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A REPORT ON THE DEMOGRAPHICS AND BELIEFS OF ALIEN ABDUCTION EXPERIENCERS

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ABSTRACT One hundred thirty alien abduction experiencers were queried to determine basic demographic characteristics and beliefs Respondents were classified into one of four categories according to the type of experience they reported—possible abductees visitees, abductees, or psychic abductees Chi-square tests were used to discover relationships between common characteristics and experience type Respondents who reported being taken on board a UFO or to a clearly alien environment are more likely to report using hypnosis to aid in recall and also to report repeat abductions Furthermore the use of hypnosis by experiencers to retrieve memories increases the likelihood of reporting both physical exams and repeat abductions Results suggest further investigation as to the role of hypnosis in the articulation of alien abduction experiences Beliefs common to the general pool of abduction experiencers indicate most report believing they encounter extraterrestrials in early childhood have repeat encounters believe other members of their families are also involved possess psychic abilities, evidence healing powers, have lived a past life, and generally describe their experiences as primarily "positive '

The number of individuals who claim to have been kidnapped by extraterrestrials (i e , "alien abduction experiencers" [AAEs]) is unknown Anecdotal or indirect attempts at projecting the number of AAEs have been controversial The 1992 Bigelow Poll, for example, claimed that at "least 2% of the population" were probable abductees. Yet this poll, based on several "indicator items," has been criticized as seriously flawed and cannot be considered accurate (Hall, Rodeghier, & Johnson, 1992) [1] In 1998, a Roper poll asked individuals if they had "been abducted by the occupants of a UFO," and 0 3% answered affirmatively (Rodeghier, 2000, p 23) Extrapolated to the larger U S population, this would equal 600,000 AAEs Attempts to pin down the number of AAEs are problematic because of social biases against people who report abduction, which may make experiencers reluctant to come forward In any case, accurately counting AAEs has proven difficult Regardless of the actual numbers, the basic fact remains that hundreds of thousands, if not millions, of people believe they have been abducted by aliens

In the last several years researchers have started to systematize their analyses of UFO and abduction percipients Researchers in all fields have begun the important move toward an interdisciplinary and inclusive study of the UFO/abduction phenomenon The abduction conference held at the Massachusetts Institute of Technology in

1992 was a step in that direction (Pritchard et al., 1994). By allowing researchers and clinicians to share information, many new hypotheses about the abduction phenomenon were generated, and some potential standards and techniques for investigation were discussed.

There is still a paucity of studies that report on basic demographic characteristics of AAEs. In fact, Rodeghier, Goodpaster, and Blatterbauer (1991, p. 62) note that until their study, only Bullard's (1987) work had "systematically documented some simple demographic characteristics." And, as they note, the portrait of the alien abduction experiencer that emerged from Bullard's work may be inaccurate because his findings were based on already published abduction accounts. Although certainly a good beginning, clearly what is needed is more direct questioning of the AAEs themselves. This article reviews several studies that have reported on AAE demographics and, more importantly, reports the demographic characteristics of 130 individuals who claim various experiences with extraterrestrials.

Surprisingly, there have been few studies that have collected data directly from AAEs. Bloecher, Clamar, and Hopkins (1985, p. 7) sent nine AAEs to psychologist Dr. Elizabeth Slater to "determine similarities and difference in personality structure, as well as psychological strengths and weaknesses." Parnell (1988, p. 161, see also Parnell & Sprinkle, 1990) tested 225 "UFO experiencers" who ranged from those who saw lights in the sky to those who claimed "to have been taken on board a spacecraft." Ring and Rosing (1990) included 265 UFO experiencers in their sample. Rodeghier, Goodpaster, and Blatterbauer (1991), using a narrow definition of abduction and rigorous selection criteria, selected 27 individuals to participate in their study. Bader[2] (2003), in a comparison of AAEs to ritual-abuse survivors, reported on an AAE sample of 55 who were selected through abduction support groups. It is fair to say each of these studies, while discounting the assertion that AAEs are severely psychopathological, found peculiarities among AAEs that distinguish them from the general population.

This article describes the demographic characteristics of respondents in the survey sample and compares those characteristics with other studies of UFO percipients as well as to the demographics of the general population. Furthermore, the sample is segmented on experience type to further refine reporting of demographic information and to examine additional psychosocial characteristics. In addition to basic demographic information, several beliefs potentially common to AAEs are described. The general purpose is not to determine if people are being stolen from their beds by an intelligence unknown to humankind, but to discern if by knowing their shared characteristics we can learn something about this phenomenon or learn something about those making abduction-related reports.

Methodology

Beginning in 1998, narratives were collected from individuals who claimed to have been contacted by extraterrestrials. The primary means of data collection was a

webpage that requested basic demographic information and asked individuals to describe their earliest and most vivid abduction experience.[3] Most individuals learned of the webpage through links on other abduction related sites—the site was also registered on Yahoo and Google to increase the number of potential hits Additionally, some individuals were solicited after posting their experiences on public internet bulletin boards or after meeting them at a UFO conference Respondents could complete this brief questionnaire anonymously, most however, chose to include contact information and expressed interest in further participation

As the complexity of the abduction experience became more evident, additional questions were asked of respondents and added to the survey instrument Those who had already completed an earlier version of the survey were contacted and asked to answer these additional questions Eventually, telephone interviews and personal interviews were conducted with a limited number of respondents As of late 2004, almost 200 surveys have been received

To confirm the narrative and demographic detail of each respondent's report, and the respondent's commitment to the accuracy of their report, in the majority of cases, they participated in an ongoing correspondence and were queried several times [4] A total of 130 individuals who responded fully to queries were included in the current data set [5]

Although part of this report categorizes all 130 respondents together as AAEs, Rodeghier, Goodpaster, and Blatterbauer (1991, p 64) have proposed a much more limited definition of who should be so categorized, based on an AAE's belief about his/her experience

1 A witness must be *taken* against his or her will from normal, terrestrial surroundings by nonhuman beings
2 These beings must take the witness to another enclosed place that is not terrestrial in appearance and is assumed or known by the witness to be a spacecraft
3 In this place, the witness must either be subjected to various procedures that appear to be examinations of some type, engage in communication (verbal or telepathic) with the beings, or both
4. These experiences may be remembered consciously or through various means of focused concentration, such as hypnosis, or by a combination of the two

Although the Rodeghier, Goodpaster, and Blatterbauer (1991) criteria include the requirement that AAEs believe they have undergone either a physical exam or some sort of communication with extraterrestrials, for this study respondents were categorized only according to the location of their experience The presence of a physical examination was then observed within each of the four larger categories

Because individuals claim to have different types of experiences with extraterrestrials, respondents were assigned to one of four categories "possible AAE," "visitee," "AAE," or "psychic AAE " Individuals assigned to the possible AAE category usu-

ally reported feeling as though they had been abducted, but were only able to report experiencing missing time Some claimed waking up with feelings of paralysis or that something was in the room with them They often reported having dreams of encounters with extraterrestrials, but did not report any conscious memories of interactions with extraterrestrials. They may have sensed a presence in the room, but had no actual memory of a being in the room, nor could they recall ever actually seeing any type of human or extraterrestrial being during these experiences

Visitees included those respondents who reported visits by extraterrestrial beings, most often in their bedrooms or homes, but sometimes in their cars, or outdoors During these experiences, beings sometimes communicated with, performed experiments on, or simply observed the visitee

To be assigned to the AAE category the individual had to report being taken on board a UFO or to a clearly alien environment Respondents who claimed to "volunteer"—as opposed to being taken—were included in this category if they were indeed taken to a nonterrestrial/UFO location. Both AAEs and visitees had conscious memories of the events—these memories may, or may not, have been enhanced through hypnosis or alternative consciousness work

Finally, individuals in the category of psychic AAEs[6] reported being abducted during their dreams, in a past life, or in other altered-consciousness states. A clear distinction was made between those people who claimed to have extraterrestrial interactions during alternative/dream states of consciousness (psychic AAEs) and those who only reported dreaming about being abducted (possible AAEs) There was a qualitative difference between the two types of reported encounters that helped support this distinction For example, psychic AAEs wrote of having control over themselves in the "dream," whereas possible AAEs included linguistic qualifiers to describe their "maybe" "possible" experiences that "seemed real "

Of the 130 respondents, 26 (20%) individuals were categorized as possible AAEs Twenty-four (18 5%) could be categorized as visitees in that they reported being visited in their bedrooms or some other location, but were never taken to a nonterrestrial location Seventy-four (56.9%) were categorized as AAEs as they described being taken aboard a UFO or to an alien location Six (4 6%) were categorized as a psychic AAE

Demographic Characteristics

Gender. Early abduction data suggested women are more likely than men to report abduction Rodeghier (1994, p 296), reporting on the CUFOS data, noted that 75% of his participants were female He also remarked that this ratio was consistent with what he knew of the samples of other researchers

More recent data, however, indicates the disparity between men and women may be disappearing Bullard (1994, p. 45), in a continuation of his earlier comparative study, found his cases after 1985 had nearly equal numbers of men and women In Bader's (2003) sample of 55 abductees, 63% were female Data in the current sample also supports the claim that the differences between the sexes concerning abduction

frequencies may be negligible Of the 130 participants, 59 (45 4%) were male and 70 (53 8%) were female [7] Classification among the four encounter types yielded similar results [8]

One likely reason for this gender difference is that it is more socially acceptable for women to talk about emotional and non-rational subjects including alien abduction experiences For example, Bader (2003) reports that participants in "new age activities and memberships in new religious movements" are disproportionately female Hopefully, the disappearing gender gap indicates an increasing social space for description of anomalous experiences by all people regardless of gender

Race. One of the most interesting—and underreported—demographics is race AAEs are overwhelmingly white The CUFOS sample was 94% Caucasian (Rodeghier, 1994) In Bader's (2003) sample of 55 AAEs, 48 (88 9%) identified themselves as white Similarly, in the current study, 85 4% of the respondents reported they were Caucasian

Native Americans are also represented within AAE samples in higher than expected numbers Only 0 9% of the population surveyed in the Census 2000 data claimed Native American heritage, yet Bader (2003) reported six survey respondents (11 1%) who identified themselves as Native American The current study likewise included five respondents (3 8%) who reported themselves as Native American

While Caucasians and Native Americans are over represented in AAE populations, African Americans are noticeably underrepresented Census 2000 data indicates 12 3% of the general population is black Despite that, Bader (2003) had no respondents who claimed to be African American, and the current study had only three individuals (2 3%) who reported being African American

Hispanic Americans seem to be only slightly less present in AAE populations as compared with the general population Although Census 2000 data suggests approximately 5.5% of the general population is Hispanic, in Bader's (2003) sample, only 2 (3 7%) reported themselves as Hispanic Similarly, in the current data set, only 3 (2.3%) claimed Hispanic heritage When broken down according to encounter type, results remained similar

Explanations for the racial homogeneity present within AAE populations have not been discussed in the published literature Data suggests Caucasians are more likely to report their abduction experiences or that experiencers are more likely to self-report themselves as white Whatever the reason, the prevalence of white AAEs warrants further attention. In terms of race, at least, it is evident that AAEs are not a representative cross section of the population

Education. There is evidence that AAEs are more educated than the general public, or at least more likely to attend higher education Bloecher, Clamar, and Hopkins's (1985) initial testing of 9 AAEs included 6 individuals who had gone to college, and 3 who had done at least some graduate work Suggestions that these AAEs were chosen for psychological testing based on their socially admirable demographics seem compelling Despite this potentially skewed sample, other studies have provided evidence for the claim to higher educational levels among AAEs

According to the Census 2000, 27 3% of the population has attended some college and 15 5% have received a degree AAEs are much more likely to begin an academic career In Rodeghier's (1994) sample of 32 experiencers, the average educational level was 14 4 years (297) On average, 50 individuals responded to queries concerning their education in Bader's (2003) study. Of those, 34 (68%) reported they had attended at least some college In the current study (N=129), 49 2% reported they had attended at least some college and 15 4% reported they had graduated Additionally, graduate degrees are as common among AAEs as in the general population In the general population 8 9% report earning a graduate degree, similarly, in the current sample 8 7% reported earning a graduate degree No differences were found by experience type

Further inquiry is certainly warranted to find out why AAEs seem to attend college in higher numbers, yet complete four-year degrees at the same rate. Because of general interactions and conversations with individuals in the sample, it is my impression that many AAEs may attend continuing education courses with no intention of earning a degree, but rather attend for personal edification and growth Obviously, this impression needs to be supported with actual evidence of what types of education AAEs seek out, and why

Clearly, the method and means of data collection in the current study could skew results concerning level of educational attainment Individuals who have access to computers and who have the leisure time to attend UFO conferences are more likely generally to be more educated Additionally, as Rodeghier notes, better-educated people are better able to complete questionnaires and arguably, are more confident in their perceptions of their experience, and so more likely to report anomalous events [9]

Marital status. Marital status does not seem to be a defining characteristic of the AAE population For the most part, the studies of Rodeghier and Bader (2003) and the current study have distributions of marital status similar to the general population. Census 2000 data reports 54.5% of the population is married Similarly, 64 7% of Rodeghier's sample,[10] 54.7% of Bader's (2003), and 48.1% of the current data set reported being married [11] Likewise, when broken down according to experiencer type, no apparent trends emerge regarding marital status.

Occupation. Occupation seems also not to be a distinguishing factor of individuals who think they have interacted with extraterrestrials. Fifty-one of Bader's (2003) 55 AAEs identified their current occupational status Twenty-nine (56.9%) described their positions as white collar Only 4 (7 8%) described themselves as blue collar and 18 (35 3%) were not in the labor force [12] In the current study, 19 2% of the respondents reported they were professionals Interestingly, 9 2% of the respondents reported their occupation as "artist" Again, when divided according to experience type, no specific trends were apparent concerning occupation

Other Characteristics

Many UFO/abduction researchers have pointed to the fact that psychopathology among AAEs is no higher than among the general population as evidence of the

normalcy of AAEs (Spanos et al , 1993, Parnell & Sprinkle, 1990, Rodeghier, Goodpaster, & Blatterbauer, 1991, Bartholomew, Basterfield, & Howard, 1991) Although this may be true, it is also true that AAEs are "not psychologically representative" of the general population (French, 2001, p 107)

The differences among AAEs have been well documented Rodeghier, Goodpaster, and Blatterbauer (1991) reported higher levels of loneliness and unhappiness and greater likelihood to suffer from sleep disturbances. Parnell and Sprinkle (1990, p 45) noted AAEs tend to "endorse unusual feelings, thoughts and attitudes, to be suspicious or distrustful, and to be creative imaginative, or possibly have schizoid tendencies " Parnell (1988) reports a similar finding Ring and Rosing (1990) found significantly high levels of childhood trauma among AAEs And, perhaps most disturbing, Stone-Carmen (1994) related that 57% of her sample reported suicide attempts

In addition to the above-mentioned characteristics, there are several variables that have been discussed in the literature as possible defining traits of the AAE population or characteristics common to alien abduction experiences The next sections describe and explore some of these traits

Childhood abductions. Since the mid-1980s it has become fairly well known and documented that AAEs generally believe they were first abducted/visited at an early age (Hopkins, 1981, Randle, Estes, & Cone, 1999) The current study is consistent with this observation. Of those who answered the questions, 82 (66 1%) claimed to have their first experience between birth and age 10 Half—64 respondents (51 6%)—reported being abducted at age 5 or earlier Only 15 (12 4%) reported their first experience occurred at age 30 or later

The current sample suggests that, for the most part, individuals report that these experiences begin in childhood However, many AAEs do not report their experiences, or for that matter even remember their experiences, until much later in life To understand exactly what these individuals remember, and when, could certainly be the subject of further questioning An initial examination of reported age at first experienced abduction according to experience type does not indicate any relationship between those two factors

Repeat abductions. Another characteristic that has become more evident with the systematic exploration of the abduction phenomenon is the "repeat abduction" of the experiencer (Hopkins, 1981). Bullard (1987, p 9) notes that Sandra Larson was the first reported repeat abduction to be investigated Beginning then, AAEs have increasingly reported that their experiences are not isolated events. Bullard (1994) reports that in his initial study only 12 of the 270 catalogued cases referenced repeat experiences In the second catalogue of 451 cases, however, that number increased to 114 The current study includes an overwhelming number of individuals who claim to have multiple experiences (87 7%)

Interestingly, the likelihood of a respondent reporting repeat abductions depends on the type of experience ($p = 061$)[13] (see Table 1) Those who fell into the "possible abductee" category were more likely to report only one experience compared to the other AAEs. One possible explanation for this is the consistency of the remembered

Table 1. Repeat Abductions by Encounter Type

Encounter Type	Repeat Abduction No	Yes	Total
Possible AAE	7 (26 9%)	19 (73 1%)	26 (100 0%)
Visitee	3 (12 5%)	21 (87 5%)	24 (100 0%)
AAE	5 (6 8%)	69 (93 2%)	74 (100 0%)
Psychic AAE	1 (16 7%)	5 (83 3%)	6 (100 0%)
Total	16 (12 3%)	114 (87 7%)	130 (100 0%)

experience with a "classic" abduction scenario It could be that as an individual becomes more committed to the idea that he/she may have had an encounter with an extraterrestrial intelligence, then he/she may begin to adhere to conceptions of traditional ET encounters

In terms of the overall alien abduction experience, repeat abductions may seem like a definite trend: however, researchers should be careful about assigning too much importance to the repeating nature of the experience. It is quite possible, and even plausible, that many people who have only one experience do not report the event Additionally, if an individual experiences something strange only once—waking paralyzed, unexplained bruises, mysterious nosebleeds, or any number of anomalous experiences—it may be easier for them to shrug it off and forget about it. When someone experiences several of these things over time, however, they may be more likely to explore the possibility of having had an abduction experience Likewise, once an individual has committed to the belief that s/he has an experience with extraterrestrials, it is understandable that s/he would then interpret various strange events via the abduction paradigm Therefore, the incidences of "one-time" abduction experiences may be underreported

Genetic link. Another reported characteristic of abduction accounts is an apparent "genetic link" among AAEs. This genetic link manifests itself in two important ways within the alien abduction phenomenon First, many AAEs claim that other members of their families are also experiencing similar events (Hopkins, 1987, Randle, Estes, & Cone, 1999). A majority of alien abduction experiencers in this sample (64 6%) report that they believe or know other members of their family are also experiencing abductions In the current sample, there are at least three instances with multiple members of the same family This is certainly one area that warrants further investigation

A second way the genetic link manifests itself is through the biological connection some AAEs claim to have with their extraterrestrial visitors In the current sample, 53 1% report that they have had the momentary feeling they might not be human Furthermore, 25 respondents explicitly indicated they believe they are part extraterrestrial No significant patterns emerge to suggest the genetic link is more likely to be present in experiencers who have particular types of encounters.

Abuse. One of the more controversial characteristics that has been linked to the

abduction phenomenon is that AAEs have a higher than average incidence of experiencing physical or sexual abuse as a child In the current study, 40 2% of those providing a response indicated that they had "been the victim of physical or sexual abuse "[14] Although this question did not discriminate between physical or sexual abuse, or between that experienced as a child versus as an adult, the high prevalence of abuse certainly deserves more attention Rodeghier (1994, p 340) claims that relevant abuse research suggests a lifetime prevalence of about 30 to 32% for some type of sexual abuse experienced by women For men, that figure decreases to 15% The numbers represented in this survey are higher than those generally reported However, as noted, these numbers were collected with broad questions and simply point to a potential useful area of future research No significant relationships emerge between encounter type and likelihood of abuse

Hypnosis. Another controversial issue within the study of AAEs is the use of hypnosis Although the effectiveness of hypnosis in retrieving memories is beyond the scope of this paper, the current survey instrument does address the number of AAEs who use hypnosis to aid in memory retrieval Generally, in the literature, many of the cases reported have involved hypnosis. Newman and Baumeister (1996, p. 105) report that as many as 80% to 90% of alleged alien abduction accounts are recovered with the aid of hypnosis In his review of abduction, Rodeghier (2000, p 20) reports that investigators claim that most abductions are "immediately forgotten after the experience" and although "many abductions are recalled consciously," most are not

Considering that much of the reporting has been done by clinicians to date, those figures are not terribly surprising What is interesting is that in the current study, only 40% claimed to have used hypnosis to help recall a possible extraterrestrial event And, of those 52 individuals, many underwent hypnosis only after recognizing they had experienced something strange Similarly, in Bullard's (1987) sample of 97 cases, 31% used hypnosis Lower still, in Bader's (2003) study, only 20% report using hypnosis to retrieve abduction memories

The dissimilarity of these numbers can be explained in a variety of ways First, as the controversial nature of hypnosis becomes more widely known within the UFO/AAE community, AAEs may be either less likely to use hypnosis to remember events or they may be less likely to report using alternative consciousness techniques Among those who present to clinicians, hypnosis may be used more often to retrieve memories; however, among those who do not seek therapy to explore their experience, hypnosis may be less prevalent

When broken down according to type of experience, those respondents who report using hypnosis were more likely to be included in the AAE category, ($p = .006$) (see Table 2) Seventy-five percent of respondents reporting using hypnosis to aid in the recall of an abduction event described experiences consistent with abduction Obviously, without further questioning the causality cannot be discerned, i e , did hypnosis lead to the abduction memory? However, it is not unrealistic to suggest that individuals who undergo hypnosis are then more likely to conform to traditional, and well-known, descriptions of the typical abduction experience

Table 2. Encounter Type by Hypnosis

Encounter Type	Hypnosis Used No	Yes	Total
Possible AAE	21 (26 9%)	5 (9 6%)	26 (20 0%)
Visitee	18 (23 1%)	6 (11 5%)	24 (18 5%)
AAE	35 (44 9%)	39 (75 0%)	74 (56 9%)
Psychic AAE	4 (5 1%)	2 (3 8%)	6 (4 6%)
Total	78 (100 0%)	52 (100 0%)	130 (100 0%)

This hypothesis is supported by the fact that in the current data the statistical relationship between hypnosis and the likelihood a person has experienced repeat abductions nears significance ($p = 064$) (see Table 3) Although most AAEs report repeat experiences regardless of whether they have been hypnotized, those who are hypnotized are even more likely to report multiple experiences Thus, 94.2% who were hypnotized reported being abducted more than one time, whereas only 83 3% who were not hypnotized claimed more than one experience. Only 3 respondents (5 8%) who reported using hypnosis did not claim multiple experiences.

Furthermore, there is a relationship between whether a respondent underwent hypnosis and whether they claimed to experience a physical exam ($p = 002$) (see Table 4). About 64% of those hypnotized reported a physical exam versus only 36% of those who were not hypnotized

Researchers need to clearly differentiate whether hypnosis was used to initially recall an abduction experience, or whether it was used to further explore an already discovered abduction experience In addition, researchers should discern whether participants are working with a support group or therapist and using alternate forms

Table 3. Multiple Abductions by Hypnosis

	Hypnosis Used No	Yes	Total
Single	13 (16 7%)	3 (5 8%)	16 (12 3%)
Multiple	65 (83 3%)	49 (94 2%)	114 (87 7%)
Total	78 (100 0%)	52 (100 0%)	130 (100 0%)

Table 4. Physical Exam by Hypnosis

	Hypnosis Used No	Yes	Total
No physical exam	50 (64 1%)	19 (36 5%)	69 (53 1%)
Physical exam	28 (35 9%)	33 (63 5%)	61 (46 9%)
Total	78 (100 0%)	52 (100 0%)	130 (100 0%)

of consciousness to explore memories of their experiences. The fact that commonly known characteristics are more often reported by those who undergo hypnosis must serve as a warning flag to researchers and clinicians alike of the dangers of confabulation and memory implantation Additionally, since hypnosis is positively associated with inclusion in the AAE category, repeat abductions, and the reporting of physical exams, the relationship among these elements should be further examined

Physical Exam and Encounter Type

Finally, as an individual's reports more closely conform to the standard abduction narrative, so too is that individual more likely to report experiencing a physical exam, ($p < .005$) (see Table 5) Thus, 68.9% in the AAE category report having an exam

While not discounting the importance of Rodeghier, et al 's (1991) characterization scheme, the current findings encourage researchers to continue to think about the defining characteristics of an abduction experience Is it an "abduction" only if a physical exam is experienced? Is it no longer a "visitation" if the experience is negative or if a physical examination is provided? What is it when an individual reports going willingly to a nonterrestrial location and undergoing reproductive examinations? Further research could help operationalize each of these categories and determine what, if any, are the significant corollaries

Positive vs. negative experience. Despite the prevalence of evil, baby-stealing aliens in the mass media, the experiences of people who report alien abductions are frequently positive, which is consistent with the expectations of the general public According to a CNN poll conducted in 1997, 44% of respondents said they believed that extraterrestrials would be friendly, while only 26% expected aliens to be hostile In the current study 50% of the respondents indicated that their experiences were predominately positive Similarly, Bader's (2003) survey recorded that 47 1% describe their experience as positive In the current study, 28 5% reported that their experiences had both positive and negative aspects, and only 20.8% described their experiences to be primarily negative No trends were evident when quality of experience was broken down according to encounter type

Harder (1994) reported that in a sample of 29 individuals who had a conscious memory of physical contact, 25 of them reported having a "good feeling" about their experience In addition, 22 reported having continuing interactions with extraterres-

Table 5. Physical Exam by Encounter Type

Encounter Type	Physical Exam No	Yes	Total
Possible AAE	21 (80 8%)	5 (19 2%)	26 (100 0%)
Visitee	21 (87 5%)	3 (12 5%)	24 (100 0%)
AAE	23 (31 1%)	51 (68 9%)	74 (100 0%)
Psychic AAE	4 (66 7%)	2 (33 3%)	6 (100 0%)
Total	69 (53 1%)	61 (46 9%)	130 (100 0%)

trials Harder (1994, p 28) noted this was consistent with other researchers who have posited that initial fear reactions are soon replaced by positive feelings

One thing to note about the quality of the experience as described by AAEs is the seeming inconsistency between experience and attribution Many individuals talk of painful medical examinations and frightening situations, yet simultaneously describe their experience as a positive thing. Twenty-five (43 1%) respondents in the current study who report physical exams also report having a positive experience The fact that these people have attributed a larger purpose or meaning to their experience is important Some AAEs claim that those individuals who think the aliens are acting in the best interest of humans are really simply deluded Likewise, experiencers who report a positive experience explain that those individuals who are having negative experiences simply have not yet come to recognize the larger purpose of abductions. The ways these people explain the motives and intent of the aliens certainly warrants further exploration, as do the argumentative and justificatory positions they assume

Message for humanity. An additional noteworthy result is that as individuals report an increasingly definite experience, the likelihood that they will report receiving a message for humanity increases ($p = .043$) (see Table 6) This finding may not be particularly surprising considering the way the various types of accounts are defined For example, within possible AAEs, experiencers do not remember any beings and only have hazy, general feelings about any type of interactions which may have gone on It is not surprising then that they would not report having received a message from extraterrestrials Those experiencers in the AAE category, on the other hand, often report both physical and mental interactions with extraterrestrials, so the likelihood of them receiving a message obviously increases

PSI abilities. One of the most striking relationships is between AAEs and psychic abilities Although a full 50% of the general population generally report they believe in E S P, an overwhelming 93 8% of those in the current study claim to actually possess some sort of psychic ability—ESP, clairvoyance, precognition, or psychokinesis [15] The likelihood of an individual reporting paranormal abilities is not related to the type of experience they claim to have had

Abduction literature has noted that paranormal abilities are often cited by experiencers to be a result of their abduction (Appelle, Lynn, & Newman, 2000; Bullard, 1994; Ring, 1992) Some AAEs also cite their purported paranormal abili-

Table 6. Message by Encounter Type

Encounter Type	Message No	Yes	Total
Possible AAE	19 (73 1%)	7 (26 9%)	26 (100 0%)
Visitee	9 (37 5%)	15 (62 5%)	24 (100 0%)
AAE	33 (44 6%)	41 (55 4%)	74 (100 0%)
Psychic AAE	2 (40 0%)	3 (60 0%)	5 (100 0%)
Total	63 (48 8%)	66 (51 2%)	129 (100 0%)

ties as the reason why they were chosen for abduction They claim that because they are more open to alternative realities, or because they possess paranormal abilities, the extraterrestrials chose to contact them

Unfortunately, many times, the connection between belief in their paranormal abilities and alien abduction works to portray the AAE as abnormal Auton, Pope, and Seeger (2003, p 718) reported that "paranormal belief is not indicative of psychopathology" Their study actually found that high believers in the paranormal function "just as normally as low believers" There were, however, environmental factors that were consistent within level of belief for participants For example, high believers had more friends with similar beliefs and watched more paranormally oriented television programming

Healing powers. One characteristic common to AAEs that has not yet been widely reported concerns the belief that they can psychically heal themselves or others Although this belief is not related to the type of encounter experienced, 61 7% of the respondents reported that they could heal themselves or others.

Again, as with paranormal abilities, this is a higher percentage than those in the general population who even believe such a thing is possible According to a 2001 Gallup poll, 54% of those asked believed that psychic healing was possible This same poll reported that the number of people who believe in "psychic or spiritual healing" has increased 8% since 1990 A similar increase was reported in a 1997 Yankelovich Partners poll that compared belief levels measured in 1976 to those of 1997 In 1976, only 10% of respondents reported they believed in "faith healing," whereas in 1997 that number had increased to 45% (Nisbet, 1997)

Past lives. Another significant difference between the AAE population and the general population concerns the belief that they have lived a past life Gallup Polls since 1990 have indicated a general belief in the possibility of reincarnation. In 2001, for example, 25% of those asked believed in the possibility of reincarnation

Although many people believe in the possibility, not many report actually believing they have lived a past life In 1990 and 1996, the Gallup Poll asked people if they "felt that you were here on Earth in a previous life or existence in another body" In 1990, 8%, and in 1996, only 9%, believed that they had Many of the AAEs (88, or 68 8%) in the current study report they have lived a past life. Some of the respondents report that in those past lives they were then too in contact with extraterrestrials Those respondents in the possible AAE group were less likely to report belief in a past life ($p = 005$).

Vivid dreams. One of the more terrestrial explanations of what is happening to these people concerns sleep disturbances Hypnagogic and hypnopompic imagery—particularly vivid dreams or sensations experienced just as one falls asleep or awakens—may be able to account for some of the reported extraterrestrial encounters However, Rodeghier (1994, p 298) asked 24 AAEs "Have you ever experienced particularly vivid dreams while falling asleep or just before waking?" Twenty percent reported hypnagogic imagery and "about the same proportion" had the experience of hypnopompic imagery upon awakening Neither of these figures, according

to Rodeghier, is "excessively high." In the current study, 89.1% reported that they had experienced vivid dreams in their lifetime. Several respondents made marginal notes when answering "yes" to this question that indicated they "had also had an abduction" or that "it was nothing like an abduction." It is interesting that these respondents distinguished between the two experiences, most likely because they too are aware of attempts to explain alien abduction experiences as incidences of sleep disturbances. Again, the experiencing of vivid dreams was not related to a particular encounter type.

Limitations/Conclusions

Any study which purports to describe the population of alien abduction experiencers is invariably limited in its generalizability for a number of reasons. First, many individuals who claim contact with extraterrestrials are reluctant to come forward and report their experiences. Currently, all data on AAEs is based on individuals who self-selected and chose to share their experiences. The differences between those who come forward with their experiences and those unwilling to share their experiences would certainly be interesting, but is currently impossible to discover. Additionally, this sample may be biased since these respondents had access to the internet and/or the ability to attend UFO conferences, both of which require at least some amount of disposable income [16]. Finally, the small number of respondents who reported psychic abductions limits conclusions about that group.

A further limitation applicable to all of these measures concerns the context in which the data is gathered. Psychological research has shown that people are more likely to express belief in paranormal abilities when the researcher has a personal belief in paranormal abilities (see Smith, Foster, & Stovin, 1998, for a summary of relevant research). That is not to say that the attitude of the researcher changes the belief of the percipient, but it can change the willingness of the experiencer to express that belief. In terms of this sample, participants were assured of their anonymity. In addition, some remarked they had worked with an abduction researcher, were part of a support group, or were actually interviewed at an experiencer conference. Each of these variables would make subjects more comfortable expressing nontraditional beliefs. Furthermore, many AAEs made several credibility claims when writing to the author "I know this sounds crazy but . . ." or "I'm really a highly functional person by society's measures . . ." Comments like these were often included in the materials returned by the respondent. It is not unreasonable to think that some of this is due to the unknown nature and perspective of the author. Similarly sympathetic situations should be created to measure the extent to which the general population would express belief or possession of paranormal abilities.

In summary, this study cannot claim to have fully explored all possible characteristics or potential contributors to the alien abduction experience. However, it does begin to examine the main source of evidence and testimony regarding the nature of these events—the AAEs themselves.

