

iF DESIGN STUDENT AWARD

Sustainable Development Goals of the United Nations.



UN GOAL 9 – Industry, Innovation and Infrastructure

Building resilient infrastructure, promoting sustainable industrialisation, and fostering innovation.



UN GOAL 13 – Climate Action

A call for urgent action to combat climate change and its effects.

EVALUATION CRITERIA

Does it solve a problem?

Innovation, elaboration, uniqueness, value and usability

Moral-ethical standards

Human Dignity, awareness of environmental standards, social responsibility

Solidarity – does it strengthen group relations

Common goals and the collective, addressing social conflict

Economic calculations

Efficient use of resources, feasibility, ease of implementation, long-term perspective

Beneficial experiences

Positive experience, aesthetic potential, spatial ambience, social responsibility, comfort and pleasure

RESEARCH

CONTEXT

2060: HALFWAY TO THE END OF THE CENTURY

Within the next thirty-five years, predictions for climate consistently show worsening global conditions and an overall declining outlook for the future of the planet. Temperatures will increase, causing more rainfall, sea level rises and deforestation through droughts, flooding, wildfires and pests (*EPA, 2014*). Polluting greenhouse gas emissions will contribute to an increase in acid rain, as well as some natural processes which are accelerated by increased temperatures. This in turn will create accelerating levels of acidity in soil and groundwater reserves, which is harmful to most plant species by stunting growth and reducing water uptake.

Forests will decline as droughts and excessive rainfall ravage the landscape, causing ground conditions to worsen with erosion and lack of biodiversity (*EPA, 2014*). Some regions such as Iceland and Scotland suffer from a history of extreme weather conditions, deforestation and excessive grazing of animals, leading to a severe lack of forests. These areas are also historically volcanic. Global resource availability will decline, and manufacturing processes will become more expensive, driving up the cost of currently abundant materials like fertilisers and aggregates. Volcanic rock and ash fields are often active, barren and completely unusable, but what if we used this otherwise obsolete material for the regeneration of natural environments?

This report will initially focus on developing an airship for neutralising the effects of acidification on soils, followed by an analysis of other areas of application within agriculture, wildfires, wildlife, civilian uses and research to ensure frequent usage of the aircraft in various locations on a versatile platform. We have a responsibility to do what we can to combat the ever-changing environment caused by climate change and must innovate, research and apply new technologies and solutions to do so.

PROBLEM ONE.

Climate change, acid rain, deforestation, and ground stabilisation are interconnected problems that could be addressed by the intelligent use of common but otherwise unused materials such as alkaline volcanic rock. Warming temperatures increase rainfall, wind speeds, wildfires, erosion, and soil and water acidification, which in turn all affect the quality of forests. Plants prefer alkaline environments, and the acidification of soil will make it more difficult for plants to grow. Alkaline volcanic rock aggregate and ash are materials that could be used to neutralise soil acidity, protect from erosion, and promote the growth of forests and crops in the form of fertiliser. What would an aircraft look like that could achieve large-scale extraction, transport, and deployment of these materials over large areas with minimal infrastructure and reduced impact on the environment?

AIRSHIP FOR EXTRACTING, TRANSPORTING AND DEPLOYING ALKALINE VOLCANIC ROCK FOR NEUTRALISATION, STABILISATION AND FERTILISATION OF ACIDIC SOIL

EFFECTS OF CLIMATE CHANGE ON ACID RAIN

Although climate change and acid rain are separate problems, both share the root cause of toxic gases released alongside greenhouse gases from industrial smoke. The two are distinct but related, and acid rain has a greater effect on regions with increased industrial activity and precipitation.

A warmer atmosphere would influence the occurrence and severity of acid rain. Many of the chemical reactions that lead to the formation of acid rain are affected by accelerated by higher temperatures, suggesting that global warming is likely to increase the formation of acidic materials. Increased precipitation, cloud cover and wind will subsequently also increase the likelihood of acid rain. (*Unfccc.int, 2021*)

WHAT IS ACID RAIN?

