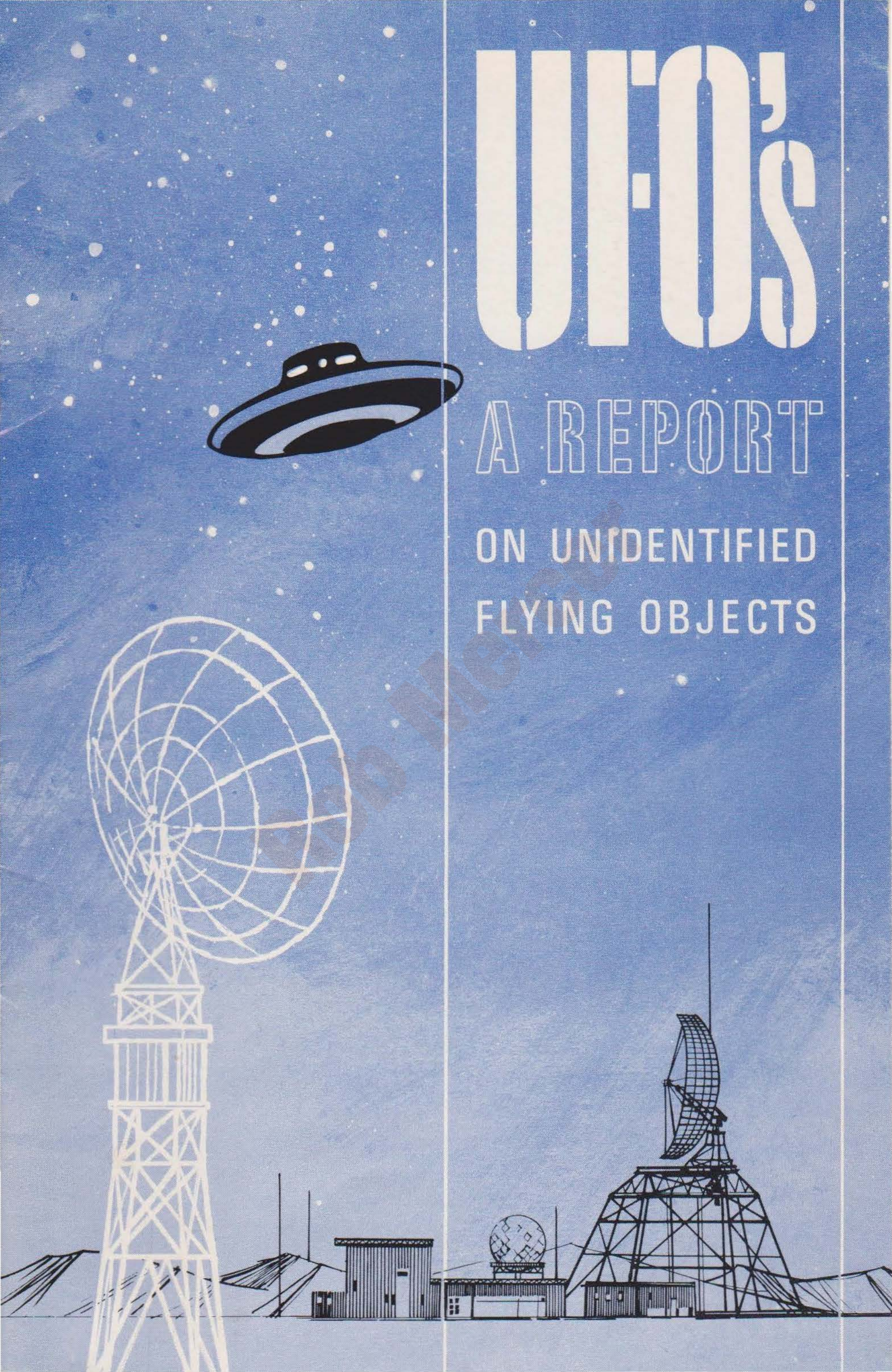
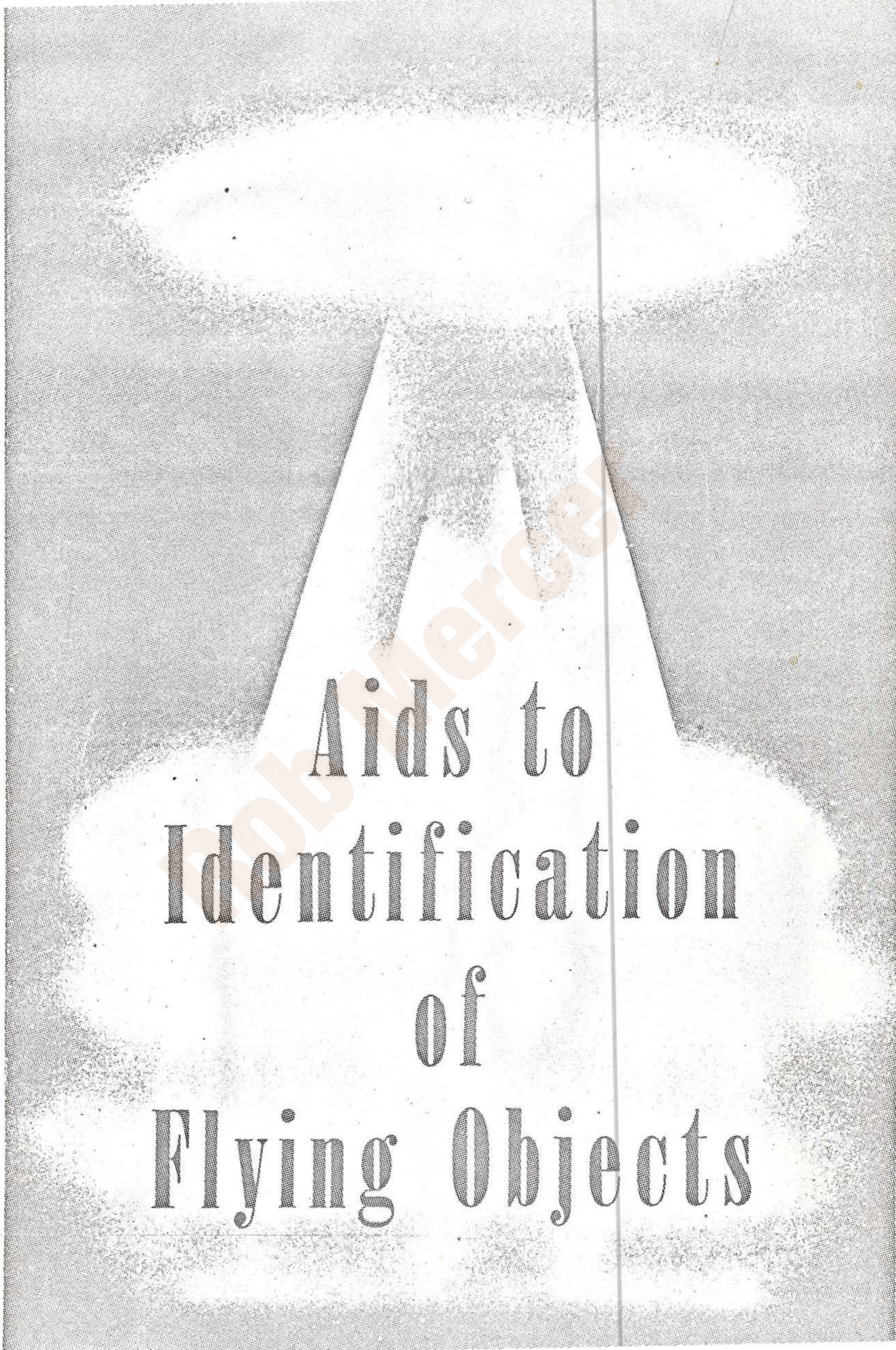
UFO's

A REPORT ON UNIDENTIFIED FLYING OBJECTS



AIDS TO IDENTIFICATION OF FLYING OBJECTS



Aids to Identification of Flying Objects

See sighting
22 Oct 54
Marysville Ohio

The Researcher
V. 1 No 2
June/July 1968

WHAT IS ANGEL'S HAIR

(This article is written by Josef Roesmer, Consultant to the Institute. Roesmer is a radiochemist with a Pittsburgh laboratory, studying charged-particle, low-energy nuclear fission.)

Angel's hair, the elusive substance that has been observed in the vicinity of landing and launching sites of UFOs, is an inexhaustible subject for speculation as to its chemical composition, its formation, and particularly its raison d'etre. Let us examine some descriptions of Angel's Hair for meaningful scientific information:

1. Its physical appearance has been compared with "a fluffy blanket," or "long streamers of white stuff," or "almost like cobwebs," "stringy," "like shredded white wool," and "like spun glass."

2. Held between the fingers for a few minutes, Angel's Hair dissolves "into nothing," sometimes leaving a "burning sensation."

3. According to an observer in California, it remained on trees and telephone lines for months.

4. Angel's Hair often seemed "to jump" from a bush or tree and tended to cling to one's hair.

Some of these observations apparently contradict each other; for example, that Angel's Hair has been seen for several months on trees and telephone lines, and its disappearance when held between fingers.

In scientific terms, Angel's Hair can be described as a white substance which either sublimes or hydrolyzes when brought into contact with the moisture of human skin, and it can be charged electrostatically by friction, i.e., it does not conduct electricity. Its formation appears to be related to the propulsion system of UFOs since it is formed where UFOs require, as it were, an excess power over that needed for simple flight, namely for landing, launching, or a sudden change of course.

It has been suggested that Angel's Hair could be nitrogen pentoxide, N_2O_5. True, N_2O_5 is a colorless solid which sublimes without melting. However, N_2O_5 has a vapor pressure of one atmosphere at 33°C; above 0°C, it starts to decompose into NO_2, a reddish-brown gas of metallic odor. Furthermore, N_2O_5 reacts with water to form nitric acid with considerable evolution of heat. This reaction will occur even with the small amounts of moisture on human skin. However, the nitric acid will react immediately with the amino acids which make up human skin, particularly with phenylalanine. The result of this reaction is the orange stain on the skin, which cannot be removed by washing. Nobody who has handled Angel's Hair has reported this color reaction. Thus, N_2O_5 most probably is not Angel's Hair.

If the description "dissolves into nothing" can be taken literally, then one might suspect one or several noble gas compounds. To date, our knowledge of noble gas compounds is limited to those containing xenon. However, these compounds are fairly volative and are white. Possibly, Angel's Hair is an argon compound, since argon is the noble gas in air with the highest abundance.

Presently, we are still unable to answer our initial query.

It may be trivial to say that the surest way to discover more about Angel's Hair is to obtain a sample. Incidentally, a so-called weighing bottle, which is nothing but a small glass vessel with a perfectly fitting ground joint lid, the male joint being ground on the outside of the bottle and the female joint on the inside of the lid, would be the ideal container for Angel's Hair. Since Angel's Hair disappears when warmed to body temperature, it would be advisable to store the container with Angel's Hair in a refrigerator, until it can be submitted for laboratory analysis.

UFO Research Institute
Suite 311
508 Grant Street
Pittsburgh, Penna. 15219

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1968

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Maj. H. Quintanilla, Chief
Project Blue Book
Foreign Technology Div.
Wright Patterson AFB
Dayton, Ohio

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Figs 3, 4 + 5: Examples of anomalous propagation.

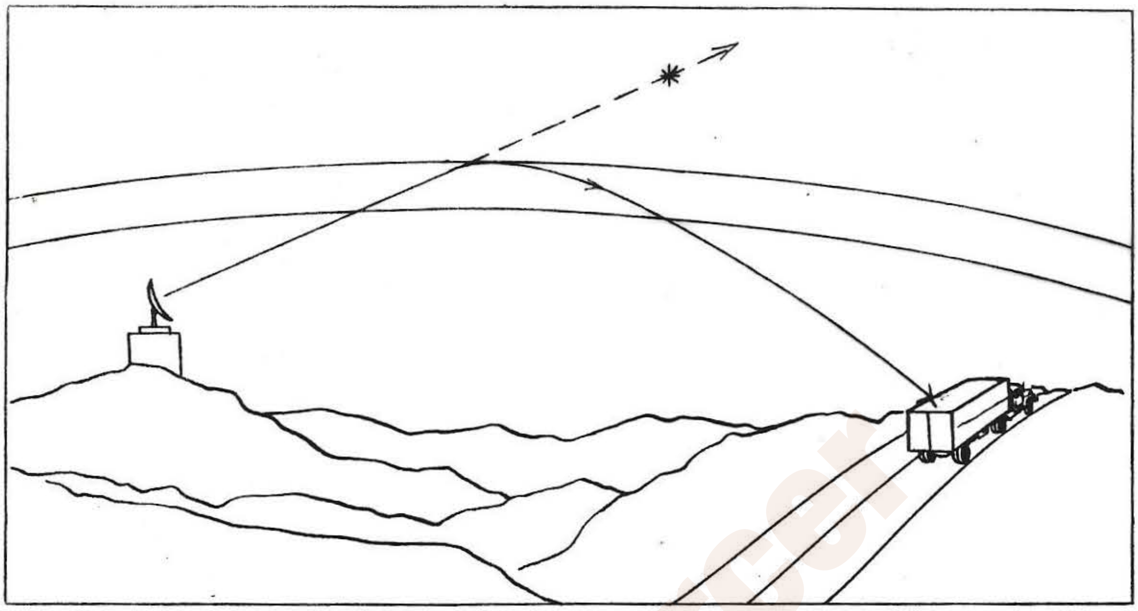

Figure 3 Inversion layer causes the radar beam to bend and pick up the truck on the highway giving the appearance of a high slow-moving target.

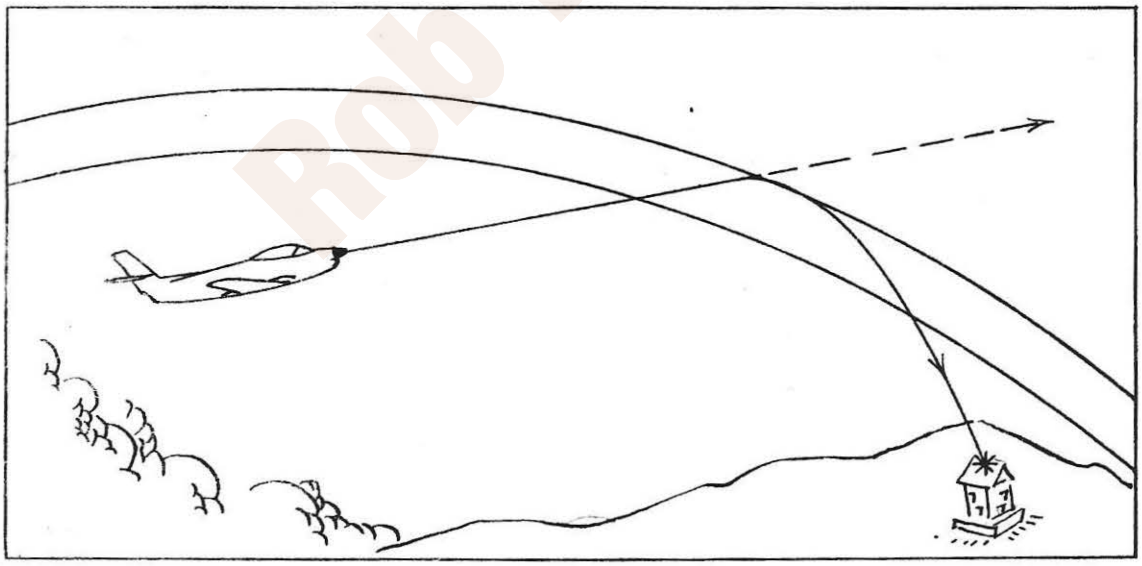

Figure 4 An airborne radar can get a ground return from an inversion as shown above. One occasion when the pilot tried to close, he nearly flew into the ground.

