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Physical Evidence Related to UFO Reports: The Proceedings of a Workshop Held at the Pocantico Conference Center, Tarrytown, New York, September 29 - October 4,1997

Abstract

The purpose of this four-day workshop was to review purported physical evidence associated with UFO reports, with a view to assessing whether the further acquisition and investigation of such evidence is likely to help solve the UFO problem, namely the determination of the cause or causes of these reports.

Seven UFO investigators presented a variety of physical evidence that they claimed was associated with UFO reports: photographic evidence; luminosity estimates; radar evidence; interference with automobile functioning; interference with aircraft equipment; apparent gravitational or inertial effects; ground traces; injuries to vegetation; physiological effects on witnesses; and analysis of debris. There was in addition a presentation of investigations into recurrent phenomena that occur in the Hessdalen Valley in Norway.

A review panel was composed of nine scientists of diverse expertise and interests. The panel offered comments and criticisms concerning the investigations that were presented, and also prepared a summary of their overall response, with the following key elements:

- Concerning the case material presented by the investigators, the panel concluded that a few reported incidents may have involved rare but significant phenomena such as electrical activity, but there was no convincing evidence pointing to unknown physical processes or to the involvement of extraterrestrial intelligence.
- The panel nevertheless concluded that it would be valuable to carefully evaluate UFO reports since, whenever there are unexplained observations, there is the possibility that scientists will learn something new by studying these observations.
- However, to be credible, such evaluations must take place with a spirit of objectivity and a willingness to evaluate rival hypotheses.
- The best prospect for achieving a meaningful evaluation of relevant hypotheses is likely to come from the examination of physical evidence.
- The chances of a significant advance are considered to be greater now than at the time of the Colorado Project that led to the Condon Report thirty years ago, because of advances in scientific knowledge and technical capabilities, and in view of the example of a modest but effective UFO research project provided by the French space agency CNES.

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Preface

P. A. STURROCK

In December 1996, Mr. Laurance S. Rockefeller, Chairman of the LSR Fund, invited me to review with him the status of our understanding of the problem posed by UFO reports.[1] We agreed that the problem is in a very unsatisfactory state of ignorance and confusion. I expressed the opinion that this problem will be resolved only by extensive and open professional scientific investigation, and that an essential prerequisite of such research is that more scientists acquire an interest in this topic.

In searching for some way to encourage such interest, Rockefeller and his colleague Mr. Henry Diamond and I conceived of a workshop at which prominent investigators of UFO reports would meet with a panel of eight or nine scientists with wide-ranging interests and expertise. We agreed that the workshop should focus on physical evidence associated with UFO reports, and I agreed to serve as director.

This workshop should be regarded as a typical enterprise of sponsored scientific research. With administrative support of the Society for Scientific Exploration, I submitted a proposal to the LSR Fund in February 1997. After some negotiation, this proposal was accepted, and the necessary funds were transferred from the Fund to the Society. The Society's role has been strictly administrative: the role of the Society is to encourage and support research, not to control or direct research. Accordingly, as is normal in sponsored research, responsibility for the conduct of the workshop and for the preparation of this report was vested in the director.

This report contains the following material: a summary report prepared by the scientific review panel; an introduction; eleven sections dealing with specific types of physical evidence; reflections on how the panel's suggestions might be implemented; a guide to supporting documentation to be found on our web site;[2] and eight appendices. Except for the appendices and those sections for which the authorship is specified, many participants contributed to each section.

It is a pleasure to extend my thanks to Laurance Rockefeller for his interest in and support of this project; to Henry Diamond and Charles Tolbert for their administrative support; and to all the participants who first struggled valiantly to present and to absorb complex information, and then worked for many months to present their thoughts and advice in what is hopefully a readable form.

In re-reading the Condon Report that has played such an important role in the history of the UFO problem, I note that on October 31, 1968, University of Colorado President Dr. J. R. Smiley wrote in his letter of transmittal of their report to the Secretary of the Air Force, "We hope and believe that [this report] will have the effect of placing the controversy as to the nature of uniden-

[1] For a history of the UFO concept, see for instance Jacobs (1975).

[2] http://www.jse.com

tified flying objects in a proper scientific perspective. We also trust that it will stimulate scientific research along lines that may yield important new knowledge."

Of course, this unofficial workshop lasting only three days is a very modest undertaking compared with the two-year-long Colorado Project that was supported by both the Air Force and the Central Intelligence Agency. Nevertheless, the intent and spirit of the workshop was such that all the participants would join with me in echoing the same aspirations that Dr. Smiley articulated in relation to the Condon Report almost thirty years ago.

1. Summary Report of the Scientific Review Panel

V. R. ESHLEMAN, T. E. HOLZER, R. JOKIPII, F. LOUANGE, H. J. MELOSH
J. J. PAPIKE, G. REITZ, C. TOLBERT, AND B. VEYRET

On September 30 - October 3, 1997, a workshop was convened at the Pocantico Conference Center in Tarrytown, New York, in which this scientific review panel met with the investigators. The panel and workshop director also met in San Francisco on November 28 - 30, 1997. The participants addressed the problem of understanding the cause or causes of UFO reports, which have continued worldwide for at least 50 years. The investigators were asked to present their strongest data to the review panel. The thrust of these presentations was that at least some of the phenomena are not easily explainable. The panel focused on incidents involving some form of physical evidence, with clear recognition of the dangers of relying wholly on the testimony of witnesses and of the importance of physical measurements for distinguishing among hypotheses.

It may be valuable to carefully evaluate UFO reports to extract information about unusual phenomena currently unknown to science. However, to be credible to the scientific community, such evaluations must take place with a spirit of objectivity and a willingness to evaluate rival hypotheses.

The history of earth science includes several examples of the final acceptance of phenomena originally dismissed as folk tales: two centuries ago, meteorites (then regarded as stones falling from the sky) were in this category. The reality of ephemeral phenomena such as ball lightning and sprites was questioned until quite recently.

It was clear that at least a few reported incidents might have involved rare but significant phenomena such as electrical activity high above thunderstorms (*e.g.,* sprites) or rare cases of radar ducting. On the other hand, the review panel was not convinced that any of the evidence involved currently unknown physical processes or pointed to the involvement of an extraterrestrial intelligence. A few cases may have their origins in secret military activities.

It appears that most current UFO investigations are carried out at a level of

rigor that is not consistent with prevailing standards of scientific research. However, the panel acknowledged the initiative and dedication of those investigators who made presentations at this workshop, both for their efforts to apply the tools of science to a complex problem long neglected by the academic community, and for their diligence in archiving and analyzing relevant observational data.

The panel concluded that further analysis of the evidence presented at the workshop is unlikely to elucidate the cause or causes of the reports. However, the panel considers that new data, scientifically acquired and analyzed (especially of well documented, recurrent events), could yield useful information. In this case, physical scientists would have an opportunity to contribute to the resolution of the UFO problem.

The panel made the following observations:

- The UFO problem is not a simple one, and it is unlikely that there is any simple universal answer.
- Whenever there are unexplained observations, there is the possibility that scientists will learn something new by studying those observations.
- Studies should concentrate on cases which include as much independent physical evidence as possible and strong witness testimony.
- Some form of formal regular contact between the UFO community and physical scientists could be productive.
- It is desirable that there be institutional support for research in this area,
- The GEPAN/SEPRA project of CNES (Centre National d'Études Spatiales — the National Center for Space Research) in France (see Appendix 1) has since 1977 provided a valuable model for a modest but effective organization for collecting and analyzing UFO observations and related data.
- Reflecting on evidence presented at the workshop that some witnesses of UFO events have suffered radiation-type injuries, the panel draws the attention of the medical community to a possible health risk associated with UFO events.

The panel also reviewed some of the conclusions advanced in 1968 by Dr. Edward U. Condon, director of the Colorado Project. He asserted that "nothing has come from the study of UFOs in the past 21 years that has added to scientific knowledge," and that "further extensive study of UFOs probably cannot be justified in the expectation that science will be advanced thereby." While agreeing with the first conclusion and its extension to the present, the panel considers that there always exists the possibility that investigation of an unexplained phenomenon may lead to an advance in scientific knowledge.

The panel considers that the chances of such an advance are greater now than they were in 1967 because of the advances in scientific knowledge and

technical capabilities, and in view of the GEPAN/SEPRA model for data acquisition.

2. Introduction

P. A. STURROCK

Over the last fifty years, people throughout the world have become familiar with UFO reports. These reports have been attributed to a wide range of causes including hoaxes, hallucinations, planets, stars, meteors, cloud formations, ball lightning, secret aircraft, and extraterrestrial spacecraft. Despite the abundance of such reports, and despite great public interest, the scientific community has shown remarkably little interest in this topic. This may be due in part to the fact that there are no public funds to support research into this issue, in part to the assumption that there are no data worth examining, in part to the belief that the Colorado study that led to the Condon Report (Condon & Gillmor, 1969) has effectively settled the question, and possibly in part to the perception that the topic is in some sense "not respectable." The relative importance of these four causes is unclear, but it seems likely that each has had some impact in dampening the interest of the scientific community in this subject.

The general perception in the scientific community is that, if UFO reports pose a scientific problem at all, it has more to do with psychology and the science of perception than with physical science. Indeed, most reports simply comprise narrative accounts of what someone saw or thought he saw in the sky. Sometimes the reports involve more than one witness, and sometimes an event is witnessed from two or more different locations. However, the fact is that physical scientists cannot get involved in the UFO problem unless there is physical evidence. The purpose of this workshop was to assess whether or not there is any such evidence. If the answer is no, then there is no way that physical scientists can contribute to the resolution of this problem. If, on the other hand, the answer is yes, then it should be possible for physical scientists to contribute to the resolution of this problem.

It should perhaps be stressed that it would be unreasonable to ask a panel of nine scientists, meeting for only a few days, to do much more than make a preliminary assessment of some limited category of evidence related to this complex and controversial topic. It would certainly be highly unreasonable to expect such a panel to solve, in only a few days, a problem that has remained unsolved for fifty years. Science advances by the development of an informed consensus on well defined questions (see, for instance, Ziman, 1968), but scientists can arrive at an informed consensus only if (1) sufficient research has been carried out, and (2) the results of that research have been presented to and evaluated by the scientific community. For the UFO problem, these first two essential steps have yet to be taken.

A workshop to review claims of physical evidence related to UFO reports

was held at the Pocantico Conference Center at Tarrytown, New York, from September 29 through October 4, 1997. The organization responsible for this workshop was the Society for Scientific Exploration. The Society was responding to an inquiry from Mr. Laurance S. Rockefeller, Chairman of the LSR Fund. Plans for the workshop were in the hands of Dr. Peter A. Sturrock, Professor of Applied Physics at Stanford University, who served as Director of the workshop. In developing plans, Sturrock was assisted by a steering committee comprising Dr. Thomas E. Holzer of the High Altitude Observatory of the National Center for Atmospheric Research, Boulder; Dr. Robert Jahn, Professor of Aerospace Engineering at Princeton University; Dr. David E. Pritchard, Professor of Physics at the Massachusetts Institute of Technology; Dr. Harold E. Puthoff, Director of the Institute for Advanced Studies in Austin; Dr. Yervant Terzian, Professor of Astronomy and Chairman of the Astronomy Department at Cornell University; and Dr. Charles R. Tolbert, Professor of Astronomy at the University of Virginia. Mr. Henry Diamond of Washington, DC, provided administrative advice and support. Puthoff and Pritchard served as moderators of the scientific sessions.

Seven experienced UFO investigators were asked to review specific categories of evidence. Dr. Richard F. Haines of Los Altos, California, undertook to review photographic evidence and also reviewed aircraft equipment anomalies; Dr. Illobrand von Ludwiger of Feldkirchen-Westerham, Germany, discussed radar evidence; Dr. Mark Rodeghier of the Center for UFO Studies in Chicago discussed automobile engine anomalies; Mr. John F. Schuessler of Houston discussed injuries to witnesses; Dr. Erling Strand from Ostfeld, Norway, presented evidence involving video records and spectroscopic data; Dr. Michael D. Swords, Professor in the General Studies Science Department at Eastern Michigan University discussed inertial anomalies; Dr. Jacques F. Vallee of San Francisco presented energy estimates and also discussed material evidence; and M. Jean-Jacques Velasco of CNES, Toulouse, France, presented evidence concerning radar events, ground traces, and injuries to vegetation.

Evidence presented at the workshop was studied by a Scientific Review Panel comprising Dr. Von R. Eshleman, Emeritus Professor of Electrical Engineering at Stanford University; Holzer; Dr. J. R. (Randy) Jokipii, Regents' Professor of Planetary Sciences and Astronomy at the University of Arizona in Tucson; Dr. Francois Louange, Managing Director of Fleximage, Paris, France; Dr. H. J. (Jay) Melosh, Professor of Planetary Science at the University of Arizona in Tucson; Dr. James J. Papike, Head of the Institute of Meteoritics and Professor of Earth and Planetary Sciences at the University of New Mexico in Albuquerque; Dr. Guenther Reitz of the German Aerospace Center, Institute for Aerospace Medicine, in Cologne, Germany; Tolbert; and Dr. Bernard Veyret of the Bioelectromagnetics Laboratory at the University of Bordeaux, France. Eshleman and Holzer served as co-chairs of this panel.

