APPENDIX A5

DETECTABILITY OF PLASMA TARGETS

1. If it is assumed that, in the first instance the target is a spherical plasma body, the following conditions could exist:

- The sphere could be large in dimension compared with the radar wavelength

- The radar echoing area of the simple sphere is a function of its ratio of circumference to the illuminating wavelength [$2\pi a/\lambda$ (where a is the sphere radius)]

- For large values of $2\pi a/\lambda$, the RCS approaches the optical RCS (πa^2)

- The sphere, if homogeneous and perfect would be aspect-insensitive. (U)

2. In theory it is seen, therefore, that if a UAP was a stable plasma sphere of adequate electron density, a metre in diameter and comprised of entirely reflecting gaseous material, then its maximum radar echoing area for all practical purposes, when illuminated by a E/F Band(0.10m) radar, could be about ~16 square metres. For D/E(L) Band radars the value computes to ~five square metres. However, there may be several other factors of importance for a plasma UAP which could significantly affect its detectability; and in practice (as mentioned at page 5-3, paragraph 12), the real values (L Band) are estimated as falling somewhere between -60dB (0.000001m^2) and +8m^2. Any **surface absorption** of the radar signal, which, in theory, should have little effect when the wavelength is large compared to the target dimensions, is not necessarily the case here, as it is by no means certain that the UAP plasma (inside it's outer shell, or surface) can be considered a resonant body. Or, indeed, that it's surface remains a consistent and constant reflector, especially as many UAP reports indicate that the body is constantly changing colour and often varying slightly in shape. The response of the body as a **reflector** when compared against the characteristics of the radar is clearly a key factor. (R)

3. **Target Characteristics** Target RCS fluctuation plays a significant role in the detection performance of all radars. In general, radars, (apart from Weapon Control/Tracking Radars, which may dwell for relatively long periods on their chosen target) inspect their targets at repeated and sometimes regular intervalsin the form of dwells or scans, and by illuminating them with bursts of pulses. If it is reasonably assumed that a plasma UAP is a cloud of swirling ionised gases with variable electron density (possibly interspersed with periods of greater plasma stability), then for much of the time the radar reflectivity may vary rapidly, possibly uniquely from pulse-to-pulse (Swerling Case 2), rather than from scan-to-scan (Swerling Case 1). Further, the fluctuations may vary continuously from scan-to-scan (Case 3); or finally, so rapidly as to vary from pulse-to-pulse (case 4). (U)

4. If the plasma entity has several, possibly variable-density cores (as sometimes visible and reported as variable colour centres within a single buoyant body, and as always the case where a UAP comprises a grouping of multiple bodies (e.g. 'Triangle', 'Oblong', or Balls either 'in a row', or 'stacked'), this further adds to the complexity and variability of any radar reflecting characteristics the

object might have. The steady (non-fluctuating case), sometimes called Case 5, is extremely rare in normal radar practise, due to the inherent nature of flying targets.(R)

5. **Practical Effects** The detection capability of a radar depends upon the signal (wanted) to noise (unwanted) ratio. The practical effect of RCS fluctuations, applicable to the UAP scenario, is most simply illustrated by one example. For a typical radar with a requirement of probability of detection of 0.95, against a steady target, a signal/noise ratio of 4 (~6dB) is required. If the target is fluctuating according to Case 1, above, a ratio of ~48 (16.8dB) would be necessary. In radar range terms this turns out to be a range performance reduction by a factor of 3.28. This effect can be mitigated somewhat by illuminating the target with a larger number of pulses and averaging them out. However, there is a limit to the number of pulses emitted, and which impinge on a target from an early warning-type radar during its typical continuous-scan mode of operation. For targets which exhibit Case 3 and Case 4 fluctuations the situation is even worse - and it is believed that this is the case for most, if not all, of the plasma UAP events. Hence, the factors which account for the intermittent detection of most UAP events on the radars, can be well justified in engineering and scientific terms. The precise limitations on the UKADR radars are discussed at Volume 3.(U)

WORKING PAPER NO. 6

EXOTIC TECHNOLOGIES

EXOTIC TECHNOLOGIES

INTRODUCTION

1. UAP reports usually describe objects seen at a distance and these reports can only provide, at best, approximate angular speed and size (and often a very vague diameter). For this reason, in the absence of mass or linear velocities the information is almost useless when trying to apply the laws of physics controlling the ability of a 'craft' to land (or hover) and take off again.