FOOTNOTES

1 A second survey, conducted by the Roper Organization in 1998, used the same "indicators " Results seem to indicate the number of potential AAEs dropped significantly—from over 3 7 million in 1991 to 2 2 million in 1998 Rodeghier (2000, pp 22–23) discusses some of the biases or sampling errors that may account for this decline

2 A complete data set was received from Professor Bader after personal correspondence

3 This survey can be found under the author's research links at www bates edu/~skelley/.

4 The author wishes to thank the many experiencers who continue to respond as new issues are raised

5 Not all subjects chose to respond to all follow-up questions For example, several individuals were unwilling to answer questions about their psychic abilities or questions they perceived as judging their mental state Footnotes indicate where $N < 130$ for the remainder of the essay

6 Bullard (1987) introduced this term to describe alien "contact" without bodily transportation

7 Percentages do not equal 100%, as there was one subject who indicated "other" as his/her sex

8. Tables including raw numbers according to encounter type are included in Appendix A, only when results warranted further discussion or were significant were they included in the text

9 Personal correspondence

10 Personal correspondence

11 Concerning marital status, N=106. Twenty-four participants did not provide a response regarding marital status

12 Not in labor force included retired, homemaker, unemployed, and student

13 Although this relationship only *approaches* significance, the fact that only 6 psychic AAEs were included in the sample warrants its inclusion for discussion

14 For this query, N=87 Although general data collection began in 1996, this specific question was not added until 1998. Whenever possible, respondents were recontacted to gather this information In other instances, they were unwilling to provide this information

15 Of those who claimed to have paranormal abilities, 86% reported having ESP, 78 3% clairvoyance, 82 2% precognition, and 48 8% psychokinesis

16 Although some people contacted the author via regular mail after her name appeared in the *Idiot's Guide to Extraterrestrial Intelligence*, the majority of participants responded via email

APPENDIX A

Encounter Type by Gender

Encounter Type	Male	Female	Other	Total
Possible AAE	13	13	0	26
Visitee	12	12	0	24
AAE	32	41	1	74
Psychic AAE	2	4	0	6
Total	59	70	1	130

Encounter Type by Race

Encounter Type	Caucasian	African-American	Hispanic	Native American	Other	Total
Possible AAE	24	0	0	0	2	26
Visitee	19	2	0	1	2	24
AAE	63	1	3	4	3	74
Psychic AAE	5	0	0	0	1	6
Total	111	3	3	5	8	130

Encounter Type by Education

Encounter Type	<9th	9–12	H S Grad	Some College	College Grad	Some Grad	Grad Degree	Total
Possible AAE	0	1	7	12	5	1	0	26
Visitee	1	1	2	12	4	0	4	24
AAE	0	1	11	36	11	5	9	73
Psychic AAE	1	0	1	4	0	0	0	6
Total	2	3	21	64	20	6	13	129

Encounter Type by Marital Status

Encounter Type	Single	Married	Divorced	Widowed	Other	Total
Possible AAE	9	9	5	0	0	23
Visitee	6	8	2	0	0	16
AAE	17	34	8	2	1	62
Psychic AAE	3	0	1	1	0	5
Total	35	51	16	3	1	106

Encounter Type by Occupation

Encounter Type	Unempl	Retired/ Student	Labor	Sales	Mgmt	Profess	Comp	Artist	At Home	Self-Empl	Total
Possible AAE	0	6	5	5	2	2	1	3	2	0	26
Visitee	0	2	2	5	1	4	2	2	1	5	24
AAE	2	8	10	6	9	19	5	6	5	4	74
Psychic AAE	3	1	0	1	0	0	0	1	0	0	6
Total	5	17	17	17	12	25	8	12	8	9	130

Age of First Abduction by Encounter Type

	Reported Age at First Abduction				
Encounter Type	0–5	6–10	11–30	31+	Total
Possible AAE	13	2	8	2	25
Visitee	11	3	5	5	24
AAE	39	12	12	6	69
Psychic AAE	1	1	2	2	6
Total	64	18	27	15	124

Genetic Link to Aliens by Encounter Type

	Genetic Link		
Encounter Type	No	Yes	Total
Possible AAE	15	11	26
Visitee	13	11	24
AAE	31	43	74
Psychic AAE	2	4	6
Total	61	69	130

Encounter Type by Abuse

	Abuse		
Encounter Type	No	Yes	Total
Possible AAE	10	8	18
Visitee	8	3	11
AAE	32	23	55
Psychic AAE	2	1	3
Total	52	35	87

Quality of Experience by Encounter Type

Encounter Type	Negative	Positive	Neither/Both	Total
Possible AAE	6	9	11	26
Visitee	2	13	9	24
AAE	19	39	16	74
Psychic AAE	0	4	1	5
Total	27	65	37	129

Psychic Abilities by Encounter Type

	Psi		
Encounter Type	No	Yes	Total
Possible AAE	2	24	26
Visitee	2	22	24
AAE	4	69	73
Psychic AAE	0	6	6
Total	8	121	129

Healing Abilities by Encounter Type

	Healing		
Encounter Type	No	Yes	Total
Possible AAE	12	14	26
Visitee	7	16	23
AAE	29	44	73
Psychic AAE	1	5	6
Total	49	79	128

Past Lives by Encounter Type

	Past Life		
Encounter Type	No	Yes	Total
Possible AAE	14	11	25
Visitee	9	15	24
AAE	17	56	73
Psychic AAE	0	6	6
Total	40	88	128

Vivid Dreams by Encounter Type

Encounter Type	Vivid Dreams No	Yes	Total
Possible AAE	3	23	26
Visitee	1	23	24
AAE	9	64	73
Psychic AAE	1	5	6
Total	14	115	129

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THE EFFECT OF THE LABEL "UFO" ON MEMORY FOR AMBIGUOUS PICTORIAL STIMULI

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ABSTRACT The scientific community frequently explains Unidentified Flying Objects (UFOs) as ambiguous but natural aerial phenomena that are misperceived by witnesses due to the influence of their expectations and beliefs, also termed their *perceptual set* However, there has been very little research into the effect of a UFO-related perceptual set on recall of ambiguous pictorial stimuli Forty undergraduate psychology students drew from memory ambiguous pictures recalled under four label conditions (UFO aeroplane, ambiguous, and self-derived) Statistical analysis revealed no significant difference among the label and control conditions on either measures of detail or the addition of features This suggests that in a controlled environment, perceptual set does not affect accuracy of recall of previously witnessed ambiguous pictures Relevance to actual sightings of UFOs is discussed

Understandably, sightings of Unidentified Flying Objects (UFOs) that are interpreted by witnesses as "extraterrestrial spacecraft" are frequently rationalized by a skeptical scientific community as misperceptions of natural phenomena Accordingly, explanations for reports of unusual nocturnal lights and daylight discs include stars, planets, clouds, aeroplanes, and seagulls (the controversial verdict of the Robertson Panel in relation to the Tremonton, Utah, film of 1952). One implication of the "misperception" hypothesis might be that individuals who see UFOs are inherently more prone to misperception than nonwitnesses (Rhine, 1969, Westrum, 1977, Hines, 1988)

However, a recent study by Dear and Jinks (2005) has determined that frequent witnesses to anomalous visual phenomena (including UFOs) do not differ from nonwitnesses in their performance on recall and recognition-based memory tasks. That is, witnesses appear no more susceptible to sighting a UFO because of some intrinsic deficit in their perceptual and cognitive processes Nevertheless, the misperception hypothesis may still be relevant to UFO sightings in that certain aerial phenomena could exist which are intrinsically unrecognizable to *all* percipients For example, the physical influence of atmospheric or geomagnetic activity could distort recognizable stimuli into unrecognizable objects As a consequence, stars, the moon, clouds,

or even aeroplanes perceived from peculiar angles might be labeled "UFOs" by a proportion of these percipients

In western society the prevalent view is that UFOs are some form of extraterrestrial spacecraft (Raimer, 1999), so for a witness to see a UFO it is reasonable to assume that they must possess some level of prior belief that UFOs are objectively real Therefore, a nonbeliever might (correctly or incorrectly) generate a meteorological explanation for a sighting, while the believer might (correctly or incorrectly) proclaim they observed a "flying saucer" This is known as the individual's *set*, or their predisposition to a specific interpretive response (Reed, 1972) Furthermore, a witness who personally labels their unusual aerial sighting a "UFO" might at a later time recall its form in a completely different way. For example, the planet Venus may be mistaken for "a metallic cigar with windows through which extraterrestrial occupants can be seen" (Evans, 1982)

Assuming a relationship exists between UFO sightings and prior UFO belief, it is interesting to speculate to what degree personal interpretation influences the amount of *detail* recalled from an alleged UFO experience Specifically, does the prior possession of a UFO set (or any set, for that matter) improve or hinder accurate memory of the event? Surprisingly little research has focused on this question, and that which does is often old and obscure Nevertheless, there is some evidence for the improvement of memory due to set. For example, ambiguous scenes accompanied by verbal labels have been shown to enhance recall and recognition of detail in the picture (e g , Bower, Karlin & Dueck, 1975) Likewise, De Santis and Haude (1993) argue that the availability of a meaningful interpretation of an ambiguous pictorial stimulus facilitates its encoding and later retrieval Stimuli interpreted as meaningful are also recognized more easily than nonsense patterns (Wiseman & Neisser, 1974) However, these results pertain only to *correct* labels. If labels are inaccurate, recall may suffer (Steinfeld, 1967).

Accordingly, a skeptic might argue that since the label UFO (meaning extraterrestrial spacecraft) is by its very nature incorrect, then recall of the event will necessarily be poor Alternately, the skeptic might acknowledge that the phenomenon a witness experiences may in certain circumstances be truly ambiguous, therefore cannot be objectively labeled (although they would argue such a label must exist, albeit unobtainable to the observer without further details being made available) However, they might allude to the fact that none of the studies mentioned above used truly meaningless scenes. That is, ambiguous stimuli in these studies tend to be pictures of common objects with features removed or distorted (e g , Koutstaal et al , 2003) or figure-ground and reversible figures ("chimeric objects") having two possible interpretations (e g , Lee, 1960, Magnié, Besson, Poncet & Dolisi, 2003)

Studies that use truly ambiguous stimuli consisting of randomly drawn patterns without any fixed meaning consistently demonstrate that (among other factors) perceptual set *hinders* recall of detail Such patterns include Rorschach ink blots and meaningless drawings (e g , Wiseman & Neisser, 1974) Thus Kuhlmann (1906) found that when a subject was required to recall and draw previously witnessed meaning-

less patterns and certain features of the patterns subjectively resembled those of a familiar figure, the subject's sketch matched the familiar figure more closely than the original pattern This suggests the *distortion* of recall by perceptual set, in this case expectation based on knowledge of the features of a familiar figure Similar results have also been achieved using chimeric figures (Carmichael, Hogan, & Walter, 1932, Patel, 1961) In a more recent study, Schooler et al (1990) demonstrate that recall of a stimulus that does not have a clearly corresponding label (i e , is essentially meaningless) is impaired when a verbal description is forced on it

Extrapolating these findings to experiential recall, it could be predicted that the ability of witnesses to remember the details of ambiguous pictorial stimuli *without* a given label will be superior to the same stimuli that have been labeled with a potential (but necessarily irrelevant) interpretation No studies, however, have examined memory for details of ambiguous figures in terms of the UFO label, although it might be speculated that witnesses' recall of the features of their UFO experiences might be poorer than experiences not assigned a label, for example, if the witnesses could describe what they saw but were "unsure" of what it was The primary aim of the study is therefore to determine whether prior labeling of a meaningless drawing as a UFO impedes later recall of the drawing's details compared to a condition where the same drawing is assigned no label

It is also interesting to speculate whether different labels generate different levels of recall Undoubtedly there exists in popular skeptical literature (e g., Hines, 1988, Shermer, 1997) a pervasive yet empirically unsupported assumption that when people witness an unknown aerial event and personally label it a UFO, they become somewhat "hysterical," are overinfluenced by belief systems associated with the label and consequently show poor recall of the event As Sagan (1995) writes, "When we notice something strange in the sky, some of us become excitable and uncritical bad witnesses " According to this hypothesis, it might be predicted that even in an experimental setting the alleged emotional influence of the label "UFO" will lead to greater distortion of memory for detail than a more mundane label such as "aeroplane " A secondary aim of the study was therefore to determine whether differences exist in recalled pictures alternately labeled UFO and aeroplane, both concepts assumed to be widely known in western culture

Method

(a) Participants

Forty University of Western Sydney (UWS) undergraduate psychology students participated in the study for course credit Twenty participants were male and 20 female, with ages ranging from 18 to 35 years (M = 21 20, SD = 3 5) Participants were randomly assigned to one of four experimental groups (10 in each group) The research was approved by the UWS ethics committee (protocol number 03/204) and conducted according to the UWS ethics guidelines for human research

(b) Apparatus

Pictures 133, 162, and 240 from Magnie, Besson, Poncet, and Dolisi (2003) were adapted for use in this study as Pictures 1, 2, 3, and 4 respectively in Fig. 1 Each picture was reproduced onto an overhead transparency Participants used white A4 paper with a black 15 3 × 13 5 cm border to draw recalled pictures. In order to analyse recall of detail of the pictures, each was reproduced onto A4 paper with features numbered and illustrated in color Standard equipment included an overhead projector and projector screen, watch, and 2B lead pencils As a distraction task, two worksheets were developed, one containing simple pattern recognition problems and the other basic mathematics problems

(c) Procedure

In a classroom setting, participants were shown in series each of the four pictures projected onto a screen via the overhead projector Each picture was associated with one of four labeling conditions, these being (1) the label of "UFO," (2) the label of "aeroplane," (3) the label of "ambiguous," and (4) a self-derived label Prior to the presentation of any one picture, participants were given verbal instructions relevant to a labeling condition Thus for conditions 1 and 2 the instructions were, "This picture may resemble an UFO/aeroplane " For condition 3 the instruc-

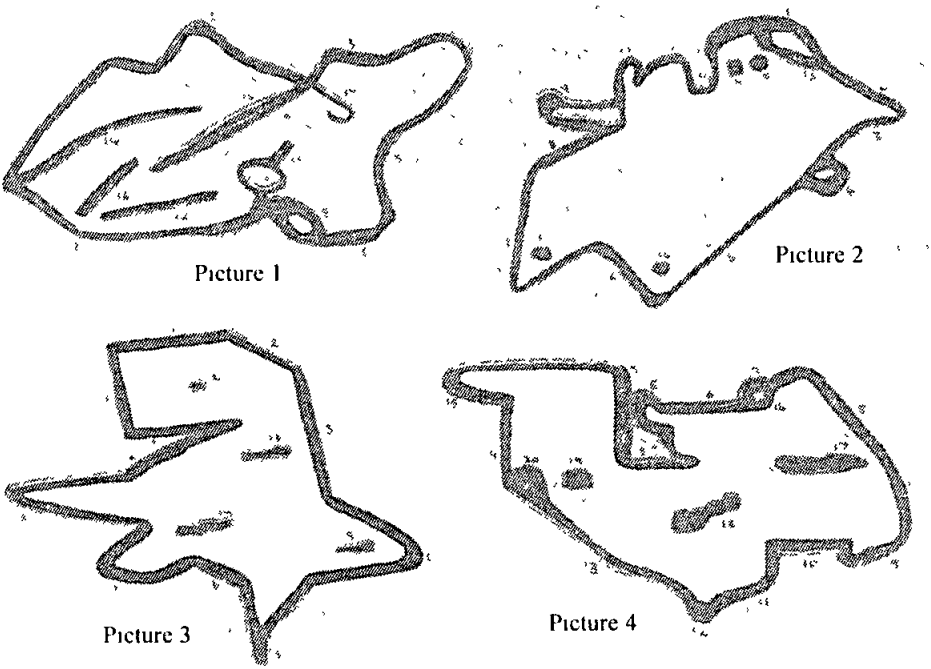

Fig 1

tions were, "This is an ambiguous picture " For condition 4, the instructions were "Please think of one word that describes the next picture, you do not need to write this down " With respect to conditions 1 and 2, the use of verbal labels such as aeroplane and UFO as the operational equivalent of perceptual set is common to most of the research in the area (e g , Carmichael et al , 1932, Van Dam, Peeck & Uhlenbeck, 1979, De Santis & Haude, 1993) With respect to the distinction between conditions 3 and 4, pilot studies indicated that participants have a propensity to look for meaning in unlabeled pictures and "self-label" them. For example, they might see the picture, think of a duck, and use this self-derived interpretation to assist (for better or worse) recall. Condition 3 therefore attempted to reinforce a "no label" condition by deliberately emphasizing the ambiguous nature of the stimulus In contrast, condition 4 allowed self-labeling, thereby determining the effect this process might have on stimulus recall compared with the formal label of "ambiguous."

Following the verbal instructions, a picture was shown on the overhead projector for 10s Participants were then asked to attempt the worksheets After 5 minutes they were instructed to stop the worksheets and were given 2 minutes to draw the picture that had been previously displayed On completion of the drawing the participants were instructed to either watch the screen for the next picture (following any of the first three pictures), or thanked for their participation and debriefed with regards the purpose of the study (following the fourth picture) Participants therefore submitted four drawings to the experimenter at the completion of the session The order of picture presentation and label condition was randomized among the four groups of participants Only the age and sex of the participant was recorded on their drawings

(d) Drawing analysis

The technique used to analyze and score the participants' drawings was adapted and expanded from the feature-based scoring scheme utilised by Bozeat, Lambon Ralph, Graham, Patterson, Wilkin, Rowland, Rogers, and Hodges (2003) Integral features of the original pictures were identified by the researchers and a marking criterion was established based on the nearness of the participants' drawings to each of these features The number of features identified for each picture were Picture 1 (17), Picture 2 (17), Picture 3 (15), and Picture 4 (20) The scoring criterion for each feature in a participant's recalled drawing was either 0 (little or no resemblance to the original), 0.5 (resemblance to the original but differed in some aspects, e g , orientation or relative importance), or 1 (reasonable resemblance to original feature) Drawings were judged for accuracy by two independent raters blind to the experimental conditions Accuracy scores for each drawing were converted to a percentage correct of details accurately recalled by the drawer To assess any creative embellishments to a drawing, a second score for additional features was recorded Features present in the drawing but not in the original picture received a score of 1 A total score for additions was therefore calculated for each drawing

Results

An inter-rater reliability analysis (Salkind, 2006) was performed to determine reliability between the two raters on their scores for the 160 drawings (4 × 40 participants) Reliability was considered acceptable (986) and each drawing was assigned a final score denoted by the average of the scores given by the two raters (Table 1) A single factor within-subjects multivariate ANOVA (SPSS v 12) examined potential differences among means for the four labeling conditions regarding the two dependent variables of accuracy and additions (Table 1) No significant differences were found among conditions for either accuracy or additions; $F(6,34) = 1.896$, $p > 0$ 05

It should be acknowledged, however, that valuable information may potentially have been lost through the quantification of participants' drawings As such, each drawing was examined holistically to determine whether label condition might have influenced drawing in a manner independent of accuracy and additions. It transpired that only one of the 160 drawings appeared to the experimenters to contain qualitative information undetected through the drawing assessment procedure used in the present study (Fig 2) When questioned, the participant who drew the picture explained that the self-derived label was "ghost " This would suggest that the scoring procedure was a valid method of measuring recall of ambiguous pictorial stimuli, and that neither experimenter-induced or internally derived labeling of such stimuli has a significant influence on accuracy or embellishment of this recall

Discussion

The results of the study indicate that there is no statistically significant difference between the label of UFO and the label "ambiguous" on the recall or embellishment of detail of meaningless pictorial stimuli. In addition, no differences existed between the UFO and aeroplane label conditions, suggesting that any atypical reaction (emotional or cognitive) to the label UFO does not interfere with immediate perception of details in the pictures The similarity between the ambiguous labeling and self-labeling conditions suggest that forcing the term "ambiguous" onto pictures in condition 3 is not disadvantaging participants to any greater extent than instructing them to derive their own word for the picture

Applying these results to actual sightings, it could be suggested that a witness who interprets an unusual experience as a UFO will be no worse at describing the details

Table 1. Mean Accuracy and Additions Scores for Label Conditions

	Accuracy		Additions	
Label	M	SD	M	SD
Airplane	40 67	14 51	1 99	2 02
UFO	43 56	14 74	1 91	1 79
Ambiguous	37 10	14 32	1 68	1 68
Self-derived	37 88	15 68	1 68	1 52

Fig 2 Recall of Picture 2 with self-derived label of "ghost"

of the event at a later time than a witness who interprets the same stimulus as an aeroplane, or who believes there is no necessary interpretation (i e , it is inherently ambiguous) Admittedly, a number of intervening factors caution against such an extrapolation The small sample size makes it hard to draw firm conclusions There is also the possibility that the label UFO might be considerably more bizarre than aeroplane Research has shown that normal stimuli paired in bizarre contexts are easier to remember than those paired in normal ways (Iaccino, 1996) For example, the phrase "a CLOCK is drinking the WINE" contains elements better remembered than "a FROG is on top of the BARREL " Conceivably, labeling a meaningless drawing a UFO might facilitate memory for detail due not to the label's meaning, but rather the novelty of it

Also important is the inherent difference that exists between a classroom setting and a legitimate experience It is highly likely that the label of UFO generates a greater emotional response in the latter setting compared with the former, and as a consequence may have a more distorting effect on memory for the event Therefore, repeating the study in a naturalistic setting might arguably generate a different result, perhaps more in line with the less experimentally controlled findings of Simpson (1979/1980 cited in Hines, 1988) In this study, participants outdoors were set up to see a UFO on a nearby hill (a purple spotlight) and subsequently made incorrect judgments regarding broad aspects of the stimulus, for example, overall shape and position Perhaps ambiguous stimuli similar to those used in the present study could be used in order to examine recollection of features more detailed than simply shape and position of a nondescript light Memory for color and depth might also be tested in such a setting, since these variables are intrinsic elements of a recalled experience Participant's traits should also be measured, such as prior belief or tolerance of ambiguity, to evaluate their impact on the staged sighting

The 5-minute period between exposure to the picture and recall might also be unrepresentative of an actual UFO sighting A UFO label could be applied to a witness' sighting, however, this label might only hinder recollection of detail after a long period of time has elapsed between the event and the recounting The role played by post-event information on recall of a visual scene over periods of days and weeks is certainly controversial (Windschitl, 1996) Nevertheless the present study focused primarily on the immediate impact of label on memory The long-term influence of label must be the subject matter of future studies

The discussion isn't complete without mention of the potential relationship between the present findings and those of studies examining eyewitness testimony and crime scenes Loftus (1975) discredited the unquestioning reliance on eyewitness

testimony as fact and demonstrated the ease with which a witness can be led to remember false information, for example, schema-consistent information, or information consistent with later questioning, rather than the actual event or scene Nevertheless the assumption that the findings of standard eyewitness testimony research are generalizable to UFO sightings is questionable For example, witnesses of an automobile accident or a bank robbery (the typical subject matter of eyewitness testimony studies) are faced with a situation that is acknowledged to have an objective reality and the stimuli involved are commonly recognizable objects such as a street sign or a gun In contrast, UFO witnesses are faced with a very different situation: the reality of what they saw may be scientifically questionable and the stimuli they recall may be completely novel. The affective responses to these kinds of eyewitness reports have an additional potential for variation Witnesses to crime are likely to have negative emotional associations regarding the event, whereas the affective response of a UFO witness may include feelings of awe and wonder It is therefore appropriate that the current research specifically relating to the UFO phenomenon and perceptual set is performed

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AN ANALYSIS OF MULTIPLE UAP PHOTOGRAPHIC IMAGES (MAY 23, 1971, AUSTRIAN ALPS)

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ABSTRACT This paper presents an analysis of 11 consecutive color photographs and related eyewitness testimony of an alleged unidentified aerial phenomenon (UAP) taken over at least a 10 minute period beginning at about 12 30 p m on May 23 1971, about 30 miles south-southwest of Graz, Austria by Mr Rudi Nagora, 25 Details of the camera lens, film characteristics and other relevant optical and historical details are presented Each frame shows a dark and/or "metallic' object in the daytime sky Its flight path was determined on several adjacent frames by overlapping relatively unchanging cloud and fixed background details No evidence of pixel distortion is found surrounding any image of the object as might be produced by radiated heat, nor is there evidence of double exposure, a suspension thread above the UAP images, or mismatch of pixel dimensions within the UAP image or outside it There is evidence of finite object motion blur in some frames where stationary background detail is in focus A geometric composite analysis of all images supports the view that the UAP's three-dimensional form is not circular in planform but rather a blunt-cornered isosceles triangle with flat bottom and convex upper surface The object remains unidentified at this time

As photoanalysts recognize, every photographic image calls for a slightly different approach in its study that takes into account the unique circumstances under which it was obtained This is particularly true in the examination of photographs of anomalous phenomena, such as alleged UAP where one must establish an even stronger case than usual to support its alleged anomalous nature According to a recommendation made by the Society for Scientific Exploration's 1997 UAP workshop's scientific review panel at Pocantico, New York, the decision to investigate a new photo case should be taken only if two conditions are met (a) the original documentation (photo negative) is available for study, and (b) there must be at least one other independent source of information, either witness testimony or some other physical record (Louange, 1999, pp 136–138) Also mentioned as being important is establishing the authenticity and flawless operation of the photographic equipment and photo acquisition as well as providing evidence that the image is not a result of a film defect or blemish (either on the raw negative film or in later processing) While it is very difficult to find photo cases that will meet all of these requirements, the present case fulfills most of them Only the possibility of a deliberate photo-processing hoax can-

not be evaluated, even though it is highly unlikely. As Louange correctly points out, "proving the authenticity of a purported UAP photograph is at best relative since only negative conclusions may be considered as final, so that authenticity can never be demonstrated absolutely." But should this obvious fact prevent one from seeking other potentially useful probative evidence? Of course not.

It is also important to note that the present photographs and past analyses in Germany have raised many acrimonious accusations between their proponents and opponents. The intent of this paper is not to add to such clamor but to provide additional insights about the photos themselves. The author takes no position on the origin or ultimate identity of the object that was photographed.

Description of the Sighting Event

The following details from a tape-recorded interview with the photographer, Mr Rudi Nagora, took place with the author in Munich on August 26, 1999. An earlier version written by the witness (Nagora, 1971) contains basically the same facts (with some differences) that the author considers inconsequential relative to the overall reliability of the photographs. Mr and Mrs. Nagora were driving in their automobile just after noon in the Austrian Alps on May 23, 1971, during a Sunday outing during their summer vacation. They were about 30 miles SSW of Graz (approx. Lat. 46° 40′ N, Long. 15° 20′ E.) relatively near the border with Yugoslavia [now Slovenia](see Figure 1) at the time. He stopped the car and got out to look around. Then both witnesses heard a "buzzing" or "high pitched whistling" sound coming from a spot in the sky near the position of the sun. At first Nagora saw nothing due to the sun's extreme brilliance. He tried to reproduce this sound by whistling, which I recorded. Then he saw a single, bright-silver, "metallic" object overhead, and he called his wife Hildegard's attention to the object. She remained inside their car, as she was pregnant at the time.

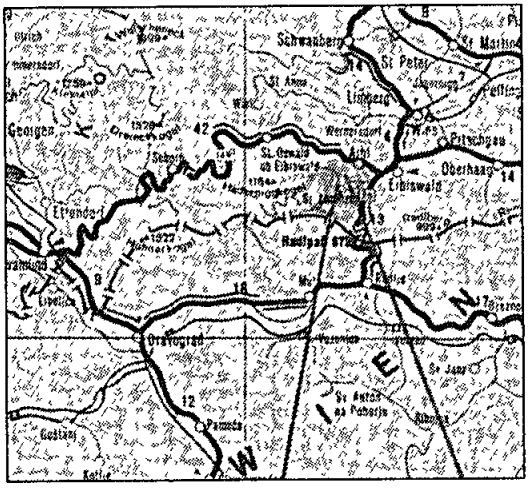

Figure 1
Map of sighting area

Nagora told me he had an inexpensive 120-format, plastic camera with him loaded with a fresh, 12-exposure roll of Agfa color film He claimed that he had only one roll of film with him that day He began taking photographs of the object from different locations, all within the same general area near the road in a nearby field that sloped gently downward (to the south?). He said that he manually advanced the film immediately after each exposure (each requiring about five to eight seconds) while looking down at the viewfider in the back of the camera Each time the UAP hovered in the sky, it rocked back and forth much as a spinning top wobbles Then very quickly it would move at very high sped or "jump" to another part of the sky (sometimes behind him) without warning and in irregular directions, come to an almost instantaneous halt, and wobble again, much like a child's top oscillates before falling over He was impressed with the apparent precision of its wobble He said that he tried to take photographs of the object each time it came to a stop in the sky but could not always do so Several times, when he had finally located the new position of the aerial object and was about to take a photo, it would jump out of sight to yet another new location. At other times, the object could not be seen at all for several minutes, he assumed a cloud concealed it He also said that the object hovered for from five to eight seconds just before it disappeared for the last time

He said he was both excited and nervous the whole time and recalled running around in the grassy field near their automobile in order to get a better vantage point Nagora said that he felt a visceral vibration and heard the noise from the sky each time the UAP seemed to come nearer to him In my analysis I assumed that he ran around the grassy field within about a one hectare area during these exposures, a fact confirmed by von Ludwiger (1997), who asked the witness questions on my behalf before my interview with the witness in 1999. Later Nagora said that his wife, being eight months pregnant, remained inside their car the entire time He recalls seeing a contrail from a jet aircraft in the sky at high altitude during this time and that he never experienced engine trouble nor did the electrical clock in the car malfunction during or after the event

Ancillary Details

Nagora was interviewed by Illobrand von Ludwiger in the summer and winter of 1997 and the following additional facts were learned (von Ludwiger, 1998a, 1998b)

1 A reconstruction of the event showed that the total sighting (including photography) lasted from 10 to 20 minutes [1] Nagora considers his ear-

[1] This raises the issue of Nagora's self control He knew that he had only 12 exposures on his new roll of film yet he did not know how long the UAP would stay in sight In view of this he obtained good quality photos when many people probably would have snapped all 12 exposures in a hurry being unsure of how long the object would remain visible This suggests either a high degree of discipline and self control in the witness or a deliberate hoax in which he carefully planned each photograph

lier estimates to be inaccurate, he claimed he could recall the total duration only approximately The reasonableness of this statement is supported by much psychological research on the perception of "filled" and "open" passage of time (Bindra & Waksberg, 1956), wherein the emotional state of a witness contributes to the distortion of time. Of course, this temporal uncertainty raises the possibility that other claimed facts may also be in error by some unknown amount and/or that previous interviews were poorly carried out. One crude "natural clock" is found in the visible changes in cloud shape in clearly adjacent frames This suggests that many minutes elapsed between some frames [2]

2 Nagora claimed that the UAP hovered in one location for a period of time (typically 10 to 30 seconds) and rocked back and forth like a top that is beginning to fall over Then it would very quickly accelerate to another location in the sky, stop, and begin to wobble again. This sequence repeated itself many times He said that he took each photograph during the UAP's hovering phase The UAP was not visible for minutes at a time

3 He admitted being "nervous" and "excited" during the event and recalled running around the field by as much as 20m distance

4 Nagora said that three other witnesses arrived together while he was taking the photos, two women [one about 24 and the other over 60] and an older man All three spoke with a German accent When they saw him taking photos they thought he knew what the object was and asked him about it He replied, "I don't know;" at one point he said to them, "don't disturb me." They thought the object was some kind of new airplane As they left the area the man remarked, "I hope your pictures come out well " Nagora also noticed that three or four local farmers, cutting grass with scythes in the same field he was in, had also been watching the object. He spoke with them and learned that they had seen other UAP in the same vicinity before having a similar shape Unfortunately, he did not obtain the names of any of these witnesses

5 Sometime after taking his last exposure the UAP "came much nearer to the ground," to between 500 and 1000m altitude At that time he thought that the object's diameter was from 25 to 30 meters

6 Nagora said that he has never taken a photograph of a UAP before or after this event nor has he ever earned money for taking photographs of any kind

7 After receiving the developed prints from the local drug store, he showed

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[2] Henke (1995b, p 185) refers to earlier work by Webner's (1982) dealing with cloud shape changes and concludes that, given various assumptions, about 37 minutes elapsed between the first and last photograph

them first to the druggist there Then he loaned them to Helmut Reitz, his dentist, to examine for a week After that he showed them to friends during the next several weeks and claimed he then put the prints and negatives in a drawer for "some months " According to von Ludwiger (1997), Nagora became interested in the subject of UAP after this time and located the address of a UAP researcher, Frau Ilse von Jacobi, a follower of the controversial American writer George Adamski. The first UAP investigator to study these photos was Adolf Geigenthaler late in 1971

8 Nagora also said he has never been contacted by any government representatives in regard to these photographs

9 Nagora copyrighted his entire set of photographs well after the event at the suggestion of a photographer He said that several writers had ". . made a lot of money with my images." He felt that this was not fair since he had never received any money for his photos

On January 21, 1972, both Mr and Mrs Nagora signed a semiofficial "declaration of honour" under oath that stated (in part), "the series of photos "Nagora UFO" were taken with an AGFA Click-1 camera with an [sic] AGFA colour film CN17, without any other technical auxiliary means of any kind, and without any manipulations, and that the photos were made without any interruption, and in a direct sequence by Mr Nagora These photos were (made) exactly as I and my wife saw the flying object, when the pictures were made. They are true pictures of a flying object, disc-shaped, with a diameter of about 12 to 15 meters"[3] (Geigenthaler, 1976, p 189) Additionally, Professor Käsbauer of the University of Munich had a colleague perform a polygraph test on both Mr and Mrs Nagora in 1976, both "passed" the various questions, although what these questions were is not known Nagora said categorically that he did not toss a small disc or model up into the air at any time during these photographs

Because of the high quality of this particular set of photographs and the notoriety they have received, mostly in Europe since 1971 (see Henke, 1995a, 1995b, 1996a, 1996b, Hennell, 1976, Webner, 1982, 1994), the images and related witness testimony have been analyzed several times This body of evidence, mostly in German, is not repeated here I do, however, want to corroborate some of the reported findings and also add some new findings of my own for benefit of English readers Other conjecture and research by Geigenthaler, Hennell, Hesemann and Schneider, Klein, Maltner, von Ludwiger, and Webner, on both the pro and con side of the authenticity of these photos, is discussed below

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[3] Nagora changed his estimate of the object's size over the years and thereby provided skeptics with ammunition to challenge the believability of his entire narrative But it is well known that size and distance estimates of unfamiliar objects may be notoriously inaccurate in the absence of other corollary visual cues His distance estimate probably came from a statement made by British photo expert, Percy Hennell who examined the set of prints around 1971, according to Geigenthaler (1971)

Review of Previous Research

The earliest reports and analyses of the Nagora images were made by Adolf Geigenthaler, an engineer (1971, 1972). He examined the original negatives over several years and concluded that

1. The twelve photos, taken sequentially, were always focused on the same flying object having a disc shape at different moments in its flight and (at times) passed through or behind clouds.
2. Several photo experts (Percy Hennell and Professor Hubert Maltner) examined these negatives and prints and found them to be "true" (i.e., not faked). Thus, the British photo expert Percy Hennell examined a set of small positive prints and later wrote that not only were the images "very interesting" but that the object was probably from 12 to 15 meters in diameter
3. Geigenthaler said, "I could not falsify photos like these."
4. Photomicrographic analyses show identical film granulation characteristics making up the UAP's image as are found in surrounding areas.
5. The photographer's background and honesty was found to be of the highest order

Nevertheless, there are a number of problems with Geigenthaler's analysis and interpretations, discussed below.

Another examination of the Nagora film was performed by Webner (1982), clearly a skeptic. His arguments were focused mainly upon the earlier work performed by Geigenthaler (1976). Webner's objective was to try to show that Geigenthaler's arguments did not really constitute valid "evidence and that there were some unclear facts" surrounding the photographs (Henke, 1995a, p. 149). Webner noticed that solar reflections from automobile hubcaps seemed to appear similar to those from the apparently metallic disc seen in several of Nagora's exposures. He concluded, without examining the negatives, that the Nagora images looked so much like the hubcaps he (Webner) had photographed they probably were of a hubcap tossed into the air. Indeed, in 1986 Webner demonstrated for Westdeutscher Rundfunk (WDR) TV his ability to toss a hubcap up into the air and also photograph it by himself. Yet good scientific proof does not rest upon a strongly stated belief in one hypothesis, but upon rigorous examination of *all* available evidence related to it and other competing hypotheses as well.

More recently Henke (1995a, 1995b, 1996a, 1996b) has followed a more thorough approach in reexamining the witness's narratives and photographs. His extensive four-part series (in German) examines the history of the alleged event and prior research findings in some detail. He provides details of the camera, lens, and film used; discusses photographic image details and frame-to-frame correspondence of cloud details, examines the relationship between exposure time, estimated angular velocities, and image blur, angular and shape relationships between the image and various

fixed scene detail, and offers a point-by-point rebuttal of the Mutual UFO Network–Central European Section's (MUFON–CES) positive position on this controversial case One of the familiar facts that emerges from Henke's review of the various versions of what Nagora said he did before and during his photography is that human recall clearly is subject to various sources of error See Haines (1980, pp 76–91, 1999, pp 36–38) for further detailed discussion of this important subject and specific tests that can be carried out to approach the truth of the matter Of course, recall errors are not necessarily deliberate

Henke's final position is that the photos are the result of a deliberate hoax wherein a small model was thrown up into the air and photographed repeatedly Space doesn't permit repeating all of his arguments here Henke writes, "Instead of focusing on the objective hints [the photos], serious researchers should concentrate on the witnesses [sic] statements Then they wouldn't have to waste time sitting in front of their PC!" [personal computer, performing image analyses] (1995a, p 156)

I cannot entirely agree with Henke's above statement since an integrated and thorough comparison must be made between both the photographer's (and when available, other witnesses') testimony of what happened and analysis of *all* of the resulting photographic imagery. Henke appears to be negatively biased against this set of photographs, wholly on the grounds of inconsistencies he finds in Nagora's statements over the years, inconsistencies which could arise from many sources (for example, inconsistent or imprecise questioning by UAP investigators, a progressive understanding by Nagora of what was truly important to the investigators about his experiences, change of his memory of the incident through interactions with so many different people, including scientists, engineers, and the press, embarrassment about some of the alleged details at first which he later overcame, etc)

Finally, Klein (1995) performed a computerized comparison of cloud overlap and light reflectance off the UAP relative to the sun's location in the sky He found that both the angular length and tilt angle of the object varied in a manner that was *not* consistent with a fake model hypothesis.

Another computer animator and member of MUFON–CES, Herr Kammermeier, studied these images (von Ludwiger, 1998a) and concluded that some 10 minutes had passed between frames 11 and 13.[4] where virtually identical ground details allow for frame-to-frame alignment of the camera's optical axis [5] Much has been written about temporal factors between these 12 photographs Unfortunately, there is no

[4] The term 'frame' refers to the number nearest the exposure in question on the original negative To reduce confusion about exposure number I have elected to use a two-number designation, e g 8/11 8 refers to the consecutive exposure number and 11 to the frame number printed nearest the exposure on the edge of the film

[5] Of course this conclusion depends upon various assumptions concerning wind speed and direction as well as some detailed knowledge of cloud dynamics in this particular region This conclusion is important to establishing the overall event duration with which to confirm or dispute Mr Nagora's estimate

way to be certain of this aspect of the case, even knowing wind direction and velocity well above ground level at the time.

An unsuccessful attempt was made in the late 1970s to locate the photography site in the Austrian Alps by Peter Milger of (Hessischer Rundfunk) TV station ZDF in Mainz who traveled there with Nagora

Finally, Schneider and Malthamer (1976) included a general discussion on this case in the book *Das Geheimnis der unbekannten Flugobjekte* Suffice it to say that this case remains controversial

Regional Weather

Weather data for May 23, 1971, at 7·00 a m , 2 00 p m , and 7 00 p m for the village of Deutschlandsberg, Austria (Lat. 46° 49′ N, Long. 15° 13′ E) was collected by the Zentralanstalt für Meteorologie und Geodynamik in Vienna These records are summarized in Table 1 This particular weather station is only about nine miles north of the sighting location A professional meteorologist provided the following abbreviated summary of the local weather for the mid-morning hours.