Acid rain describes any form of precipitation that contains high levels of nitric and sulfuric acids and is caused by toxic industrial smoke containing sulphur dioxide, nitrogen oxides, and chloride. These chemical compounds break down in the atmosphere into their respective acids - sulphuric, nitric, and hydrochloric - which are deposited to earth in the form of rain, snow, mist, or solid particulates (*Unfccc.int, 2021*). Nitrogen is also emitted as ammonia (NH₃), which mainly originates from intensive livestock farming (*Sanderson et al., 2006*). Normal rain is only slightly acidic, with a pH of 5.6, while acid rain generally has a pH between 4.2 and 4.4 (*Nunez, 2019*). pH describes the Potential of Hydrogen and is the logarithmic scale used to measure acidity.

EFFECTS OF ACID RAIN ON SOIL ACIDITY, WATER ACIDITY AND FORESTS

The deposition of nitrogen and sulphur oxides into ecosystems results in increased acidity as the ammonium (NH₃) can be transformed into nitrate (NO₃) with the release of hydrogen – the chemical component defining acidity. Acid deposition is a recognised problem in Europe and North America, but there is also potential for considerable damage to ecosystems in developing countries (*Sanderson et al., 2006*). Nitrate anions can pull Calcium and Magnesium ions with them as it leaches from soils, resulting in increased acidification and reduced fertility.

Acid rain also has several harmful ecological effects on wetlands, streams, lakes and groundwater. Acid rain makes these waters more acidic, resulting in more aluminium absorption from the soil, which is carried into lakes and streams, making them toxic to aquatic animals. (*Nunez, 2019*)

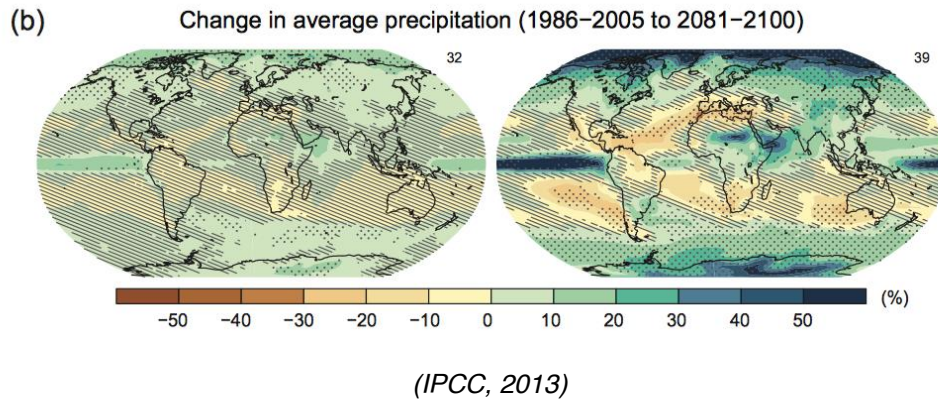
Acid rain and fog also damage forests, especially those at higher elevations. The acid deposits rob the soil of essential nutrients and release aluminium into the soil, making it hard for trees to take up water. Tree needles and leaves are also harmed by acids. The effects of acid rain, combined with other environmental stressors, leave trees and plants less healthy and more vulnerable to cold temperatures, insects, and disease, and inhibit trees' ability to reproduce (*Nunez, 2019*).

Although some soils can naturally combat acidity, in some regions where the soil's Buffering Index (the capacity to resist pH changes) is low, acid rain can have a much more harmful effect and artificial help may be required to neutralise this.

EFFECTS OF CLIMATE CHANGE ON SOIL EROSION

Soil erosion is caused by heavy rainfall, high winds and a lack of plants and root systems to create structure within the ground. Deforestation and excessive grazing of animals can leave soil exposed and vulnerable to the elements.

Projections show that future rainfall and storm changes will vary by region as some areas may have more precipitation, and some may have less or little change. However, the global average annual precipitation is projected to increase, rainfall from heavy precipitation events will increase, and storms are predicted to move farther to the poles. The average intensity of rainfall will likely increase, with events becoming more frequent, particularly in tropical and high-altitude regions. Heavy rainfall events that currently occur every one in 20 years are expected to become two to five times more frequent by 2100.



Wind strength associated with tropical storms is likely to increase, and the intensity of hurricanes will increase with rising ocean temperatures. Precipitation falling as rain rather than snow, and glacial melts will further affect higher altitude regions. (EPA, 2014)

Increases in extreme weather, high winds and rainfall increase the frequency and intensity of erosion. Plants, shrubs, and tree root systems are critical stabilisers of soil and help reduce erosion. Encouraging plant growth by increasing soil quality and alkalinity creates more stable environments less vulnerable to erosion, which will lead to reforestation and consequently an increased uptake of carbon dioxide from the atmosphere and improved air quality.

