Beyond the Earth

Schematics for ‘Companion Guide for Earth’ archival elements residing within Geosynchronous Orbit

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ABSTRACT

The long-term communication of 'essential' information is of moral and ethical interest to a number of global stewardship entities including bioethics observatories, climate/ biosphere regulators, planetary protection authorities and hazardous waste custodians as well as international communities who wish to preserve artifices of cultural heritage for the benefit of their descendants; records which should be responsibly committed to multi-generational memory for the long-term sustainability of our common home. Conserving the commensurability of these intersubjective resources therefore necessitates the consolidation of discernible, inductive materials and auxiliary communicative strategies [such as those employed within the Search for Extra-Terrestrial Intelligence] in order to successfully bequeath intelligible ‘messages’ beyond deep time and space.

This manuscript outlines specifications and design considerations for the forthcoming ‘Companion Guide for Earth’ artefacts that are presently under-development by the Beyond the Earth foundation for the purposes of deep time ‘interpretability preservation’ i.e. providing an intuitive, non-partial introductory guide that should theoretically support bottom-up commensurability for the discoverer(s) over protracted intervals of cosmic time; regardless of the recipient’s state of cultural evolution, social conventions, linguistic structure(s), cognition, ontogenic or phylogenetic traits, morphology, sensory perceptions or genetic heredity. These introductory guides and consolidated proemial resources aim to coordinate the archaeology of the future by providing a locally-accessible, exosemiotic interpretation of our civilisation’s intelligible artifices (alongside vital planetary/ biota resources and records as redundancy information) therefore allowing the discoverer to formulate intelligible deductions about this material before facilitating the recovery of additional terrestrial/ celestial repositories for accessing a more elaborate legacy of our civilisation and generation(s).

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BRIEF HISTORICAL CONTEXT

The eclectic range of artefacts and 'messages' we dispatch into the vast expanse of space may become one of the most enduring remnants of our present civilisation, but how does his protracted legacy adequately document the plurality of societal values, the diversity of our species' abstract cognition and the consequential common cultural heritage of our heterogeneous world? On a pragmatic note, how does this diverse material provide accessibility for a recipient who may not possess any convergences within our state(s) of cultural evolution, social conventions, linguistic structure(s), cognition, ontogenic or phylogenetic traits, morphology, sensory perceptions or genetic heredity?

Disregarding the early artefacts deposited upon the Lunar surface [for posterity] by the manned Apollo missions, humanities' initial messages to the cosmos focused upon defining the nature of our biota and the Earth system it inhabits to entities who may not share any convergences within these phylogenic or ontogenic properties (or even a common environment). Our first [physical] emissaries to the stars exemplified this forethought through the rigorous selection of 'postcard' contents in order to provide an accessible, commensurable account of the principle material the authors wished to convey – an essential portrait of the messages' complex, evolving home world. The Pioneer 10/ 11 plaques [1] offered a limited (and at times controversial [2]) perception of our world which placed an emphasis upon facilitating this accessibility above the introduction of complex, telluric narratives or conceptualised ethnological expressions. This initiative then paved the way for the now iconic Voyager Records [3, 4]; both of which built upon this intelligible foundation to offer a more elaborate inception point for our world at interstellar distances. In the interval between these launches, the LAGEOS plaque [5] also hosted a message with provisions for accessibility – however the intended recipients of this epigraph is the populace that will inhabit Earth's surface [up to] 8.4 million years from now.

Since then, numerous other artificial envoys have been composed by the international community for the preservation of increasing quantities of information beyond Earth's atmosphere [6]. Perhaps the most ambitious of these proposals is/ was the KEO satellite [7]; the first probe exclusively-designed for astronautical communication with our descendants 500 centuries into the future from a slowly decaying Low Earth Orbit. The Long Now Foundation's 'Rosetta Project' [8] – an initiative which is more analogous to the earlier 'postcard' strategies – provided a multilingual guide to aid in comparative translation of 1,500 Terran languages on the European Space Agency's Rosetta spacecraft. A rich repository of Mars-related fictional media [9] was deposited onto the Martian surface by the Phoenix lander, the Immortality Drive [10] on the International Space Station stores the DNA of eight Westerners, the artist Trevor Paglen has placed an archive of one hundred photographs [11] (without descriptions) in Earth orbit and the Arch Mission Foundation is now in the midst of spreading large human datasets (such as the English Wikipedia encyclopaedia) across our local stellar neighbourhood [12]. Concurrently, both the Lunar Mission One [13] initiative and MoonArk [14] project will pioneer 'Lunar Museums' of human knowledge under our satellites' regolith and on its surface respectively while the One Earth Message [15] project intends to upload a contemporary 'Golden Record 2.0' to the New Horizons probe – a modifiable repository which may become the fifth message-bearing object to leave our Solar System.

PROBING THE INCOMMENSURABILITY DEBATE

While these ever-advancing archives seem to demonstrate a characteristic linear increase within information capacity consistent with other contemporary data storage technologies, the increasing density of their respective libraries also present an epistemological causality; (1) the scope of explanatory 'primers' may be incapable of adequately communicating advanced narratives that are required for integrative, cognitive assimilation of these complex repositories (an extension of the 'encoding-decoding' paradox [16] between rational entities who may not share mental faculties), (2) elaborated concepts may possess ethnic or generational [or anthropocentric] partiality that may infringe upon the general comprehension of contents and (3) unintentional meta-message information may further emphasise any underlying hegemonic partisanship embedded within our communication channels – obstacles which may be disruptive if the future discoverers are descended from indigenous cultures such as the Trumai, Haida or Nivkh peoples.

Terrestrial communication channels are the inevitable outcome of our species' millennia-long experimentation within distributed cognition in order to establish intelligible discourse and social cohesion with our fellow Tellurians [17] so there is reason to believe that these strategies may be maladapted to communicate with entities that do not occupy our resident position within space and time. Cognitive tools such as inscribed symbols, images and phonetic conjugations are unique products of our species' in-situ environmental interactions, neurology, sensory modalities and other phylogenic parameters, but they are also shaped by endocentric affiliation(s), collective sociocultural history and our subconscious induction into other inherited conventions (paradigms that have historically bestowed cooperative advantages within a resident biome). Concurrently, we cannot assume that the recipient will neatly categorise their reality into synonymous dividends familiar to our own present-day perceptions; a modality dilemma which presents obvious consequences for our prevalent sensory apparatus, cognitive tools and mental suppositions. Multitudes of authors [18, 19] have also identified potential impasses within these communication assumptions. Prototypical properties long deemed to be 'universal' such as telluric mathematics and science may largely be specific to our own societal proliferation(s) and epistemology, therefore such quantifying methodologies may plausibly be an artificial product of human creation – as Kronecker one profoundly stated; "God made the positive integers, all the rest is man's work".