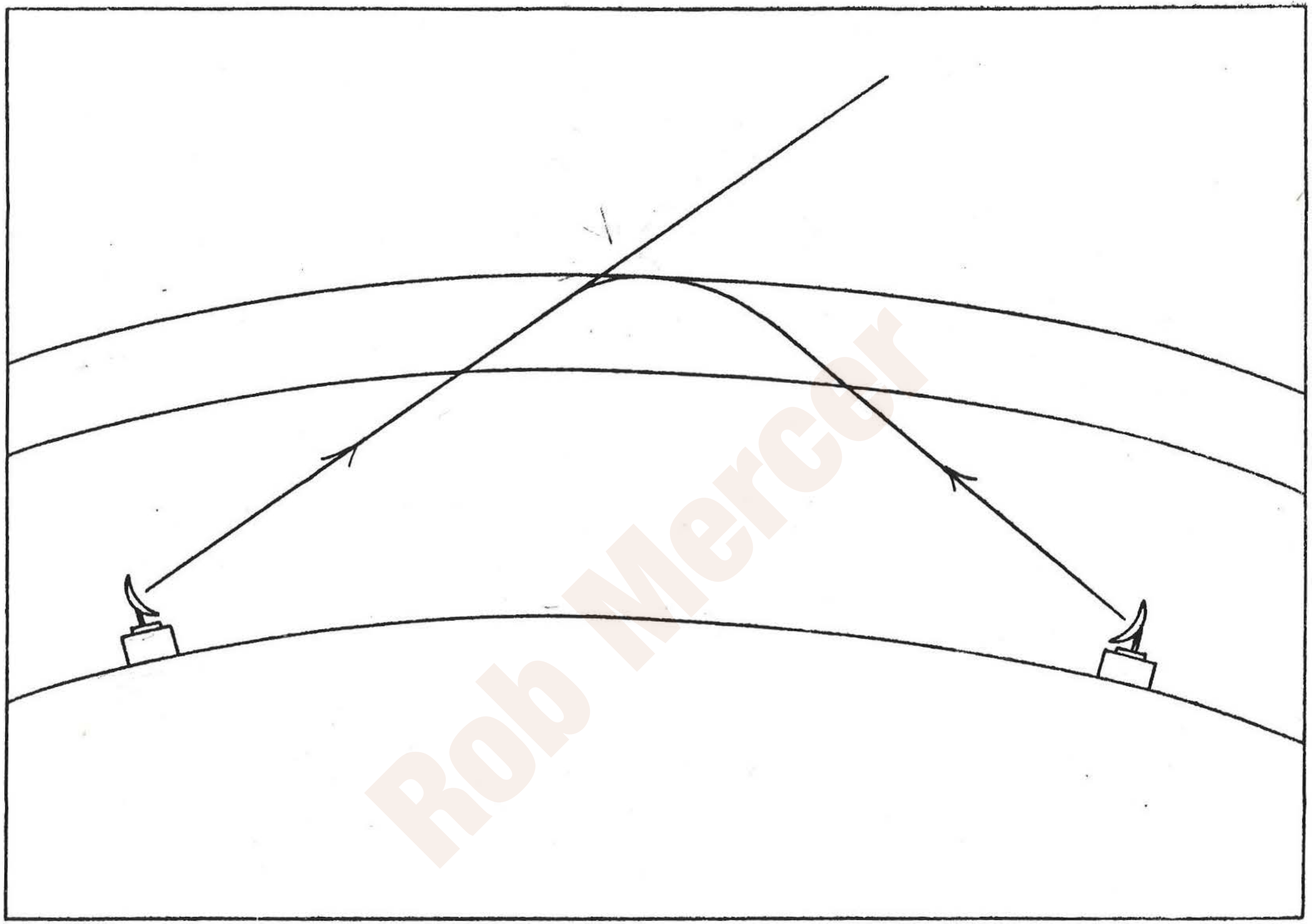

Figure 5 How an inversion layer can cause interference between two stations a great distance apart. Normally these two stations are so far apart the operators would not expect interference between the two.

* * * * * * * * *

The disorientation that pilots experience during night formation flight may result from what is called the autokinetic illusion. The autokinetic illusion is a visual phenomenon in which a stationary spot of light against a dark background appears to move erratically. It is known to have been experienced by pilots when they were observing formation lights on other aircraft (8). In fact, this illusion can disorient a trained pilot to the extent that he will spin in a link trainer (8). In a recent night formation flight accident a surviving pilot reported that he "saw" the other two aircraft in the formation peel-off to the left when, actually, they had not changed course (16). On the basis of this false information he maneuvered his aircraft so as to collide with the other two with a resultant loss of one pilot and three F-86D aircraft. The "peeling-off" of these two aircraft is typical of the nature of the autokinetic illusion.

Investigations of the autokinetic illusion reveal that the apparent movement is greatest and most frequent when small (point-source), dim lights are being viewed; but it is still present in the case of large light sources (6, 7) and, although to a lesser degree, when viewing patterns of lights (8). Therefore, the use of more or larger area reference lights in formation flight should cause a reduction in the autokinetic effect. It has been demonstrated that autokinetic movement was frequent and large when only one reference light was visible during formation flight, was much reduced when two reference lights were visible, and reduced even more when tree reference lights were visible (8).

* * * * * * * * *

REFERENCE WADC TR 55-124

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BALL LIGHTNING BIBLIOGRAPHY

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Reference Department

LIBRARY OF CONGRESS

Washington: 1961

EXTRACT FROM METEOROLOGICAL GLOSSARY (QC854-G7) - CHEMICAL PUBLISHING COMPANY-1951

BALL LIGHTING - An occasional incident during thunderstorms is the appearance of ball lightning. The circumstances vary considerably. The size of the balls varies greatly, from the size of nuts to spheres a foot or two in diameter. The most frequent balls are between 10 cm. and 20 cm. in diameter. Sometimes they occur immediately after a brilliant flash of ordinary lightning, at other times when there has been no flash at all. Sometimes only a single ball is seen, at other times the same observer sees two or three and several are reported in one locality. Sometimes the balls drift through the air and vanish harmlessly, but in some cases a ball has exploded on reaching the ground. Usually there is no sign of heating where a ball has passed, yet there is one case where clean holes were bored through several window panes, the glass appearing to have been melted. Ball lightning has been observed in closed rooms, but whether it penetrates the walls or forms inside is not quite certain. The light is seldom brilliant, though occasionally observers have been dazzled. Cases are on record where a ball has broken up into smaller ones, but these are rare. In some cases the balls develop during very heavy rain; in other cases when there has been no rain for several minutes. A ball may last for a few seconds or several minutes. Its movement is never fast, generally the speed is comparable with a walking pace, but it is not clear how the ball lightning is propelled. Probably in most cases it is carried by air currents. Apparently ball lightning does not occur when there is much wind.

Pearl-necklace lightning - Ball lightning has been associated occasionally with pearl-necklace lightning. This phenomenon is a development of an ordinary lightning flash. Immediately after the flash a number of bright lights are seen. These lights are of uniform size and appear like pearls on a string. They last about a couple of seconds.

Phenomena with some likeness to ball lightning have been produced artificially by the use of very powerful electric machines. N. Hesehus* used a transformer giving 10,000 volts and connected one pole to a vessel containing water, the other to a copper plate 2 to 4 cm. above the water. The discharge between the plate and the water took the form of flames, now conical, now spheroidal. The fiery spheroids were very mobile, going from side to side of the copper plate at a breath. In these flames atmospheric nitrogen was being burned to nitric oxide, NO, as in one of the industrial processes for "fixing" nitrogen, but the flames did not float away into the free atmosphere. There is therefore no reason to assume that ball lightning is a globe of nitric oxide. The fact that the globular form is maintained by ball lightning seems to require an electrical attraction between the outer layers and a central nucleus so that the mechanism can not be merely chemical. At present the phenomenon is entirely inexplicable.

*Phys Z., Leipzig 2, 1901, p. 579

The Goodyear Tire & Rubber Company

Akron, Ohio 44316

July 17, 1968

Lt Col Hector Quintanilla
Chief, Aerial Phenomena Office
Aerospace Technologies Division
Production Directorate
Wright-Patterson Air Force Base, Ohio 45433

Dear Colonel Quintanilla

Thank you for your letter of July 10, inquiring about the whereabouts of our two Goodyear airships on June 13, 1968. Neither of our airships was in the area of Dayton, Ohio, on that date.

One was in San Antonio, Texas, while the other was in Rochester, N.Y.

One of the blimps was in Dayton from approximately May 7 through May 15, but neither has been in that area since then.

It would appear, then, that we cannot be of assistance in helping you to clear up the matter of the sighting in question.

Sincerely

Carl Dangel

Community Relations

C Carl Dangel
dmo

Spoke with Mr. Crosier, area code 216 phone 794-3127 regarding the Goodyear Blimp, flight plan for June.

Left Flint, Michigan 4 Jun to Akron

Left Akron, 7 Jun to Flint

Left Flint to Akron 12 Jun

Left Akron to Wheeling 13 Jun

Left Wheeling to Akron 14 Jun

----

25 June blimp flew in the Akron area from 1645 EDT to 2330 EDT

28 June blimp flew in the Akron area from 0800 EDT to 0830 EDT

Departed Akron area on 28 Jun at 0830 for Hershey, Pa, arrived in Hersey, Pa at 1815 EDT.

OFFICE OF INFORMATION TELEPHONE 882-3931 and 882-3932

NEWS RELEASE

UNITED STATES AIR FORCE

AIR PROVING GROUND CENTER

AIR FORCE SYSTEMS COMMAND EGLIN AIR FORCE BASE, FLORIDA

EGLIN AFB, Fla., Nov 18--CHEMICAL TRAILS--Chemical trails such as these have been creating quite a stir during the past week throughout the southeastern part of the United States. The trails were visible in the sky around the sunset hours and were made by vertical probe research rockets launched by the Air Proving Ground Center here. The rocket firings were made in conjunction with the International Quiet Sun Year (IQSY) program. It is during this time that scientists around the world study the effect of the sun on the ionosphere, a part of atmosphere starting about 40 miles above the earth's surface and reaching to about 500 miles. The chemical trails were visible from Miami, Fla., to Texas. (USAF PHOTO)

Nicht im Handel

Sonderabdruck aus Vol. V, 1959, Fasc. 3-4

ASTRONAUTICA ACTA

Herausgegeben von W. v. Braun, A. Eula, B. Fraeijs de Veubeke, J. M. J. Kooy, F. I. Ordway III, E. Sänger, K. Schütte, L. I. Sedov, L. R. Shepherd und J. Stemmer

Schriftleitung: F. Hecht, Wien

Springer-Verlag in Wien

D. H. Robey[1]

Cold Re-Entry of Space Vehicles at Meteor Speeds

Contacts for last known address of
Military Personell

discharged

Military Personal Center
9700 Page Boulevard
ST. Louis, Mo. 63132

or call

A.V. 698-7141

Reserves

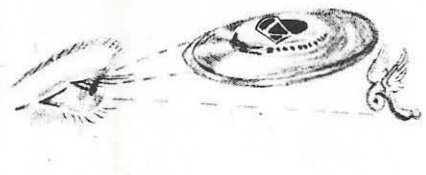
Air Force Reserve Personnel Center
Denver, Colo.

IDENTIFY CORRECTLY unusual sightings

Reduce to ½ size for briefing

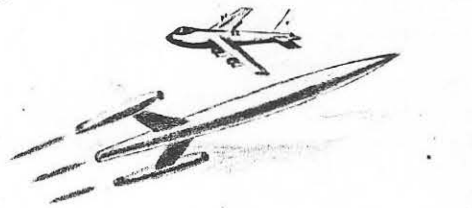
GENERAL

DUE TO PROLONGED OBSERVATION OF THE SKY BY DAY AND NIGHT, FAMILIAR OBJECTS SUCH AS METEORS, AIRCRAFT, BALLOONS, ASTRONOMICAL BODIES, SEARCHLIGHTS, BIRDS, ETC., WILL BE FREQUENTLY OBSERVED BY GOC PERSONNEL. DUE TO ATMOSPHERIC CONDITIONS, REFLECTIONS, SOUND, SPEED, POSITION, ETC., SUCH COMMON OBJECTS MAY SOMETIMES BE MISINTERPRETED AS "UNIDENTIFIED FLYING OBJECTS." BY BECOMING FAMILIAR WITH THE APPEARANCE OF SUCH OBJECTS, GROUND OBSERVERS CAN BETTER DETERMINE THEIR IDENTITY.



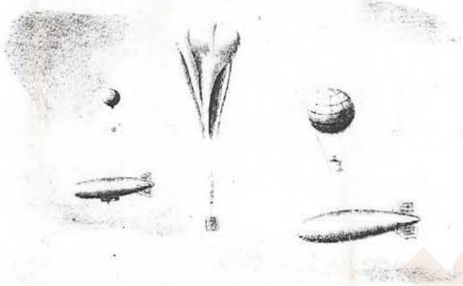
OPTICAL PHENOMENA

OPTICAL PHENOMENA WHICH HAVE BEEN REPORTED AS UNIDENTIFIED FLYING OBJECTS VARY FROM REFLECTIONS ON CLOUDS AND LAYERS OF ICE CRYSTALS (SUNDOGS) TO MANY TYPES OF MIRAGES. THEY MAY BE ELLIPTICAL OR LINEAR, BUT ARE GENERALLY ROUND IN SHAPE. IN COLOR, THEY ARE GENERALLY YELLOW, AND MAY BE STARLIKE OR TAKE THE FORM OF A LARGE, LUMINOUS GLOW. THERE IS NO LIMIT TO THEIR SPEED, ALTHOUGH THEY MAY BE STATIONARY. THE SUNDOG TYPE OF PHENOMENA TAKES THE FORM OF A LUMINOUS HALO AROUND THE SUN, WITH ONE TO FOUR IMAGES OF THE SUN ALONG THE HALO CIRCLE AT INTERVALS OF 90 DEGREES. OTHER REPORTS OFTEN HAVE TO DO WITH BRIGHT PLANETS OR EVEN THE MOON SHINING THROUGH A LIGHT OVERCAST.