The review panel and director met in executive session in San Francisco from November 28 to 30,1997.

Sections 3 to 13 contain brief summaries of the material presented at the workshop together with brief comments by the panel. Section 14 presents a summary of ideas that have been advanced by workshop participants as to how some of the panel's suggestions might be implemented. The appendices comprise correlative information and discussions. Supporting documentation may be found in articles cited in the reference list and on the web site [http://www.jse.com] (see Section 15).

It is necessary to refer frequently to the official French research program that was set up in 1977 as "GEPAN," and restructured in 1988 as "SEPRA" (see Appendix 1). To avoid confusion, we refer to this project throughout (except in Appendix 1) as "GEPAN/SEPRA."

3. Photographic Evidence

Photographic evidence can contribute to a better understanding of the UFO phenomenon if the evidence has sufficiently strong credentials that the possibility of a hoax can be ruled out. It is also highly desirable that the photographic evidence be accompanied by strong witness testimony, but it is very difficult to meet these requirements (as in the case of remotely operated scientific monitoring stations) because of the unpredictable nature of UFO events (events that give rise to UFO reports). In order to be confident of the authenticity and flawless operation of the equipment and acquisition, it is necessary to plan an observational program very carefully. This approach has been adopted by Strand and is discussed further in Section 6. However, such equipment must normally be run in an automatic mode so it is unlikely that there will be witness testimony to accompany the data acquisition.

On the other hand, photographic and similar evidence are sometimes acquired in connection with unexpected and incomprehensible UFO events. In these cases, there will normally (but not invariably) be witness testimony but, since the data acquisition was not planned, the equipment, operation and analysis will probably not be optimal and there may indeed be some question concerning the authenticity of the claimed data.

Haines presented in some detail one case in which an intriguing photograph was obtained, but the intriguing aspect of the scene was unknown to the photographer at the time the photograph was taken. This event occurred on October 8, 1981 at about 11:00 am Pacific Daylight Time on Vancouver Island, British Columbia, Canada. It has been described in detail elsewhere (Haines 1987), and a copy of that article is to be found on the Web Site (see Section 15).

In 1984 Haines received on loan, directly from its owners, two connected frames of 35 mm color negative film. The lower number frame shows a child standing in front of a fireplace, and the higher number frame shows a daytime view of a mountain with evergreen trees on the bottom and a white cloud near

the top of the mountain. The intriguing aspect of the latter frame was that it showed a silvery oval-shaped object set against the blue sky. The photographer and her family were making a rest stop in a Canadian provincial park and the exposure was made on impulse because of the beauty of the scene.

Haines and his father, Donald Haines, spent four days with the principals of the case visiting their home and the site where the photograph was taken (north of Campbell River, British Columbia) exactly two years later. Fortunately, the weather conditions were comparable with those of October 8, 1981. Donald Haines, a registered civil engineer and land surveyor, carried out a land survey of the relevant area.

The object appeared to be a disk with the near edge tipped downward, possibly with a rounded "dome" or protuberance on its upper surface. Richard Haines provided detailed information concerning the camera, the lens and the film. Haines had analyzed the negative using a microdensitometer; the blue sky and cloud were quite bright and the brightest spot on the disk was even brighter. The luminance gradient of the brightness of the disk was measured and found to be consistent with what would be expected for a diffusely reflecting metal object, with a shape similar to that indicated by the photograph and the known position of the Sun. The color photograph was also analyzed by making black and white enlargements on different wavelength-sensitive papers. The negative was also digitally scanned using a Perkin-Elmer scanning densitometer, using three separate color filters which matched the film's three dye layers.

Haines was especially diligent in looking for evidence of a double exposure, but found no such evidence. He also looked for a possible significant linear alignment of pixels or grains which might result from the presence of a thin supporting line or thread, assuming that the object was a small model hanging beneath a balloon, but no such evidence was found. Haines tested for differential edge blur, such as might be produced by linear motion during the exposure, but found no such blur.

Haines also attempted to identify the object in the photograph as something mundane. He considered, in particular, the possibility that a Frisbee had been thrown into the air and photographed. The principals did own a Frisbee, but it was dull black, not shiny, and the principals steadfastly denied having produced the photograph in this way. Haines experimented with several other Frisbees. He attached a dome to the top of one Frisbee and tried to fly it, but it would fly no more than about ten feet before losing lift. Haines also calculated that a Frisbee would have displayed noticeable edge blurring in the photograph.

This case is instructive in showing what detailed analyses of a photograph can be made using modern analytical equipment, but it suffers from the severe drawback that there is no witness testimony to accompany the photograph. While the panel was impressed with Haines' thorough analysis of the evidence he had available, there was some concern that a film defect or blemish may

have been introduced during processings, and there was considerable discussion concerning the crucial point that an object that had appeared on the photograph was apparently not seen by the photographer or by her companions. The picture was taken with a single-lens reflex camera, which means that the object must have been in the field of view of the viewing screen as the photograph was being taken. Haines explained that there is published research which shows how perceptual "blindness" can occur even when physical objects are clearly present in the environment. Louange also pointed out that an object that is angularly small, stationary, and not expected to be present, is not as likely to be noticed as a similar object that is moving.

The panel expressed the opinion that detailed analysis of photographic evidence was unlikely by itself to yield evidence sufficient to convince a neutral scientist of the reality of a new strange phenomenon unless a number of additional detailed conditions are met (see Appendix 2). They also expressed concern that, now that modern digital techniques are easily available in photo laboratories, it may never be possible to rule out possible hoaxes without convincing, corroborative eye-witness accounts.

For further information about photographic cases, see Section 15 and Appendix 2.

4. Luminosity Estimates

When witnesses of unidentified aerial objects are debriefed by investigators, some of the most striking statements concern the luminosity of the phenomenon, according to Vallee. It is not unusual to hear expressions such as "it lit up the whole landscape," or "every object in the area stood out, thrown into intense relief," but it is normally difficult to go beyond these subjective statements to obtain reliable quantitative estimates of the luminosity of the phenomenon. Vallee summarized data for six cases of unexplained aerial phenomena that have been reported by qualified observers over a 20 year period, with a view to making estimates of the optical power output. Vallee's estimates range from a few kilowatts to many megawatts.

Case #1 occurred on August 27,1956, near McCleod, Alberta, Canada. The witnesses were two Royal Canadian Air Force pilots who were flying in a formation of four F86 Sabre jet aircraft. The planes were flying due west over the Canadian Rockies at 36,000 feet about one hour before sunset. One of the pilots saw a "bright light which was sharply defined and disk-shaped," that resembled "a shiny silver dollar sitting horizontal," situated below the planes but above a thick layer of clouds. It appeared to be considerably brighter than sunlight reflecting off the clouds. The duration of the sighting was estimated to be between 45 seconds and 3 minutes. The first pilot to notice the object reported the observation to the flight leader and then took a photograph on a Kodachrome color slide. This case and this photograph were subsequently analyzed by Dr. Bruce Maccabee (Maccabee, 1996). Maccabee has presented an argument against the propositions that the phenomenon is due either to

reflection of sunlight by the clouds or to lightning. From the available data, Maccabee estimates the luminosity of the object (the power output within the spectral range of the film) to be many megawatts.

Case #2 occurred in late September 1965 at Fort-de-France (Martinique). Two French submarines accompanied by a supply vessel were returning to France from Norfolk, Virginia, stopping at Martinique. One evening, according to the report, when there was a dark sky and clear weather, a large luminous object arrived slowly and silently from the west, flew to the south, made two complete loops in the sky above the vessels, and vanished like a rapidly extinguished light bulb. The object was observed by a highly qualified helmsman from the deck of one of the submarines. He took six pairs of binoculars to the conning tower and distributed them to his companions. There were in all 300 witnesses, including four officers on the submarine Junon, three officers on the submarine Daphne, a dozen French sailors, and personnel of the Martinique weather observatory. The appearance of the object was such as to suggest either a large ball of light or a disk on edge. Its color was that of a fluorescent tube, and its apparent luminosity was that of the full Moon. It moved slowly and horizontally, at a distance estimated to be about 10 kilometers, and left a whitish trace in the sky similar to the glow of a television screen. After the object first vanished, the halo remained visible for a full minute. Some time later the halo reappeared and the object then emerged as if "switched on." After further maneuvers, the object flew away.

Based on the descriptions of the witnesses, Vallee estimates that the luminosity of the object was of order 2 megawatts.

Case #3, that occurred at Voreppe, France on November 5, 1976 at 8:10 p.m., was investigated by GEPANISEPRA (GEPAN 1976; see also Appendix 1). The director of a physics laboratory at the Nuclear Research Centre in Grenoble saw a luminous disk in the sky as he was driving. Several other witnesses reported a similar observation on the same day. The main witness, considered to be a reliable scientist, gave a precise description of the position (in front of mountains), size and speed, as well as of the luminosity of the disk compared to the luminosity of the moon. The illumination of the landscape was reported to have been brighter than the illumination produced by the full moon when it is at the zenith. From this fact, and from the relevant geometrical considerations, the GEPANISEPRA investigator estimated the minimum transmitted luminous energy to be 6 kW if the estimated altitude of 500 m was correct, or 24 kW if the altitude was 1,000 m.

Case #4, that was also investigated by GEPANISEPRA, occurred at Gujan-Mestras, France, on June 19, 1978 at about 1 am. GEPANISEPRA was advised by the Gendarmerie that three witnesses had reported seeing a large luminous object that had emitted a loud noise. They also reported that the public lighting in the town had been extinguished for a few minutes as if triggered by morning light. The GEPANISEPRA investigators carried out a site investigation and made measurements of the triggering threshold of the photo-cells

that controlled the public lighting system. This information led the investigators to an estimated radiated energy in the range 40 kW to 5 MW.

Vallee reviewed briefly two other cases: Case #5 occurred on December 30, 1966 in Haynesville, Louisiana, and Case #6 occurred on August 24, 1990 at Greifswald, Germany. Vallee cautioned the panel that the estimates of luminosity presented at the workshop are raw approximations derived from a comparison of the estimated intensity in the visible band with the intensity of known sources, such as the full moon and automobile headlights, and from assumptions concerning the distance and perhaps size of the source.

The panel noted that the human eye is a very poor device for measuring absolute luminosities: the state of dark adaptation of the eye affects the amount of light reaching the retina, and different parts of the retina respond differently to light. Furthermore, the above luminosity estimates were apparently based on the assumption of isotropic emission. This may be a reasonable assumption for a natural phenomenon, but could be inappropriate if a case involves a technological device. For instance, aircraft landing lights are highly anisotropic. A 1 kW source that is beamed with a half-angle of 3.6 degrees has the same intensity as a 1 Mw isotropic emitter. Furthermore, the distance estimates may be quite dubious. Hence the power estimates derived for the above cases must be considered quite uncertain. The most promising cases will be those for which some form of physical interference took place (such as an effect on a public lighting system), but these call for detailed investigation by specialists familiar with such systems.

For further information about luminosity estimates, see Section 15.

5. Radar Evidence

Velasco presented information on radar cases drawn in part from the files of GEPANISEPRA (see Appendix 1). He pointed out that one catalog (the "Weinstein catalog" now under development at GEPANISEPRA), with 489 cases in all, contains 101 (21%) radarlvisual cases (cases that involve both radar detection and visual observation), and the files of the US Air Force Blue Book project contain 363 cases of which 76 (21%) are radarlvisual cases. Since 1945, reports of aeronautical cases have been collected by order of the French Air Force Chief of Staff. From 1977 on, information from civil and military observations made in French air-space have been sent to GEPANISEPRA (see Appendix 1). It should be noted that civil radar information usually refers only to objects containing a transponder, whereas military radar equipment can detect any object greater than two square meters in radar equivalent surface area. From 1982 on, twelve French aeronautical cases were reported to GEPANISEPRA. Of these, only three or four cases may be considered to be radar-visual cases of the UFO type.

One of these cases is particularly interesting. This case occurred on January 28 1994, about 70 kilometers southeast of Paris, at a height of 11,700 meters, under excellent meteorological conditions. An object was first noticed by a

steward who happened to be in the cockpit, and his observation was then confirmed by the copilot. The captain then saw the object. It was above the thick layer of altocumulus clouds at 10,500 meters. The captain described the object as resembling a gigantic disk (diameter about 1000 meters, thickness about 100 meters) with slightly fuzzy edges. The witnesses suddenly lost sight of the object when the edges appeared to go out of focus and the object disappeared.

Corresponding radar information was obtained from the military air traffic control (ATC). The object was positively detected by radar for a period of 50 seconds. The apparent speed of the object was measured first as 110 knots, then as 84 knots, and subsequently as zero. The altitude of the object was not recorded by radar. The radar was also tracking a nearby commercial aircraft and appeared to be in good working order. There appears to be good correspondence between the radar measurements and the visual observations.