Wind velocity at the altitude of the clouds was most likely higher than at the ground Nonetheless, the UAP reported could not have been a passive, airborne object such as a balloon if the witness's testimony is to be believed

Table 1. Selected Weather Data Surrounding the Sighting Date and Location

	Local Time		
	7 00 a m	2 00 p m	7 00 p m
Wind speed (ground level) Beaufort scale	0[1]	**0**	0
Wind direction	East	**SW**	NW
Visual range (meters)	7.000	**35,000**	50.000
Cloud cover and (horizontal) visibility	5/10	**6/10**	3/10
Air Temperature (degrees C)[2]	14 4	**18.8**	16 1
Relative humidity (%)	80	**57**	59
Ground condition	dry	**dry**	dry

1 Calm 0–1 mph

2 Minimum air temperature this day was 11° C and maximum was 23° C

The Photographic Evidence

On June 21, 1997, the author received a set of enlarged (approx 20 85cm wide by 20cm high) positive color prints and a full-size, color Xerox copy of 12 frames of the original color negatives from Illobrand von Ludwiger of the Society for the Scientific Investigation of Anomalous Atmospheric and Radar-Phenomena (the former MUFON–CES) in Feldkirchen-Westerham, in Bavaria, Germany, along with a request to study this evidence to see what more might be learned

Eleven of the 12 color photographs received are presented here (Figures 2–12)

without cropping Photographic exposures (also referred to as frames) are designated here by two numbers *a*/*b* where: *a* = consecutive photograph number on film roll, and *b* = number printed on the edge of the negative strip nearest that frame. These two numbers do not always coincide, because Kodak employs a constant distance numbering system that does not necessarily align with the exposed area This particular film roll had 12 frames/exposures but 17 edge numbers. One frame (8/11) was deleted because of greatly motion-blurred images Selected measurements for all 12 frames are included in Table 2 The major axis of the object's "body" orientation is given (in degrees) measured counterclockwise from the vertical (side of frame). In Figures 3, 4, and 8 the object is relatively thin and probably seen from the side

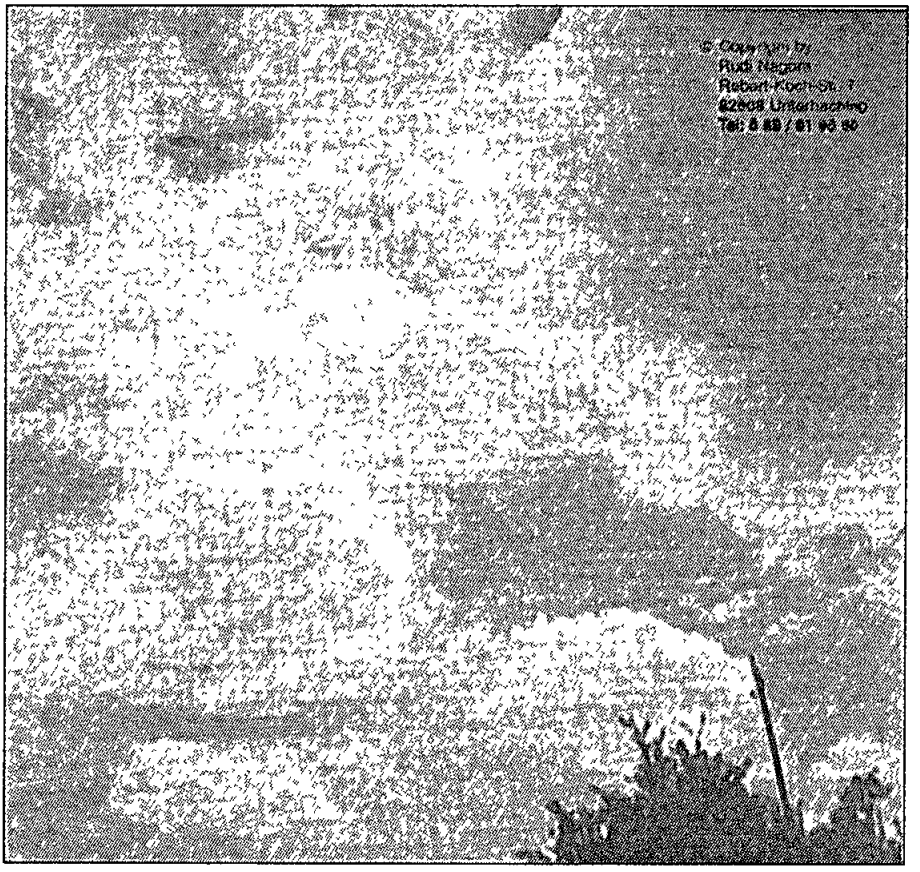

Figure 2 Frame 1/1 l/h = 3 28, major axis orientation = +85°, object's width on negative = 1 76mm

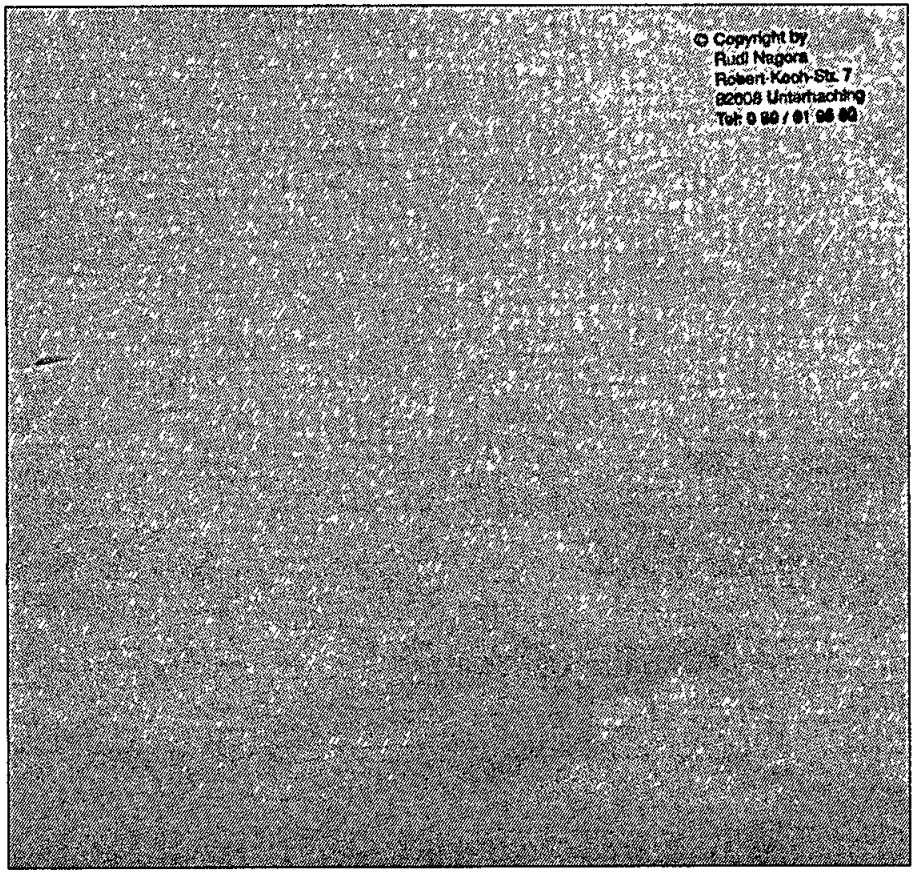

Figure 3 Frame 2/2 l/h = 5 16, major axis orientation = +86°,
object's width on negative = 1 90mm

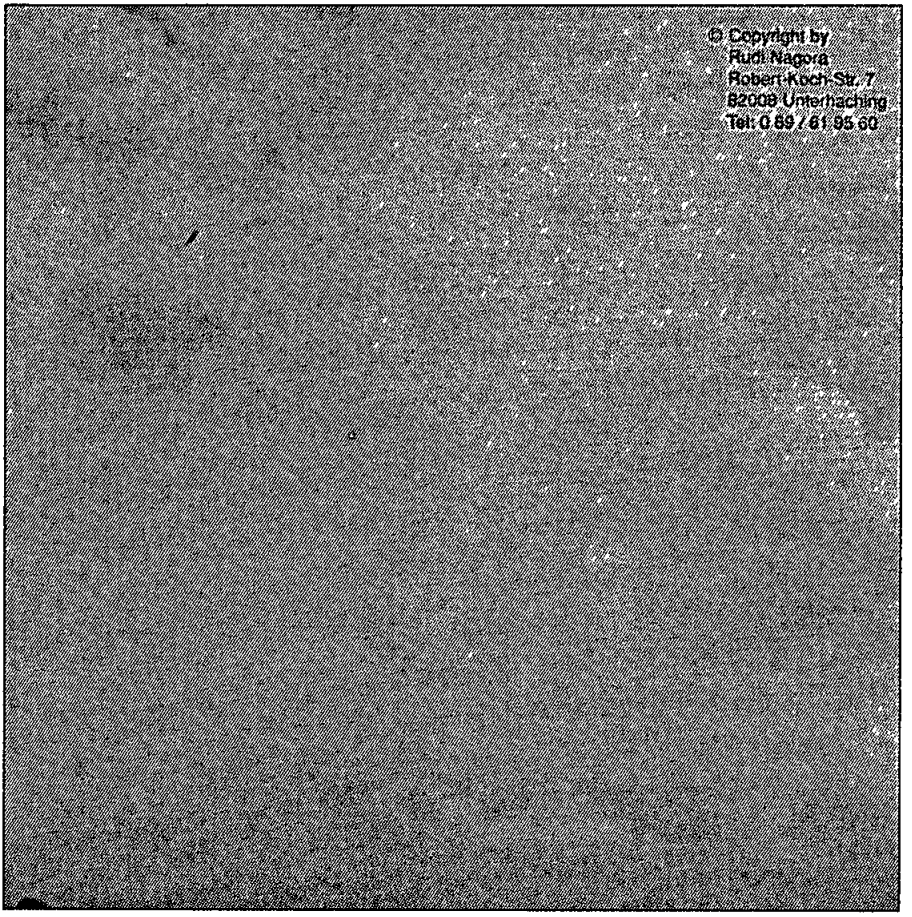

Figure 4 Frame 3/4 l/h = 3 80 major axis orientation = +40°
object's width on negative = 1 35mm

Figure 5 Frame 4/5 l/h = 2 03, major axis orientation = +88°,
object's width on negative = 1 60mm

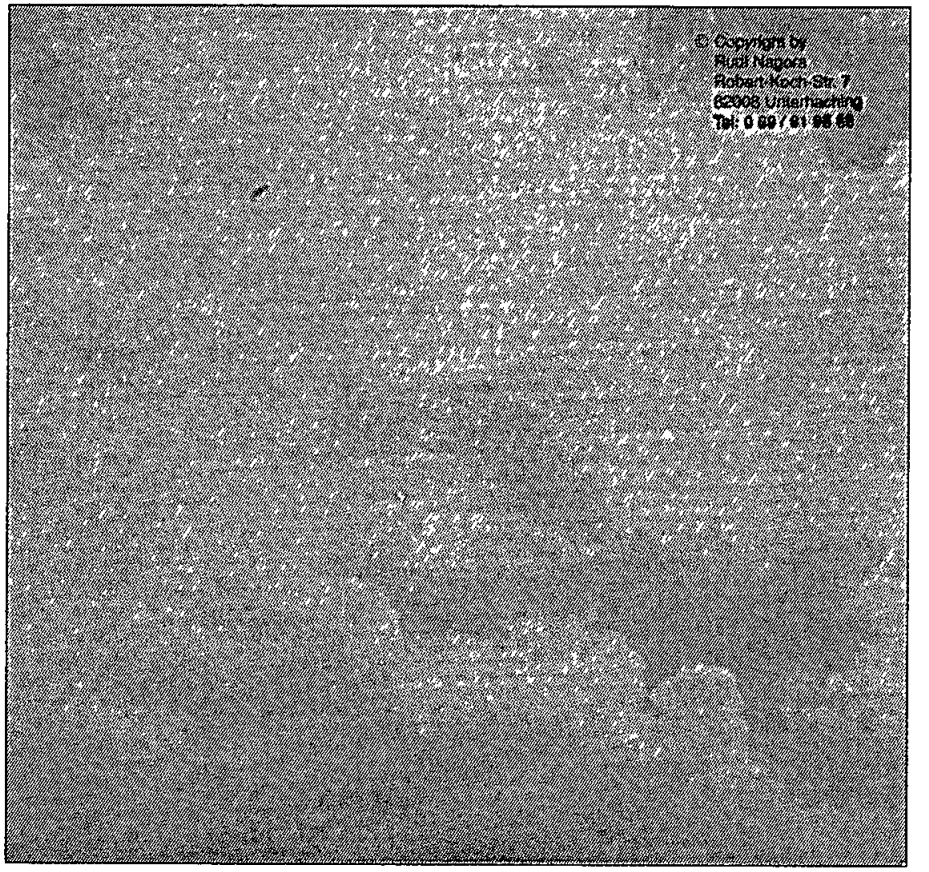

Figure 6 Frame 5/7 l/h = 3 09, major axis orientation = +46°, object's width on negative = 1 22mm

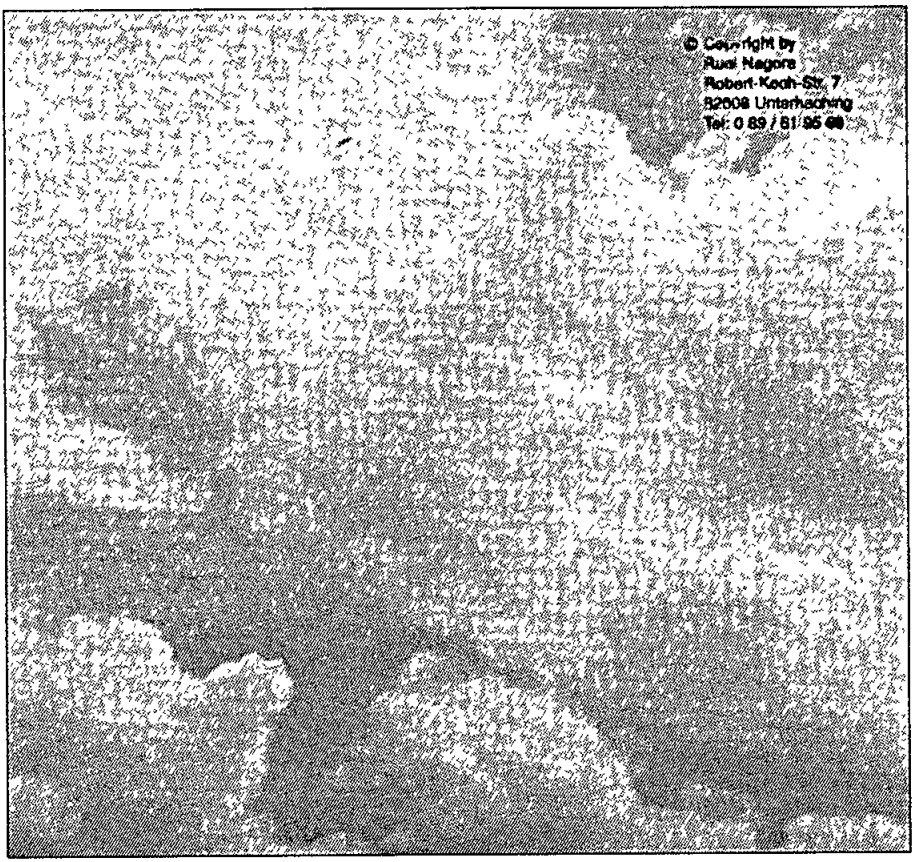

Figure 7 Frame 6/8 l/h = 4 46 major axis orientation = +52°, object's width on negative = 1 17mm

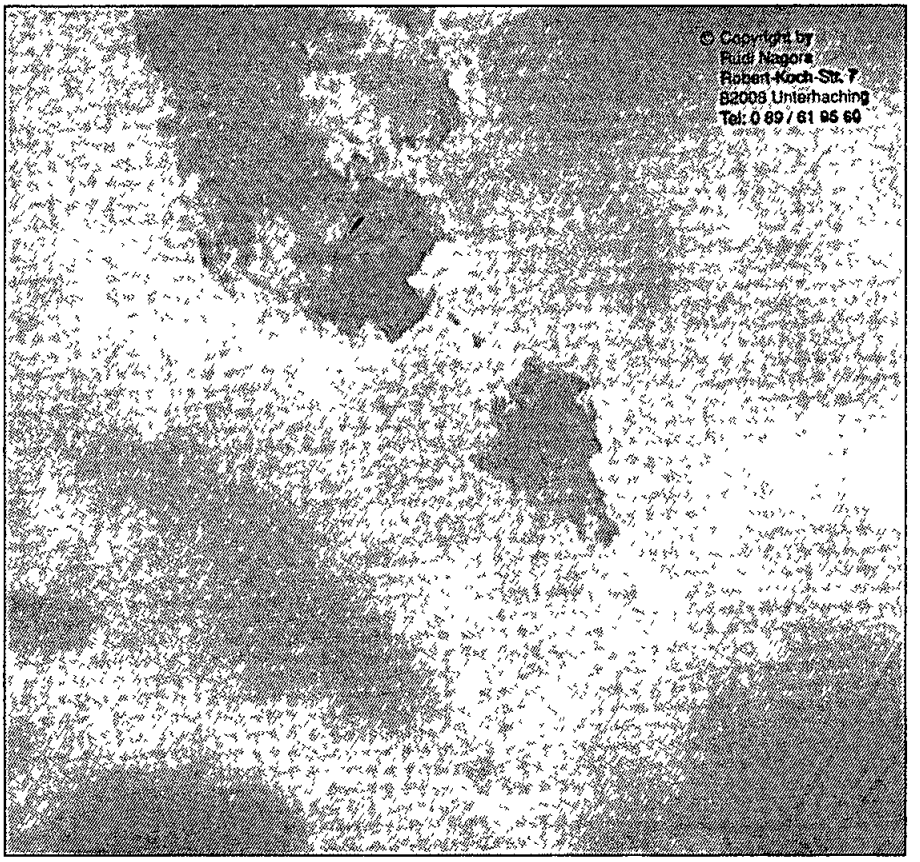

Figure 8 Frame 7/10 l/h = 5 71, major axis orientation = +32°
object's width on negative = 1 21mm

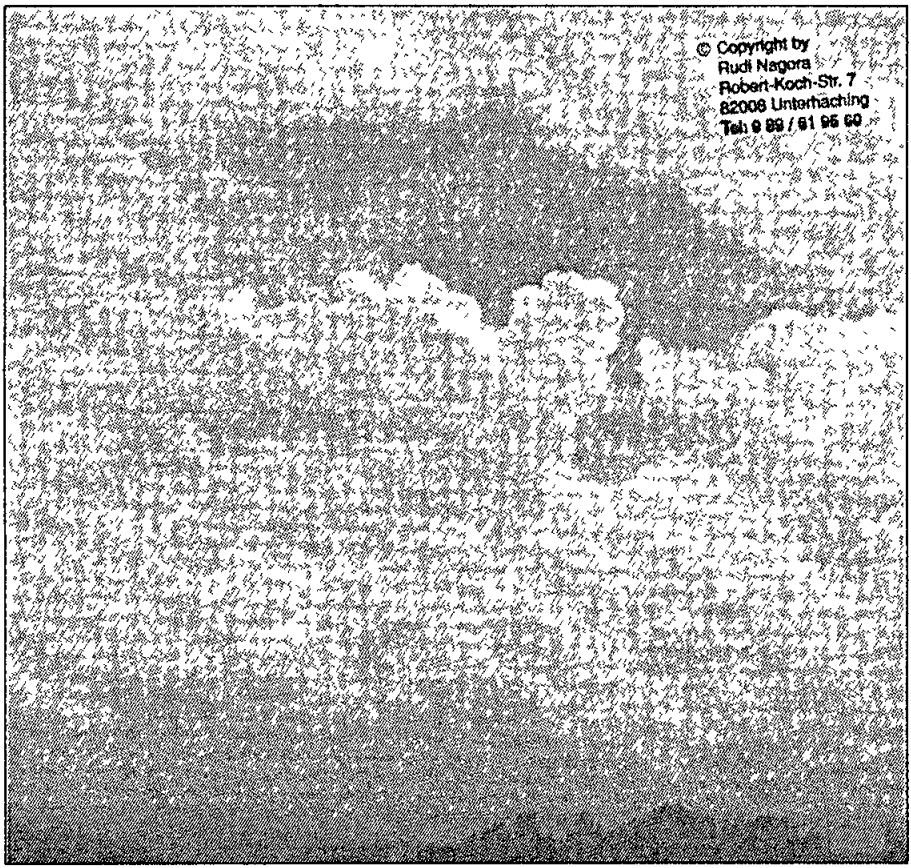

Figure 9 Frame 8/11 l/h = 1 52, major axis orientation = +46°,
object's width on negative = 0 77mm

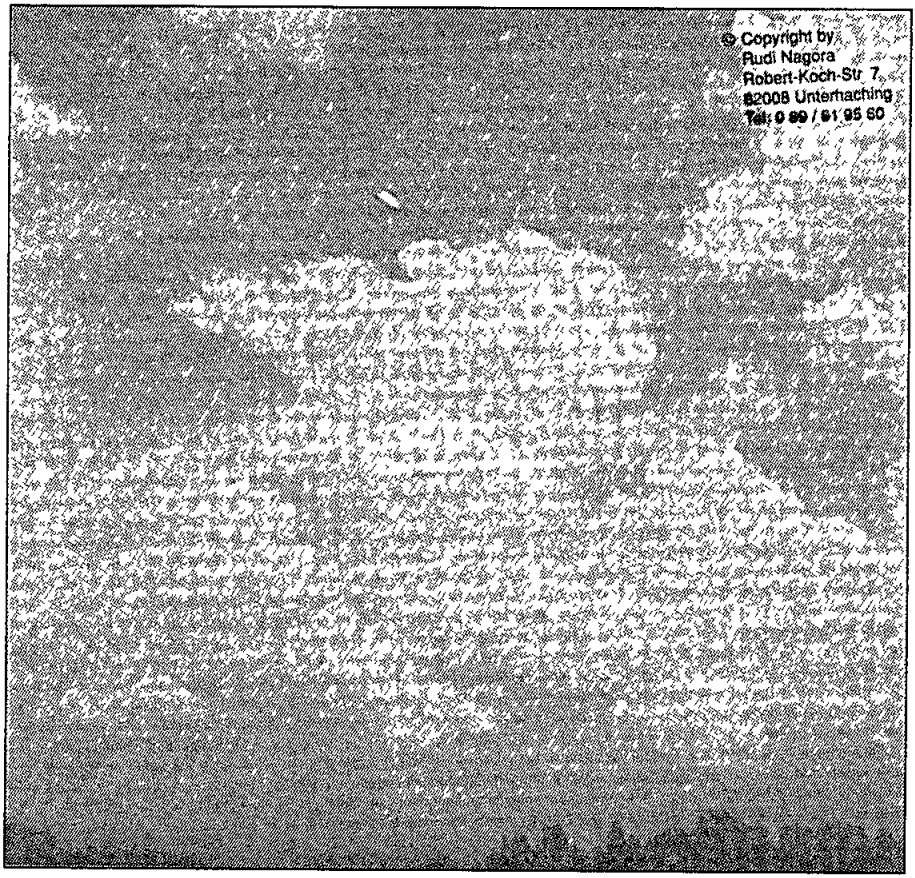

Figure 10 Frame 9/13 l/h = 2 66 major axis orientation = +94°, object's width on negative = 1 67mm

Figure 11 Frame 10/14 l/h = 2 71, major axis orientation = +96°, object's width on negative = 1 64mm

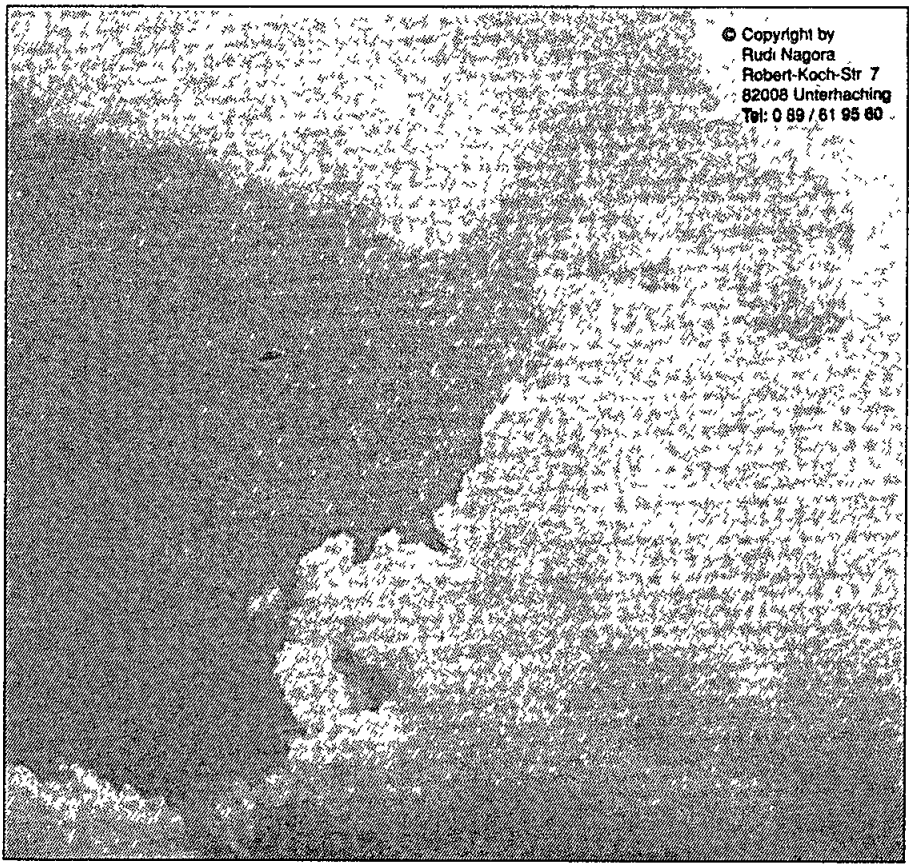

Figure 12 Frame 11/16 l/h = 3 57, major axis orientation = +80°, object's width on negative = 1 41mm

The last frame on the film (12/17) showed a meadow of medium-tall grass in the foreground, a narrow road on the right, and beside the road a row of trees A single power pole is also visible, supporting several electric power cables This frame is not included here because no clear UAP image could be found in it

Each original 120-format frame on the negative sheet measured 67mm high by 65mm wide so that the color enlargements the author received from von Ludwiger represented approximately a 3×-magnification factor (with only minor cropping). Each frame was then enlarged from the original negative by the magnification given in column 8 of Table 2 to permit more accurate length and height measurements

Table 2. UAP Image Dimensions at Optical Magnification Indicated

Consecutive image no	Frame no	Location of UAP[1] X	Y	Height (mm)	Length (mm)	Length/Ht ratio	Optical magnific	Approx[2] orientation (deg)	Comments
1	1	42 50	32 00	26 6	87 3	3 3	22 1	+85	Dark with lighter central spot
2	2	1 15	8 25	18 2	94 0	5 2	20 1	+86	Gray on left, lighter on right side
3	4	4 54	5 10	17 6	66 8	3 8	27 1	+40	Evenly dark gray
4	5	4 71	5 88	39 2	79 4	2 0	22 2	+88	3-D disc shape with dark and light sides
5	7	6 00	4 41	19 6	60 5	3 1	19 6	+46	90% dark with spot highlight on right side
6	8	8 00	3 16	13 0	58 0	4 5	22 1	+52	100% dark
7	10	8 20	5 10	10 5	60 0	5 7	21 8	+32	98% dark with spot highlight on right side
8	11	4 66	7 50	25 0	38 0	1 5	22 0	+46	UAP motion blur
9	13	8 77	4 51	31 0	82 4	2 7	22 3	+94	Bright top surface and dark thin line under
10	14	6 04	2 30	30 1	81 3	2 7	22 2	+96	Upper right surface illum , lower left dark
11	16	6 29	8 10	19 6	70 0	3 6	44 0	+80	3/5th dark (left) and 2/5th light (right)
12	17	(no UAP image Horizontal area shot with foreground grass, trees electrical power pole and electric lines visible)							

Notes 1 X refers to the distance (cm) from the left side of the enlarged full frame print to center of UAP Y refers to the distance (cm) from the top of the enlarged print to the center of UAP

2 Major orientation refers to the clockwise rotation from vertical (deg) relative to the major axis of the UAP image

3 The UAP length dimensions conform very closely with those found by Henke (1995b, pg 187, Col 2)

A careful comparison was made between scene details on each negative and the corresponding details on the above enlargements to determine the amount of cropping that had been done on the enlargements It was found that every frame had been cropped either at the top, the bottom or both by an average of 5% of the vertical dimension Only two frames (1/1 and 12/17) had been cropped on the right side by about 2% of their width, the reason for this cropping is not known Importantly, an examination of these cropped-out regions *on the original negatives* showed no evidence of hoaxing such as very thin suspension threads, a person or suspect shadow, a model, etc.

Camera and Lens and Operation

(1) Camera

The camera[6] was an Agfa model Click-I manufactured in the 1960s (Figure 13) This simple, inexpensive instrument employs a manually triggered, spring-loaded shutter with speeds from 1/30 to 1/48 second [7] Its weight is 8 2 ounces loaded with film Three aperture settings are possible using a metal lever on the left side of the lens housing Marked "full sun," "cloudy," and "yellow filter," each is positioned in front of the shutter manually The first has a diameter of approximately 5mm while the last two share a common diameter of about 6mm; the ratio of area between the two being 1·1 44 or about one *f* stop

Nagora said he used the full-sun aperture setting, i e , 19 6mm^2 area and never changed it. The camera's viewfinder provides a 48° wide by 44° high field of view with the viewer's eye located near enough to see the maximum available field of view. The entire viewfinder area was clear and free from any visible marks or other defects

I loaded a fresh roll of Agfa 120 positive color film into his camera and photographed sunlit cumulus cloud and bright-blue sky scenes with distant power lines also passing through the field These images were digitally scanned and compared with Nagora's exposures The results are discussed below

(2) Lens

The visible portion of the glass lens measured 1 8cm diameter and the limiting aperture located immediately behind the metal shutter measured 0 88cm diameter The measured distance from this limiting aperture (assumed to be very near the focal

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[6] Mr Nagora sent me his camera without hesitation various tests were made on it that are described in the text

[7] This second duration was measured using a photoresistive cell placed at the film plane and constant light source on the optic axis so as to illuminate the cell when the shutter was open The shutter was opened manually and the resulting waveform output was displayed and recorded on an oscilloscope (375 mv offset voltage 100 ma current) The shutter's "open-close" waveform is characterized by a smooth, almost linear open phase followed by a negatively decelerating closure phase lasting approximately twice as long Very nearly 95% of the total exposure occurred in 1/48th second

point of the lens) to the film plane was 4 38cm The lens focal length was approximately 43mm. Its approximate hyperfocal distance would be about 12–16 inches at *f*/9 5 and the angular width of an exposed frame is 42° arc.

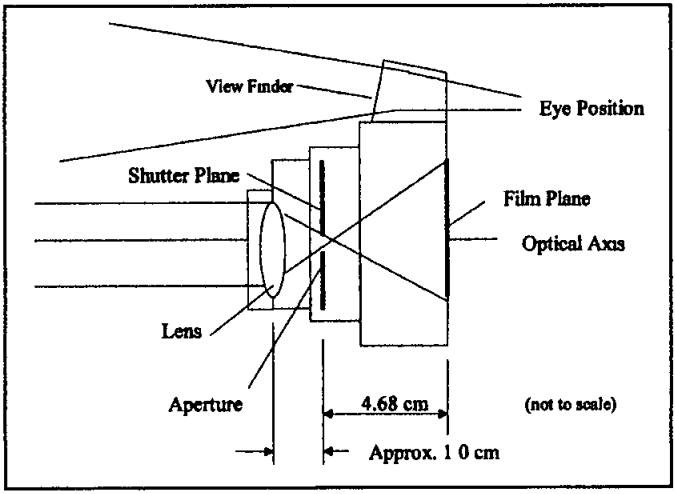

Figure 13 Vertical half section of the camera with selected dimensions

The resolution limit of the lens was checked using an RIT Alphanumeric Resolution Test Object (Rochester Institute of Technology, 1974) It was found to provide somewhat better than 8 4 line pairs per mm on the optical axis using the smallest diameter aperture under full sunlight illumination of the test pattern This relatively low measured resolution was probably due to slight camera motion during these exposures

Regarding the possibility of light leakage within the camera, opaque plastic walls separate the exposure area behind the lens from both the unexposed film and exposed film on each side of it There is a very small possibility of light leakage from the first to one or both of the adjacent compartments; however, if such light leakage did occur it is virtually impossible that it could have produced the highly structured and localized UAP images seen on this roll of film. light leakage typically produces a relatively even distribution of stray light across an edge of the just exposed frame which may taper off in density

Film and Processing

Nagora used Agfa 120-format color print negative stock (type CN-17) This film is 61 mm wide without sprocket holes and is pulled forward by a manually operated advance reel The "frame" (image area) measures 55mm wide by 55mm high The exposed roll of film was taken to a local drug store the day after the event

Condition of the Negatives

Both sides of each original negative[8] were carefully examined using a light microscope with back-illumination and low-angle front illumination using a magnification of from 5 to 30 power While they all showed numerous long, thin scratches and fingerprints from years of handling, and some transparent microscopic particles embedded in the emulsion there were no obvious, large, diffuse, or opaque emulsion flaws of any kind except one. A single, semitransparent (1 4mm diameter) circle was found on one frame located well away from the UAP image It was probably produced during wet chemical processing There is no doubt that Figures 2–12 are from the original negatives

Comparison of Optical Axis of the Viewfinder and Lens

It is of interest to note that in every one of Nagora's exposures the UAP image was in the upper-left hand quadrant of the frame, a fact also mentioned by Henke (1995b, p 183) When asked about this, Nagora said that he thought he had always centered the object approximately in the viewfinder but only upon looking at the developed photos did he notice this offset An attempt was made to find out why this might have happened and also to determine if a different photographer using his camera would obtain similar results when photographing something without preplanning.

The first step was to perform a careful analysis of the location of the viewfinder's field of view outline relative to the image at the film plane A rigid camera support was used to stabilize the camera some distance from a large, flat, white surface normal to its optical axis Colored dots were made on the surface around the visible edge of the viewfinder's field of view (V) Then, with the shutter held open and the camera back removed, a second set of different colored dots was added to the surface indicating the visual projection of the outline of the film (F) It was found that both the top and bottom edges of V and F were parallel and of equal (with very small) displacement while the left vertical edge of F was significantly nearer to the left vertical edge of V than was its right-hand edge In short, if the user wanted to center an object in the viewfinder's field there was a small alignment bias toward the left of the film's center by from 5 to 10% of the total width of the frame

For the second test I loaded Nagora's camera with a roll of ASA 200 color 120 film and asked my wife to take several outdoor photographs with it I said that I would identify the object she was to aim at and photograph on the count of two I called out slowly, "one," "two," "top of that tree" (I pointed it out to her clearly), "three." She wasn't told the reason for these tests She quickly raised the camera to her right eye (as Nagora had done), aimed it, and depressed the shutter latch We repeated this twice more and the developed prints showed a remarkable thing In each trial she imaged the target object in the upper-left quadrant of the photograph In fact it lay

[8] Nagora loaned all original negatives to the author on August 26, 1999, during a visit to Munich He said he was not willing to send them through the mail

very near the top edge of the frame in the second test Later she said that each target seemed to be centered in the viewfinder. The targets I selected were about 50–70 feet away in order that viewfinder parallax problems should have been minimal And so it is possible that Nagora was influenced unknowingly in a similar manner due to this small, lateral "misalignment" of the camera's viewfinder

Power Pole and Line Image Analysis Results

The electrical power pole visible in frame 1/1 was scanned at 2475 dpi where the four lines intersect it to determine if the sun's azimuthal position might be determined from a discriminable brightness gradient It was found that the left 1/5th of the pole's diameter was brighter than the remaining 4/5ths on the right, suggesting that the sun was positioned perhaps 15° left of the pole relative to a line connecting the camera and power pole Clouds clearly diffused the sunlight in this frame, however, and no high-contrast ground shadows are visible in frame 1/1.

The parallel power lines visible in the lower-right corner of frame 7/10 (Figure 8) were also digitally scanned at 800 dpi normal to their length to see how much edge blur from camera motion normal to the power lines there might be. These lines were thicker and darker than in any other of the frames. An almost sinusoidal luminance distribution was found for each power line with maximum darkness centered on each line Each appears to be slightly out of focus while the UAP is very dark and sharply defined suggesting no significant camera motion for this frame

Attempt to Reconstruct the UAP's Probable Flight Path

Despite the fact that Nagora said he was not able to take a new photograph every time the object stopped in a new location, it was felt important to try to reconstruct its relative flight path over time as Geigenthaler (1978) and Henke (1995b, p 184) also had done Each of the photographic enlargements was examined for corresponding detail from frame to frame. For example, frames 1/1, 3/4, 4/5. 8/11, 9/13, and 12/17 showed clear profiles of trees and/or distant hills. Frames 1/1, 3/4, 4/5, 7/10, 8/11, 9/13, 10/14, and 12/17 showed one or more sets of power lines These relatively fixed scene details provided valuable clues about the direction of the camera's optical axis both horizontally and vertically. The angle of diverging power lines in frame 1/1 permitted the spatially adjacent frame (7/10) to be located exactly although an estimated five minutes had gone by and the background clouds had changed shape to some degree In other instances, some cloud patterns in adjacent frames clearly represented the same formations (except for shape changes caused by the wind) Except for some rather minor differences, both Geigenthaler's and Henke's earlier work was independently replicated in this regard

The total angular width of this photographic collage is just over 180° The UAP traveled over a horizontal angle of about 150° arc Likewise, the overall height of the collage is approximately 85 8° arc The UAP moved over a total vertical angle of 46°

arc (without regard to frame order) Thus, the UAP traveled over one-half of the 360° of arc of the sky during this sighting Von Ludwiger (1998) estimated that the compass direction of the UAP in exposure 6/8 was approximately at due south.