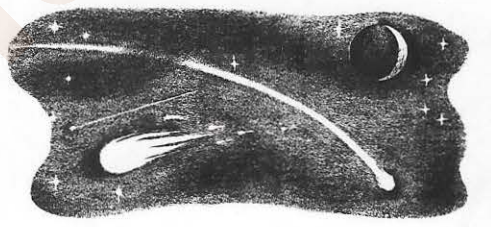
AIRCRAFT

AIRCRAFT SIGHTINGS WHICH ARE SOMETIMES REPORTED AS UNIDENTIFIED FLYING OBJECTS VARY IN SHAPE FROM CONVENTIONAL TO CIRCULAR OR ELLIPTICAL. THEIR COLORS--SILVER TO BRIGHT YELLOW--ARE OFTEN RESPONSIBLE FOR THE FAILURE TO IDENTIFY. JET EXHAUSTS SHOW YELLOW OR RED. GENERALLY, AIRCRAFT FLY IN ONLY ANGULAR PATTERNS. SMALL OBJECTS CROSSING MAJOR PORTIONS OF THE SKY CAN BE RULED OUT, AS CAN OBJECTS MAKING RIGHT-ANGLE TURNS OR SUDDEN REVERSALS OF DIRECTION. NUMBERS GREATER THAN 20 ARE MORE LIKELY BIRDS THAN AIRCRAFT.



BALLOONS

BALLOONS MAY BE ROUND, CIGAR-SHAPED, PINPOINT SIZE OR HAVE THE APPEARANCE OF BOWLING PINS. THEY WILL GENERALLY APPEAR VERY SMALL TO THE OBSERVER. THEY MAY BE VISIBLE BY DAY OR NIGHT, BUT MORE GENERALLY AT SUNSET OR SUNRISE. IN COLOR THEY SHOW SILVER, WHITE OR MANY TINTS. THEIR SPEED IS NEVER GREAT NOR ARE THEIR COURSES ERRATIC. GENERALLY THEY APPEAR TO BE HOVERING OR MOVING SLOWLY. THEY MAY APPEAR SINGLY OR IN CLUSTERS, AND A BALLOON MAY SUDDENLY BURST AND DISAPPEAR ALTOGETHER.

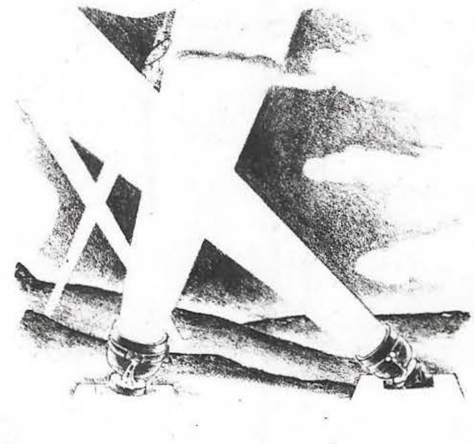


METEORS

METEORS VARY IN SHAPE FROM ROUND TO ELONGATED AND IN SIZE FROM TINY PINPOINTS TO THE PROPORTIONS OF MOONS. IN COLOR THEY VARY FROM FLAMING YELLOW (MOST COMMON) TO RED, GREEN OR BLUE. THEY TRAVEL AT HIGH SPEEDS, CROSSING A LARGE PORTION OF THE SKY IN A FEW SECONDS UNLESS APPROACHING THE OBSERVER HEAD-ON. THESE ARE GENERALLY SINGLE PHENOMENA, BUT OCCASIONALLY MAY BE OBSERVED IN SMALL GROUPS: THEY MAY BREAK INTO SHOWERS AT THE END OF THEIR TRAJECTORIES. AT NIGHT, METEORS MAY LEAVE LUMINOUS TRAILS WHICH CAN PERSIST FOR AS LONG AS 30 MINUTES. THEY ARE RARELY OBSERVED DURING THE DAY, WHEN THEY LEAVE A WHITISH TO DARK SMOKE TRAIL.

STARS AND PLANETS

THE PLANETS--VENUS, MARS, JUPITER AND SATURN--ARE GENERALLY BRIGHTER THAN ANY STAR, BUT TWINKLE MUCH LESS UNLESS VERY CLOSE TO THE HORIZON. STARS TWINKLE CONSTANTLY AND WHEN NEAR THE HORIZON CAN GIVE THE IMPRESSION OF FLASHING LIGHT IN MANY COLORS. THE SHAPE OF BOTH IS THE SAME, AND THEY NEVER APPEAR LARGE. IN COLOR THEY SHOW MOSTLY YELLOW, BUT MAY HAVE RAINBOW VARIATIONS. STARS ARE OFTEN REPORTED AS MOVING IN ERRATIC FASHION, BUT THIS IS DUE TO THE PSYCHOLOGY OF THE OBSERVER MOST PEOPLE BEING UNABLE TO CONSIDER A POINT AS BEING STATIONARY. NO BRIGHT STARS APPEAR IN CLUSTERS--A REPORT OF FOUR OR FIVE BRIGHT, CLUSTERING LIGHTS RULES OUT STARS. STARS IN THE EAST ALWAYS GO HIGHER IN THE SKY AS THE NIGHT PROGRESSES, WHILE THOSE LOW ON THE WESTERN HORIZON SET WITHIN AN HOUR OR TWO.



SEARCHLIGHTS

SEARCHLIGHT BEAMS VARY IN SHAPE FROM ROUND TO ELLIPTICAL, AND IN SIZE FROM TINY TO LARGE, LUMINOUS GLOWS, DEPENDING UPON CLOUD HEIGHTS. THEIR COURSE MAY BE STATIONARY, STRAIGHT, CIRCLING OR ERRATIC. SCATTERED CLOUDS MAY MAKE THEM SEEM TO DISAPPEAR REAPPEAR IN DIFFERENT PORTIONS OF THE SKY.

CREDIT TO 4602ND AISS

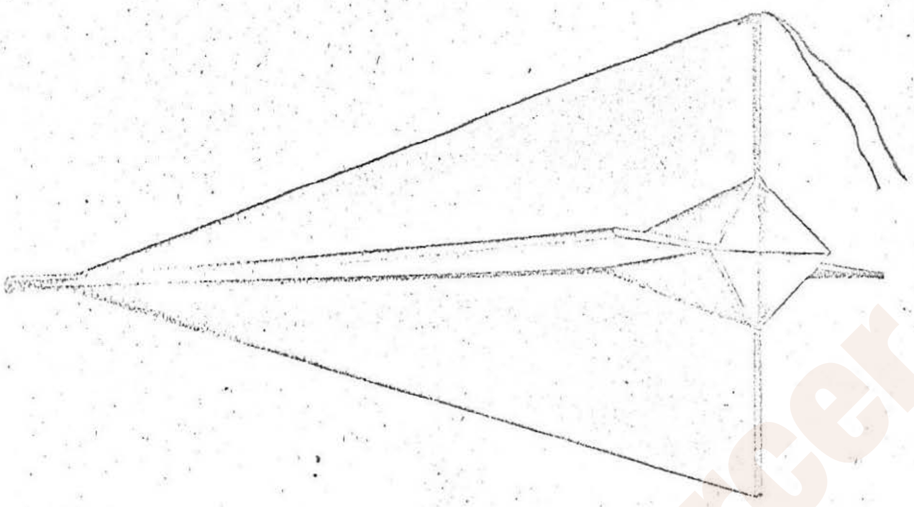
DIRECTORATE OF CIVIL AIR DEFENSE, HQ. ADC, ENT AFB, COLORADO SPRINGS, COLORADO

DART TARGET, TYPE K-11

Size: 6′ x 16′

Radar Reflective

ock Number	*Part Number*	*Color*
6920NSL	Spec. UTC 4040	Aluminum



The K-11 dart target is 6 feet wide at the rear nd 16 feet long. Its wings are constructed of oneycomb material which is bonded to an aluminum foil skin. An X-band corner radar reector is mounted at the rear of the target, with riangular fairings extending forward for streamning.

The K-11 dart target comes in kit form. Each it is intended to provide 10 flights, and includes wings, 2 radar reflectors, 24 nose section angles, kit for repairing damaged wings, and all the necessary hardware. All instructions for assembly, balancing, and repairing the K-11 target are included in the kit.

The operational use of the K-11 dart target is the same as the MF-1 target. Its larger size makes it much easier to see, track, and hit than the smaller MF-1. It will absorb many times more gun or cannon fire than the MF-1 and still fly in a stable manner. When lowered by parachute, the K-11 target is usually reusable, notwithstanding gun or cannon fire damage.

DART TARGET, TYPE K-12

Size: 8′ x 20′

Radar Reflective

ock Number	*Part Number*	*Color*
6920NSL	Spec. UTC 4140	Aluminum

The K-12 dart target is similar to the K-11 arget except that it is larger, being 8 feet wide t the rear and 20 feet long. When preparing it or use employ the same procedures as for the K-11.

Operational use of the type K-12 is the same as the K-11 dart target except that it is easier to see, track, and hit because of its larger size.

It also employs an X-band corner radar reflector mounted at the rear of the target.

ELECTRO-MAGNETIC EFFECTS

ASSOCIATED WITH

UNIDENTIFIED FLYING OBJECTS (UFOs)

By

Washington, D. C., Subcommittee
of the
National Investigations Committee
on Aerial Phenomena (NICAP)
1536 Connecticut Avenue, N. W.
Washington 6, D. C.

* * * * *

June 1960

FAA Information

The FAA tracks everything in the air, but they do not pay any attention to specific aircraft unless they have called in a IFR flight plan. Unless a strip is made of the aircraft when one asks the FAA for any aircraft in the area, they will not have any record. The FAA only follows those aircraft that have filed an IFR flight plan. The strip that was mentioned above is about 7-8 inches long and contains information about the particular aircraft.

Thus if one gets a negative answer for aircraft in the area it is possible that the aircraft had not files an IFR and thus the FAA would not have any record of such an aircraft.

SP 109

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FACTS ABOUT UNIDENTIFIED FLYING OBJECTS

Robert L. Chartrand
Specialist in Science and Technology
Science Policy Research Division

Assisted By:
William F. Brown
Analyst in Science and Technology
Science Policy Research Division

May 5, 1966

Washington, D.C.

HANDWRITING ANALYSIS

Hugh Legget Sr.
Bureau of Criminal Identification
London, Ohio

Director of F.B.I.
Laboratory Handwriring Section
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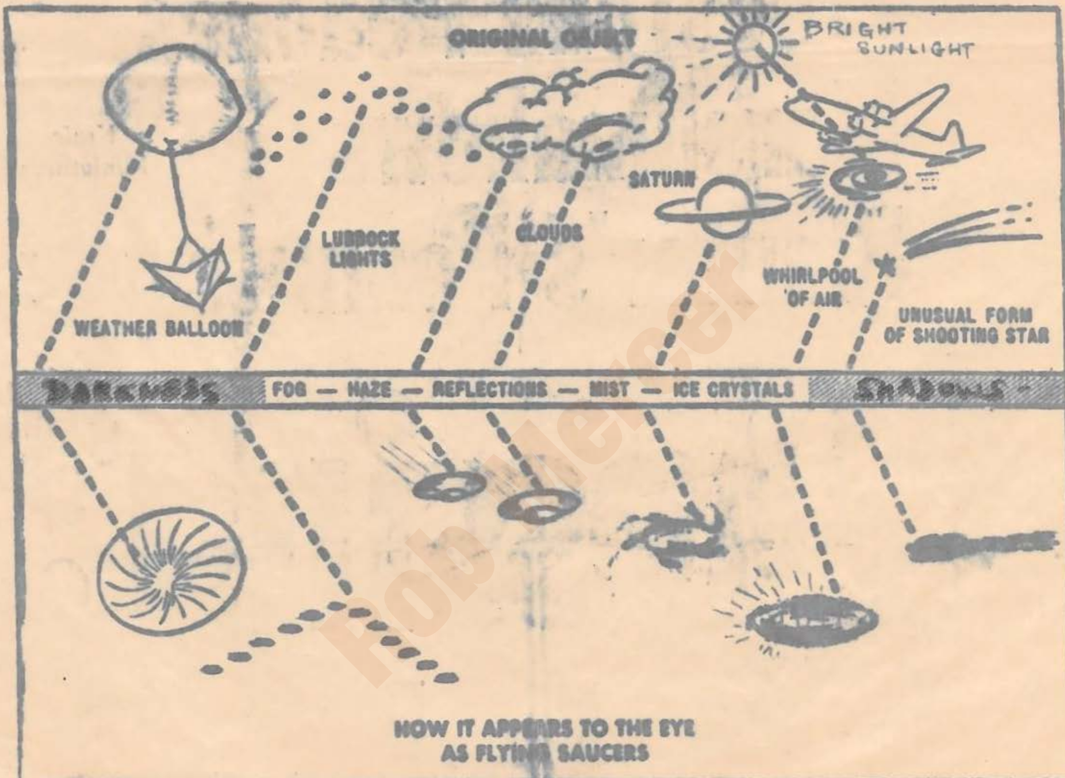

DO YOU HAVE "SPUTNIKITIS"?—Most of the UFO's—unidentified flying objects—reported are real, all right, but they're not what they seem. So says Dr. Donald H. Menzel, director of Harvard college observatory, Cambridge, Mass. Sketched, above, are some causes of those sightings, as explained by Doctor Menzel. No scoffer, he, Menzel does believe there are some saucer reports which "represent natural phenomena that we simply still do not fully understand."

Hynek

bd

INCIDENT AT EXETER

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except [illegible] list –

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2		FILE INFORMATION
3		NOTE AND RETURN PER CONVERSATION
4		SEE ME SIGNATURE

REMARKS

Publication; No.68-646
Interstellar Propulsion - A Possible Future Derivative Of Air-Breathing Technology.

FROM	DATE
AFAPL (APRT) J. Meshi, 2/Lt.USAF	27Aug.1968
	PHONE 52175

DD FORM 1 OCT 60 95 Replaces DD Form 94, 1 Feb 50, and DD Form 95, 1 Feb 50, which will be used until exhausted.

No. 68-646

INTERSTELLAR PROPULSION – A POSSIBLE FUTURE DERIVATIVE OF AIR-BREATHING TECHNOLOGY

by

H. D. FRONING, JR.
McDonnell-Douglas Corporation
Santa Monica, California

AIAA Paper
No. 68-646

AIAA 4th Propulsion
Joint Specialist Conference

CLEVELAND, OHIO / JUNE 10-14, 1968

Preface

"... It is by no means true that the (fixed) stars can be reached only after journeys of many generations in duration, during which numerous generations are born, grow to maturity and die again, until finally the distant great-grandchildren will perhaps reach the destination of the embarkers. Neither is it true that the foreign galaxies which are removed from us by hundred thousands of light years, are fundamentally unattainable because of our limited lifetime, and that nature has confined us to our small corner of the universe. No, we need not resign ourselves and meekly lay our hands in our lap. The infinite universe is sufficiently small that it remains accessible to the personal abilities of each one of us, up to its outermost reaches; everything is attainable to Man..."