Von Ludwiger also presented information concerning radar evidence, drawing in part on the results of studies that he had carried out in association with other members of the Mutual UFO Network (MUFON) Central European Society (MUFON-CES). For a certain period of time, they were able to obtain records from both civil and military ATC radar systems. The Swiss Military ATC was particularly cooperative, and provided several hundred hours of radar data over the time period 1993 to 1996. Radar data were also obtained from Belgian sources through the good offices of Professor A. Messens (SOBEPS, 1991). Military ATC radar systems provide three-dimensional information, whereas civilian ATC radar systems provide only two-dimensional information. Furthermore, the functioning of civilian ATC radar systems normally depend upon the cooperation of a transponder in the object being tracked. For this reason, civilian ATC radar records are usually not helpful for the study of unidentified objects. Moreover, there is the general problem that ATC systems are designed to register only targets for which the flight characteristics fall within certain parameter ranges. For instance, any object that moves faster than Mach 4, or does not follow a smooth trajectory, will be rejected by the system whether civil or military, and so will not be tracked. A further limitation, relevant to the study in hand, is that conditions for a good radar record and conditions for a good visual sighting are quite different. An object can best be seen if it is at low altitude, but radar systems normally do not detect objects at low altitude.

In the United States, the Federal Aviation Administration (FAA) radar routinely records on tape all targets, not just aircraft with transponders. Of course, radar systems record only objects that are sufficiently close and have high enough altitude. Although it is unlikely that private investigators will be able to obtain regular access to these records, such access has been granted on occasion. Such data can be very helpful in providing physical evidence for cases that have reliable witness testimony, in which case the records can be compared to witness testimony to determine whether an object seen visually

was also recorded on radar, and — if so — to obtain accurate velocity estimates.

According to von Ludwiger, there are many events, involving both visual observations and radar responses, in Swiss airspace but the radar records are not publicly available. However, one case for which radar records were released occurred on June 5, 1996 at about 2:30 p.m. Six employees, including radar operators, of the military ATC at Dubendorf, Switzerland observed from their building in Klothen a large silvery disk apparently at a distance of 1700 meters. It appeared to be rotating and wobbling at an altitude of 1300 to 2000 meters. There was a corresponding recording of a target by three radar devices.

Von Ludwiger also mentioned a number of other cases of radar targets, some of which followed curious trajectories unlike those of conventional aircraft. Recognition of these anomalous trajectories typically came some time after the events when the radar data were analyzed. Von Ludwiger considers this to be one reason that (except for two cases) it was normally not possible to find corresponding visual observations. Von Ludwiger considers that for many of these cases the most likely explanation involves anomalous atmospheric refraction of the radar signals, but that some cases for which the radar records showed very long connected trajectories may have been produced by real objects. (See Appendix 4.)

The panel concludes from these presentations that the analysis of radar records is a very specialized activity that requires the services of radar experts. (See, in this connection, Appendix 4.) The panel also notes that information from military radar can be obtained only with the cooperation of military authorities, and that most military authorities do not offer this cooperation. Although intriguing cases have been presented by both Velasco and von Ludwiger, further study of this phenomenon by means of radar-visual cases may not be feasible unless the relevant authorities recognize the mission of an official UFO research organization (as has been done in France) and give the investigators clearance for access to some of the unexploited raw data. It would be necessary for the research organization to help implement adequate software modules that can read and store available data in a mode of operation that does not interfere with the primary mission of the system.

6. Hessdalen Project

Strand summarized the design and operation of the Hessdalen Project. Hessdalen is a valley in central Norway, 120 kilometers south of Trondheim. The valley is 12 kilometers long and a maximum of 5 kilometers wide. The hills to the west and to the east rise to about 1,000 meters above sea level. Most people in the valley live at a height of about 800 meters.

In December 1981 the inhabitants of the Hessdalen valley began to report seeing strange lights. They were sometimes visible three or four times a day. There were hundreds of reports during the period 1981 to 1985, but the phenomenon began to decrease during 1984, and since 1985 there have been com

paratively few sightings. Most observations were on winter nights: there were comparatively few during the summer or during the day.

Witnesses reported observations that seemed to fit into three different categories:

> Type 1: A yellow "bullet," with the sharp end pointing down.
> Type 2: A strong blue-white light, sometimes flashing, always moving.
> Type 3: A pattern comprising many light sources with different colors that moved as if they were physically connected.

In 1983, a small group with five participants set up "Project Hessdalen." They received assistance from the Norwegian Defense Research Establishment, the University of Oslo, and the University of Bergen. They carried out field work in the Hessdalen valley from January 21, 1984 to February 26, 1984, when up to 19 investigators were in the field at the same time. The project then involved three stations with observers and their cameras, some cameras fitted with gratings to obtain spectroscopic information. At the principal station, observers used the following equipment: cameras, some fitted with gratings; an infrared viewer; a spectrum analyzer; a seismograph; a magnetometer; radar equipment; a laser; and a Geiger counter.

Lights that were recorded to be below the contours of the mountains must have originated in the Hessdalen region, but lights that were recorded to be above the crest line may have originated at a great distance. Without triangulation or other information, it is impossible to determine the distances of the lights. However, some of the events that were seen as lights were tracked also by radar. If taken at face value, the radar measurements would imply speeds up to 30,000 kilometers per hour. (However, see Appendix 4.)

During a period of four days, unknown lights were seen on 10 occasions, and the flux-gate magnetometer registered 21 pulsations, of which 4 appear to correspond with the observations of lights, suggesting an association between some of the unknown lights and magnetic disturbances. The gratings on the cameras were intended to obtain spectroscopic data: the spectra appear to be continuous, with no indication of either emission lines or absorption lines.

Observations continue to be reported from the Hessdalen valley; the rate is now about 20 reports per year. An automatic measurement station, for installation in Hessdalen, is now being developed and prepared at Ostfold College (Norway), that is the present base of Project Hessdalen. This station will include a CCD-type camera in the visible region. The output from the CCD-camera will be fed automatically to a computer which will trigger a video recorder. This automatic station will hopefully prove to be but a first step in the development of a network of stations.

As a result of this presentation, the panel concluded that there would be merit to designing and deploying a not-too-complicated set of instruments. These should be operated according to a strict protocol in regions where the probability of significant sightings appears to be reasonably high. It is recom-

mended that, as a first step, a set of two separate video recorders be equipped with identical wide-angle objectives and installed on two distant fixed tripods to help eliminate the possibility that some of the apparent motions detected by video recorders are due to the operators' hand movements or ground vibrations. It would also be useful to set up two identical cameras, one of which is fitted with a grating. However, experience so far at Hessdalen indicates that a grating may not be adequate for obtaining spectroscopic information. In view of the great importance of spectroscopic data, it would be highly desirable that special equipment be developed and deployed for obtaining high-resolution spectroscopic data from transient moving sources. This may be a nontrivial problem.

If it proves possible to obtain useful results from a small system, such as suggested above, one may be able to make the case for the design and implementation of a permanent surveillance network. This should be designed as a multi-purpose system so that costs and data can both be shared. This could resemble the Eurociel project that was studied in Europe in the 1980s at the request of GEPAN/SEPRA. (See Appendix 1.)

The panel notes that in cases that involve repeated, semi-regular sightings of lights (such as are said to occur at Hessdalen in Norway and at Marfa in Texas), it is difficult to understand why no rational explanation has been discovered, and it would seem that a small investment in equipment and time should produce useful results.

7. Vehicle Interference

Rodeghier reviewed a small but important fraction of UFO reports that are said to involve effects on electric lights, automobiles, and other machines of various sorts. These reports have occurred throughout the modern era of UFO reports (since 1947) and come from all over the world, although (as with all UFO reports) they come primarily from Western nations. Of such reports, those that involve claims of vehicle (mainly automobile) interference have received most attention. One such case is discussed below. **A** more comprehensive discussion of vehicle interference cases is presented in the report by Rodeghier (1981). (See Section 15.)

Haines City, Florida, March 20, 1992

Based on his review of the original MUFON report, Rodeghier presented the following summary of this case.

At about 3:50 a.m. on March 20, 1992, patrolman Luis Delgado in Haines City (near Orlando), Florida, was checking the doors at local businesses. After turning onto 30th Street, he saw a green light in his rearview mirror. Seconds later, the interior of his patrol car was illuminated with a green glow. An object began pacing his car, moving from the right side to the front of the vehicle several times. Delgado called Police Dispatch at 3:52 a.m. and asked for backup

and said "Something is following the vehicle." When the object moved in front of his car for the third time, Delgado pulled off the road. When he did so, the engine, lights, and radio on his patrol car ceased to function.

The object was about 15 feet long and thin, with a 3-foot high center area. It was a strange color of green, and the color seemed to "flow over the surface." The object was hovering about 10 feet off the ground. As he was stopped, the object shone a bright white light into the interior of his vehicle. At that point Delgado got out of his car and tried to call Police Dispatch on his walkie-talkie, but it would not function. He noticed that the air around him had chilled and he could see his breath fog. According to weather records, the temperature at that time was about 60 F. Shortly thereafter, the object sped away at a fantastic speed in about two or three seconds, moving low over the ground. Another officer arrived just after the object had departed and found Delgado sitting in his police vehicle with the left door open and one foot on the ground. He was shaking and crying and unable to talk. Eventually he recovered and filed an incident report. The patrol car functioned normally after the event, and Delgado suffered no health problems. Review of the calls to the dispatcher indicate that the duration of the event was in the range 2 to 3 minutes.

Rodeghier pointed out that the Haines City report is typical of many other vehicle interference reports in the following respects: according to the report, the object was quite close to the witness (a "close encounter" case); the object was of modest size; the object projected a beam of light into the vehicle; the witness did not suffer any injury; the witness did experience an anomalous effect (in this case, the chill in the air); and the object moved at very high speed when it departed.

According to Rodeghier, many such cases have been reported, and he has prepared a catalog of 441 vehicle interference cases (Rodeghier, 1981). (See Section 15.) It is noteworthy that vehicles with diesel engines are affected only very rarely (less than 1% of all vehicle interference reports).

According to Rodeghier, several hypotheses have been advanced to explain these effects:

1. The ignition or other electrical system may have been disrupted by high static electric or magnetic fields.
2. Ignition of the gas-air mixture may have been affected by ionization of the ambient air.
3. Fuel may somehow have been prevented from entering or leaving the carburetor.
4. The engine operation may have been disrupted by electric fields induced by an alternating magnetic field, possibly of low frequency.

Clearly, laboratory tests on automobiles and their engines could be highly informative. Some such tests have in fact been carried out. Staff of the Colorado Project (Condon & Gillmor, 1969) attempted to determine the effect of a static magnetic field on a simulated automobile ignition system. The staff

found that spark plugs continued to operate even in static magnetic fields as high as 20 kilogauss. The Colorado Project staff also investigated the possibility that an automobile involved in such a case might display a change in the pattern of its remanent magnetism (its "magnetic fingerprints"), but they found that this had not occurred for the one case they examined. Rodeghier reported that tests by Australian investigators on vehicles involved in two events (Adelaide, South Australia, 1977, and Liverpool Creek, Queensland, 1979) also found no changes in remanent magnetism. On the other hand, Randles and her colleagues (Randles, 1979) found a change in magnetism for a vehicle involved in an event that occurred at Thaxted, Essex, England in 1977.

The panel found these reports to be intriguing. In order to contribute to the analysis of such cases, however, scientists would wish to have available evidence of a variety of types, certainly including narrative accounts, but also involving more concrete information such as radar records, tape recordings, *etc.*

For further information about vehicle interference cases, see Section 15.

8. Interference with Aircraft Equipment

Richard Haines presented a summary of his extensive research into pilot-UFO sighting reports. He now has a catalog of over 3,000 pilot reports, of which approximately 4% involve transient electromagnetic effects allegedly associated with the presence of strange objects. Another catalog of aircraft-UFO-encounter cases (referred to by Velasco in Section 5) is being compiled by Weinstein (1997) as a GEPAN/SEPRA project; this catalog currently contains several hundred aircraft-UFO-encounter cases.

Haines pointed out some of the reasons that make pilot-UFO sighting reports especially valuable to the UFO investigator:

1) Pilots have received a great deal of relevant specialized training and possess practical flight experiences which better qualify them to report accurately what they see.
2) Pilots are highly motivated, yet do not over-react during stressful situations.
3) Pilots can change their flight path so as to see the ground behind the object and thereby establish a maximum slant range to it.
4) Pilots can use their radio to contact ground support for further information or assistance.
5) Aircraft have a wide variety of instruments that react differently to electromagnetic radiation.

Nevertheless, according to Haines, even an experienced pilot can be deceived by some of the unusual phenomena listed in Appendix 3.

Haines focused on cases that appear to involve transient electromagnetic (EM) disturbances that occur only while one or more objects are seen flying near the airplane and which return to normal as soon as the object departs (Haines 1979; 1992). Haines has compiled a catalog of 185 such EM events

which occurred over a 51-year period (1944-1995), and has developed a taxonomy of electrical-system malfunctions on modern airplanes with which to categorize and better understand them. The largest category of effects is airborne radar contact, while the second largest category is radio interference or complete but temporary radio failure.

Haines discussed two pilot reports in detail, one of which was an interesting case that occurred at 2105 EST on March 12, 1977 between Buffalo and Albany, New York, that involved United Airlines flight 94, a nonstop flight from San Francisco to Boston. The DC-10 airplane was under the control of autopilot system #2 and was flying at 37,000 feet altitude. The entire sky was dark and clear ahead and above the airplane, except for a partial undercast with small clouds extending to about 20 miles ahead. The aircraft was flying at an indicated air speed of 275 knots (true air speed 530 knots). The aircraft was about half way between Buffalo and Albany, and had just changed from contact with the "FROM" VOR (Very-High-Frequency Omnidirectional Bearing) signal emanating from Buffalo to the "TO" signal from Albany, The aircraft was just south of Syracuse, New York.

