts' conclusion that Sputnik 2 was carrying corner-reflectors, obviously designed to provide the strongest possible return for a weak signal.

As a result of research that followed, scientists were finding that they could tell not only the shape of an object, but whether it was tumbling, spinning, rolling or stabilized.

This added bit of sophistication was of particular use in the case of one early U.S. satellite which had been successfully launched, but had failed to appear in its predicted orbit. After combing the skies, trackers found the satellite all right, but in the wrong orbit. To analyze what went awry, they compared the launch velocity with the satellite's new position in space (determined by conventional radar tracking).

This revealed the object's new mass, and thereby the amount of excess fuel consumption.

Then the signature analyst went to work, and figured out the rate and direction of the satellite's tumbling. Combined with its mass, these measurements, told the investigators the amount of energy required to produce the change in position.

Trouble Spot Found

A process of elimination narrowed down the likely trouble spots to a particular stuck engine swivel—the only possible source of so much misdirected energy.

Other satellites, such as Echo 2 and the Pegasus series, have been given the RSA treatment on repeated occasions. In the case of the first Nimbus weather satellite, launched Aug. 28, 1964, analysis was needed to provide tumble and spin data that telemetry from the satellite could not.

A secret U.S. Air Force launch on June 9, 1966, from Vandenberg AFB in California, reportedly was the unusual combination of an Agena D rocket equipped with four solar panels. When one of the panels failed to unfold properly, an informed source said, signature analysis was used to determine which one.

Most Air Force launches are classified, but today the art of RSA has been refined so far that practically everything about it is secret anyway.

In fact, the technique has become so revealing that it is not even called analysis any more—it is out and out Space Object Identification (SOI).

First Rate Analysts

There are fewer than two dozen first-rate analysts in the entire country, and they have the highest security clearances. Yet their work is fairly humdrum: one analysis after another, sometimes as many as 700 a month, most of them about as exciting as last week's mail.

"It's just an ordinary, nonvoluntary assignment," said an Air Force official. "They're not told beforehand how dull it will be."

SOI has expanded manyfold in the last three or four years, however, to where it now includes many sources of information so cloak-and-dagger that they make an old fashioned classified signature analysis seem like a public announcement. In addition to radar information, analysts now make use of such things as reports from spies (possibly CIA but probably military) on the political climate at the time of the launch; analyses of technical papers at international conferences, which may help reveal the state-of-the-art and thereby indicate a country's most advanced capabilities; and reports from other observatories and tracking stations around the world.

"Black Art" Perfected

By sifting all these sources, the analysts have carried their "black art," (as one of them, a USAF lieutenant, has called it) to its highest state: in addition to an orbiting object's shape and motion, it is now possible, within limits, to determine its intent! The characteristics of the spacecraft, its orbit and (both politically and technologically) the country from which it came can often pin down an object as being a weather satellite, a communications satellite, a "spy-in-the-sky" or even—though the necessity has not yet arisen and hopefully never will—an orbiting bomb.

The analysts have for some time been compiling a catalog of signature data on the various shapes and body motions of different space vehicles, against which radar reflections can be compared for quick identification.

The signature book is used in the same way as police use "mug shots" to spot criminals from among a large number of candidates.

The next step is to design a computer that can make such comparisons automatically, in a fraction of a second. Picking out hostile missiles on the fly is already within the capability of SOI, but human analysts require at least a few minutes, and that much time is too expensive a luxury for the Missile Age.

Unfortunately, such a computer is proving to be a rather large stumbling block. A computer can make distinctions just as fine as any human, if it can be told how, but the art is such an intuitive one that it is proving next to impossible to tell the machine what is desired of it.

Actually, the problem is even more complicated than that. Recognizing a missile is not enough. It is more than likely that any attacking missile would be accompanied by chaff or decoys, and whereas spotting a hostile "something" would be adequate for civil defense warnings, the actual warhead-carrying vehicles would have to be identified for counter-attack.

Orbiting satellites can offer the same problem. Among the possible ways of deceiving a radar analyst might be enclosing the object in a balloon (inflated after it reached orbit), or deploying dummy antennas or body panels.

"Since DOD (the Department of Defense) has an announced capability of destroying satellites from the ground with Zeus, Thor and Minuteman missiles," wrote RCA expert Charles Brindley in June of 1965, "the simplest antidote for apprehension would be to shoot down everything up there that is not ours. However, all Russian flights do not necessarily have a military role, and we can imagine the international hue and cry that would arise if some Russian cosmonaut or even a Russian scientific vehicle were puffed into vapor by a U.S. nuclear warhead."

For this reason, rapid, accurate identification is more important now than ever before, as more than 1,150 man-made objects are hurtling around in various orbits, confusing the issue.

One device that may lead to increased accuracy is the laser beam. A radar beam can measure no spacecraft feature smaller than one wavelength, which means, with current tracking devices, nothing smaller than three or four feet. The laser, however, shoots a beam of light, not radar, and uses wavelengths down in the millimeters and centimeters. This means that it can see much smaller features that are presently undetectable.

Power is Problem

The problem is power. Getting a strong enough laser beam to satellite height will require more efficient power supplies than are now available.

Ultimately, SOI might be accomplished from a vast central data complex buried far beneath the desert. Coded information from a worldwide network of laser-equipped tracking stations, together with available launch data and other information, would all be fed continuously into a giant computer that would analyze it in seconds and trigger alarms throughout the country if an emergency occurred.

Until then, however, SOI will remain a black art, and its practitioners will pursue the humdrum jobs that may one day determine the fate of the nation.

TECHNOLOGY

Computer Saves Drivers Both Time and Money

➤ MOTORISTS in San Jose, Calif. are saving $882 a day because of a computer that controls traffic lights.

"A computer can be used to control traffic efficiently and economically," Mr. A. R. Turturici, director of public works, said. San Jose city officials have decided to install a permanent computerized traffic control system as a result of a three-year study completed by the city and the International Business Machines Company.

An IBM 1800 data acquisition and control system will be delivered in November, and eventually will coordinate many of San Jose's 235 traffic signals.

Use of a computer reduced by 17 percent the waiting time for cars at traffic lights on a three-mile artery that serves 35,000 vehicles a day.