The thrust of any object must be slightly less than the body mass on landing and twice its weight for an acceleration on lift-off of 1g. If an object of say 5 or 20 metres diameter were to lift off, using (conventionally understood) thrust then a **significant** blast and scorching effect must be expected on the surface. No such after-effects are reported in the thousands of UAP reports held in MOD.

2. **Exotic Solutions** Exotic solutions may be postulated but these often lead to the necessity for some form of force beyond human understanding and contrary to the laws of physics as we understand them. This leads to such ideas as:

- Gravity Cancellation
- Teleportation
- Propulsion without reaction
- Force Fields

3. Intergalactic travel requires ~four million years for a return trip (travelling at just less than the speed of light), or three years, even to a nearby planet at a velocity of 20Km sec^{-1} - a planet on which we can determine no sign of life in the form which would indicate 'beings' and their technology.

UAPs AS PROPELLED VEHICLES

4. The majority of UAP sightings can be attributed as relatively easily explainable natural or human phenomena - explainable, for example, as one of the many options explored at the database auxiliary tables. There are, however, the remaining, relatively few events which are not so easily explainable. One of the extreme postulations is that these 'residual' UAPs are, in fact, genuine constructed air vehicles, which use potential scientific and engineering principles which are beyond currently applied knowledge. Thus they must have some sort of propulsion systems which would provide the extraordinary range of velocities and accelerations (and presumably both endo- and exo-atmospheric capabilities) frequently reported. It is only possible to explore the propulsion possibilities which fall within the human realms of conceptual thinking. It must therefore be recognised that there is a limit to real engineering (as within the current limits of understood technologies) and that, if the postulation is true, that methods of propulsion may, in fact, be possible beyond our current understanding in the UK.

5. Several side-issues in which current aeronautical engineering may progress and which may be relevant may also be explored. These include:

- The use of plasmas to reduce airframe drag.
- Plasma 'coatings' as a method of RCS reduction.
- Combined chemical and electric nuclear propulsion.
- Magnetic propulsion.
- Hypersonics.

6. It is surmised that the requirement would be to propel the object at ~> Mach 8 or more and that alternatives (as understood within currently accepted engineering capabilities) would be capable of exceeding scramjet or conventional rocket velocities. Research and development on hypersonic technology is expanding, principally in the

technology is expanding, principally in the USA. The projected (USAF) priority plan is to produce unpiloted air-breathing aircraft with a Mach 8-12 capability and transatmospheric vehicles which can operate between the upper-air-breathing and sub-orbital flight regimes, as well as highly supersonic vehicles at Mach 4 to 6.

7. It is assumed that the fuel options are intrinsic (fuel carried internally), partially extrinsic (some part of the fuel is obtained externally e.g. from the atmosphere) or the propulsion energy is entirely extrinsic (e.g. from some sort of external field). The foregoing examples are understood as, respectively, chemical or electric or nuclear (e.g. rocket), air-breathing (e.g. jet engine), or a system which uses a field (e.g. magnetic field) - of which the only vehicular example is terrestrial (e.g. levitated train).

ANTI-MATTER (ANTI-PROTON PROPULSION)

8. A variety of conceptual engine types are potentially feasible. The following performance capability would be possible, using just **one gram** of the anti-matter:

- 100Kg payload accelerated to a velocity of the order 1000Km s^{-1} (Rocket)

- Launch a 1000 Ton payload into a Mars mission (Rocket)

- Payload/gross weight ratio improvements by a factor of three to five (Air-breather). This would involve the use of anti-matter to amplify the SI of standard cycle engines.

