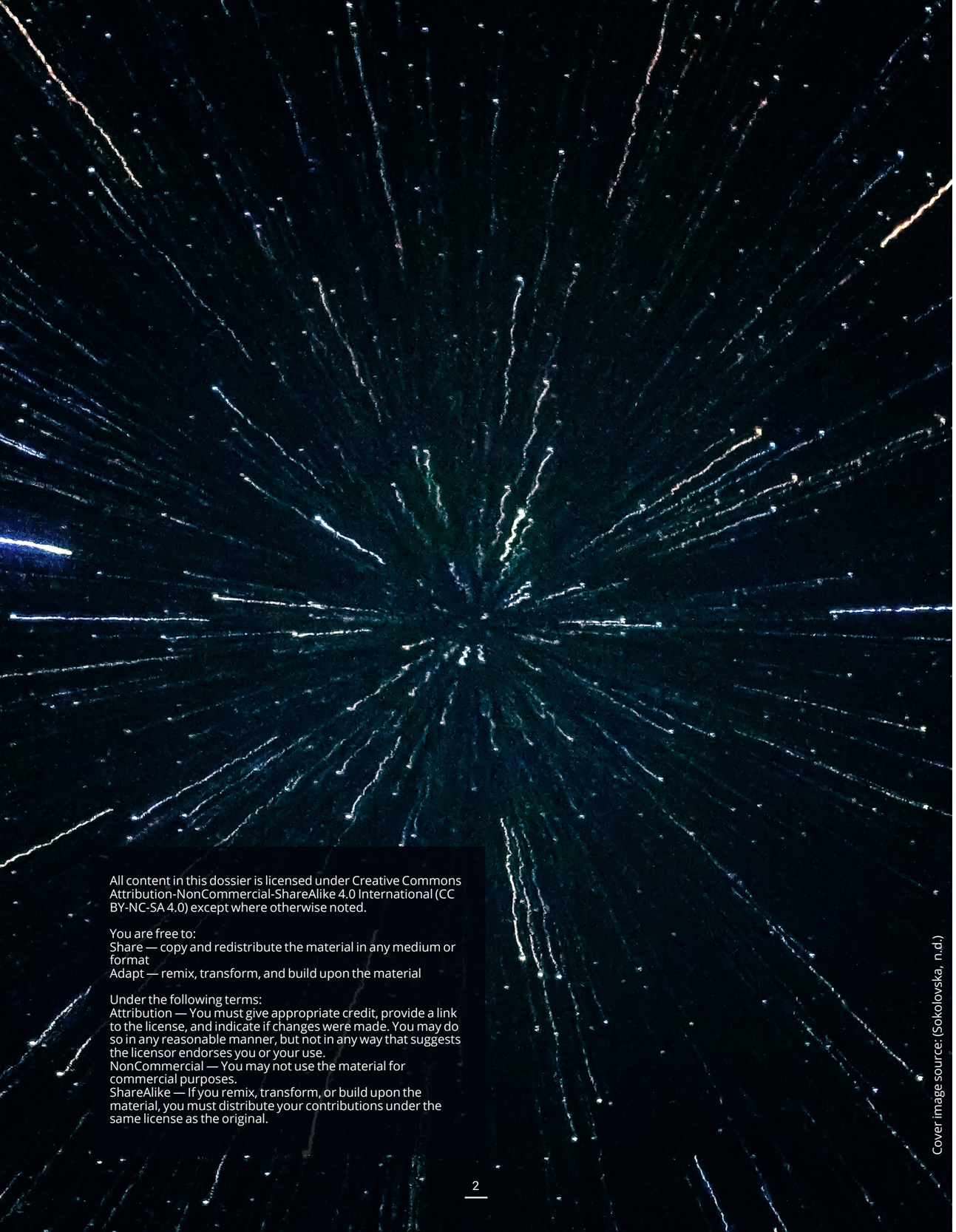
THE FUTURES OF SPACETECH

SHAUN ALFONSO, THOMAS CHANGARATHIL, SHREYA CHOPRA, VÉRONIQUE CLAUDE, & SAMAH KAMALMAZ

MDES. STRATEGIC FORESIGHT AND INNOVATION
OCAD UNIVERSITY

SFIN 6021 | FORESIGHT STUDIO
PROF. HELEN KERR & PROF. SUZANNE STEIN

SFIN 6013 | STRATEGY DEVELOPMENT
PROF. LORRAINE RANDELL



Cover image source: (Sokolovska, n.d.)

