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'An Energy Account for *Spaceship Earth*'

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Abstract

This article positions the inventor, visionary, poet, engineer, architect and scientist R. Buckminster Fuller as an epic storyteller about energy (although he might have preferred the tag 'comprehensive anticipatory design scientist'). It draws on energy accounts from a range of Fuller's lectures, workshops and books; from his *Operating Manual for Spaceship Earth* through to his recommendations for the creation of a 'global energy grid'. It discusses Fuller's and related energy perspectives from the 1940's through to the 21st century. Fuller's ideas of synergetics and a scenario Universe incorporating a 'world-around' energy grid have continued to inspire current energy road maps. His energy storytelling was the infrastructure for a 'world accounting system based on energy.' The challenges of energy resources, energy security and energy transition persist today, albeit in revised forms. Current talk of circular economies, planetary boundaries and system transformations is usually presented without acknowledgement, or perhaps awareness, of the rich and imaginative visual and textual storytelling that have served as their foundations. The article revisits Fuller's energy narratives, and asks what kinds of storytelling are possible and productive when thinking about energy in the Anthropocene.

Introduction

> I must observe also that we're not going to sustain life at all except by our successful impoundment of more of the Sun's radiant energy aboard our spaceship than we are losing from Earth in the energies of radiation or outwardly rocketed physical matter. We could burn up the Spaceship Earth itself to provide energy, but that would give us very little future.[1]

R. Buckminster Fuller's story of humanity's future on board *Spaceship Earth* was also a story about energy. Fuller was an inventor, visionary, poet, engineer, architect and scientist, and was one of the 1960s best known public intellectuals. In 1964, the very first BBC *Horizon* programme was a profile of him: 'The World of Buckminster Fuller'. He is credited by Stewart Brand with inspiring *The Whole Earth Catalog*[2] and

John Cage, writing in 1971, predicted that the 21st century would regard the revolutionary era of the 1960s as one defined by Buckminster Fuller.[3] Above all, Fuller was a storyteller concerned with the future. The self-styled 'prognosticator' and 'forecaster'[4] should perhaps most appropriately be termed a 'comprehensive anticipatory design scientist' in recognition of his redefinition of design thinking.[5] Fuller was famous for giving impromptu and comprehensive lectures about industrial design problems and environmental crises, weaving together life experiences with complex scientific theories. His varied publications on humanity's perceived predicament attempted to cover an astonishingly broad scope. His unruly theoretical excursions were littered with neologisms and unorthodox punctuation. Fuller is perhaps best known for his work on geodesic domes. These were inspired by the processes, systems and structural integrities found in nature. He is also credited with popularising the idea of 'ephemeralisation' or 'the doing of ever more with ever less, per given resource units of pounds, time, and living in ever-increasing numbers.'[6] This principle is at the core of contemporary cradle-2-cradle thinking, environmental efficiency and sustainability paradigms, albeit in less transformational terms.[7] While rarely acknowledged by environmentalists, Fuller is credited with anticipating much contemporary environmental thought and practice in the twentieth century.[8] Most significantly Fuller contributed to establishing the notion of Spaceship Earth – the audacious redefinition of the home planet as a vehicle journeying in space. In 1969 Fuller published his *Operating Manual for Spaceship Earth*, where he described Earth as, 'an integrally-designed machine which to be persistently successful must be comprehended and serviced in total.'[9]

The title of this paper 'An Energy Account for Spaceship Earth', refers to the multiple meanings of the word 'account': narrative, chronicle, record, story; but also measure justification, calculation, tally or inventory. Energy accounts can take many forms, depictions of data, visualisations of resource flows and narratives of energy use. Spaceship Earth, a framing of the planet in techno-scientific terms as a hybrid entity, was a figure adopted by both environmentalists and technocrats to argue very different positions in the same terms.[10] It calls up notions of earthly lifeboat, earth ark, earth system or earthly replica. Fuller's mode of narration about Spaceship Earth and its entanglements encapsulates the tendency to attempt to bring technology, society and environment to a single horizon of understanding. It displays the simultaneity of energetic storytelling and accounting procedures. It both captures and provokes a condition whereby the storyteller covers for the engineer, or the prophet saves the day for the book-keeper.

Spaceship Earth was a prominent concept from the 1960 to the 1990s, when it was gradually replaced with the concept of sustainability. It nevertheless continued as a reference point in thinking about environmental sustenance and technical maintenance; efficient governance and stewardship. It has resurged more recently in anthropogenic climate change research and in particular in the twenty first century discourse of the Anthropocene and planetary boundaries. All of these reference the perceived threat of earthly limits, and a doomed future for planet earth and its inhabitants through their own actions. Discussions around energy transitions away from a fossil-fuelled economy, and questions about future energy systems, have sparked renewed interest in questions of planetary management and stewardship.