EFFECTS OF CLIMATE CHANGE ON FORESTS

Forests are an essential part of ecosystems, providing clean water and air, recreation, wildlife habitat, carbon storage, climate regulation, and a variety of forest products. Climate change has the potential to worsen many of the threats to forests, such as fires, erosion, drought, and pest outbreaks. (*climatechange.chicago.gov, n.d.*)

Climate change is expected to increase the risk of drought in certain regions and the risk of extreme precipitation, erosion and flooding in others. Many trees are adaptable to drought, but repeated temperature increases and droughts could cause exponential additional damages on top of those experienced in the past. Drought increases wildfire risk since dry trees and shrubs are faster to ignite and provide rapid fuel to fires. Drought also reduces trees' ability to produce sap, reducing their protection from invasive and destructive insects such as pine beetles.

High wind speeds and hurricanes also cause damage to forests. For example, in 2005 hurricanes Katrina and Rita damaged a total of 22km² of forest. The amount of carbon released by these trees is roughly equivalent to the total amount of carbon absorbed by all U.S. forests in a single year. (*climatechange.chicago.gov, n.d.*)

It is important that forest replanting is accelerated alongside the rate of damage caused by climate change. Addressing the root cause as well as the effects of climate change could be achieved by helping promote forest growth in areas with low forest coverage or areas with high fire risk.

REWILDING EFFORTS IN AFFECTED AREAS

Organisations such as Mossy Earth are already contributing to rewilding efforts in Iceland and Scotland, where historic deforestation, erosion and excessive grazing have altered those regions beyond self-repair. Iceland and Scotland have large deposits of alkaline volcanic rock and could be optimal locations for neutralisation and fertilisation efforts, making efficient use of local materials.

EFFECTS OF ALKALINITY ON WILDLIFE

Since wildlife depends on the growth of plants to survive, it can be assumed that encouraged plant growth creates an encouraged animal population. However, such ecosystems lie in fine balance and can easily be disturbed. If soil acidity were controlled to regulate a growing reduction of soil pH back to its natural level, it can be assumed that wildlife populations won't be negatively affected. Animal populations take a long time to adapt to changing environmental conditions, so regulating and stabilising these conditions would be beneficial to them.

VOLCANIC ROCK TYPES, ACIDITY, AND LOCATIONS

Some volcanic rock types are alkaline in makeup and are mineral rich, acting as a good substitute for fertiliser and an acidity regulator. Basaltic scoria is a volcanic rock that is formed by ejection from a volcano and cooled in the air to form grains. It is dark in colour, glassy, and full of micro-cavities which form as dissolved gases expand under lower pressure. Other alkaline types of rocks include andesite, gabbro, diorite, granodiorite, and granite, although basalt and andesite are the most commonly available in a surface-level aggregate form. The pH of basalt can range from 7 to 9.5 for dark grey dense basalt, 7 to 8.5 for reddish dense basalt, and an abrasion pH of 9 for basalt rock dust. This is due to the release of silicate ions when basalt rock dust comes into contact with water (Casarotto and Lázaro Valentin Zuquette, 2014). Volcanic cones of scoria can be left behind after eruptions, usually forming mountains with a crater at the summit. Vast surface-level scoria fields also exist – for example, the Grimsnes Volcanic Field in Iceland - and would be prime locations for extraction.

BASALT MATERIAL PROPERTIES AND USES

Basalt has excellent UV resistance, chemical resistance and insulative properties, and is currently used for protective coatings, construction and insulation. These properties can be beneficial for vegetation to protect roots from UV, cool temperatures and harmful chemicals.

Scoria is used in horticulture. Because it can hold water in its vesicles, it can improve the water-holding capacity of planting soils. When sorted to specific sizes and tightly packed, it is also effective for stabilising soil against erosion (Sigurdsson and Houghton, 2015). Basaltic Scoria is also commonly used as loose construction aggregate in Europe and the United States, as well as in the production of cinder blocks although most processes currently use concrete. All of these properties would make it an excellent material for ground stabilisation, water retention, alkalinization, and growth and protection of plants. Because of its rural and volcanic locations, it can be difficult to extract, process and transport without proper infrastructure, so an airship with on-board facilities could be suitable.