Eugen Sänger
VII International Astronautical Congress
Rome, Italy 1956

INTERSTELLAR PROPULSION-A POSSIBLE FUTURE DERIVATIVE OF AIR-BREATHING TECHNOLOGY

H. D. Froning, Jr.
McDonnell Douglas Corporation
Santa Monica, California

Abstract

In this paper a preliminary analysis is made as to the basic vehicle and technology requirements for relativistic interstellar craft which utilize their flight medium as a basic fuel or energy source. Because such concepts are analogous to air breathing (ramjet) propulsion, approximate equations for the flight performance of such vehicles have been derived by utilization of classical ramjet performance equations and the Special Law of Relativity. A schematic representation of such an interstellar ramjet concept and its flow field regions are derived for the more generalized case of relativistic flight. It is shown that as vehicle speeds begin to approach the propagating speed of electromagnetic radiation, time passage within the vehicle system will slow down from the standpoint of a stationary observer while from the standpoint of the moving vehicle, interstellar distances external to the vehicle system will shrink with a corresponding increase in the density of the interstellar medium. It is further shown that these relativistic effects may cause fuel and engine efficiency demands to diminish with increasing flight velocity, becoming the least at the higher speed, mid-flight portions of the longest journeys. This provides hope that the vehicle technology and assurance, that may be eventually developed by means of relatively short journeys within our solar system and to nearby star systems, would be adequate to permit the confident embarkation upon much more ambitious journeys to the further limits of the universe.

Introduction

Air-breathing propulsion systems are now operating over an ever increasing range of atmospheric flight conditions with some postulated future SCRAMJET applications requiring speeds above Mach 20. However, certain investigators have postulated an even more bold application of ramjet-like propulsion - Relativistic Interstellar Flight.

It is realized that interstellar flight is certainly beyond current technology, and is not likely to be achieved within this century nor probably within the lifetime of any person at this gathering. Nevertheless, the characteristics of interstellar flight have already been considered by various investigators during the past several decades. Moreover, certain of these investigations have revealed some encouraging prospects for its attainment by means of interstellar propulsion concepts which are analogous to present day air-breathing propulsion systems. While such an application is certainly not of immediate concern at this time, it is of interest in achieving a greater perspective of the ultimate potential of propulsion concepts which utilize their flight medium to generate or augment their propulsive capabilities.

The technical material contained in this paper is documented in Douglas Aircraft Company Technical Paper No. 4752, "Some Preliminary Propulsion System Considerations and Requirements for Interstellar Space Flight" (Unclassified), September 1967[6]. However, this material is based upon personal investigations which were not sponsored by the author's company or any other U. S. aerospace organization. Therefore, any views expressed in this paper must be considered to be those of the author and not necessarily the official views of the author's company or of any other U. S. aerospace organization.

I. Interstellar Flight Possibilities

Interstellar distances are usually specified in light years; the nearest star Alpha Centauri is, for example, 4.3 light years distant; the distance to the centroid of our Milky Way galaxy is approximately 30,000 light years; to the neighboring Andromeda Nebula is approximately 750,000 light years. The current dimensions of the entire physical universe is estimated by some to be 20 billions of light years in extent. Because a space vehicle can fly relative to the earth at a speed no greater than the speed of light, it was once believed that the length of the human lifetime would limit the achievable range of even the ultimate manned interstellar vehicle to a few light decades, that is to a tiny portion of our Milky Way system that contains only the several stars in the more immediate vicinity of our solar system.

However, investigators such as Sänger have demonstrated that this limitation does not exist and that the normal life span of the human inhabitant of such a vehicle is adequate to traverse any conceivable astronomical distance, not only to the other galaxies, but to the outermost limits of the cosmos. This remarkable fact is, of course, due to the fact that the laws of classical Newtonian mechanics no longer apply to vehicles traveling at relativistic velocities. Instead the laws of Einstein's Special Law of Relativity are valid. Sänger[1] has applied the special law to derive the more general flight mechanics expressions for vehicles capable of relativistic flight. In particular, he has derived the expressions for the flight velocity and flight duration of interstellar vehicles undergoing constant flight acceleration and deceleration in the space-time reference system of the moving vehicle.

For the condition of a constant value of flight acceleration during the initial half of any interstellar journey followed by an equal value of flight deceleration during the final half of the journey, the expression for the total vehicle flight duration can be written in the form:

$$T_e = \frac{2C}{\dot{V}_e} \cosh^{-1}\left(1 + \frac{\dot{V}_e S}{2C^2}\right) \tag{1}$$

where:

T_e = journey duration in the space-time reference system of an observer which is at rest with respect to the vehicle (terrestrial space-time) - sec.

S = journey distance in the space-time reference systems of an observer which is at rest with respect to the vehicle (terrestrial space-time) - cm.

V = vehicle speed in the space-time reference system of an observer which is at rest with respect to the moving vehicle (terrestrial space-time) - cm/sec.

C = propagating speed of electromagnetic radiation in the space-time reference system of an observer which is at rest with respect to the moving vehicle (terrestrial space-time) - cm/sec.

$\dot{V}_e$ = vehicle flight acceleration in the space-time reference system of the moving vehicle (vehicle space-time) - cm/sec^2.

Equation (1) has been used to determine the influence of interstellar flight distance and vehicle flight acceleration upon the total interstellar flight duration as measured by the actual physical aging of the vehicle and its propulsion and payload systems (including any human occupants). These relationships are calculated for constant vehicle flight acceleration (and deceleration) values of 0.1, 1.0, and 10 earth gravities, and are shown in Figure 1.

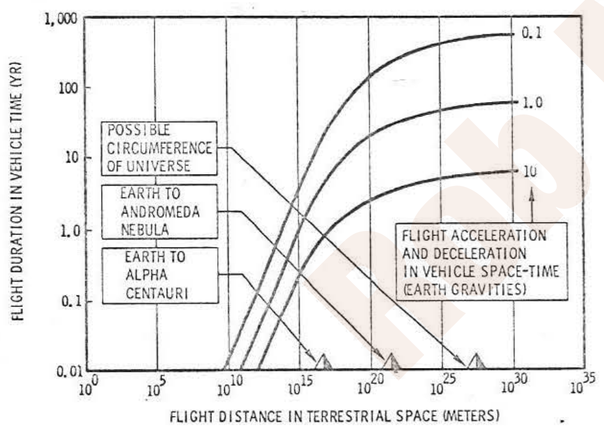

Figure 1 - Flight Duration in Vehicle Time

It is seen that vehicle accelerations of magnitude 10^{-1} earth gravity result in long flight durations for all possible interstellar missions. However, for spacecraft accelerations of magnitude 1.0 earth gravity, astronomic distances to the nearest star, the center of our galaxy and to the nearest spiral galaxy can be traversed in vehicle times of approximately 6, 20, and 25 years respectively. This occurs despite the fact that such journeys will take approximately 6, 30,000, and 750,000 years respectively in the space-time reference of a terrestrial observer, and is due to the spatial and temporal dilations that occur during the relativistic flight portions of the journey. Even distances of the magnitude of what some astronomers believe to be the present extent of the physical universe can be traversed in times less than a man's lifetime, as measured by the actual physical aging of the vehicle and its crew. Furthermore, it is seen that any life support system advances or anti-gravity developments which would permit vehicle flight accelerations to increase to magnitude 10 earth gravities, would decrease the duration of even these longest interstellar journeys, to values no more than are currently being considered for interplanetary flight within our solar system.

It must be emphasized that these trends are based upon the special law of relativity which is exact only for non-accelerating flight in gravity free space. Nevertheless, if it is reasonably valid, one must conclude that there is no fundamental barrier to the exploration of almost any conceivable distance within our physical universe within a man's lifetime. However, the enormous challenge yet remains, to achieve the level of technology that would be required for such exploration.

II. Interstellar Propulsion Concepts

The interstellar flight potential of propulsion systems, which rely entirely upon the energy that resides within terrestrial fuels carried on-board the vehicle, have been considered by various investigators. Ackeret[2] has shown that attainable flight velocity of such a propulsion stage would be limited to values on the order of 10^{-1} of the speed of light for even the most energetic thermonuclear reactions. Shepherd[3] has further shown that the acceleration of such vehicles would be limited to the order of 10^{-3} of earth gravity acceleration, and the resulting flight times to the nearest stars would be hundreds of years. Sanger[1] has determined the maximum performance that is achievable by such a propulsion stage, assuming total radiative decomposition of matter and no thermal radiation loss transverse to the velocity vector. For this condition, flight accelerations of magnitude 1.0 earth gravity are achieved, and, therefore, reasonably short interstellar flight durations result. However, enormous vehicle growth factors of magnitude 10^9 to 10^{12} are required for typical galactic and intergalactic journeys. As such, it has been concluded that propulsion systems, which rely solely upon the energy that resides with on-board terrestrial fuels, require either excessively large interstellar flight durations or excessively large growth factors.

For the reason that pure rocket propulsion systems (which rely entirely upon the energy that resides within on-board terrestrial matter) appear unacceptable for interstellar flight, investigators such as Bussard[5] have been led to consider interstellar propulsion concepts which can extract, not only the energy that resides within our own terrestrial matter, but also that energy that resides with the tenuous but vast celestial matter of interstellar space itself. Such concepts are analogous to ramjet propulsion systems in that they would utilize their flight medium to augment the fuel supply carried on-board the vehicle. Furthermore, it will be shown that under certain conditions the flow field about an interstellar ramjet that is traversing an interstellar medium is equivalent to that of a ramjet traversing the earth's atmosphere.

It is impossible to identify the most promising celestial fuel source for an interstellar ramjet at this time since the matter and energy distributions within the fabric of interstellar space is not yet adequately understood. However, astrophysical research by investigators such as Ort, Pawsey and Bracewell(4) indicate that neutral hydrogen atoms constitute a major portion of known celestial matter. A mean neutral hydrogen density of the order of 1 atom/cm^3 and density variations about this value of the order of at least 10^2 to 10^3 are expected within our Milky Way galaxy. Ionized hydrogen constitutes a lesser portion of celestial matter, but does exist in a great many regions of appreciable size, especially in the vicinity of the hotter (type O and B) stars. Therefore, neutral and ionized hydrogen atoms are probably the most promising interstellar fuel sources that can be visualized at this time.

Electric and magnetic fields also exist throughout the interstellar medium. Therefore, a potential interaction will exist between these fields and those generated and propagated by the moving vehicle system. The nature of this interaction would be expected to influence: (a) the magnitude of interstellar material that is affected and ingested by the vehicle system, (b) the intensity of the combustion reaction and the magnitude of the mass flow momentum increase occurring within the vehicle system in the form of thrust, and (c) the magnitude of the mass flow momentum decrease occurring external to the vehicle system in the form of aerodynamic and magnetohydrodynamic drag.

Mankind's present knowledge of propulsive processes and plasma physics is probably inadequate for even gross predictions of the actual propulsion processes that may someday be utilized for interstellar ramjet flight. Nevertheless, certain processes have been examined. Bussard(5) has considered fusion reactions (nucleon rearrangements) that could occur within the interstellar hydrogen that is ingested by the vehicle. These reactions would accelerate the "un-burned" interstellar material to high exit velocity and is probably one of the most powerful interstellar combustion processes that can be envisioned at this time.

No attempt will be made to postulate the characteristics of an interstellar ramjet at this time. However, the propulsion process proposed by Bussard in Reference 5 can be considered for the purpose of visualizing the magnitude of the required vehicle technology development. It has been shown that for this particular propulsion process and for the expected hydrogen density within our galaxy, ratios of vehicle inlet area to vehicle total weight of from 5 to 5,000 square miles per ton could be required for adequate flight acceleration. This would require a vehicle of very low average density. Such a tenuous vehicle could include a relatively dense nucleus but a major portion of its fabric may have to be composed of intense magnetic fields - rather than rigid structures. Such fields would have to contain and control the propulsion processes and provide payload protection by deflecting oncoming interstellar material (which at high speeds could be impacting at cosmic ray energies). Furthermore, these fields must not induce excessive momentum decrease (magnetohydrodynamic drag) in the region of interstellar space external to the vehicle system.

Enormous technical advances will surely be required in order to evolve an interstellar technology. However, certain current scientific research may be applicable to the eventual achievement of such a goal. One example could be achievement of the current goal of controlled fusion power by means of plasma containment by magnetic techniques. Such techniques could possibly be applied to the control of similar fusion processes which could conceivably be associated with interstellar combustion. Another example could be, advances in superconductivity research which may permit the evolution of superconducting magnets with extremely intense magnetic fields. Such fields could conceivably permit the control and containment of interstellar propulsion processes by means of a very tenuous vehicle structure.

III. Interstellar Ramjet Flow Field

The configuration of an interstellar ramjet and its flow regions cannot be postulated at this time. However, a schematic representation can be established. Figure 2 shows such a schematic representation as would be viewed by a hypothetical observer in a space-time reference system identical to that of an earth-bound observer. This space-time reference will be defined as being at rest with respect to the moving (on-coming) vehicle and will be referred to as "terrestrial space-time." This space-time reference system should not be confused with the space-time reference system which is attached to the moving vehicle and which will be referred to as "vehicle space-time." It should also be noted that since the outer boundaries of the vehicle system may not necessarily consist of rigid structures, they are simply defined as the perimeter of the region in which the vehicle propulsive processes are occurring.

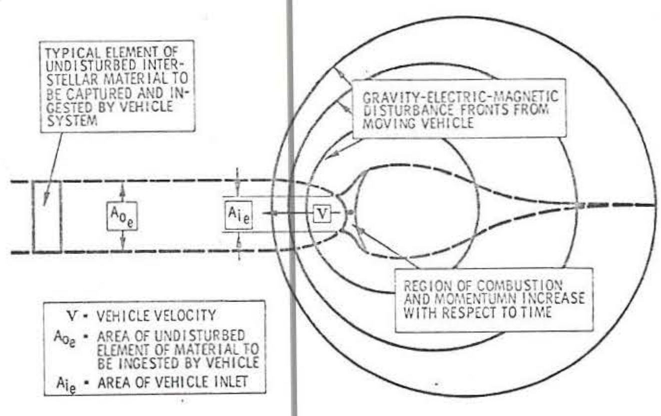

Figure 2 - Flow Field in Terrestrial Space-Time

External to the vehicle is the region of interstellar space which has already been affected by any gravity-electric-magnetic disturbances propagated by the moving vehicle. For the purpose of this schematic representation, these disturbances are shown to be propagating spherically and at optic velocity. Also shown is the undisturbed region of interstellar space which includes a given disc-shaped element of interstellar material which is yet to be disturbed, captured and ingested by the oncoming vehicle. If a positive magnetohydrodynamic coupling is established between the electric and magnetic fields of the vehicle system and those of the interstellar medium, the ratio of the cross sectional area of this element of material (A_{oe}) to that of the vehicle inlet (A_{ie}) could conceivably be greater than unity. If a negative coupling is established, this ratio could conceivably be less than unity.