LAND ACKNOWLEDGEMENT

We pay respect to the Algonquin, the Missis-saugas of the Credit, the Haudenosaunee, the Anishinaabe, and the Huron-Wendat people, who are the traditional guardians of this land.

We acknowledge their long standing relationship with this territory, which remains unceded.

We pay respect to all Indigenous people in this region, from all nations across Canada, who call Toronto and Ottawa home.

We acknowledge the traditional knowledge keepers, both young and old.

And we honour their courageous leaders: past, present, and future.

THE AUTHORS

SHAUN ALFONSO

Interdisciplinary designer, formally trained as industrial designer, with experience in visual design. Skills and interests include product/ service design, strategic design, and branding.

THOMAS CHANGARATHIL

Technology researcher with extensive experience in data analytics, engineering, process improvement, strategy development, and communications.

SHREYA CHOPRA

Multidisciplinary designer from India passionate about decolonizing design futures in emerging tech. Skills and interests include design research, systems thinking, and strategic foresight.

VÉRONIQUE CLAUDE

Multidisciplinary designer with experience in various design methods including communication design, campaign strategy, UI and UX design, and experiential design.

SAMAH KAMALMAZ

User experience design and strategy consultant drawing on extensive experience in diverse leading design roles creating impactful architectural interiors and user interfaces.

TABLE OF CONTENTS

1.0 GLOSSARY

AUGMENTED REALITY (AR)
This technology uses camera technology to overlay digital information and graphics over real-world video/images.

ARTIFICIAL INTELLIGENCE (AI)
An academic and professional discipline that seeks to replicate the emergent property of intelligence in computer systems.

BIOENGINEERING
Systematic modification to genetics for a desired and predetermined result.

BIOTECHNOLOGY
A field synthesizing biological entities and systems with technology to develop new systems or products.

BLOCKCHAIN
Blockchain technologies work on a distributed network of computers (nodes) that store and validate transactions in a database structure called blocks. Blockchains provide a structure in blocks that make it difficult to modify without affecting all associated blocks on the blockchain.

CRISPR
A new method of genetic editing that is enabling breakthroughs in genetic modification.

DATA SCIENCE
A professional discipline that uses mathematical and statistical tools to solve machine learning problems.

DEEP LEARNING
A subset of Machine learning that uses multi-layered neural networks that can improve the performance, feasibility, and effectiveness of machine learning algorithms.

DEEP TECHNOLOGIES
Groups of technologies that develop innovative products which have paradigm-shifting effects on the industries in which they are released. Deep tech leverages advances in computing to solve previously untenable problems and challenges in a range of fields including advanced materials, artificial intelligence, biotechnology, blockchain, drones and robotics, phonetics and electronics, and quantum computing (BCG, 2019).

DIGITAL TWIN
A virtual version of a real-world artifact.

DISTRIBUTED LEDGER
A copy of the entire Bitcoin (or similar blockchain) transaction ledger that exists on all computers (nodes) on the blockchain network.

INTERNET OF THINGS (IOT)
A term referencing devices connected over the internet.

MACHINE LEARNING (ML)
A subset of artificial intelligence that uses large datasets to learn and improve performance of computer systems or associated components (such as algorithms).

MIXED REALITY (MR)
A term denoting an XR system composed of both VR and AR elements.

NEURAL NETWORKS
A series of algorithms that enable computer systems to recognize relationships in large and complex sets of data.

NON-FUNGIBLE TOKEN (NFT)
A digital asset protected in an incorruptible “token” preventing its contents from duplication and modification.

PROOF-OF-STAKE
A validation protocol where computers on a blockchain network validate smart contracts by proving the amount of a stake (Ether in the case of Ethereum contracts) they have within the contract.

PROOF-OF-WORK
A validation protocol where computers on a blockchain network solves complex mathematical problems as a means of validating transactions on a blockchain.

SMART CITIES
Cities that integrate data and IoT to support processes and decision-making within its boundaries.