Spaceship Earth

In the 1960s the space missions represented the epitome of what modern technological society could accomplish. At the same time they called attention to environmental concerns about the planet: overpopulation, pollution, and exhaustion of resources. The most familiar images of humanity's home planet are the NASA photographs 'Earthrise', Apollo 8, 24 Dec 1968 and the 'Blue Marble' or 'Whole Earth', Apollo 17, 7 Dec 1972. These images associated with both the space age and the environmental movement introduce the twin ideologies of 'one world' (human universality) and the 'whole earth' (fragile ecology). The astronauts' view was also famously invoked in the Brundtland Report, *Our Common Future* in 1987. In *Apollo's Eye*, Cosgrove argues that, although superficially contradictory, both global visions – the 'world without borders' and the 'delicate bounded earth' were tied to a 'global mission' of 'human territoriality'.[11] Apollo's eye is 'synoptic and omniscient, intellectually detached.'[12] At the same time these technologically produced images created an illusion of 'whole earth' as an artefact which could be managed, encoded into systems, shaped and controlled – that is – understood as *Spaceship Earth.* The Apollo missions' images permitted the astronauts in a tiny artificial capsule to capture a view of the Earth from space. In turn this allowed for the re-imagination that the Earth itself could be conceived a spaceship, constantly worried about, monitored and controlled.

We see something of R. Buckminster Fuller's particular notion of Spaceship Earth and its energy account in *Nine Chains to the Moon,* his stargazing narrative from 1938. Before visits to space were considered possible Fuller was calling for more

adventurous thinking so that 'earthians' could achieve their full cosmic potential. He writes,

> Scientific shelter design is linked to the stars far more directly than to the earth. STAR-GAZING? Admittedly. But it is essential to accentuate the real source of energy and change in contrast to the emphasis that has always been placed on keeping man 'down to earth' the teleologic dwelling designer MUST visualize his little shelters upon the minutely thin dust surface of the earth-ball, dust which is a composite of inert rock erosion, star dust, and vegetable compost, all direct star (sun) energy resultants.[13]

Fuller's dusty earth ball was intimately connected to the stars – its source of cosmic energy and change. The idea that the Earth was a spaceship, a closed system with finite resources, was allegedly first used by Fuller in a discussion about the US space rocket programme in 1951 and later in lectures in the 1960s at MIT, Harvard University, Black Mountain College and other academic venues.[14] In the context of mid-century anxieties, above all relating to the Cold War, there was enormous appeal in the notion of planet Earth as a unified and balanced artefact. Throughout his various texts Fuller consistently warned of the dangers threatening humankind: including poverty, economic inequality, pollution, energy consumption and warring nations. The only apparent escape route from crisis was to develop scientific and technological regimes of efficiency and self-sufficiency. In 1969 he published his version of Earth stewardship, informed by systems theory and cybernetics: *Operating Manual for Spaceship Earth: A bold blueprint for survival that diagnoses the causes of environmental crisis*. In Fuller's terms the new conditions for humanity required acknowledging that 'we are all astronauts'.[15]

Fuller's book took part in the redefinition of the Earth as spaceship: artefact, vehicle and system. Fuller's spaceship had a limited 'carrying capacity' merging scant resources with spatial constraint in a vision of the earth as a fragile craft.[16] If the Earth is conceived as a spaceship – an 'interconnected structure of delicate sensors and integrated intelligences'[17] – then it followed that the crew needed to exercise care and concern for maintaining the liveable conditions on board – or as space scientists would describe them the Life Support Systems (that mimic the constraints of the biosphere on space stations). Steering of the craft involved management of atmosphere, water, resources, and above all energy. Fuller cautioned, that,

> …up to now we have been mis-using, abusing and polluting this extraordinary chemical energy-interchanging system for successfully regenerating all life aboard our planetary spaceship.[18]

The most important condition for the passengers on board Spaceship Earth was that they had not been provided with an instruction manual. Humans had inhabited Earth

for approximately two million years 'hardly knowing they were onboard a ship'. The implication was that Spaceship Earth, a dynamic, mobile, designed, hyper-sensitive object, prone to malfunctions, was no longer as tolerant of human ignorance.

> We have thus discovered also that we can make all of humanity successful through science's world engulfing industrial evolution provided that we are not so foolish as to continue to exhaust in a split second of astronomical history the orderly energy savings of billions of years' energy conservation aboard our Spaceship Earth.[19]

Fossil fuels – accumulated over billions of years – were Spaceship Earth's 'savings account' or 'storage battery'. They were described by Fuller as deposited through the action of dynamic Earth processes: 'photosynthesis and progressive, complex, topsoil fossilization buried ever deeper within Earth's crust by frost, wind, flood, volcanoes, and earthquake upheavals.'[20] Fuller's depiction of readily available cosmic energy reads like a paean to renewable energy: only by understanding the Earth's scheme could humanity continue to 'progressively harness evermore of the celestially generated tidal and storm generated wind, water, and electrical power concentrations.'[21] In many ways Fuller anticipated 21st century attempts to recast the Earth's energy system in terms of zero carbon energy accounting:

> The natural energy income in, for instance, the harnessable ocean tides, wind sunpower and alcohol-producing vegetation, can be made to flow through the wires and pipes to bring adequate energy to bear on the levers, to step-up man's physical vantage efficiently to take care of all of humanity.[22]

Fuller was advocating a radical transition in energy use that was simultaneously a civilizational paradigm shift, of benefit to all of humanity. Fuller's energy account for Spaceship Earth came with a warning:

> We cannot afford to expend our fossil fuels faster than we are 'recharging our battery,' which means precisely the rate at which the fossil fuels are being continually deposited within Earth's spherical crust. [23]

