Journal of Scientific Exploration, Vol. 12, No. 3, pp. 345–358, 1998 0892-3310/98
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Estimates of Optical Power Output in Six Cases of Unexplained Aerial Objects with Defined Luminosity Characteristics[1]

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Abstract — An analysis of six cases of unexplained aerial phenomena observed by qualified observers over a twenty-year period in various parts of the Earth and in known physical conditions yields estimates of optical power output ranging from a few kilowatts to thousands of megawatts. This paper surveys the methods by which this parameter can be derived from witnesses' statements, it discusses the various hypotheses one could propose to account for the observations and it calls for a broad re-examination of sighting files in an effort to apply this methodology to a larger sample and to better understand the luminosity characteristics of the reported objects.

Keywords: UFOs — UFO sightings — physical evidence

Introduction

Some of the most striking statements made by witnesses of unusual aerial objects during their debriefing by investigators have to do with the luminosity of the phenomenon. They frequently use expressions like "it lit up the whole landscape" or "every object in the area stood out, intensely thrown into relief." Beyond these subjective statements (which could be affected by physiological and psychological factors) it is difficult to obtain reliable quantitative data on the power output of the observed objects. Typically the witnesses are surprised by the phenomenon and it is rare for them to have any basis of comparison or calibration. A few such cases do exist, however, and a special effort has been made here to derive estimates from the data.

Obvious cautions are immediately raised by this exercise. By definition the source of the luminosity is an unknown phenomenon. We do not know if the light is a primary manifestation of its internal physical state (as would be the case for the sun) or a secondary one, as would be the case for the moon or an automobile headlight. We do not even know if most of the electromagnetic energy is released in the visible domain to which human witnesses and most cameras react.

Given these cautions one can, at best, hope to bracket a physical range to characterize the phenomenon in question. More relevant than the actual

[1]Presented at the Physical Evidence Related to UFO Reports Workshop, Tarrytown, New York, Sept. 30-October 3, 1997.

numerical values obtained in a few cases is the methodology involved in acquiring and processing such parameters.

Case Studies

The cases that follow have been extracted from a larger sample where luminosity or power output data could be obtained. We have excluded some extreme cases (such as the Tunguska explosion of 1908 in Siberia) and all cases involving a single observer, leaving six adequately documented and researched incidents with multiple witnesses. In cases no. 2 and 3 the primary witnesses are known to the author, who has interviewed them personally. In case no. 4 the author has visited the site. In other cases we rely on the data assembled by qualified investigators, all of whom are known to us.[2]

Case no. 1: August 27, 1956. McCleod, Alberta (Canada) — Classification: MA-1[3]

The witnesses in this MA-1 case are Royal Canadian Air Force pilots who were flying in a formation of four F-86 Sabre jet aircraft (Figure 1). The planes were flying at 36,000 ft (about 11 km), headed due west over the Canadian Rockies, about an hour before sunset.[4] As they were approaching a large thunderhead R. J. Childerhose, the pilot in the second position (left side of the formation) saw a "bright light which was sharply defined and disc-shaped" or "like a shiny silver dollar sitting horizontal," far below the planes but above the lower layer of clouds. It appeared to be "considerably brighter than the sunlight." (Figure 2.)

Sighting duration was variously quoted at 45 seconds (Klass, 1968) to three minutes. The pilot reported the observation to the flight leader, then took a photograph of it. That photograph, a Kodachrome color slide, was subsequently analyzed by Dr. Bruce Maccabee who considered the hypotheses that the object was a cloud, a plasma phenomenon, or ball lightning (kugelblitz). We refer the reader to his detailed study[5] while presenting here only a summary of his arguments.

The cloud hypothesis was contradicted by two facts, namely the equal brightness of the object on both sides as opposed to the darker appearance of clouds away from the sunlight, and the fact that portions of the object were brighter than the brightest clouds.

The plasma or ball lightning hypothesis has been mentioned by Klass (Klass, 1968) and by Altschuler (Altschuler, 1968). It is contradicted by the radiance of the object and the duration of the observation. Maccabee derives

[2]The author is particularly indebted to Dr. Claude Poher, Dr. Bruce Maccabee, Dr. Illobrand von Ludwiger and Mr. Jean-Jacques Velasco who made investigation reports available for this study.