MINERAL COMPOSITION

Alkaline volcanic rocks are often mineral rich and contain high levels of large ion lithophile elements like sodium (Na), potassium (K), and lithium (Li), and their relative oxides like potassium oxide (K₂O) and sodium oxide (Na₂O)(Oup.com, 2024).

ACIDIC & ALKALINE SOIL MAKE-UP

Soil becomes acidic when there is an excess of acidic cations, like hydrogen (H⁺) and aluminium (Al³⁺), compared to alkaline cations, like calcium (Ca²⁺), magnesium (Mg²⁺), potassium (K⁺), and sodium (Na⁺)(Arnall, 2017).

FERTILISERS AND NEUTRALISING SOIL ACIDITY

Fertilisers can be organic or synthetic and come in a variety of physical forms, such as liquid, pellets and powder. Controlled-release fertilizers provide a steady supply of nutrients and can be tailored to match specific crop growth stages.

Soil acidity can be corrected easily by liming the soil or adding basic materials to neutralize the acid present. The most used and most economical liming material is agricultural limestone. The limestone is not very water-soluble, making it easy to handle – basaltic scoria would be equally so. Lime (calcium carbonate) reacts with the acidity (Hydrogen) in the soil to form carbon dioxide (CO₂) and water (H₂O)(Ball, 1998).

Shown in the table below is the amount of Lime needed to neutralise acidic soils. The Buffer Index describes the soil's ability to resist changes in pH.

Table 1. Tons of ECCE* lime needed to raise soil pH to 6.8 or 6.4

Buffer index	Lime required	
	pH 6.8	pH 6.4
>7.1	none	none
7.1	0.5	none
7.0	0.7	none
6.9	1.0	none
6.8	1.2	0.7
6.7	1.4	1.2
6.6	1.9	1.7
6.5	2.5	2.2
6.4	3.1	2.7
6.3	3.7	3.2
6.2	4.2	3.7

*Effective calcium carbonate equivalent.

Table 2. Common pH preference of field crops

Crop	pH range
Legumes	
Cowpeas, crimson clover, soybeans, vetch	5.5–7.0
Red, white, and arrowleaf clover	6.0–7.0
Alfalfa, sweet clover	6.5–7.5
Grasses	
Fescue, weeping lovegrass	4.5–7.0
Sorghum, sudan, wheat	5.5–7.0
Bermudagrass	5.7–7.0
Barley	6.5–7.0

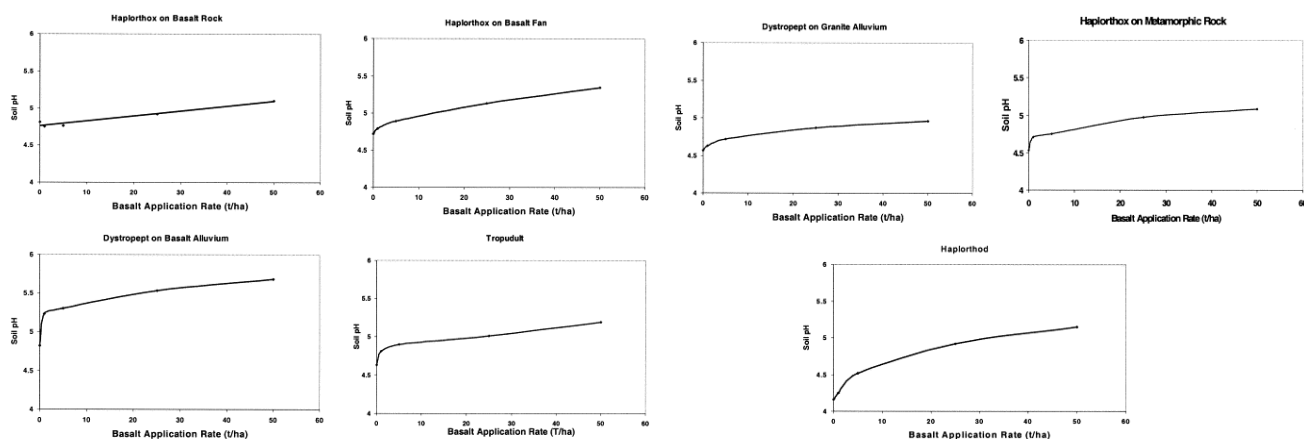
(Ball, 1998)