Suddenly and unexpectedly, the airplane began to turn to the left, making a 15 degree bank. Within a few seconds, the First Officer and the Captain looked to the left side of their plane and saw an extremely bright white light at about their own altitude. Subsequently, the Flight Engineer also looked and saw the light source. It appeared to be perfectly round and its apparent diameter was about 3 degrees of arc. However, the Captain estimated the object to be about 1,000 yards away and to be about 100 feet in size, that corresponds to an angular size of 2 degrees. "Its intensity was remarkable — about the intensity of a flashbulb," he remarked. Boston ATC radioed to ask "United 94, where are you going?" The Captain replied "Well, let me figure this out. I will let you know." He then noticed that the three cockpit compasses (that use sensors in different parts of the plane) were all giving different readings. At this point, the Copilot turned off the autopilot and took manual control of the airplane.

Based upon the fact that the object did not move laterally in the cockpit window during the 45 degree left heading change and from knowledge of the turn radius of this airplane at its stated velocity, Haines calculated the approximate distance to the object to be about 10 nautical miles. If the pilot's angular size estimate for the object is accurate, this suggests that the light source was about 2100 feet across. The object appeared to stay with the airplane for 4 to 5 minutes, after which it departed very rapidly, disappearing within about 15 seconds behind them to the west. The Captain asked ATC if they had any radar traffic in that area and received a negative reply.

The navigation system involves two gyro-suspended compasses, each coupled to a special circuit with a "mismatch annunciator flag." If the readings from the two compasses differ by 3 degrees or more, the autopilot should automatically disengage and the mismatch annunciator flag should be displayed (Powell, 1981). This forces the pilot to take manual control of the airplane.

However in this event the readings on the two compasses differed by more than **3** degrees yet the airplane remained on autopilot and the mismatch annunciator flag was not displayed.

Haines reviewed several possible interpretations of this event (cf. Perry & Geppert, 1997). It seems most probable that the malfunction of the three compasses was due to a transient perturbing magnetic field that disturbed the two primary magnetic compasses, the sensor on the wing tip nearest the object (which was controlling the active autopilot at the time) being disturbed more than the other wing-tip sensor. Upon landing, the compasses were checked and found to be in normal operating condition.

In responding to this presentation, the panel took the position that evidence of interference with aircraft equipment is interesting but, in the absence of corroborative data from flight recorders and other mechanical or electrical recording equipment, the evidence presented must be regarded as anecdotal. It is quite possible that the persons making the report summarized above did indeed see unusual and striking phenomena. It does appear that the airplane departed from its normal flight path, but this could have happened for a variety of reasons. As with reports related to other categories of physical evidence, the evidence summarized in this section should be regarded as suggestive but far from sufficient to establish any actual physical linkage between the reported luminous phenomenon and the airplane's flight deviation. In order to improve our understanding of these phenomena, it will be necessary to establish more definite facts from the case work. To this end, there should be strong efforts to quantify the observations and to obtain multiple measurements of the same event, and investigators should bring a critical attitude to the compilation and analysis of the data.

9. Apparent Gravitational and/or Inertial Effects

In his presentation, Swords focused on reports with details that, if true, are difficult to understand in terms of our familiar concepts of gravity and inertia. For instance, a report may describe an object that is stationary, yet completely silent and has no visible means of support; there is no rush of air and no roar such as one would expect if the object were being supported by a downward jet of gas. It may be reported that the object makes an abrupt velocity change — either a very sudden acceleration or deceleration, or a sudden change of direction, or both, and the witness may describe the event as being completely silent. According to Newton's third law of motion, any sudden change of momentum of an object should be accompanied by an opposite change of momentum of either matter or a field to which the object is coupled. According to reports of the type described by Swords, there is no indication of what force might support the object or what momentum transfer may have occurred.

It is clear that future reports must, if they are to be considered seriously by physical scientists, include very solid physical records that unfortunately present reports do not: most of these cases are anecdotal and therefore very diffi-

cult to assess. One of the better-documented cases occurred at approximately 11:00 p.m. on August 18, 1973. At that time, a helicopter of the US Army Reserve was en route from Columbus, Ohio, to Cleveland, Ohio. In discussing this case, Swords drew upon an investigation by Ms. Jennie Zeidman on behalf of the Center for UFO Studies (Zeidman, 1979; see also Zeidman, 1988). The four-man crew of an Army Reserve helicopter based in Cleveland, Ohio, flew to Columbus for their regularly scheduled physical examinations. At about 10:00 p.m., after the examinations had been concluded, they left the medical facility, drove back to the airport (a distance of two miles), filed a flight plan, and then took off at approximately 10:30 p.m. The night was clear, calm, starry and moonless, with 15-mile visibility. The helicopter was cruising at 90 knots at an altitude of 2500 feet mean sea level over mixed terrain averaging 1100 to 1200 feet elevation.

According to their reports, one of the crewmen saw a single red light off to the left (west), apparently heading south, when they were about seven miles east-southeast of the Mansfield, Ohio, airport. The last altitude the commander noted was the initial altitude of 1800 feet msl (mean sea level), about 700 feet above ground level. At approximately 11:02 p.m. (about three to four minutes after the above observation), the crew member in the right rear seat noticed a single steady red light on the eastern horizon. It appeared to be pacing the helicopter, and he reported this light to the aircraft commander. The light continued its approach and the commander took over the controls from his copilot and put the helicopter into a powered descent of approximately 500 fpm (feet per minute). He contacted Mansfield control tower but, after initial radio contact, the radios malfunctioned on both VHF and UHF. The red light increased in intensity and appeared to be on a collision course at a speed estimated to be above 600 knots. The commander increased the rate of descent to 2000 fpm.

A collision appeared imminent, but the light suddenly decelerated and assumed a hovering relationship above and in front of the helicopter. The crew reported seeing a cigar-shaped gray metallic object that filled the entire windshield. It had a red light at the nose, a white light at the tail and a distinctive green beam that emanated from the lower part of the object. The green beam swung up over the helicopter nose through the main windshield and into the upper tinted window panels, bathing the cockpit in green light. There was no indication of noise or turbulence from the object. After a few seconds of hovering, the light accelerated and moved off to the west, showing only the white "tail" light. The object made a sharp 40 degree course change during its departure.

While the object was still visible, the crew noted that the altimeter read 3500 feet with a rate of climb of 1000 fpm, despite the fact that the collective (the main power control that causes a helicopter to ascend or descend) was still in the full-down position. The commander raised the collective and the helicopter climbed nearly another 300 feet before positive control was re-

gained, at which time the crew felt a slight bump. Radio contact with Akron/Canton was then easily achieved. If these accounts are correct, the helicopter ascended from 1800 feet to about 3800 feet even though the helicopter controls were set to cause it to descend.

The Mansfield helicopter case is a particularly puzzling event since it involved not only the testimony of the helicopter crew but that of independent ground witnesses also. These witnesses include a mother, three of her children (ages 13, 11 and 10), and a stepchild (age 13). The witnesses were originally driving in the family automobile, then parked it, whereupon two of the children got out of the car for a better view. All the witnesses first saw an unidentifiable pair of lights (one red, one green), and then the encounter between the "object" responsible for the lights and the oncoming helicopter. Their accounts are consistent in their essential elements, the most memorable aspect being the powerful green light that lit up both the ground and the helicopter. This element received further confirmation from another set of witnesses who were retiring that evening in a nearby house, when they were disturbed by the clattering of a helicopter and by a powerful beam of green light that swept over their house and brightly illuminated their son's bedroom. Related evidence comes from an airline pilot who (in the Mansfield area, about 1.5 hours before the helicopter event) reported unidentified traffic that had the appearance of a strong blue-green light source traveling at an altitude of about 30,000 feet. Cleveland ATC could not detect any object painting an image on their radar screens and so were unable to identify the object.

According to Swords, there was one item of physical evidence that could have been investigated but apparently was not. The commander reported that the magnetic compass began to spin during the event. The compass continued to spin after the event and it was subsequently removed because it was unserviceable. Swords reported that some years after the event Captain Coyne expressed the opinion that his compass, that had not previously malfunctioned, had somehow become demagnetized, but it was not clear whether this opinion was merely a conjecture or whether it was based on laboratory tests.

The panel finds reports of this type quite interesting, but without the existence of any solid physical evidence (such as analysis of the magnetic compass might have provided), it is difficult for a panel composed of physical scientists to draw any conclusions. The panel also found it curious that the commander did not know where to go to report what appears to have been an extraordinary event. He contacted the Federal Aviation Authority Chief of Operations at Hopkins field, but this official could not suggest an agency with which the commander should file his report. About a month later, the commander filled out an operational hazard report. Rodeghier advised the panel that, since the termination of Project Blue Book in late 1969, there has been no official body to receive UFO reports in the U.S.A.

For further information about the Mansfield helicopter case, see Section 15.

10. Ground Traces

A few of the reports that have been investigated by GEPANISEPRA show ground traces that may be associated with the events reported by witnesses. Similar cases have been documented by other investigators. Phillips (1975) prepared a catalog of 561 such cases as a CUFOS report.

GEPANISEPRA has investigated only cases for which the following conditions are met:

1. Information concerning the event has come to GEPANISEPRA from an official source such as the Gendarmerie, local police, *etc.*
2. The event is recent (a few hours to a few days old).
3. The area has been protected and the traces have been preserved.
4. Sampling and measurements have taken place within a short time after the event.
5. Meteorological conditions have been favorable for preservation of the traces (no rain, *etc.*).

It is also desirable, but not essential that the event has independent credible multiple witnesses.

The first steps — to protect the site, to make measurements, and to begin collecting samples — are usually carried out by the Gendarmerie who have a complete set of instructions in a manual prepared by GEPANISEPRA, who have also devised procedures to be implemented by specialized laboratories for the collection and analysis of samples. When the services of a specialized laboratory are requested, the laboratory personnel will go to the site for *in situ* sampling.

Soil has the capability of retaining the effects of several processes including mechanical, thermal, magnetic, radioactive, and physicochemical processes.

Mechanical: A continuous or brief mechanical pressure causes a distortion of the soil. The compression of the soil can be measured by a penetration instrument, for instance.

Thermal: Measurement of the quantity of water in the soil, as compared to nearby control samples, allows determination of the amount of energy required to reduce the water content to that level.

Magnetic: Some soils have a high magnetic remanence. In this case, it is useful to examine the magnetic pattern of the soil with the help of magnetometers either *in situ* or (after sampling) in a laboratory.

Radioactivity: Such measurements may be made *in situ* or carried out on samples in the laboratory.

Physicochemical: Samples from the trace region and control samples away from the trace region can be analyzed for molecular, atomic and isotopic composition, *etc.*

Velasco described in detail their investigation of an event that occurred near Trans-en-Provence, France, on January 8, 1981 at about 5:00 p.m. (Bounias,

1990; Vallee, 1990; Velasco, 1990; see Section 15.) One weakness of this case is that there was only one witness. The witness was working in his garden when he heard a low whistling sound. Upon turning around, he saw an ovoid object in the sky that approached the terrace at the bottom of the garden and landed. The witness moved forward cautiously to observe the strange phenomenon but, within a minute, the object rose and moved away in the same direction from which it had arrived. It continued to emit a low whistle. The witness approached the scene of the apparent landing and observed circular depressions, separated by a crown, on the ground.

The Draguignan Gendarmerie arrived the next day (January 9) to investigate the report and, following GEPANISEPRA instructions, took samples from the ground and from the vegetation. The Gendarmerie found two concentric circles, one 2.2 meters in diameter the second 2.4 meters in diameter. Between the two circles was a raised area 10 cm wide. They found, on this raised area, two sectors, diametrically opposite, each about 80 cm long, that contained black striations similar to abrasion traces.

A team from GEPANISEPRA carried out a site visit on February 17, 1981, 40 days after the event. The trace was still visible since there had been very little rainfall since January 8. The arc-shaped area, lighter than the rest of the terrain, was still visible. The soil in this region was heavily compacted, forming a crust. Soil samples were taken both on January 9 and on February 17. These samples were then forwarded to various laboratories equipped for physical and chemical analyses. It was found that the compacted soil had a thickness of 6-7 mm. There was no trace of organic compounds such as one might expect to be produced by combustion. There was some evidence of iron in the form of striations about 1 micron thick, but the iron was not accompanied by chromium, manganese or nickel as would be the case for steel. There was some evidence of polymers. Traces of phosphate and zinc were also found. Traces visible as striations seemed to have been produced by a combination of mechanical and thermal effects.

Visual and microscopic examination revealed that, apart from the striations, the soil had been compacted without major heating, since the structure of calcium carbonate was not affected. Velasco has made an order-of-magnitude estimate indicating tnat, to produce the measured compression of the soil, one would need a stationary object of about 700 kilograms. On the other hand, the same indentations in the soil could have been made by an object of lower mass if the object were moving at a few meters per second at the time of impact.