When attempting to communicate across deep space and cosmic time, the debate naturally arises as to whether 'foundational' aspects of our anthropocentric communicative infrastructure are capable of adequately disseminating details about our species [and planetary system] to entities that may not share convergences within Darwinian evolution, cognition, biology, environment or other analogous, ontogenic characteristics. As communication is always a collaborative process between sender and receiver, we can trust the dexterity of a recipient to a certain extent but provisions should be made in order to compensate for any foreseeable obstacles that may impact commensurability – considerations which may demonstrate a crude form of altruism that can better permeate the communicative void between isolated senders and recipients. Descriptors used within primer strategies should attempt to mutually accommodate the recipient's potential mental faculties (even if the directionality of this appeal is quite broad) while also clearly providing tangible metasemiotic evidence to lead the receiver's intuition towards a particular outcome i.e.

consciously supporting tentative inferences that the sender deems 'correct' while mitigating circumstances for oblique, 'inaccurate' translations. The development of such strategies is by no means an easy task and requires sustained, multidisciplinary cooperation but the advancement of these particular exosemiotic descriptors is already largely explored by the Search for Extra-Terrestrial Intelligence (SETI) community in order to draft theoretical responses to 'who speaks for Earth? [20]' for hypothetical extra-terrestrial communication scenarios. However, besides the moral, ethical and democratic advancements made by this particular enterprise, there remains little practical exemplars that embody this bottom-up intuitive account of our species, biome or home world within the plethora of physical artefacts we dispatch into space.

Towards the goal of preserving the commensurability of humanities' intelligible artifices over protracted periods of deep time, the Beyond the Earth foundation is committed to practically experimenting with SETI communications strategies and identifying/ advancing other primer guides for the benefit of physical emissaries that may aid in both deep time archaeology by our distant descendants or Passive-METI applications over intervals of cosmic time. Considering; (1) we only possess one particular [still evolving] sentient agent to craft and test these artifices upon, (2) the telluric roots of our inherited cognitive tools and (3) the many variables which presently inhibit our civilisation from predicting the cognitive trends our descendants may likely take during their ensuing cultural evolution, the purpose of these 'Companions Guide for Earth' artefact will be to simply aim to provide an intersubjective looking glass by which a recipient may perceive our shared reality from the perspective of our collective civilisation. This prototypical outlook will be based upon empirical, *a posteriori* observations that will be rendered into intuitive, exosemiotic devices.

The initial steps in establishing this degree of commensurability will focus upon extrapolating these iconic primers from shared perceptions of fundamental constants. This will [hopefully] enable the receiving entity to solicit intelligible deductions about our civilisations' epistemology through this general, [intended] non-partial content before providing adequate redundancy information for practical, cognitive-reinforcement activities (in order for the recipient to continually reassess and refine any procured hypotheses about signifiers). These interpretations may then be further corroborated [or refuted] by discovered celestial/ terrestrial repositories; an atlas of which will be included within these 'companion guides' for further archaeological scrutiny. This sustained, interdisciplinary discourse will [hopefully] also promote philosophical contemplation on the nature of human intelligence(s) and provoke crucial public reflection into how our species could appropriately express its' heterogeneous voice to an evolving, and potentially conscious cosmos.

THE BEYOND THE EARTH FOUNDATION

Beyond the Earth is a non-profit, interdisciplinary foundation established to formally examine the diverse fragments of humanities' cultural heritage [within spacecraft relics, interstellar transmissions and the terrestrial biome] and other perennial legacies that can be observable over protracted intervals of space-time for the benefit of current archival projects and future archaeological deductions. This intelligible signature of humanity can be considered an integral, physical property of the Earth system; an artificial field of intelligent design surrounding our planet which we aim to investigate in order to ascertain how we could intelligibly support the comprehension of our evolving world through deep space and cosmic time.

The long-term communication of information is of moral and ethical interest to a number of global stewardship entities including bioethics observatories, climate regulators, biosphere conservators and hazardous waste depository authorities as well as international communities who wish to preserve artifices of cultural heritage for the benefit of their distant descendants; records which should be responsibly committed to multi-generational memory for the long-term sustainability of our common home. Humanity is now authoring this indelible legacy of Earth through the many pioneering artefacts that enable protracted record-retention however, the creation of appropriate primers that may support the communicative faculties of [biological or culturally] distant recipients is largely under-explored and necessitates appropriate action. To contribute to this heritage, the Beyond the Earth foundation is collaboratively engineering intersubjective 'companion guide to Earth' artefacts that will reside within a stable orbit around our planet in order to support long-term comprehension and archaeological observations of essential resources. These experimental ,cognitive tools will specifically focus upon correlating [mutual] epistemological properties based upon

empirical constants while also conserving; interrelated elements from the plurality of Earth’s cultural heritage, a variety of datasets from a multitude of disciplines and also the locations of additional terrestrial/ celestial vaults of civilisation for further extrapolation – all of which will be micro-etched onto a series of discs and encased within 'Earth' capsules before being launched aboard future geostationary satellites. Each artefact will be highly versatile and relatively inexpensive to fabricate/ insert into orbit; providing the capability for updated iterations to be developed over inter-generational periods – thus increasing the likelihood of discovery as well as adding to the overall information capacity of this intelligible network.

These libraries and associated ideographic icons are principally developed as a multidisciplinary platform for practically probing the incommensurability issue faced when communicating with hypothesised entities that may not share our genetic heredity, sense modalities, cognition or other elements of convergent evolution alongside additional ontogenic properties. As such, these articulated elements will employ intuitive cues, exosemiotic primers (such as the auxiliary language ‘Lincos’) alongside corroborating redundancy information and strategic testing phases in an attempt to understand and mitigate telluric partiality embedded within deep time and interstellar communicative activities as well as further advance investigations into alternative primer strategies.