SMART CONTRACT
A blockchain component through which Ethereum projects are developed and shared.

STRUCTURED QUERY LANGUAGE (SQL)
A programming language that enables data analysts to retrieve, filter, and organize data from large and complex databases.

VIRTUAL REALITY (VR)
A fully digital and immersive experience that is accessed through a headset and goggles that use optical lenses to create a fully immersive digital experience.

EXTENDED REALITY (XR)
A term inclusive of other forms of reality such as virtual readily (VR), augmented reality (AR), and mixed reality (MR).

2.0 FORESIGHT WORK

INTRODUCTION

SCANNING

SCENARIOS

INTRODUCTION

THE FUTURES OF SPACETECH

Space technology is a growing field that is just starting to seep into the private sector (Businesswire, 2021; Deloitte, 2019, MorganStanley, 2020). It was previously solely under the governments' purview because they were the only organizations with the resources and authoritative power required to launch missions with no direct commercial value. However, the downstream advancements in technology that the initial space race enabled accelerated several technology sectors. These sectors have grown over the last 60 years and have become increasingly interested in occupying space (Deloitte, 2019, MorganStanley, 2020). The commercial value is now apparent. Big Tech as an industry has developed titanic corporations and billionaires that can satisfy the immense capital requirements to venture into space. However, as we grapple with a raging climate crisis, humans priorities and opportunities on Earth loom large (IPCC, 2018; NASA, n.d.). This dossier seeks to illustrate the future worlds we might move into from today and present a set of robust strategies capable of guiding our persona organization, Gaia, into the future. We hope to enable decision-makers within Gaia to make intelligent, long-term strategic decisions and inform their values and priorities over the coming decades.

EXECUTIVE SUMMARY

This section of the dossier will review the strategic foresight process and the research and insights developed for the client, Gaia.

The foresight section highlights foresight methods of environmental and trend scanning. These trends and drivers foster rich scenarios with details and sound internal logic (world-building) that stress test organizational strategies.

The strategy section of this dossier will contain SpaceTech's analysis of Gaia as an organization and its competitive landscape. This information will feed into the strategy development and planning process and culminate by testing these strategies within the various scenario worlds during the wind tunnelling process.

Finally, we will present the implications of the wind tunnelling process as a set of robust strategic options and adapted strategies. These strategies empower Gaia to achieve its vision and maintain the agility to adapt to an uncertain future.

SCANNING

OVERVIEW

The foresight technique of scanning helps our team and client anticipate potential prospects or challenges and recognize current critical problems for future outcomes(Cuhls, 2019). Scanning involves seeking signals to identify emerging issues and trends. Our team outlines the methodologies that highlighted trends in the following section. SpaceTech's group scanning process led to exploring three key trends: climate change, accelerated technological development, and space commoditization. The signals and implications of these significant trends are examined and summarized. The key trends are followed by a brief look at a few of the relevant and supporting drivers for Gaia, including biodiversity loss, genome projects and editing, big data, AI, new blockchain applications, and reusable spacecraft.

PROCESS

Before forming SpaceTech, our team members individually researched and scanned trends relevant to the future of space. Most of these space trends pertained to technology: AI Synthesis, Avatars, Friendly Robonauts, Industrial Space Robots, and Ocean Worlds. The remaining trends address other framework categories: Earth Observation for Everyone (social), Race to Fusion (economic), Artificial Gravity (environmental), Space Race: Next-Gen (political), and Cosmic Feminism (values). The research and interest surrounding these initial trends were the catalysts for our team formation influences Gaia's trajectory.

Team SpaceTech was born based on a shared interest in the future of technological advancements and space exploration. More importantly, SpaceTech is concerned with the broader implications of these developments for humanity at large. After a thorough discussion of our early research and peer trends, SpaceTech used a collaborative and conversational method to narrow our scope to three overarching trends. Thus, SpaceTech selected increasingly affordable space travel, climate change, and rapidly evolving technology because they have far-reaching impacts on and off-world for humanity. Our team also researched relevant drivers and key supporting technologies such as AI advancements for tech development and reusable spacecraft for launch affordability. Our key trends and drivers then served as the basis for our scenario-building exercises.