Keeping Spaceship Earth with a fully charged battery on a steady course would be the responsibility of 'planners, architects and engineers', as, according to Fuller, these professions and practices allowed for a more holistic rather than specialized view, and were thus considered more capable in taking on the managerial responsibilities for Spaceship Earth. They would be aided by the principles of good management and the use of a state-of-the art computer monitoring of Earth. The computer, Fuller argued, was capable of 'bringing all of humanity in for a happy landing.'[24]

Earth Stewardship

Such successful steering of the Spaceship Earth was linked to notions of Earth governance and control expressed as stewardship. The economist Kenneth Boulding took up the metaphor of the well-organised space-faring machine in his 1966 article, 'The Economics of the Coming Spaceship Earth'.[25] He proposed a 'spaceman economy' or 'closed economic system' with an ethic of responsible management of the Earth as opposed to the 'cowboy economy' of the 'open system':

> For the sake of picturesqueness, I am tempted to call the open economy the 'cowboy economy', the cowboy being symbolic of the illimitable plains and also associated with reckless, exploitative, romantic, and violent behavior, which is characteristic of open societies. The closed economy of the future might similarly be called the 'spaceman' economy, in which the earth has become a single spaceship, without unlimited reservoirs of anything, either for extraction or pollution, and in which, therefore, man must find his place in a cyclical ecological system which is capable of continuous reproduction of material form even though it cannot escape having inputs of energy.'[26]

Spaceship Earth offered the blueprint for a strict economy of 'circulation' and for a technology of material energy and information flows, of material exchange and renewal, for the Earth's living space. Intimations of the frontier thesis of American history and cultural politics are self-evident. In the spaceship economy, informed by notions of scarcity, the primary concern was tight control of reserves or 'stock maintenance'. This was influential in the development of ecological economics and the notion of an ecological footprint.

> In the last few decades, mankind has been overcome by the most fateful change in its entire history. Modern science and technology have created so close a network of communication, transport, economic interdependence – and potential nuclear destruction – that planet earth, on its journey through infinity, has acquired the intimacy, the fellowship, and the vulnerability of a spaceship.[27]

In 1966 the British economist and political scientist, Barbara Ward published *Spaceship Earth* which promoted a science-based politics that could redirect social energy. 'This space voyage is totally precarious' she wrote, 'We depend upon a little envelope of soil and a rather larger envelope of atmosphere for life itself. And both can be contaminated and destroyed.'[28] The expertly steered spaceship became an allegory for the need of a new balance of power between the continents, of wealth between North and South, and of understanding and tolerance in a world of economic interdependence and potential nuclear destruction. For Ward, the United

Nations held the promise of steering the unity of the planet's carrying capacity.[29] Her later writings were co-authored with French environmentalist René Dubos, including a publication produced to coincide with the UN Stockholm Conference on the Environment in 1972 - the first 'Earth Summit'. Titled *Only One Earth* and subtitled *The Care and Maintenance of a Small Planet* – it is presented, like Fuller's book, as a technical reference manual, with its call for humanity to 'accept responsibility for stewardship of the earth.'

Concerns around resource security and environmental security supplemented the global issues of military and energy security at a time when 'the environment' was understood to be more under the control of humans than ever before, not least because the human potential for technological intervention was so unprecedented. The metaphor of the spaceship plays on notions of both holism and purpose. But it also hides the contingency of the Earth system, implying that everything could be ship-shape given proper governance. It also encourages the notion that there is a fixed limit to the Earth's carrying capacity just as there is a fixed complement for a vessel. This argument has been used to justify brutal ideas about population control, for example in Paul Ehrlich and Garret Hardin's work, and more recently in Lovelock's writings. Garrett Hardin's 1972 science fiction parable, *Exploring New Ethics for Survival: The Voyage of the Spaceship Beagle* interweaves an exposition of the 'population problem'[30] within the framework of a story set on board a spaceship named *Beagle*, a space-age counterpart of Darwin's famous vessel.[31] Hardin wrote this tale as an extension of his contested 1968 essay, 'The Tragedy of the Commons'.[32] Hardin used talk of a troubled Spaceship Earth to advocate the suspension of humanistic moral values in favour of 'lifeboat ethics'- derived from naval law and practice. The scientific systems of the spaceship provided energy, synthesis of food and recycling of waste. In other words, technology was proven capable of supplying all 'daily needs'. It was impossible however, to expect any kind of stability from the changeable, argumentative and fickle passengers, in other words, 'the real problem of a spaceship is its people.'[33]

All of the above: the notion of a well-managed system, the idea of a steady state economy, political unity and good governance – were implied in Fuller's energy projects for Spaceship Earth. However, his response contrasts sharply with the Malthusian or even anthropophobic tendencies of Hardin and Ehrlich. In the context of perceived energy crises Fuller had stated, 'There is no energy crisis, only a crisis of ignorance.' Fuller held up human ingenuity against all possible limits with regard to the planet's cosmic energy. He argued that while growing populations might

consume more, this would not exhaust the world's natural resources because of exponential advances in ephemeralization – doing more with less. In a typically energetic pronouncement from Fuller he applies a playful tone to his suggestion that distribution is more of an issue than sheer numbers: 'There is room enough indoors in New York City for the whole 1963 world's population to enter, with room enough inside for all hands to dance the twist in average nightclub proximity.'[34]