Beyond the Earth is a registered non-profit, public benefits and education foundation (SC048652) that adheres to both the egalitarian and common heritage of humankind principles; premises of international law which designate that defined elements of humankind’s collective (cultural and natural) heritage should be held in trust and protected from exploitation for the benefit of future generations.

OBJECTIVES

a. To foster unique public engagement and educational opportunities within SETI and long-term communicative strategies, astrobiology, temporal social sciences, planetary stewardship praxis, the arts and humanities while also promoting inclusive, cross-cultural discourse on developing best practices for speaking in a single yet heterogeneous voice for Earth in line with the UNISPACE+50 resolutions (2018).
b. To establish introductory, micro-etched archives that can facilitate 'interpretation preservation' over intervals of cosmic time from orbit; 'Companion Guide to Earth' libraries that will contain an essential, non-partial records which will subsequently benefit archaeological observations performed by our distant descendants.
    - To preserve foundational portions of knowledge from a myriad of disciplines and conserve intricate, telluric records while also conveying the interdependence of our planet with its' inhabiting biota.
    - To further develop an iconic, instrumental pidgin lexicon that mitigates partiality while denoting how to further interpret archival resources. This primer encyclopaedia and related implicit cues will be compiled through peer-led, interdisciplinary academic investigation and [online] public consultations.
    - To coordinate the recovery of elaborate, terrestrial [and celestial] archives while also providing intelligible keys for interpreting these repositories.
    - To responsibly deter future human interference with long-duration, hazardous waste storage facilities e.g. nuclear, chemical deep geological depositories.
c. To support the conservation of celestial heritage sites/ artefacts in context with current debris/ contamination mitigation guidelines while also authoring intelligible artifices that can be adopted by similar projects for deep time/ space communication strategies.
d. To contribute peer-led research, ethical considerations and public knowledge to qualitative investigations that aim to address some of the most profound questions facing human culture and its' democratic proliferation within outer space in accordance with the articles of the Outer Space Treaty (1967).
e. To encourage international, cooperative learning between different ethnic backgrounds, language speakers and parties with specific accessibility requirements across national borders as per the principles outlined within the Vienna Declaration (1999) in order to collectively undertake this common, multifaceted challenge.
f. To communicate the importance of supporting cooperative, international learning over multi-generational timeframes and conduct analysis on the societal implications for partaking within this temporal dialogue.

CAPSULE ASSEMBLY DIAGRAM [OPEN]

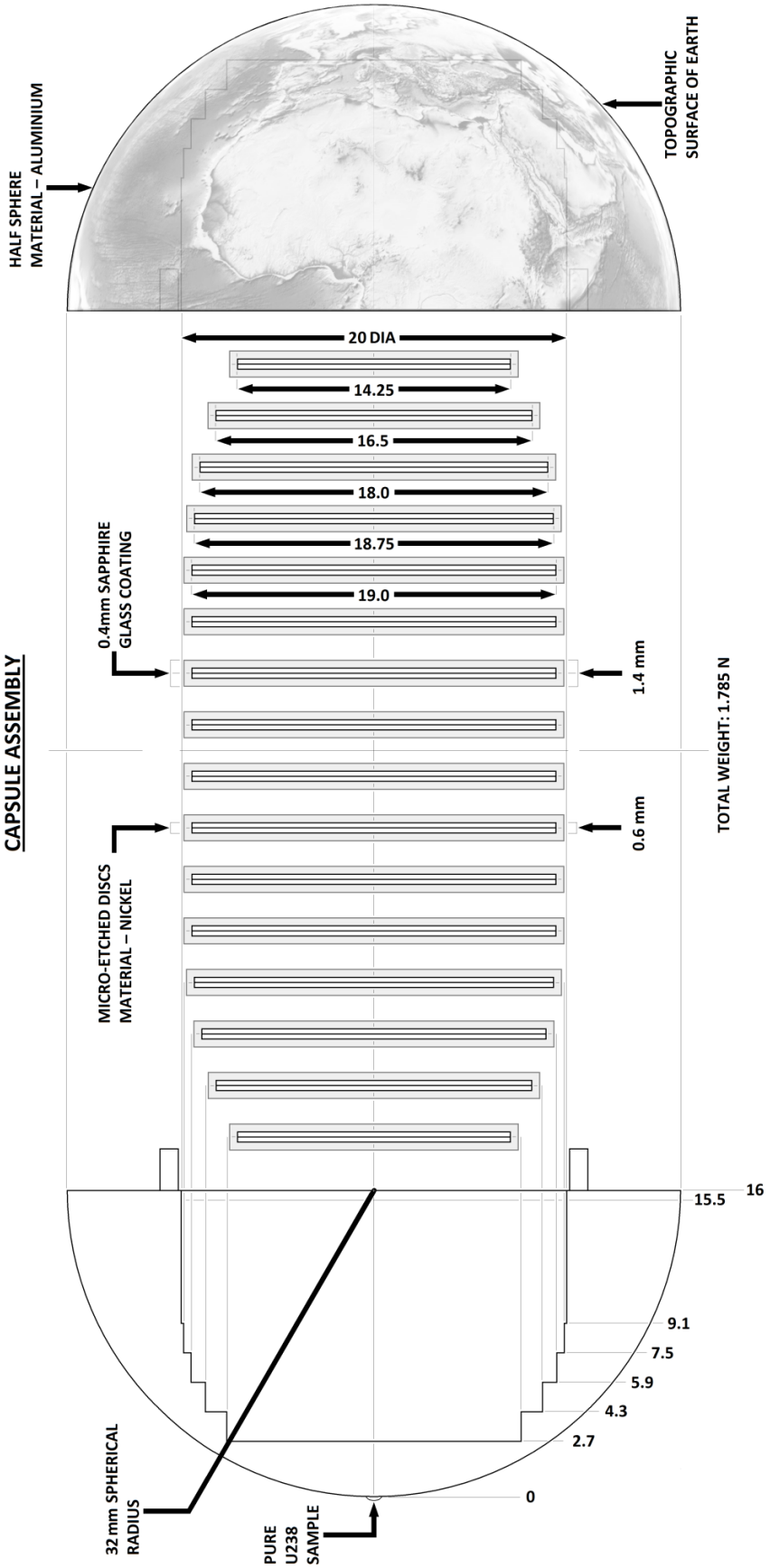


Fig. 1: Capsule Assembly (Open TS Section).