A space-time reference which measures spatial and temporal quantities from the standpoint of the moving vehicle system (in vehicle space-time) is the most meaningful reference from the standpoint of the vehicle itself and its propulsive processes. At low flight speeds this space-time reference is equivalent to the space-time reference of a stationary observer, the only difference being that the vehicle appears stationary and the undisturbed interstellar medium is moving with respect to the vehicle. However, the vehicle and its flow field characteristics will not be equivalent in both space-time reference systems at relativistic vehicle speeds.

Figure 3 shows the representation of the vehicle system and flow field of Figure 2 as would be observed in the space-time reference system of an observer moving alongside a vehicle that is traveling at relativistic speed. Again it is emphasized that the vehicle and flow field representation is only schematic and not intended to imply in any way the expected geometry of an interstellar ramjet or of its associated flow field.

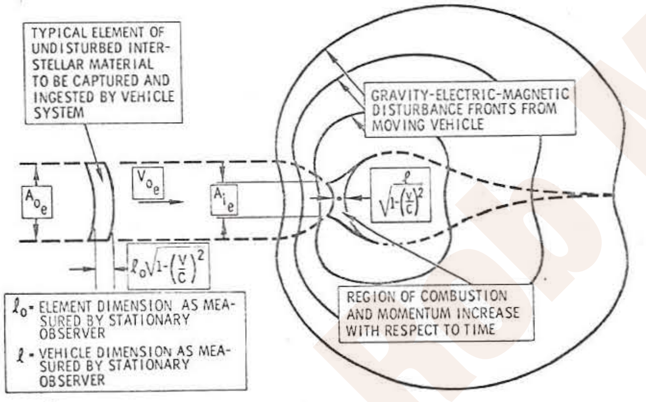

Figure 3 - Flow Field in Vehicle Space-Time

It is seen that all dimensions of the vehicle system that have a component in the vehicle flight direction will be subject to relativistic dilation and will appear longer from the standpoint of a moving observer than from the standpoint of a stationary observer. On the other hand, all dimensions of the disturbance fronts that propagate from the vehicle and have a component in the vehicle flight direction will be shorter from the standpoint of a moving observer than from the standpoint of a stationary observer. Furthermore, all dimensions of the given element of undisturbed interstellar material (that is yet to be affected and ingested by the vehicle system) that have a component in the vehicle flight direction will be shorter from the standpoint of the moving vehicle system and its propulsive processes.

This element of interstellar material will therefore appear more dense from the standpoint of the vehicle system and its propulsive processes than from the standpoint of a stationary observer.

For the case of non-relativistic ramjet flight, the undisturbed flight medium can be considered to be of uniform density and moving with a uniform velocity with respect to the vehicle system. For the more general case of relativistic ramjet flight, the undisturbed flight medium cannot be considered to be of uniform density and moving with a uniform velocity with respect to the vehicle system. This is because each sub-element within a given element of interstellar material (that is to be ingested by the vehicle system) may have a different velocity component in the vehicle flight direction (and hence relativistic dilation) with respect to the particular locality within the vehicle system in which its particular propulsion processes will occur. Therefore, for the more generalized case of relativistic ramjet flight, the vehicle and vehicle flow field geometry and kinematics are more complex than for classical (non-relativistic) ramjet flight.

IV. Interstellar Ramjet Performance

It has been shown that for the more general case of relativistic ramjet flight the classical ramjet flow field model is not valid, and the classic ramjet performance expressions are, therefore, not exact. However, one may consider the less general case wherein the cross sectional area of the stream tube of undisturbed interstellar material (which is to be subsequently affected and ingested by the vehicle system) is approximately equal to that of the vehicle inlet. For this special case, the free stream velocity and free stream density of every sub-element of this free stream can be considered to be approximately the same from the standpoint of the vehicle system and the initial propulsive processes. Therefore, it may be possible that for this special case, the free stream velocity and density of the interstellar medium can be considered to be approximately uniform with respect to the vehicle system, and the classical ramjet performance equations can be expected to be approximately valid, even at relativistic flight speeds.

Therefore, for this special case, the flight vehicle acceleration ($\dot V_e$) of a ramjet-like vehicle in vehicle space-time can be written in terms of the classical ramjet performance expression:

$$\dot V_e = \left[\left(C_{T_e}\cos\alpha_e - C_{D_e}\right)\frac{\rho_{oe}\,V_{oe}^2\,A_{ie}}{2\,M_e}\right] - \frac{\cos\theta_e}{g_e} \qquad (2)$$

where:

α_e = vehicle angle of attack, in vehicle space-time

Θ_e = angle between vehicle velocity vector and gravity acceleration vector, in vehicle space-time

C_{T_e} = vehicle thrust coefficient in vehicle space-time - defined as the net mass flow momentum increase with respect to time occurring within the vehicle boundaries divided by:

$\rho_{oe}V_{oe}^2A_{ie}/2$

C_{D_e} = vehicle drag coefficient in vehicle space-time - defined as the net mass flow momentum decrease with respect to time, occurring outside the vehicle boundaries divided by: $\rho_{oe}V_{oe}^2A_{ie}/2$

This mass flow momentum decrease includes both aerodynamic and magneto hydrodynamic flow resistance.

A_{ie} = frontal area of the vehicle engine inlet, in vehicle space - cm^2

M_e = vehicle mass, in vehicle space-time - gm

g_e = gravity acceleration at position of craft, in vehicle space-time cm/sec^2

V_{oe} = the oncoming (free stream) velocity of the captured interstellar matter (prior to being disturbed by the vehicle system) in vehicle space-time - cm/sec

ρ_{oe} = the average (free stream) density of the captured interstellar matter (prior to being disturbed by the vehicle system) in vehicle space-time - gm/cm^3

for the special case of rectilinear flight, with $\alpha_e = 0$ and $\theta_e = 90°$:

$$\dot{V}_e = \left(C_{T_e} - C_{D_e}\right)\frac{\rho_{oe}\ V_{oe}^2\ A_{ie}}{2\,M_e} \tag{3}$$

if, in the space-time reference system which is at rest with respect to the moving vehicle (terrestrial space-time), the vehicle flight velocity (V) is large in comparison with the average drift velocity (V_D) of the undisturbed interstellar material:

$$V \cong V_{oe}$$

and therefore Equation (3) can be approximately written:

$$\dot{V}_e = \left(C_{T_e} - C_{D_e}\right)\frac{\rho_{oe}\ V^2\ A_{ie}}{2\,M_e} \tag{4}$$

From the Special Law of Relativity, the ratio of the length (ℓ_{oe}) of a given element of material in vehicle space-time to its length (ℓ_o) in the space-time reference of an observer which is at rest with respect to the moving vehicle (terrestrial space-time) can be approximately expressed as:

$$\frac{\ell_{oe}}{\ell_o} = \left[1 - \left(\frac{V}{C}\right)^2\right]^{1/2} \tag{5}$$

For a given mass and cross sectional area, the ratio of the density of this given element of material in vehicle space-time (ρ_{oe}) to its density in terrestrial space-time (ρ_o) is inversely proportional to its length ratio. Therefore:

$$\frac{\rho_{oe}}{\rho_o} = \left[1 - \left(\frac{V}{C}\right)^2\right]^{-1/2} \tag{6}$$

and Equation (4) can be approximately written:

$$\dot{V}_e = \left[\left(C_{T_e} - C_{D_e}\right)\frac{A_{ie}}{M_e}\right]\left[\frac{\rho_o\,V^2}{2}\quad\left|1 - \left(\frac{V}{C}\right)^2\right|^{-1/2}\right] \tag{7}$$

Thrust coefficient (C_{T_e}) can be defined in terms of the ramjet propulsion parameters: "capture ratio", "equivalence ratio", "combustion efficiency", and "specific impulse", by the classical relationship:

$$C_{T_e} = \frac{2g_e\left(\dfrac{A_{oe}}{A_{ie}} \times ER_e \times N_{ce} \times I_{se}\right)}{V} \tag{8}$$

where:

$\dfrac{A_{oe}}{A_{ie}}$ = "capture ratio" - the ratio of the cross sectional area of the free stream tube of captured interstellar material to the area of the engine inlet, in vehicle space-time. (However, it is remembered that for the purpose of this special case this ratio is assumed to be approximately 1.0).

ER_e = "equivalence ratio" - the ratio of the total engine mass flow involved in the combustion interaction to that of the captured free stream, in vehicle space-time. (If the incoming interstellar material is the predominant fuel source, this ratio approaches unity. If the on-board terrestrial matter is the predominant fuel source, this ratio can be much greater than unity.

N_{ce} = "combustion efficiency" - the ratio of fuel mass flow that is actually involved in the combustion reaction to the total fuel mass flow passing through the engine system in vehicle space-time.

I_{se} = "specific impulse" - as inferred from measurement of engine exhaust velocity, in vehicle space-time - cm/sec. Values of I_{se} could be expected to approach but never exceed 3×10^{10} cm/sec (the propagating speed of electromagnetic radiation).

The product of $A_{oe}/A_{ie} \times ER_e \times N_{ce} \times I_{se}$ can be considered to be a direct measure of the vehicle propulsive efficiency. If this vehicle propulsive efficiency parameter is defined as (γ_e), Equation(8)can be written:

$$\dot{V}_e = \left[\gamma_e\left(\frac{2g_e}{V} - \frac{C_{D_e}}{\gamma_e}\right)\frac{A_{ie}}{M_e}\right]\left[\frac{\rho_o\ V^2}{2}\left\{1 - \left(\frac{V}{C}\right)^2\right\}^{-1/2}\right]$$

or

$$\dot{V}_e = \left[\gamma_e\left(1 - \frac{V}{2g_e}\,\frac{C_{D_e}}{\gamma_e}\right)\frac{A_{ie}}{M_e}\right]\left[g_e\,\rho_o\,V\left\{1 - \left(\frac{V}{C}\right)^2\right\}^{-1/2}\right] \tag{10}$$

From initial inspection of Equation (10) it is seen that the first and most obvious flight criteria that must be satisfied is that the ratio of vehicle drag coefficient to vehicle propulsive efficiency must be maintained at a value less than $2g_e/V$ in order that vehicle acceleration is, indeed, achieved during the initial accelerating portion of the journey. Therefore, as vehicle velocity increases from low (sub-optic) values to large (near-optic) values, it is increasingly important that any magnetic and electric fields generated for the purposes of mass flow momentum increase within the vehicle boundaries (thrust) do not result in a large corresponding mass flow decrease outside the vehicle boundaries (drag). The quantity $1 - \frac{V}{2g_e}\frac{C_{D_e}}{\gamma_e}$ can be considered to be a measure of the vehicle flight efficiency. If the vehicle drag coefficient (due to aerodynamic and/or magneto hydrodynamic flow resistance) can be made to approach zero. C_{D_e}/γ_e can also be made to approach zero and the value of this vehicle flight efficiency parameter will approach 1.0. As C_{D_e}/γ_e approaches $2g_e/V$ (the value at which vehicle acceleration must approach zero) the value of this vehicle flight efficiency parameter approaches zero. If this vehicle propulsive efficiency parameter is defined as ν_e, Equation(10)can be written as:

$$\dot{V}_e = \left[\gamma_e\, \nu_e\, \frac{A_{ie}}{M_e}\right]\left[g_e\, \rho_o\, V \left|1 - \left(\frac{V}{C}\right)^2\right|^{-\frac{1}{2}}\right] \qquad (11)$$

The quantity (A_{ie}/M_e) can be considered to be a measure of the average density of the vehicle region (wherein all propulsive processes are taking place). As such, it can be considered to be a measure of the vehicle structural efficiency. If this vehicle structural efficiency parameter is defined as σ_e, Equation(11)can be written:

$$\dot{V}_e = \left[\gamma_e\, \nu_e\, \sigma_e\right]\left[g_e\, \rho_o\, V \left|1 - \left(\frac{V}{C}\right)^2\right|^{-\frac{1}{2}}\right] \qquad (12)$$

The left hand bracket of Equation(12)represents the portion of vehicle performance that is influenced by vehicle propulsive efficiency, vehicle flight efficiency and vehicle structural efficiency. It is, therefore, that portion that is influenced by vehicle technology over which the designer has some degree of control. The right hand bracket represents that portion of vehicle performance which is influenced by the fuel or energy density that exists within interstellar space, (ρ_o) and by the fundamental behavior of time and space. It is, therefore, that portion over which the designer has no degree of control.

It should be remembered, however, that these expressions are based upon the Special Law of Relativity which is exact only for non-accelerating flight in gravity free space and non-rigorous assumptions as to the vehicle flow field. Therefore, they are useful only for the identification of vehicle flight performance trends, not for the computation of precise data.

V. Vehicle Technology Requirements

If one makes the bold assumption that man will someday evolve interstellar vehicle systems capable of relativistic flight one must also assume that they can be evolved by means of a logical series of developments over a terrestrial time period that is meaningful with respect to the lifetime of a technical earth bound civilization. This would probably include analysis and ground tests within planetary laboratories, test flights within our solar system and finally, test flights within the aerospace volume between earth and the nearest star systems. However, a critical fundamental technology problem yet remains if man desires to then embark upon longer interstellar journeys to the further reaches of our galaxy and to the even further reaches of the universe itself. This problem is due to the fact that, although the longest of interstellar journeys can possibly be made satisfactorily short from the standpoint of the vehicle itself and its on-board systems, such journeys would be prohibitively long in terms of elapsed earth time and hence for the acquisition of the flight data by earth bound technical personnel.

Therefore, for a truly significant interstellar technology to be evolved within a meaningful terrestrial time span, it would appear the two following criteria must be met: (1) laboratory tests and test flights which can be accomplished within reasonably short intervals of elapsed earth-time within our solar system, must provide the necessary confidence to embark upon the much more ambitious journeys to the most nearby star systems, and (2) test flights that can be accomplished within reasonable short intervals of elapsed earth-time between earth and the most nearby star systems must provide the necessary confidence to embark upon the much more ambitious interstellar journeys to the further and more unknown reaches of the universe.

However, these shorter and lower speed journeys cannot explore the higher relativistic speed environment that would be associated with the mid-flight portion of longer journeys to the further reaches of the universe. Nor will they provide data upon interstellar (fuel) densities that will be encountered throughout these longer journeys. Therefore, to have the necessary confidence to embark on these longer journeys, there must be some assurance that the vehicle performance demands and/or celestial fuel demands will be much less at the higher speeds and longer distances which would be associated with longer interstellar flights. It is therefore of interest to determine if there is any hope that this may occur.