- Possibility of 'fusion engine'.

The rocket (i.e. exo-atmospheric mission) potential is encompassed by the relation $M(\Delta)^2 \sim 10^5$, where M is the mission mass (metric tons) and ΔV the velocity increment (measured in $km.s^{-1}$). It is believed that the application of anti-matter can be developed for solid core, gas core, plasma core and beam core rocket motors with adaptations for the air-breathers. Parametric studies have been made to this effect in the USA.

9. **Material Storage** Cooling is among the most serious problems to be solved. Portable storage for containing the 'anti-matter', in the form of rings and ion traps, would be necessary. The particles are typically confined within a plasma volume (e.g. 200cm (long) by 5cm (dia) with a vacuum $<10^{-12}$Torr and a magnetic field of 10T). This could all fit into a large truck, including all support equipment and provide ~30 to >100 days of storage time. The dimensions given might store $\sim 10^{13}$ anti-protons at 20-50KeV and is considered to be a factor of 100 down on the limit. According to authoritative sources a few milligrams of anti-matter might be produced annually by a nation with the resouces to do so.

NATIONAL CAPABILITY

10. **USA** In 1987 it was stated that the US could construct an intense source of low-energy anti-protons in three to four years and thereafter deliver (store) 10^{14} low energy protons annually. It was hinted that a five to seven year programme might be started (or already had been). This information, given in a 1987 closed seminar, was given public-release in 1994. One of the prime applications envisaged is for air-vehicle propulsion. The cost of a R&D programme would be ~$400M, over a ten year period. In addition to propulsion, non-propulsion applications of anti-matter have been proposed in medical (tomographical imaging), therapy and bio-medical detectors.

11. **UK** That anti-matter is a key topic of interest is confirmed by a series of papers, and, in particular reports of CERN activities in which UK participate. A recent review paper (P T Greenland, Imperial College London) relates Newton's search for a cause of gravity and the relationship between gravitational mass and inertial mass. Anti-hydrogen has been produced at CERN, but the trapping and control of the anti-hydrogen is not yet achieved to enable instrumentation and measurement to

be obtained, for example for a comparison with conventional hydrogen. The approach is to produce traps to contain, separately, anti-protons and positrons both at liquid helium temperatures. Anti-hydrogen is then obtained by the combination. The work so far has used the highest energies achieveable by the Low Energy Anti-proton Ring (LEAR). No anti-hydrogen has yet been trapped at low temperature. There are no indications of any current experiments or early developments of future potential applications of anti-matter for propulsion purposes.

12. **Former Soviet Union** Scientific papers report the conceptual design of anti-matter storage devices, for example, positron storage rings. These, including the 'IREN' project are at the design experimental and very early development stages. In particular, important work is proceeding on the use of Gamma-Ray Lasing in the matter and anti-matter research fields.

13. **France & Italy** French aspirations seem to be significantly aimed at whether some stars (and even some entire galaxies) may exist which are made up of anti-matter. The possibility of this scenario will, in theory, be proved if anti-matter (single anti-helium nucleus in cosmic ray flux) are detected in cosmic rays. Results are awaited from the a current Shuttle project. Further work is being funded by NATO and the EU. In 1996, two scientists at the Italian National Nuclear Physics Institute reviewed anti-matter as an area of future research and proposed future experimental projects. They pointed out that the possible existence of anti-matter was first postulated in 1928, and that recent exo-atmospheric experiments were delayed following the Shuttle disaster. As a result four balloon-borne experiments had occurred and the planned work (Italy-Russia) will also examine anti-matter components of cosmic rays. The possible existence of cosmological ant-matter, with a symmetric universe and matter and anti-matter separated into domains remains a fundamental question.

14. **ROW Nations** There is no evidence that any ROW nation has scientific or engineering capability, leading to real developments in the field of anti-matter.