Since each full frame subtends 48° (horiz) by 46° (vert) arc,[9] several important features of this photographic series may be determined Assuming that this collage is approximately accurate, the length (l) of each UAP image (measured from the 3 x color positive prints received from von Ludwiger, Figures 2–12) was converted to distance from the camera (i e , the third dimension of its flight path) assuming each of two fixed UAP lengths These values are presented in Table 3

Table 3. Calculated UAP Angular Width and Distance (Assumes 48° arc frame width)

Frame/Image No /No	Film Frame Width (mm)	Length of UAP (mm)	Calculated Angular Size of UAP (deg)	Calculated Distance to UAP-100 (ft)	Calculated Distance to UAP - 1(ft)
1/1	208 6	7 9	1 82	3,150	31 5
2/2	208 6	8 8	2 02	2.833	28 3
3/4	197 5	4 4	1 07	5 353	53 5
4/5	197 5	7 3	1 77	3,237	32 4
5/7	200 5	5 4	1 29	4.444	44 4
6/8	210 0	5 1	1 17	4.902	49 0
7/10	210 5	6 1	1 39	4.127	41 3
8/11	208 5	~3 8	~0 87	6.579	65 8
9/13	208 7	7 8	1 79	3,200	32 0
10/14	208 4	7 4	1 70	3.369	33 7
11/16	210 0	6 2	1 42	4,032	40 3
12/17	210 0	(no image)			

Note UAP—100 ft refers to an assumed 100 ft diameter "UAP "
UAP—1 ft refers to an assumed 12" diameter hubcap "UAP "

Angular Coordinates of Each UAP Image

An XY grid was laid over a UAP flight path diagram (Figure 14) to determine the azimuth and elevation angles of each UAP image They are summarized in Table 4. Since the azimuth angle of the camera's line of sight is not known, it is almost impossible to establish magnetic north, therefore, the azimuth angles are only relative (set to the center of frame 2/2) While the points are connected with straight lines this is only a convenience; Nagora emphasized that he was not able to obtain a photograph of the UAP each time it stopped to hover Note that frame 7/10 extends off the right

[9] Some cropping was done on each exposure A careful comparison between original negative and enlarged print showed that each frame was cropped differently In several cases useful foreground (stable reference) detail was cropped out Nevertheless, as stated earlier, an inspection of these cropped out areas on the original negatives showed no evidence of hoaxing

side of this drawing and is, therefore, drawn slightly smaller than the other frames In fact, as Column 2 of Table 3 indicates, frame 7/10 was as large (or larger) as the others Frame 1/1 was purposefully omitted in Figure 14 because it was very near (slightly left and lower than) 7/10. Frame 10/14 also was purposefully omitted in Figure 14 for reasons of clarity; being almost superimposed upon 9/13

Table 4. Azimuth and Elevation Angles for each UAP Image

Frame/Image No /No	Azimuth Angle to Right of 2/2 (deg)	Elevation Angle (deg)
2/2	0	38
3/4	57	27
4/5	78	22
5/7	81	43
6/8	108	50
7/10	148	67
8/11	81	20
9/13	90	27
10/14	78	33
11/16	105	45

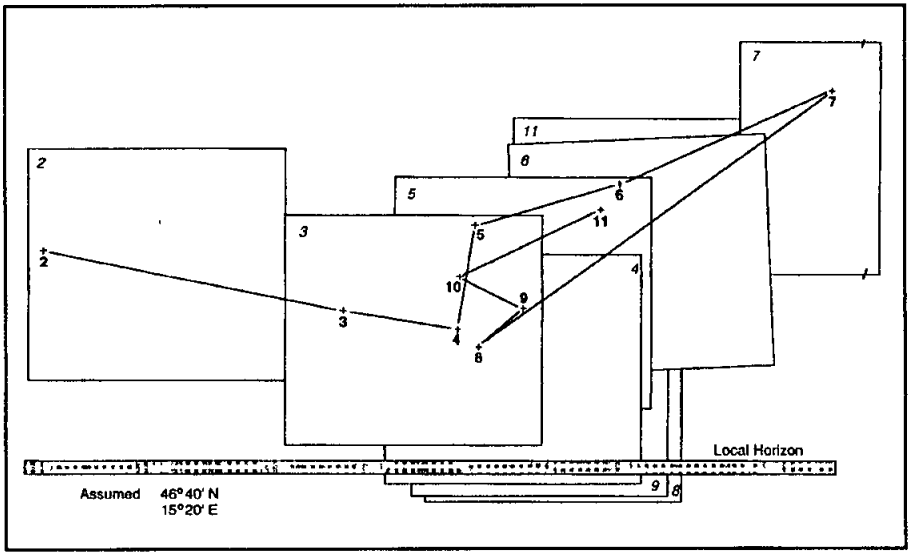

Figure 14 Vertical Plane Representation of Data of Table 4

Analysis of Discontinuous UAP Movements toward and away from Photographer

Using the azimuth plot of the photocollage and the calculated distance to the UAP from column 5, Table 3, a polar plot was constructed (Figure 15) showing that the UAP's movements alternated toward and away from the witness's location It is interesting to note that the UAP returned to almost the same location in the sky three times (namely, 4/5, 9/13, and 10/14) to within about 150 feet of the same location (depending upon its distance from the camera) for some unknown reason Since frames 9/13 and 10/14 were adjacent it is possible that Nagora snapped them close together in time before the UAP had time to move very far This finding tends to argue against the hubcap/model hoax hypothesis because of the difficulty in achieving this degree of positional accuracy of a tossed model into the sky twice in a row. Nevertheless, this is still possible The longest single flight segment was between frame 7/10 and 8/11

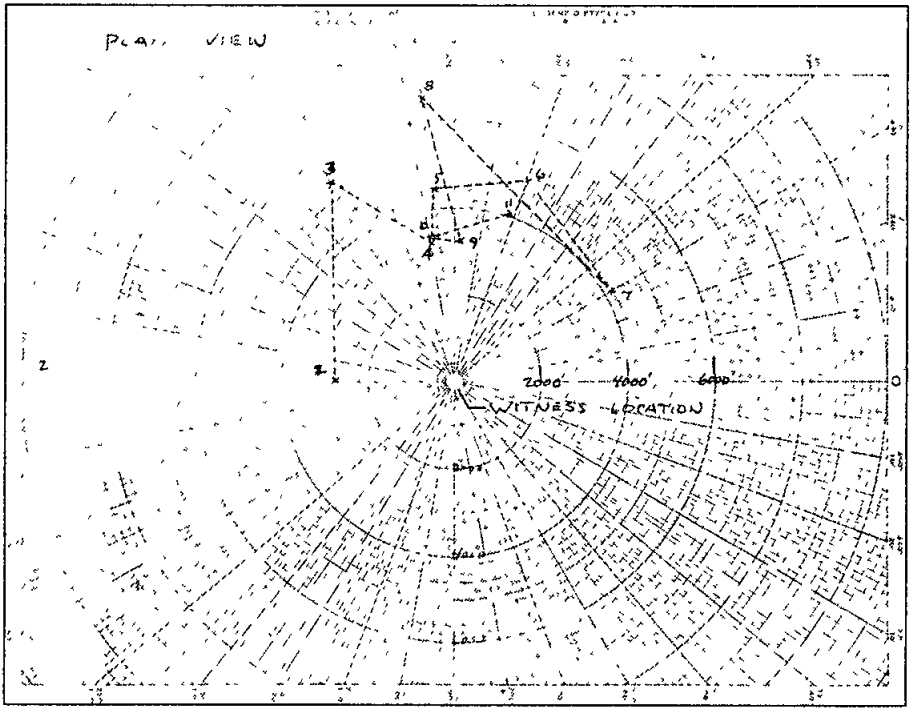

Figure 15 Polar coordinate plot of UAP movement in plan view assuming continuous frame-to-frame movement

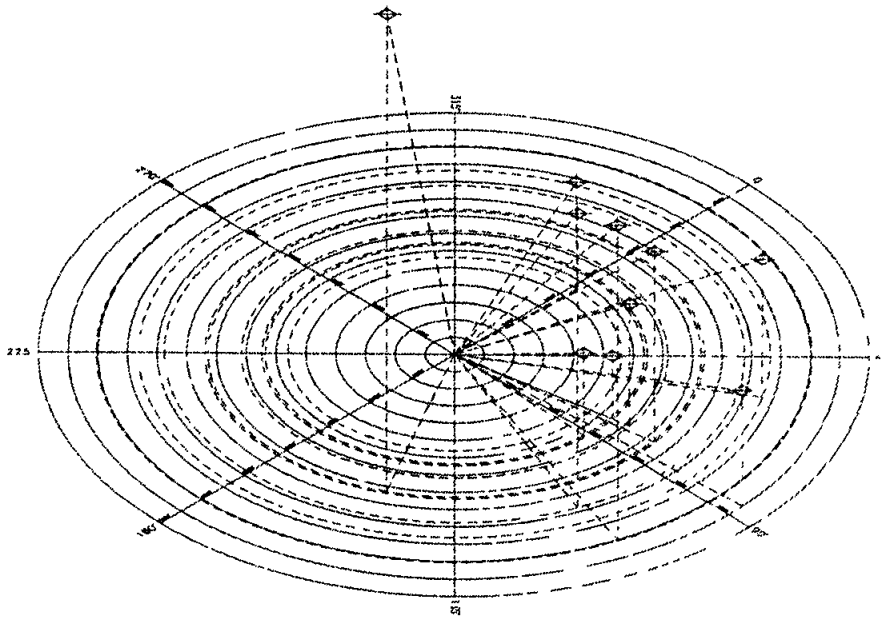

Figure 16 Three-dimensional model of UAP flight path

If the photographic collage made from all 11 frames (for example, Henke, 1965b, p 184) is wrapped around the surface of a hemisphere whose base represents the local horizontal plane, is centered at the witnesses' location, and the distances (D) from Table 3 are extended from the camera's position at the center of the hemisphere, an approximation of the three dimensional locations of the UAP over time can be generated from an arbitrary vantage point (Figure 16)

Analysis of UAP Gravitational Orientation

It is also of interest to study the gravitational orientation of the UAP in each photograph For a rigid body, the thickness of each UAP photographic image is positively correlated with its pitch and roll angles These calculations are only possible when the following parameters are known or assumed. (1) l/w ratio of the UAP image, (2) camera's elevation angle above the local horizontal, and (3) assumed 3-D geometrical shape of the UAP Fortunately, in frame 2/2 the bottom surface of the UAP is found to be flat and its l/h ratio = 5 2, meaning that the UAP is 5 2 times wider than it is thick (see the following section for more details on each image) Assuming that the UAP is a rigid, three-dimensional, symmetrical object, then frame 2/2 must show the UAP directly from the side[10] Knowing that the angular elevation of this UAP

[10] There are only two frames where the bottom of the UAP is flat (nos 2/2 and 7/10)

image above the horizontal is 38° arc indicates its gravitational orientation to be the same, 38° Thus, the orientation of 7/10 is equivalent to the angular elevation of the UAP itself or 67°. When both the top and bottom surface of the UAP is convexly curved it is more difficult to determine its pitch angle relative to the camera's line of sight

Additional Image Processing

Each original negative was photographically enlarged by a factor of approximately 20 times to produce UAP images of approximately the same size A Bessler enlarger (halogen lamp) with 63mm Nikon objective set was used at *f*/5 6 and 55-second exposure The paper used was Ilford medium weight IPRA 1MD Glossy (8" × 10") paper with an RA4 process These positive prints clearly showed individual film grains[11] with the maximum width of the UAP measuring from 27 to 47mm across Clearly, the UAP image was definitely not a random artifact produced by the film grains either in size or depth of color and luminous contrast These enlarged UAP images are reproduced in Figures 17–27 to illustrate the high amount of detail present in the image of the object

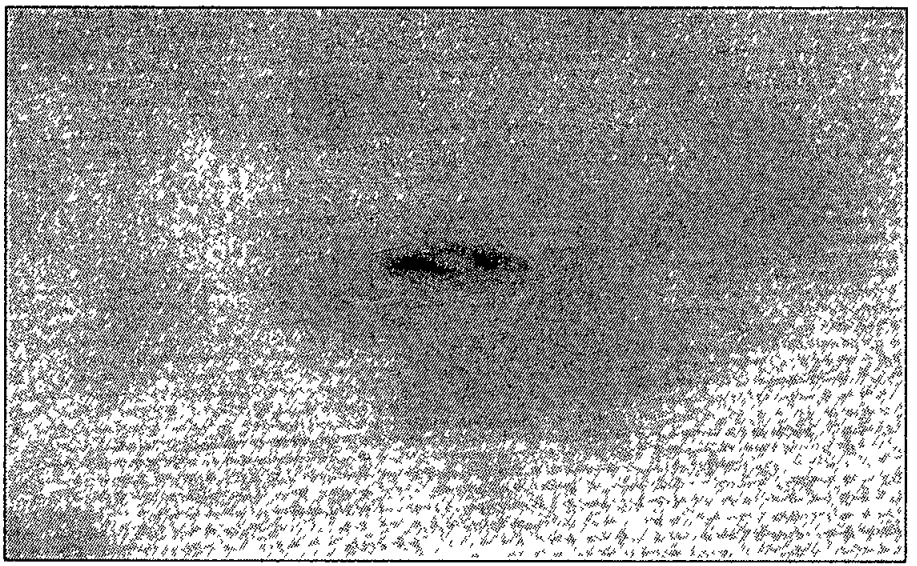

Figure 17 Photographic enlargement of Frame 1/1 Approx magnification = 221x

[11] Individual film grains at this magnification measured about 0 2 mm diameter

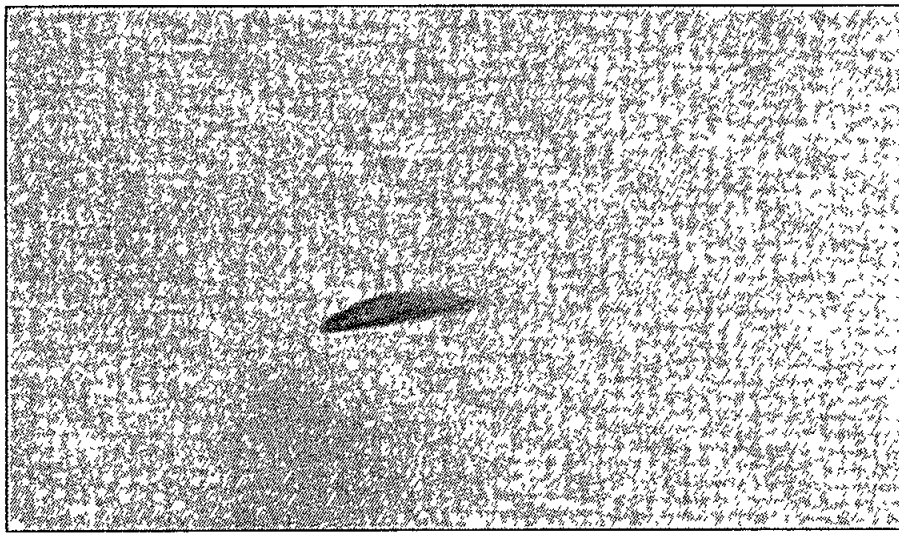

Figure 18 Photographic enlargement of Frame 2/2 Approx magnification = 20 1x

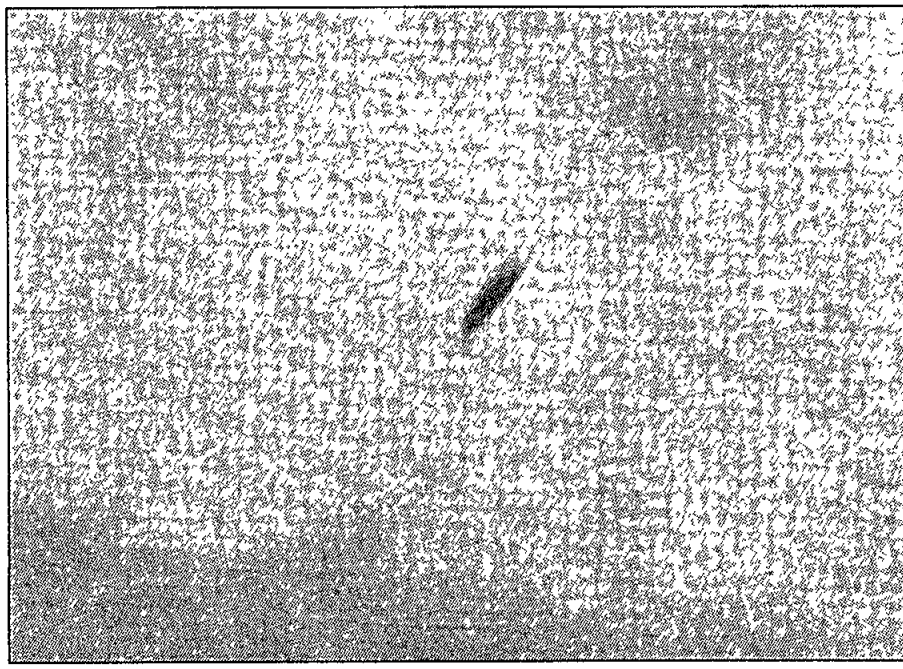

Figure 19 Photographic enlargement of Frame 3/4 Approx magnification = 27 1x

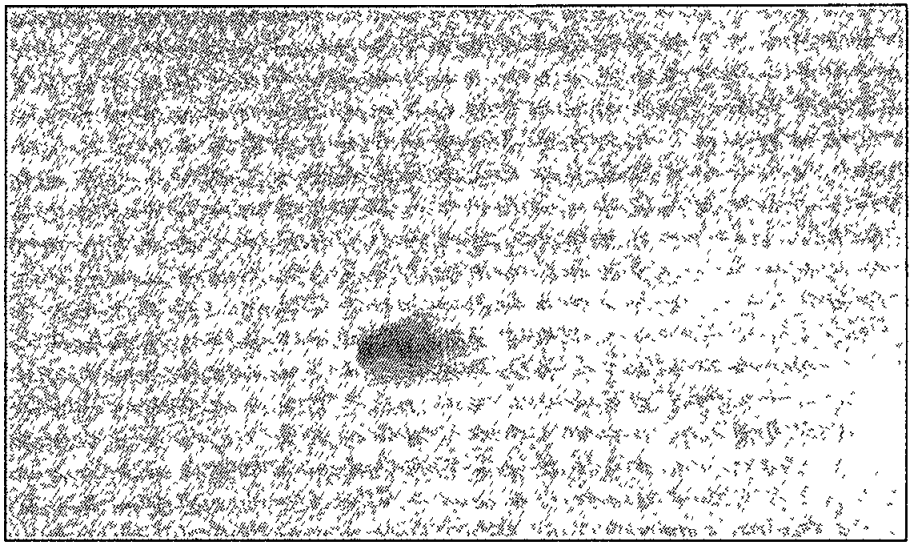

Figure 20 Photographic enlargement of Frame 4/5 Approx magnification = 22 2x

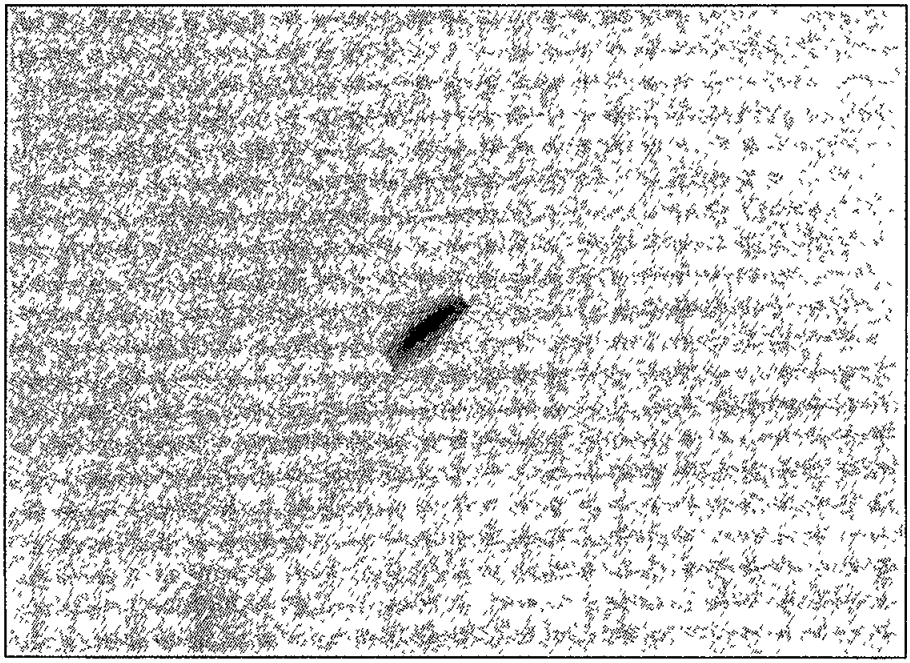

Figure 21 Photographic enlargement of Frame 5/7 Approx magnification = 19 6x

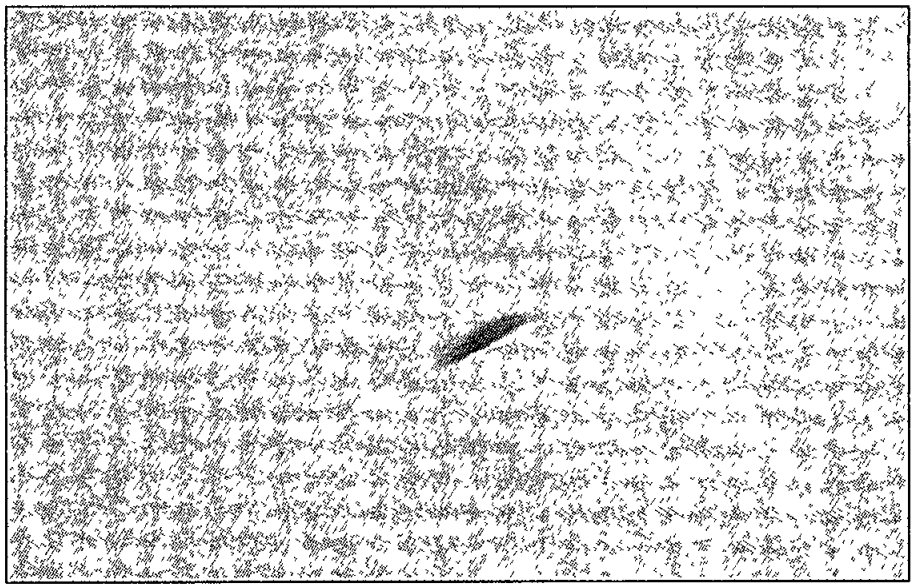

Figure 22 Photographic enlargement of Frame 6/8 Approx magnification = 22 1x

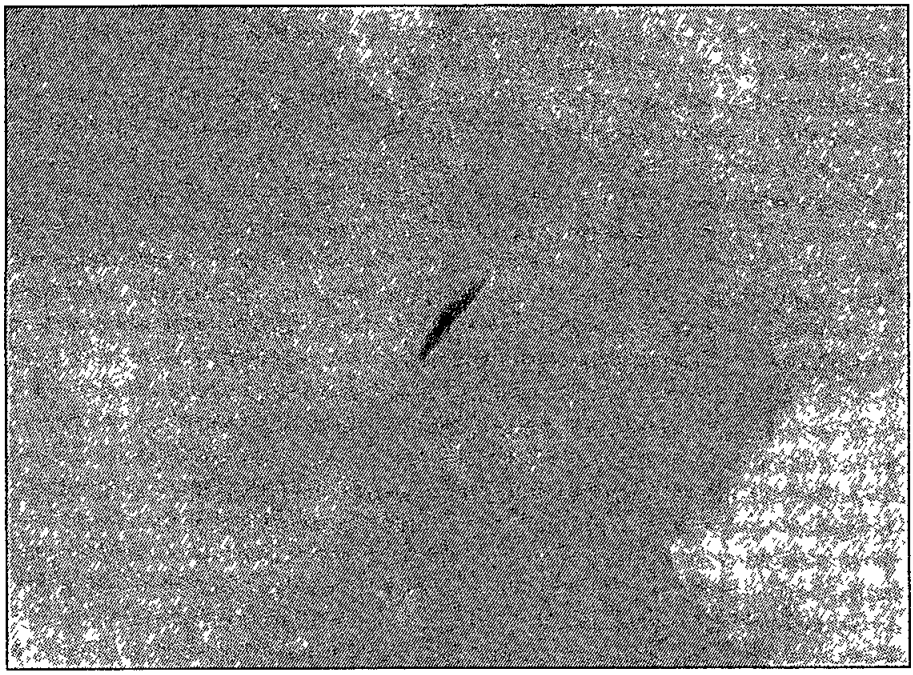

Figure 23 Photographic enlargement of Frame 7/10 Approx magnification = 21 8x

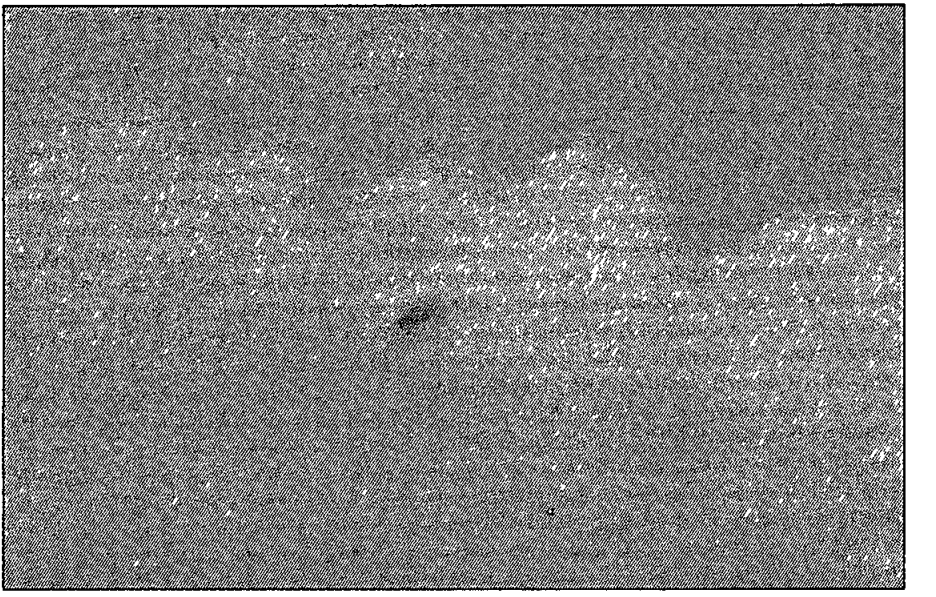

Figure 24 Photographic enlargement of Frame 8/11 Approx magnification = 22 0x

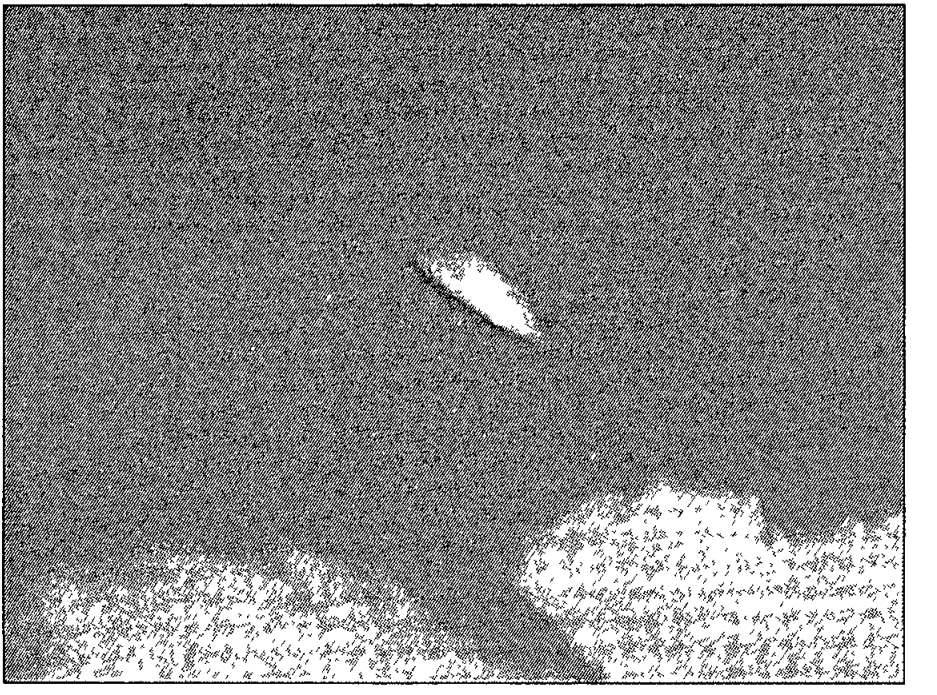

Figure 25 Photographic enlargement of Frame 9/13 Approx magnification = 22 3x

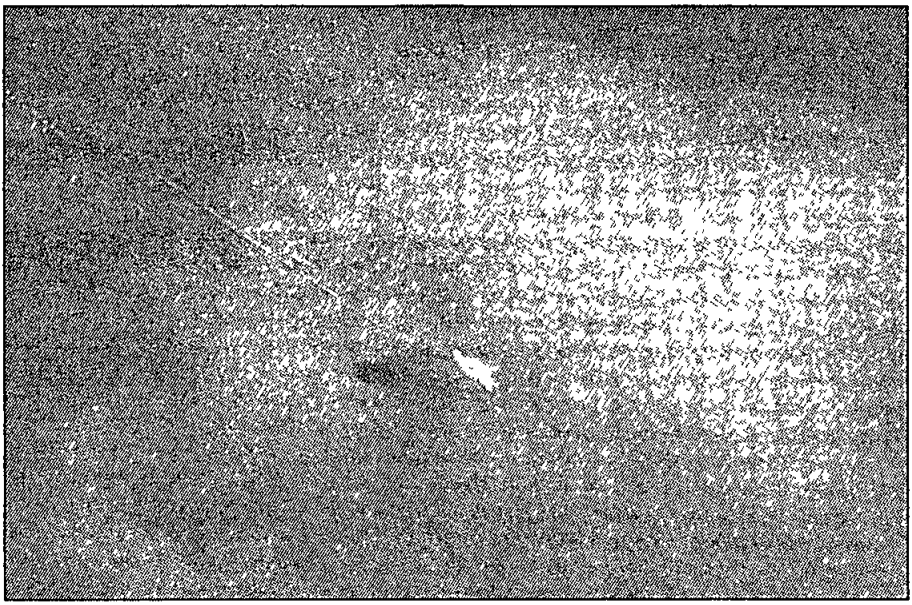

Figure 26 Photographic enlargement of Frame10/14 Approx magnification = 22 2x

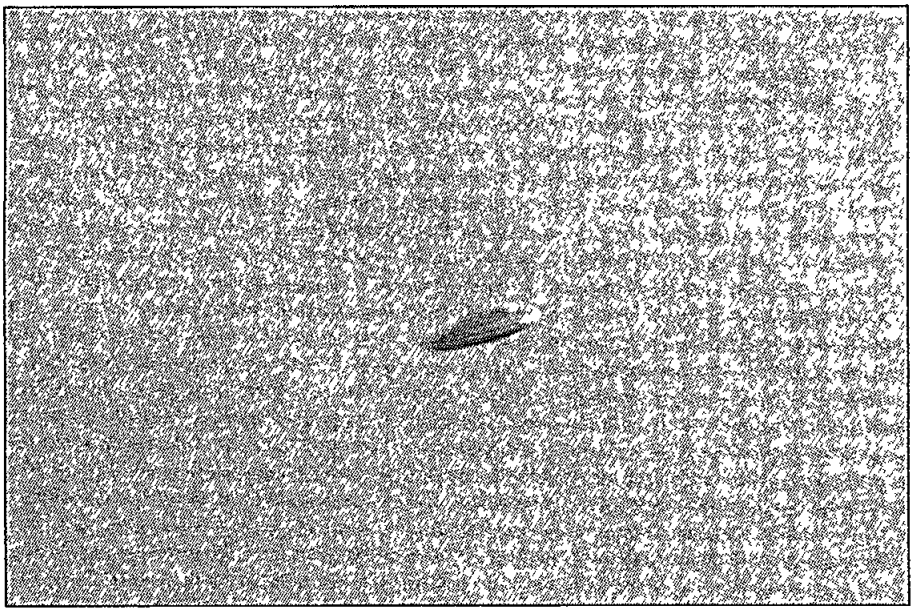

Figure 27 Photographic Enlargement of Frame 11/16 Approx magnification = 44 0x

DETERMINATION OF THE OBJECT'S GEOMETRIC OUTLINE

Minimum object silhouette The next measurements considered object orientation relative to the camera's line of sight and its length (l) to height (h) ratio (thickness) If the UAP is a rigid, three-dimensional, symmetrical object (e g , oblate spheroid that is round in planform), then its l/h ratio will change only with a change in pitch angle relative to the camera A sphere's l/h ratio will always be one regardless of pitch angle Careful examination of the enlargements in Figures 17–27 shows that the bottom surface of the UAP in images 2/2 and 7/10 was flat and therefore seen directly from the side yet at an unknown yaw angle The l/h ratio of all 11 images, ordered by radius of bottom surface curvature, is given in Table 5 Minor differences were found relative to values given in Table 1 The bottom surface curvature was determined graphically using greatly enlarged images of each photograph presented in Figures 17–27

Table 5. Ratio of UAP Images Ranked Ordered by Bottom Surface Curvature

Frame/Image No /No	l/h Ratio	Approx Radius (units arbitrary)	Comments relative to bottom surface and overall image
7/10	6 2	0	Bottom flat, dark body
2/2	5 5	0 0	Bottom flat, dark body
3/4	4 4	33 3	Very slight curve, 4/5th dark
6/8	4 5	15 5	Very slight curve, dark body
10/14	3 4	15 0	Very slight curve, 2/5th dark
5/7	3 1	14 9	Med curvature, 7/8th dark
1/1	3 3	14 8	Med curvature, 4/5th dark
9/13	2 7	14 8	Med curvature, 1/15th dark
11/16	3 6	14 5	Med curvature, dark line with blurred solar reflection
4/5[1]	2 0	10 5	Med curvature, 1/2 dark
8/11	~1 5	——	Blurred

Note 1 This image is enlarged due to obvious vertical motion blur which makes it difficult to establish its actual edges or curvature

These l/h ratios vary over 4 1 times (i e , 6 2/1 5) If the object is round in planform, Nagora never happened to photograph it, i e , *none* of these images show a round object An alternative explanation is that it is not round but has a different planform shape

A candidate, three-dimensional, rigid shape of the present unidentified object was reconstructed using a 3-D modeling software package[12] using geometric data from each of the eleven images This program's iterative solution was reached by integrat-

[12] The software used was CFD-GEOM running IRIX 6 5 operating system on an SGI minicomputer

ing the object's outline across all available frames; the data set was reduced to one "fundamental, best-fit" outline geometry, two views of which are presented in Figure 28

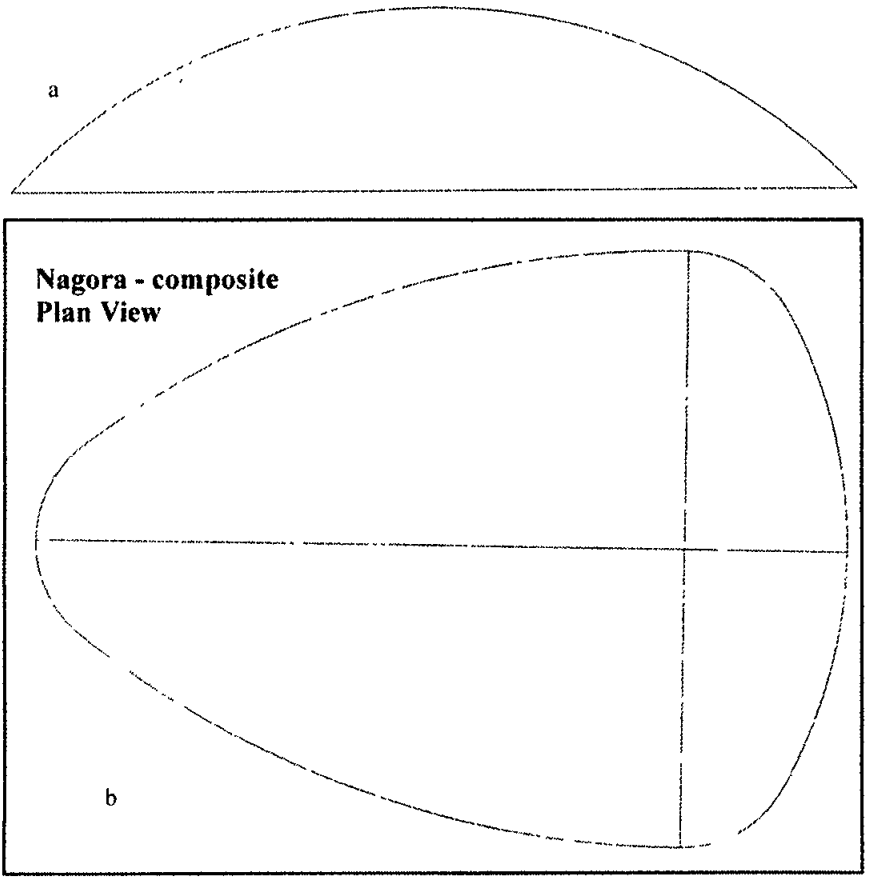

Figure 28 Fundamental object geometry (a) side view, (b) planform view

Discussion

This photographic case contains many of the now familiar elements of mystery and strangeness one finds in alleged UAP cases While there is no objective evidence of a conspiracy (e g., photo-lab double exposure or other deliberate hoax) it remains a possibility This and related questions simply cannot be answered without more information than is available Indeed, all of the available evidence must stand on its own merits Yet the internal consistency of object shape, surface reflections, orientation, background sky luminance and color, and other factors is high indeed and sup-

ports the proposition that a solid, three-dimensional object was photographed as claimed by Nagora

(1) The Issue of Witness Credibility

Henke's (1995a, p. 153–156) point-by-point comparison of Nagora's testimony surrounding these photographs given over the years raises important questions, some of which remain unanswered Most of his points address the issue of the overall credibility of the photographer While most of these differences of testimony over time may be only the result of a faulty memory or overzealousness, others may perhaps suggest deliberate deception (for example, absence or presence of other witnesses at the site, and a progressive increase in the estimated velocity of the object during later retellings of the story) Whether or not these differences prove their case sufficiently appears to depend on one's viewpoint about the existence and validity of UAP phenomenon in the first place

The author found Nagora to be a pleasant, relaxed, creative, and intelligent man who never has made any large amount of money from his photos and who appeared only to want to find out what the object was that he photographed

(2) The Fake/Model Hypothesis

One hypothesis proposed by skeptic Klaus Webner (1982) and repeated by Henke (1995b) is that Nagora made a small model (or used an automobile hubcap), tossed it up into the air many times, and took photographs of it in flight There are a number of reasons why I do not believe this hypothesis is supported by the evidence, in addition to another reason offered by von Ludwiger and Klein

First, while a 12-inch diameter hubcap could have been thrown into the air the distances shown in column six of Table 3, it is problematic that Nagora could have taken 11 consecutive photos of the object without some of the exposures showing some camera motion and/or object motion Only frames 4/5, and 8/11 show (minimal) object-edge blur while the background clouds show no blurred edges; Nagora did an exceptionally good job in stabilizing his camera during the majority of these exposures This finding supports Nagora's statement that he waited for the UAP to come to a stop before taking a picture

Second, the location of the UAP image is found to remain within the upper left-hand quadrant in every frame [13] The likelihood of someone achieving this degree of positional consistency soon after tossing a two- or three-pound hubcap into the air is small indeed Of course, the possibility still exists of an accomplice who threw a model into the air

Third, a reconstruction (discussed above, see Figure 28) of the probable three-dimensional geometry of the present object suggests that it was not round in planform (like a hubcap or Frisbee) but an isosceles triangle with broadly rounded cor-

[13] This matter was also discussed earlier in the section "Comparison of Optical Axis of the Viewfinder and Lens"

ners, a flat bottom, and gently convex upper side When a flat-bottomed object having this planform shape is thrown into the air with a rotational forward motion, similar to throwing a Frisbee, and its (slightly) convex surface remains on top like a wing it doesn't "fly" predictably (it wobbles due to alternating increase and decrease in lift) and can't stay aloft very long It is problematic if such a small model could travel the required distances given in Table 3 When Hesemann (1989, p 13) suggested that " not a single man-made object would be able to fly in such a way" he probably was referring to the alleged erratic, high-speed flight of the unidentified object rather than the possible flight of an airplane or small model

Von Ludwiger and Klein (1994) also suggested that if an accomplice had thrown a small model up into the air he would have been visible in at least some of these photos, which wasn't the case. Yet, as Eggesin (1999) states in this regard, the accomplice could have hidden somewhere out of sight such as in a nearby ravine. Whether or not an accomplice could achieve such positional repeatability of a tossed model in three frames (4/5, 9/13, and 10/14) is problematic indeed.

