THE 4TH SIGN

By Kathryn Draper

OBJECTIVE

An object or signal in, on or around the moon with the purpose of drawing the attention of future generations or possible intelligent forms of extra-terrestrial life towards the archive on the moon.

POTENTIAL IDEAS

- An object in orbit
- An electronic signal
- Radioactivity and magnetism

AN OBJECT IN ORBIT AROUND THE MOON

Geosynchronous orbit:

- It is quite a useful idea to have an object in orbit directly above the archive site. However the orbital radius for a geosynchronous orbit around the moon, given by the equation $r^3 = \frac{GM}{\Omega^2}$ where M is mass of the Moon and Ω is the Moon's rotational angular velocity, the required radius is 95,000km whereas the Moon's sphere of influence ends at 66,000km.

Lagrangian point orbit:

- Points L1, L2 and L3 are unstable although halo or Lissajous orbits are possible around these points. With all of these orbits, however, various amounts of station keeping is necessary so would not be suitable for the time span of the project.
- Points L4 and L5 are theoretically stable as the ratio of the masses of the Earth and Moon is greater than 24.96. Unfortunately if solar perturbations are taken into account the orbit will only remain stable for roughly 1000million years, if the effect of the other planets in the solar system is considered the orbit will only survive for a few million years.

Low 'frozen' orbit:

- Most of the possible lunar orbits are unstable due to gravitational perturbations with only a few inclinations available for long term, stable orbits. At these inclinations, of which 4 are known, a low orbit can supposedly be maintained indefinitely.

In the case of all of these orbits there is the severe risk of collisions with meteoroids or space debris or debris resulting from meteoroid impacts with the Moon. These collisions would either damage the object fatally or knock it out of orbit, then causing it to either spiral away from the Moon or crash into its surface. There are also risks from solar radiation and cosmic rays.

Overall having the 4th Sign to be an object in orbit around the Moon does not seem realistic in the long term.

AN ELECTRONIC SIGNAL

Battery-powered electronic signal:

- Any standard battery manufactured would not last the duration of the project so the signal would quickly fail.

Solar-powered electronic signal:

- A solar powered device would have to be on the surface of the Moon, rather than buried for protection, and so would be likely to suffer impacts and get damaged irreparably.

Radioactively-powered electronic signal:

- The radioactive material would have to have a sufficiently short half-life as to provide near constant power supply but long enough as to provide power for the entire project. The power provided by a radioactive material is inversely proportional to its half-life.

It seems that an electronic signal not work as the 4th Sign as the power sources for an electronic device would not survive long enough for the entire duration of the project.

RADIOACTIVITY AND MAGNETISM

Radioactivity:

- Radioactivity could be used as a signal itself rather than being a power source for an electronic signal. If the radioactivity was not a power source the half-life could be as long as necessary to last for the entire project but would still have to be giving off a noticeable amount of radiation.
- The type of radiation used couldn't be too harmful to the beings finding it, whether that would be future generations or extra-terrestrial intelligence.
- As any object on the Moon would most likely have to be beneath the surface, the radiation would have to be able to pass through the surface relatively easily.

Magnetism:

- The magnetic field created by the object would have to be big enough or the amount of the substance unusual enough to be noticeable.
- The material must also be able to keep its magnetic field for a long time.

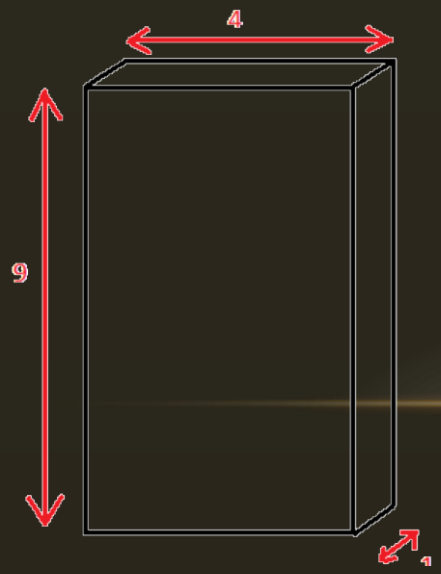
Combination (Gadolinium):

- Gadolinium is a rare-earth metal with a shiny, silver-white colouration that is both ductile and malleable.
- Gadolinium is not especially reactive although it dissolves in acid, reacts slowly with water and while unreactive in dry air in moist air it will tarnish to a flaky white solid that does not prevent further oxidisation.
- It is found in various minerals and can be obtained from its ores by turning it into $GdCl_3$ or GdF_3 and then passing a current through the compound or reacting it with calcium.
- It is also magnetic, more magnetic than iron at low temperatures, and has a radioactive isotope, gadolinium-152, which decays by alpha decay to form samarium-148, and has a half-life of 108×10^{12}. Samarium-148 decays to form neodymium-144 which then decays to form cerium-140 which is stable. All of the radiation occurs as alpha decay.
- The radioactive gadolinium-152 has an abundance of 0.2% and the pure form of the normal element costs roughly $450 per 100g.
- Rather than just using the radioactive isotope a mixture of isotopes should be used so that even when the gadolinium-152 decays the rest of the isotopes will remain magnetic.