[3]The classification scheme (*e.g.* MA-1) was presented in a previous paper by Vallee.

[4]R. J. Childerhose: Affidavit written in May 1958, and private communication to Dr. B. Maccabee.

[5]Maccabee, Bruce. "Optical Power Output of an Unidentified High Altitude Light Source." Private communication.

Fig. 1. Photograph of an unidentified high altitude bright light source. Picture taken by Royal Canadian Air Force pilot R. J. Childerhose on August 27, 1956 from an altitude of 36,000 ft (app. 11 km). The object was higher than app. 4 km and was observed for more than 45 sec. If acting as an isotropic Lambertian radiator, the power output within the spectral range of the film would have been in excess of 10^9 W. *(Courtesy of Bruce Maccabee)*

Fig. 2. Childerhose was flying west in the second position (left side) of a formation of four F-86 Sabre jets of the Royal Canadian Air Force. *(Courtesy of Bruce Maccabee)*

the radiance L by solving the standard photographic equation, corrected for the effects of atmospheric attenuation:

$$L = 4Ef^2 exp[(b-a)/cos\theta]/Tcos^4\phi \quad (1)$$

where

$$E = H/t. \quad (2)$$

H is the film exposure level in J/cm^2 and t is the shutter time in seconds. L is the radiance of the object in the direction of the camera in W/sr/cm^2, E is the irradiance on the focal plane of the camera in W/cm^2, and f is the ratio of the focal length to the diameter, as set by the operator of the camera. The factor $\exp[(b-a)/\cos\theta]$ corrects for atmospheric attenuation, b being the optical thickness of the atmosphere from the ground to the altitude of the plane, a the optical thickness to the altitude of the object and θ the zenith angle of the slant path from the plane to the object. T is the transmission of the optics (aircraft window and lens) and f is the angle between the optic axis of the camera and the optical path from the lens to the image.

We refer the reader to Maccabee's analysis for an excellent discussion of the range of values of these parameters. He finds a value between 1.09 and 1.34 for the attenuation correction factor, a value of 0.7 for T, shutter time of 1/125 at f/8 and a value of 0.95 for $\cos^4\phi$. The average density over much of the image is estimated at 0.12, leading to a value of $H = 10^{-4}$ J/cm^2.

Inserting these values into (eq. 1) and (eq. 2) gives estimates of radiance of 1.7 to 2.0 W/sr/cm^2 if the object was at distances of 6 or 20 kilometers, respectively. Assuming that the object was a Lambertian emitter with constant emittance over its surface, Maccabee finds a range of 2.5×10^9 W (2,500 megawatts) to 3×10^{10} W (30,000 megawatts) for the power output within the spectral range of the film. As he rightly points out, however, "the total power emitted over all frequencies might be much greater."

Case no. 2: September 1965. Fort-de-France (Martinique)—Classification: MA-1

On July 1, 1965, two French submarines, the Junon and the Daphné, escorted by the logistic support vessel Rhône, left the Toulon navy base in the Mediterranean and sailed toward Gibraltar. The ships traveled first to La Horta in the Azores, then to Norfolk, Virginia, to conduct a series of joint operations with the U.S. Navy, which was engaged at the time in the recovery of a Gemini capsule near Bermuda; the French submarines escorted the aircraft carrier Wasp. Later the ships went through Hurricane Betsy, whose effects they avoided by diving to three hundred meters. On the way back to France they stopped for ten days at Pointe-à-Pitre, Guadeloupe, and for one day at Saintes before reaching the island of Martinique, where they anchored in late September 1965.

It was during their layover in Fort-de-France one evening, by a dark sky and

clear weather, that a large luminous object arrived slowly and silently from the west, flew to the south, made three complete loops in the sky over the French vessels, and vanished like a rapidly extinguished light bulb (Vallee, 1990).

The person who reported this case to us, Mr. Michel Figuet, was at the time first *timonier* (helmsman) of the French fleet of the Mediterranean. He observed the arrival of the object from his position on the deck of the submarine Junon. He had time to go up to the conning tower, where he took six pairs of binoculars and distributed them to his companions. There were three hundred witnesses, including four officers on the Junon, three officers on the Daphné, a dozen French sailors, and personnel of the weather observatory.