Vehicle performance and celestial fuel demands during any interstellar journey can be expressed in terms of the product of: vehicle propulsive efficiency, vehicle flight efficiency, vehicle structural efficiency and interstellar fuel density. This can be shown by rearranging Equation(12)into the form:

$$\gamma_e\, \nu_e\, \sigma_e\, \rho_o = \dot{V}_e\left[g_e\, \rho_o\, V \left|1 - \left(\frac{V}{C}\right)^2\right|^{-\frac{1}{2}}\right]^{-1} \qquad (13)$$

It can be seen by inspection that if the vehicle flight acceleration is maintained at an approximately constant value, the required product of vehicle:propulsive efficiency x flight efficiency x structural efficiency x celestial fuel density will diminish with increasing flight velocity, becoming the least at the mid-flight portions of any interstellar journey (where flight velocity and relativistic space-time dilation is greatest).

The journey mid-point must be considered to be one of the more critical portions of any interstellar journey, especially for longer flights between galactic systems. For these flights, the journey mid-point will occur between the two systems in a region where the expected interstellar density would tend to be the least, and where uncertainty in the expected vehicle efficiencies and interstellar density would tend to be the greatest.

Vehicle performance and celestial fuel demands at the journey mid-point can be related to the total journey distance for flight profiles which consist of a constant value of vehicle acceleration during the initial half of the journey followed by an equal value of deceleration during the final half. This can be accomplished by utilizing the following expression from Reference 1 for the maximum velocity (V/C)max which occurs at the journey mid-point.

$$\left(\frac{V}{C}\right)_{MAX} = \tanh\left[\cosh^{-1}\left(1+\frac{\dot{V}_e S}{2C^2}\right)\right] \qquad (14)$$

From Equations (13) and (14), one can compute the vehicle efficiency and celestial fuel demands that will exist at the journey mid-point as a function of total journey distance. Figure 4 shows such a computation for the three levels of flight acceleration and deceleration (0.1, 1.0, and 10 earth gravities) considered in Figure 1. These demands are normalized by comparing them with those that will exist at the journey start which, for the purpose of this example, is assumed to occur at a ramjet take-over speed of (V/C) = 10^{-5} (3,000 meters/sec).

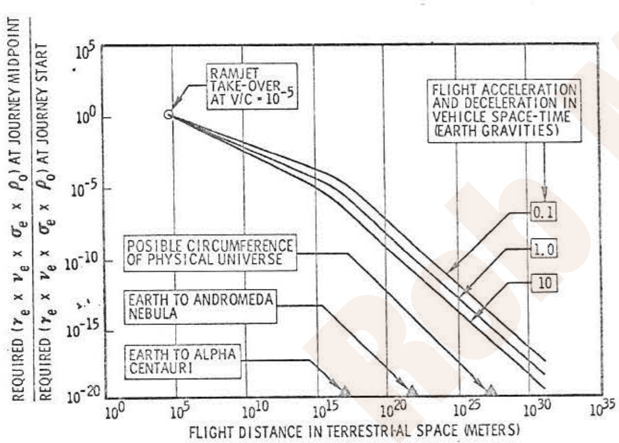

Figure 4 - Vehicle and Fuel Demands

It is seen that the vehicle efficiency and celestial fuel demands at the journey mid-point will decrease with increasing journey distance, becoming the least for the longest journeys (where relativistic flight velocity and space-time dilation is greatest). It is seen that they will decrease even more during higher acceleration-shorter duration journeys (where relativistic flight velocity and space-time dilation at the mid-point of a given interstellar journey will be even greater). This provides some hope that achievement and demonstration of a satisfactory margin of vehicle performance and celestial fuel supply during relatively short and low speed journeys within our solar system and to the most nearby star systems, could provide the necessary confidence that even more adequate margins could be achievable during subsequent longer journeys to the further and more unknown reaches of the universe.

VI. Conclusions

It would certainly be most premature to conclude from the preceding discussion that interstellar flight will be a future technological accomplishment. Such a conclusion must await a much more rigorous and comprehensive analysis and a much greater technical understanding of the many complex ramifications of interstellar flight. Nevertheless, it is believed that it provides at least some encouragement as to the prospects for its eventual attainment. In particular it has been concluded that:

- There is the distinct possibility that at relativistic velocities, an interstellar vehicle can traverse almost any conceivable distance - to the very outermost limits of the universe - within the lifetime of the inhabitants of such a vehicle. However, vehicles which rely primarily upon the energy that resides within onboard terrestrial matter appear unable to accomplish such relativistic flight.

- Ramjet-like propulsion concepts, which can extract the predominant portion of their energy from the tenuous yet enormous volume of interstellar matter that resides within cosmic space, show the only promise for accomplishing relativistic interstellar flight. Such vehicles may not resemble presently envisioned terrestrial ramjet craft in any way and are beyond current technology. However, such vehicles are not necessarily forever beyond the technological capabilities of man.

- One of the most critical interstellar ramjet flight regions may occur at the mid-flight portions of longer journeys where interstellar (fuel) density will tend to be the least, and uncertainties in the expected vehicle efficiency and interstellar density will tend to be the greatest. However, for such vehicles, relativistic effects tend to cause fuel demands and vehicle efficiency demands to diminish with increasing flight velocity becoming the least at the higher speed, midflight portions of the longest journeys.

- This provides hope that the technology and assurance that may someday be developed over a reasonably short terrestrial time span by means of reasonably short journeys within our solar system and to nearby star systems, would be adequate to permit the confident embarkation upon much more ambitious journeys to the further limits of the universe.

From these conclusions one could almost imply that nature, through the extraordinary behavior of time and space, is providing not only the theoretical possibility of interstellar flight, but also, for ramjet-like vehicles, the technological possibility as well. It is therefore believed that these encouraging prospects challenge the propulsion scientist and engineer of the future to consider interstellar flight as a possible future derivative of air-breathing technology.

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Acknowledgements

The author wishes to acknowledge and express his gratitude for the constructive comments given with respect to this paper by: Dr. Robert M. Wood, Dr. J. K. Wall, and Dr. R. A. Willett, of the Advanced Systems and Technology Department of the Douglas Missiles and Space Systems Group. Their helpful comments were incorporated into Reference 6, from which the technical material in this paper has been partially extracted.

INTRODUCTORY SPACE PHYSICS

VOLUME II

PHYSICS

370

UNITED STATES AIR FORCE ACADEMY

INTRODUCTORY SPACE PHYSICS

PHYSICS

370

UNITED STATES AIR FORCE ACADEMY

76

Kite with flashlight batteries and bulb attached were retrieved by law enforcement authorities in the Moline, Illinois area after a rash of sightings had been reported in the area by numerous local citizens.


HI-FLIER
GIANT
HI-GLOW

LIGHTS IN THE SKY (NIGHT)

1. Stationary for 1/2 hour or more: no sound (STAR)

2. Red-green-white flashing, steady course: sound or no sound (HIGH AIRPLANE)

3. Swift-moving, straight or slightly curved path, less than 10 seconds. May hear rumble. (METEOR)

4. Starlike, bluish-white or white, silent, steady course, curved course, erratic side-to-side jumps. May disappear suddenly or goes in earth shadow. (SATELLITE)

5. Bright starlike moving light or cluster of lights; most white, plus red and green, bright lights turning off and on, approach and departure of smaller lights (all colors). White ---- orange when low in sky. Speed and uniformity of motion of satellite, but sometimes changes in direction; follow-the-leader pattern. Not fast. Durations 10-30 minutes, may repeat pattern. No sound. (NIGHT REFUELING MISSION)

6. Oval object, glowing, swooping or stationary or circling, single or multiple, at least 0.5 cloud cover, long duration (hours or more), all same size. Sometimes overlap or "pass behind or in front". Can disappear or appear suddenly. No sound. Evening hours (to midnight or so). No markings. All same color (SEARCHLIGHTS)

7. Very bright, single or double, may hover, then move to either side: often no sound, may turn off suddenly. (AIRCRAFT LANDING LIGHTS)

8. Small brilliant disc in sky, morning or evening twilight. Stationary or very slowly moving; gradually turning from white to red (evenings) or red to white (mornings). May seem to dart side-to-side, up-and-down, but average position constant. (BALLOON)

9. Low over horizon; flashing red-green, long duration (30 minutes to 4 hours) average position slowly changes (rising or setting). Distorted blob in binoculars. May seem to dart briefly in various directions. (STAR)

1. Multiply observed object seen in detail having characteristics of appearance or behavior that do not match any known object.

2. One-observer case, similar to above.

2a. Any other multiple observer case.

3. Object well observed but at a distance, or else small in size; outline visible but no detail; behavior not consistent with normal expectations.

4. Distant or small object poorly observed, no details, only the apparent behavior is striking.

5. Poorly observed object, behavior not unusual.

6. Rumor.

DAYLIGHT OBSERVATIONS

1. Teardrop or tadpole (verticle, big end up), or circular. White in color, perhaps dangling line visible, or smaller object below; drifting slowly (surface wind irrelevant).

2. Cigar or saucer-shape silhouette: hovering or moving: distant or small (no sound).

3. Lens-shaped white object, pointed at ends, fuzzy or sharp outline, stationary or moving slowly.

4. Rainbow-colored patches of light, usually rectangular and small.

5. Round white disc, sharp edges, just over cloud layer below airplane (seen from airplane). Paces airplane. May appear to go into and out of clouds.

PROJECT BLUE BOOK

SPECIAL REPORT NO. 14

(ANALYSIS OF REPORTS OF UNIDENTIFIED AERIAL OBJECTS)

PROJECT NO. 10073

5 MAY 1955

AIR TECHNICAL INTELLIGENCE CENTER
WRIGHT-PATTERSON AIR FORCE BASE
OHIO

Copy No. 55

RECOMMENDED BOOKS ON ASTRONOMY AND THE SPACE SCIENCES

Prepared by the

Public Information Office
of the

Smithsonian Astrophysical Observatory
60 Garden Street
Cambridge, Massachusetts, 02138

It is extremely difficult to prepare and maintain a truly up-to-date bibliography of space books. Science, especially in the exploration of space, progresses so rapidly that no book can possibly include all the latest discoveries. For example, no book on astronomy listed here will tell you that Saturn has 10 moons. Janus, the tenth and smallest satellite of Saturn, was only discovered in January 1967.

It is also difficult to prepare any bibliography without making some inadvertent errors or omissions. To those readers--and authors--who feel slighted by our listings, we apologize. There are literally hundreds of good books on space, and we have merely attempted to suggest a small, representative sample.

We have tried to give the price of all suggested books; however, some of those titles without prices are now out of print and available only in library collections. Students may find also that many expensive editions have now been issued in paperback. So, before ordering books from a publisher, check with your local librarian to see what is available. Your librarian will also be the best source for the titles of new and revised space science books.

James C. Cornell Jr.
Public Information Officer

17 Jan 67

— Info only —

An experimental re-entry vehicle in the Advanced Ballistic Re-entry Systems (ABRES) program was launched down the Air Force Western Test Range today at 1735 hours, Pacific Standard Time, using an Atlas F-ICBM booster from Vandenburg AFB, California. The Atlas-ABRES combination was launched by members of the 6595th Aerospace Test Wing. The Air Force Systems Command, Ballistic Systems Division, manages the ABRES program which is aimed at developing an even more effective re-entry vehicle for this nations ICBM deterent force.

In the missile launch from Vandenburg AFB on the 17th of January an occurance called visual phenomena took place. This occurs when the missile launchings take place in the early evening or early morning hours. The missile upon leaving the lower altitudes and passing out of the earth's atmosphere leaves a bell shaped shock wave. The sun shining on this shock wave creates unusual patterns in the sky.

The Vandenburg PIO mentioned that persons were observing the above as far off as Salt Lake Utah and Flaggstaff, Arizona.

The Physics and Metaphysics of Unidentified Flying Objects

William Markowitz
(Marquette University)

Reprinted from *Science,* September 15, 1967, Vol. 157, No. 3794, pages 1274-1279

UFOIRC-6601

THE REFERENCE FOR OUTSTANDING UFO SIGHTING REPORTS

UFOIRC

UFO INFORMATION RETRIEVAL CENTER, INC.
P.O. BOX 57, RIDERWOOD/MARYLAND 21139, USA

APPENDIX H

U. S. Department of Commerce Weather Bureau

Information on Ball Lightning

AFOSR 68-1656

UFOs and Related Subjects: An Annotated Bibliography

LYNN E. CATOE
Library of Congress

Air Force Office of Scientific Research
Office of Aerospace Research ★ USAF

MG Brief
Nr 4
P. 11

OPERATIONS & TRAINING

UFO'S SERIOUS BUSINESS

Unidentified flying objects - sometimes treated lightly by the press and referred to as "flying saucers" - must be rapidly and accurately identified as serious USAF business in the ZI. As AFR 200-2 points out, the Air Force concern with these sightings is threefold: First of all, is the object a threat to the defense of the U. S.? Secondly, does it contribute to technical or scientific knowledge? And then there's the inherent USAF responsibility to explain to the American people through public-information media what is going on in their skies.

The phenonoma or actual objects comprising UFO's will tend to increase, with the public more aware of goings on in space but still inclined to some apprehension. Technical and defense considerations will continue to exist in this era.

Published about three months ago, AFR 200-2 outlines necessary orderly, qualified reporting as well as public-information procedures. This iswhere the base should stand today, with practices judged at least satisfactory by commander and inspector:

- Responsibility for handling UFO's should rest with either intelligence, operations, the Provost Marshal or the Information Officer - in that order of preference, dictated by limits of the base organization;

- A specific officer should be designated as responsible;

- He should have experience in investigative techniques and also, if possible, scientific or technical background;

- He should have authority to obtain the assistance of specialists on the base;

- He should be equipped with binoculars, camera, Geiger counter, magnifying glass and have a source for containers in which to store samples.

What is required is that every UFO sighting be investigated and reported to the Air Technical Intelligence Center at Wright-Patterson AFB and that explanation to the public be realistic and knowledgeable. Normally that explanation will be made only by the OSAF Information Office. It all adds up to part of the job of being experts in our own domain.

ANNUAL PROFICIENCY CHECKS

The pilot's annual proficiency check, performed under the provisions of AFR 60-2, is to be accomplished during the period 120 to 180 days following his birthday. The initial phasing into this new time cycle is presenting a problem for some pilots whose annual check dates are due prior to the 120 - 180-day period. There is a question as to whether new tests must be taken on the anniversary of the last proficiency check to continue validity of flying status, and again during the period 120 - 180 days after the next birthday.

Headquarters USAF clarified this matter in a letter to all commands, "AFR 60-2 Annual Flying Examinations," dated 3 November 1959. The letter provides that the pilot's most recently completed proficiency check will be valid until 180 days after his next birthday, thus obviating the necessity for an additional examination. After the first proficiency check has been accomplished under the new time schedule, the provisions of the cited regulation will continue to apply.