(3) The Photo-Lab Reconstruction Hypothesis

It is possible for a roll of film to be exposed in the field with natural backgrounds and then to use special procedures in the laboratory to add other (e g., UAP) details, objects, etc , and create a second negative that is claimed to be "original." However, this is both difficult and expensive, and a hoaxer would need to have an important reason for doing so Since Nagora took the photographs of the clouds seen, he would have had to be a participant in such a conspiracy There is literally no way to be certain that this hypothesis is not the correct one, this underscores one of the difficulties in studying so-called highly anomalous data

Conclusions

Based upon the present photographic analyses and findings of previous investigators several general observations and conclusions are offered First, a good deal of prior thoughtful research has been carried out on these photographs This research (in German) has provided a useful foundation of the main issues that deserved further study Among these issues were

(a) A deliberate hoax hypothesis wherein it was postulated that a small model was tossed into the air and photographed. I reject this hypothesis for two reasons; the first is based on my theoretical analysis of the most probable three-dimensional shape of the UAP Having available for analysis 11 photographs of the same object taken from different angles made it possible to model its fundamental three-dimensional shape, i e , a single shape that fit all of the individual outlines This analysis suggests that the UAP was not an oblate spheroid, flattened disc, or hubcap in planform but rather an isosceles triangle (in planform) with small radius corners, a flat bottom, and slightly convex top surface It is known that an object having such a three-dimensional shape would not fly any great distance with stability if tossed with a high rpm rotation like

that used in throwing a Frisbee. Of course, such a model could have been launched into the air by other means, but it would still exhibit unstable flight soon after launching. The second reason for rejecting the model hypothesis is based on the fact that the UAP was photographed in almost the same location in the sky three separate times, which seems difficult to do deliberately from the ground. The only other reasonable explanation that could support a model hypothesis would be a self-propelled, remotely controlled model. But even a powered model airplane engine might be expected not only to produce some object motion blur but also a heat trail behind the model. No object edge blur or heat trail was found on these photographs.

(b) The next issue raised by previous researchers had to do with Nagora's credibility. The various points that they raised in this regard were primarily circumstantial and, indeed, weakly supported. I personally found Nagora to be a bright, energetic, and credible man, indeed his friends and colleagues vouched for him, and he has not made any money from his photographs.

(c) My analysis explains another issue raised earlier concerning the consistently poor centering of the UAP within these photographs. I discovered that this is probably the result of a fixed angular offset between the camera's view finder and its photographic optical system.

My second conclusion is that if the witnesses' testimony is accurate, this UAP could not have been an astronomical body, man-made test aircraft, or balloon for various reasons. It remains unidentified.

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EXAMINATION OF THE TRAJECTORIES OF ANOMALOUS OBJECTS IMAGED DURING THE STS-48 SPACE SHUTTLE MISSION

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ABSTRACT On September 15 1991, during the STS-48 mission, a camera on the Space Shuttle Discovery captured a video sequence showing a number of objects moving through space NASA explained the objects as shuttle-generated debris particles Some of the objects exhibited abrupt changes in course at one point in time and NASA attributed this to the firing of one of the shuttle's attitude control rockets Scientists outside NASA later did detailed studies revealing characteristics of the objects' motions that they believed did not conform to NASA's debris hypothesis In a 1995 paper Mark Carlotto described a frame overlay method that he used to create a time-exposure image from this STS-48 video sequence The image revealed that some of the unidentified objects in the video followed curved trajectories indicating that they experienced prolonged periods of acceleration that cannot be attributed to the relatively brief firing of a shuttle thruster rocket acting on nearby debris particles This paper describes two possible mundane explanations for the path curvatures the forces generated by atmospheric drag and by pressures induced by the sublimation of ice particles The orientations of these force vectors relative to the video image plane were computed and compared quantitatively to the orientations of the object trajectories It is shown that several of the objects depart significantly from trajectories that could have been the result of the action of the natural forces considered leaving no apparent explanation for the objects' motions that would be consistent with the shuttle debris interpretation It is concluded that only the more extraordinary interpretations seem viable the objects were self-propelled by a force other than ice sublimation or were accelerated by the Earth s gravity at a sufficient distance from the shuttle for the resultant path curvature to be seen in the video

INTRODUCTION

On September 15, 1991, during Flight STS-48, a camera in the payload bay of the Space Shuttle *Discovery* recorded a video sequence near the limb of the Earth showing objects that seemed to behave in a highly unusual manner The video was taken while the camera was recording lightning storms on the night side of the Earth over the Indian Ocean and Southeast Asia

The objects began appearing about a minute after orbital sunrise against the background of the Earth's surface, which was still in darkness The objects appear at various locations, moving in different directions A little over a minute after the first

object appeared, a flash of light can be seen, and many of the objects seem to respond to it by moving in roughly the same direction—towards the upper right-hand corner of the field of view The angular sizes of the objects are near or below the camera's resolution, their true size, form, speed, and distance from the camera cannot be determined

After viewing the video, several scientists and engineers affiliated with NASA (1991) concluded the objects were small ice particles a short distance from the space shuttle They argued that the flash of light and the apparent reaction of the objects to it were the result of the firing of a vernier attitude-control thruster in the tail section of the shuttle

Papers were subsequently published disputing the NASA conclusion based on the motions of the objects, prompting further arguments in support of the NASA position. Kasher (1995/1996) presented several arguments against a causal link between shuttle thruster firings and the objects' motions, based primarily on his analysis of the objects' behavior over the brief span of time in which they were observed to make their most abrupt changes in course after the light-flash event

The subject of this paper is a critical examination of one of the observations first reported by Carlotto (1995) He showed that several of the objects exhibited trajectories with small but noticeable curvatures, contrary to what would generally be expected for small debris particles co-orbiting with a spacecraft This curvature suggests that the objects may have been self-propelled or that the Earth's gravitational field was accelerating them The latter explanation would require the objects to be very far away from the orbiter

The curving trajectories of these objects do seem remarkable There are, however, explanations for the observed path curvatures that are at least qualitatively consistent with the debris hypothesis If the extraordinary implications of the path curvatures are to be accepted, these "mundane" possibilities must first be carefully considered A detailed quantitative evaluation of their plausibility is presented here

A View of Object Trajectories over Two Minutes

The video sequence was taken by a camera on the aft bulkhead of the space shuttle's cargo bay The camera was looking backward along its orbital track and imaging the Earth's surface near the horizon Frames from the video were digitized to a size of 640 by 480 pixels Measurements of the distances between stars identified in the video indicated that the vertical width of the camera's field of view was 40 degrees by 30 5 degrees The first of the objects began appearing in the video about a minute after orbital sunrise over a period of about 2 minutes

Figure 1 shows a time-exposure composite of video frames separated by 1 second over the time period in which the objects appeared Some objects entered the field of view from the edges of the video frame at various points but at least 8 of them appeared within the frame The objects that moved on curved trajectories are in the rectangular areas labeled "A" and "B" in the image

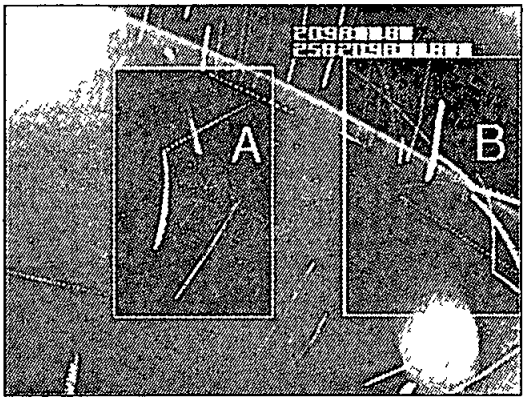

Fig 1 Time exposure composite of entire field of view in the STS-48 video using video frames spaced 1 second apart The two rectangular areas contain objects that move on curved trajectories

The light flash originates in the upper left of the video and occurs about midway through the 2-minute period of time represented by this image. The positions in the video frame where several of the objects are seen to undergo sharp changes in course mark their positions at the time of the light flash

Figure 2 shows a closer view of the area labeled "B" in Figure 1 The positions of objects M5 and M6 indicated by the black arrows clearly show that they both responded to the light flash with radical changes in course, but not by simply changing their direction Both objects were originally on linear paths At the time of the light

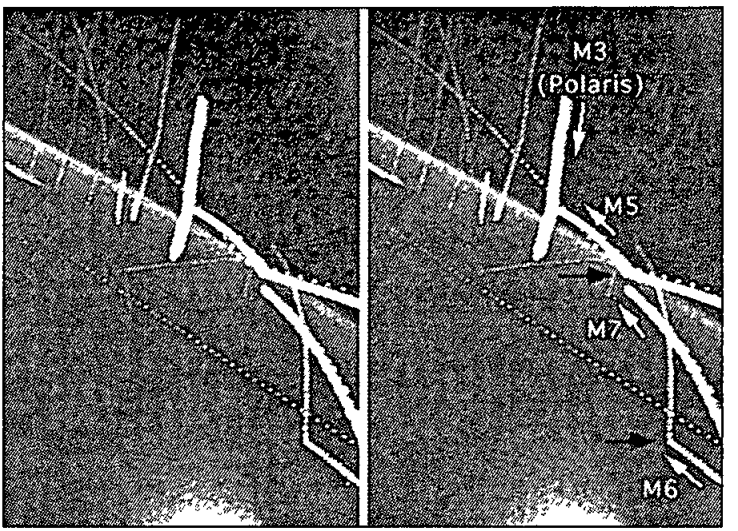

Fig 2 Enlargement of Area B in Fig 1 The objects labeled M5, M6, and M7 were three objects with curved paths that Carlotto discovered The labels are the designations assigned by Carlotto (1995) White arrows indicate directions of the objects' motions Black arrows indicate positions of Objects M5 and M6 at the time of the light flash Object M7 entered the field of view after the light flash

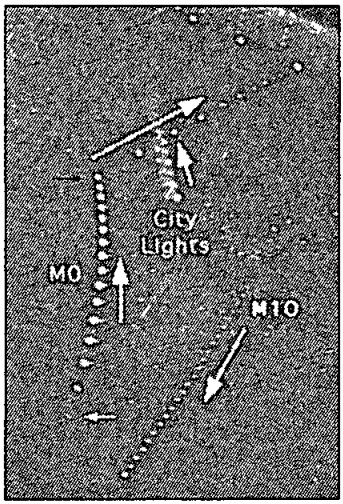

Fig 3 Enlargement of Area A in Fig 1 showing the curvature in Object M0's trajectory The small white arrow indicates the position at which the object first appears The black arrow shows its position near the moment of the light flash Large arrows show directions of motion of M0, city lights, and a second object designated M10 that appeared after M0 and moving in the opposite direction Time interval between overlaid frames is 5 seconds

flash, Object M5 immediately alters its original linear course and follows a curved trajectory until the camera pans down toward the cargo bay and the objects are no longer in view—a period of over one minute The shuttle's L5D vernier thruster, which has been suggested as the cause of the objects' abrupt changes in course, fired for only 1 2 seconds If M5 were a debris particle and the thruster was responsible for its path curvature, the curved segment of its path could exist for only 1 2 seconds

At the moment of the light flash, Object M6 alters its course from one linear trajectory (from lower right toward the upper left) to another This change in course puts M6 on a trajectory that at first is directed almost straight up but then curves to the left after about 15 seconds

The first object to appear in the STS-48 video sequence, designated M0 by Carlotto, also follows a strongly curved path as shown in Figure 3 A second object, designated here as M10, follows a nearly linear path with a slight bend near the time of the light flash

The changes from linear to curvilinear motion of Objects M5 and M6 are among the characteristics suggesting that neither of the proposed mundane explanations for the objects' curved trajectories is applicable Unless both objects were already aligned with the vectors of forces acting in the vicinity of the shuttle, it would seem that there should have been some curvature in the objects' paths apparent prior to the flash as well as after their course change This argument will be developed in the more detailed critiques given subsequently.

Natural Forces Acting on Objects in the Near-Earth Space Environment

Some real physical forces were acting on the objects to deflect them from linear trajectories But even in the near vacuum of outer space, natural forces do exist that

could influence the motions of small debris particles near the space shuttle and cause them to move on curved rather than straight-line paths The two most likely suspects by far are

1 *Sublimation* Assuming the objects are ice particles, they could be accelerated away from the sun by the pressure of ice sublimating into vapor from the particles' own surfaces heated by exposure to sunlight in the vacuum of space
2 *Atmospheric drag* The tenuous atmosphere can deflect small debris particles in much the same way that the wind generated by a moving car will affect the trajectory of a piece of paper thrown from the car

Either of these forces could cause small debris particles to follow curved trajectories Both forces could also act together, assuming the debris particles are composed of ice.

Sublimation As a Propulsive Force

Water ice sublimates (transforms directly from solid to vapor) in a vacuum at a temperature of −73° C Whether or not ice debris from the shuttle would have actually sublimated is not known The equilibrium temperature of ice particles exposed to sunlight is largely dependent on the concentration of heat-absorbing impurities in the ice, a factor that is difficult to estimate and could vary greatly between different debris particles from different sources Some ice particles in the shuttle's vicinity are not necessarily even composed of water Frozen droplets of leaking propellants from the shuttle's reaction-control thrusters could also be sources of ice

What can be determined is the direction that sublimation vapor pressures would have pushed any ice particles that might have appeared in the video. If the objects were ice particles, their sunward surfaces would have been heated to a higher temperature than surfaces facing away from the sun The pressure generated by the ejection of any sublimated water vapor from the particle surfaces would have been greater on the sunward side, resulting in a net force deflecting the objects in the direction opposite to the sun

While a search of the available literature revealed no reported observations of the motions of small ice particles near a spacecraft being affected by sublimation, it seems to be a possibility that should not be ignored

Atmospheric Drag

While the Earth's atmosphere is extremely tenuous at the space shuttle's orbital altitude, it does exist At the high velocities necessary to achieve orbit, the drag forces are small but significant enough to have a measurable effect even on the motion of the space shuttle itself over a period of a several hours Early in the shuttle program, NASA scientists found evidence that atmospheric drag could indeed affect the motion of shuttle debris particles, causing them to follow curved trajectories

NASA wanted to establish the nature and quantities of shuttle-generated sources of

contamination that might interfere with scientific instruments For that purpose, several shuttle flights carried an instrument package called the Induced Environment Contamination Monitor (IECM). One of the instruments was a stereo camera that took time exposures to record the sizes, distances, and motions of shuttle debris particles over the cargo bay. Clifton and Benson (1988) reported that some of the debris particles photographed followed curved paths as shown in Figure 4

In their report, they concluded that:

> The curvature of particle tracks is not due to shuttle rotation, but appears to be caused by the particles aligning themselves with the velocity vector of the Orbiter due to drag from the residual atmosphere

The curved tracks were usually seen early in the missions before most of the debris had been "blown" away from the shuttle by the atmospheric drag The STS-2 orbital altitude at 290 km was more than 250 km lower than the 572-km altitude of the Discovery orbiter during the STS-48 mission, so atmospheric drag was probably a more significant factor in the earlier mission However, the effects of the tenuous atmosphere on small debris particles cannot be discounted, even at the high altitude of the STS-48 mission, because the density and size of the objects are unknown

Constraints on Parabolic Trajectories

At this point, we have two possible forces that might be at work in the space environment near the shuttle and that might have been responsible for the seemingly

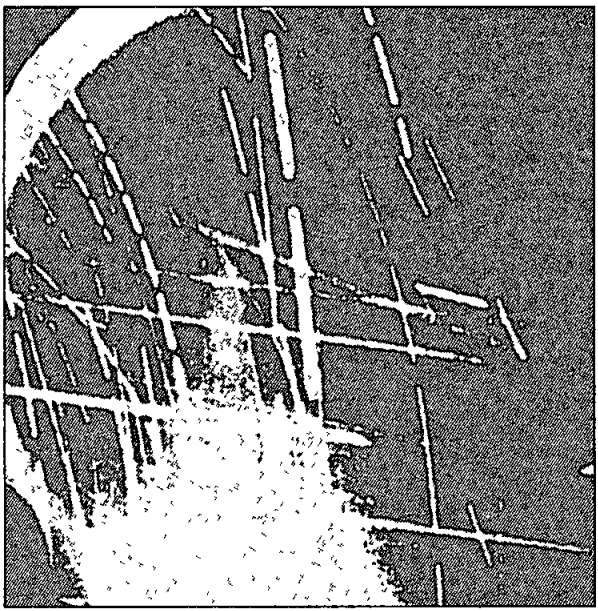

Fig 4 Time exposure photograph of debris tracks from Clifton and Benson (1988) The photograph was taken by the IECM camera during the STS-2 mission in 1981 The gaps in the particle tracks were created by a "chopper" mechanism to mark regular time intervals of one second

unusual curvatures of the objects' paths, but no good idea about the magnitudes or direction of these forces While the magnitudes of possible drag and sublimation forces may be unknowable, the information available from NASA was sufficient to determine the directions in which both forces must have acted relative to the video frames A cursory examination of the video shows that the space shuttle was moving toward the lower right with respect to the video frame, so atmospheric drag forces would tend to deflect small particles toward the upper left The lens flare in the upper left corner indicates that the sun was to the lower right, so sublimation pressures would also tend to deflect particles towards the upper left if they were made of ice

All of the most obvious path curvatures in the video do in fact show a deflection toward the upper left with respect to the video frame (Figure 2) This could be seen as an indication that the objects' paths were being influenced by sublimation pressures or atmospheric drag Either of these mundane explanations would be preferred according to the parsimony heuristic after a cursory qualitative inspection

But visually inspecting the video only tells us that the two force vectors would tend to push small debris particles in a direction somewhere in the upper-left quadrant of the image. A range of possible directions over 90° leaves a rather large margin of uncertainty! A more detailed analysis of the information I have obtained on the geometry of the possible sublimation and drag forces relative to the STS-48 video frame shows that the prosaic explanations fail the parsimony heuristic To understand why, it is first necessary to understand the relationship between the shape and orientation of an object's path to the direction in which a force is acting (the magnitude and direction together comprise a vector)

When an object is subjected to a constant force, its velocity component in the direction of the force vector increases at a constant rate while the velocity component perpendicular to the force vector remains constant As illustrated in Figure 5, the result is that the object follows a parabolic path

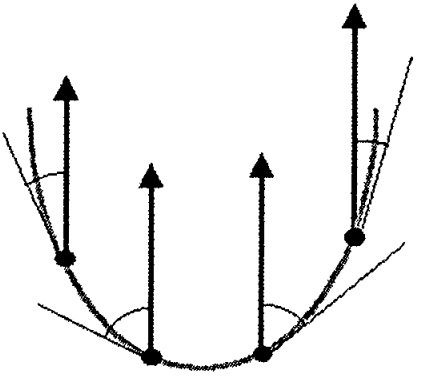

Fig 5 Illustration of a parabolic path showing the relationship between the acute angle between the tangent to the object's path (gray) and the direction of the accelerating force (black arrows) The angle is indicated by the arcs between the force vector and the path tangent lines The angle always decreases in the direction of the force vector

Regardless of the magnitudes of the forces and the mass and velocity of the object, there are two important constraints on the shape of a parabolic trajectory that must be obeyed

1. When traversing the object's path starting at the point where the path line and force vector are perpendicular to each other, the acute angle between a tangent to the path line and the force vector decreases monotonically. This is so regardless of the object's position, speed, or direction when first observed These angles are indicated by the arcs drawn between the path tangents and the force vector in Figure 5.
2 The path curvature decreases as the path direction converges on the force vector Eventually, the path becomes nearly linear and is aligned with the force vector.

If an object's path is linear over the time it is observed, then no conclusion can be reached about the influence of the force on the object, since the mass and speed of the object might be too great for the path curvature to be noticeable But if the observed path curvature violates either of these two constraints, the suspected force vector can be conclusively ruled out as the cause of the curvature.

These constraints also apply regardless of the angle of the force vector relative to the image plane and angle of the path plane relative to the image plane Tilting and rotating the image of Figure 5 changes the apparent curvature in an orthogonal projection on the image plane, but the resulting curve is still a parabola However, there may be significant distortions from a parabolic curvature in an image caused by perspective that have to be taken into account, as described subsequently

Quantitative Force Vector Orientations

To determine if the objects' paths satisfied or violated the constraints of parabolic form, it was necessary to acquire precise quantitative values for the directions of the two force vectors relative to the video frame To do this, the first task was to find the camera's pointing direction relative to the celestial sphere The camera's pointing direction is the direction the camera is looking at the exact center of the image (the "principal point") and is the direction that is perpendicular to the plane of the image (the "plane normal") The details of the procedure for computing the celestial coordinates of the principal point of a video frame are given in Appendix A

The next task was computing the directions of the force vectors relative to the celestial sphere Then, using the coordinates of the image principal point and the coordinates of the force vectors, the orientations of the force vectors relative to the image frame could be determined The details of the procedure for determining the vector orientations on the celestial sphere and relative to the image frame are given in Appendix B

The celestial coordinate system is illustrated in Figure 6. It is similar to the more familiar reference system of geographic latitude and longitudes But celestial longi-

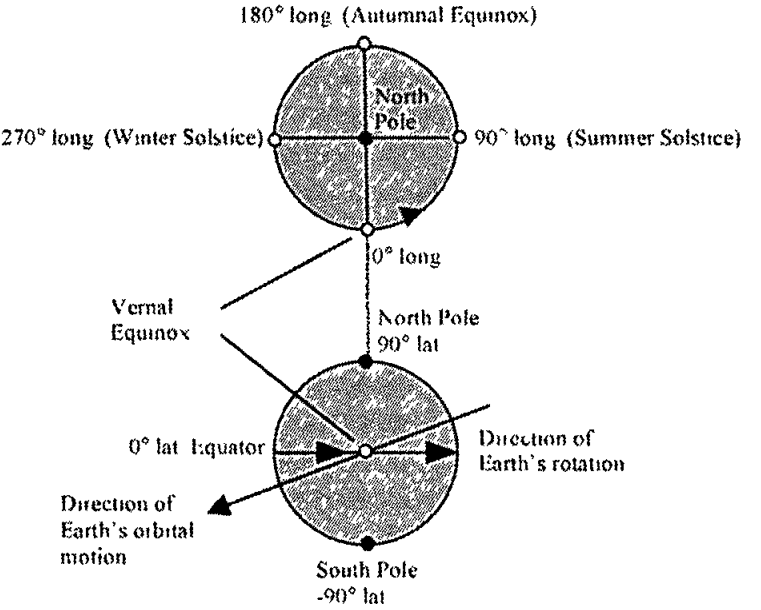

Fig 6 Diagram illustrating the celestial coordinate system Top view is looking down at the Earth's North Pole Lower view is looking at the Earth from the direction of the sun when it is at the vernal equinox position

tude (referred to as "right ascension" by astronomers) is measured along the Earth's equator from the point where the projection of the equator on the celestial sphere intersects the ecliptic plane (the vernal equinox point) rather than from a point on the rotating Earth Celestial latitude (also referred to as "declination" by astronomers) is the angular distance of the object north or south of the equator The celestial coordinates of the fixed stars are constant for most purposes, they undergo no significant changes except over a period of years

The sun's celestial coordinates at the time of the STS-48 video were obtained from a planetarium software application The velocity vector coordinates were obtained from the Freedom of Information Act Office of NASA The celestial coordinates of the direction the camera was pointed were computed from measurements of the pixel positions in the video of identifiable stars whose celestial coordinates are known I derived the equations for coordinate transformations necessary for this task as described in Appendix A, but they are variants of standard equations used in astronomy and celestial navigation Their correctness was verified against equations presented in Sidgwick (1980), an authoritative astronomy source

Relative to the image plane, the directions of the hypothetical force vectors in three dimensions are expressed in terms of two spherical coordinates

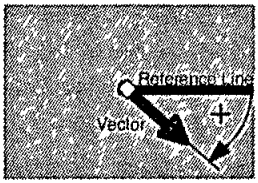

Fig 7 Diagram illustrating the direction of positive azimuth angles for vectors projected onto an image The angle is measured from the zero-degree reference line drawn from the principal (center) point of the image horizontally to the right edge The small diamond indicates the principal point

1 *Azimuth* As illustrated in Figure 7, the angle measured clockwise from a horizontal line on the image drawn from the principal point to the right edge to the line representing the projection of the vector onto the image plane When a negative value of azimuth is given, it means the angle was measured counterclockwise from the image horizontal.
2 *Elevation* the angle between the image plane and the vector. The elevation is here taken as positive when the vector points away from the viewer and negative when it points toward the viewer The complement of the elevation is usually referred to as the incidence angle

The celestial coordinates of the principal point and the image-relative coordinates of the force and north vectors are shown in Table 1 for three different times The last row, for 20 40 26 GMT, gives the coordinates just before the camera moves to another scene

Table 1. Orientation of the Camera's Principal Point on the Celestial Sphere and Azimuths and Elevations Relative to the Image Axes

	Principal Point		North Azimuth	Sun Vector		Velocity Vector	
Time (GMT)	Dec	RA		EL	AZ	EL	AZ
20 38 56	75 7	284 5	343 3	-2 1	52 1	-51 9	73 8
20 39 54	76 9	297 7	355 6	-4 4	51 1	-52 0	74 5
20 40 26	77 3	305 8	2 6	-5 5	50 3	-52 0	75 4

Over a span of 90 seconds that includes the light flash event, at 20 39 24, the direction from the principal point to the sun (the sun vector) was found to have an azimuth close to 52°, while the sun vector's elevation angle varied from –2.1° to –5 5° (nearly parallel to the image plane but pointing slightly toward the viewer) Therefore, any force associated with sublimation of ice would have been pushing the objects in the opposite direction from the sun vector 230° clockwise from the image horizontal in the image plane and at an angle slightly away from the observer

During the same time period, the space shuttle's velocity vector maintained an orientation close to an elevation of –52° while the azimuth varied from 73 8° to 75 4° The small change could be due to the shuttle drifting slightly from its preprogrammed attitude, although the difference is within the margin of measurement error associated with the camera resolution limit. Varying the pixel coordinates of the stars used in the computations by 1 pixel in all directions around the values

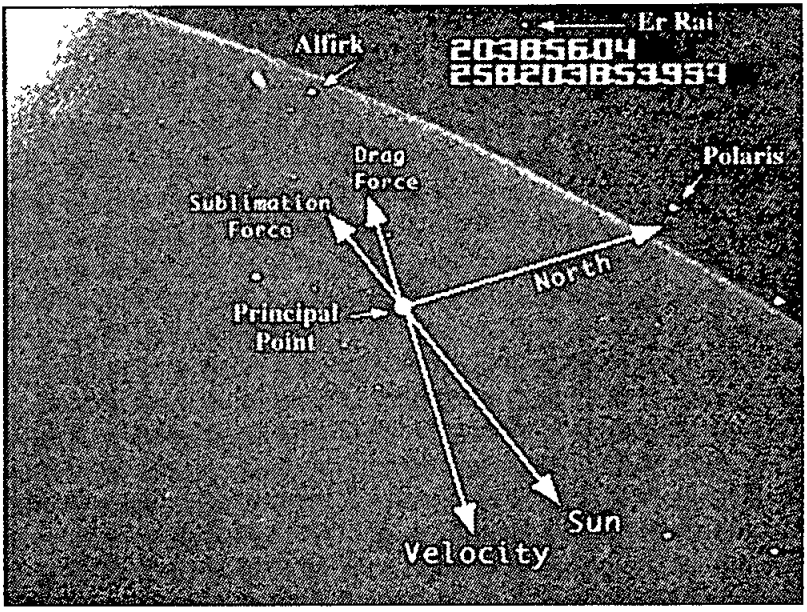

Fig 8 Azimuths of the sun and velocity vectors in the Frame labeled 20 38 56 Alfirk and Er Rai are the stars used to determine the image pointing vector orientation on the celestial sphere The drag force vector is pointed 180° from the velocity vector and the sublimation force vector is 180° from the sun vector

actually measured was found to change the values of all vectors by a maximum of less than ±1° This appears to be a reasonable estimate of the error margin in the computations associated with the resolution limit of the camera. The camera did not appear to have been moved relative to the spacecraft during this time span.

Figure 8 shows the directions for the vectors and the north azimuth, which turns out to point in a direction reassuringly close to the North Star Polaris, as it should The celestial coordinates of the other two stars that are labeled—Alfirk and Er Rai—were used to determine the orientations of all the vectors

The high inclination of the shuttle velocity vector relative to the plane of the image requires that the effects of perspective be taken into consideration This is the same effect that makes the sides of a road appear to converge at a point from the perspective of a driver on a long, flat stretch of highway As Figure 9 illustrates, the effects of perspective can easily lead to misjudgments if not taken into account The convergence constraint described previously would conclusively rule out the force vector as responsible for the curvature of path B in this diagram while it would be a likely explanation for the curvature of path A Simply assuming that all force lines should appear to be parallel to the force vector at the center of the image would incorrectly lead to the opposite conclusion

While the inclination of the lines of drag force implied by the shuttle velocity

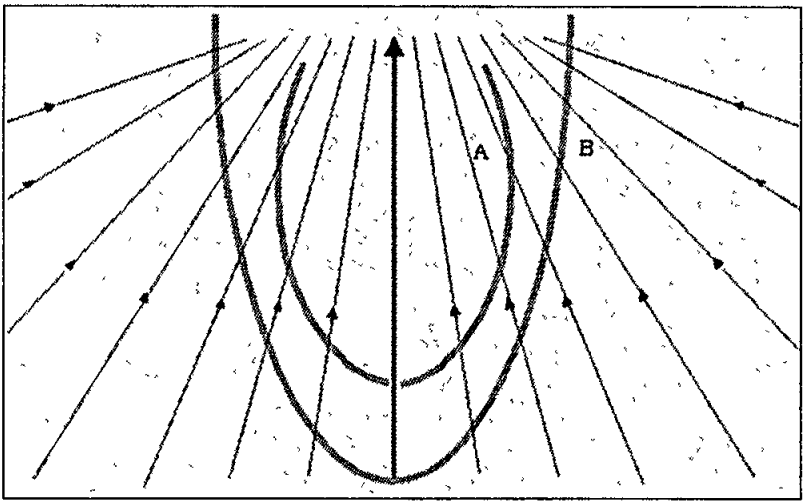

Fig 9 Illustration of the effect of viewer perspective on the perceived shape of a parabolic path for a force vector at a high inclination angle to the image plane Path A actually converges on the direction of the force lines while path B diverges, even though the angles made to the force vector through the principal point of the image (heavy vertical line) suggest the opposite is the case

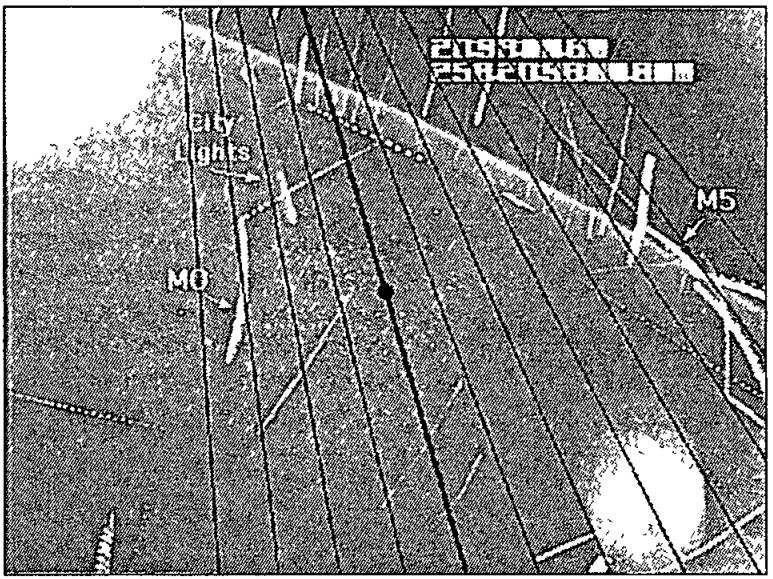

Fig 10 The lines of the space shuttle's velocity vector projected onto the plane of the video image The heavy line near the center runs through the principal point of the image The black dot at the center indicates the position of the principal (center) point of the video frame

vector was not as extreme as what is shown in this illustration, it was found to be significant Appendix C describes how the effect of perspective on vector directions was determined

Figure 10 shows the computed projections of the lines of drag force across the video frame The computed velocity vector azimuth angle of 74° is only applicable for the line that passes through the principal point of the image

In our preliminary qualitative examination of the video, it was noted that the deflection of M5's path, like those of other objects, seemed to be in the same direction as the two forces acting in the space environment near the shuttle The quantitative analysis indicates this is not the case Figure 10 clearly shows that the path of object M5 diverges from the direction of the local drag force lines M5's motion clearly violates the first of the two constraints that parabolic trajectories must obey Its deflection from a linear trajectory cannot be attributed to drag forces The azimuth of the hypothetical force vector associated with sublimation is within half a degree of the drag force azimuth in this region of the video frame, so the deflection also cannot be due to sublimation pressures or a combination of the two forces

It is also immediately apparent in Figure 10 that the strong curvature of the trajectory of object M0 prior to the light flash does converge with the lines of drag force as might be expected for a small debris particle influenced by atmospheric drag But so too, does the track of the city lights nearby The movement of the city lights, of course, has nothing to do directly with drag forces near the shuttle, but surface features will appear to move in the direction opposite the direction the space shuttle is traveling. While the path of M0 is consistent with a particle influenced by drag forces, it is also consistent with an object at a distance from the shuttle and hovering over the same position relative to the Earth as the shuttle moves away. Figure 11 shows that M0 moves at nearly the same apparent speed as do the city lights This matching of apparent speed would be purely coincidental for a debris particle near the shuttle but not for a vehicle hovering above a fixed position on the Earth's surface

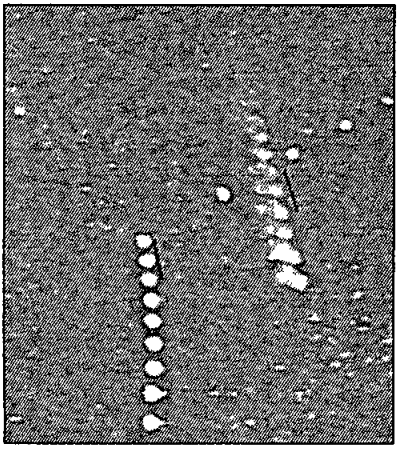

Fig 11 An enlarged view of the position of M0 and the city lights to its right at 5-second intervals The two black lines showing the movement of both features over 10 seconds are the same lengths, indicating that M0 and the surface lights were moving at similar apparent speeds relative to the shuttle

Comparison of Object Trajectories to Force Vectors

Equipped with quantitative knowledge of the directions of the possible natural force vectors, we can now perform a survey of the trajectory-to-force-vector comparisons for several of the objects in the video. For clarity, the background has been largely blacked out in these enlargements, with a small area of the horizon left in for reference The arrows on each image indicate the direction opposite the sun's position (the sublimation force vector) at 20:40:26 GMT, the time at which the scene changes To avoid cluttering the images, the direction of the drag force vectors are omitted, but the object paths that diverge from the sublimation force direction diverge even more from the direction of the drag force vector at that time.