All witnesses aboard the Junon saw the object as a large ball of light or a disk on edge arriving from the west at 9:15 p.m. It was the color of a fluorescent tube, about the same luminosity as the full moon. It moved slowly, horizontally, at a distance estimated at ten kilometers south of the ships, from west to east. It left a whitish trace similar to the glow of a television screen.

When it was directly south of the ships the object dropped toward the earth, made two complete loops, then hovered in the midst of a faint "halo." (Figure 3).

Mr. Figuet told the author that he observed the last part of this trajectory through binoculars; he was able to see two red spots under the disk. Shortly thereafter, the object vanished in the center of its glow "like a bulb turned off." The trail and the halo remained visible in the sky for a full minute. At 9:45 p.m. the halo reappeared at the same place, and the object seemed to emerge as

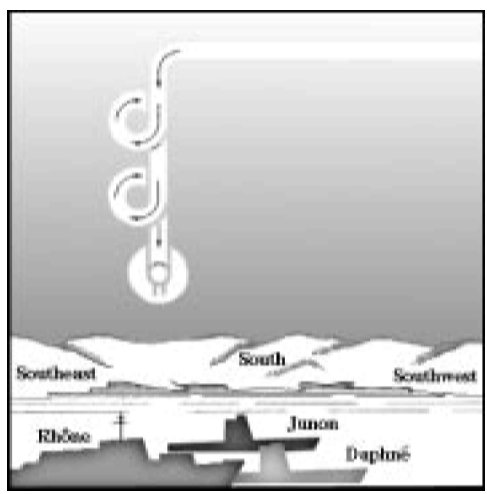

Fig. 3. The harbor at Fort-de-France.

if switched on. It rose, made two more loops and flew away to the west, where it disappeared at 9:50 p.m. The next day Mr. Figuet compared notes with a communications engineer who had observed the same object from the Navy fort. Together, they called the weather observatory at Fort-de-France. The man who answered the call had also observed the object. He stated that it was neither an aircraft, nor a rocket.

In 1988 the author was able to interview Michel Figuet in Brussels. He confirmed the maneuvers and the appearance of the object and stated that he had met again with some of the crew members whose recollections of the facts were equally precise. A landscape illuminated by the full moon receives 0.318 lux, or 1.8×10^{-3} W/m^2. Since there is agreement among the observers that the object had approximately the same brightness as the full moon and was situated about 10 kilometers away, we can compute its total luminosity as:

$$P = I \times A \tag{3}$$

where I is the intensity in W/m^2 and A is the area over which light is spread.[6]

Here,

$$P = 1.8 \times 10^{-3} \times 4\pi r^2 \tag{4}$$

where $r = 10{,}000$ m, which gives $P = 2.3 \times 10^6$ W (2.3 megawatts).

Case no. 3: December 30, 1966. Haynesville (Louisiana)—Classification: CE-2

The third case is drawn from the official U.S. files. It took place at 8:15 p.m. on December 30, 1966, in the vicinity of Haynesville, Louisiana. The witnesses are a professor of physics, Dr. G., and his family. Inquiries with the weather bureau disclose that the weather was overcast, with fog and a light drizzle, ceiling about three hundred feet, all parameters that are in agreement with the witnesses' statements. There was no thunderstorm.

In early 1967 the author came across this sighting while reviewing the files of the U.S. Air Force as an associate of Dr. J. Allen Hynek at Northwestern University. The report by Dr. G. and his family had not been followed up by Air Force personnel, so we decided to pursue it on our own. Dr. G. told Dr. Hynek and myself that he was driving north that night on U.S. Highway 79 between Haynesville and the Arkansas border when his wife called his attention to a red-orange glow appearing through and above the trees ahead to their left. They continued to observe it as they drove down the highway. It appeared as a luminous hemisphere, pulsating regularly, ranging from dull red to bright orange, with a period of about two seconds. There was no smoke or flame that would have been characteristic of a fire.

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[6]The author wishes to thank David A. Newton for bringing to his attention some important corrections and improvements to his initial calculations in this case and those that follow. (Private communication, August 8, 1993).