The panel was intrigued to learn that ground traces appear to be associated with some UFO reports. These traces could of course be spurious with no relation whatever to the reported event, they could be due to hoaxes, or they could in fact be related to a real event. Clearly, it is essential to devise measurement procedures that can distinguish between these three possibilities. For this to be possible, it would definitely be helpful to have "baseline" measurements for some likely spurious causes and for hoaxes. The possible spurious causes

would of course depend upon the location in which the event occurs. For instance, in the Trans-en-Provence case in which the event occurred in a vegetable garden, the trace may have been caused by some piece of gardening equipment such as a metal water barrel. Similarly, someone perpetrating a hoax might have used a standard or manufactured wheeled object. Rather than leave the effects of such spurious causes or hoaxes up to speculation, it would clearly be advantageous to have firm information on which to base a judgment such as could be provided by relevant experiments. The investigators could move a water container to a similar patch of earth, or create a trace with a wheeled heavily laden object, and then compare measurements of those traces with measurements of the trace associated with the UFO report.

Experiments such as the above could be specific to a particular case or they could be generic. If such experiments became the rule rather than the exception, it would become possible for an investigator to consult a catalog of spurious causes or of hoaxes as well as a catalog of claimed "real" events.

For further information about the Trans-en-Provence case, see Section 15.

11. Injuries to Vegetation

In some cases that involve an apparent disturbance to the soil, there may also be an apparent injury to vegetation. Velasco stated that four such cases have been investigated by GEPAN/SEPRA: the "Christelle" case of November 27, 1979; the "Trans-en-Provence" case of January 8, 1981; the "Amarante" case of October 21, 1982; and the "Joe le Taxi" case of September 7, 1987.

In the Christelle case, in which grass was flattened in a uniform direction, plant physiology analysis was subsequently carried out by Professor Touze of the Laboratoire de Physiologie Végétale de l'Université Paul Sabatier (the Center for Plant Physiology, Paul Sabatier University), Toulouse. The Trans-en-Provence case will be discussed later in this section. In the Amarante case, that took place near Nancy, grass was lifted up, the amarante leaves withered, and the amarante fruit seemed to have exploded. The plant physiology was examined by Professor Abravanel , also of the Laboratoire de Physiologie Végétale de l'Université Paul Sabatier (the Center for Plant Physiology, Paul Sabatier University), Toulouse. In the Joe le Taxi case, birch leaves were affected by the incident, and a biochemical analysis was carried out by Professor Michel C. L. Bounias of the Biochemistry Laboratory at INRA (National Institute of Agronomy Research), University of Avignon.

In the Trans-en-Provence case of January 8, 1981, discussed also in the previous section (Bounias, 1990; Vallee, 1990; Velasco, 1990; see Section 15), the Gendarmerie took one sample 1.5 meters from the center of a ground trace on January 9 and another sample, 20 meters from the center, on January 23. On February 17, 1981, investigators from GEPAN/SEPRA visited the site and took a series of samples beginning at the center of the ground trace and ending

10 meters from the center. Bounias examined the samples in his laboratory. The principal procedure for biochemical analysis was that of determining the chromatograms of the pigments. This yielded information for a number of biochemical components (chlorophylides; xanthines; oxychlorophylls; lutein; chlorophyll A; chlorophyll B; pheophytins; and β carotene).

In samples taken from the periphery of the ground trace, the chlorophyll A content had been reduced by 33%, the chlorophyll B content by 28% and the pheophytin content by 31%. Bounias also found that the β carotene content had been reduced by 50-57% and the violaxanthine content by 80%. The above changes, which normally occur as the result of aging of a plant, were found both in the samples removed by the Gendarmerie within one day of the event, and by the samples taken by the GEPANISEPRA investigators 40 days after the event. As one may see from the article by Bounias (1990), the biochemical changes show a strong correlation with distance from the center of the event. It appears that the magnitude of the effect is associated with a specific quantity (the difference in free enthalpy) associated with the biochemical change. According to Bounias, the glucide and amino-acid content of very young leaves had been changed to become nearer the content characteristic of old leaves.

Bounias carried out certain experiments to try to determine what form of trauma may have been responsible for these biochemical changes. As a toxicologist, Bounias rejected the hypothesis that the changes could have been caused by a deliberate act involving chemical poisons. Bounias also found that some of the changes could have been caused by powerful microwave radiation. However, microwave radiation by itself would not explain the photosynthetic breakdown or certain other characteristics of the injuries. Bounias found no evidence of effects that one might expect to be produced by ionizing radiation. This is consistent with the fact that there was no trace of radioactivity at the site.

Velasco also reported the GEPANISEPRA investigation into the "Amarante" case that occurred at Nancy on October 21, 1982. The witness, who is a biologist, reported that an ovoid object descended into his garden but did not descend lower than 1 meter above the ground. The witness observed the object for 20 minutes before it took off vertically into the sky. The witness did not hear any sound or feel any heat during the encounter, nor were there traces on the ground, However the witness reported that, just before the object departed, the grass blades stood up straight. Subsequent investigations showed that this phenomenon could be reproduced in the laboratory by using very intense electric fields (several tens of kV/m).

The GEPANISEPRA investigators found that the amarante plants located near the object had become desiccated whereas similar plants further away were in normal condition. The fruit of plants from the vicinity of the object looked as if they had been cooked. Further biochemical analyses of the sam-

ples gave results consistent with what one would expect of plants that had been dehydrated.

The panel was impressed by the detailed information that can be obtained by laboratory investigation of samples of vegetation taken from the location of a claimed UFO incident. It appears that a great deal more could be done in the way of laboratory experiments to study the effects of various kinds of radiation and other forms of trauma upon vegetation. One should also examine the kinds of effects that could be produced by techniques that might be involved in a hoax, such as chemicals, heat from a blow torch, *etc.* Such studies would help identify a hoax, if it has been perpetrated, or the studies may lead to the conclusion that a hoax is a very unlikely explanation of the traces. In the latter case, it may or may not be possible to identify the type of technological device that would produce the radiation, or combination of radiations, necessary to produce the identified injuries to the vegetation.

For further information about the Trans-en-Provence case, see Section 15.

12. Physiological Effects on Witnesses

UFO reports sometimes include references to physiological effects on witnesses. These effects can range from mild temporary sensations to long-term injuries. Such cases were reviewed by Schuessler. (See Schuessler, 1996, and Section 15).

Among the temporary sensations experienced by witnesses, Schuessler gave the following examples: a strong sensation of heat that was reported in association with an event at Mount Rouge, Quebec, Canada on September 20,1972; a "cold" feeling reported by a witness to an event near Eggardon Hill, England, on September 24, 1974; an experience of shock, reported by two witnesses to an event near Tyler, Texas, on November 26, 1976; a sensation like being "hit with a wet blanket" and a very uncomfortable feeling of being unable to move, reported by two witnesses of an event that occurred near Anderson, Indiana, on August 12, 1981; and a tingling sensation, an inability to move, and an experience of having the hair on the neck stand on end, that were all reported by a witness of an event that occurred near Barnsley, Yorkshire, England, on August 15, 1956.

Schuessler also described several cases in which witnesses experienced multiple sensations including the following: uncontrollable hand motion; eye irritation; difficulty in breathing; an acid taste in the mouth; a sensation of the hair on the arm standing up; loss of consciousness; eye damage so that the witness could barely see; a mark on the hand of a witness where she reported that she has been hit by a beam; a red crust of soft skin on the face that felt sensitive to the touch; and a sensation of heat. Physiological effects were reported that could be long lasting, including the following: burns; temporary deafness; singeing of hair; laceration; swelling; nausea, that could continue for months and could lead to weight loss; loss of sight that could take months to overcome; severe itching; memory loss; bum marks; double vision; nose bleeds; and

change of urine color. For more information on cases leading to such effects, see Schuessler (1996).

Schuessler gave an extensive account of a notable case that occurred near Dayton, Texas, on December 29, 1980 (Schuessler, 1981; 1988; 1998). This is known as the "Cash-Landrum" case since it involved Betty Cash, then a 51 year old business woman, and Vickie Landrum, then a 57 year old employee in a restaurant. It also involved Landrum's grandson Colby, then 7 years old. According to their reports, they encountered a large diamond-shaped object hovering above the road in front of them. Flames were belching from the bottom of the craft. The interior of the car became hot, forcing them to leave the vehicle. However, Colby and Landrum returned to the vehicle out of fear. Cash remained outside the automobile for seven to ten minutes. The object rose into the night sky and moved away. According to their reports, the object was accompanied by 23 helicopters that Cash and Landrum assumed to be military.

The witnesses were initially affected mainly by the heat and the bright light, and they developed headaches. During the night, Colby vomited repeatedly and his skin turned red. The same happened to Landrum. Cash fared even worse: large water blisters formed on her face and head, and by morning her eyes had swollen shut. The three witnesses continued to have severe nausea: even water would make them vomit; they developed diarrhea, and their health deteriorated severely. Cash was taken to a hospital where she was treated as a bum patient. This was the first of more than two dozen periods of hospital confinement for Cash.

Schuessler listed the following medical problems developed by the three witnesses: eyes swollen, painful and watery; permanent damage to the eyes; stomach pains, vomiting and diarrhea; sores and scarring of skin, with loss of pigmentation; excessive hair loss over a several-week period, the new hair having a different texture from the old; loss of appetite, energy and weight; damage to fingernails and shedding of fingernails; increased susceptibility to disease; and cancer.

The Cash-Landrum case seems to be unique in that there is detailed documentation of the injuries (photographs, *etc.),* and of the subsequent medical treatment. The case seems also to be unique in that it appeared to involve military helicopters, raising the possibility that a secret military operation was in progress (Schuessler, 1996).

As Schuessler pointed out, most witnesses who suffer from injuries do not tell their physicians about the events that appear to have led to injuries and, if they do, they find that the physician does not believe them. Follow-up examinations are rare, and investigators usually collect little more than anecdotal data. Nevertheless, some patterns seem to emerge concerning the types of injury that are reported: it appears that bums (and/or sensation of heat) and eye problems are the most frequently reported forms of injury.

The panel members were concerned with these accounts, since it appears

that some events related to UFO reports may constitute a public health problem. However, the evidence is weakened by the fact that, in most cases, no unaffected and independent witness is present. The available evidence (that is admittedly sparse) seems to be indicative of microwave, infrared, visible, and ultraviolet radiation, although a few cases seem to point towards high doses of ionizing radiation such as X-rays or gamma rays. Most of the reported eye problems (sometimes long lasting) may be attributed to strong UV radiation. Superficial burns may be due to UV radiation, but deeper bums may be due to microwaves. It may be noted that injuries to vegetation (see Section 11), that include desiccation and "aging," also may be due in part to microwave radiation.

Unfortunately, cases that involve injuries to animals and people are usually not well documented, and lack an adequate description of the injuries and of the follow-up investigations (if any). Research is also made difficult by the fact already mentioned that victims typically give no information to the attending physician and that, when they do, the physicians tend not to believe them. This does not help in the medical diagnosis and treatment. Some cases come to the attention of UFO investigators only years after the event. Nevertheless, it appears that the reported cases involve very uncommon injuries, that have probably been brought about by sources of intense radiation that are usually not accessible to the public.

Schuessler's presentation included an account of the protocols developed by UFO medical experts for the investigation of such cases. The panel suggested that additional relevant tests include tests for radioactive contamination or intake, and also tests for possible chromosomal changes in the lymphocytes that might yield evidence of exposures to ionizing radiation. Investigators and physicians could employ some of the general procedures developed and published by the International Commission on Radiological Protection (ICRP), for responding to emergency and accidental exposures to ionizing radiations.

For the well-being of victims, and for research purposes, it is important that victims receive treatment rapidly. For this to occur, it is necessary that doctors should be educated to immediately report cases of unusual injuries, such as those mentioned in this section, to an official organization. For research purposes, it is essential that there be strong witness testimony supplementary to that of the victims of the event. Furthermore, it would be helpful if an investigation protocol could be developed for this important category of cases that would guide the investigators as well as the examining physicians.

For further information about physiological effects on witnesses, see Section 15.

13. Analysis of Debris

Vallee reviewed several cases in which material samples were reported to be associated with unexplained aerial events. Vallee specified four criteria that led to his selection: the documentation of witness testimony; the

circumstances surrounding the recovery of the specimen; evidence linking the specimen to the reported object; and laboratory analysis of the samples.

Vallee devoted most time to a case that occurred at Council Bluffs, Iowa, on December 17, 1977. Several residents of the town observed a bright flash at 7.45 p.m. The flash was followed by flames 8 to 10 feet high. When the witnesses reached the scene of the event, they found a large area of a dike at Big Lake Park, on the northern city limits, covered with a mass of molten metal that glowed red-orange and had ignited the grass.

Police and firefighters reached the scene within minutes of the event. One law-enforcement officer described the molten mass as boiling and running down the edges of the levee over an area of about 4 to 6 feet in extent. The central part of the material remained warm to the touch for another two hours. There were 11 witnesses in all. Two of the eleven witnesses had observed a lighted object in the sky prior to the fall of the material.

The sample recovered from the event was analyzed at Iowa State University and at the Griffin Pipe Products company. It was found that the metal was mainly iron with small amounts of alloying materials such as nickel and chromium. The analysts concluded that the material was similar to carbon steel. However, they eliminated the following four possibilities:

a) An unknown person poured molten metal on the ground as a hoax;
b) An unknown person created molten metal as a hoax by using thermite and ordinary metal;
c) The material came from equipment from an aircraft; or
d) The event was due to a meteoritic impact.