ELECTRIC PROPULSION TECHNOLOGIES

15. Chemical propulsion requires large propellant mass compared with electrical methods. Hence, assuming that a UAP of undetermined origin could somehow enter and leave earth's atmosphere, (with the capability of some unknown propulsion method) the remaining journey (from wherever it came from and returned to) could presumably use one of the 'electric' propulsion methods for which the technologies are currently understood. However, these produce low thrust levels (mN), as shown at Table 1.

16. **Arcjets** produce an arc typically in the exhaust nozzle of a chemical thruster. For electric propulsion (EP) although their thrust is higher than other EP methods, there is the mass penalty of the chemical propellant required.

17. **Stationary Plasma Thrust (SPT)** produces ionised xenon, which draws in electrons from a cathode after the xenon propellant passes through electric and magnetic fields in a discharge chamber.

18. **Ion thrusters (IPS)** also use ionised xenor propellant.

19. **Field Emission Propulsion (FEP)** is a future concept assessed to produce a higher specific impulse (Isp) but at low thrust levels.

20. None of the methods at Table 1 were conceived as primary methods of spacecraft propulsion.

21. On board power requirements (for a 18mN UK IPS design with an Isp of 3466) is ~600W, worst case. The thruster exhaust velocity is ~40,000$m.s^{-1}$. For satellite position-keeping, 40Kg of propellant held in a titanium storage tank (mass ~10Kg), would provide a planned life of ten years. Even a small thrust,

coupled with orbital dynamics could be used to escape from earth orbit.

22. Despite the foregoing possibilities there is no evidence that an extra-terrestrial vehicle (comprising solid matter as we know it and using any of these techniques has visited earth and left again. Any visitation **must** be followed by a departure, otherwise artifacts would remain. The basic requirements of space travel, atmospheric entry, descent and landing must be followed by take off, ascent and escape atmospheric/gravity back to space again. In earth-science terms this could only be currently achieved with mixed propulsion technologies.

PROJECTED ENERGY

23. Much has been postulated in the scientific press on the possibility of transferring energy to an air vehicle (which would then convert it to thrust), either continuously or in pulse form. Technology has reached the stage where it is possible (with proof of principle tests) to transmit RF or laser energy to a moving platform, where it is collected for on-board use. This is dependent on providing and maintaining a suitable tracking system. A US Air Force Research Lab. Laser system, tested in 1997 allows a small rocket-mounted parabolic mirror to collect pulsed laser energy from the ground which is concentrated onto inlet air, which in turn becomes a plasma. [redacted]

S.27

There are no indications from any UAP event that observed phenomena can be using propulsion of this type, since the laser energy required to achieve this over extra-terrestrial distances would be not only enormous, but seen/detected on earth.

TORSION, GRAVITY AND LASER FIELDS

24. **Torsion Fields: Definition and Properties** Torsion fields are generated by a scalar field and spin. A torsion field is present even if there are no spins. Attempts have been made to describe torsion fields by the use of Maxwell's theory on a post-Remannian space-time equivalence principle to electromagnetic phenomena. These fields have been the subject of research since 1913 (EINSTEIN) and E. CARTON, BLONDO (France), MYSHKIN AND SHIPOV (Russia), HALT (NASA-USA). Torsion Engines, Generators and Torsion waves have been researched (especially in the Former Soviet Union, at the Inter-Industry Innovative Research Centre, MOSCOW). These are claimed to be waves which travel at 5 to 20 times the speed of light. Main Russian/CIS workers are KOZYREV, YEGANOVA, L. PUGACH.

25. Large scale studies of 'torsion fields' and their manifestation in nature have been made in Russia [1] and, it is claimed, "have resulted in the development of several unique methods and technologies unparalleled anywhere in the world and with which important fundamental and applied problems can be tackled in many areas of science and technology".

26. It is claimed that applications exist in the areas of:

- Remote Sensing
- Geovision and Geo-scan
- Modelling planets, the sun and other space objects.