	PRELIMINARY SCAN	SUPPLEMANTARY SCAN
SOCIAL		
	• Earth Observation for Everyone	• Space Leisure/Tourism • Decolonisation
TECHNOLOGICAL		
	• Industrial Space Robot • Friendly Robonauts • AI Synthesis • Avatars • Ocean Worlds	• Genetic Modification • Biomimicry • Automation • Deep Tech
ECONOMIC		
	• Race to Fusion	• Cryptocurrencies • Wealth Inequality • Space Commoditization • LEO Development
ENVIRONMENTAL		
	• Artificial Gravity	• Impacts of Climate Change • Space Trash • Pandemics and New Diseases • Water & Food Insecurity • Terraforming
POLITICAL		
	• Space Race: Next Gen	• Militarization of Space • Rise of China
VALUES		
	• Cosmic Feminism	• Diversity in STEM • Extraterrestrial Life

KEY TRENDS

CLIMATE CHANGE

Source: (Pixabay, n.d.)

Category:
Environmental

Related trends:
- Sixth extinction event
- Water insecurity

Counter trends:
- Geoengineering
- Renewable energy Nuclear fusion Electric vehicles

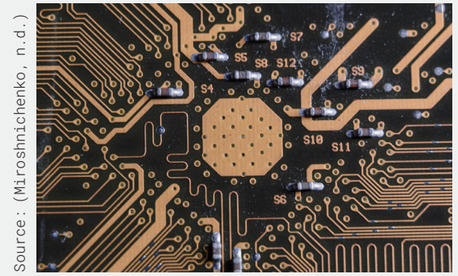
Intensifying climate changes threaten to disturb many critical systems essential for human welfare.

SIGNALS
- Record Atmospheric CO2 levels.
- Rising surface temperatures melting ice sheets (NASA, n.d.).
- 30% increase in ocean acidity (The Ocean Portal Team, 2018).

IMPLICATIONS
- Sea level rise: Sea level could rise by up to 2.5m by 2100 (Sweet et al., 2017). 200 million people would be displaced by this time.
- Food insecurity: By 2050, an extra 148-201 million people could be at risk of protein deficiency (Medek et. al, 2017).
- Health risks: There could be up to 120 more heatwave days by 2100 (Perkins-Kirkpatrick and Gibson, 2017). Higher temperatures could increase instances of malaria, dengue fever, and hemorrhagic fever.
- Economic decline: By 2050, increased concentrations of Ozone may reduce crop yields by 5% (Jaggard et. al, 2010).

EXTRAPOLATIONS
- 1.2 billion people could be displaced by 2050 (Institute for Economics & Peace, 2020).
- Political instability and conflicts: Escalating water, food, or economic insecurity may cause distressed populations to contest their governments, thereby increasing risk of civil or international conflicts (Bowles et. al, 2015).

ACCELERATING TECHNOLOGICAL DEVELOPMENT



Source: (Miroshnichenko, n.d.)

Category:
Technological/ social

Related trends:
- Hyperconnectivity
- Fourth industrial revolution
- Aautomation & robotisation

Counter trends:
- Digital divide
- Energy insecurity

The development and adoption of new digital technologies is accelerating and may catalyze further paradigm shifts in human experience.

SIGNALS
- Exponential technological growth:
  - Moore's Law and reducing costs- the historical trend that results in a doubling of computing power every two years, in tandem with declining costs of data storage and genome sequencing.
- AI & automation:
  - AI is extending into other industries such as transportation, healthcare, commerce, and manufacturing (Grand View Research, 2020).
- Advanced robotics:
  - The average cost of robots has halved in the last 30 years (Tilley, 2020).
  - There are 2.7 million industrial robots being used globally, an average of 113 per 10,000 workers worldwide (IFR, 2020).
- Big Tech and digital oligarchy:
  - Apple, Microsoft, Amazon, Alphabet (Google), and Facebook are the five largest publicly traded tech companies.
  - Big Tech platforms wield tremendous influence over internet users and their activities.

IMPLICATIONS
- Digital divide: Half of Earth lacks access to the internet and the digital economy (Luxton, 2016).
- Blockchain expansion: Business models which incorporate blockchain may shift commerce to be more decentralized and secure using smart contracts, NFTs, and digital Identities (Massey & Pawczuk, 2019).
- Cybersecurity: The impact of cyberattacks could expand as computing power and connected IoT devices grow.