Global Energy Grid

For Bucky Fuller the term 'energetic' encompassed his conception of the universe as an enormous field of energy with the Earth as a 'spinning, cosmos-zooming earth ball.' His neologism 'synergetic' combined 'energetic' with 'synergy' to refer to the integration of energy in a system. Earthians, he summised, were more than capable of realising their cosmic energy potential. It was their fossil-fuelled success, however, that had got them into trouble:

> '… we are in an unprecedented crisis because cosmic evolution is also irrevocably intent upon making omni-integrated humanity omnisuccessful, able to live sustainingly at an unprecedentedly higher standard of living for all Earthians than has ever been experienced by any; able to live entirely within its cosmic-energy income instead of spending its cosmic energy savings account (i.e., the fossil fuels) or spending its cosmic-capital plant and equipment account (i.e., atomic energy) –the atoms with which our Spaceship Earth and its biosphere are structured and equipped – a spending folly no less illogical than burning your house-and-home to keep the family warm on an unprecedentedly cold midwinter night.'[35]

This trenchant quote from *Critical Path* (1981) summarises Fuller's view of the global crisis as one of reckless and illogical energy expenditure on Spaceship Earth. According to him, the first task on humanity's 'critical path' to averting the crisis would be to build a global energy grid to stop needless squandering of the 'cosmic energy savings account'. Fuller's research had led him to conclude that humanity could satisfy 100% of its energy needs while phasing out fossil fuels and nuclear power. In one example, he had calculated that a wind turbine fitted to every high-voltage transmission tower in the US could generate three-and-a-half times the country's total power output at the time. Fuller predicted that his global energy grid would be operational by 1989.

> The world energy network grid will be responsible for the swift disappearance of planet Earth's 150 different nationalities. We now have 150 supreme admirals, all trying to command the same ship to go in different directions, with the result that the ship is going around in circles – getting nowhere.[36]

Fuller's 'Global Energy Network International' (GENI) would make the most efficient use generating capacity in different parts of the world, sending surplus to satisfy demands wherever needed. It was seen as a way of distributing renewable energy around the planet, dealing with the intermittency and availability problems suffered by solar and wind power in particular. Fuller developed his ideas for a scenario Universe incorporating the 'world-around' energy grid. He tested his claims that the energy grid had world-unifying potential in the World Game, an antidote to Cold-War military games and doomsday scenario planning. Fuller called for the elimination of nations in favour of a single government that would operate in the interests of the entire planet – making it work for all of humanity. The World Game was conceived as a methodology as well as a programme. This political-social-resource scenario game relied on a computer to gather data and make allocations based on need, but above all it required serious game playing. The giant simulation explicitly declared energy as the basis for society including a logical re-organization of all of the world's resources, and proposed no less than an end to the Cold War and the institution of World Peace.

> To the World Game seminar of 1969 I presented my integrated, world-around, high-voltage electrical energy network concept. Employing the new 1500-mile transmission reach, this network made it technically feasible to span the Bering Straits to integrate the Alaskan U.S.A. and Canadian networks with Russia's grid, which had recently been extended eastward into northern Siberia and Kamchatka to harness with hydroelectric dams the several powerful northwardly flowing rivers of north-easternmost U.S.S.R. This proposed network would interlink the daylight half of the world with the nighttime half.[37]

The World Game was played on versions of his Dymaxion map (1943)- a new cartographic logic for mapping the Earth as an undistorted projection of contiguous islands surrounded by ocean – indeed the world as seen by a circumnavigating oceanic vessel, world criss-crossing aircraft, or orbiting spaceship. The Dymaxion map laid the Earth out with no North, South, East or West and encouraged contemplation of the globe as a comprehensive whole. His collaborator, student and co-founder of the World Game Institute in 1972, Medard Gabel, published *Energy, Earth and Everyone: A Global Strategy for Spaceship Earth.* Fuller's ambition was to make the planet comprehensible as a synergetic artefact, one that would override the Earth as simply a question of bounded territories. This transpired as a diverse and inclusive platform of energy fields, energetic relations, calculable energy resources and expenditures, and as a measure of vastly different kinds of cosmic capabilities.

Fuller's ambitions for a synoptic, unified world view has informed the utopian narratives of the EU Roadmap 2050, and the Shell Energy Scenarios 2050. For Roadmap 2050, The Office for Metropolitan Architecture (OMA) working with the European Climate Foundation (ECF), visualised a utopia of connected cities – a Continuous City, *Eneropa* – sharing energy from tidal, wind, solar, geothermal and biomass resources. OMA's representation reveals interconnected complementary energy strategies that exploit the geography and climate in different regions across the European continent. It replaces nations with new energetic entities – 'Solaria', the 'Isles of Wind' and 'Geothermia'. Although not daring to claim such connectivity could lead to 'world peace', it is clear that *Eneropa's* European wide energy grid owes much to Fuller's World Game played on the Dymaxion map (1961). And, in the manner of Fuller, it redraws traditional conceptual boundaries in imagining a different kind of energy future for Europe.