Object M5

As previously noted, M5 does not conform to the first constraint on parabolic trajectories convergence of the path with the direction of the force vector This is shown again in the enlargement of Figure 12 M5 was a relatively slow-moving object This enlargement shows the object's position at 5-second time intervals in order to show the spacing between them, providing a way to measure the object's apparent speed

The change from a linear to curvilinear path at the moment of the light flash is

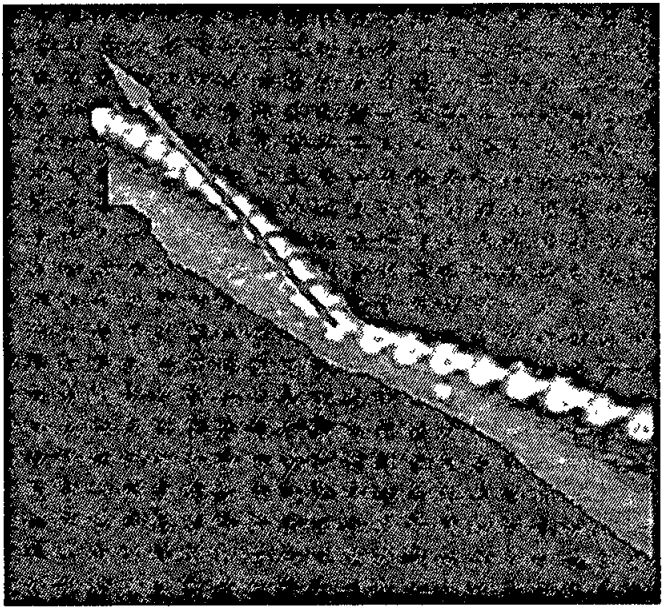

Fig 12 Orientation of the trajectory of Object M5 with the local force vectors The solid gray line is the Earth's horizon, retained to provide context The light flash occurred at the point where the trajectory changed from linear to curvilinear Time interval between frames is 5 seconds

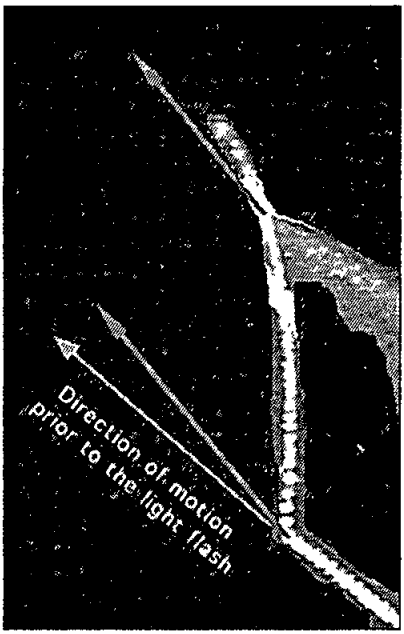

Fig 13 Orientation of the trajectory of object M6 with the local force vectors Time interval between frames is 1 second

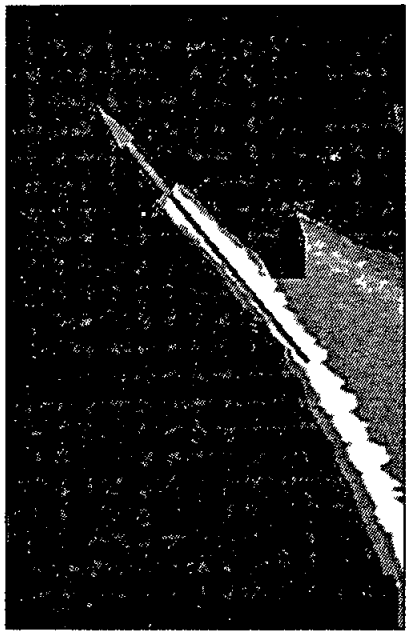

Fig 14 Orientation of the trajectory of object M7 with the local force vectors Time interval between frames is 1 second

especially interesting. Prior to the light flash, M5 is moving in a straight line that is clearly not aligned with the two force vectors (both represented by the single gray arrow) local to the spacecraft A small particle might, of course, exhibit no effect from such forces over a limited span of time if either its mass or speed were sufficiently great However, the spacing between the object's positions after the light flash indicates that there was no significant decrease in speed after that event, only a change from a course roughly parallel to the image plane to a direction away from the viewer If the curvature were due to either of the local forces, some indication of path curvature should have been present before the light flash as well as after

Object M6

Figure 13 shows that M6 conforms to the first constraint governing parabolic trajectories that could be influenced by drag or sublimation forces. The path converges with both the drag and sublimation vectors However, the increase in curvature as the path converges on the force vector violates the second constraint on the relationship between force and motion The curvature should decrease, not increase, as the path aligns itself with the force vector The path should exhibit the most pronounced curvature immediately after the point where the object changed course, but instead it appears to be completely linear until about 15 seconds later

If M6 is following a parabolic trajectory, the curvature suggests that the force influencing the object's motion is directed roughly 90° counterclockwise from the sublimation and drag vectors The only natural force vector that corresponds with that orientation is the Earth's gravitational force, and, as noted previously, the path curvature it would produce could only be noticeable if the object were a great distance from the shuttle

As was the case for M5, M6 also follows a linear course that parallels the image plane until the light flash occurs But in contrast to M5, M6 was clearly moving at a slower speed before the light flash than after, as indicated by the smaller spacing of the spots marking the object's positions at the 1-second time intervals The slower speed prior to the light flash should have resulted in a more highly curved path before the flash than afterwards, had forces in the vicinity of the shuttle been responsible

Object M7

M7 is shown in Figure 14 The path of this object does not appear to violate either of the two constraints on the behavior of a small particle influenced by the forces in the local shuttle environment

Object M11

The object designated M11 in Figure 15 is one of several objects not previously noted, probably due to its faintness relative to other objects But the track it leaves on the time-exposure overlay is worth comment Like the better-known M1, M11 makes its first appearance at the horizon, repeating that remarkable spatial coincidence (note that the track of a bright star ends very close to the point where the object appeared, suggesting that it may have come over the horizon).

The object veers from its original course at the moment of the light flash But with

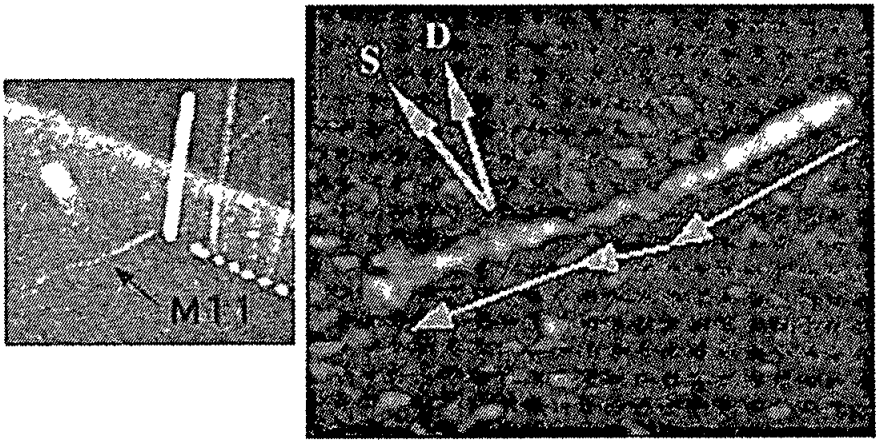

Fig 15 Object M11 Time interval between frames is less than 1 second The first jog in the object s path occurs at the moment of the light flash The sublimation vector is indicated by the arrow labeled "S" and the drag force vector by the arrow labeled "D"

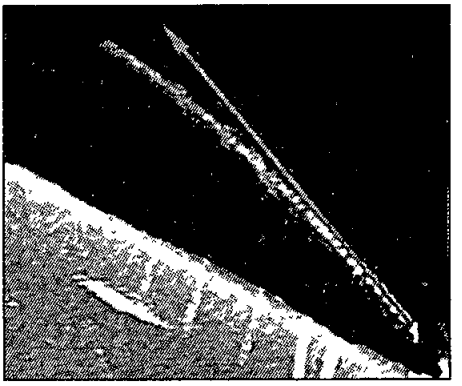

Fig 16 Orientation of Object M13 to the local force vectors Time interval between frames is 1 second

seeming stubbornness, it resumes its original heading about 30 seconds after the light flash and in opposition to any propulsive force generated by the forces local to the shuttle if it were a debris particle

Object M13

Another faint object in the video that has not been discussed before has been designated M13 here It is in the upper left of the area labeled B in Figure 1 and in the enlargement of Figure 2 This object entered the video frame from the right edge, moving to the left until the light flash occurred It then began moving toward the upper left at a steeper angle, its trajectory curving to the left Figure 16 shows that the object was initially traveling in a direction close to that of the two force vectors in the local shuttle environment but its path ultimately diverged from the local force vectors at a substantial angle

Discussion and Conclusion

All but one of the objects in this video appear as small white spots because their angular size is at or near the resolution of the camera But this is by no means sufficient to dismiss them as shuttle debris given the evidence to the contrary The stars in the video also appear as small white spots, and it is their motion alone that tells us they are stars hundreds of light years from Earth and not ice particles a few feet away from the camera Similarly, it is the motion of the other objects in the video that indicate that they, too, may be something other than small nearby debris particles

Of the six objects following curved trajectories described previously, only two do not exhibit significant violations of the constraints on parabolic trajectories that would have been induced by the two forces known to act in the vicinity of an Earth-orbiting spacecraft The deviations from trajectories that could be explained by drag forces or sublimation pressures are generally greater than 10°—well above the estimated ±1° margin of measurement error

It may seem possible that the trajectories observed to be inconsistent with the action of atmospheric drag could be attributed to turbulent or complex flows in the

atmospheric medium created by the spacecraft's own passage through it. That would mean that the objects following such seemingly anomalous paths could still be debris particles after all. However, according to Wallace and Hobbs (1977) the mean free path between collisions of atmospheric molecules at an altitude of 150 km is 100 meters The mean free paths are much longer at the altitudes at which the space shuttles orbit My own computations indicate that at the 572-km altitude of *Discovery* on the STS-48 mission, the mean free path of atmospheric molecules is nearly 100 km

In contrast, at altitudes of 40 km, where turbulence and other complex fluid behavior might be a consideration, the mean free path of air molecules is on the order of 10^{-5} meters—about nine or ten orders of magnitude shorter At the altitudes of space shuttle orbits, atmospheric molecules interact with debris particles and with the spacecraft itself but not with each other as required for an assemblage of molecules to behave as a fluid. Thus, the only forces acting on a debris particle near the space shuttle would be those examined in this paper atmospheric drag acting in the direction opposite to the spacecraft's motion or the propulsive force generated by sublimation acting on an ice particle in the direction opposite to the sun Neither force appears to account for the observed trajectories of several of the objects in the STS-48 video

Carlotto's original suggestion that some of the objects followed curvilinear trajectories near the horizon because they were moving around the curvature of the Earth cannot be proven. But in combination with the equally interesting possibility that the objects possessed their own sources of propulsion, it appears to be the only remaining explanation that cannot be disproved.

It is often said that the "burden of proof" is on those making extraordinary claims There is merit to that assertion But it would be more accurate to say that the burden falling to the proponents of an extraordinary hypothesis is a burden of *disproof* of the conceivable mundane explanations Unless other explanations have escaped the author's attention, it appears that that burden may have been met for the objects in the STS-48 video on the basis of their trajectories alone

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APPENDIX A
DETERMINING THE CELESTIAL COORDINATES OF THE IMAGE PRINCIPAL POINT

The process of finding the directions of force vectors on the celestial sphere begins with using the positions of identifiable stars in the video frame to determine the direction of the camera's line of sight, which is the same as the principal point of the video frame

This in turn requires computing the elevation and the north-relative azimuths of points on the celestial sphere from the known celestial coordinates of the stars and also doing the reverse computing the celestial coordinates of a point on the celestial sphere given its elevation and azimuth and the celestial coordinates of the principal point.

The north-relative azimuth will here be referred to simply as "azimuth" but should not be confused with the azimuth of vectors relative to the image frame previously described For astronomers, elevation means the angle of the target object above the observer's horizontal plane and the azimuth is the angle of the object from due north

It is often more convenient to work with the angular distance from the zenith to the observed star The zenith angle is the complement of the elevation angle The azimuth is generally taken to be positive going toward the east from the north direction, so an object due east of the observer would have an azimuth of 90° Due west is 270°

In the celestial coordinate system, the longitude (or right ascension) is zero at the point where the projection of the Earth's equatorial plane on the celestial sphere intersects the ecliptic plane. Longitudes are positive going east from that point. Celestial latitudes (or declinations) are zero along the projection of the Earth's equator on the celestial sphere The point where the Earth's North Pole intersects the celestial sphere is at +90° declination and the South Pole is at –90°

Astronomers are usually interested in the positions of stars relative to the local horizon of the place where they are doing their observing But we are interested here in the positions of stars relative to the image plane of the camera aboard the Space Shuttle *Discovery*, which recorded the video, and the image plane serves just as well as a reference as the Earth's physical horizon

The zenith point, where the elevation is +90° above the image plane, can be arbitrarily defined as whatever direction the camera happens to be looking the principal point of the image

Whether the azimuth and elevation are needed relative to a physical horizon or to the image plane of a camera, the equations for computing the elevation and azimuth are the same If the observer's zenith is at celestial coordinates ($lat0$, $lon0$) and the observed object is at ($lat1$, $lon1$), then the equation for the north-relative azimuth, α, is

(1) $\alpha = \text{atan2}(\sin(\Delta lon)\cos(lat1), \sin(lat1)\cos(lat0) - \cos(\Delta lon)\cos(lat1)\sin(lat0))$

where Δlon is the difference in longitudes. $lon1 - lon0$. The symbol "atan2" represents a trigonometric function that takes two arguments and returns a value between 0° and 360°

The elevation, ε, of the object is

(2) $\varepsilon = \text{asin}(\cos(\Delta lon)\cos(lat1)\cos(lat0) + \sin(lat1)\sin(lat0))$

Local coordinates relative to compass directions are by convention a left-handed system, so azimuth increases counter-clockwise from the north direction about the image principal point when looking towards the local zenith As a result, once the azimuth for a star is computed, the north direction relative to the image axes is obtained by measuring an angle clockwise from the star about the principal point

To use the expressions for azimuth and elevation in computer programs, it is more convenient to define the expressions of equations (1) and (2) as a pair of mathematical functions that return the azimuth and elevation of a star at ($lat1$, $lon1$) for an observer with an orientation where ($lat0$, $lon0$) is at the observer's zenith.

$$\alpha = \text{AZ}(lat0, lon0, lat1, lon1)$$
$$\varepsilon = \text{EL}(lat0, lon0, lat1, lon1)$$

The celestial coordinates of the image principal point must be computed based upon the azimuths and elevations of stars appearing in the image as measured from the principal point. The expressions that return the values of celestial latitude and longitude given the observer's celestial coordinates and the object's measured elevation and azimuth can be written as

(3) $lon1 = lon0 + \text{AZ}(lat0, 0, \varepsilon, \alpha)$

(4) $lat1 = \text{EL}(lat0, 0, \varepsilon, \alpha)$

Again for convenience, equations (3) and (4) can be used to define a second pair of functions referred to here as LAT($lat0$, ε, α) and LON($lat0$, $lon0$ ε, α), given the star's elevation and azimuth from a known position on the celestial sphere The LAT and LON functions together are, in effect, the inverse of the EL and AZ functions

The elevation of the principal point relative to a star can easily be determined from distance measurements in pixels on the image It is simply the complement of the angular distance from the image principal point to the star (i e , the zenith angle) Zenith angles can be approximated fairly closely by multiplying the distance in pixels from each star to the principal point by the width of the field of view in degrees and dividing by the width of the image in pixels

But a more exact value of the zenith angle can be easily computed by the following algorithm, given the pixel coordinates of the star ($x1$, $y1$), the width and height of the image, w, and h, and the width of the horizontal field of view in degrees, HFOV

Determining the azimuth of the principal point relative to a star's position is not as straightforward as determining its elevation, but it can be computed using the zenith angles returned by the Image_Zenith_Angle algorithm for any two identifiable stars in

Algorithm Image_Zenith_Angle ($x1, y1, w, h$, HFOV)
$x0 = w/2$
$y0 = h/2$
$z = w / (2\tan(\text{HFOV} / 2))$
$\Delta x = x1 - x0$
$\Delta y = y1 - y0$
RETURN
Zenith_Angle = atan ($\sqrt{(\Delta x^2 + \Delta y^2}$ / z)

the image. The key to the problem is to recognize that there are two and only two points on the celestial sphere that can be at the computed zenith angle of ζ_1 from the star, S1, and at the zenith angle, ζ_2, from star S2. These are the points where the circle of co-elevation ζ_1 drawn on the celestial sphere around the position of star S1 intersects the circle of co-elevation ζ_2 drawn around S2's position as shown in Figure A1.

Figure A1 shows these points of intersection in two views. In the lower view, both circles of co-elevation are viewed on edge, making them appear as straight lines intersecting at a Point U, which will be the same as either Point A or Point B in the

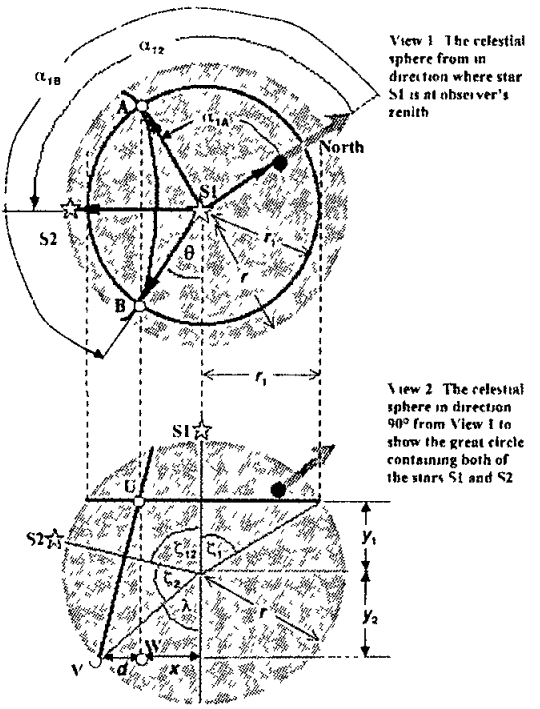

Figure A1 Diagram showing the views of the celestial sphere that permit the derivation of the celestial coordinates of an image's principal point from the zenith angles formed by two stars, S1 and S2. Circles of co-elevation around the two stars are indicated by the heavy black lines. The two possible positions of the image principal point are indicated by small white circles labeled A and B in the upper view. Azimuth directions are indicated by arrows in upper view.

upper view depending on which direction the 90° rotation was performed to obtain the lower view The upper view is the celestial sphere with star S1 at zenith The dark circle contains all points on the celestial sphere at a zenith angle ζ_1 from S1

To determine the celestial coordinates of the image principal point, the angle ζ_{12} must also be known and this is computed by the EL function using the latitudes and longitudes of the two stars The value of this angle is independent of the order in which the coordinates of the two stars are passed. In other words, ζ_{12} always equals ζ_{21} for any two stars S1 and S2.

The angle ζ_{12} in Figure A1 is the zenith angle of star S2 when S1 is at the viewer's zenith Similarly, the angle α_{1A} and α_{1B} are the azimuth angles of points A and B when S1 is at the viewer's zenith. Recalling that one of these two points on the celestial sphere is the principal point of the image, our goal is to determine their celestial coordinates This can be accomplished for Point A by invoking the LAT and LON functions with the arguments being the latitude and longitude of S1, the elevation $90° - \zeta_1$, and the azimuth of Point A when viewed from the position where S1 is at the zenith

From inspection of the upper view of FigureA1 it can be seen that.

(5) $\alpha_{1A} = \alpha_{12} + \theta - 90°$

The latitude and longitude of Point B be can be similarly computed given that·

(6) $\alpha_{1B} = \alpha_{12} - \theta + 90°$

Which of the two points, A or B, is the actual principal point can be decided by using the angle measured on the image about its principal point from S1 to S2 If this angle is closer to the difference between the azimuths computed for S2 and S1 with A at the viewer's zenith (i e , $\alpha_{A2} - \alpha_{A1}$) than it is for the difference in azimuths of the same pair of stars with Point B at the viewer's zenith (i.e., $\alpha_{B2} - \alpha_{B1}$), then the image principal point is Point A. Otherwise, the principal point is Point B

Remaining is the task of computing the value of the angle θ, the derivation of which is given below followed by a concise algorithm for the procedure of obtaining the principal point coordinates

From inspection of the lower view of Figure A1 the following relationships can be seen to hold·

$$\lambda = \pi - \zeta_{12} - \zeta_2$$

$$\angle UVW = \frac{\pi}{2} - \zeta_2 + \frac{\pi}{2} - \lambda = \pi - \zeta_2 - \lambda = \zeta_{12}$$

$$y_1 = r\cos\zeta_1$$

$$y_2 = r\cos\lambda$$

$$\tan(\angle UVW) = \tan\zeta_{12} = \frac{y_1 + y_2}{d} = \frac{r(\cos\zeta_1 + \cos\lambda)}{d}$$

Or

$$(7)\quad d = r\frac{\cos\zeta_1 + \cos\lambda}{\tan\zeta_{12}}$$

where r is the radius of the celestial sphere

Again from inspection of the lower view of Figure A1

$$(8)\quad x = r\sin\lambda - d$$

Combining (7) and (8)

$$(9)\quad x = r\left(\sin\lambda - \frac{\cos\zeta_1 + \cos\lambda}{\tan\zeta_{12}}\right)$$

The lower view of Figure A1 shows that the radius of the circle of co-elevation about S1 in the upper view of Figure A1 is

$$(10)\quad r_1 = r\sin\zeta_1$$

Because the distance from S1 to Point B in the upper view of Figure A1 is r_1 and from the definition of the sine function

$$(11)\quad \sin\theta = \frac{x}{r_1}$$

Substituting for x from (9) and for r_1 from (10) into (11) gives

$$\sin\theta = \frac{\sin\lambda - \dfrac{\cos\zeta_1 + \cos\lambda}{\tan\zeta_{12}}}{\sin\zeta_1}$$

Or

$$(12)\quad \theta = \arcsin\left(\frac{\sin\lambda - \dfrac{\cos\zeta_1 + \cos\lambda}{\tan\zeta_{12}}}{\sin\zeta_1}\right)$$

The expression for the angle θ in (12) can then be substituted into (5) to compute α_{1A} and into (6) to compute α_{1B} and those two angles can in turn be used to compute the latitude and longitude of the principal point

The procedure for computing the principal point latitude and longitude based upon the previous derivations is stated more concisely as the Principal_Point algorithm on the following page

The symbols referenced in this algorithm are from the diagram of Figure A1.

Algorithm Principal_Point(lat_1, lon_1, lat_2, lon_2, ζ_1, ζ_2, ppt_angle$_{12}$)

$\zeta_{12} = 90° - \text{EL}(lat_1, lon_1, lat_2, lon_2)$
$\alpha_{12} = \text{AZ}(lat_1, lon_1, lat_2, lon_2)$
$\lambda = 180° - \zeta_{12} - \zeta_2$
$d = (\cos(\zeta_1) + \cos(\lambda)) / \tan(\zeta_{12})$
$\theta = \text{asin}((\sin(\lambda) - d) / \sin(\zeta_1))$
$\alpha_{1A} = \alpha_{12} + \theta - 90°$
$\alpha_{1B} = \alpha_{12} - \theta + 90°$

$lat_A = \text{LAT}(lat_1, 90° - \zeta_1, \alpha_{1A})$
$lon_A = \text{LON}(lat_1, lon_1, 90° - \zeta_1, \alpha_{1A})$
$lat_B = \text{LAT}(lat_1, 90° - \zeta_1, \alpha_{1B})$
$lon_B = \text{LON}(lat_1, lon_1, 90° - \zeta_1, \alpha_{1B})$

$\alpha_{A1} = \text{AZ}(lat_A, lon_A, lat_1, lon_1)$
$\alpha_{A2} = \text{AZ}(lat_A, lon_A, lat_2, lon_2)$
$\alpha_{B1} = \text{AZ}(lat_B, lon_B, lat_1, lon_1)$
$\alpha_{B2} = \text{AZ}(lat_B, lon_B, lat_2, lon_2)$

IF ABS ($\alpha_{A2} - \alpha_{A1}$ - ppt_angle$_{12}$) <= ABS ($\alpha_{B2} - \alpha_{B1}$ - ppt_angle$_{12}$)
THEN RETURN lat_A, lon_A
ELSE RETURN lat_B, lon_B

The correctness of this algorithm can be verified as follows

> Select any three points, P1, P2, P3, on the celestial sphere Use the AZ and EL functions to compute the azimuths and elevations of P1 and P2 as viewed from P3 Then call the Principal_Point function with the coordinates of P1 and P2, the zenith angles (90° minus the computed elevations) and the difference in the azimuths as viewed from the third point The function should return the latitude and longitude of P3

The procedure for determining the celestial coordinates of the video frame's principal point is as follows.

1 Use an astronomy computer application to identify a pair of stars, S1 and S2, in the image and record their celestial coordinates, lat_1, lon_1 and lat_2, lon_2
2 Measure the angle ppt_angle12 centered on the principal point *counterclockwise* from S1 to S2

3 Use the Image_Zenith_Angle algorithm to compute the zenith angles, ζ_1 and ζ_2 for S1 and S2 respectively relative to the image principal point
4. Use the Principal_Point algorithm to compute the celestial latitude and longitude of the principal point

Appendix B
Determining Vector Orientations Relative to the Celestial Sphere and to the Video Frame

After the celestial coordinates (lat_p, lon_p) of the principal point were computed for a video frame as described in Appendix A, the north direction relative to the image axes was obtained by measuring clockwise on the image by an angle equal to the north-relative azimuth of one of the stars used in the Principal_Point function The north-relative azimuth of a star, S, at celestial coordinates (lat_S, lon_S) in an image with the principal point at coordinates (lat_p, lon_p) is obtained by invoking the AZ function

$$\alpha_{p-S} = AZ(lat_p, lon_p, lat_S, lon_S)$$

The sun vector orientation relative to the principal point was found by invoking the AZ and EL functions for the image principal point and the sun's coordinates at the time the video was taken

$$\alpha_{p-SUN} = AZ(lat_p, lon_p, lat_{SUN}, lon_{SUN})$$

$$\varepsilon_{p-SUN} = EL(lat_p, lon_p, lat_{SUN}, lon_{SUN})$$

Finally, the sun's azimuth relative to the image horizontal was obtained by adding the sun's azimuth relative to the north direction in the counterclockwise direction (the direction of increasing azimuth angle) This procedure is illustrated in Figure B1

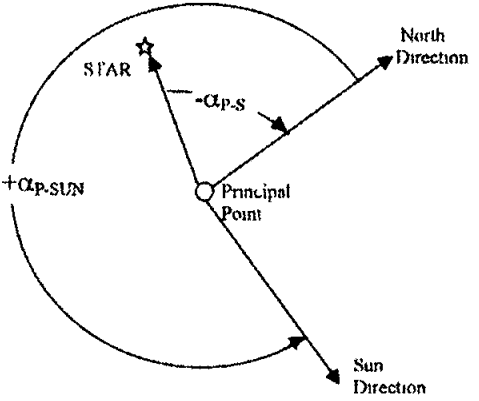

Fig B1 Illustration of how the sun direction in an image is determined after finding the North direction from the north-relative azimuth of a star The celestial coordinates of the image principal point are considered to be the local zenith

The celestial coordinates used for the sun were latitude 2 972° longitude 173 126° This is the sun's true-of-date position for September 15, 20 37.10 UT, about one minute before the events of interest commence in the STS-48 video The sun moves from this position by less than 5 seconds of arc over the span of time involved and it is therefore treated here as a fixed star.

The declinations and right ascensions of the shuttle's velocity vector were obtained by converting the M50 Cartesian coordinate data obtained from NASA The NASA parameter designations are shown in Table A1 below

Table A1. Cartesian M50 Velocity Components Used to Compute the Celestial Coordinates of the Space Shuttle Velocity Vector

Time (GMT)	V95L0190C V_x (feet/sec)	V95L0191C V_y (feet/sec)	V95L0192C V_z (feet/sec)
20 38 56	−16074 742	888 259	−18924 070
20 39 54	−16761 684	−414 462	−18334 000
20 40 26	−17104 957	−1118 733	−17983 461

Conversion of the Cartesian coordinates to angular declination, δ, and right ascension, ρ, is straightforward

$$\delta = \text{atan}\left(\frac{v_z}{\sqrt{v_x^2 + v_y^2}}\right)$$

$$\rho = \text{atan2}\,(v_y, v_x)$$

The M50 coordinate system is defined in reference to the mean equator of January 1, 1950 The coordinates were converted to the "true of date" values for September 15, 1991, displayed by the planetarium application used to find star positions The two reference frames differ due to the effects of precession of the equinoxes and nutation, although the differences were found to be insignificant

The velocity vector orientation to the video frame was found in the same manner as the orientation of the sun vector

Appendix C
Perspective and the Slopes of Parallel Lines

Parallel lines at an incline to the plane of a photograph appear to converge at a point toward the ends of the lines that are farther away from the observer (the vanishing point) The greater the straight-line distance from the observer to a point, the smaller is the angular distance of that point from the principal point in the observer's field of view As a consequence, if the projection of an inclined straight line does not pass directly through the image's principal point, the ray from the far end of the line

will intersect the image plane at a distance closer to the principal point than does the far end Figure C1 illustrates this effect by showing a "photograph" of two arrow-shaped objects at the same distance from the viewer and inclined at the same angle

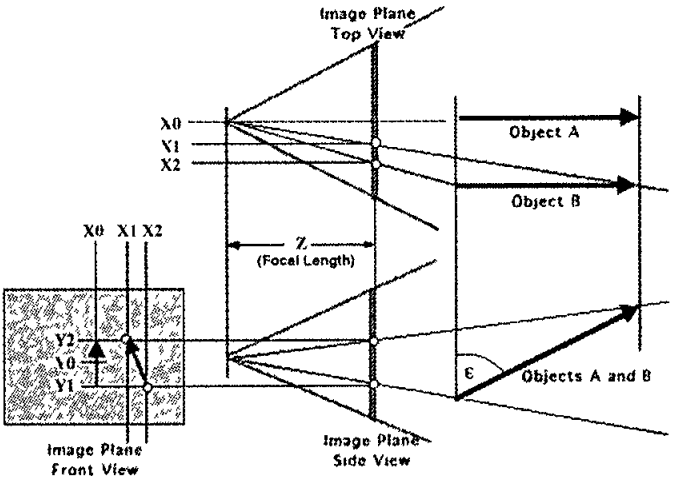

Fig C1 Illustration of perspective The front view of the image plane shows a simulated photograph of two the two arrow-shaped objects A and B in front of the observer

The projection of Object B on the image plane slopes toward the projection of Object A, which runs through the center Object B slopes because the difference in the positions of the bottom ends of the arrows in the horizontal direction, X2–X0, is greater than the difference in the projected positions of their top ends, X1–X0 But the length of both projections in the vertical direction is the same Y2–Y1 The arrows are inclined to the image plane only in the vertical (Y) image direction and are vertically foreshortened along that axis The shift of the top of Object B toward the principal point is strictly in the horizontal (X) direction

Given that the origin of the principal point in the image is ($x0, y0$), the equation for the apparent slope, m, of a linear feature whose projection passes through a point (x, $y0$) in the image is

$$m = \frac{z}{x_0 - x} \tan(90° - \varepsilon)$$

Where x is the X coordinate of the point (x, $y0$), z is the focal length in units of pixels, and e is the elevation angle of the projected linear object relative to the image plane If the elevation angle e is zero or if $x = x0$, then the slope is infinite and the projection of the linear feature will run in exactly the same direction in the image as it would in an orthogonal projection (where all rays are drawn from the object to intersect the projection plane at a 90° angle)

The X- and Y-axes used in this equation are not generally the same as the image

vertical and horizontal directions The Y-axis is the orientation the linear feature would have if it intersected the image principal point (as Object A does in the illustration) The X-axis is perpendicular to the Y direction in the image plane

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ANGEL HAIR PHYSICAL ANALYSES: A REVIEW

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ABSTRACT There are over 200 case reports of the angel hair phenomenon reported in the literature However cases in which samples were collected and meaningful analyses carried out are relatively few in number This paper reviews these previous analyses Early analytical methods were limited in scope but more recent methods such as mass spectrometry have provided much better information on the composition of some angel hair samples Spider web is most often considered the source of angel hair, but sample contamination improper analytic processes, and the personal biases of investigators have complicated the study of this phenomenon Nevertheless commonalities across cases may provide clues about this substance

WHAT IS ANGEL HAIR?

Angel hair can be described as a fine, commonly white, apparently silk-like substance seen to fall to earth in conjunction with the reported appearance of unidentified flying objects (in about half the cases), or often attributed to UFO activity despite the absence of a UFO sighting. The material is commonly described as fibrous in nature, like strands of silk, wool, nylon, asbestos, or "spun glass " It has a tendency to degrade or sublimate over time, and in many cases it has been reported to completely vanish, even in sealed containers (Boldman, 2001)

Angel hair has been blamed on a wide variety of conventional sources such as industrial residues, radar chaff, and plant fibers, but the discarded webs of ballooning spiders is by far the most common explanation Young spiders emit strands of silk, and rising air currents pull them aloft to migrate Both ballooning spider activity and angel hair reports occur most often during clear, dry, fall days, so they have often been considered one and the same phenomenon However, this comparison has significant limitations For instance, the *sublimation* (change of state of a substance directly from a solid to a gas) of angel hair argues against the spider-web hypothesis Spider webs do not sublimate, in fact, they are one of the strongest natural fibers known

EARLY ANALYSES

Early reports of angel hair were limited to superficial physical descriptions of the substance, such as strand length and areas covered by the fall, or to its apparent

relationship to more familiar materials such as "strange white hair" or "resembling silk." A typical example is found in the *Annual Register* (London), 1821, part 2, p 681, pertaining to a "rain of silk" that occurred in October 1820 in Pernambuco (modern Recife), Brazil.