In particular it is claimed that extraction, filtering, visualisation, processing and analysis of torsion field information which is embedded in aerospace imagery, both surface and subsurface (e.g. oil deposits). There is no indication in the papers discovered of the potential use of torsion fields for direct propulsion.

27. **Laser Propulsion** A (CO_2) laser-powered test rocket was flown in 1997. Although only 15cm in diameter and some 50 grams in mass, it is envisaged that this may be a forerunner for future space (or orbital) travel.

Projections and modelling claim a Mach 5 capability, to 100,000ft altitude. The laser provides thermal energy (collected from the beam) and used to produce air-breathing thrust. At altitude, conventional rocket fuels would be used to boost to escape velocity.

MICROWAVE PROPULSION

28. Low frequency microwave beams are not suitable for on-board energy collection. The problems are those of diffraction, and the requirment for large antennas on board the vehicle. Also, the low breakdown threshold of the atmosphere limits the received power density. The selection of high frequencies is limited by the EM atmospheric windows (e.g. 34, 94, 140 or 220GHz). Atmospheric attenuation also increases with increased RFs. It is assessed[1] that a 15m diameter craft could logically use a 35GHz system with the high power rectifying antenna ('rectenna'), which is a solid state converter. Within the atmospheric propagation breakdown limits ($4KWcm^{-2}$) this antenna could receive ~5.6GW. At an RF of 200 GHz Benford and Myrabo[2], suggest an array of focused 10KW gyrotrons could provide a launch station. With the overall power assessed at 30MW a huge 550m diameter array would be required to ensure adequate energy (10MW on a one meter diameter receive antenna), reaches the vehicle at the extremity of the atmosphere because of the extinction loss en-route (even using the 220GHz atmospheric 'window'). Conceptually, a space-based, (LEO) passive relay station could be used to pass the EM energy beamed from a terrestrial station onto the vehicle in space, where the energy would be converted this time for use in an ion thruster engine.

29. It is beyond the scope of this report to include fine details of the design of such a craft other than to list the key features which might have a bearing on the potential UAP connections in answering the enigmatic question - "Can a craft capable of extra terrestrial travel with the reported characteristics be conceived within the limits of 'earthbound' capabilities"? The key features follow with UAP-related comments in square brackets

(a) **Size** The microwave craft proposed has a 15m diameter. [This falls within some reported UAP diameters].

(b) **Mass** A launch mass of 1400Kg is proposed (surface area loading $7.9Kg.m^2$). This is an aerodynamic (e.g. wing) loading similar to that of ultralight aircraft. This leads to the conclusion that every conceivable means must be used to lighten the mass even to the point of carrying no propellant - hence the idea of using a microwave-induced 'air spike' and beamed energy sources. The point that immediately diminishes the UAP connection here is that energy conversion is used and atmospheric thrust is produced. Hence, there will always be, as far as can be deduced, some type of acoustic effect. [In other words an observer will hear very loud sounds, contrary to UAP reports] However, if it is possible to place all the electromagnetic air acceleration technology on the outside of the body this may not be the case.

(c) **Materials** Thin film materials with adequate tensile and compressive strength could, conceivably, be made. Silicon Carbide based materials (exotic fibres) have been suggested. The thin film materials might be microwave-reflective, acting simultaneously as the rectenna. Any collected spare power could be used, for example, to power the air-spike.

(d) **Propulsion** Several propulsion configurations have been proposed. The first is the pulsed detonation engine (PDE), or 'microwave-thermal

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[1] "Hyper Energetic Manned Aerospacecraft Propelled by Intense Pulsed Microwave Beam" L.K. Myrabo. SPIE Vol. 2557 1995

[2] "Propulsion of Small Launch Vehicles using Millimetric Waves" SPIE Vol. 2154 1994

air breathing engine'. The PDE uses microwave-supported detonation to heat the air working fluid and is based on what, in principle, is the air-breathing ramjet. A combined cycle engine (i.e. air-breathing and rocket) might be envisaged for a transatmospheric role. Clearly this would only operate in the atmosphere and velocities of Mach 5-6 are claimed to be possible without an air spike. [Hence, to return to the possible 'UAP' similarities this type of craft could not be extra-terrestrial unless it used another type of propulsion outside the atmosphere] Another endo-atmospheric option is the Magneto-Hydro Dynamic Fanjet (MHDF), where powerful Lorentz body forces are exerted on external air working fluid. In effect the active microwave-powered 'armature' accelerate the passive 'field coil' - which is the air channel used for momentum exchange.