Fuller's proposals for energy system change anticipated many contemporary discussions concerning energy. In the broader context of planetary-scale environmental disruptions caused by an escalating demand for energy there are still calls for far-reaching transformation of energy provision systems and the entire reconfiguration of the energy sector towards new technical or institutional arrangements predicated on low carbon sources. Current cumulative worldwide investment in fossil fuel extraction and processing however, continues to outstrip investment in renewables. And when few resources are so unequally consumed across the world as energy, notions of 'us humans' all steering the spaceship, or being in the same boat, or connected for world peace are readily dismissed as illusory. Spaceship Earth and its energy grid has endured in the main as a metaphor that underpins notions of technical management and planetary control. Fuller's vision lent itself to a particular encompassing view: a way of perceiving the world as fabricated by humans and thus leaving humanity in charge of optimizing relations between energy resources and energy needs. In other words, the Earth's cosmic energy narrative could be reduced to a tally of inputs and outputs.

Planetary boundaries

> This balmy springtime for humanity is known as the Holocene. But we are now in a new era, the Anthropocene, defined by human domination of the key systems that maintain the conditions of the planet. We have grabbed the controls of spaceship Earth, but in our reckless desire to "boldly go", we may have forgotten the importance of maintaining its life-support systems.[38]

Knowledge of dynamic earth systems and the interactions of the atmosphere, hydrosphere, biosphere, heliosphere, cryosphere, lithosphere – air, water, life, sun, ice and rock – has greatly expanded since Fuller's day. Acknowledgement of the significant ways in which humans are changing Earth systems has unsettled existing notions of boundaries and threshold conditions and warned of planetary crisis and tipping points.[39] The renewed sense of planetary crisis is expressed in the concerted uptake of the idea of the Anthropocene – the proposal that devastating human-induced changes to Earth systems signal a new geological epoch[40] and its 'collateral concept'[41] of planetary boundaries. This discourse has drawn on 1960s narratives of Spaceship Earth and in particular its accounting system. Moreover, the strategic vantage point from whence Spaceship Earth could be both monitored and piloted signals a kind of ' "de-Earthed" imaginary, the product of a technoscientific culture that developed in parallel with the dynamics that have led us into the Anthropocene.'[42]

The planetary boundaries hypothesis first proposed in 2009 by Johan Rockström and colleagues at the Stockholm Resilience Centre, and updated in 2015 has become an influential framework for discussing global environmental problems and solutions.[43] It follows a persistent line of thought that frames environmental crises as a management problem within the notion of a limited and fragile Earth – an operable Biosphere. It identifies nine global biophysical limits to human development: climate change; ocean acidification; stratospheric ozone depletion; biogeochemical nitrogen and phosphorus cycle levels; global freshwater use; land system change; biodiversity loss; chemical pollution and atmospheric aerosol loading. It further suggests that transgressing any of these interdependent boundaries will have catastrophic consequences. With its emphasis on a 'safe operating space for humanity', and its concerns over the 'carrying capacity' of the Earth, planetary boundaries thinking draws on the spaceship earth metaphor, and Buckminster Fuller's terminology in *Operating Manual for Spaceship Earth.* The planetary boundaries hypothesis has also renewed discussions on appropriate stewardship of Earth systems, still conceived of as life support systems *as if* on a spaceship. Mike Hulme warns that such powerful metaphors, circulating around the Earth, are never innocent. As he asks in his response to planetary boundaries thinking:

> Is the Earth a spaceship to be steered on a journey, an Earth mother with which we must bond or, careful here, a dashboard with dials to be managed so that the indicators are kept out of the red zone?[44]

In the early 21st century, the question of limits has thus resurfaced along with bold definitions of what those limits might be. These limits are accompanied by the terminology of tipping points, critical thresholds and boundaries of abrupt climate and ecosystem change, which in turn have reenergized warnings of 'deleterious or potentially disastrous consequences for humans.'[45] Although current discourse around the Anthropocene and planetary boundaries acknowledges a good deal more uncertainty about the future than the 'managing spaceship earth' precedents from the 1960s and 1970s ever admitted to, it nevertheless reveals the same blurring between ideas of stewardship and operational procedures. It also shares the same admixture of hubris and humility: marveling at human power and floored by its vulnerability. On the one hand Rockstrom's vision is to promote the idea of planetary stewardship, or joint governance at the planetary scale through revised research and policy collaborations such as the Earth League and Future Earth.[46] His vision is to 'launch an Apollo type endeavor –which starts now– of addressing exactly this integrated science for transition to global sustainability.'[47] On the other hand, 'planetary boundaries' together with 'the safe and just operating space", 'green competition' and 'the energetic society' have been enlisted for achieving sustainable development goals in a move that claims to go beyond 'cockpit-ism.'[48] These conceptual moves that come packaged with an application of the notion of Spaceship Earth are under-recognised as such. Just as the Earth Sciences move towards thinking in terms of more dynamic systems and a cosmic expanding universe, so paradoxically, their pronouncements also helps to cement conservative responses focused on control, where concomitant notions of circular causal relations and cybernetic dynamization produce their own kinds of fixities.