Charles Fort recorded many early cases of anomalous falls of web-like substances One such event—an unusual case that may or may not be "true" angel hair—occurred on October 16, 1883, in Montussan, France (Fort, 1941, p 62, quoting Francis Dussaut, "Nuage formé d'une matière solide floconneuse," *Nature* (Paris) 2 (1883) 342) What is odd is that the substance fell during a rainstorm.

> According to a witness a thick cloud, accompanied by rain and a violent wind, had appeared. This cloud was composed of a woolly substance in lumps the size of a fist, which fell to the ground The Editor (Tissandier) says of this substance that it was white, but was something that had been burned It was fibrous M Tissandier astonishes us by saying that he cannot identify this substance

What was not unusual (notwithstanding Fort's surprise at the lack of identification), is the absence of any meaningful analysis This may have been understandable given scientific limitations in 1883, but it has been a recurrent theme in other angel hair cases until recently

The first chemical analysis on record occurred after a large quantity of extremely long strands fell on September 20, 1892, around Gainesville, Florida (Corliss, 1983, p. 61, quoting George Marx, "On Spiders' Web," *Proceedings of the Entomological Society of Washington* 2 (1892) 385) Multiple witnesses miles apart reported that some strands were 300 yards long Samples were sent to the Entomological Society in Washington, D C A microscopic and chemical examination found an absence of structure with fine, slender threads that appeared "solid as glass rods . not hollow, not the slightest appearance of a cell-wall." As it burned readily, it was concluded not to be of mineral origin Chemical examination indicated

> Potassic hydrate coagulates and nearly destroys the specimen Iodine alone turns it a yellow-brown color Acetic acid decidedly contracts it Zinc chloride partially destroys it and does not produce the violet color which would result were the substance cellulose, it is also rendered more opaque by this reagent Nitric acid coagulates it, leaving a small burned residue . it is destroyed or coagulated by hydrochloric acid, nitric acid, potassic hydrate, and by Schultz's solution

Following the Gainesville case, there were no chemical analyses of angel hair until the 1950s (the decade with the largest number of cases on record) Several angel hair samples were examined in the early 1950s by an entomologist, with the conclusion that the substance was spider web, but there is no mention of any chemical analysis as a basis for this conclusion

Analysis in the 20th Century

The first documented chemical analysis in the 20th century was in October 1953 This analysis and subsequent cases are listed chronologically

Victoria, Australia, October 10, 1953. A UFO was seen to discharge a white trail, described as "strange shiney filaments" which covered wires and trees According to Australian researcher Keith Basterfield (1966)

> a sample was recovered and made available for laboratory analysis The examination revealed that the substance consisted of a nylon-like amorphous mass with traces of magnesium, calcium, boron and silicon Since then the original material, which was kept in an air-tight container, shrank from three to a mere half-inch without residue

There were also trace elements found, but the author could find no record of what these were, or the analysis methods used (Basterfield, 2001)

Shepparton, Victoria, Australia, May 12, 1954. Angel hair fell in strands averaging 30 feet in length A sample was collected and sent in an air-tight container to the Australian Flying Saucer Bureau for analysis (Hervey, 1975, pp 73–74) A subsequent report indicated the substance was pure white, silky, odorless, warm on touch like cotton, and different than cobwebs The threads were not sticky and stretched easily

Under a microscope, the threads appeared very fine and uniform, but coarser when compared to cobwebs There was a resemblance to raw silk or nylon, with a tendency to degrade unless kept in an air-tight container The substance was not water soluble The material burned rapidly leaving no ash or odor

Florence, Italy, October 27, 1954. Over 10,000 soccer fans witnessed two luminous discs during a game (Stevens, 1976, pp 56–57) A large quantity of angel hair fell which clung to everything, described as "white filaments " Samples were collected and taken to the Institute of Chemistry at the University of Florence for analysis·

> The substance was found to have a "fibrous structure, w/ mechanical resistance to contraction and torsion, burns rapidly, leaving a transparent residue " It was found to contain in decreasing order calcium, silicon, aluminum, magnesium, iron and boron

Horseheads, New York, February 21, 1955. A very unusual fall of angel hair occurred in early morning covering one-half square mile The material was described as "cobwebby grey fibres," with some "ragged sheets" many feet in length (*CSI News Letter*, 1957, p 5) No UFO was reported Several analyses were done Professor Charles B Rutenber of the chemistry department at Elmira College reported the substance to be gray, "badly damaged, slightly radioactive cotton fiber" that might have originated from an atomic bomb test in Nevada

His conclusion, along with another chemist, was that the substance was a "a short-

staple cotton, possibly lint from waste cotton used in industrial plants" (Sanderson, 1957, p 5)

John B Diffenderfer, a chemist at a local Westinghouse laboratory, also performed an analysis and found the substance was 30% carbon, with calcium, silica, aluminum, iron, and about 10 other trace elements Diffenderfer concluded the substance was formed from powdered milk residue, supposedly from the Dairylea milk processing plant in Elmira

However, milk plant chemists Louis R Hermani and Robert L Mix contradicted Diffenderfer, stating that the substance was composed of "cotton and wool fibers with pieces of fine copper wire mixed in. . It looked like it might have come out of a carpet sweeper bag" (Towner, 1955, p. 64). While the results were contradictory, there was no mention of ballooning spiders as the cause, and spiders do not balloon in February

Melbourne, Victoria, Australia, July 10, 1956. In a classic angel hair fall, the Melbourne coastline and suburbs were draped with the substance, which hung from utility lines and trees The angel hair was said to vanish within hours, but a sample was recovered for analysis by the Commonwealth Scientific and Industrial Organisation The substance was tested with ethyl acetate, acetone, and lactophenol dye, then magnified and burned There was no conclusion as to what the substance was, but it could not be identified (World roundup, 1956, *CSI News Letter,* 1957, Stevens, 1977)

From the *Bournemouth (U K) Echo,* July 10, 1956

> Web-like Threads Puzzle Scientist· Millions of white web-like threads drifting through Melbourne's seaside suburbs hang from lines and wires, stick to cars and clothes, catch in trees, and vanish in a few hours. Six scientists of the Australian Commonwealth Scientific and Industrial Organisation have studied the threads Said one of them "it's not wool, it's not cotton, it doesn't come from feathers, it's not cellulose fibre, and it doesn't look like a synthetic fibre " Some of them are thinking in terms of webs of spiders yet to be identified; but, as the threads have a melting quality, they are further puzzled.

Cincinnati, Ohio, September 25, 1956. UFO researcher Leonard Stringfield's wife observed several white tufts float down to the front yard of their home Mrs Stringfield gathered some of the substance with a stick and placed it in an airtight jar Stringfield states it resembled "white asbestos fibre" and seemed to curl when touched (Stringfield, 1957, pp 51–52) After contacting the Air Force, M/Sgt Oliver D Hill was dispatched from Wright-Patterson AFB on October 12, 1956, to retrieve the sample An interesting aspect of this case is Hill's remarks in his trip report (U.S Air Force, Project Blue Book Case Files, microfilm roll no 26)·

> I took additional pictures of the area In so doing, I noticed a white object floating in the air and retrieved it, but on contact with my hand it completely disappeared. I made no mention of this incident to Mr Stringfield

Analysis of the sample for the Air Force was apparently done by C. G. Cocks and L Leatherland A memorandum in the Blue Book case file contains the following results·

> Microscopical examination reveals that these fibers are multifilament bundles The individual fibers seem to be monofilaments and not staple fibers The individual filaments are usually small being about 2 to 4 microns in diameter A rough birefringence measurement gave + 0 029. The filaments seem to be slightly oval in cross section though no sections were [file unreadable] The oval shape may cause some error in birefringence, but the range of birefringence for regenerated cellulose is 0 021 to 0 029 The birefringence of some other synthetics are nylon 0 060, dynel 0 005, Dacron 0 173, orlon –0 002, and acrilan –0 005 The size and birefringence also eliminates all natural fibers ordinarily encountered with the possible exception of spider web and this seems unlikely since it would be difficult to make yarns of it The fibers are insoluble in acetic acid, chloroform, dimethylformamide, and 90 per cent [sic] phenol They are soluble in cuprammonium hydroxide and also in concentrated HCL This is characteristic of regenerated cellulose fibers, either viscose or cuprammonium rayon This solubility behavior eliminates cellulose acetate, vinyon HH, dynel, vinyon N, nylon, wool, vicara, orlon, acrilan, and Dacron the finest viscose filaments are 1 denier while cuprommonium has been produced as fine as 0 4 denier 0 4 denier would be approximately 3 microns in diameter while 1 denier is about 3 microns in diameter Since the unknown runs 2 to 4 microns it is probably cuprammonium rayon

Blue Book's conclusion was "Analysis from ASD showed specimen to be a rayon residue thrown into air by defective filter" But in other Blue Book correspondence, the Air Force was adamant that spider web was the causative factor

Ichinoseki, Iwate Prefecture, Japan, October 4, 1957. Angel hair fell following a sighting of a tadpole-shaped UFO, about 240 miles northeast of Tokyo. The material consisted of threads like spider webs, in great profusion What little information is available indicates that chemical analysis showed the material to be organic, was dissolvable in hydrochloric acid, and would burn An x-ray (roentgen) analysis showed a crystal structure different from spider webs (Webster, 1958, p 26)

Washington, Sharon, and Crawfordville, Georgia, October 12, 1959. Multiple witnesses observed "brown or black footballs" traveling southeast to west, followed by an angel hair fall covering a vast area The substance was described as "threads from 10' to 50' long connected at 3/4" intervals by minute particles resembling snowflakes the threads would remain visible for a few minutes and then disappear"

This case received wide attention as witnesses included a radio personality, a fire chief, and a Georgia state patrolman Project Blue Book and Robbins Air Force Base became involved due to the publicity, which seems to have alarmed them The Blue

Book file on this case contains a "Flash Report" dated October 22, 1959, sent by Capt George T Gregory to Col Shoop, which states in part (U S. Air Force, Project Blue Book Case Files, microfilm roll no 37)

> At 1300 hours, 14 Oct 59, a gossamer silk-like substance continued to fall from the sky over Sharon, Ga. For almost 2 hours According to UFO regulations, this material was investigated by Provost Marshal's office, Robbins AFB, Ga under the personal direction of Maj Rust.
>
> In a telephone conversation between Maj Friend and Maj. Rust regarding the best approach to this problem, it was explained to Maj Rust that incidents of this type (called angels hair) have been reported numerous times during the last ten years. Maj Rust was advised to collect samples of this substance

Five samples were collected and submitted to the Chemicals and Materials Laboratory at Robbins AFB The Laboratory Report (Project NR· C-785) notes that analysis included "Spectiographic analysis of all samples, or the aqueous or acid extractions of the samples. Wet chemical analysis of samples for non-metal elements " The results were that no unusual elements were identified in the samples with the exception of high amounts of silver in one and some silver in three others The report concludes, "It is a good possibility that cloud seeding with a silver salt could have caused the phenomenon."

Entre Ríos Province, Argentina, January 17, 1963. A "formation" passed over Entre Ríos that was seen to discharge angel hair Observers recovered vitreous particles that had fallen, and a subsequent analysis of these found them to consist of "an amalgam of silicon, boron, calcium, and magnesium" (Creighton, 1965)

Ste. Anne, Manitoba, Canada, September 18, 1968. Farmer Marius Magnan witnessed three dull metallic, gray, football-shaped objects at an estimated altitude of 2,500 feet and at a distance of 2 miles He stated the objects were equidistant, traveling northwest to southeast in a vertical orientation at a tremendous speed that he could not determine.

The objects were discharging a white substance from the upper surface "just like popcorn, popping from a corn popper." Magnan said that this substance streamed upward from the first two objects, forming an arc between them that was "white as steam" and remained stable despite rapid velocity. The substance emitted by the third object did not interact with the first two, rather cascaded down the sides and floated to the ground. Following the disappearance of the objects, a white, fibrous substance began to fall, settling on foliage, buildings, and power lines. A sample was analyzed by the University of Manitoba (Hairy material, 1969)

> The University of Manitoba conducted an infrared spectroscope analysis of white fibrous material which fell on a farm in Manitoba from the sides of a UFO on September 18, 1968 The material was found to be cellulose like and unstable, with a uniform fiber diameter of one two-hundredth millimeter [5 microns]

The substance was determined to be rayon coated with a gummy substance.

Houston, Texas, November 6, 1968. Two teenage boys reported a disc-shaped UFO, said to be 200 feet in diameter, discharge angel hair Gene Senter, then president of the Houston Science Discussion Club on UFOs, investigated and recovered a twig with angel hair that was placed in a plastic bag and then frozen

On December 20, 1968, the *Houston Post* reported (Gribble, 1988)

> A chemical analysis had failed to identify a substance resembling angel hair which was found six weeks ago in the Spring Branch area. The substance floated to earth shortly after two teenage boys said they saw a UFO hovering in the air on November 6 David Wuliger, a professor at the University of Houston said a chemist analyzed the substance in the laboratory of a multi-million dollar petroleum industry company Wuliger stated that the substance would not dissolve in water, alcohol and sulfuric acid, among other things Microscopic and tactile examination indicates the substance is fibrous, elastic, relatively strong, somewhat sticky and white in color

Sudbury, Massachusetts, October 22, 1973. June Margolin (with a background in biochemistry) was alerted to an unusual web fall by her son In addition to the falling web-like substance, she observed a shiny globe or ball-shaped object Interviewed by NICAP investigator Charles Valentine, she stated, "When I first noticed it, I had a feeling that it wasn't really all that far away and it was like a ball of shiny molten something or other" Angel hair fell in large amounts, draping trees and telephone lines Margolin collected a sample that was placed in the refrigerator, yet the substance still dissipated into strong white threads According to her, "they were extremely strong," and "more like nylon" (*Weston (Mass.) Fence Viewer,* 1973).

UFO investigator Raymond Fowler began an immediate investigation, and the University of Massachusetts field station examined a sample Microscopic examination determined that it was not spider webs There was not enough material to conduct a wet chemical analysis, so the remaining substance was subjected to mass spectrometer, thermal gravimetric, X-ray fluorescence and diffraction analysis by multiple laboratories

An X-ray spectrum taken using an Edax system at 20 kev indicated sodium, aluminum, silicon, sulfur, chorine, potassium, calcium, iron, nickel Another analysis was done with a CEC 21-104 mass spectrometer, which indicated potassium, silicon, calcium, and phosphorus as major inorganics, with aluminum, oxygen, chlorine, iron, sulphur, and manganese in smaller amounts The substance was 95% organic (unidentified), and 5% inorganic

Yet another analysis (method unknown) indicated that "the sample immediately charred and molecules of the following mass numbers were detected 16, 18, 26, 28, 44 and some heavier species This would indicate compounds such as methane (CH_4), water (H_2O), carbon monoxide (CO), nitrogen (N), ethane (C_2H_6), butanes, propanes and higher organics " (Fowler, personal files)

Examination by electron microscope at 5000X indicated the smallest fibrils were 25 microns and were smaller than asbestos fibrils The fibers were surrounded by a transparent matrix and were said to change in size over time. Fowler (1981, p 104) states that, as in many other cases, "Not one of the laboratories could identify the source of the material in question."

Midway, Texas, October 23, 1973. The day following the Sudbury case, Bonnie Callier observed two metallic cigar-shaped objects Retrieving a camera, she was able to photograph one of the objects. Approximately 20 minutes later, she observed migrating monarch butterflies becoming entangled in "sheets of a web-like substance" falling to earth A grapefruit-size sample was retrieved from a mesquite tree, wrapped in wax paper, and stored in a box Twenty years later this material was sent to the University of Texas at Austin for analysis, where it was analyzed by two engineering students (Turner & Wong, 1994)

The Nuclear Research Facility performed an alpha-beta-gamma nuclear particle test, and determined the material was not radioactive. A neutron activation survey indicated high concentrations of sodium, potassium, zinc, and lanthanum, a rare-earth element (see Table 1)

Table 1. Neutron Activation Results for Unidentified Sample

Element	Concentration (ug/g)	Element	Concentration (ug/g)
As	< 5	La	9 8
Ba	< 190	Na	5,700
Co	1 3	Sb	< 4
Cr	< 32	Sc	< 0 1
Cs	< 1	Se	< 20
Eu	< 0 5	Sm	< 0 5
Fe	200	Th	< 2 0
Hf	< 0 5	Zn	3,300
K	3,490		

Observation with an optical microscope indicated an index of refraction estimated to be 1 55 Electron microscopic examination at 3500X showed the smallest fibril to be 0.1 micron The material had a physical resemblance to spider capture silk

Amino acid tests were performed on cleaned samples using a derivatizer-analyzer system model 420H The results of this test were compared to known orb spider silk (see Table 2)

The conclusion reached was that the sample was spider silk produced by a cribellar spider However the presence of zinc and lanthanum was unexplained and probably contamination

Sonora, California, October 12, 1976. Multiple independent witnesses were drawn outside by an unusually loud noise like "six jets." They observed a large red oblong UFO hovering with a wobbling motion. After approximately five minutes, the UFO shot off in an upward arc, disappearing in one second The following morning, sev-

Table 2. Amino Acid Compositions of Unidentified Sample and Orb Spider Silk

Amino Acid	Unidentified Sample Mol (%)	Orb Spider Silk Mol (%)
Aspartic	6 98	6 00
Glutamic Acid	7 01	7 30
Serine	11 91	9 81
Glycine	23 17	24 79
Arginine	3 05	2 65
Threonine	5 05	4 92
Alanine	19 11	14 39
Proline	2 25	8 78
Tyrosine	3 22	2 74
Valine	5 45	4 98
Methionine	0 84	—
Isoleucine	3 11	2 75
Leucine	5 80	4 69
Phenylalanine	2 44	1 92
Lysine	0 63	3 31
Histidine	—	0 97

eral angel hair samples were found and subsequently analyzed by David Miletich at the University of Chicago The samples were found to be "whitish, fibrous material of uniform composition being quite fine with frequent branching" (Hendry, 1977) The primary constituents were chiefly carbon and nitrogen Miletich concluded that it was not spider web

A sample tested at the Michael Reese Hospital Microbiology Lab showed the sample to be sterile, not even showing common *Pseudomonas* bacteria after culturing in a growth medium A crystal and liquid scintillation test showed the sample to be contaminated with a low level of radioactive tritium Tritium is a radioactive isotope of hydrogen that can be produced in nuclear reactors or particle accelerators It was suggested that the contaminated sample could have been "exposed to some sort of nuclear fission, fusion or annihilation event "

Quirindi, New South Wales, Australia, August 10, 1998. At least four witnesses reported "20 silver balls" performing very complex maneuvers. Angel hair was seen to stream from the objects during acceleration and right-angle turns Witnesses reported the angel hair appeared to consolidate into long, white strands that slowly fell to earth, draping on telephone lines and trees It was described as white, cotton-like and strong, requiring a good tug to break, but quickly sublimated to nothing upon handling (Chalker, 1998, *USA Today,* 1998)

A sample was placed in a clean yogurt container sealed with plastic wrap and sent to researcher Bill Chalker for analysis When received, the sample had shrunk to the size of a match head The substance was then sampled through the plastic wrap with an eppendorf syringe to determine if there was a gas phase present, but none was found (Basterfield, 2001)

Video microscopic imaging showed the substance to be identical to a control sample of spider web, however, it was noted that the witness had added additional material to the sample that was possibly spider web This is known to have occurred in several cases

Esperance, Western Australia, June 9, 1999. A huge fall of "white filamentous threads" covered hedges, trees and power lines The fall may have covered up to 10,000 square kilometers Some strands were thirty feet in length (also described as four and a half meters) According to angel hair researcher Brian Richards (personal communication), witness Marilyn Burnet had a sample analyzed

> I had some of that sample analyzed spectrographically and with electron microscopy Copper, aluminum, zinc, iron, sodium, manganese, silicon and a number of other minerals were found in it, which eliminated the spider's web theory

Alessandria, Italy, October 18, 2002. A fall of angel hair covered a large area including roofs, cars, and trees A sample was recovered in a sterile container and examined by the Consiglio Nazionale delle Ricerche (CNR) in Parma using a stereomicroscope in clear field, dark field, with direct light and reflected light at 70x.

Analysis by CNR indicated that the substance (Izakovic, 2003).

> unequivocally showed that the filaments were not of biological origin but that they were similar to textile fibers, of non-vegetable type (as cotton is), synthetic (as rayon) Particularly, said filaments presented clear alternation of bright and more dark [sic] segments and the presence of segments, but not in constant intervals, that were able of refracting the light, this last is typical of synthetic polymer textile fibers

This conclusion was disputed by the Agenzia Regionale per la Protezione Ambientale (ARPA) in Turin, which proclaimed the material to be spider web But investigator Riccardo Cart commented on ARPA's analysis·

> The technicians of this institution [ARPA] have passed judgment that the filaments are nothing else tha[n] spider web that is produced by a special species of ground spiders, however in these articles were not given any technical details or supplied tests that supported such declaration

Cart concludes with.

> The important thing is that their opinion [CNR] was absolutely in conflict with that ARPA gave from that what they were able to observe they have arrived at the conclusion that it was not a biological compound, but a synthetic fiber (that they were not able to identify using available instruments)

Conclusion

Angel hair has been observed and collected for well over 100 years, but only analyzed in some depth in the past 50 or so years Although some samples seem to be identified as spider web, other samples were not so easy to attribute to a known source.

Flammability and small fibril size seem to be reported in enough instances to be considered characteristic of the phenomenon Past analyses have concentrated more on the elemental as compared to the molecular composition of the samples. More contemporary methods, such as Fourier Transform Infrared Spectrometry and gas chromatography, have begun to shed light on the molecular composition of angel hair, but there is no widespread consistency that has been found across the unidentified samples, which adds to the puzzle of angel hair

A relationship between angel hair and the UFO phenomenon exists primarily from witness testimony, beyond this, the enigmatic nature of angel hair persists Accordingly, if and when the opportunity presents itself, new samples of angel hair will deserve a close scientific analysis with the most powerful analytic methods available

Thanks to Mark Rodeghier, Stuart Appelle, Frank J Reid, and Phyllis Budinger for their patient and professional assistance

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ANALYSIS OF ANGEL HAIR SAMPLES

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ABSTRACT Analytical data concerning the chemical composition of angel hair are presented from four different events that were analyzed by this laboratory These data probably represent a summation of what is known to date regarding this substance Angel hair appears to originate from a biological source that is not yet identified This fibrous material is very close to fibroin generated by caterpillars and spiders It is emphasized that considerably more analyses are needed to further elucidate the mystery of angel hair

The source of angel hair has not yet been determined This is mainly because quality analytic data on previous samples have been rare However, there have been a few analyses done in the past that contain very reliable data pertaining to the molecular structure of the fiber

Haaland and colleagues at Oak Ridge National Laboratory conducted an amino acid analysis on angel hair retrieved from a fall in Sudbury, Massachusetts, on October 22, 1973 (Haaland, Holleman, & Welch, 1975) A UFO was observed concurrent with the fall They found the sample "compatible with the conclusion that the material was the web or silk of a ballooning species of spiders "

Turner and Wong (1994) also came to the same conclusion in their excellent analysis of angel hair from a fall in Midway, Texas, that occurred just one day after the Sudbury event, on October 23, 1973 This latter event coincided with multiple UFO sightings The analysis was done 20 years afterwards and employed a variety of tests, including amino acid analysis

An analysis done in Australia of another angel hair drop after a UFO passed over Victoria in October 1953 concluded that "the substance consisted of a nylon-like amorphous mass with traces of magnesium, calcium, boron, and silicon " The elements were probably environmental debris, e g , dirt or dust Unfortunately the laboratory and analytical tests employed are not identified in this report (Basterfield, 2001)

There have been misleading analyses reported, which has complicated matters Most common are the reports that rely solely on one analytical test, such as elemental analysis, to hypothesize the angel hair source One example was the angel hair event on October 27, 1954, in Florence, Italy, where a UFO was also sighted Elemental analysis showed boron, silicon, magnesium, and calcium From these data it was

speculated that the composition is similar to borosilicate glass (Stevens, 1976, pp 56–57) However, it seems evident that the analysts were observing trace elements from environmental debris, such as dirt and dust, which clings to the sticky surfaces of the angel hair, rather than the angel hair itself Prior to SEM/EDS elemental instrumentation, and still today, many of the instruments used for elemental analysis are usually set up with a limited window of detection That is, for some X-ray fluorescence data usually only elements between atomic numbers of sodium (Z=11) and lead (Z=82) are detected Carbon (Z=6), nitrogen (Z=7), and oxygen (Z=8), the principal elements of angel hair (see below), will not be detected The lessons are that elemental analysis does not tell how molecules are put together, and one needs to understand the limits and capabilities of the instrumentation used

The samples studied for this report represent materials from a variety of sources, with some having a reasonable probability of being related to UFO activity A UFO was observed to be simultaneous with one fall In another fall, a loud droning noise of unknown origin was heard, and the sample turned in part to a gel-like substance

A variety of analytical tests were employed, and the report is arranged by test type Descriptions of these tests can be found in the Appendix Not all of the same tests were employed for each sample for various reasons

Samples

Each sample had at least one of the attributes characteristic of angel hair No spiders or spider eggs were noted on microscopic examination on any of the four samples The sample from Los Gatos had no visible surface material, such as droplets. Two samples (Sacramento and Burlington) were promptly received after the event and tightly sealed so that any volatiles could be examined Additionally, the Burlington sample was observed to turn to "goo" on sampling A trace of angel hair remained The Shenandoah sample is the only one analyzed in which a UFO was also observed at the time of the fall. Photographs of the sites are included when available. Pertinent tests were done which hitherto had not been performed on recovered angel hair

Other angel hair samples received by this laboratory are not included in this report for a number of reasons Microscopic analysis clearly indicated spider eggs in one sample In other cases nothing unusual was linked to the fall, such as a UFO sighting, angel hair sublimation, and/or the analytical results did not reveal any unique anomaly

Angel hair collected October 19–20, 1977, Los Gatos, California. Two stored angel hair samples in tight glass containers were found November 1998 in the attic of John Timmerman of CUFOS They had been stored for a number of years The samples are from the same event, though documentation does not indicate any details of the case One sample is clearly identified as originating from the late, well-known ufologist Paul Cerny and has a handwritten note from him This handwriting matches that of the other sample. And the information indicates the samples were obtained at roughly the same time (October 19–20, 1977) and location (Los Gatos, California) Timmerman's discovery of these samples provided my first opportunity for analysis of angel

hair No photographs of the site were available, but photographs of the samples as received by this laboratory in December 1998 are included (see Figures 1 and 2)

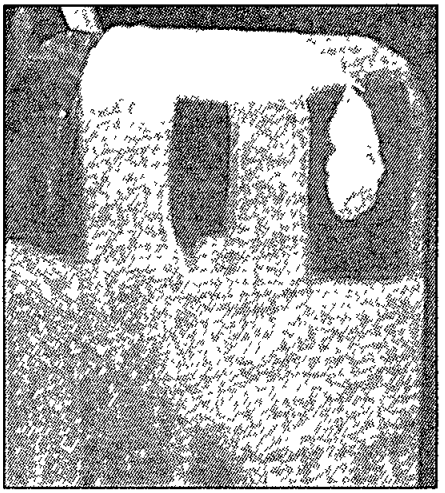

Fig 1 Angel hair collected October 20, 1977, daytime Photograph by John Timmerman

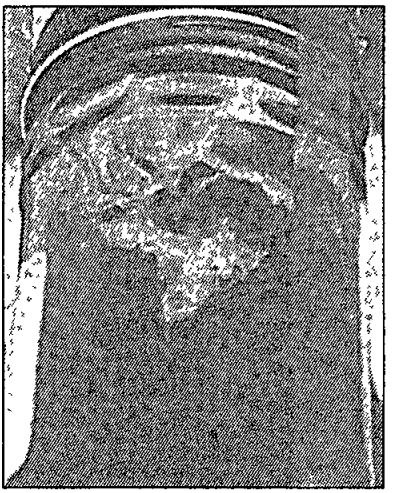

Fig 2 Angel hair collected October 19, 1977, before dark Photograph by John Timmerman

Angel hair found 30 miles north of Sacramento, California, on I-5, November 11, 1999. Thomas Brewer was driving on Interstate 5 about 30 miles north of Sacramento on his way to Alaska He observed strings of fiber-like material of varying lengths (from a few inches to 50 feet), floating at different elevations This continued for approximately 10–15 miles, when he noticed some of it on the highway shoulders, trees, signs and lawn He collected samples of the material and noted the material diminished in size over a period of time Brewer took photographs of the material at the site of the fall (see Figures 3, 4, and 5) No other unusual phenomena were noted in the sky, and there were thin, wispy clouds overhead Angel hair researcher Brian Boldman forwarded three samples of the material to this laboratory in January

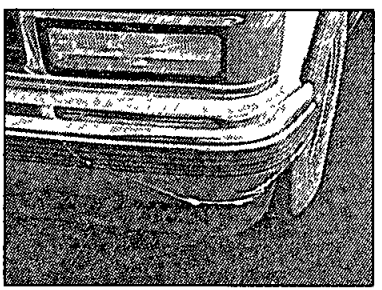

Fig 3 Angel hair on Brewer's truck

Fig 4 Angel hair on pavement (Cassette tape for size estimate)

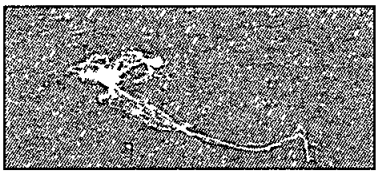

Fig 5 Angel hair on pavement

2000 Other documentation of this event appeared on Art Bell's website at www artbell com/stringy html, which is no longer online (see Brewer, 2000).

Angel hair deposited in Burlington, West Virginia, September 19, 2000. On the morning of September 21, 2000, Retha Rutherford found white fibrous "spider-web"–like material in her yard. It did not look like the usual rope-like angel hair, as in the Sacramento case above. She took several pictures and her husband sampled the material (see Trainor, 2000, for a case description). Mrs. Rutherford reports, "When trying to collect the samples of the stuff it turned to a clear goo somewhat like the slimy stuff you see when you cut okra." On the previous night at approximately 7 00 p m she heard a loud "droning" sound, similar to that from a large airplane This sound lasted about an hour, yet the source of the sound was not visually obvious. Subsequent to the droning sound, their dog became ill and vomited Mrs Rutherford also experienced a severe sinus attack Samples were received by this laboratory via Nancy Talbott on September 28, 2000. See Figures 6 and 7

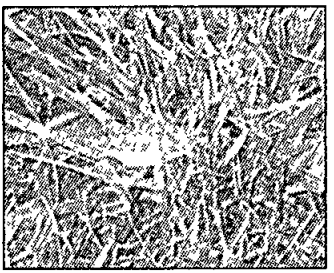

Fig 6 Close-up of angel hair clump

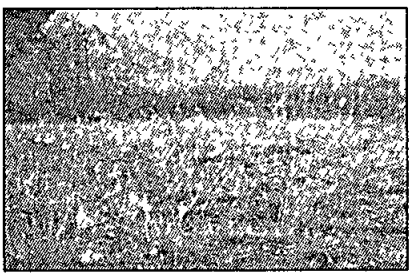

Fig 7 Angel hair in Rutherford's yard

White fibrous material observed falling from the sky in Shenandoah, Iowa, October 4, 1981. On Sunday, October 4, 1981, between 12 30 and 6.00 p m , globs of white, fibrous material were observed floating from high in the sky There were copious amounts, and it was floating in giant spirals. It stuck to trees, bushes, and telephone wires, everywhere in town and the surrounding country An intriguing coincidence about this angel hair sample is that at 12·30 p m. a UFO with the appearance of a silver dollar was sighted It was in view for approximately one minute and was about 60° above the horizon It appeared to stand still, then suddenly sped up and disappeared. It was a bright day with a clear sky. The witnesses completed report forms that are the only known documentation This laboratory received samples on July 16, 2001, via Nancy Talbott No photographs are available from this event

MICROSCOPIC ANALYSIS

All samples were examined with a Leica GZ6 stereomicroscope interfaced to a Kodak Digital Science MDS 120 camera. The powerful SEM microscope was used on the Los Gatos sample only and was more revealing [1]

The SEM analysis of the Los Gatos sample shows the angel hair fibers appear as bundles of fibers rather than single strands like spider webs This is dramatically apparent in the photograph in Figure 8

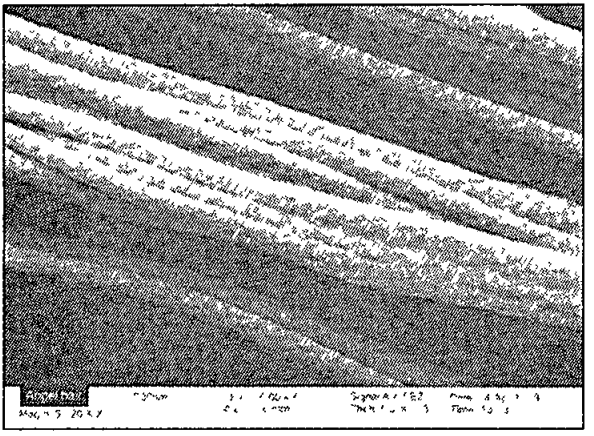

Fig 8 Angel hair bundles from SEM image

The individual strands are also thinner (170–270 nanometers, or 0 17–0 27 microns) than typical spider web (370–640 nanometers, or 0 37–0 64 microns) Ko, et al , 2001, contain data that show variances in the diameters of spider silk Most silk strands have a diameter of only a few microns, however many strands can be less than one micron Both Ko (2001) and Foelix (1982) report silk from cribellate spiders as fine as 0 01–0 03 microns The angel hair samples do not appear to have tiny adhesive droplets adorning the fiber, common in some spider webs But it should be noted that spiders produce different types of silk, which have varying properties depending on the desired use *Spider Facts* (2006), published by the Explorit Science Center in Davis, California, lists some of the uses as wrapping or ensnaring prey, holding egg sacs, and traveling with wind currents The latter use is called "ballooning " Not all webs have droplets [2] Photographs of angel hair and spider web at 10 microns and 300 nanometers are shown in Figures 9 through 12

Stereomicroscope photographs obtained (60x) of the Sacramento, Burlington, and Shanandoah samples are very similar Observed are very fine fibers, of which most

[1] When this sample was received, Frontier Analysis had access to a SEM Microscope from another laboratory After 1999 it was no longer available

[2] See more information on spider web at www xs4all nl/~ednieuw/Spiders/InfoNed/webthread html

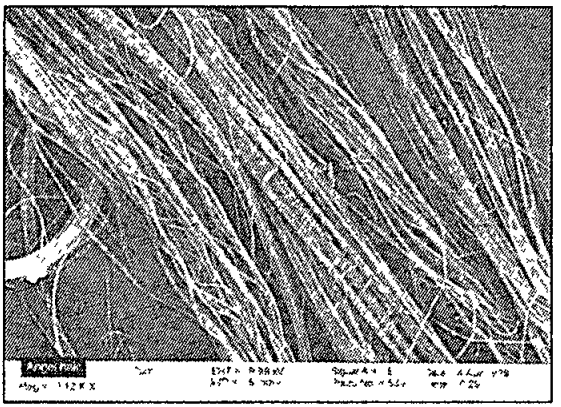

Fig 9 Angel hair (10 microns)

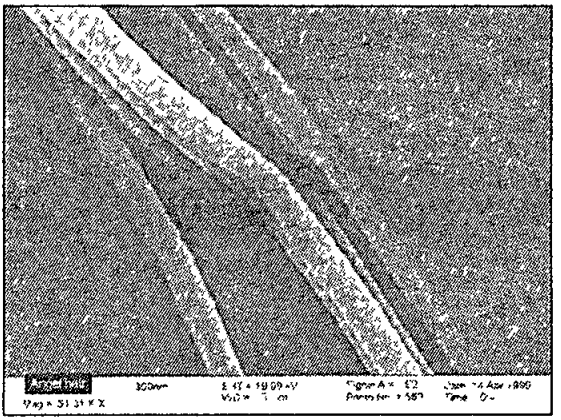

Fig 10 Angel hair (300 nanometers)

are bundled in a rope-like fashion similar to the Los Gatos angel hair. A few singlets are observed and are of very fine denier, probably less than 1 micron There are tiny droplets on these samples, which are difficult to observe at this magnification They are more easily viewed on the single strands A few of these single strands are noted with white arrows (see Figures 13, 15, and 16)

Infrared analysis

Infrared analysis provided information on the molecular structure of the angel hair fibers for all four samples. Analysis was done on the Nicolet Avatar 360 FT-IR spectrometer using the Harrick SplitPea sampling accessory (Keller, 1986) Additional spectra were obtained from the Sacramento sample over a four-month period to check for decomposition Also, the same sample was weighed periodically for 48 days to check for weight loss