EXTRAPOLATIONS
- Physical digital integration: Development of smart cities and digital twins may blur the lines between real and virtual worlds.
- Human Augmented Intelligence: According to the futurist and Google's director of engineering Ray Kurzweil, human minds may be able to link directly to cloud networks through nanobots in the 2030s or later, enabling augmented intelligence (Eugenios, 2015).

SPACE COMMODITIZATION

Source: (SpaceX, n.d.)

Category:
Economic/Political

Related trends:
- NewSpace
- Space militarization
- Space tourism

Counter trends:
- Space traffic
- Resource scarcity
- Light pollution
- Space pollution

Lower launch costs considerably expand economic, military, and scientific opportunities to utilize space (Jones, 2018, p.7).

SIGNALS

- Affordable Launch Services:
  - In 2010, the SpaceX Falcon 9 initiated a major drop in launch prices (Jones, 2018, p. 3).
  - Low-Earth orbit launch cost: NASA Space Shuttle - $54,500/kg vs SpaceX Falcon 9 - $2,720/kg (Jones, 2018, p.1).
- Private and public space partnerships:
  - In May 2020 SpaceX's Dragon spacecraft crew docked with the ISS.
- Small satellites:
  - Growing prevalence of small satellites for Earth observation, broadband internet, and communications (Lappas and Kostopoulos, 2020).
- Space tourism:
  - Suborbital: Virgin Galactic's SpaceShipTwo can reach an altitude of 90km and costs $200-250k per ticket. Blue Origin's New Shepard can reach 100km altitude.
  - Orbital: SpaceX: Japanese billionaire Yusaku Maezawa has put down a deposit for a 2023 trip to the moon.

IMPLICATIONS

- Global Space Economy: Space based industries may generate revenue over $1 trillion in 2040 compared to $350 billion today (Morgan Stanley, 2020).
- Militarization of Space: In the future, low-cost space launches may be a choice for resolving military issues (Jones, 2018, p. 8).
- In-Space Manufacturing: As the cost to launch per kilogram continues to decrease, 3D printing and manufacturing in space could be more economically feasible.
- Space debris: The risk of collisions and resulting space junk could increase with further commercialization and utilization of space (ESA, 2020).

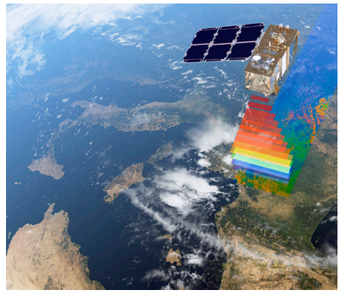
EXTRAPOLATIONS

- Space Habitats: Orbital settlements could fulfill scientific, military, and commercial value propositions and support human habitation and life support systems (Jones, 2018, p. 9).
- Mission to Mars: SpaceX is designing the Starship spacecraft and Super Heavy rocket system that could transport humans to Mars (SpaceX, n.d.).

Source: (NASA, 2019)

COSMIC FEMINISM
SOCIAL

The future of space travel is more feminist and inclusive.



Source: (ESA.ATG Medialab, n.d.)

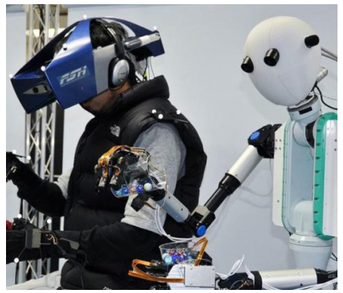
EO4E (EARTH OBSERVATIONS FOR EVERYONE) SOCIAL/ENVIRONMENTAL

Satellite Earth observations continue to become a critical source of data to address environmental and socioeconomic issues for the betterment of all humankind.

Source: (Airbus, 2020)

FRIENDLY ROBONAUTS
TECHNOLOGICAL/SOCIAL

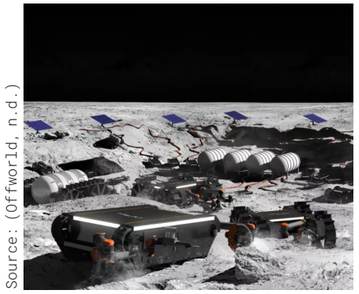
Emotionally intelligent AI to be functionally and socially part of the space crew for long term missions in space.