UNCLASSIFIED

Technical Report No. F-TR-2274-IA

UNIDENTIFIED AERIAL OBJECTS

PROJECT "SIGN"

AMC

INTELLIGENCE DEPARTMENT

Release Date: February 1949

HEADQUARTERS AIR MATERIEL COMMAND

WRIGHT-PATTERSON AIR FORCE BASE

DAYTON, OHIO

S-11750-18

UNCLASSIFIED

DOWNGRADED AT 3 YEAR INTERVALS
DECLASSIFIED AFTER 12 YEARS.
DOD DIR 5200.10

WF-(B)-O-9 JUL 48 10M

3-1

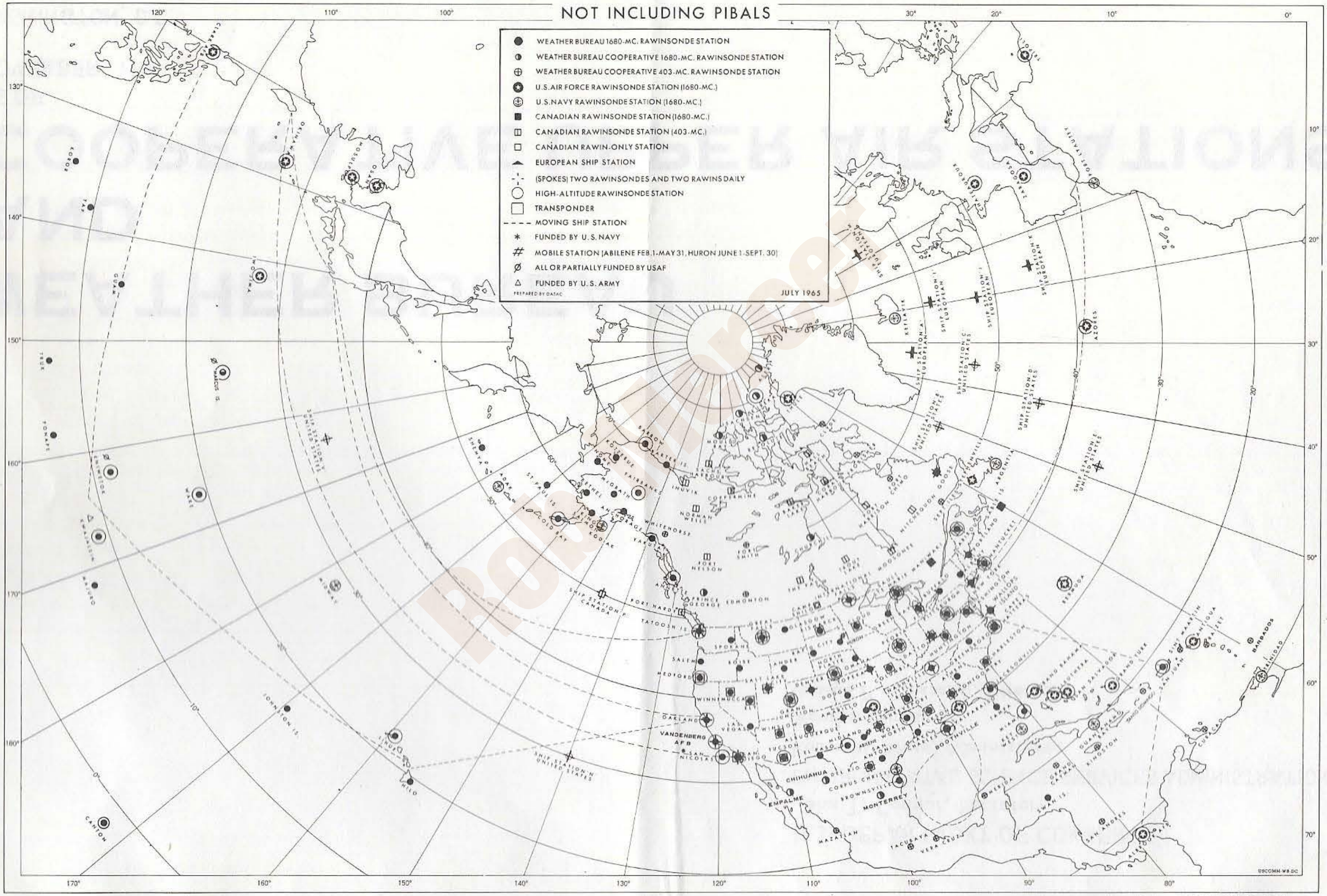
U.S. DEPARTMENT OF COMMERCE
John T. Connor, Secretary
ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION
Robert M. White, Administrator
Weather Bureau
George P. Cressman, Director

WEATHER BUREAU AND COOPERATIVE UPPER AIR STATIONS

AS OF
NOVEMBER, 1965

WASHINGTON, D.C.

UPPER-AIR NETWORK



U. S. DEPARTMENT OF COMMERCE
ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION
WEATHER BUREAU

NOVEMBER 1965

SUMMARY

Number of Stations Participating in Various Programs

	Rawinsonde	Winds Aloft*
# United States except Alaska and Hawaii	69	138
Alaska	14	14
Antarctic	2	2
# Carribean Area	2	3
Hawaii	2	4
Pacific Islands (not including Hawaii)	9	9
Cooperative and Special Project Stations		
United States except Alaska and Hawaii	4	4
Bahamas	0	1
Canada	14	14
Caribbean Area	8	8
Mexico	7	14
+ Ocean Stations	6	6
Pacific Islands	4	4
South America	4	4
TOTALS	145	225

*Includes rawinsonde stations.
#See additional stations listed under "Cooperative Stations".
+Reports are supplemented by moving-ship programs.

SUMMARY OF RAWINSONDE PROGRAM

	Number of stations equipped with					No. of stations versus No. of observations daily			Intermediate rawins
	SCR	WBRT	GMD	Other	Total	1-daily	2-daily	4-daily	2-daily
# United States except Alaska and Hawaii	-	52	17	-	69	-	67	2	18
Alaska	-	14	-	-	14	-	14	-	-
Antarctic	-	-	2	-	2	2**	-	-	-
# Caribbean Area	-	1	1	-	2	-	2	-	-
Hawaii	-	-	2	-	2	-	2	-	-
Pacific Islands (not including Hawaii)	-	-	9	-	9	6	3	-	-
Cooperative and Special Project Stations									
United States except Alaska and Hawaii	-	-	4	-	4	1	1*	1	-
Canada	7	1	6	-	14	-	14	-	-
Caribbean Area	7	-	1	-	8	1	7	-	-
Mexico	4	-	3	-	7	3	4	-	-
Ocean Stations	-	-	-	6	6	-	6	-	6
Pacific Islands	-	-	4	-	4	1	2*	-	-
South America	2	-	2	-	4	1	3	-	-
TOTALS	20	68	51	6	145	15	125	3	24

*Stations observing on a non-scheduled basis.
**2-daily during the summer flying season.
#See additional stations listed under "Cooperative Stations".
+Reports are supplemented by moving-ship programs.

Station		Latitude (N)		Longitude (W)		Type of rawinsonde equip.	Elevation for raob purposes (gpm)	Scheduled radiosonde or rawinsonde observations				Scheduled winds-aloft observations			
		°	'	°	'			0000 GCT	0600 GCT	1200 GCT	1800 GCT	0000 GCT	0600 GCT	1200 GCT	1800 GCT
ABILENE	TEX	32	26	099	41							P	P	P	P
ABILENE UAU	TEX	32	26	099	41	GMD	534	RS[1]		RS[1]		RW[1]		RW[1]	
ALAMOSA	COLO	37	27	105	52										P
ALBANY	NY	42	45	073	48	GMD	86	RS		RS		RW	P	RW	P
ALBUQUERQUE	NMEX	36	03	106	37	WBRT-R	1619	RS		RS		RW	P	RW	P
ALPENA	MICH	45	05	083	34										P
AMARILLO	TEX	35	14	101	42	GMD	1095	RS		RS		RW	RW	RW	RW
AMUNDSEN SCOTT	AARC	90	00 S			GMD	2800	RS		2		RW		2	
ANCHORAGE	A	61	10	149	58	WBRT	29	RS		RS		RW	P	RW	P
ANNETTE	A	55	02	131	34	WBRT	37	RS		RS		RW	P	RW	P
ATHENS	GA	33	57	083	19	WBRT	246	RS		RS		RW	P	RW	P
BARROW	A	71	18	156	47	WBRT	8	RS		RS		RW	P	RW	P
BARTER ISLAND	A	70	08	143	38	WBRT	15	RS		RS		RW		RW	
BECKLEY	W VA	37	47	081	07								P		P
BETHEL	A	60	47	161	48	WBRT	39	RS		RS		RW	P	RW	P
BILLINGS	MONT	45	48	108	32								P		P
BINGHAMTON	NY	42	13	075	59								P		P
BIRMINGHAM	ALA	33	34	086	45								P		P
BISHOP	CAL	37	22	118	22										P
BISMARCK	ND	46	46	100	45	WBRT-R	505	RS		RS		RW	P	RW	P
BOISE	ID	43	34	116	13	WBRT	868	RS		RS		RW	P	RW	P
BOOTHVILLE	LA	29	20	089	24	WBRT	3	RS		RS		RW		RW	
BOSTON	MASS	42	22	071	02								P		P
BROWNSVILLE	TEX	25	54	097	26	WBRT	7	RS		RS		RW	P	RW	P
BUFFALO	NY	42	56	078	44	GMD	218	RS		RS		RW	P	RW	P
BURLINGTON	VT	44	28	073	09								P		P
BURNS	ORE	43	35	118	57							P	P	P	P
BYRD	AARC	80	01 S	119	31	GMD	1530	RS		2		RW		2	
CANTON IS	PAC	02	43 S	171	43	GMD	4	RS				RW	P		P
CAPE HATTERAS	NC	35	16	075	33	GMD	4	RS		RS		RW	P	RW	P
CARIBOU	ME	46	52	068	01	WBRT-R	191	RS		RS		RW		RW	P
CASPER	WYO	42	55	106	28								P		P
CHARLESTON	SC	32	54	080	02	WBRT-R	13	RS		RS		RW	P	RW	P
CHEYENNE	WYO	41	09	104	49								P		P
CHRISTIANSTED	VI	17	45	064	44							P		P	
CINCINNATI	OHIO	39	04	084	40								P		P
COLD BAY	A	55	12	162	43	WBRT	30	RS		RS		RW	P	RW	P
COLUMBIA	MO	38	58	092	22	WBRT-R	238	RS		RS		RW	P	RW	P
COLUMBUS	OHIO	40	00	082	53								P		P
DAYTON	OHIO	39	52	084	07	WBRT-R	297	RS		RS		RW	RW	RW	RW
DEL RIO	TEX	29	22	100	55	WBRT-R	314	RS		RS		RW	RW	RW	RW

Station		Latitude (N) °	'	Longitude (W) °	'	Type of rawinsonde equip.	Elevation for raob purposes (gpm)	Scheduled radiosonde or rawinsonde observations 0000 GCT	0600 GCT	1200 GCT	1800 GCT	Scheduled winds-aloft observations 0000 GCT	0600 GCT	1200 GCT	1800 GCT
DENVER	COLO	39	46	104	53	WBRT	1611	RS		RS		RW	RW	RW	RW
DES MOINES	IA	41	32	093	39										P
DODGE CITY	KANS	37	46	099	58	WBRT	791	RS		RS		RW	P	RW	P
DULUTH	MINN	46	50	092	11								P		
EL PASO	TEX	31	48	106	24	WBRT	1193	RS		RS		RW	P	RW	P
ELY	NEV	39	17	114	51	WBRT-R	1980	RS		RS		RW	P	RW	P
EUGENE	ORE	44	07	123	13								P		P
EVANSVILLE	IND	38	03	087	32								P		P
FAIRBANKS	A	64	49	147	52	WBRT	135	RS		RS		RW	P	RW	P
FARGO	ND	46	54	096	48								P		P
FLINT	MICH	42	58	083	44	WBRT-R	234	RS		RS		RW	P	RW	P
FT WAYNE	IND	41	00	085	12								P		P
FORT WORTH UAU	TEX	32	46	097	25	WBRT-R	180	RS		RS		RW	RW	RW	RW
FRESNO	CAL	36	46	119	43								P		P
GLASGOW	MONT	48	13	106	37	WBRT	696	RS		RS		RW		RW	P
GOODLAND	KANS	39	22	101	42								P		P
GRAND JUNCTION	COLO	39	07	108	32	WBRT-R	1474	RS		RS		RW	P	RW	P
GREAT FALLS	MONT	47	29	111	21	WBRT-R	1123	RS		RS		RW	RW	RW	RW
GREEN BAY	WISC	44	29	088	08	WBRT	210	RS		RS		RW	P	RW	P
GREENSBORO	NC	36	05	079	57	WBRT	273	RS		RS		RW	P	RW	P
GREENVILLE	SC	34	54	082	13								P		P
GUAM/TAGUAC	PAC	13	33	144	50 E	GMD	111	RS		RS		RW	P	RW	P
HARRISBURG	PA	40	13	076	51								P		P
HARTFORD	CONN	41	56	072	41								P		P
HAVRE	MONT	48	33	109	46										P
HILO	HAW	19	43	155	04	GMD	11	RS		RS		RW	P	RW	P
HONOLULU	HAW	21	20	157	55							P	P	P	P
HUNTINGTON	WVA	38	22	082	33	WBRT-R	246	RS		RS		RW		RW	P
HURON	SD	42	30	098	13										P
HURON MOBILE UAU	SD					GMD	393	RS[3]		RS[3]		RW[3]		RW[3]	
INDIANAPOLIS	IND	39	44	086	17								P		P
INTERNATIONAL FALLS	MINN	48	34	093	23	WBRT	360	RS		RS		RW	RW	RW	RW
JACKSON	MISS	32	20	090	13	WBRT-R	94	RS		RS		RW	P	RW	P
JACKSONVILLE	FLA	30	25	081	39	GMD	5	RS		RS		RW	P	RW	P
JOHNSTON ISLAND	PAC	16	44	169	31	GMD	3	RS		RS		RW	P	RW	P
KAHULUI	HAW	20	54	156	26							P	P		P
KING SALMON	A	58	41	156	39	WBRT	15	RS		RS		RW		RW	
KNOXVILLE	TENN	35	49	083	59								P		P
KOROR WCI	PAC	07	20	134	29 E	GMD	30	RS				RW		P	
KOTZEBUE	A	66	52	162	38	WBRT	5	RS		RS		RW		RW	
LAKE CHARLES	LA	30	07	093	13	WBRT	5	RS		RS		RW	P	RW	P
LANDER	WYO	42	49	108	44	WBRT	1696	RS		RS		RW	P	RW	P