Perhaps of most concern is that thinking in terms of 'operable life-support systems' and 'planetary boundaries' places humans in the role of Earth-fixers. Geoengineering is a term that describes the global-scale technologically driven interventions in, and management of, the Earth. Current geoengineering options fall into two main categories: Solar Radiation Management (SRM) and Carbon Dioxide Removal (CDR). SRM schemes for reflecting sunlight back into space include for example, releasing sulphate particles into the stratosphere to enhance the Earth's albedo, or 'global dimming' by placing millions of tiny mirrors in near-Earth space orbit. CDR schemes to remove CO_2 from the atmosphere include the dumping of pulverized limestone in the oceans to neutralize acidification and the burial of charred biomass to promote carbon sequestration. The fundamental premise of such schemes is of Earth-altering. For the most part geoengineering proposals assume that the Earth is

an operable system with flows of energy that can be controlled and mastered by humans. As Bonneuil and Fressoz observe, 'Still more here than with nuclear tests or the imaginary of 'Spaceship Earth,' the entire Earth is now explicitly reified as object of experimentation and control.'[49]

The contemplation of planetary scale engineering is increasingly presented as a necessary evil, as an inevitable response to the emerging dangers of anthropogenic impacts on Earth systems. There are many that are convinced that the climate system has the potential for sudden and dangerous shifts, that carbon mitigation efforts are failing or moving too slowly to avert environmental disaster, and that therefore the Earth and sky need to be 'fixed' or controlled in the manner of a planetary thermostat perhaps or an air-conditioning unit. Clive Hamilton responds: 'as if we know enough to install and begin to operate a "global thermostat". Truly this qualifies as monstrous hubris.'[50] The disastrous conditions of the so-called Anthropocene epoch and the trespassing of 'planetary boundaries' can already be said to have come about as a result of human planetary scale manipulation: extractive systems and fossil-fuelled accelerations. Geoengineering can thus be understood then as both a trigger, and ultimate response to the Anthropocene. But as Duncan McLaren has noted, 'discourses of the "Anthropocene" give a misplaced confidence in the controllability of earth systems.'[51] A position that maintains that all Earth systems are already irrevocably and irreversibly affected by human activities, leaves little choice but to take control or even enhance them. In other words, geoengineering could simply be considered an ongoing project of Earth systems management – and a continuation of the inevitable if risky programme for Spaceship Earth.

Energy accounts

Narratives around Spaceship Earth reveal many different stories or strategies for change. There are accounts that tend towards a hubristic expression of human potential while other narratives present the limits of human agency. Another set of narratives ask the reader to follow the procedural rule book that seeks to control an unruly humanity. Standing apart from all of these is a body of unruly storytelling and provocative narrative improvisations. Buckminster Fuller's energetic storytelling was a foundation for his 'world accounting system based on energy' that recognised both a 'synergetic universe' and a human history of 'reckless and illogical energy expenditure'. The challenges of energy system change, and the parallel and closely linked challenge of telling whole stories about energy, have not changed much since Fuller's day. And while we puzzle over how to come to terms with a sense of

jeopardy when it comes to energy transitions and climate change, we still tend to steer towards and foreground those accounts we perceive as more reliable and certain and perhaps therefore (to some) more reassuring. The Anthropocene and associated concept of planetary boundaries warn of environmental threats and limits and many commentators have understood this to encourage a focus on ideas of control, scientific authority and incontrovertible evidence. For Melissa Leach such moves imply 'a closing down of uncertainty or at least its reduction into clear, manageable risks and consensual messages.'[52] Some versions of 'planetary management' extend ambitions far beyond the governance of merely human affairs (in all their intractable unruliness) and aspire to take even greater power over the 'Earth System'. Many fear that this logic puts society on a path that leads to large-scale geoengineering, with unknown and unacknowledged consequences. Proponents seem unwilling to acknowledge that it was precisely the domineering rhetorics of control that got humanity into its current unstable relationship with its earthly home in the first place. That one fact suggests that a significantly different kind of Earth accountability is needed, informed by notions of care, solidarity and responsibility from within the diversity of human relations with energy.

However, whichever route is taken, the fact remains that despite the intensity and persistence of the challenges of steering a Spaceship Earth, humans clearly don't have, and will never have, a reliable operating manual. What kind of energy narratives are possible in the Anthropocene? Thinking about living with energy in the Anthropocene suggests the need to go well beyond reliance on the capabilities of integrated knowledge systems or the processes of Earth system governance. It also requires cultivating diverse accounts of human imagination rather than depending on fixed accounting procedures. While Fuller's storytelling has informed notions of a controllable home planet as an artefact it also points to a re-entangling of diverse human values and aspirations with the unknowable and uncontrollable complexities of the Earth and the 'invisible energy events of the universe.'[53] In the epilogue to *Utopia or Oblivion* he writes, '[T]he environment always consists of energy – energy as matter, energy as radiation, energy as gravity, and energy as "events".'

Fuller's energy narratives– from statistics, through mappings and games to storytelling– were about imagining transformation and proposing a radically different energy future. At times however, his unbounded faith in *human* energy and ingenuity and the promise of technological control seems misplaced even dangerous. Moreover his exhilaration at Earth's cosmic bounty is at odds with the prevailing

mood of doom that not only pervaded his own time but persists today, not least with escalating warnings of catastrophic environmental change. And yet his tale of human, or earthian, synergy with the home planet also conveys a sense of wonder. The distinctive combination of audacity and urgency in Buckminster Fuller's narratives is timely. It again feels like an important combination as humanity seeks stories that help imagine energy transitions in the Anthropocene.