(e) **Rectenna** For microwave on-board collection an off-board source must exist. [In the UAP context there has been no detectable source on earth or from space which, using conventional EM-waves at any wavelength someone on earth would have surely intercepted; especially in view of the huge power requirements].

30. There are several other key factors in the completion of the design, for example the production of a heatshield (if re-entry is required), artificial gravity, aerodynamic stability and control, plasma radiation shield (hazardous radiations), life support, and communications. [It is, however, seen that even this vehicle, if possible with today's technology, would be unlikely to achieve the characteristics attributed to UAP events]. It is of interest that the conceptual body shapes tend to be saucer-like. This is probably pure co-incidence - as many UAP events reported are, in fact, not necessarily 'saucer shaped!!

SUMMARY -PROPULSION OPTIONS

31. Propulsion mode is the key factor in considering whether it would:

(a) Be possible to construct a vehicle with reported UAP attributes and potentially (until proved otherwise) with an extra-terrestrial capability, using existing 'earth' technology.

(b) Be possible to conceive such a craft which can move with zero or near-zero sound and change the direction of movement almost instantly.

CONCLUSIONS

32. In attempting to explore the potential technologies which would be essential in order to construct a craft with the exceptional characteristics, attributed to UAP it is important to note that:

- No reliable report exists of a landing and take-off of an object known to contain 'beings'.

- No spacecraft or occupants can be seen anywhere on earth and not even small artifacts have been left on earth to confirm the existence of a 'spacecraft' in the form of metals or other materials. None have apparently ever crashed, despite sighting reports for thousands of years.

- There is no evidence of attempts at communication between the alleged occupants of the 'craft' and humans - or messages/items left behind as a form of communication.There is no evidence that any nation has a current capability to produce and trap anti-matter for propulsion purposes.

33. Hence, there are no new technologies or methods which could be exploited beyond those already known or being researched. There have been no

opportunities for accurate size or shape measurements, no examinations of unknown or special materials or of any types of devices which could aid in the dtermination of what the phenomena comprise or be used in order to replicate the UAP as an air-vehicle as a result of the presence of UAP in the UKADR. In the absence of measurable artifacts, the best estimate of the nature of UAP can only be assessed by a careful analysis of all the available reported characteristics and the hope of correlating not only reports from diverse sources but the frequency of reports with other measurable events, such as weather, meteors, etc.

	Thrust (N)	Isp (S)	Uses
CSP	1-500	<320	Extensive
ARCJET	<1	550	Wide
SPT	0.04-0.20	1600	Limited
IPS	0.062-0.25	3000	Experimental
FEEP	<0.001	4000	Future

TABLE 1: ELECTRIC PROPULSION OPTIONS

WORKING PAPER NO. 7

SIGHTLINE RATES OF FLYING OBJECTS

&

METEORITES

SIGHTLINE RATES OF FLYING OBJECTS

INTRODUCTION

1. This brief paper is intended to relate to frequent UAP reports where objects cross through the observer's field of view at what are often, reportedly, extra-ordinarily high velocities. Typical examples are those of satellites and meteorites.