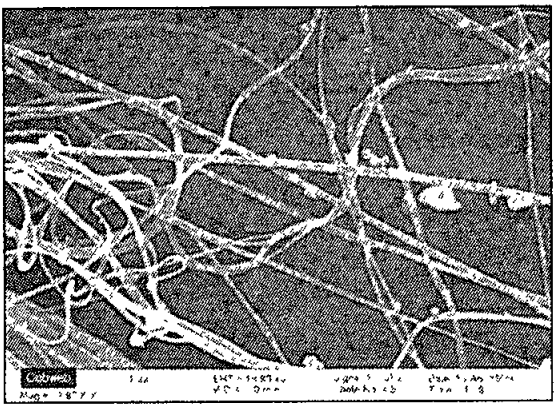

Fig 11 Spider silk (10 microns)

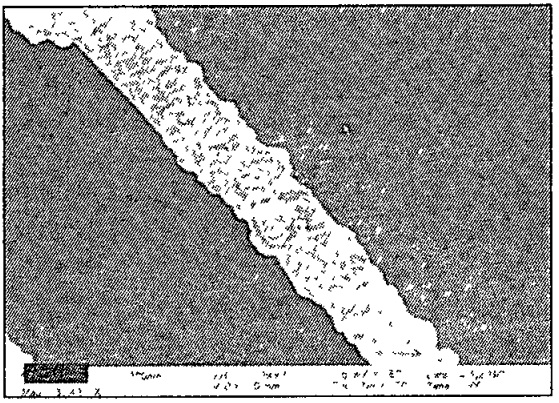

Fig 12 Spider silk (300 nanometers)

Fig 13 Angel hair (Sacramento)

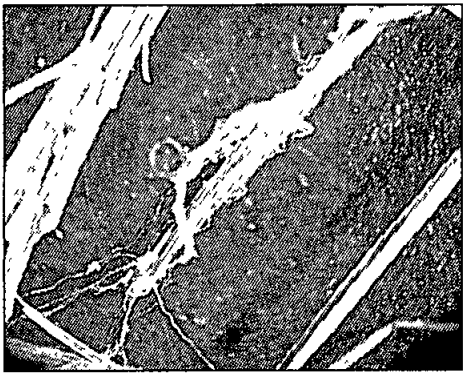

Fig 14 Angel hair on weed (Burlington)

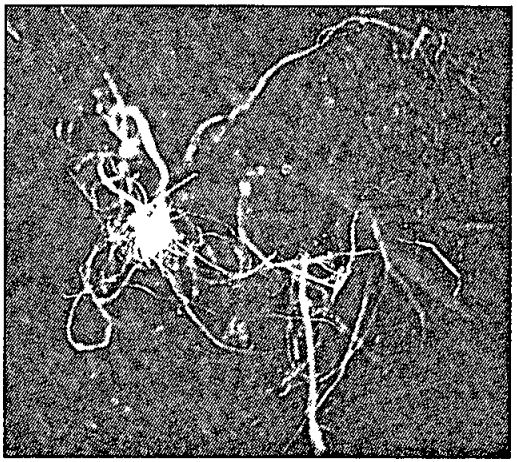

Fig 15 Angel hair clump (Burlington)

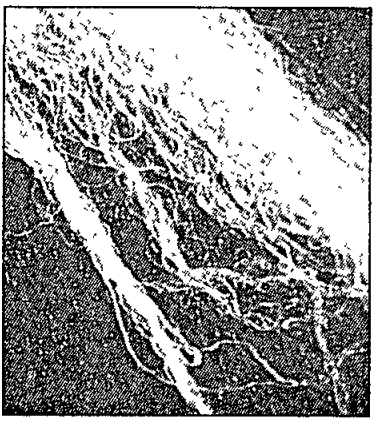

Fig 16 Angel hair (Shenandoah)

Angel hair from all four events produce nearly identical spectra, which indicate they all have a similar molecular composition (see Figure 17) The infrared spectra show prominent absorption bands due to N–H (3700–3000 cm^{-1}) and secondary amide C=O (1650–1600 cm^{-1}) and CNH (1580–1470 cm^{-1}), as well as other weak to moderate bands that identify the strands as a protein material. Additionally, there are very weak bands due to an ester C=O (1723 cm^{-1}) and CH_2 (2922 cm^{-1} and 2850 cm^{-1}) in two samples due to a very small amount of ester with long alkyl chains coating the fiber (see the following section on chloroform extracts for further analysis of the ester) The spectral bands are very similar to those from spider silk, tent caterpillar silk, and processed silk (silk scarf) Figure 18 contains reference spectra from a silk scarf, caterpillar silk, and spider silk for comparison

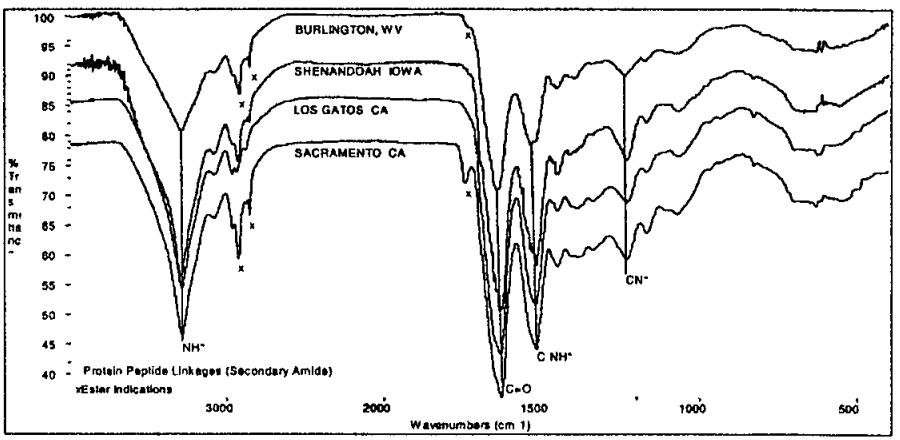

Fig 17 Infrared spectra of Burlington, Shenandoah, Los Gatos, and Sacramento angel hair

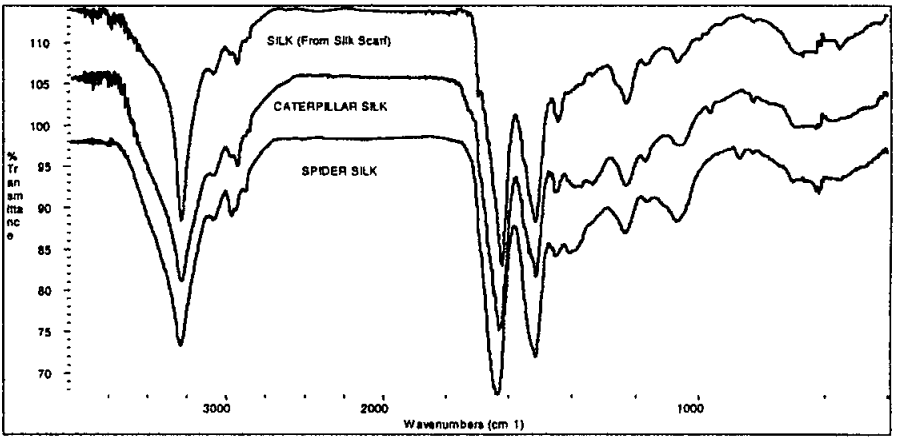

Fig 18 Reference infrared spectra of spider silk, tent caterpillar silk, and silk from a silk scarf

Several spectra of the Sacramento angel hair fiber taken over a four-month period show no differences This indicates no deterioration of the sample occurred Additionally, weights from this sample taken over a period of 48 days reveal no evidence for weight loss

Chloroform Extracts

Angel hair fiber is insoluble in chloroform Chloroform extractions were done on two samples to analyze any extraneous surface material, e g , the ester indicated to be present in the previous infrared analyses Infrared spectra were obtained from the extracts The Los Gatos and Sacramento samples were analyzed because ample amounts were available to perform the extractions

Infrared analysis of the chloroform extract of the Los Gatos angel hair shows both weak ester C=O (1732 cm^{-1}) and carboxylic C=O (1712 cm^{-1}) and spectral patterns typical of a CH_2 in long carbon chain (2980–2750 cm^{-1} and 720 cm^{-1}) There were

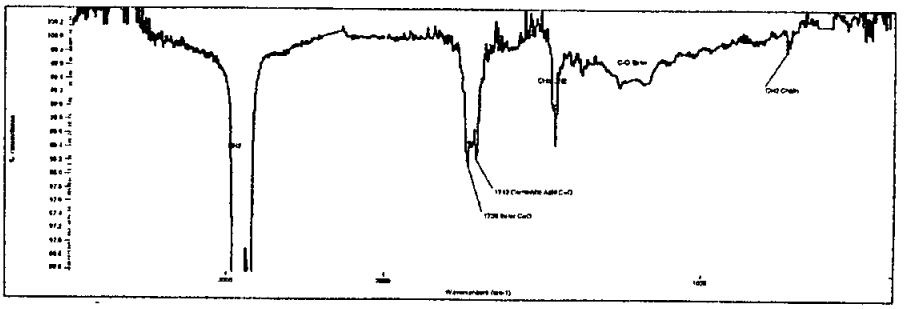

Fig 19 Infrared spectrum of Los Gatos chloroform angel hair extract

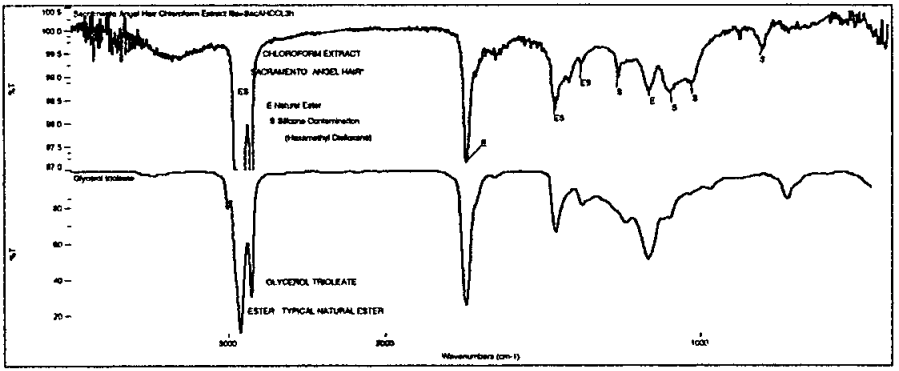

Fig 20 Infrared spectra of Sacramento angel hair chloroform extract (top) and reference of a glycerol triester (bottom)

only trace amounts of these materials, and their low concentrations did not permit more specific identifications It is unknown if these components are contaminants or components coating the fiber (see Figure 19)

The Sacramento angel hair extract shows an ester C=O band (1745 cm^{-1}). An infrared spectrum of the extract more specifically suggests the ester is similar to a glycerol ester with long hydrocarbon chains, which is a typical natural ester Also detected is a silicone contaminant, which is an additive from the rubber stopper used to seal the angel hair container. Spectra of the angel hair extract and a reference of a glycerol triester are displayed in Figure 20

EDS ENERGY DISPERSIVE X-RAY SPECTROSCOPY ELEMENTAL ANALYSIS

SEM/EDS elemental analysis was only done on the Los Gatos angel hair. The advantage of SEM/EDS analytical elemental analysis is that the elemental window of detection is much wider than in some other instrumental approaches For example, SEM/EDS can detect elements with atomic numbers as low as carbon (Z=6), nitrogen (Z=7), oxygen (Z=8), and most other elements of the periodic table

The Los Gatos angel hair elemental analysis supports the infrared data by showing major elements to be carbon, nitrogen and oxygen (see Table 1) These elements, and their concentrations, fall within the range of protein amide biological substances Very low levels of sodium, silicon, sulfur, and possibly chlorine are also indicated The latter elements are most likely due to trace environmental contaminants

Table 1. Atomic Concentration (Percent), Los Gatos Angel Hair

C	N	O	Na	Si	S	Cl
64 0	15 2	19.2	0 8	0 6	0 2	0 1

HEADSPACE GC–MS ANALYSIS

Samples from Sacramento and Burlington were sent to another laboratory for headspace GC/MS analysis These samples were acquired immediately after the event and tightly sealed in vials and Ziploc bags in an attempt to trap any volatile materials possibly emitted by the samples The other two samples were analyzed years after the events and any volatiles would have long ago escaped from their containers

Headspace volatiles from a tightly sealed vial containing the fresh sample from the Sacramento event were carefully sampled and examined before any outside air could be introduced This analysis shows primarily a light hydrocarbon mix consisting of 2-methylpropane (C_4H_{10}), 2-methyl-1-propene (C_4H_8), 2-methyl-1-butene (C_5H_{10}), 2-methylpentane (C_6H_{14}), 3-methylpentane (C_6H_{14}), hexane (C_6H_{14}), 2,2-dimethylpentane (C_7H_{16}), two C_6H_{12} (MW=84) hydrocarbon structures (specific isomers unidentified), and one C_8H_{16} hydrocarbon (MW=112) (specific isomer unidentified) These hydrocarbons are most likely exhaust contamination from the witness vehicle which was parked nearby Also indicated are carbonyl sulfide (COS) and carbon disulfide (CS_2). Traces of heavier hydrocarbons are present such as eicosane ($C_{20}H_{42}$) and tricosane ($C_{23}H_{48}$) None of these materials were detected in a blank run for comparison to the sample headspace Other components are not from the sample because they are also in a blank or contamination For example, silicon-containing components are probably column bleed from the GC analysis, and some are contaminants from the rubber-stopper additives also detected in the chloroform extract of this sample The detailed information, i e , GC chromatogram retention time with peaks as identified by MS, is shown in Table 2 The quality of the data search is also displayed

The headspace GC/MS results of the Burlington angel hair sample are most interesting In discussing these results the sampling of the angel hair first needs to be described A rubber glove was used to pick up the sample The rubber glove was turned inside out and sealed in a Ziploc bag (inner bag) This bag was in turn sealed in another Ziploc bag (outer bag) GC/MS data were obtained first from the outer bag (two runs), the inner bag, and inside the glove

A number of components are related to the sample These are identified as primarily a mixture of fatty acid amides Some closest hits in the MS search files specifically suggest the following amide-type components 4-methylpentanamide ($C_6H_{13}NO$), hexadecanamide ($C_{16}H_{33}NO$), dodecanamide ($C_{12}H_{25}NO$), and n-tetradecanoic acid amide Also detected at much lower levels were some heavier hydrocarbons such as eicosane ($C_{20}H_{42}$) and 2-methylhexadecane ($C_{17}H_{36}$) The eicosane was also detected in the Sacramento angel hair sample All of the components detected are higher molecular weight materials, which are solid at room temperature, though with enough vapor pressure to be detected by GC-MS It is suspected many of the lighter materials (if present) were lost in the sample transferral and because Ziploc bags would not be expected to confine volatiles for very long There are a number of components that are attributed to the system blank or consid-

Table 2. Headspace GC/MS Results, Sacramento

Retention Time (min)	Qual	Blank System Check	Qual	Head Space above Angel Hair in Vial
3.8		Air		Air
4.0		Air (mostly N_2)		
4.1			**78**	**carbonyl sulfide (COS)**
4.3			**47**	**2-methylpropane**
4.4			**91**	**2-methyl-1-propene**
5.3			**59**	**2-methyl-1-butene**
5.6	91	dichloromethane	95	dichloromethane
5.8			**9**	**carbon disulfide**
6.4			**49**	**2-methylpentane**
6.7			**87**	**3-methylpentane**
7.0			**91**	**hexane**
7.6			**64**	**2,2-dimethylpentane**
7.7			**90**	**C_6H_{12} (MW=84) methylcyclopentane**
8.5			**81**	**C_6H_{12} (MW=84) methylcyclopentane**
9.8			**10**	**C_8H_{16} (MW=112) 2,4,4-trimethyl-1-pentane**
12.8	45	hexamethyl-cyclotrisiloxane	64	hexamethylcyclotrisiloxane
18.1	38	octamethyl-cyclotetrasiloxane	72	octamethylcyclotetrasiloxane
20.7			9	Tert-butyl (trimethylsilyl) (amino)chloro(penta-fluorophenyl)borane
22.5			47	decamethylcyclopentasiloxane
26.9			53	dodecamethylcyclopentasiloxane
36.1	38	hexamethyl-cyclotrisiloxane		
39.4			*70*	***Silicone grease***
39.8	14	1 3,5,7 9,11-hexaethylbicyclo [5 5 1]hexasiloxane		
46.8	25	tetracosamethylcyclo-dodecasiloxane		
	64	octadecamethylcyclo-nonasiloxane		
48.9	38	tetracosamethylcyclo-dodecasiloxane		
50.7			**90**	**eicosane**
54.3			**89**	**eicosane**
56.4			37	octadecamethylcyclononasiloxane
57.0		Silane	53	
58.6			**89**	**tricosane**

Qual = quality of the search [0 ⟶ 100 (best)] Code Smaller point size for materials attributed to the blank or unrelated to the sample, bold-italic, smaller point size for suspected contaminants from sample packaging bold, larger point size, for materials related to the sample

ered unrelated to the sample Most contain silicon and are due to contaminants which are most likely from the glove They are most concentrated in the sampling from the inner bag and the glove Table 3 contains information on GC retention time, MS peak identifications, and search quality (Note The data from both runs of the outer bag are combined)

Table 3. Headspace GC/MS Results, Burlington

Retention Time (min)	Qual	Blank System Check	Qual	Outer Bag (1st run + 2nd run)	Qual	Inner Bag	Qual	Inside Glove
4 5		Air		Air		Air		Air
4 9		Water		Water		Water		Water
19 7			*83*	*siloxane (Hexamethyl-cyclotrisiloxane)*	*83*	*siloxane (Hexamethyl-cyclotrisiloxane)*	*83*	*siloxane (Hexamethyl-cyclotrisiloxane)*
24 2							9	**N,N'-bis(N-butyl) ethylenediamine**
25 4					*12*	*methyltripropoxy-silane*		
28 2					50	**nonanal**	38	**1-ethyl-2-pentyl-cyclopropane**
28 22	80	2-ethyl-hexanoic acid	64	2-ethyl-hexanoic acid				
29 8							*9*	*7-trimethylsilyl methylene-bicyclo [3,3,0]octan-2-one*
30 0					*9*	*trimethyl-3-penten -2-yl-silane*		
34 4					*39*	*trimethylsilyloxime (trimethylsilyl ester derivative of 3,5-dioxo octanedioic acid)*	*40*	*trimethylsilyloxime (trimethylsilyl ester derivative of 3,5-dioxo octanedioic acid)*
38 3		siloxane						siloxane
42 4			50	**4-methyl-pentanamide**	43	**hexadecanamide**	50	**dodecanamide**
42 8			59	**hexadecanamide**	37	**hexadecanamide**	59	**dodecanamide**
43 5			30	**eicosane $C_{20}H_{42}$**			59	**n-tetradecanoic acid amide**
44 3			16	**2-methyl-hexa-decane**			64	**n-tetradecanoic acid amide**
44 4			86	**dodecanamide**	80	**hexadecanamide**		
55 8			86	**hexadecanamide $C_{16}H_{33}NO$**	72	**n-tetradecanoic acid amide**		
57 0	14	9-octadecenoic acid m/z 239 56		in blank (m/z 239, 56)				

Qual = quality of the search [0 ⟶ 100 (best)] Code Smaller point size for materials attributed to the blank or unrelated to the sample, bold-italic, smaller point size for suspected contaminants from sample packaging, bold, larger point size, for materials related to the sample

Conclusions

Angel hair fibers examined from four events by this laboratory are chemically identical and identified as a polymer containing protein-amide type linkages Also coating the fiber is a natural long chain fatty ester type material, in some cases visually apparent as droplets These data suggest that angel hair originates from a biological source However, the specific source remains unidentified, though it is most similar to fibroin excreted by caterpillar or spider It is difficult to differentiate angel hair fiber from spider and caterpillar silk [3]

Based on witnesses accounts, and limited analytical data, there are indications that the Shenandoah and Burlington angel hair falls are related to the UFO phenomenon. The Shenandoah fall/UFO association is largely supported by the multiple-witness accounts of UFO activity subsequent to the fall Unfortunately, the sample was analyzed 20 years after the event. The Burlington angel hair fall is especially interesting Not only is there a possibility of UFO activity, albeit not confirmed, there is also the report of a "goo" formation Headspace GC–MS analysis of the volatiles suggests the goo might be composed of an assortment of amide-containing materials. Could these be decomposition products of angel hair? And, the angel hair did not fall in long strands as is typical of ballooning spider falls, but instead fell in clumps

In comparison, there is no report of UFO activity for the Los Gatos and Sacramento angel hair falls, and no good analytical data to support an unusual source other than ballooning spiders Initially, analysis of these samples showed promise as having what was thought to be unique properties The Los Gatos angel hair fibers were extremely thin and no droplets were apparent However, the literature on spider silk demonstrates that its thickness can vary from micron to submicron levels, with some reported strand thickness very similar to the angel hair from Los Gatos Additionally, silk varies depending on spider use, and some silk does not have droplets The Sacramento sample was received soon after the event so that any volatiles due to possible angel hair sublimation products (though none reported) could be examined by headspace GC–MS analysis Indeed, it did appear unusual that light hydrocarbons were found in the tightly sealed sample. But these types of materials cannot be related to decomposition or sublimation of angel hair that is a protein type species and is highly nitrogenated It was obvious that the proximity of the witness's vehicle to the sampling area easily introduced exhaust contamination into the samples But these two samples were included to show some unique properties attributed to angel hair in the past may not be anomalous compared to spider and insect silk Therefore, such findings are not conclusive proof that a sample is anything but silk or silk-like material from a terrestrial source

It is also important to point out that none of these samples was from a case with a clear and definite association between the UFO phenomenon and the recovered angel hair Even in the Shenandoah case, the UFO was *not* seen to emit the angel hair

[3] Full analytical reports on these four incidents by the author are noted in the references Contact the author for more details

Nor did the angel hair in this and the Burlington case sublimate, as has been reported in the most intriguing incidents Thus, although the analyses reported here point to a naturally produced substance as the probable source for the samples, this shouldn't be taken as evidence that *all* angel hair has the same composition as these four

Recommendations

Clearly a broader database is required than the analyses completed to date to make a final determination about angel hair Most important is the need for angel hair from events coinciding with witnessed UFO activity More samples are needed from a variety of locations and from falls at different times of the year A predominance of data is from falls in the United States and in the month of October

Proper sampling is needed It should be done as soon as possible after the event. The samples should be placed in clean, well-sealed glass jars or vials. Ziploc bags are not recommended However, if used, the bag containing the sample should be enclosed in one or two other Ziploc bags

Proper analytical testing is required This analyst recommends a combination of tests, and some important tests include infrared analysis for molecular structure of the fiber and surface materials, SEM/EDS for microscopic and elemental analysis, headspace GC–MS for any volatile materials, and amino acid analysis to determine the mole percent amino acids comprising the fiber and comparing the results to known compositions of caterpillar and spider silks Besides an analytical chemist, other scientists experienced in various disciplines should also examine the data, e g , entomologists and arachnologists

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Appendix
Definitions of the tests used in this analysis

EDS (Energy Dispersive X-ray Spectroscopy): X-ray fluorescence identifies elements and their semiquantitative amounts. Samples are stimulated with X-rays that cause them to emit X-ray fluorescence radiation This emitted radiation is resolved into a spectrum characteristic of each element. This EDS system can be interfaced to an SEM (scanning electron microscopy) microscope.

GC–MS (Gas Chromatography–Mass Spectroscopy): Gas chromatography is a separation technique applicable to volatile samples The separation depends on the interaction of sample components with the stationary phase of the chromatography column and the gas mobile phase. The separated components are detected with a universal detector like the flame ionization detector (FID) and thermal conductivity detector (TCD) The components are detected using mass spectroscopy. Mass spectroscopy is useful for identification and quantification of low-level organics The sample molecule is ionized using a variety of techniques and the masses of the ionized molecules and fragments are measured using electric or magnetic fields. From this information, the molecular weight of the molecule can usually be determined, as well as the structure of significant fragments

Infrared Spectroscopy (IR): Infrared spectroscopy is used for the molecular structure identification and quantification of solids, liquids, and gases An infrared spectrum is the result of light (in the 2–25 micron wavelength range) interacting with the

vibrations of molecules. The particular set of vibrations of a molecule gives rise to specific spectral absorption bands, often referred to as the "fingerprint" spectrum

SEM (Scanning Electron Microscopy): Scanning electron microscopy is a method for characterizing the topography and texture of rough or polished materials over a large magnification range (25 to 1,000,000x) while maintaining substantial depth of focus A beam of electrons is systematically scanned in a raster fashion across a sample. The result is a variety of electron-induced signals that provide a great deal of morphological, physical, and chemical information about a sample These signals include secondary electron, backscattered electrons, and characteristic X-rays Secondary electrons form the signal primarily used to produce SEM images of the sample

SEM/EDS (Scanning Electron Microscopy/Energy Dispersive X-ray Spectroscopy): This is an elemental identification using an energy dispersive X-ray (see EDS definition) interfaced to a scanning electron microscope (see SEM definition)

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Book Review

Simon Conway Morris *Life's Solution Inevitable Humans in a Lonely Universe* New York Cambridge University Press, 2003 464p

This is a good book that has nothing (directly) to do with UFOs On the other hand, it probably has everything (indirectly) to do with them

Life's Solution is about evolution in the cosmos, but most especially about biological evolution It concentrates on the evolution of life here on Earth, of course, because that is what we know But from that examination, Morris reaches for fundamental principles that direct that evolution These fundamental directive principles are scientific, not religious (although Morris himself is a profoundly spiritual man) What they indicate to Morris (and to me) is that the basic parameters of physics, chemistry, and geometry funnel the vast array of mutations and diversity into a limited number of biological designs, which are the selected paths to survival and success.

Whether one wants to see a subtle directive hand of a divine designer behind all of this is entirely up to one's own philosophical preferences Morris and I would Richard Dawkins and CSICOP would not This is a point worth mentioning because the book really is the answer to the sociological problem we have with Intelligent Design as well.

The reader is doubtless aware that there is a wave of unscientific pressure that has arisen to place what is clearly a religious theory (Intelligent Design, or ID) into the high school science classroom This is wrong-headed and one of the few things upon which Morris, Dawkins, CSICOP, and I could agree Morris's book, although not intended as such, is the scientific answer to the only sticky point that the ID proponents have been able to make They say that if one is to take materialist evolutionists of the accidentalist school seriously, then there is no way that life could have originated, nor any of several important advancements taken place The argument is simple Estimate the number of steps necessary to build a living organism Assume that every step had several possible options Then, assume that every option that occurs must be built upon with every second-stage possibility, yielding over many thousands or even millions of steps a bewildering array of possible outcomes, from which the few successful ones could not possibly have beaten the odds People like astronomer Fred Hoyle did the crude math, and the odds to beat are beyond astronomical

The randomness and accidentalness which causes the logical legitimacy, and the real world absurdity is the fault of people such as Stephen Jay Gould (1991), who led a school of thought in biology that overemphasized the accidental nature of evolu-

tion so as to short change the effective design governance of the physical environment Gould's thinking was the result of the nonscientific side, which biological evolutionists sometimes exhibit an inappropriate mixing of science with a theorist's own brand of religion—atheism. When this mix occurs, the theorist may allow a form of paranoia to take over, fearing the hand of a Designer somehow sneaking back into the science. Stressing an overpowering *random* element to evolution was Gould's protective fence against the incursion of the divine This, then, led him to his ultimately ridiculous signature statement· No matter how many times the motion picture film of evolution is rewound and run forward, the results will be radically different and unrecognizable This error of emphasis is what opened the door to the siege-gun argument of Hoyle and the ID proponents, an intellectual sin of Gould the pseudoscientist, which came back to haunt him and his colleagues

It is ironic that it is Gould the atheist (and others like him) who gives the religionists the opportunity to invade science, while it is Morris the Christian who defeats their arguments For *Life's Solution* is exactly that—the solution that life found to beat those Hoylean odds The odds-beater is convergent evolution, which shows that not all options are equally likely It demonstrates that most options are not only unlikely but also essentially impossible It shows that certain designs are so powerfully in sync with the real physical worlds that they *must* arise It shows, in fact, that life elsewhere, advanced life, will be very much like advanced life here.

Morris includes a tremendous number of instances of convergent evolution in his book Many of them are obviously relevant to our ufological interests, many are subtler, but all, in the end, are extremely pertinent to the extraterrestrial hypothesis (ETH). The reason is that ufology has been attacked on exactly this ground—that the occupants seen in close encounters cannot be real because they are too much like us, too humanoid in body plan Accidentalist biologists, such as George Gaylord Simpson (1964) and Theodosius Dobzhansky (1972), made the point long ago that ETs would not be at all similar to us humans

In the 1960s and 1970s, that view was taken up by the SETI community, including Carl Sagan (1981), and by the UFO community as well, including J. Allen Hynek and Jacques Vallee You can see that anti-ETH view emerging in Hynek and Vallee's *The Edge of Reality* (1975), where they converge around the idea that the whole UFO business is just too strange to be anything so simple as ET. Vallee was writing *Messengers of Deception* (1979b) at the time, in which he unloads a full-blown anti-ETH model for UFOs Hynek was clearly moving along a similar trajectory, finally writing in the MUFON *Symposium Proceedings* (1983) about "The Case against ET" Both ufological superstars accept the accidentalist biological axiom that ET will not be like us, not be of humanoid form, and certainly will not be at home in our gravity nor our atmospheric constitution

Well, Morris explodes all of that *Life's Solution* elevates the school of convergent biology to its rightful place in the forefront of evolutionary thought, and does so scientifically It sheds the paranoia, the atheists' fears that caused the closed thinking and produced the extreme accidentalists And it reaches out to include all of science

physics, mathematics, and chemistry alike (There are, by the way, biologists who severely resent this unwanted intrusion into "their" field, and who make such derisive comments as, "We may as well all retire and let the physicists derive all biology from protons and electrons ")

This revolution in paradigm is hardly complete As recently as the late 1980s and 1990s, the convergent school was still the ugly stepdaughter to be kept in the closet Slowly, individuals such as R D K Thomas (1986) began organizing symposia at the American Association for the Advancement of Science annual meeting to give the field's researchers and their promising results a stage from which to be heard I was privileged to listen to many of these researchers and inspired to write "Modern Biology and the Extraterrestrial Hypothesis" (1991) and "Could Extraterrestrial Intelligences be Expected to Breathe our Air?" (1993) as curatives to the errors of the accidentalists, which had been accepted by Hynek, Vallee, and others

I don't blame our very bright, legendary ufologists Biology is not their field, and it is easy to miss the biases and preconceptions, regardless—especially in smooth talkers such as Gould or Sagan Many people in ufology welcomed those papers, while others were chagrined or uncomfortable [1] No one in our field seemed qualified to give them a credible evaluation. So, it was with a bit of nervousness, as well as pleasure, that I sent them to Morris He liked them—a lot He agreed generally with the science, it was convergent biology as he saw it scientifically He said that he would have been happy to reference the papers and ideas in the book had he known of them That was a relief There is always some ego concern in all this But it was just as much a relief that this world-leader biologist was agreeing that the ETH had no obvious problems vis-à-vis biological science Morris, by the way, is no closet ufologist. He's a scientist, a real one If we ever get strong, physical evidence for our subject, he'd look at it with the eye of a scientist, not someone with a closed mind That's all we should ask of anyone

Meanwhile, at the end of his book, he writes the following fictional scenario of how he and a friend witnessed an extraterrestrial craft landing and then met the occupants His words suggest volumes about how thoroughly he feels that physics, chemistry, and geometry will funnel convergent designs

> The vehicle landed at 15 47 GMT, just over a mile from Kimmeridge, on the south coast of England "Just in time for tea?" murmured my companion, as we climbed through the long grass, insects rising in the summer air There, already sitting on the ground, were the three extraterrestrials As we joined them, I asked, "Would you like some water?" "Or perhaps something stronger?" suggested my companion "Thank you," came the grave reply "We ourselves are thirsty, on such a warm day And maybe something for our plants?" The chlorophyll of the alien species blended well with the surrounding vegetation, its flowers a deep purple

[1] Jacques Vallee was quick to remind me, appropriately, that even if my views on biological and atmospheric convergence were conceivable I had still not addressed all his concerns

> When our visitor picked up one of the pots, it slipped and in catching it he grazed his finger Red blood oozed to the surface "Haemoglobin, I suppose?" They nodded Our hands clasped, both warm to the touch It seemed superfluous to ask, but the beating of a vein hinted at the inevitable dual circulation system and arteries with their elastic proteins. One of them sniffed the air appreciatively, the world smelt beautiful as their and our nasal glomeruli registered the olfactory signals As the swallows screamed overhead, the minute hairs in our ears and the auditory equivalents of the extraterrestrials acted in the same way, transducing the sound into a register of inner music. "Observe the pointed wings of those flying animals—swallows, did you say?—clearly migrants, just as at home " We strolled slowly back down the hill, towards the sea. Despite the steepness of the slope, the aliens were confident, their balancing mechanisms the same, their walking movements controlled by the same neural network We stopped on the cliff edge, in the bay three dolphins moved westwards "Fast and effective swimmers, I see, what other shape could they possibly have?" All of us looked at them with common delight, through camera-eyes, lenses full of crystallins and retinas with opsin molecules making photons into sight. By now dusk was falling, Venus already bright in the sky It was time to go home. "Before you leave, may I ask where you are from? Was it a very long journey?" But we already had guessed "A long journey? Well, only in some ways Where is our home? Why, the planet we call Earth, of course Surely you already knew in your hearts that there is only one Earth?" We were, of course, looking at ourselves

And, if you are confused about what Dr Morris is saying there at the end of this brief fictional encounter, my letter exchange with him indicated that he means his scene to be a meeting of species evolved on two different planets, but planets so similar that they are both legitimately Earths, and their evolved advanced lifeforms (both there and in all the other, many Earths) are, essentially, ourselves

Many scientists, of course, do not and will not get it They are still living in the extreme accidentalist paradigm Long ago, in 1965, an astronomical colleague of Hynek wrote to him about humanoids and ETs.

> We have read reports by reliable persons who have seen manlike figures associated with UFOs The policeman in New Mexico last year and a minister in Australia about 1959 are good examples I know that the law of probability says that some place in the infinite universe there are solar systems with planets similar to ours. I also know that in an infinite situation that a manlike creature could exist, but I find it too much to hope for, to have our first contact with intelligence from another source, to be with a manlike creature I'm better prepared to meet with an octopus wearing a silk hat bearing an antenna. If reliable witnesses have seen manlike

> creatures, I believe that they are men from earth and if our own country is not the source of these fantastic vehicles, our Air Force intelligence had better find out who is

Probably it would be easier to just deny that such events had happened at all That's what establishment scientists would do Hynek couldn't do that, so he was driven to even stranger hypotheses

In the present, the establishment continues its old refrain Another Dr Morris, Desmond, said in 2005.

> I daresay that out of all the thousands or millions of galaxies in the universe, somewhere something could understand our messages, but I think the chances are that the aliens we meet will not be even bipedal and bilaterally symmetrical We may meet something which is an amorphous blob, and there wouldn't be any form of communication possible I think the chances of meeting men with slightly funny faces, the kind you get in space operas and science-fiction movies, is utterly remote

So, one Dr Morris will be very right, and one will be very wrong Knowing the non-scientific sociology that produced one of the two schools of thought, I know on whom I am betting

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The Center for UFO Studies is an international group of scientists, academics, investigators, and volunteers dedicated to the continuing examination and analysis of the UFO phenomenon The purpose of CUFOS is to be a clearinghouse for the two-way exchange of information—where UFO experiences can be reported and where UFO experiences can be researched

CUFOS maintains one of the world's largest repositories of data about the UFO phenomenon The material is available for study, research or examination by any qualified individual or organization CUFOS currently has more than 50 000 cases of UFO sightings and experiences on file, and a library of more than 5,000 books and magazine volumes on all aspects of the UFO phenomenon

The mission of the Center for UFO Studies is to promote science and scholarship in ufology through the scientific collection, study, evaluation and dissemination of information about the UFO phenomenon

CUFOS promotes a general public understanding of the UFO phenomenon through various activities and projects The *International UFO Reporter*, published quarterly reports on current news and sightings and includes articles on UFO topics The *Journal of UFO Studies* presents scholarly papers on ufological matters CUFOS also publishes monographs and special reports of interest to the field

The Center was founded in 1973 by Dr J Allen Hynek (1910–1986), who became involved with UFOs as scientific consultant to the U S Air Force from 1948 to 1968 He was the first speaker to present testimony at the 1968 hearing on UFOs held by the House Committee on Science and Astronautics and later appeared before the United Nations to support the proposed establishment of an agency to conduct and coordinate research into UFOs and related phenomena In the early 1970s, Hynek coined the phrase "close encounters of the third kind," and acted as technical adviser to director Steven Spielberg on the movie of the same name He was scientific director of CUFOS until his death

CUFOS is a non-profit organization supported solely by contributions All contributions are tax-deductible and enable CUFOS to continue its work A $25 00 contribution entitles you to become an associate of CUFOS and receive the *International UFO Reporter* for one year