Notes

[1] R. Buckminster Fuller, *Operating Manual for Spaceship Earth*, Lars Muller Publishers 2008
[2] Stewart Brand writes: 'Back in 1967 the insights of Buckminster Fuller initiated the *Whole Earth Catalog*. The artists I hung out with in those days had all been electrified by Stewart's earlier, most radical book – *Nine Chains to the Moon*.' Stewart Brand (ed.) *The Next Whole Earth Catalog: Access to Tools*, 2nd ed. (New York: Random House, 1981); p. 32.
[3] John Cage (1971). 'Diary: How to improve the world (you will only make matters worse)' *New Literary History III*, *C1*, 201-214.
[4] R. Buckminster Fuller, *Operating Manual for Spaceship Earth*, Lars Muller Publishers 2008; pp. 22-23.
[5] Fuller's 'Comprehensive Anticipatory Design Science' was originally outlined in 1927, while teaching at MIT.
[6] R. B. Fuller, 2008 *Utopia or oblivion: The prospects for humanity*. Baden, Germany: Lars Müller. (Original work published 1969); p. 26.
[7] See for example, McDonough, W., & Braungart, M. (2002). *Cradle to cradle: Remaking the way things work*. New York, NY: North Point Press, 2002)
[8] See Timothy W. Luke, 'Ephemeralization as Environmentalism: Rereading R. Buckminster Fuller's *Operating Manual for Spaceship Earth'* in *Organization and Environment* (2010) 23 (3): 354–362.
[9] R. Buckminster Fuller, *Operating Manual for Spaceship Earth*, Lars Muller Publishers 2008.
[10] See Sabine Hohler, *Spaceship Earth in the Environmental Age, 1960-1990* (London: Routledge, 2014).
[11] Denis Cosgrove (2001) *Apollo's Eye: A Cartographic Genealogy of the Earth in the Western Imagination*, (John Hopkins University Press, 2001); p. 265; 289.
[12] Denis Cosgrove (2001) *Apollo's Eye: A Cartographic Genealogy of the Earth in the Western Imagination*, (John Hopkins University Press, 2001); p. 2.
[13] R. Buckminster Fuller, *Nine Chains to the Moon* (1938) (Carbondale, Illinois: Southern Illinois University Press, 1963); p. 59.
[14] R. Buckminster Fuller, *Your Private Sky R. Buckminster Fuller: the Art of Design Science,* Joachim Krausse and Claude Lichtenstein (eds.) Lars Muller Publisher 1999; p. 11.
[15] R. Buckminster Fuller, *Operating Manual for Spaceship Earth*, Lars Muller Publishers 2008
[16] The concept of 'carrying capacity' used by ecologists to define the maximum number of representatives of a given species that a habitat can support without permanently corrupting the environment and endangering the life of the species. It is closely linked to the notion of sustainable development and the discourse around ecological limits.
[17] R. Buckminster Fuller, *Operating Manual for Spaceship Earth*, Lars Muller Publishers 2008.
[18] R. Buckminster Fuller, *Operating Manual for Spaceship Earth*, Lars Muller Publishers 2008.
[19] R. Buckminster Fuller, *Operating Manual for Spaceship Earth*, Lars Muller Publishers 2008; p. 128.
[20] R. Buckminster Fuller, *Operating Manual for Spaceship Earth*, Lars Muller Publishers 2008; p. 128.
[21] R. Buckminster Fuller, *Operating Manual for Spaceship Earth*, (Lars Müller Publishers 2008); p. 129.
[22] R. Buckminster Fuller, *Utopia or oblivion: The prospects for humanity*. (Baden, Germany: Lars Müller, 2008); p.301.
[23] R. Buckminster Fuller *Operating Manual for Spaceship Earth*, Lars Muller Publishers 2008; p.129.
[24] R. Buckminster Fuller, *Operating Manual for Spaceship Earth*, Lars Muller Publishers 2008; p. 138.
[25] See Peder Anker, 'The Ecological Colonization of Space' *Environmental History*, Vol.10, No.2 (April 2005); pp.239–268 and Chapter 6, 'The Ecological Colonization of Space', Peder Anker, *From Bauhaus to Ecohouse: A History of Ecological Design* (Baton Rouge: Louisiana State University Press, 2010).
[26] Kenneth E. Boulding, 'The Economics of the Coming Spaceship Earth,' in *Environmental Quality in a Growing Economy*, Essays from the Sixth RFF Forum on Environmental Quality held in Washington D.C., March 8 and 9, 1966, ed. Henry Jarrett (Baltimore: Johns Hopkins University Press, 1966).
[27] Barbara Ward, *Spaceship Earth* (New York: Columbia University Press, 1966).
[28] Barbara Ward, *Spaceship Earth* (New York: Columbia University Press, 1966); p. 15.
[29] Barbara Ward, *Spaceship Earth* (New York: Columbia University Press, 1966).