SIGHTLINE RATE GEOMETRY

2. The basic geometry assumption is that, from the initial visual contact, the object continues in a straight line until it goes out of sight due to some local obscuration or reaches the observer's visual horizon. The largest angle through which an object can pass is from horizon to horizon. Usually the angular sector crossed (or at least seen by the observer) is much less. The angle crossed is usually viewed either in azimuth or elevation. On occasions the object is diving and often disappears during the process - and these are usually explainable as burning-up meteorites or space debris. The greatest tangential velocity occurs when either the object is passing exactly overhead or when at a 90° azimuth offset. Velocities always appear to be greater when objects are closer to the observer, even though they are identical to those at greater range which pass through the same enclosed angle but take longer because the distance subtended is greater. The human perception of speed is often distorted by any accompanying sound. Many UAPs are reported as 'silent'. However, it is borne in mind that if any sound is present it can give added perception of speed (see Working Paper Nos. 1 and 8).

3. On the spur of the moment, accounting for surprise and even incredulity, later embellishment, misunderstanding and over or under estimation; it is clear that the time and velocity figures given by a UAP witness can be wildly inaccurate. Further, more than one witness at the same event may provide conflicting evidence. Often, events are reported as duration of 'about ten seconds' or 'two to five seconds' and through small angles. Further, those not regularly concerned with aircraft can only be expected to give very approximate altitudes (ranges). However, the evidence cannot be ignored, as taken together with other information from the same sighting and with other witnesses, which may come from nearby. --Crude target track construction can be made - hence a process of elimination of options is assisted. Further, untrained observers regularly have difficulties with range assessments and grossly misrepresent objects as being "beyond the moon", or "about 2 fields away".

4. The Field of View(FOV) available is clearly much larger when the observer is in an advantageous position, e.g. open countryside, on a hill, or (without obscuration) viewing over the sea or, finally, in the air. Even so, for often inexplicable reasons, and with clear FOVs, objects are sometimes only seen fleetingly. Velocity discrimination/estimation is much more difficult - even for aircrew in this case, unless in a parallel course or catch-up/overtake/being overtaken scenario.

PARAMETERS

5. The attached plots at Figures 1 and 2, although accurate, are intended as a guide in the analysis of a UAP sighting, where the witness provides one or more of the following.

- Start (elevation angle) and finish (elevation angle)
- Time of observation together with some idea of the angle passed-through
- Time and altitude of an objects' passage.

The plots are for objects 'flying' at constant altitudes. If an object is either climbing or diving then a different calculation is needed.

INTERPRETATION

6 Figure 2 (for both endo-and-exo-atmospheric targets) enables a target speed to be approximated, based on witness assessments of angle traversed (az or el), range and time of observation:

$$v = \frac{R\varphi}{t}$$

where φ = Angle traversed (radians) = Deg/57.29

R = Witness estimate of target range

t = Witness estimate of duration of sighting

7. The same approximation applies to space-based objects. In this case it is assumed that exo-atmospheric objects can be at any altitude above the earth.

8. It is important to note that the method used is based on the assumption that moving objects travel tangentially through the estimated angle, with respect to the observer's position. Any movement at other angles with respect to the observer would increase the track-length flown and thus, in a given time, increase the object's velocity.

EXO-ATMOSPHERIC OBJECTS

9. **Meteorites** Diving objects (e.g. often shown to be meteorites/meteors) are frequently reported. These are high velocity ionised trails caused by meteor-body friction with air molecules, which then ionises; usually with a fiery tail/trail, lasting only a few seconds. RF reflection from trails (utilised for scatter HF communications purposes), occurs in the (approximate) 30 to 120MHz range. Meteor-trail duration is measured in hundreds of milliseconds. Two categories describe the **rate** at which meteors strike the earth's atmosphere. The **periodic** group (known as meteor 'showers'), which have a yearly cycle and the **sporadic** group which are, though more random, occur year-round. In the context of UAP sightings:

- 'Showers' occur for periods from hours to days at a rate of the order 20 to 50 per hour. [1] These are often present, though not necessarily visible, due to the interference of moonlight. The forthcoming occurrence of showers can be predicted, because both the earth's (and the meteor stream's orbits) are known - hence the intersection can be calculated. What is not known is the shower density. There is a shower density cycle repeating every 33 years. There is no connection between meteorite activity and sun spots or solar flares.