When the car came to a point about one mile from the source of the light, it suddenly brightened to a blinding white, washing out the headlights and casting sharp shadows. This burst of light not only forced Dr. G. to shield his eyes, but it woke up his children, who had been sleeping in the back seat. After about four seconds it returned to its red-orange appearance.

Several sightings were described by other persons in the area. One witness reported that about six days before a similar bright light had been seen near the same location.

When the University of Colorado received funding from the U.S. Air Force for a scientific study of UFOs, the author called Dr. Edward Condon's attention to this case. A field investigation was conducted by several scientists from Boulder but failed to locate the actual site. Dr. Condon concluded in his published report that the case was "of interest," and it remained as one of the many unidentified sightings in the University of Colorado files (Condon, 1969).

After the University of Colorado project was disbanded and after the Air Force, following its recommendations, closed down its own Blue Book, study of the case was resumed on a private basis. We came into contact with a qualified investigator, Mr. W., who had also pursued his own research with Dr. G. Through them the author learned that Mr. W. and Dr. G. had pinpointed the actual site where the object had hovered. The area in question is a clearing about thirty feet in diameter, located to the west of some railroad tracks. The chief dispatcher stated that no rolling equipment was within fifty miles of the location that night. The nearest high-tension power lines are about nine miles away to the west.

All the trees at the periphery of the clearing exhibited a blackening or burning of the bark in a direction pointing to the center of the area, as if they had been exposed to an intense source of radiated energy. Clearly we would like to know whether the wood was burned by light energy, direct heat, or chemical combustion. From an estimate of the energy required to produce the depth of the burn it may be possible to estimate the power of the source, assuming it was located in the center of the clearing fifteen feet away. However this work has not been done.

Fortunately, there are other ways to arrive at a power estimate, as Dr. G. realized when he saw that the light from the object washed out his own headlights about ten feet ahead of the car. This enabled him to equate the intensity of the unknown object, which is given by its power output divided by the square of the distance, to the intensity of his headlights, which is given by their power output, known to be 150 watts, divided by the square of ten feet. This gives a lower limit for the power output of the UFO.

The Condon report, which reprinted Dr. G.'s calculations, uses the very simple formula:

$$P = 150d^2 \tag{5}$$

where d = distance between the car and the object.

This formula is arrived at as follows: Calling I_c the intensity of the car headlights at a distance of 10 feet ahead of the car, I_u the intensity of the unknown source at distance d, and P the optical power output of the object we can write:

$$I_c = 150/(10 \text{ feet})^2 \tag{6}$$

and

$$I_u = P / d^2 \tag{7}$$

The fact that the headlights were washed out by the unknown source at a ten-foot distance provides a lower limit for I_u. If we assume that we can detect a "just noticeable difference" (JND) between I_u and $(I_u + I_c)$ we write:

$$I_u = 100\, I_c \qquad \text{(from Weber: JND curves)} \tag{8}$$

which leads to:

$$P / d^2 = 100\,(150 / 10^2) \tag{9}$$

or $P = 150d^2$.

In his report, Dr. Condon estimated the distance at 2,400 feet, which gave an energy of 9×10^8 W (900 megawatts) for the UFO. A more correct estimate is given by the subsequent investigation since the clearing is actually located 1,800 feet from the observation point. The energy output becomes 5×10^8 W (500 megawatts). These figures are approximations only: As David Newton has since pointed out in correspondence with the author, the fact that the car headlights were not radiating uniformly in all directions but were directed onto the road by reflectors, should be taken into account in any refined calculations.

Case no. 4: November 5, 1976. Grenoble (France)—Classification: MA-1

Another remarkable observation made near Grenoble, France, on November 5, 1976, by a senior French scientist is relevant here. As in the previous case, there were multiple witnesses and the duration was long enough to allow details of the object and its trajectory to be seen and recalled. There were two other remarkable characteristics: first, it was possible to establish the distance of the object with precision; second, the exceptional qualifications of one of the witnesses provided some physical parameters that have rarely been available in UFO cases.