The origin of the sample therefore remains unidentified.

Vallee also discussed the following cases:

Maury Island, Washington, June 21, 1947. Debris that was claimed to be associated with an aerial explosion appeared to be similar to debris from a Tacoma slag mill, leading the authorities to conclude that the case was probably a hoax. However, some aspects of the case have never been fully elucidated.

Campinas, Brazil, December 14, 1954. An object, described as disk-like, was said to have wobbled and lost altitude and to have emitted a thin stream of silvery liquid that was subsequently determined to be tin.

Vaddo Island, Sweden, November 11, 1956. Witnesses found a shiny "rock," hot to the touch, near the landing site of a strange object. The "rock" was found to be composed of tungsten carbide and cobalt.

Vallee also gave brief mention of the following cases: Aurora, Texas, April 17, 1897; Washington, D. C., 1952; Ubatuba, Brazil, date on or before September 1957; Maumee, Ohio 1967; and an event that occurred in Bogota, Columbia either in 1975 or in 1976.

The panel found that reports of unusual metallic residue following the observation of an unexplained aerial phenomenon are detailed enough for comparative studies to be undertaken. The Council Bluffs case is notable since the conditions of witness availability and reliability, on-site testimony from law-enforcement officers, and rapid analysis, appear to have been satisfied. Some of the other cases, such as the Bogota case and the Ubatuba case, are sufficiently intriguing to encourage investigators to expand their field investigations.

None of the cases presented provide clear proof of a sample that is outside present scientific knowledge. Nevertheless, the panel encourages the search for further cases for which Vallee's four conditions are met, and urges that the associated material samples be subjected to careful analytical studies of elemental and isotopic compositions, *etc.*

For further information about the analysis of debris, see Section 15.

14. Recommendations Concerning Implementation

P. A. STURROCK

The purpose of this section is to summarize ideas of what might be done to implement the panel's suggestions that were presented in their Summary Report (Section 1). The panel's observations and recommendations may perhaps be summarized very briefly as follows: The UFO problem is not simple and should receive more attention, with an emphasis on physical evidence; regular contact between UFO investigators and the scientific community would be helpful, as also would institutional support; and the possibility of health risks associated with UFO events should not be ignored.

The panel was greatly impressed by work reported from GEPAN/SEPRA, the French project originally GEPAN and now known as SEPRA (see Appendix 1), and there is no doubt that the best prospect for real advance in our understanding of the UFO problem would be the creation of similar projects in other countries, for the following reasons:

1. Such a project could be mandated to obtain access to relevant data such as police records, radar records, *etc.*
2. The project could organize and draw upon a network of laboratories and consultants.
3. The project could set up and maintain a central database.
4. The project could construct and operate one or more mobile "observatories" that would include a number of cameras and other detectors including, as a minimum, optical, infrared, spectroscopic, acoustic, magnetic and radiation instruments.
5. New cases could be investigated from the outset purely on the basis of data collected by official channels and procedures.

6. If there is indeed a health hazard associated with some events related to the UFO problem, some government office should offer a response to this hazard.

Even the most speculative hypotheses could be evaluated by a well conceived and well supported project. For instance, an analysis of the isotopic composition of material specimens could provide evidence that a specimen is probably of extraterrestrial origin, and analysis of the spectra of stationary objects, if it were to yield evidence of red-shifts or blue-shifts corresponding to a fraction of the speed of light, could indicate that some extraordinary physical process is involved. However, material specimens are rare, and it would take special equipment (that does not now exist) to obtain high-resolution spectra of transient and unpredictable sources.

We realize that not every country could duplicate GEPAN/SEPRA, since not every country has a national police force similar to the French gendarmerie. Furthermore, the creation of any such project would represent a political act that can be taken only by a national government for its own reasons or in response to public pressure.

For these reasons, it is necessary to be realistic and look for more modest approaches that could be initiated without government action. It would appear that progress is most likely to come about through incremental changes in institutional support and incremental changes in level of interest, these changes occurring symbiotically. We therefore inquire into what small positive changes could be made by scientists and by private institutions such as societies, journals, universities and foundations.

The most important change that could be made by scientists is to become curious. In view of the fact that modern UFO reports began in 1947, in view of the emergence of clear patterns in UFO reports (as was established some time ago by Poher [1973] among others), and in view of great public interest, it is remarkable that the scientific community has exhibited so little curiosity in the past.

There is no doubt that this lack of curiosity is due in part to a lack of reliable and accessible information. When Sturrock carried out a survey of members of the American Astronomical Society in 1975, he asked if members would like to obtain more information about the UFO problem, and most respondents replied that they would (Sturrock, 1994; 1994b; 1994c). Sturrock also asked whether members would like to acquire this information from lectures, symposia, books, or journal articles; most respondents wanted only journal articles. At that time, most editors of most scientific journals would not consider accepting an article on the UFO problem. Since that time, the Society for Scientific Exploration has been founded, and its journal is now in its 12th year of publication. However, the journal can be found in only a few university libraries. Hence the situation persists that it is not easy for scientists to obtain information about the UFO problem by the normal process of going to the library and looking up journal articles.

Clearly, there is a need for a change in policy on the part of journal editors. The scientific community would become much better informed if the major multi-disciplinary scientific journals were to carry occasional review articles that could guide readers to the specialized journals where more detailed information could be found.

Similarly, it would be very helpful if the major scientific societies were occasionally to include a review lecture or a review session containing several lectures devoted to the UFO problem. Specialized societies could also play an important role. For instance, a meteorological society could review those meteorological phenomena that are most likely to be responsible for UFO reports.

It is likely that more scientists at universities would take an interest in this problem if they felt that their activities would receive the same recognition and level of support as their more conventional research. Moreover, students would become better informed if there were occasional lectures or seminars on this subject. Investigators could help this process by developing resource material for such seminars.

However, even without waiting for such a change in policy of journals, societies and universities, scientists could exhibit a great deal more curiosity than they do now. Of course, it must be professional curiosity if it is to lead to professional results. It is not enough for a scientist to occasionally pick up a tabloid at the supermarket check-out stand. To become at all knowledgeable about the subject, a scientist should read the Condon Report (Condon & Gillmor, 1969), the report of the UFO Subcommittee of the American Institute of Aeronautics and Astronautics (Kuettner *et al.*, 1970) and its supporting articles (MacDonald, 1971; Thayer, 1971), and obtain as much information as possible about government-sponsored studies such as U. S. Air Force projects Sign, Grudge and Blue Book. [See, in particular, Blue Book Special Report No. 14 (ATIC 1955).] Jacobs (1975) remains an excellent introduction to the history of this topic. He or she would then be well advised to read some of the reports of GEPAN/SEPRA, the French official study group. (See Appendix 1.)

Study of the material mentioned in the preceding paragraph may arouse sufficient interest that a scientist would wish to become involved in actual research. Unfortunately, it would be far more difficult for a scientist to plan effective research on the UFO problem than in his or her main research area. The scientist would therefore be well advised to collaborate with one or more investigators with experience in field work or some other aspect of UFO research. Such collaboration would be greatly facilitated if, as the panel recommended, there were "some form of formal regular contact between the UFO community and physical scientists." Such contact could help acquaint a broader spectrum of UFO investigators with the normal procedures, protocols and standards of scientific research.

The proposed further contact could take the form of workshops similar to that held at Pocantico: such workshops could focus on some more limited as-

pect of physical evidence, or they could deal with quite different aspects of UFO research. The panel recognized the importance of "strong witness testimony," but of course physical scientists have no expertise relevant to that aspect of the problem; it might therefore be very helpful to hold a workshop dedicated to the collection and evaluation of witness testimony.

In the absence of government funding for UFO research, foundations and corporations can play an important role. It is likely that significant progress would be made if funds were to be made available for the support of (a) further workshops similar to the Pocantico workshop, (b) a few research projects that might be identified during the workshops, and (c) one or more symposia at which the results of these research projects would be presented and discussed.

The UFO problem is very complex and it is quite impossible to predict what might emerge from research into this area. But the same is true of any really innovative and exciting area of scientific research. As the panel remarked "Whenever there are unexplained observations, there is the possibility that scientists will learn something new by studying those observations." What is learned may bear no relation to the concepts that were entertained when the research was undertaken. We venture to hope that more scientists will take an interest in this curious subject so that there will be more progress in the second half century than there has been in the first half century. There could hardly be less.

15. Web-Site: Supporting Documentation

The following documents may be found on the web site [http://www.jse.com].

Section **3.** *Photographic Analysis*

Haines, R. F. (1987). Analysis of a UFO photograph. J. *Scientific Exploration,* 1, 129.

Haines, R. F., & Vallee, J. F. (1989). Photo analysis of an aerial disc over Costa Rica. J. *Scientific Exploration,* 3, 113.

Haines, R. F., & Vallee, J. F. (1990). Photo analysis of an aerial disc over Costa Rica: New evidence. J. *Scientific Exploration,* 4, 71.

Section 4. Luminosity Estimates

Vallee, J. F. (1998). Estimates of optical power output in six cases of unexplained aerial objects with defined luminosity characteristics. J. *Scientific Exploration,* 12 (in press).

Section 7. Vehicle Interference

Rodeghier, M. (1981). UFO *Reports Involving Vehicle Interference.* Evanston, Illinois: Center for UFO Studies.

Section 9. Apparent Gravitational and/or Inertial Effects

Zeidman, J. (1979). A *Helicopter-UFO Encounter over Ohio.* Evanston, Illinois: Center for UFO Studies.

Sections 10, 11. Ground Traces, Injuries to Vegetation

Bounias, M. C. L. (1990). Biochemical traumatology as a potent tool for identifying actual stresses elicited by unidentified sources: Evidence for plant metabolic disorders in correlation with a UFO landing. **J.** *Scientific Exploration,* 4, 1.

Vallee, J. F. (1990). Return to Trans-en-Provence. **J.** *Scientific Exploration,* 4, *19.*

Velasco, J-J. (1990). Report on the analysis of anomalous physical traces: The 1981 Trans-en-Provence case. **J.** *Scientific Exploration,* 4, 27.

Section 12. Physiological Effects on Witnesses

Schuessler, J. F. (1996). *UFO-Related Human Physiological Effects.* LaPorte, Texas: Geo Graphics Printing Co.

Section 13. Analysis of Debris

Vallee, *J. F.* (1998). Physical analyses in ten cases of unexplained aerial objects with material samples. **J.** *Scientific Exploration,* 12 (in press).

Appendix 1
Offical UFO Investigations in France: the GEPANISEPRA Project

F. LOUANGE **AND** J-J. VELASCO

For more than 20 years, the French space agency has conducted a non-military but official investigation into UFO reports. In its first phase, the project was named GEPAN and its focus was primarily on UFO reports. Subsequently, the project was renamed SEPRA and was assigned a more general responsibility for studying all atmospheric reentry phenomena. In the body of the report, we have for convenience referred to the project as "GEPANISEPRA." This appendix gives a brief summary of the history, mission, operations and achievements of this project.

The French space agency is known as CNES (Centre National d'Études Spatiales). It was founded in 1962 to conduct French space activities on a national basis and also in the context of the European Space Agency (ESA) or of other international collaborations. CNES currently has 2,500 employees. The CNES headquarters are in Paris but its technical center is in Toulouse.

GEPAN (Groupe d'Études des Phénomènes Atrospatiaux Non-identifits — Study Group for Unidentified Aerospace Phenomena) was established as a department of CNES in Toulouse in 1977. At that time, its head was Dr. Claude Poher, who had already performed statistical analyses of files containing sever-

al thousand observations worldwide (Poher, 1973). CNES set up a scientific advisory board comprising astronomers, physicists, legal experts and other eminent citizens to monitor and guide GEPAN's activities.

The first tasks undertaken by GEPAN were:

- To establish data collection procedures in conjunction with the Air Force, civil aviation authorities, the Gendarmerie (French internal police), meteorological offices, the national police, *etc.*.
  To conduct statistical analyses of eye-witness reports.
- To investigate previously reported cases.

These initial studies led to the following conclusions:

Those events that remain unexplained after careful analysis are neither numerous nor frequent.

The appearance of some reported phenomena cannot readily be interpreted in terms of conventional physical, psychological or psycho-social models.

- The existence of a physical component of these phenomena seems highly likely.

Following these initial steps, GEPAN undertook to develop a more theoretical but rigorous approach to these studies. It was clear at the outset that it would be necessary to consider both the physical nature and the psychological nature of the phenomenon. In order to fully understand a witness's narrative account, it was necessary to consider not only the account but the psychology and personality of the witness, the physical environment in which the event occurred, and the witness's psycho-social environment.

GEPAN negotiated agreements with the Gendarmerie Nationale, the Air Force, the Navy, the meteorological offices, police, *etc.* These negotiations led to procedures by which these organizations provided GEPAN with relevant reports, video tapes, films, *etc.*, which were then processed and analyzed either by GEPAN or by associated laboratories. However, from 1979 on, GEPAN worked mainly with reports from the Gendarmerie since these reports proved to be best suited for GEPAN's purposes.

GEPAN developed a classification system to reflect the level of difficulty in understanding the reports:

Type A: The phenomenon is fully and unambiguously identified.
Type B: The nature of the phenomenon has probably been identified but some doubt remains.
Type C: The report cannot be analyzed since it lacks precision, so no opinion can be formed.
Type D: The witness testimony is consistent and accurate but cannot be interpreted in terms of conventional phenomena.