USING BASALT FOR NEUTRALISATION

The use of basalt dust for soil improvement is not new. Basalt rock dust has an abrasion pH of 9, therefore applying the materials to soil has a liming effect. Researchers in the 1930s successfully used basalt quarry wastes to improve degraded lands and for growing forest trees. Further research was conducted on a series of long-term field trials in Mauritius using sugarcane as the test crop. Application rates were high (up to 180 t/ha (Tonnes per Hectare)), but the effects of the increased yield of sugar continued throughout the length of the trial, indicating that a single large application could be effective over many years.

In the study, crushed basalt scoria ground to three degrees of fineness was applied to a surface sample of an Oxisol (a highly weathered and degraded soil low in minerals). With increasing rate of application, soil pH increased, and Calcium, Magnesium, and Potassium derived from the basalt also increased. The effects were more pronounced with more finely ground basalt and increased incubation time (Gillman, Burkett and Coventry, 2002).

The figure below summarizes the effects of the study. In some applications, there was a steady increase while in others an initial sharp pH increase followed by a gradual rise was observed. Application rates of about 25 t/ha were generally needed to raise soil pH above 5.



(Gillman, Burkett and Coventry, 2002)

ROCK/ASH HARVESTING AND PROCESSING

Basaltic scoria could be harvested from the air by means of excavating, sweeping or vacuuming depending on granulate size. Larger aggregates would need to be crushed to the appropriate size using machinery within the airship, or on local plants on the ground. Material could be stored either within a separate unit on the bottom of the airship or within vertical chambers on top of the processing unit.

A separate solution may be that material is gathered, processed and stored on the ground ready for pick-up and deployment. This would allow for larger-scale activity, more time spent flying and deploying and would reduce the weight of machinery on the aircraft but would require separate infrastructure which may not exist within the context of the scenario discussed so far.

APPLICATION

Fertilisers, and in this case basaltic scoria, could be applied to vegetation in a variety of physical forms, such as powder, pellets or granules. Granulation improves the properties of fertiliser by ensuring that the end product is of optimum size and shape for transport, storage and usage. Fertiliser granules are typically between 1 and 5mm, with a majority size of 2 to 4mm. This uniform size ensures even coverage and efficient, controlled leaching into the soil (*Woodroof, 2021*). This is essential in calculating specific volumes and dosages for affected acidic areas, in order to correctly neutralise the effects of acid rain and ensure optimal plant growth. Granulate and pellets must be small enough not to damage plants as they fall, but also large enough to reach the ground and successfully neutralise fertilise.

Powdered basaltic scoria released into the air could also more widely neutralise acid rain and would be an inexpensive inorganic way of introducing nutritive components that are beneficial to animals, plants and generally the environment (*Google Patents, 2004*). However, fine powder applied directly to vegetation poses the risk of smothering leaves and reducing the capabilities for photosynthesis, or a release of alkalinity that is too rapid for plants to adapt to, so deployment must be precise and calculated.

SUMMARY OF PROBLEM 1.

Climate change has had and will continue to have a damaging effect on forests through high winds and rainfall causing erosion, increased temperatures and rainfall causing acidification, and droughts causing wildfires. Alkaline volcanic rock like basaltic scoria could be used to neutralise future increases in acidification, ground stability and water retention, all in the effort of better forest health and reforestation. An airship could extract, process, transport and deploy the scoria over areas with no infrastructure to reforestation locations to neutralise acidity, fertilise and protect from erosion.

As discussed, the use of basaltic scoria as a neutraliser and fertiliser has the potential to last between several months to a year per application. Granular basaltic scoria used as a neutralizer would have a slow rate of release and a life span of 2 to 5 months. Alkaline pellets would need to be applied 2-3 times per year to combat growing acidity and retain neutral soil for optimal growing. Although the large areas of land that require regeneration would take long to completely cover with the granulate, this still leaves much time throughout the rest of the year when this vehicle isn't in use. I will now discuss other potential uses that occupy different locations and times of the year, ensuring that the aircraft can be deployed regularly, is cost-effective and resource efficient.