CAPSULE ASSEMBLY DIAGRAM [CLOSED]

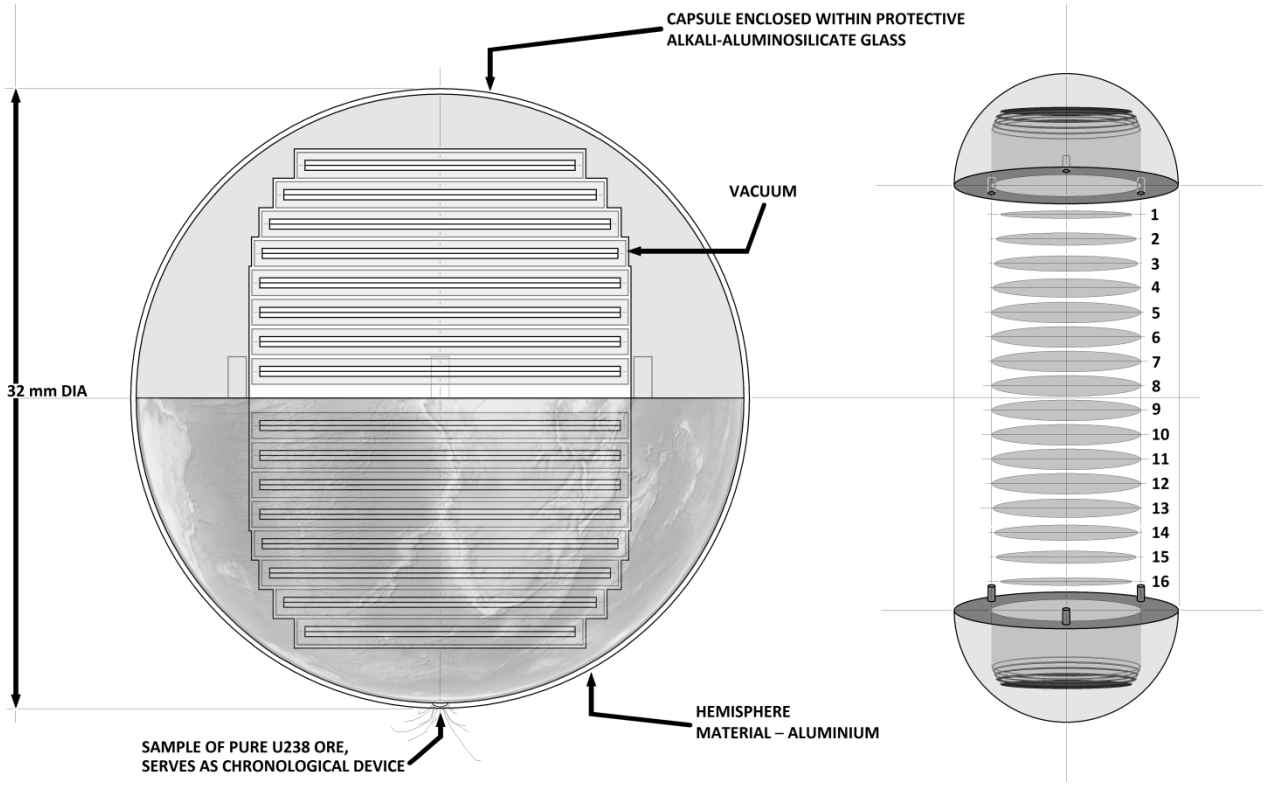


Fig. 2: Capsule Assembly (Closed TS Section) & Visualisation (Off-Perspective)

CAPSULE TECHNICAL SPECIFICATIONS

Hemisphere Diameter:	~32 mm
Mass (Sphere & Bracket):	0.1821 kg
Total Weight:	1.7859 N / 0.4015 lb
Materials:	
Hemispheres:	Space-Grade Aluminium
Protective Shell:	Alkali-Aluminosilicate glass
Discs:	Nickel composite
Disc Coating:	Sapphire Glass (Al_2O_3)
Attachment Plate:	Space-Grade Aluminium
Plate Screws:	Space-Grade Aluminium
Plate Cover:	Alkali-Aluminosilicate glass
Reflector Plate/ Skirt:	Concave [scientific-grade coated] Mirror
Estimated Payload Cost: (Assuming $10,000 per 1.0 lb):	~$4015.00 / £2993.00

MATERIALS & SHELL SPECIFICATIONS

The archives' shell is comprised of flight-grade aluminium with a tiered enclosure to support the microscopically-etched discs. Aluminium has been proven to be a robust, lightweight material that has been rigorously tested within the astronautics industry while also providing the necessary mechanical strength to protect the contained discs over long periods of time. This material also offers sufficient resistance (lower that lead, but with additional aforementioned benefits) against cosmic radiation sources and remains relatively stable over a wide range of temperature changes (estimated -250°C – 300°C fluctuations within proposed orbit [23]). A highly detailed, topographic map of Earth will be rendered over the spherical surface, providing an accurate graphic visualisation of Earth's surface while also presenting its' current tectonic configuration (to depict a geological epoch for the origin of this archives). This three-dimensional visualisation will also aid in supporting the graphical depictions of Earth's surface [and affiliated vault atlas] contained on the enclosed discs; enabling the recipient to re-calculate and adjust the perspectives of these supplied models.

A pinhead-sized sample of pure ^{238}U, much like the sample included on the Voyager Records [24], will also be used as a chronometric device on each archive's exterior – embedded within the 'Antarctica' region of the capsules shell [facing outwards into space]. An individual who discovers a capsule will be able to deduce the relative age of the repository by determining the rate of decay of ^{238}U to ^{235}U alongside a comparative analysis of the geological landmass. This determined time scale will, thereafter, be further corroborated by additional information (i.e. human conceptions of time, millisecond pulsar periods etc.) contained on the discs inside each sphere.

A layer of Alkali-Aluminosilicate 'Gorilla' glass will be set over the surface of each sphere to provide further protection and mechanical strength for the enclosed discs. This 'shock absorbing' layer can thereafter be safely dissolved via [continuous] application of concentrated Phosphoric Acid [25] (instructions icons to be detailed on bracket plate) without damaging the aluminium shell or the topographic surface.