- 'Sporadics' exhibit a Poisson distribution but with a diurnal variation.

- In addition to the familiar largest fire-ball-producing meteors there are tiny grains not visible to the human observer. Radio and radar methods allow the latter to be detected. As the meteorite rate may have a bearing on the production and presence of some types of 'UAP', attempts will be made to correlate meteorite density against the trend of UAP reports.

10. This latter condition reflects the fact that at dawn (local time) a meteor will cut the longest path in the atmosphere, while at mid-day the meteor will appear to strike the atmosphere vertically. As the size of meteors varies between smaller than a grain of sand to those that survive and impact the earth's surface, the initial mass varies inversely with its probability of arrival. Consequently, smaller meteors make up a significant proportion of all meteors arriving and are not large enough to be seen visually.

[1] Lovell A.C.B. Meteor Astronomy UP 1954 P248.

11. Associated with the size is the electron line density (ELD). These are classed as either 'over' or 'under' dense: Under-dense ELD is $<2x10^{14}$ electrons per metre. Over-dense trails are considered to be a tubular plasma cloud (hence the links with other phenomena of interest to this study). The duration of over-dense trails is generally longer than that of under-dense trails. Trails can be manipulated by the effects of both wind-shear and high altitude winds, which distort their tracks. A brief examination of recent UK meteorite velocity measurements shows velocities from about 11km per second minimum to 72km per second maximum, with a mean of around 40km per second. The International Meteor Organisation produce a Meteor Shower Calendar, which is used elsewhere in this report as the basis for some statistical analysis against the UAP report rate. (see Volume 1 Annex F)

12. The probability of observing meteor trails visually is low and apparently not equally distributed over the earth. For communications purposes it has been found that the best trails occur according to the distribution at Figure 1, and it might be supposed that this density also reflects the most likely locations where higher visual opportunities occur. This changes according to geographical latitude. The meteor scenario, in relation to reported UAP events is an enigma. Firstly, it is important to note the increased presence of more UAP reports in coincidence with periods of high (or higher) meteorite activity. This does not necessarily mean that observers are only seeing meteors. Further, it does not mean that UAP reports are always caused by meteors. There are bound to be reports generated by a host of other causes. On the other hand it could mean that some UAP are formed by meteors as the residual effect of the meteors enormous energy. These postulations are examined further, statistically, at Volume 1 Annex F, where it is clear that this is the case.

13. **Satellites** Other, frequently reported objects, almost always described as 'steady lights' are probably satellites in low earth orbit (LEO) (see Working Paper No. 17). The sightline rate of these is clearly dependent on orbital altitude and speed.

14. Observation curves are at WP No17, and assume an observer is stationary on the earth's surface. Geo-stationary satellites can be ignored, as by definition they have no sightline rate. Low earth orbit satellites have a practical maximum altitude of ~1000Km and orbit at a velocity of ~7Km sec^{-1}. This equates to an angle-rate of about 4° per minute.

15. If an observer spotted a satellite from rise to set (most unlikely) covering a full 180° (45 minutes), or even for 15 minutes, current public knowledge is such that it would be identified as such and not reported as a UAP, or even reported at all.

16. In UK latitudes the satellite orbit would have to be at an inclination >50°. Viewing conditions must also be correct to observe a satellite:

- It is unlikely in daylight.
- Its size must be large (small debris is not seen).
- The light falling on the satellite, which is then reflected must be adequate. Other data concerning the observation of satellites and hence the probability of being mis-reported as UAPs, is at Working Paper No. 17.

PLASMAS, CHARGED AEROSOLS AND SPRITES

17. It is evident that when plasmas, particularly sprites and any higher altitude phenomena, which depend on luminosity due to electrical charges, that sightline rates can be extremely high. These phenomena, often described as 'nocturnal lights' are described at Working Papers Nos. 2, 5, 19, 21, and 24. They frequently appear as having significant angular size and, because of their high speeds (despite being at altitudes from a few kilometres to tens of kilometres), are often