Reports of Type A and Type B were further subdivided into astronomical, aeronautical, space, miscellaneous, and identified. GEPAN carried out statis-

tical analyses aimed at classifying cases according to sets of physical characteristics.

Two types of investigations were carried out on individual reports:

- Mini-investigations, that were applied to cases of limited significance; and
- Full investigations, that were applied to unexplained cases (Type D) in which effort was made to obtain as much information as possible, including gathering and analyzing physical and biological evidence.

During the GEPAN phase, the project initiated several lines of research involving other laboratories and consultants. These were aimed at seeking a possible basis for modeling unexplained aspects of UFO reports, as well as seeking new techniques for the more active investigation of UFO events by the development of detection systems. These research topics included:

- Research on possible magnetohydrodynamic propulsion systems;
- Study of facilities to collect unexpected atmospheric phenomena on a worldwide basis, that led to the proposal of the Eurociel Project to develop a network of ground stations equipped with wide-angle observation systems and powerful real-time processing algorithms;
- Methodology for image analysis (photographs, videos, etc.); and
- Study of aeronautical cases, especially radar-visual cases.

In 1988, GEPAN was replaced by SEPRA (Service d'Expertise des Phénomènes de Rentrées Atmosphériques — Atmospheric Re-entry Phenomena Expertise Department). M. J-J. Velasco, who had been a member of GEPAN since the very beginning, took charge of this new project that was then assigned a wider mission. This new project was called upon to investigate all re-entry phenomena including debris from satellites, launches, etc. However, the budget was drastically reduced so that research into UFO reports could not be maintained at the earlier level. Nevertheless, all existing official procedures concerning data collection have been maintained to ensure continuity in receiving reports.

After 21 years of activity, the GEPAN/SEPRA files now contain about 3,000 UFO reports supplied by the Gendarmerie. About 100 of these reports were found to justify specific investigations. Of this number, only a few cases remain unexplained today.

There have been attempts by SEPRA to increase the scope of the project at least to a European level, but this has not yet been successful. One of these attempts was the "Eurociel" project: the basic concept was to implement two sets of wide-angle optical detection stations, sited some tens of miles apart following a parallel of latitude, each station to be equipped with CCD-type cameras, with a minimum of one in the visible and one in the infrared. The output from these cameras would feed data into a microcomputer that triggers recording of the data when the computer determines that a change has suddenly

occurred. The data from all these stations would be stored in a central facility to permit the calculation of trajectories. Such a system could detect lightning, meteors, unknown satellites, and other known or unknown phenomena.

During the GEPAN phase, the project produced many reports and investigations and technical documents concerning topics related to the study of UFO events. These reports were made publicly available. These reports are no longer being disseminated, but some information can still be requested from CNES.

Appendix 2
Procedures for Analysis of Photographic Evidence

F. LOUANGE

The Panel recommends that, given a new alleged UFO photograph, the decision to invest effort into its investigation should be taken only if both of the following conditions are fulfilled:

a) the original documentation (negative, slide, videotape) is available, and
b) there is at least one other independent source of information — either witness testimony or some other physical record.

If, after visual examination, the displayed object has not been identified (planet, balloon, cloud, etc.), investigation should be performed in two steps:

Step 1 consists of establishing or rejecting the authenticity of the photograph (or other record), taking into account evidence for unintentional false operation of equipment and various spurious phenomena that may affect the recording equipment. However, this concept of authenticity is at best relative, since in this area of investigation only negative conclusions may be considered as final, so that authenticity can never be demonstrated absolutely.

Step 2, if warranted, consists of extracting as much information as possible from the photograph or other record, so as to obtain as much information as possible about the object of interest (size, shape, distance, albedo, emitted energy, spectrum, etc.).

When the original film is available and analysis seems justified, all technical data concerning the site, viewing conditions, camera, film, processing, etc., must be collected. If the camera is available (in an ideal case still loaded with the original film), it must be used to perform the following calibrations:

a) Photos of density patterns for relative photometry;
b) Photos of sources calibrated in intensity, in various positions in the frame (for absolute photometry);
c) Photos of spatial frequency patterns, to determine the modulation transfer function (MTF); and
d) Photos taken at the same site as the original, eventually with models to simulate the object.

The film should be processed under rigorously controlled conditions (if it has not already been processed commercially). If the camera is available but empty, the same operations should be conducted with a film of the same type as the original.

The investigator should visit the original site and make measurements concerning the three-dimensional geometry of the observed landscape or this information should be extracted from detailed maps. If the photograph has been acquired at nighttime, an astronomical map of the sky at the time of acquisition will be necessary. The investigator should determine the meteorological conditions from the official offices or air bases in the neighborhood with particular attention to the horizontal visibility. The investigator should also take into account all quantified or quantifiable elements of the witness testimony including the estimated shape, angular size, velocity, color, etc.

For analysis of the photograph, it is essential to work from the original negative. This should be carefully washed and examined under a microscope to look for possible tell-tale artifacts and scratches, and to check the regularity of the grain structure so as to detect multiple exposures. The negative should be analyzed by conventional photographic instruments (enlarger, projector, etc.), and the information on the negative should be digitized by a microdensitometer.

Once digitized, the image may be analyzed by computer analysis, using the classical tools of contrast enhancement, noise suppression, contour detection, restoration, etc., and more specialized techniques such as maximum-entropy analysis that may be used to remove the effects of target motion and/or camera motion. Such analysis will assist in the detection of a possible hoax. For instance, a suspension thread may be brought into evidence through standard differential operations. Also, one may estimate the distance (hence the size) of the object through MTF computations, based on an analysis of atmospheric diffusion and contour blurring. If there are black areas on the object, it is possible to obtain estimates of the distance by comparing the luminance of such regions with other identified black parts of the scenery. If the object is nearer than the minimum depth of field, one should be able to detect geometrical distortions in the image. If the operator had a slight movement while taking the picture, analysis of the corresponding blur on the object and on other elements of the landscape may allow the calculation of a possible range for the distance of the object.

In the case of a color photograph, one should carry out the above procedures in three steps using three appropriate color filters for scanning.

If an event is recorded on a cine camera, each frame may be analyzed as above. However, it is now possible to obtain additional information by combining and comparing the sequence of images.

In principle, images recorded by video cameras may be subjected to comparable analyses. However, video records suffer from one very important weakness: since the basic data is in electronic form, it could have been modified by

the use of suitable electronic equipment, so that the authenticity of a video record will depend even more critically upon the credibility of the witness testimony.

Appendix 3. Formation Flying

V. R. ESHLEMAN

A recurrent theme in certain UFO reports is the concept of an apparition that flies in formation with an aircraft-borne observer. Without making a judgment on any such reports, we could recommend that UFO investigators familiarize themselves with natural phenomena that display this "flying-in-formation" characteristic. Greenler (1980) is a useful resource, from which the attached list was made. The precise mechanisms for the origin of most of these phenomena have been determined and are explained in Greenler, but quite a few have still not been deciphered satisfactorily. Even an experienced observer might be surprised in seeing a particularly rare example. I have studied certain related phenomena in my research involving electromagnetic probing of planetary atmospheres, but was quite astonished a few years ago when I saw a particular example of the following list. A bright white light flew for minutes in perfect formation between my aircraft and the ground, with the air below and above apparently being transparently clear.

Formation flying phenomena:

Arcs: Kern, Lowitz, Wegener anthelic, Hastings anthelic, Tricken anthelic, Parry, alternate Parry, suncave Parry, sunvex Parry, upper tangent, lower tangent, supralateral, infralateral, circumzenithal, circumhorizontal, anthelic, subanthelic, contact.
Halos: Hevel, 8 degree, 18 degree, 22 degree, 46 degree, circumscribed.
Bows: fog, cloud, dew, supernumerary.
Rainbows: primary and secondary; direct and reflected; raindrop and ice crystal; white, red, and red-to-blue.
Pillars: sun, moon, city-light, anthelic.
Rings or Circles: Bishop, Bottlinger, parhelic, subparhelic, coronal.
Dogs: sun, moon, elongated, subsun.

One should also consider:

Nighttime: moon, Venus, Jupiter, bright stars, *etc.*, gegenschein, zodiacal light, comet, in-cabin light reflected by window.
Other forms: glory (specter of the Brocken), subsun, wet and dry heiligenschein, seven suns, lenticular and other distant small clouds, several different kinds of mirages.

The phenomenon which was a special surprise to me is one in the final grouping, the subsun, due to particularly stably falling, flat, horizontal, hexagonal, ice crystals which were sufficiently few in number that the air appeared clear in every direction except the solar specular direction to the side of and below the airplane, where they efficiently mirrored the sun.

Appendix 4. Electromagnetic-Wave Ducting

V. R. ESHLEMAN

It is possible that some of the radar cases presented to the panel have a natural explanation. It seems likely that some possible natural explanations could be investigated without cooperation or assistance from the controlling military authorities except for a time record of unidentified traces that occur during designated test periods.

Some of the observations suggest that time-variable atmospheric ducting may on occasion result in echoes being obtained from distant ground locations as a result of refraction. Some of accounts described (a) groups or swarms of echoes that persist for some time in the same general location; (b) apparent trajectories of echo sources that exhibit sudden changes in the vertical and/or horizontal positions; and in particular (c) the tendency of apparent echo sources to concentrate over mountain tops. These are all characteristics to be expected of ducting conditions due to weather. These effects can come and go over long periods of time and they can also lead to scintillation or other changes over short time periods. (See, for instance, Hall & Barklay 1989.)

An atmosphere is said to be "superrefractive" when a horizontal light or radio ray curves downward with a radius of curvature that is less than the distance to the center of the planet. The atmosphere of the planet Venus is at all times globally superrefractive below an altitude of about 30 kilometers. In principle, echoes could be obtained from every area of the spherical surface of Venus from a radar system located at any position on the surface. If the air of Venus were perfectly clear, an observer would see all areas of the surface, all areas repeating in range to indefinite distances. In the four giant planets also, the large gradients of refractivity (or density) in their atmospheres produce superrefractive conditions.

The Earth's atmosphere is normally not superrefractive. However, common weather effects (in particular thermal inversions, where the air temperature increases with altitude, and/or the water-vapor content decreases with altitude) can and do produce regions of superrefraction that are localized geographically and in height. As a result, atmospheric ducts (channels that trap and conduct radar waves) can form that carry the signals far beyond the normal horizon. Such ducts can bend rays down to a distant surface area or, more easily, to a distant mountain top. Backscattering of the radar energy from the ground or from discrete objects on the ground then results in echoes that ap-

pear to the radar to be due to a target that is far away and (if the angle of elevation of the returning energy is measured) high in the atmosphere. A similar transient ducting of sound can produce the experience of hearing the whistle of only one particular train out of the many that originate at difference times from a busy track in the next valley.

As is well known, atmospheric ducting is the explanation for certain optical mirages, and in particular the arctic illusion called "fata morgana" where distant ocean or surface ice, which is essentially flat, appears to the viewer in the form of vertical columns and spires, or "castles in the air."

People often assume that mirages occur only rarely. This may be true of optical mirages, but conditions for radar mirages are more common, due to the role played by water vapor which strongly affects the atmospheric refractivity in relation to radio waves. Since clouds are closely associated with high levels of water vapor, optical mirages due to water vapor are often rendered undetectable by the accompanying opaque cloud. On the other hand, radar propagation is essentially unaffected by the water droplets of the cloud so that changes in water vapor content with altitude are very effective in producing atmospheric ducting and radar mirages.

With regard to "impossible" flight paths that may appear to be indicated by some of the echoes obtained by military radars, it is important to note that the records presented to the panel are based on measured time delays and measured elevation and azimuth angles-of-arrival of the reflected energy from the echoing object. As presented, certain target positions were plotted as height versus time. But height is computed from two parameters: (1) the measured time delay, which is a very good indication of range; and (2) the measured vertical angle of arrival, which may not be a valid representation of the vertical direction to the target. In particular, when ducting occurs, reflections from distant and distinct surface targets (buildings, bridges, trucks, ***etc.)*** may be received at elevation angles of several degrees, so that a ground target at a range of 100 kilometers, for example, would appear to represent an object at a height of several kilometers. Atmospheric turbulence would distort the duct and could cause sudden changes in angle of perhaps a few tenths of a degree, which would be interpreted as a sudden change in altitude of the order of half a kilometer. The horizontal angle of arrival would also be affected by turbulence, adding to the chaotic character of the apparent flight path.

Ducting to and from distant mountain tops requires less refractive bending than echoes to and from lower surface areas, and should therefore be more common. This may explain the concentration of apparent targets over mountains. A test of this hypothesis would be to place a radio receiver, tuned to the radar frequency, on or near the top of a mountain associated with unidentified targets. It should be connected to an antenna that has its unobstructed receiving lobe centered in the azimuthal direction of the radar and its vertical pattern extending from zero to at least several degrees in elevation. If ducting does in fact occur, the occurrence of unidentified radar echoes would be found to be

correlated with major increases in the strengths of the radar signals measured by this receiver.

Appendix 5. Sprites

V. R. ESHLEMAN

One of the optical displays reported by E. Strand may be of special significance as a tentative bridge across the wide gulf that exists between the UFO and scientific communities.