DISC FABRICATION & CONSIDERATIONS

The methodology for micro-etching onto a series of nickel discs [26] (U.S.; patents; 8717650, 8264757, 7961367, 7830573) has been extensively pioneered by the company 'Stamper Technology Inc. / NanoRosetta'. This process uses a focused laser to write the information onto a photosensitive material that is coating a glass disc. This recorded material is developed like photography film to form the microscopic information before the plate is then electroformed; resulting in a thin disc of solid nickel with slightly elevated (micro-sized) information across the surface – much like ink on pages of a book. The resolution of initial introductory markings will be visible by the unaided [present-day human] eye before decreasing in scale; the majority of these content can be thereafter easily viewed under 100x magnification thus increasing the surface area for information inscription. At a resolution of 200dpi, each side of a single disc is capable of containing 1000 pages of micro-etched information on a 19mm ≤ surface. Each disc will then be coated within a thin layer of Sapphire glass (Al_2O_3) to provide additional tensile strength and long-term chemical stability alongside protection from corrosive liquids, high/ low temperatures fluctuations, pressure and sources of radiation. Impact/ collision testing is also presently being undertaken.

The foundation is also ensuring that these companion guides are constructed within the necessary sterile laboratory conditions before conducting additional sterilisation procedures in line with Planetary Protection Protocols [27] (specifically Category III-IV procedures). As these archives will reside in Earth orbit for millennia, it is necessary to factor in any 'temporal contamination' that may occur over expanses of geological time and responsible plan accordingly.

These micro-etched, analogue archives have a distinct advantage over widely-available, magnetic storage or solid state devices in that their contents will [largely] not become compromised by predicted cosmic radiation sources or experience decay. Further to this, as the material is [microscopically] etched, this method is comparable to some of the existing, oldest remnants of our pre-historic, ancestral heritage - a fitting legacy for objects that may outlive their architects. Additional technology for storing information may be incorporated within subsequent generations of these companion guides, however this will be at the discretion of the foundation's trustees and project directors.

LIBRARY OF CONTENTS:

The below table details the principle subjects onto the surface of each disc (see 'Capsule Assembly' diagrams for the corresponding location of each disc); Northern hemisphere will contain quantified details about life on Earth, human physiology/ cognitive acumen, our planet and its' dynamic cycles along with 'translated' anthropocentric concepts while the Southern hemisphere will depict heritage resources, linguistics, ontogenic traits and population statistics.

Northern Hemisphere:

Disc	Side	Contents
8	**A**	Photographs of Earth, ~300 Photographs.
	B	Sounds of Earth w/ spectrograms (AV).
7	**A**	Sounds of life w/ spectrograms (AV).
	B	Biota library, ecosystem properties etc.
6	**A**	*Ramazzottius varieornatus* genome sequence
	B	Portrait of humanity; anatomy, holobiont & mental faculties.
5	**A**	Phylogenetic tree of life diagram & heredity.
	B	DNA, genetic structure & evolution.
4	**A**	Chronicle of subterranean vault/ waste depository locations & future Earth tectonic configurations.
	B	Earth biome, structure & climate information
3	**A**	GAIA Mollweide star map, Solar System properties & celestial archive atlas
	B	Matter, periodic table, chemical compounds & aromas
2	**A**	AV player instructions & diagrams
	B	Collaborative activity instructions, instrument graphics & harmonics.
1	**A**	Inductive primer guides & ideographic almanac
	B	Atmospheric spectrum magnification guide.

Southern Hemisphere:

Disc	Side	Contents
9	**A**	'Language: Hello' introduction & magnification guide.
	B	~1000 language translations; The Preamble to the Universal Declaration of Human Rights [28].
10	**A**	~1000 Panlex [29] Swadesh vocabulary lists.
	B	Map of ethnic/ indigenous groups & multiculturalism.
11	**A**	Telluric language family tree, civilisation & proliferation.
	B	Sounds of Earth's cultures w/ spectrograms (AV).
12	**A**	a & b – Engraved analogue music w/ spectrograms (AV).
	B	a & b – Engraved analogue music w/ spectrograms (AV).
13	**A**	a & b – Engraved analogue music w/ spectrograms (AV).
	B	a & b – Engraved analogue music w/ spectrograms (AV).
14	**A**	a & b – Engraved analogue music w/ spectrograms (AV).
	B	a & b – Engraved analogue music w/ spectrograms (AV).
15	**A**	a & b – Engraved analogue music w/ spectrograms (AV).
	B	a & b – Engraved analogue music w/ spectrograms (AV).
16	**A**	a & b – Engraved analogue music w/ spectrograms (AV).
	B	a & b – Engraved analogue music w/ spectrograms (AV).

The foundation is implementing a series of creative open calls for public participation including;

- A drawing competition for children (8-14) worldwide to illustrate 'humans' for the archive; 'contemporary cave painting'. Drawings will be featured upon the archive bracket (detailed below).
- A photography competition to demonstrate simple, relatable properties of Earth/ nature/ humankind on 1A.
- A 'playlist' of suggested musical compositions from diverse ethnic/ indigenous backgrounds [final 'playlist' will be chosen by ethnomusicologists]. Content will be featured upon Discs 12 – 16 (A & B).

PRIMERS & RECIPIENTS

These experimental [visual] libraries are constructed to hopefully provide a commensurable, introductory guide for recipients that may not share convergences within; our species' in-situ environmental interactions, cognition, sensory modalities and other phylogenic parameters alongside cultural properties such as endocentric affiliation(s), collective sociocultural history, distributed cognitive materials and other inherited conventions.

Present Generations:

The initial recipients of these guides are the numerous [present] generations of ethnic populations and indigenous communities who can immediately avail of all contents used to develop these archival elements as well as the numerous educational/ participation opportunities to communally craft these artefacts. The Beyond the Earth foundation is committed to encouraging international learning and social cohesion within this common, multifaceted challenge while also promoting democratic access to spatial resources and inspiring responsible human proliferation within our surrounding celestial environment over these projected intervals of time.

Immediate descendants (100 - 1,000 years):

Our immediate descendants may not experience sufficient divergences within cultural/ biological evolution to warrant the extensive considerations employed within these archival elements. In this case, the artefact will predominately contain redundancy information for these recipients along with intricate [antiquated] records of our biosphere/ generational legacy that may prove beneficial for academia or for posterity within museum displays etc.