We are indebted to GEPAN, the French government's official UFO investigation task force (now known as SEPRA), for communicating to me the details of the case, which the author had the opportunity to discuss with them at

length prior to visiting the site in 1988.[7] In accordance with their policies, the names of the witnesses have been changed. The official files, of course, contain full particulars and in-depth interviews with all concerned.[8]

The first witness in the chronology of this observation is a Miss M., who was watching television at her home in the town of Rives, near Grenoble. The time was 8:08 p.m. She saw a bright light outside and called her father. Both went out on the balcony and observed an intense white source crossing the sky at high speed from the northwest to the southeast, disappearing behind the mountains in the direction of Montand. The father, when interrogated by the gendarmes, stated that the light appeared to be spinning.

While these two witnesses were observing the object in Rives, a French physicist we will call Dr. Serge was driving seven miles away near Voreppe on the road that goes from Rives to Grenoble. He had just returned from Paris on a plane that landed at Grenoble airport, and he was driving to his home. Looking up, he saw a luminous disk moving in the sky. He stopped his car and got out to observe it carefully. The time was 8: 10 p.m.

The disk, according to Dr. Serge, was brighter than the full moon. It was slightly flattened (with an aspect ratio of 0.9) and an angular diameter about twelve arc minutes (the full moon has an angular diameter of about thirty arc minutes). The object was white in the center and bluish-white at the periphery. It was surrounded by an intense green halo about two or three arc minutes thick.

At the beginning of the observation, the disk was almost directly overhead. It flew at a constant velocity toward the east-southeast in less than eight seconds, covering approximately 1.3 degrees of arc per second. At that point the disk stopped, without changing size, and hovered for three to ten seconds. Then it started again in a different direction, thirty degrees away from the previous course, at much greater speed, covering about eight degrees of arc per second and passing in front of Le Taillefer Mountain, thirty-six kilometers away. Dr. Serge lost sight of the disk when it passed behind Le Néron Mountain, nine kilometers away.

The whole sighting had lasted about twenty to twenty-five seconds and there was absolutely no sound at any time. The sky was clear, no wind at ground level, and the temperature was about 40 degrees F. Late in 1988 the author drove through the area where the sighting had been made. The photographs and the drawings included in the GEPAN report do not do justice to the majesty of the site. Mountains rise on both sides of the Isère River. In places the road runs at the foot of sheer granite walls. This topography provides a fair estimate of the object's distance at various points, since it was seen flying behind one mountain and in front of another.

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[7]GEPAN stands for Groupe d'Étude des Phénomènes Aériens Non-identifiés, while SEPRA stands for Service d'Étude des Phénomènes de Rentrée Atmosphérique. Both organizations were based in Toulouse, at the Centre National d'Études Spatiales, where files are maintained.

[8]The Grenoble observation is Gepan Case No. 76305443.

It is noteworthy that the investigation by GEPAN disclosed that a similar object had been seen three hours earlier about eighteen miles east of Rives, leaving a trail, and that a bright disk was seen two hours later by the civilian traffic controller in the tower of the military airport at Aulnat. Shortly after 8:05 p.m. that same day a witness located a few miles away near Vienne saw a slightly flattened sphere, whose light was similar to that of a very bright neon tube, with a fiery red-orange area underneath. It was about one-sixth of the diameter of the full moon and was flying very fast from the west-northwest to the east-southeast.

Given these detailed, competent observations, it is possible to bracket the energy and speed of the object with some reasonable numbers. From a careful reconstruction of the sighting it was estimated that the object was flying at an altitude of 1,500 to 2,500 feet, which would give it a diameter between six and twenty feet and a speed approximating one mile per second, or 3,600 miles per hour, during the second phase of its trajectory. Assuming that the disk gave off as much light as the full moon, as observed by Dr. Serge, its energy in the visible part of the spectrum was a modest 15 kW. This is only a minimum value, based on the assumption that *the landscape directly underneath the object* was illuminated with an intensity comparable to that of the full moon. If illumination at the much greater distance where Dr. Serge was located was also that of the full moon we would be in conditions similar to those of case no. 2, with a much higher power output value.

In the detailed interviews conducted by investigators of the French National Center for Space Studies (CNES), Dr. Serge expanded on his description of the object, noting that the halo reminded him of the color produced by the combustion of copper salts. It is also noteworthy that Dr. Serge, who serves as director of a nuclear physics laboratory, did not report the sighting to anyone and did not mention it to his colleagues. It was only when the observation by Miss M. and her father was mentioned in newspapers that he volunteered his own experience. It should be noted further that, in addition to the reports from the gendarmes, the letters from the witnesses, and the investigations by GEPAN scientists, several of the observers were interviewed in person by a judge, a former president of the regional Court of Appeals.