[30] Paul R. Ehrlich, *The Population Bomb* (1968; New York: Ballantine, 1969).
[31] Garrett Hardin, *Exploring New Ethics for Survival: The Voyage of the Spaceship Beagle* (New York: The Viking Press, 1972); p. 233.
[32] Garrett Hardin, *Exploring New Ethics for Survival: The Voyage of the Spaceship Beagle* (New York: The Viking Press, 1972); 'The Tragedy of the Commons', *Science* 162 (1968): 1243–148. It was included as Appendix B, pp. 250–264.
[33] Garrett Hardin, *Exploring New Ethics for Survival: The Voyage of the Spaceship Beagle* (New York: The Viking Press, 1972); p.92.
[34] *Prime Design* (May 1960), later published in *The Buckminster Fuller Reader* (1970) edited by James Meller
[35] R. Buckminster Fuller with assistance of Kiyoshi Kuromiya, *Critical Path* (1981)
[36] R. Buckminster Fuller with assistance of Kiyoshi Kuromiya, *Critical Path* (1981); p. xxxiv.
[37] R. Buckminster Fuller with assistance of Kiyoshi Kuromiya, *Critical Path* (1981); p. 206.
[38]Fred Pearce on Planetary Boundaries in the *New Scientist*; https://www.newscientist.com/round-up/ocean-to-ozone-earths-nine-life-support-systems/; accessed 30 September 2016.
[39] O'Riordan, T. and T. Lenton (eds.). *Addressing Tipping Points for a Precarious Future*. (Oxford University Press/British Academy, 2013).
[40] The term *Anthropocene* was introduced in 2000 by the atmospheric chemist Paul J. Crutzen and the ecologist Eugene Stoermer to refer to the present as geologically distinct from the current geological epoch, the Holocene, through the scale of human impacts on the environment.
See Paul J. Crutzen and Eugene Stoermer, "The Anthropocene," *International Geosphere-Biosphere Programme Newsletter* 41 (2000): 17–18; Paul J. Crutzen, "Geology of Mankind," *Nature* 415 (January 2002): 23. An "Anthropocene working group" convened by Dr. Jan Zalasiewicz, for the International Commission on Stratigraphy and the International Union of Geological Sciences, has since 2009 been considering formalization of the term. If accepted as a formal term this would mark the official end of the Holocene and the addition of the Anthropocene to the geological time scale. See http://quaternary.stratigraphy.org/workinggroups/anthropocene/.
[41] Noel Castree, 'The Anthropocene and planetary boundaries, forthcoming in D. Richardson *et al*. (eds) *International Encyclopedia of Geography* (Wiley-Blackwell, 2015).
[42] Christophe Bonneuil and Jean-Baptiste Fressoz, translated by David Fernbach, *The Shock of the Anthropocene* (London: Verso, 2016); p. 63.
[43] Rockström, J.; Steffen, W.; Noone, K.; Persson, Å.; Chapin, F.S.; Lambin, E.F.; Lenton, T.M.; Scheffer, M.; Folke, C.; Schellnhuber, H.J.; *et al*. 'A Safe Operating Space for Humanity'. *Nature* 2009, *461*, 472–475. Steffen, W.; Richardson, K.; Rockström, J.; Cornell, S.E.; Fetzer, I.; Bennett, E.M.; Biggs, R.; Carpenter, S.R.; de Vries, W.; de Wit, C.A. 'Planetary boundaries: Guiding human development on a changing planet'. *Science* 2015.
[44] Mike Hulme, 'A safe operating space for humanity': Do people's beliefs need to change? Transcript of lecture, 9 April 2013; 'Global Change and Biosphere Interactions', York Environment and Sustainability Institute University of York, 8-9 April 2013; http://www.mikehulme.org/wp-content/uploads/2013/03/13_04-York-speech.pdf; accessed 30 September 2016.
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[46] http://www.futureearth.info/news/future-earth-launches-eight-initiatives-accelerate-global-sustainable-development
[47]Official launch of the Earth League and Inaugural Lecture by Professor Johan Rockström, Stockholm Resilience Center - hosted by the Grantham Institute for Climate Change - Recorded on 7 February 2013; https://www.youtube.com/watch?v=6mtaSqXVzWE; accessed 1.8.2014
[48] Maarten Hajer et al. 'Beyond Cockpit-ism: Four Insights to Enhance the Transformative Potential of the Sustainable Development Goals', *Sustainability* 2015, 7(2), 1651-1660.
[49] Christophe Bonneuil and Jean-Baptiste Fressoz, translated by David Fernbach, *The Shock of the Anthropocene* (London: Verso, 2016); p. 91.
[50] Clive Hamilton, *Earth Masters: The Dawn of the Age of Climate Engineering* (New Haven and London: Yale University Press, 2013); p. 181.
[51] Duncan McLaren, 'Where's the justice in geoengineering?' The Guardian, 14 March 2015. The post was based on a lecture given at the SRM Science Conference Cambridge, 2015; http://www.theguardian.com/science/political-science/2015/mar/14/wheres-the-justice-in-geoengineering; accessed 14.03.2015.
[52] Melissa Leach, 'Democracy in the Anthropocene? Science and Sustainable Development Goals at the UN' 28/03/2013, *Huffington Post*, http://www.huffingtonpost.co.uk/Melissa-Leach/democracy-in-the-anthropocene_b_2966341.html ; accessed 30 September 2016.
[53] R. Buckminster Fuller, *Utopia or oblivion: The prospects for humanity*. (Baden, Germany: Lars Müller, 2008); p.26.

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