Distant descendants (1,000 – 10,000,000):

The archival elements and employed pidgins should provide sufficient commensurable resources that can aid in archaeological observations performed by these recipients. It is intended that these receivers will experience moderate to extensive shifts in cultural/ biological evolution and therefore require use of this introductory guide to comprehend our civilisation's perception of reality and access other intelligible artifices (these deductions can be thereafter applied to the atlas of additional underground archives/ vaults).

Observations within deep time (≥ 10,000,000):

Beyond +10 million year intervals, these introductory guides should provide basic accessibility to our civilisations' articulation but the viability of subterranean terrestrial vaults will be questionable due to active geological processes. In this case, celestial archives will remain as the only accessible media to test any intelligible deductions the recipients may glean from these 'Companion Guides for Earth'.

Communication with Extra-Terrestrial Intelligence:

The foundational primer within these artefacts utilises the artificial language Lincos in order to formulate an intuitive, mathematical guide for bottom-up descriptors however, this process is limited if we postulate that a recipient may not share convergences with human cognition or possess logical reasoning akin to our own mental capabilities. To address this potentiality, these arithmetic concepts will be further corroborated by graphical elements (based upon observable 'fundamental/ universal constants [30], - see the Voyager Record covers for examples) that are capable of adequately demonstrating simple constants which can be subsequently used to explain more elaborative ideologies and narratives. Both sets of strategies have been extensively explored within SETI literature and practically implemented within Messaging to Extra-Terrestrial Intelligence [31] activities.

Other recipients:

The foundation is also presently attempting to identify other primer strategies that are capable of communicating with additional, hypothetical receivers such as artificial intelligences, augmented biological entities and other, independently- evolved telluric species.

CAPSULE BRACKET ATTACHMENT:

The bracket is developed to securely fasten the capsule to the external hull of an appropriate satellite and also to attract attention towards this artefact through the use of specific materials which will, over time, degrade to predictable states. The reflector ‘skirt’ around the base of the capsule will reflect electromagnet radiation [over a wide incidence angle] from this artefact (though not enough to impact Earth-based observations). A protective, non-stick coating will be layered over this reflector array that will, over time, become opaque while serving as an additional sacrificial layer. Additional marker strategies are also being considered to support the memory and discoverability of these artefacts.

The plate itself will also contain a number of micro-etched elements including; ~ 2,000 Kid’s ‘Human’ Drawings from one open call channel (depicted in descending size), Disassembly (Chemical/ Temperature parameter) instructions and diagrams, redundancy AV device diagrams and other informative epigraphs.

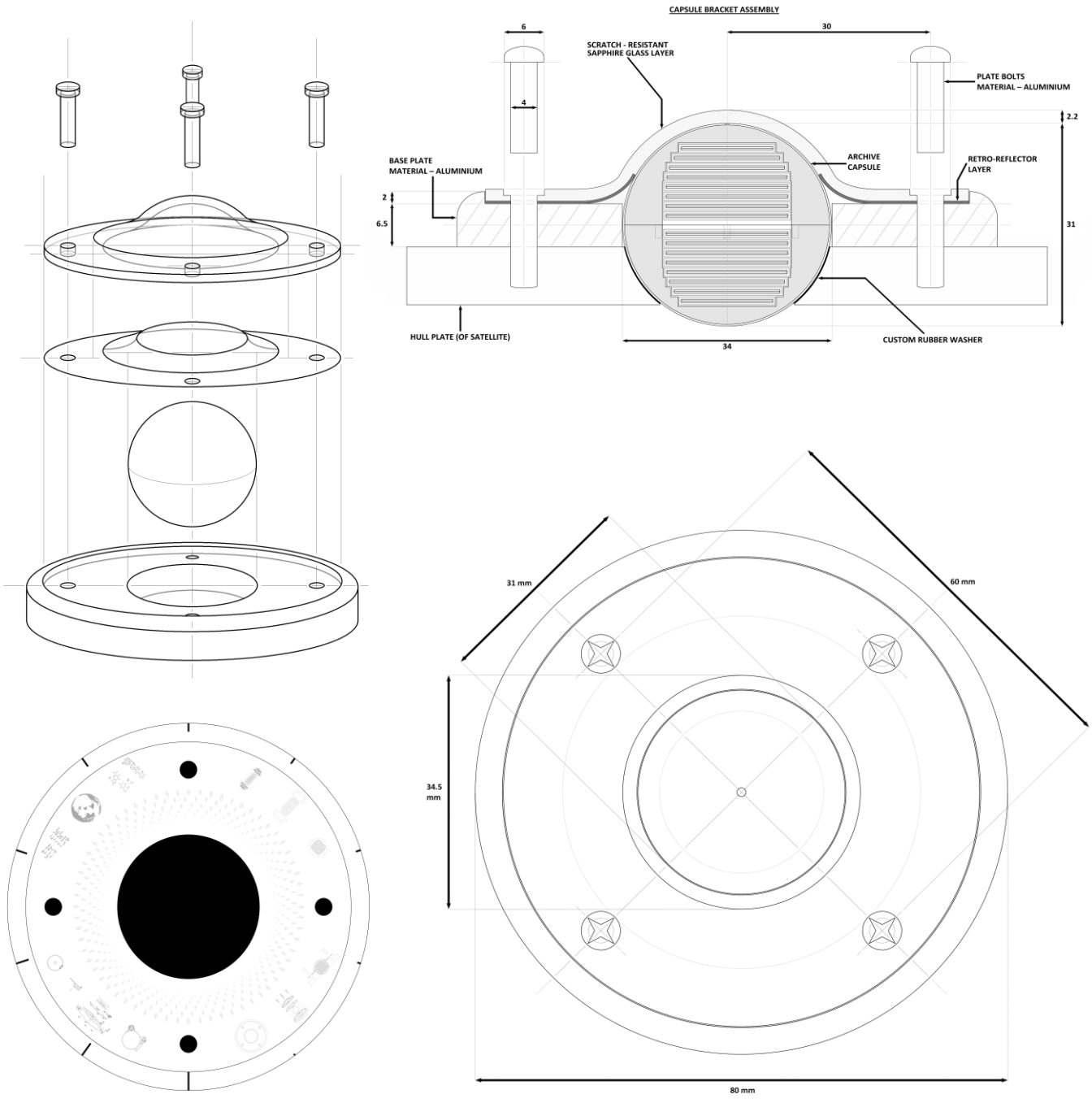


Fig. 3: Capsule Bracket Assembly and overview of micro-etched contents (bottom-left)

ORBITAL PARAMETERS

Placing these libraries within space presents a number of protracted conservation benefits including;

- Ensuring that the eventual recipient will need to demonstrate a specific level of technological sophistication and ingenuity to physically access the resident region of geosynchronous orbit.
- Pioneering ventures within space (even to the aforementioned geosynchronous orbit) will require large-scale cooperation between future inter/national populations therefore ensuring that such missions benefit a larger demography of researchers/ citizens.
- The artefacts will largely remain viable and accessible without interference from active geological processes or bio-geo-chemical cycles.
- The items of cultural heritage will remain largely unmolested from man-made acts of intentional destruction [32] or inadvertent consequences resulting from anthropogenic climate change etc.
- Protection from potential cataclysmic events that affect the global biosphere or human species.