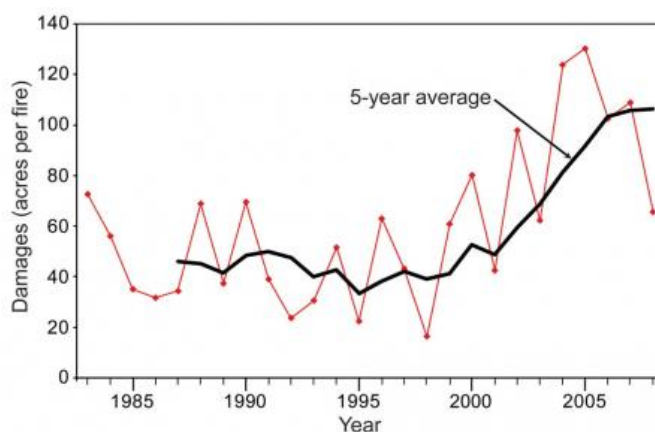
PROBLEM 2.

Wildfires are a risk that will exponentially increase with climate change and warming temperatures contributing to droughts and reducing protection from invasive pests. Wildfires release large amounts of CO₂ into the atmosphere but also produce vast quantities of alkaline wood ash which is beneficial for plant growth and soil neutralisation. How could an airship be used to reduce wildfire risk and utilise the produced materials for forests and agriculture?

AIRSHIP FOR SPOTTING, RESPONDING TO AND USING THE PRODUCTS OF WILDFIRES TO PROMOTE PLANT GROWTH.

WILDFIRES

In 2011, wildfires consumed more than 8 million acres of forest in the US, causing more than \$1.9 billion in damages. Climate change is projected to increase the extent, intensity, and frequency of wildfires in certain areas of the country. Warmer spring and summer temperatures, coupled with droughts and dry materials increase the risk of wildfire. Fires can also contribute to climate change since they can cause rapid, large releases of carbon dioxide into the atmosphere. (EPA, n.d.)



(EPA, n.d.)

Wildfires occur more frequently at certain times of the year in different regions, climates and environments. For example, the US and Australia are very prone to large wildfires in their summer months which are opposite from each other in the overall time of year. This vehicle could be deployed to both separate locations at different times to use the same resources for multiple uses in multiple areas.

Wildfires occur more frequently from May to November, with a peak in August for the US. They are more likely to occur when conditions are hot and dry. Australia is from June to May, with the peak in January or February. Seasons alternate/are opposite in those climates/regions.

This airship could be used as a mobile fire lookout, to locate and report wildfires, describe their conditions and quickly respond with on-board fire retardant. They could be stationed above high-risk locations during local wildfire seasons.

WOOD ASH

Wood ash is alkaline, so the harvesting and application of wood ash from wildfires to forests and fields would therefore counteract soil acidification and recycle nutrients removed during harvest.

SEED DISPERSION

Since Wildfires can create extremely fertile alkaline environments, there is the opportunity for the vehicle to be used for the dispersion of plant seeds over affected areas after wildfires, using the nutritious soil conditions to accelerate growth. Some extreme levels of alkaline soil can be harmful to plants, and an over-intake of minerals is damaging so the local soil acidity would need to be regulated before planting.

AGRICULTURAL USES

Similarly to using basalt dust for reforestation, this airship could be used to pick up and deploy large amounts of fertiliser across vast surfaces of land. There could be local depots of fertiliser for pickup and dispersion over large areas/multiple farms, or farms built specifically for the airship where a controlled, localised dosage can be applied to each separate field at once. There can be different dosages for each field depending on the data collected. Fertilisers are typically applied during February and March (in the UK/northern hemisphere) so the vehicle would be in use at a different time of year to the other applications being discussed.

CIVILIAN USES

OBSERVATION - WILDLIFE MONITORING

Aerial wildlife observation is needed in remote, rugged, or large-scale survey areas where it would be difficult or dangerous to survey from the ground. Aerial surveys are often used to monitor wildlife populations and behaviours to collect data that can help guide research and management policies, particularly species that are hard to observe or are spooked by the presence of humans.