Station		Latitude (N) °	'	Longitude (W) °	'		Type of rawinsonde equip.	Elevation for raob purposes (gpm)	Scheduled radiosonde or rawinsonde observations 0000 GCT	0600 GCT	1200 GCT	1800 GCT	Scheduled winds-aloft observations 0000 GCT	0600 GCT	1200 GCT	1800 GCT
LAS VEGAS	NEV	36	05	115	10		WBRT	660	RS		RS		RW	P	RW	P
LEWISTON	ID	46	23	117	01											P
LIHUE	HAW	21	59	159	21		GMD	36	RS		RS		RW	P	RW	P
LITTLE ROCK	ARK	34	44	092	14		WBRT-R	79	RS		RS		RW	P	RW	P
LOUISVILLE	KY	38	11	085	44									P		P
MADISON	WIS	43	08	089	20									P		P
MAJURO MARSHALL IS	PAC	07	05	171	23	E	GMD	0003	RS				RW		P	
MARQUETTE	MICH	46	34	087	24											P
MCGRATH	A	62	58	155	37		WBRT	103	RS		RS		RW		RW	
MEDFORD	ORE	42	22	122	52		WBRT-R	401	RS		RS		RW	P	RW	P
MEMPHIS	TENN	35	03	089	59									P		P
MIAMI	FLA	25	48	080	16		WBRT	4	RS		RS		RW	P	RW	P
MIDLAND	TEX	31	56	102	12		WBRT	874	RS		RS		RW	P	RW	P
MILFORD	U	38	26	113	01											P
MISSOULA	MONT	46	55	114	05									P		P
MOBILE	ALA	30	41	088	15									P		P
MOLINE	ILL	41	27	090	31									P		P
MONTGOMERY	ALA	32	18	086	24		WBRT-R	61	RS		RS		RW	RW	RW	RW
MUSKEGON	MICH	43	10	086	14									P		P
NANTUCKET	MASS	41	15	070	04		WBRT-R	14	RS		RS		RW	P	RW	P
NASHVILLE UAU	TENN	36	15	086	34		WBRT	180	RS		RS		RW	RW	RW	RW
NEW ORLEANS	LA	29	59	090	15									P		P
NEW YORK	NY	40	39	073	47		GMD	5	RS		RS		RW	RW	RW	RW
NOME	A	64	30	165	26		WBRT	7	RS		RS		RW.	P	RW	P
NORTH PLATTE	NEBR	41	08	100	41		WBRT-R	848	RS		RS		RW	P	RW	P
OAKLAND	CAL	37	44	122	12		GMD	6	RS		RS		RW	RW	RW	RW
OKLAHOMA CITY	OKLA	35	24	097	36		WBRT	392	RS		RS		RW		RW	
OMAHA N OMAHA UAU	NEBR	41	22	096	01		WBRT	403	RS		RS		RW	P	RW	P
PENDLETON	ORE	45	41	118	51									P		P
PEORIA	ILL	40	40	089	41		WBRT-R	200	RS		RS		RW	RW	RW	RW
PHILADELPHIA	PA	39	53	075	15									P		P
PHOENIX	ARIZ	33	26	112	01									P		
PITTSBURGH UAU	PA	40	32	080	14		WBRT-R	361	RS	RS	RS	RS	RW	RW	RW	RW
POCATELLO	ID	42	55	112	36									P		P
PONAPE ECI	PAC	06	58	158	13	E	GMD	39	RS				RW		P	
PORTLAND	ME	43	39	070	19		WBRT	20	RS		RS		RW	RW	RW	RW
PUEBLO	COLO	38	17	104	31									P		P
PUERTO CABEZAS	N	14	00	083	24										P	P
RALEIGH	NC	35	52	078	47									P		P
RAPID CITY	SD	44	03	103	04		WBRT	966	RS		RS		RW	P	RW	P
RATON	NMEX	36	45	104	30											P

Station		Latitude (N)		Longitude (W)		Type of rawinsonde equip.	Elevation for raob purposes (gpm)	Scheduled radiosonde or rawinsonde observations				Scheduled winds-aloft observations			
		°	'	°	'			0000 GCT	0600 GCT	1200 GCT	1800 GCT	0000 GCT	0600 GCT	1200 GCT	1800 GCT
RED BLUFF	CAL	40	09	122	15										P
RENO	NEV	39	30	119	47								P		P
RICHMOND	VA	37	30	077	20								P		P
ROSWELL	NMEX	33	24	104	32										P
SACRAMENTO	CAL	38	31	121	30										P
ST CLOUD	MINN	45	35	094	11	WBRT-R	316	RS		RS		RW		RW	P
ST LOUIS	MO	38	45	090	23								P		P
ST PAUL IS	A	57	09	170	13	WBRT	10	RS		RS		RW		RW	
SALEM	ORE	44	55	123	01	WBRT	61	RS		RS		RW	P	RW	P
SALT LAKE CITY	U	40	46	111	58	WBRT-R	1288	RS		RS		RW	RW	RW	RW
SAN ANTONIO	TEX	29	32	098	28	WBRT	243	RS		RS		RW	P	RW	P
SANDBERG	CAL	34	45	118	44										P
SAN DIEGO	CAL	32	49	117	08	GMD	124	RS	RS	RS	RS	RW	RW	RW	RW
SAN JUAN	PR	18	26	066	00	WBRT	6	RS		RS		RW	P	RW	P
SAULT STE MARIE	MICH	46	28	084	22	WBRT-R	221	RS		RS		RW	P	RW	P
SHEMYA	A	52	43	174	06	WBRT	38	RS		RS		RW		RW	
SHERIDAN	WYO	44	46	106	58										P
SHREVEPORT	LA	32	28	093	49	GMD	79	RS		RS		RW	P	RW	P
SIOUX CITY	IA	42	24	096	23								P		P
SPOKANE	WASH	47	38	117	32	GMD	722	RS		RS		RW	P	RW	P
SPRINGFIELD	ILL	39	50	089	40								P		P
SPRINGFIELD	MO	37	14	093	23								P		P
SWAN ISLAND	WI	17	24	083	56	GMD	10	RS		RS		RW	P	RW	P
SYRACUSE	NY	43	07	076	07								P		P
TALLAHASSEE	FLA	30	23	084	22							P	P	P	P
TAMPA	FLA	27	58	082	32	GMD	8	RS		RS		RW	P	RW	P
TATOOSH IS	WASH	48	23	124	44	GMD	31	RS		RS		RW	RW	RW	RW
TOLEDO	OHIO	41	36	083	48								P		P
TOPEKA	KANS	39	04	095	38	WBRT	269	RS		RS		RW	RW	RW	RW
TRUK ECI	PAC	07	28	151	5U	GMD		RS				RW		P	
TUCSON	ARIZ	32	07	110	56	GMD	789	RS		RS		RW	P	RW	
TULSA	OKLA	36	11	095	54								P		P
WACO	TEX	31	37	097	13								P		P
WAKE ISLAND	PAC	19	17	166	39	GMD	5	RS		RS		RW	P	RW	P
WALLOPS IS UAU	VA	37	51	075	29	GMD-R	2	RS		RS		RW	RW	RW	RW
WASHINGTON UAU	DC	38	59	077	28	WBRT-R	85	RS		RS		RW		RW	
WENDOVER	U	40	44	114	02										P
WICHITA	KANS	37	39	097	25								P		P
WILLIAMSPORT	PA	41	15	076	55										P
WILLISTON	ND	48	10	103	38										P
WINNEMUCCA	NEV	40	54	117	48	WBRT-R	1310	RS		RS		RW	P	RW	P
WINSLOW	ARIZ	35	01	110	44	WBRT-R	1492	RS		RS		RW	P	RW	P

Station		Latitude (N)		Longitude (W)		Type of rawinsonde equip.	Elevation for raob purposes (gpm)	Scheduled radiosonde or rawinsonde observations				Scheduled winds-aloft observations			
		°	'	°	'			0000 GCT	0600 GCT	1200 GCT	1800 GCT	0000 GCT	0600 GCT	1200 GCT	1800 GCT
YAKIMA	WASH	46	34	120	32								P		P
YAKUTAT	A	59	31	139	40	WBRT	12	RS		RS		RW	P	RW	P
YAP WCI	PAC	09	31	138	08	GMD	17	RS				RW		P	
YOUNGSTOWN	OHIO	41	16	080	40								P		P
YUMA	ARIZ	32	40	114	36										P

Station		Latitude (N)		Longitude (W)		Type of rawinsonde equip.	Elevation for raob purposes (gpm)	Scheduled radiosonde or rawinsonde observations				Scheduled winds-aloft observations			
		°	'	°	'			0000 GCT	0600 GCT	1200 GCT	1800 GCT	0000 GCT	0600 GCT	1200 GCT	1800 GCT
UNITED STATES															
5 MISS TEST FAC	MISS	30	28	089	42	GMD			irregular						
6 SAN NICHOLAS IS	CAL	33	14	119	27	GMD		RS		RS		RW		RW	
4 VANDENBERG AFB	CAL	34	40	120	35	GMD	113	RS	RS	RS	RS	RW	RW	RW	RW
7 YUCCA FLAT	NEV	36	57	116	03	GMD				RS		P	P	RW	P
BAHAMAS															
NASSAU	BI	25	03	077	22							P	P	P	P
CANADA															
ALERT	NWT	82	30	062	20	GMD	66	RS		RS		RW	P	RW	P
CHURCHILL	MAN	58	45	094	05	GMD	35	RS		RS		RW	P	RW	P
CLYDE	NWT	70	27	068	33	SCR	8	RS		RS		RW		RW	
EDMUNTON	ALTA	53	34	113	31	SCR	676	RS		RS		RW	P	RW	P
EUREKA	NWT	80	06	085	57	GMD	7	RS		RS		RW	P	RW	P
FORT CHIMO	PQ	58	06	068	26	SCR	36	RS		RS		RW		RW	
FORT SMITH	NWT	60	01	111	58	SCR	203	RS		RS		RW		RW	
FROBISHER	NWT	63	45	068	34	SCR	21	RS		RS		RW		RW	
ISACHSEN	NWT	78	47	103	32	GMD	30	RS		RS		RW	P	RW	P
MOULD BAY	NWT	76	17	119	28	GMD	20	RS		RS		RW	P	RW	P
PRINCE GEORGE	BC	53	54	122	40	WBRT	676	RS		RS		RW		RW	
RESOLUTE	NWT	74	41	094	54	GMD	64	RS		RS		RW	P	RW	P
SEPT ILES	PQ	50	13	066	16	SCR	58	RS		RS		RW.		RW	
WHITEHORSE	YT	60	43	135	05	SCR	698	RS		RS		RW	P	RW	P
CARIBBEAN															
BARBADOS	WI	13	04	059	30	GMD	56	RS				RW			
CURACAO	NA	12	11	068	58	SCR	9	RS		RS		RW	P	RW	P
GRAND CAYMAN	BWI	19	18	081	22	SCR	3	RS		RS		RW		RW	
KINGSTON	BWI	17	56	076	47	SCR	1	RS		RS		RW		RW	
RAIZET	FWI	16	16	061	31	SCR	8	RS		RS		RW		RW	
SAN ANDRES IS	COLU	12	35	081	42	SCR	2	RS		RS		RW		RW	
SANTO DOMINGO	DR	18	28	069	53	SCR	14	RS		RS		RW		RW	
SINT MAARTEN	NA	18	02	063	07	SCR	3	RS		RS		RW		RW	
MEXICO															
CHIHUAHUA	MEX	28	38	106	04	GMD		RS		RS		RW	P	RW	P
EMPALME	MEX	27	57	110	48	GMD		RS		RS		RW		RW	
ENSENADA	MEX	31	53	116	38									P	P
GUADALUPE IS	MEX	28	52	119	42							P	P	P	P
LA PAZ	MEX	24	10	110	18							P	P	P	P
GUAYMAS	MEX	27	51	110	55							P			P.
MONTERREY	MEX	25	40	100	18	GMD	25	RS		RS		RW		RW	

Station		Latitude (N) °	'	Longitude (W) °	'	Type of rawinsonde equip.	Elevation for raob purposes (gpm)	Scheduled radiosonde or rawinsonde observations 0000 GCT	0600 GCT	1200 GCT	1800 GCT	Scheduled winds-aloft observations 0000 GCT	0600 GCT	1200 GCT	1800 GCT
MAZATLAN	MEX	23	11	106	25	SCR	14	RS				RW			
MERIDA	MEX	20	56	089	40	SCR	11	RS		RS		RW		RW	
MONCLOVA	MEX	26	55	101	25							P	P	P	P
SOTO LA MARINA	MEX	23	46	098	12									P	P
TACUBAYA	MEX	19	24	099	12	SCR	2306	RS				RW			
TORREON	MEX	52	32	103	27							P	P	P	P
VERACRUZ	MEX	19	09	096	07	SCR	13	RS				RW			
OCEAN STATIONS															
ATLANTIC STA B		56	30	051	00		*	RS		RS		RW	RW	RW	RW
ATLANTIC STA C		52	45	035	30		*	RS		RS		RW	RW	RW	RW
ATLANTIC STA D		44	00	041	00		*	RS		RS		RW	RW	RW	RW
ATLANTIC STA E		35	00	048	00		*	RS		RS		RW	RW	RW	RW
PACIFIC STA N		30	00	140	00		*	RS		RS		RW	RW	RW	RW
PACIFIC STA V		34	00	164	00 E		*	RS		RS		RW	RW	RW	RW
PACIFIC ISLANDS															
BARKING SANDS	HAW	22	02	159	46	GMD	5		irregular						
9 ENIWETOK	PAC	11	21	162	21 E	GMD	5	RS		RS		RW	P	RW	P
8 KWAJALEIN	PAC	08	44	167	41 E	GMD	4	RS		RS		RW	P	RW	P
9 MARCUS ISLAND	PAC	24	18	153	58	GMD	9	RS				RW	P		
SOUTH AMERICA															
ANTOFAGASTA	CHIL	23	22 S	070	28	GMD	137	RS		RS		RW		RW	
BOGOTA	COL	04	42	074	09	SCR	2541	RS		RS		RW		RW	
LIMA	PERU	12	01 S	077	02	SCR	135	RS				RW			
PUERTO MONTT	CHIL	41	29	072	51	GMD	6	RS		RS		RW		RW	

1. Feb 1 to May 31
2. Nov through Feb
3. June 1 to Sept 30
4. Partially funded by USAF
5. Funded by National Aeronautics and Space Admin.
6. Funded by Pacific Missile Range
7. Funded by Atomic Energy Commission
8. Funded by US Army
9. Funded by USAF

* 6, 8 or 9 meters depending upon type of ship used

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WHAT IS A UFO AND HOW DO WE RECEIVE UFO REPORTS

A UFO is any aerial object which the observer cannot identify. UFO reports should be reported to and investigated by the closest AFB to the observer. If the sighting is identified at the local level, the report is retained in their files for 6 months and then destroyed. If after the preliminary investigation, the sighting still remains unidentified, the report is transmitted in accordance to AFR 80-17 to our office here at Wright-Patterson where a further investigation takes place. After our investigation we may place the report in one of three different categories.

(1) IDENTIFIED

(2) INSUFFICIENT DATA

(3) UNIDENTIFIED

All news releases on UFO's come from the Secretary of the Air Force, Office of Information in Washington, D. C.