Source: ([Telexistence's Telesar V robot], 2018)

AVATARS
TECHNOLOGICAL

The growing possibility of remote, immersive, real-time experiencing and exploration of space, without the need for genetic engineering.



Source: (Offworld, n.d.)

INDUSTRIAL SPACE ROBOTS
TECHNOLOGICAL

The arrival of industrial space robots would be useful for gathering information about the universe and building human habitation infrastructure in space.

Source: (Offworld, n.d.)

AI SYNTHESIS
TECHNOLOGICAL

The challenge of space exploration could push humanity beyond its biological limits using advances in biotechnology, artificial intelligence, and quantum physics.

Source: (NASA/JPL-Caltech, n.d.)

OCEAN WORLDS
ENVIRONMENTAL/TECHNOLOGICAL

The moons of Jupiter (Europa, Ganymede, Callisto) and Saturn (Enceladus, Titan) may possess the conditions necessary to support life.

Source: ([Digital artwork of a rotating torus habitat], 2017)

ARTIFICIAL GRAVITY
ENVIRONMENTAL/TECHNOLOGICAL

The development of spaceships and space colonies with artificial gravity that is close to the Earth's gravity is a growing possibility.

Source: (ITER, 2021)

RACE TO FUSION
ECONOMIC

The race for fusion energy is on, with governments, scientific institutions and private enterprises investing billions into this potentially world-altering technology.

Source: (SpaceX, 2017)

SPACE RACE: NEXT GEN
POLITICAL/ECONOMIC

Satellite positioning in orbital space is becoming increasingly competitive, due to strategic advantages for both the private sector and state actors (militaries).

DRIVERS

BIODIVERSITY LOSS (ENVIRONMENT)

Habitat destruction, pollution, and overuse of resources are the main contributors to reduced biodiversity and species extinction. Lower biodiversity diminishes ecosystems' natural ability to pollinate crops, clean air, and mitigate extreme weather. Biodiversity loss also threatens food security and other ecosystem functions (Cardinale et al., 2012).

GENOME PROJECTS AND EDITING (TECHNOLOGY)

After completing the Human Genome Project (HGP), more ambitious genome projects like the EarthBioGenome Project and the Human Microbiome Project are underway. Beyond just humans, these projects aim to collect genomes from thousands of flora and fauna, including microbes. Much like the HGP, the benefits from newer genome projects are likely to be significant and worldwide. Investments in genomics have already impacted medicine, renewable energy development, food and agriculture, environmental protection, industrial biotechnology, the justice system, and national security (Lewin et al., 2018, pg 8). Genome editing enables researchers and scientists to modify organisms' DNA, which causes physical changes such as disease resistance or altered appearance (NHGRI, 2019). Compared to earlier methods, the genome modification tool, CRISPR, has made DNA editing more accessible due to ease of use, speed, and cost-effectiveness.

BIG DATA ANALYTICS (TECHNOLOGY)

Big Data analytics involves applying advanced statistical techniques to massive and complex data sets, including structured and unstructured data from various sources (IBM, n.d.). Big Data applications include data mining and visualization, machine learning, and natural language processing. Big Data analysis increases the accuracy of scientific modelling and machine intelligence.

NEW BLOCKCHAIN APPLICATIONS (TECHNOLOGY)

Blockchain technologies utilize a distributed network of computers to validate transactions or data within its database. The oldest and most successful blockchain project is Bitcoin, which uses a "distributed ledger" to validate financial transactions. Alternatively, Ethereum uses a distributed network of "smart contracts" to validate a range of applications, including financial transactions, Non-Fungible Tokens (NFTs), and digital art. The type and quantity of applications on Ethereum are growing due to its flexibility as a blockchain platform. However, its scalability issues drive developers to develop new blockchain platforms that can address this and other energy efficiency and security concerns.