However, storage of these libraries also represents a number of disadvantages (which this foundation is presently investigating) including;

- Preserving the terrestrial memory of extant artefacts residing within these orbital regions.
- Developing adequate marker strategies in order to support memory and recovery efforts.
- The general payload costs associated with inserting artefacts into this orbital region.
- Preventing instrument interference [33] for future researchers (e.g. telescopic observations by astronomers).
- National/ private operator liability for storing passivated satellites within graveyard orbits.
- Contributing to the space debris epidemic or mitigating the possibility of near-future collisions.
- Viability of the archival medium against sources of cosmic radiation and frequent extreme temperature fluctuations.
- Temporal contamination from viable microbes residing inside the satellite/ archival element (future biota may not possess an immunity to older strains of associated diseases etc.).
- The long-term (billion year interval) stability of these orbits during Solar System evolution.

Geosynchronous Earth Orbit (GEO) is a stable region surrounding our planet that is capable of securely preserving objects for periods of cosmic time due to the relative balance between exerted radiation pressure/ solar wind emanating from our Sun and also the gravitational influence of our home world. As GEO is defined as a protected region by the Inter-Agency Space Debris Coordination Committee [34] (IADC) guidelines for contemporary telecommunication/ Earth observation infrastructure, upon passivation of the host satellite, these artefact will be maneuvered out into a further graveyard orbit just beyond GEO for secure storage. This region is still a very stable environment for the long-term preservation of these libraries and it is also capable of supporting further editions of this library over the ensuing decades (dozens of satellites are passivated into this disposal orbit per annum); therefore potentially facilitating a multi-generational portrait of our present generations. It is anticipated that slight perturbations within this region along with changes in solar pressure will eventually lead to a more elongated, elliptical orbit for most of these GEO objects; ultimately dislodging these artificial satellites into longer, heliocentric orbits after one billion years.

Present IADC space debris mitigation guidelines recommend that satellites in Low Earth Orbit (LEO) should be de-orbited into Earth's atmosphere while satellites within the GEO should be re-positioned into a designated disposal (graveyard) orbit to prevent collisions and the accumulation of space debris/ a Kessler effect [35] event within protected regions around Earth. The protected regions of Earth's atmosphere are defined as;

- Region A: Low Earth Orbit up to 2000 km above Earth's Surface).
- Region B: Geosynchronous Orbit (circular orbit with an inclination 15º to -15º around Earth's equator up to 35,785 ± 200 km).

It is proposed that each archive be positioned on a satellite that will occupy a GEO orbit which, at the end of its' operational lifespan, will be re-positioned into a super-geosynchronous orbit (Fig. 4; Region C ≥ 36,000 km). Passivated satellites within this region presently formulate an artificial belt around Earth much like Saturn's rings; an orbiting, intelligible band that will remain indefinitely around our planet (unless altered by future clean-up operations).

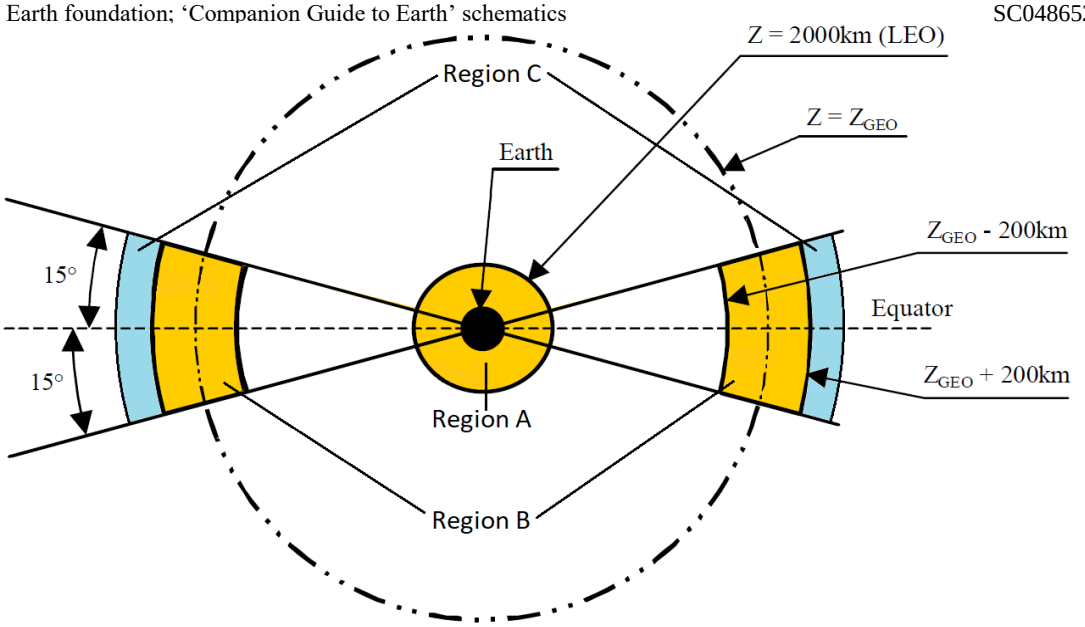


Fig. 4: IADC protected regions (as graphically rendered within IADC report) with proposed (Region C) insertion orbit.