Case no. 5: June 19, 1978. Gujan-Mestras (France) — Classification: MA-2

This incident took place near Arcachon in France on June 19, 1978, and was also investigated in depth by GEPAN.[9] While the Grenoble case was remarkable for the convergence and high quality of the observations, the present case introduces another exceptional parameter: the UFO triggered the photocells that control the lights for the whole town. From the distance and the threshold

[9]The Gujan-Mestras investigation was conducted on behalf of Gepan by Messrs. Dorrer, Mauroy, and Mouilhayrat.

level of the cell it is possible to derive an estimate of the power output of the object.

The town where the sighting took place is Gujan-Mestras. There were independent witnesses near Céon and La Réole. A local newspaper described how two frightened young men, an eighteen year-old cook named Franck Pavia and a seventeen-year-old butcher's apprentice named Jean-Marc Guitard, knocked on the door of a baker, Mr. Varisse, who was preparing the next day's bread, at about 1:30 a.m.

The teenagers had stopped on the side of the road to repair the turn signal of their car when all the lights of the town were suddenly switched off. At the same time, a powerful rumble like an earthquake made them jump. Then they saw the object. It was, by their descriptions, oval, red, surrounded with white "flames," and it flew toward them at an altitude they estimated as 11,000 feet.

At this point Jean-Marc became unable to breathe and fainted. The object then changed direction and flew away. While telling their story to the baker (who reportedly laughed at them), both witnesses were reportedly terrified, had trouble speaking, and Jean-Marc had red, teary eyes.

At approximately the same time of night a thirty-five-year-old restaurant manager named Mr. Bachère, who was driving toward Bordeaux, saw "a large orange ball, very bright" that hovered over La Réole at about 1,000 feet before disappearing. It reappeared at the same spot one minute later. Mr. Bachère's wife confirmed his observation.

Given these reports, which were transmitted by law enforcement officials to GEPAN in Toulouse, the task force decided to investigate immediately: three of their scientists were at the site the next day. They interviewed the witnesses at length, took them to the location, and had them point a theodolite to the places where the object had appeared and disappeared in an effort to establish triangulation. Finally, the witnesses were given a set of standard color samples from which they made a selection corresponding to the phenomenon they had seen.

This investigation brought to light the testimony of additional witnesses who had previously remained silent. For instance, Mr. B., a student who lived in Gujan, confirmed that he was outside when the town lights died at a time that he estimated as half an hour past midnight; concurrently, he had heard a strong, low rumble that scared him. Mr. B. saw orange flashes above the pine trees, below the cloud ceiling.

The measurements made in the field established that all witnesses had observed the same object, within the expected errors of human recall. There was rough agreement on time, duration, distance, trajectory, sound, and luminosity parameters. Understandably there were also discrepancies regarding the altitude and apparent diameter of the object. One of the witnesses who gave the more consistent measures was used as the primary source for these estimates.

The manager of the town utility department was also interviewed. He showed the investigators the location of the photoelectric cells that control the

street lights. When these cells are exposed to a light that exceeds their threshold (10 mW/m^2), they assume that daylight has arrived and they turn off the system.The results of the analysis bracket the distance between the cell and the UFO: between 135 meters and 480 meters, or roughly between 400 and 1,500 feet.Although the diameter of the disc was estimated (5 meters) this is irrelevant to the calculation of the power output, which can be determined from the luminous flux at the photocell via equation (3). Assuming a distance of 135 m one obtains

$$P \geq 0.01 \times 4\pi(135)^2 \tag{10}$$

hence $P \geq 2.3$ kW whereas for 480 m, $P \geq 29$ kW, assuming isotropic radiation from the object.

Curiously the GEPAN Report states that it assumes a continuous spectrum (black body radiation) and cites a range for the minimum power output between 160 kW and 5 MW. It is not a safe assumption that UFO emission is anything like a black body: The report states: "The fact that it was glowing red lets us put a — rat her unhelpful — value of t he wavelength of maximum emission at or above 700 nm."