Airships would be a harmless, soundless and non-destructive way of observing wildlife populations at height for an extended period of time, in person or remotely using cameras. Although they would be outclassed by drones for small-scale, short-timescale observation, drones do not have the carrying capacity for high-quality or advanced observation equipment needed for extensive surveys. They can neither observe nor track herds or packs of animals for any extended period. Airships could be used in areas where stationary airborne observation is needed but are too far from civilisation or landing areas, so a long-distance, slow-moving vehicle is optimal. Regions could include Antarctica, Patagonia, and central Africa, for the monitoring of endangered species without being intrusive to them or the environment.

Other wildlife applications could be the protection of certain endangered animals. A local unit could be stationed for their protection as well as observation, with people onboard to spot and be alert to poachers or other potential dangers.

SCIENTIFIC USES

Airships could be used for the scientific study of wildlife, geology, or biology in places that are hard to reach. Aerial observation could be used to identify oil spills, pollution and waste in the oceans, or any other task that could benefit from prolonged low-level aerial observation.

Meteorology. Although satellites and ground-level stations already provide excellent sources of data for weather predictions, low-level airborne aircraft could be used to collect meteorological data.

TOURISM

Other modes of aerial transport outclass airships for most civilian transport applications. Planes are faster, smaller and can accommodate more cargo, but need large flat areas to land and take off. Helicopters are also faster and more manoeuvrable but have a far lower passenger capacity.

Hot air balloons are a popular tourist/adventure used to travel to great heights and see the world from another perspective. However, there are some drawbacks to balloon travel, those being the method of achieving height and the uncontrolled nature of descent and travel direction since balloons are at the mercy of the wind and weather conditions.

Airships could be used to boost tourism, both in remote and populated areas. Remote locations don't commonly get much tourism but can offer unique experiences only accessible by air. Declining endangered animal populations will make ground observation more restricted and will become more valuable for people to see in the form of an aerial safari. This attraction could bring attention to declining climate/animal populations by being the only transport option available to see them. Travelling on the airship would make people aware of the difficulties facing the climate and declining animal populations.

EVACUATION/HUMANITARIAN AID

The evacuation of small to medium-sized settlements/villages in times of danger could be provided with airships as they don't need a large area to land, can carry many people, and can reach extremely rural areas, unlike planes, helicopters, or cars. They could carry medical facilities or supplies onboard for immediate treatment of patients.

SOCIAL RESPONSIBILITY

Airships could have a unique, recognisable silhouette that is recognised as a symbol of climate action. Airships are already uncommon, seeing one is rare and impactful; therefore, they carry a high potential for promoting positive messaging. The large surface area on the outside of the airship can be used for responsible branding, promoting environmental and climate-aware organisations or brands to further increase positive perception and awareness of environmental/climate issues.

People will see it as a force for good and a drive for change, looking up into the sky and knowing something is actively working to help the environment.

POTENTIAL GROUPS/ORGANISATIONS

United Nations (UN) and World Health Organisation (WHO) for humanitarian aid.

World Meteorology Organisation (WMO), United Nations Environmental Programme (UNEP), and GCOS (Global Climate Observation System) for environment and biodiversity.

World Wildlife Fund (WWF), Climate Outreach, Greenpeace, or other local organisations and charities like mossy earth.

TECHNOLOGY AND FORM FACTOR

CURRENT AIRSHIP TECHNOLOGIES

Airships currently occur as large, horizontal oblong shapes in semi-rigid and non-rigid variants with internal frames made of aluminium. The envelope is made from a lightweight compound made of polyurethane and polyester and is pressurized to give it its iconic form. Protection from UV, pollution and rupture is achieved with advanced heat sealing and a protective film called Tedlar. Ballonet airbags inside the envelope maintain the perfect shape and assist with weight distribution, while the air valve and blower allow air to be exhausted or blown when needed.

Propulsion is achieved with several engines, for example, the Goodyear GZ-20 uses two air-cooled, 6-cylinder, AVGAS-fuelled aeroplane engines that can propel the Blimp to top speeds of almost 50 miles per hour. It has rudders to steer, and elevator fins to control vertical movement. (www.goodyearblimp.com, n.d.)

LIFTING GASES

Airships use gases that are lighter than air to stay aloft, such as helium, hydrogen, or hot air. Non-flammable helium is expensive and in limited supply but is the most suitable gas for airships. It provides lower lift than hydrogen, which is the lightest element on Earth and is inexpensive and easy to obtain. However, hydrogen is highly flammable and can detonate if mixed with air. The Hindenburg, which was filled with hydrogen, was famously destroyed in an explosion in 1937.