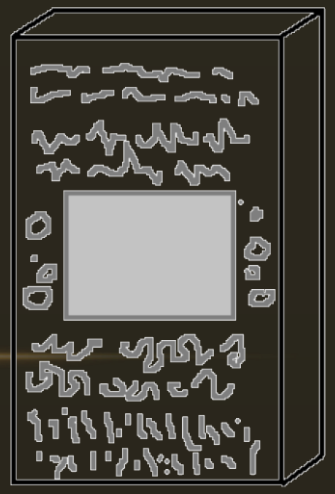
Radioactivity, magnetism or a combination of both would seem like a good idea if enough of a substance could be found as some substances will maintain their magnetism indefinitely and there are radioactive substances that have half-lifes in terms of millions or billions of years. These timescales are ideal for this project.

APPEARANCE

- The appearance would need to be obviously man-made rather than natural so ratios found in nature, such as the golden ratio and Fibonacci, should be avoided. A possible inspiration could be the monoliths from Arthur C. Clarke's 'Space Odyssey' series as an object with dimensions in the ratio 1:4:9 would not be found in nature.
- The object would also have to be large enough so that once attention has been drawn to the area it won't be too difficult to locate.
- If the monolith idea was followed through it could either be entirely constructed of the gadolinium or could be made out of stone surrounding the gadolinium. If stone was used it would be easier to carve into, whether the carvings were diagrammatic instructions as to how to use the archive or whether they acted as a Rosetta stone to display a repeated message in past and present languages.
- An object would also have to be small enough to limit engineering difficulties in terms of drilling a hole wide and deep enough for it. It would make sense to have the object being relative in scale to a human, so having dimensions in terms of metres rather than millimetres or tens of metres, somewhere in the range of 1-10 metres might be best.

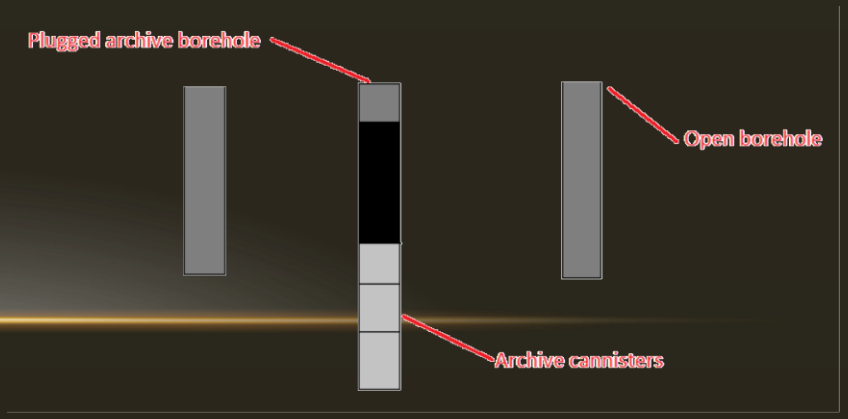


If ideas involving radioactivity and magnetism from the previous slide came to nothing then a much more passive approach could be taken which wholly relies on being found by chance. If this was so it would not be necessary to design the object to accommodate for the nature of the chosen substances magnetic or radioactive properties. The object could easily be buried at the required depth without having to have any part of it above the surface. The shape of the object could also reflect more the ease of construction, transportation and placement.
If it is considered useful to have part of the object above the surface, be it radioactive or not, the object could be placed in a borehole similar to that of the archive with the object going down deep enough that it does not matter if the top part of it is damaged. Any object would have to be made of a material that is not found naturally on the Moon and will not degrade particularly quickly in the lunar environment.



Triangulation:

- Continuing with the idea of constructing the 4th Sign in the form of boreholes, three or more boreholes could be drilled at equal distances away from the archive. These boreholes could be filled with solid gadolinium for example, certainly something magnetic, at a depth of around ten metres and possibly with the top of the borehole open despite the risks of radiation or debris in order to allow any radiation or to avoid limiting any magnetism.
- The central borehole containing the archive could also have a smaller piece of the same material so as to make it easier to locate and also reinforce that is part of the same structure.
- If necessary there could be multiple layers of boreholes in case some are damaged.
- If such an idea was followed through it would need to be checked whether radioactivity or magnetism would disrupt any equipment that scientists would want down the archive borehole.



PLACEMENT AND TRANSPORTATION

Placement:

- The object would have to be buried beneath the surface of the Moon in order to protect it from meteor impacts. In order to provide protection from solar radiation and cosmic rays the object would have to buried roughly 10 metres deep as a minimum. However part of the gadolinium would probably need to be above the surface as the radioactivity is alpha decay which can only travel a few centimetres.
- The 4th sign would have to be relatively near to the archive because a ‘breadcrumbs’ idea of a trail of objects leading to the archive, although would probably be more attention grabbing, would be far too expensive to both build and transport to the site.

Transportation:

- The monument would have to be taken to the site after the installation of the archive as it would have to be put in place by a manned mission.

INVOLVING THE SCHOOL CURRICULUM

- There could be activities at schools to design the 4th Sign both in terms of what it looks like and what material it is made of.
- If something radioactive or magnetic is chosen the nature of the substance could be linked to GCSE work.
- Arthur C. Clarke's novels could be covered in English lessons and classes could also watch the film adaptations.

THANK YOU FOR LISTENING

Any questions? I shall attempt (badly) to answer them.