Case no. 6: August 24, 1990 Greifwahl (Germany) — Classification: MA-1

Numerous eyewitness reports, supported by videotapes and photographs, make this "one of the best-documented sightings in Europe," according to von Ludwiger, to whose analysis the reader is referred for full details of the case (Von Ludwiger, 1995). Independent witnesses observed formations of luminous spheres hovering in the sky Northeast of Greifswald. Hundreds of tourists and local residents saw, photographed and filmed the phenomena, characterized by rapid accelerations and abrupt changes of direction, inconsistent with known phenomena or manufactured objects. One private investigation group received six videotapes and eleven photographs from different individuals and interviewed in person more than a dozen witnesses.

The investigation concluded that the phenomena consisted of two groups of luminous spheres that hovered nearly motionless for about 30 minutes between 8:30 p.m. and 9:00 p.m. over the Pomeranian sea. The brighter and closer group formed a circle of six luminous spheres. The second group formed the shape of a Y."

The German weather service reported that approximately 5/8 of the sky was covered with high, fleecy clouds in partly shaded masses and gray, sheet-like clouds at 2,500 meters. There was a light ENE wind and the temperature was about 60 degrees F, or 16 degrees C.

Given the number of precise observations, supported by photographs, it was possible to triangulate the position of the objects with some accuracy. From a distance of 14 km the Y formation appeared to be as bright as the full moon, according to one of the photographers, Mr. Ladwig. If the spectral distribution is equal to that of the moon, then the square distance law for the power output

of the moon with 0.138 lux yields an estimated optical power output of: $P = 1.8 \times 10^{-3} \times 4\pi \times 14{,}000^2 = 4.4 \times 10^6$ W by following the same reasoning as in the Fort-de-France situation (case no. 2).

Discussion

The figures derived from the six cases we have reviewed are summarized in Table 1. They range from low values (equivalent to the power of a small motor) to the energy range of a nuclear reactor. The estimates do not cluster around a particular value, and form no pattern. There may be several reasons for this. We may be in the position of a person trying to estimate the power of a truck by the intensity of its headlights: the actual energy figure may be orders of magnitude beyond our calculations. Alternately, light emission may be only a side effect of a hypothetical propulsion mechanism, as carbon monoxide is a side effect in the exhaust of an automobile engine.

The impact of the observations on human witnesses can be dramatic, suggesting that other physiological and psychological parameters are present. The main witness in case no. 3 (Dr. G.) was a physics professor who reported fear when confronted with the phenomenon. It forced him to shield his eyes and frightened his children, who woke up crying. One witness in case no. 5, a seventeen-year old male, developed breathing difficulties and fainted. Later his eyes appeared red and teary.

In discussing these figures one must keep in mind that the literature contains equally reliable cases when the objects were dark or had a dull surface with no light emission whatsoever, although they performed the same evolutions as the objects studied here.

Conclusion

Many investigators have been discouraged by the difficulty of deriving reliable parameters from chance observations made under uncalibrated field conditions by surprised witnesses. The present study does show, however, that a small percentage of reported UFO cases meet sufficient criteria of reliability to yield quantitative data regarding distance and brightness. From these data we have shown that it was possible to arrive at a rough estimate of power output.

In the present state of our ignorance about the physical nature of the reported objects, and given the lack of attention given the subject by scientific and technical personnel who might be in a position to improve the quality of the data, we can only speculate on the mechanisms that give rise to these emissions. A complete examination of the data reveals cases when witnesses were temporarily blinded by the light from such objects, and other cases when physiological sequelae were reported such as burns or skin injuries (Vallee, 1990). Whether the reported phenomena turn out to be natural or artificial in nature, their widely reported impact on human witnesses should encourage us to

TABLE 1.
Range of Power Output

	Small Engine (Lawn Mower)	Small Car	Large Car or Truck	Airplane, Helicopter	Airliner	Industrial Plant	Nuclear Power Station
1							XXXXXXXX 2500-30000 MW
2				XXX 2.3 MW			
3						XXXXXXX 500-900 MW	
4	XXX 15 kW						
5	XXXXXX 2.3-29 kW						
6					XXX 4.4 MW		

pursue this research and extend the coverage of existing data acquisition programs.

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