Two women reported an unusual, colored, intermittent light display that slowly moved over two hours of observation made from a remote cabin in Norway in the post-midnight hours of August **3,** 1991. The sky was clear until the end of the observation period, when a few clouds moved in. The key point about this display is that while there was no local thunderstorm activity, there was an electrical storm in the direction of the display, but the storm was 120 kilometers away. For decades, it has been conventional scientific wisdom that all of the visible electrical activity of such storms is within and below the clouds, that in this case would have been below the observers' horizon.

Recent developments in the observations and theory of electrical activity in the high atmosphere (mesosphere and low ionosphere) demonstrate that this conventional wisdom is in error (see, for instance, Pasko *et* al., 1996; Sentman & Wescott, 1995). Some of the reports of observations in the Hessdalen area could be related to phenomena that occur above storms, up to an altitude of nearly 100 kilometers, well above the observers' horizon. This electrical activity goes by the names of "blue jets," " red sprites," and "short-lived elves." There have in fact been sporadic reports of these phenomena decades ago, but these reports were dismissed by the "experts." Now these events have been captured on film and video.

This example can serve to remind us of the continual development and change that occurs in all fields of scientific knowledge, and of the potential advantages of open communication between the purported experts and interested amateur observers.

Appendix 6. SETI and UFO Investigations Compared

V. R. ESHLEMAN

My perception is that the SETI (Search for Extraterrestrial Intelligence) and UFO studies of a decade ago shared positions beyond the pale of "respectable" science. They no doubt still do in the view of many scientists. However there have been several fundamental advances during the past few years that indirectly provide some increase in plausibility for both areas, and the SETI community seems to be responding with renewed vigor. It may be useful for our

panel to consider some UFO-SET1 comparisons, and the different cultures of their respective participants. These are my personal and incomplete thoughts on this subject.

There have been recent advances concerning the question of the possible existence and state of extraterrestrial life (ETL). Knowledge that there is such life would increase the presumptive probability of extraterrestrial intelligent life (ETIL). SETI investigators search for the latter mainly by examining the radio spectrum for telltale electromagnetic signals that may be purposely sent or inadvertently leaked from a technological society. UFO investigators may invoke visitation by ETIL as a fallback or default explanation of an apparition or event which they believe cannot be explained any other way. There are huge gaps in our knowledge that must be filled in before we can pretend to understand either of these subjects.

With regard to the first question, the existence and possible abode of ETL, three major recent developments are of particular note:

1. It is only in the last few years that we have finally obtained direct evidence of the existence a planetary-sized body orbiting a star other than our Sun. We now have evidence for several (of order of 10), and more are being discovered as the Doppler observational technique is being improved. There are billions of stars in our galaxy alone, and these results suggest that stars may quite generally be accompanied by planets. One may expect that conditions on these planets would vary over a wide range, at least as wide as the range covered by the planets of our solar system. (See, for instance, Cosmovici ***et al.,*** 1997.)
2. Life that is fundamentally different from nearly all near-surface life on Earth has been found deep in terrestrial rock and in the deep ocean, where it exists under conditions long assumed to be so hostile as to be sterile. It would appear that near-surface and subterranean life forms are essentially independent and that either could exist without the other. It is also possible that life started several different times on Earth after epochs of total extinction caused by asteroidal and cometary impacts. These new findings suggest that life might have started independently at two levels on Earth, or that life can adapt to extraordinarily different environments. The development of life, under conditions that are thought to be favorable and under conditions that we previously thought to be unfavorable, may be the rule rather than the exception for the innumerable planets that probably exist in our galaxy. (See, for instance, Cosmovici ***et al.,*** 1997.)
3. A meteorite found in Antarctica and known to have come from Mars (from isotopic "fingerprinting" of its elements) has several detailed internal characteristics (structural, chemical, and elemental) that may, it is claimed, be attributed to effects of ancient microscopic life indigenous to Mars. (McKay ***et al.,*** 1996). This interpretation is controversial and research on this and other meteorites is continuing.

These subjects are currently being investigated widely and were featured among the many areas discussed at an international meeting in July 1996 held in Capri, Italy, on the subject of Astronomical and Biochemical Origins and the Search for Life in the Universe (Cosmovici *et al.*, 1997). About 200 astronomers, biologists, chemists, physicists, and other scientists from 27 countries met for this Fifth International Conference on Bioastronomy and Colloquium No. 161 of the International Astronomical Union. This meeting was supported by international and national scientific organizations including the International Astronomical Union, the International Scientific Radio Union, the National Aeronautical and Space Administration, the European Space Agency, the Consiglio Nazionale delle Richerche, and other Italian organizations; clearly, this was a mainstream scientific meeting. The SETI community was very visibly represented in all aspects of the conference, but the problem posed by UFO reports was never mentioned.

However, the UFO and SETI communities share defining attributes including a surfeit of putative evidence that remains unidentified, and the lack of a single example that can be unequivocally verified, repeated, understood, or captured. That is, both are subject areas of investigation that totally lack identified objects. Then why is one moving into the mainstream of acceptable science while the other is not?

It may not be generally realized that the several different groups of SETI observers have received and tabulated an appreciable number of URS, or unidentified radio signals, in the course of listening to billions of radio channels for hundreds of thousands of hours, looking in tens of thousands of directions. They measure signals that are noise and signals that range up to many times stronger than can be explained in terms of natural noise. They identify nearly all of the strong signals as coming from radio and TV stations, from military radars and various kinds of communications systems, from satellites and deep space probes launched by various national and international organizations, and from many kinds of equipment that leak electromagnetic energy over broad spectral bands. After very thoughtful and vigorous winnowing, there has been a residual number of strong signals received by every group that are, and will no doubt remain, unidentified. But these are not described and released to the media as something unusual or mysterious. This is because they could not be verified by other observers or by repeat observations at the same frequency and in the same direction in the sky. Improved techniques and protocols are being developed to markedly reduce the frequency of URS (even to the point where there may be concern that a real ETI signal could be discarded). Nevertheless, it is to be expected that continuing URS will persist in the SETI endeavor, and will remain unidentified and undiscussed.

The SETI participants include a large fraction of scientifically trained radio astronomers, and they employ complex and expensive equipment that includes the largest antennas and most sensitive electronic and digital systems in the world. The UFO community is much broader and diverse, and cannot

bring to bear the instrumental firepower that is routine in SETI research. In fact, no equipment is involved in most UFO case studies. The nature of UFO phenomena is such that it would be unreasonable to demand repeat observations of the same kind of incident and independent confirmation of events by different observers.

However, the status of UFO studies may be improved if we can find a way to move in a direction where independent confirmation and repeatability could be realized and become routine. Where some level of repeatability exists but explanations are incomplete (*e.g.*, in the Hessdalen project), more investigative resources are clearly required. Open channels of communication between UFO investigators and a broader scientific group may lead to natural explanations of many observations and thereby winnow the numerous reports to a few notable examples to which intense cooperative efforts could be applied.

Appendix 7. Further Thoughts on SETI and UFO Investigations

F. LOUANGE

The SETI and UFO problems may or may not be related to each other. As there does not so far exist any proof concerning this question, it seems wise to keep those two problems apart and not to confuse them. The questions raised by the UFO and SETI problems are not at all comparable, and the strategies for their research are drastically different. The SETI problem corresponds to a one-bit theoretical question: does there exist, elsewhere in the universe, any form of intelligence that has reached the technological level of transmitting intelligent electromagnetic signals that humans could detect and identify? Although this question is undoubtedly exciting and justified by existing probabilistic computations about the existence of planets, the appearance of life, the duration of a civilization, ***etc.***, the final answer is theoretically Yes or No. However, only a Yes answer will be final, since a No answer may be revised in view of technical improvements of detection techniques.

The UFO problem arises from the verified existence of a very large and coherent set of testimonies worldwide. Its approach is bound to be in three steps:

Step 1. Try by all means to identify the stimulus that has led to the report: the report may be due to inadequate information, misinterpretation of a familiar phenomenon or device, an unusual astronomical or atmospheric phenomenon, an unusual technological device, or a hoax (perpetrated by the reporter or on the reporter).

Step 2. If Step 1 has not yielded an explanation of the report, try to characterize the event that led to the report and compare it with other case descriptions.

Step 3. For any case that is strong in testimony and rich in detail, one should try to define a model. In this activity, we are clearly not dealing with a

simple question with a Yes /No (one-bit) answer. Different cases require analyses with different levels of complexity.

The SETI and UFO problems also involve different approaches. Scientists may pursue the SETI project and remain in a very familiar environment: the relevant technological area is clearly identified and one may follow a predefined strategy by specifying the frequency search band, the required receiver sensitivity, the intrinsic properties of an intelligent signal, *etc.* On the other hand, research on the UFO problem is necessarily complex, multidisciplinary, unpredictable and must be expected to evolve as research progresses. The basic detection is usually carried out by unprepared human beings, and analysis may call upon a wide range of disciplines including human perception, psychology, astronomy, image processing, physics, chemistry, *etc.* Moreover, effective research in this field must be conducted with an open mind.

Although in public opinion the UFO and SETI projects are closely associated, they should be kept clearly separated as far as serious research is concerned. The questions being addressed are quite different in nature: the SETI project aims at a simple Yes/No answer to the question of the existence of extraterrestrial intelligence, whereas research into the UFO project must be pursued with a completely open mind as to the questions that need to be posed and answered. Moreover, the respective technical strategies have nothing in common: SETI research is carried out primarily within the established framework of radio astronomy, whereas UFO research is necessarily multidisciplinary and innovative.

Appendix 8. Scientific Inference

P. A. STURROCK

In attempting to resolve a complex problem such as that posed by UFO reports, one is very much in the "gray area" of scientific research that is not well defined: the facts are to some extent shaky; some of the hypotheses are speculative; and it is not clear how to evaluate the hypotheses on the basis of the facts and of other relevant information. Furthermore, one has the difficulty of relating the analysis of individual reports ("Is this report due to a hoax?") to the global questions represented by the hypotheses ("Are some reports due to hoaxes?"). In such a situation, it is essential to have some way to organize one's analysis of whatever research is being conducted. Scientific inference is the intellectual basis of science, and the procedures of scientific inference offer a framework for organizing such analyses. (See, for instance, Good, 1950; Jeffreys, 1973.)

The formalism of scientific inference involves expressing all judgments in terms of probabilities. Where there are definite rules for deriving probabilities from the evidence, these rules can be used; otherwise, the probabilities may be

regarded as subjective. If each judgment is made by several investigators, this can provide both a mean or consensus estimate and a measure of the degree of uncertainty of that estimate. For a recent exposition of this formalism, see for instance Sturrock (1994d).

In investigating any specific case, it is necessary to work with a complete and mutually exclusive set of hypotheses. The following set of 8 hypotheses was used in Sturrock's survey of the members of the American Astronomical Society (Sturrock, 1994a; 1994b; 1994c):

a. Hoax,
b. Some well established phenomenon or device,
c. Some well established but unfamiliar natural phenomenon,
d. Some unfamiliar terrestrial technological device,
e. Some hitherto unknown natural phenomenon,
f. A technological device not of terrestrial origin,
g. Some other cause which [the investigator] can specify, and
h. Some other cause which [the investigator] cannot specify.

An investigator may begin by assigning "prior probabilities" to these hypotheses, although this is not essential. If so, each value must be greater than zero and less than unity, and they must sum to unity. Once these prior probabilities have been assigned, the investigator should then forget about his prejudices. Bayes' theorem then provides a mechanism for updating one's assessment of probabilities on the basis of new evidence. The new evidence may be a single case or an analysis of a catalog of cases. When measurements are made in terms of "log-odds" defined by $\log[(p/(1-p)]$ rather than the probability p itself, it turns out that investigators with very different prejudices should assign the same weight of evidence, measured by the change in log-odds, to the same experimental or observational data. Hence, although they may differ in their prejudices, they should be able to agree in their assessments of the evidence.

It is even more convenient to work in terms of the quantity $10*\log[p/(1-p)]$, since one may then use the familiar engineering term "db" or "decibel" to represent an assessment. For instance, if one begins with the assessment that the probability of an event being due to an extraterrestrial vehicle is 10^{-6}, one could rephrase that as saying "my assessment is –60 db." If a certain research program made that proposition even more unlikely by, say, 10 db, one would then lower that assessment to –70 db. If, on the other hand, the evidence seemed to support that hypothesis with weight 10 db, the resulting assessment would be –50 db. If six separate and completely independent studies were each to yield evidence of 10 db, the investigator would end up with an assessment of 0 db, that represents even odds of the proposition being true. That is, the evidence would have been just sufficient to change the mind of the investigator from being highly skeptical about the hypothesis to considering it just as likely to be true as not true.

It is highly unlikely that any research project that is in operation for only one or two years will solve the UFO problem. However, it could and should provide useful relevant evidence, and that evidence should lead to a measurable change in the assessments of an interested scientist. In an area such as that of UFO research, that is all that can be expected. On the other hand, several research projects, each lasting a reasonable length of time, should provide sufficient evidence that an hypothesis may be effectively definitely established or definitely rejected.

If these suggestions are considered to have merit, they could be developed into a more specific and more useful form by means of a workshop that brings together UFO investigators, professional investigators (of accidents, failures, *etc.),* physical scientists, and statisticians.

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