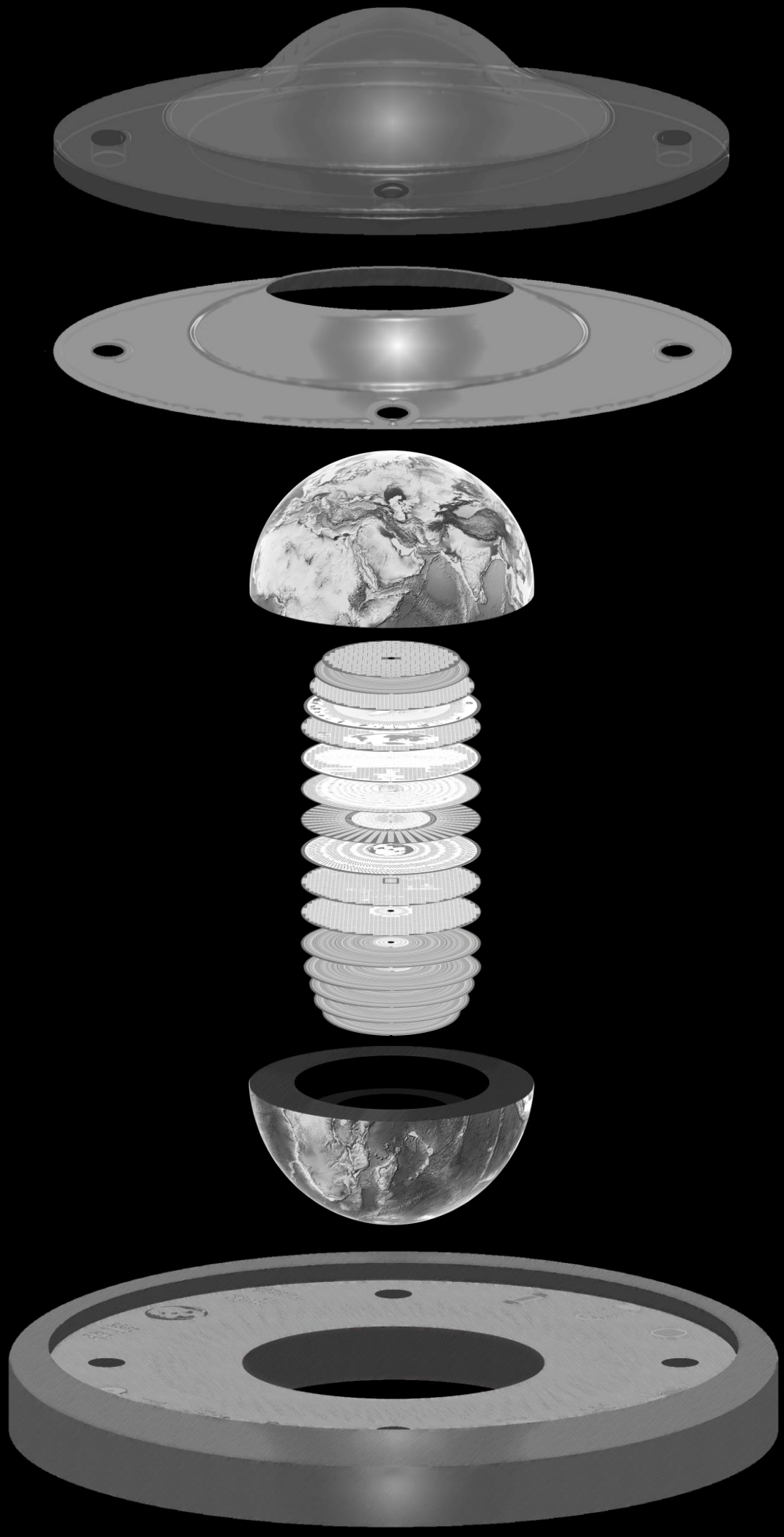
MARKER STRATEGIES

The foundation intends to implement a small retro-reflector layer across the surface of each archival element [and bracket] in order to serve as a marker strategy to entice recovery of these artefacts. This layer will be capable of reflecting electromagnetic radiation from a wide incident angle alongside additional marker strategies presently under consideration (some detailed below). We are currently working with an international community of astronomers in order to mitigate interference with terrestrial scientific observations and limit discovery opportunity to individuals who possess sufficiently powerful [amateur] telescope equipment.

The Beyond the Earth foundation is pioneering innovative research and experimental developments within new marker strategies in order to communicate the memory of these artefacts [and other sites] over periods of deep time. In this, we are invested within the LOCKSS (Lots Of Copies Keeps Stuff Safe) [36] method of information preservation whereby research and primer guides developed over the course of this foundation's activities will be freely available for adoption by other celestial/ terrestrial organisations and the general public for alternative applications i.e. time capsules, subterranean vaults, satellite 'postcards' etc. While this introductory guide will be preserved within GEO for the benefit of [local] deep time interpretability and access for Earth resources, we are also officially partnering with numerous other organisations such as Lunar Mission One and the Arch Mission Foundation to successfully disseminate this material farther beyond Earth orbit. In addition to these celestial outlets, the foundation is also directly collaborating with numerous underground cultural vaults and subterranean archives in order to retain a copy of this introductory guide [in a variety of media] within these secure terrestrial locations (for the benefit of decoding each vaults contents).

Concurrent to these activities, the foundation is also investigating the introduction of unique spectroscopic signatures to the infrastructure of this capsule/ bracket and host satellite in order to captivate interest within the orbiting object. For example, SETI literature suggests the presence of concentrated Technetium (both Tc^{98} & Tc^{97}) [37] isotopes, which are largely artificially synthesised (usually by nuclear fission technologies), will provide a unique radioactive signature that can stand out from background emissions with protracted isotopic half-lives of (Tc^{98}) 4.2 million years and (Tc^{97}) 4.21 million years respectively. Simultaneously, studies have also weighed the benefits of using Gadolinium (Gd^{152}) [38] as it is quite malleable to fabricate within, possesses an elongated radioactive half-life of 1.08×10^{14} and is also magnetic in nature (although the use of this material must be weighed against interference with the host satellite instrumentation). In addition to these, the use of [presently-deemed] 'precious' materials is also under-consideration.

In addition to these avenues, we are also contemplating the feasibility of passive radio systems (which do not necessitate maintenance/ replacement of electronics) as well as the omission of celestial signatures either by the use of materials such as 'Vantablack' [39] or through the advancement of integrated reflector antennae that may block emissions from a segment of the cosmos [or reflect focused terrestrial leakage back towards Earth]. Lunar/geo glyphs and other monumental structures with epigraphs are also under consideration in partnership with other organisations.



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