The density of air at standard temperature and pressure is 1.28 kg/m³. Helium and Hydrogen have a lift strength of 1 kg/m³ and 1.2 kg/m³ respectively. A potential future option could be vacuum chambers, which would replace the lifting gas with a near-vacuum environment. Having no mass, the density of this body would be near to 0.00 g/L, which would theoretically be able to provide the full 1.28 kg/m³ lift potential of displaced air. Vacuum airships are a hypothetical with current technology, but in future with more advanced material and manufacturing sciences could offer a superior lifting component for airships.

PROPULSION AND BATTERIES

Propulsion would be achieved with propellers driven by electric motors and would be free to rotate for versatility of movement. Additional lift force can be provided by propellers should the vacuum chambers not be capable enough.

Lightweighting is an important factor for aircraft, so the most appropriate solution for an electricity source would be hydrogen fuel cells with liquid hydrogen. They are the most lightweight and energy-dense fuel type compared to current Lithium-ion or solid-state batteries, offering up to 33,000Wh/kg compared to 300 and 500 Wh/kg respectively (Molloy, 2019).

RECHARGING

Due to the airship being stationary throughout several stages of its hypothetical tasks, there is a possibility for directional propellers to be utilized for electricity generation by turning into the wind. The individual lifting modules could rotate above their utility unit, offering creative aesthetic solutions.

AUTONOMY

An argument could be made in favour of autonomy for this vehicle since several of its tasks require high precision, and calculation, or do not require the involvement of human guidance to be successful. However, some tasks such as scientific research and observation are unpredictable and would need human intervention. Therefore, autonomy would be controlled by each different use case and the subsequent attached module.

FORM FACTOR AND MODULARITY

Having discussed several potential uses for this vehicle, a vertical, stackable, and modular form factor would be the most applicable solution to all the outlined uses of the airship. The vertical structure would have no directionality, so would be less susceptible to high windspeeds and less obstructed when travelling into opposing or shearing wind directions like with current airships. This form factor would not get in the way of activities, structures or other large objects on the ground, and would subsequently decrease the amount of space required for landing and storing the airship. Currently, airships require very large hangars for safe storage and servicing which take up vast areas of ground space. Vertical storage would be less space intensive, and docking for prolonged periods of disuse could be similar to how rockets are stabilised with a primary tower and docking arms. Aesthetically, a vertical shape would take up less area when viewed from the ground, so would be less obtrusive to observers and wildlife.

Since this airship would have several applications across multiple types of tasks requiring different levels of resources and sizes of vehicles, it could be interesting to explore a modular approach to the design. This would utilise a vertical, stackable lifting chamber to which a unit would be attached to the bottom. Larger units would have several lifting chambers stacked side by side, while smaller units would only require one. These chambers could also be used for the transporting of materials, such as the lightweight Scoria, seeds or ash.

The lifting chambers would include the directional movement components and would be identical to save material and cost and remove the need for custom-sized lifters.

CONCLUSION

This report has demonstrated that a modular aircraft could be an innovative industrial and infrastructure solution to combat climate change and its various effects, aligning with both sustainability goals 9 and 13 of the UN. Delving into its various potential uses, it demonstrates the ability to be elaborate, unique, and provide value with its activity. It would draw attention and awareness to environmental standards, social responsibility and human dignity, strengthening group relations by providing a global solution to multiple problems and social conflicts.

An airship such as this would be feasible with current and future technology, simple to implement, and would be able to use resources efficiently to great environmental benefit. The long-term perspective of climate change and its effects is also addressed in detail.

Alongside its environmental and material uses, it could also provide a positive experience to its users through the option of comfort and pleasure and has the potential to be aesthetically interesting and unique.

DESIGN BRIEF

Design an airship with a modular and vertical form factor with one identical lifting chamber and several attachments for sustainable environmental activism in remote locations, battling deteriorating climate conditions, animal populations, wildfires, agriculture, and social needs.

Consider modularity, autonomy, propulsion, size and packaging due to lifting capacity constraints. Ensure that its form factor caters to all or most of the needs discussed.

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