REUSABLE SPACECRAFT (TECHNOLOGY)

In 1981, NASA's Space Shuttle became the first reusable spacecraft to enter orbit. However, the Shuttle launch system was only partially reusable. It failed to lower the exorbitant costs of spaceflight, leading to the cancellation of the shuttle program in 2011. The private aerospace company SpaceX successfully demonstrated a reusable rocket with the Falcon 9 in 2017. SpaceX's use of reusable spacecraft and launch systems disrupted the economics and potential applications of the space industry. According to Elon Musk, SpaceX's interplanetary reusable spacecraft, Starship, promises to revolutionize space travel even further with room for 100 people and an operational cost of approximately $2 million (Wall, 2019).

ARTIFICIAL INTELLIGENCE (TECHNOLOGY)

Artificial Intelligence is a rapidly progressing field that transforms various industries through its ability to leverage large datasets. AI is performing complex tasks and developing increasingly accurate predictions and insights due to its advanced underlying algorithms.

EXTENDED REALITY (TECHNOLOGY)

Extended Reality refers to different combinations of real and virtual environments. The X refers to different kinds of existing or future computing technologies. XR technology is disrupting many industries like education, healthcare, and space technology. NASA is currently using XR simulations to research human behaviours during acclimatization to new environments and explore stellar neighbourhoods.

SCENARIOS

OVERVIEW

Scenarios seek to illustrate the extrapolation of key trends and drivers and their implications in various dimensions, including Social, Technological, Economic, Environmental, Political, and Values (STEEP-V). Building rich scenario worlds that preserve the realism of their underlying drivers produces snapshots of possible future worlds that can test the efficacy of organizational strategies.

PROCESS

The team began with a divergent scenario generation process, guided by the Manoa Method. This process allowed the team to extrapolate the primary and secondary impacts of three main “drivers of change” relevant to this project - climate change, technological development, and commercialization of space travel. By considering the possibilities of these impacts and the “cross-impacts” between the main drivers, the team generated many potential features of a future scenario world. SpaceTech drew on Dator’s Four Futures model to consider the context of STEEP-V and additional SpaceTech categories within the four main archetypes - grow, collapse, discipline, and transform.

The next step involved converging on a distinct set of cross-impacts to build scenario worlds around. The team brainstormed scenarios to develop a unique and diverse group of worlds and cross impacts while considering the Four Future’s matrix it developed. Each preliminary story featured aspects of two main archetypes based on different STEEP-V considerations.

This divergent - convergent process enabled the team to draw upon the generative capability of the Manoa Method while bringing structure and focus to the scenarios with the Four Futures. The synthesis of four future archetypes within different categories produced rich story worlds. These worlds contain unique and diverse elements that incorporated features that would extensively test Gaia’s strategic options moving into an uncertain future.

The actual future is unknown. By incorporating aspects of many future archetypes into each world, we present Gaia with the opportunity to incorporate strategies that can work effectively in a wide range of possible futures.

MANOA

Overview
The Manoa Method was the foundation of our scenario generation process. We followed the eight-step process outlined by Shultz (2015). This process involves developing futures wheels based on three emerging drivers of change and considering the cross-impacts between secondary impacts of the wheels by creating influence maps. This process set the stage for the next phase of our scenario generation process - Dator’s Four Futures Model.

Rationale
The Manoa process offered simple but effective methods of generating creative scenarios that highlight critical features of possible future worlds informing the strategy development process.

DATOR’S FOUR FUTURES

Overview
Using the Four Futures Model allowed our team to build scenario worlds based on our influence map’s cross-impacts. These distinct worlds incorporated aspects of the grow/collapse/discipline/transform archetypes while considering the impacts of various drivers and trends. These archetypes provide the scenarios with sound internal logic while incorporating the intersections of many extrapolated trends. The transform archetype led the team to develop paradigm-shifting possibilities based on social and technological innovations.

Rationale
The four archetypes will provide broad coverage so that our wind tunnelling options add stressors specific to a given archetype.

CONE OF PLAUSIBILITY

Overview
Placing our scenario worlds within a ‘futures cone’ distinguishes the level of likelihood of each scenario world. The possible/plausible/probable/wildcard distinction orients the synthesis of key drivers, trends, and their impacts relative to their likelihood and timeline.

Rationale
This consideration will help focus strategic adaptation efforts after testing strategies during the wind tunnelling process.

PROCESS RATIONALE

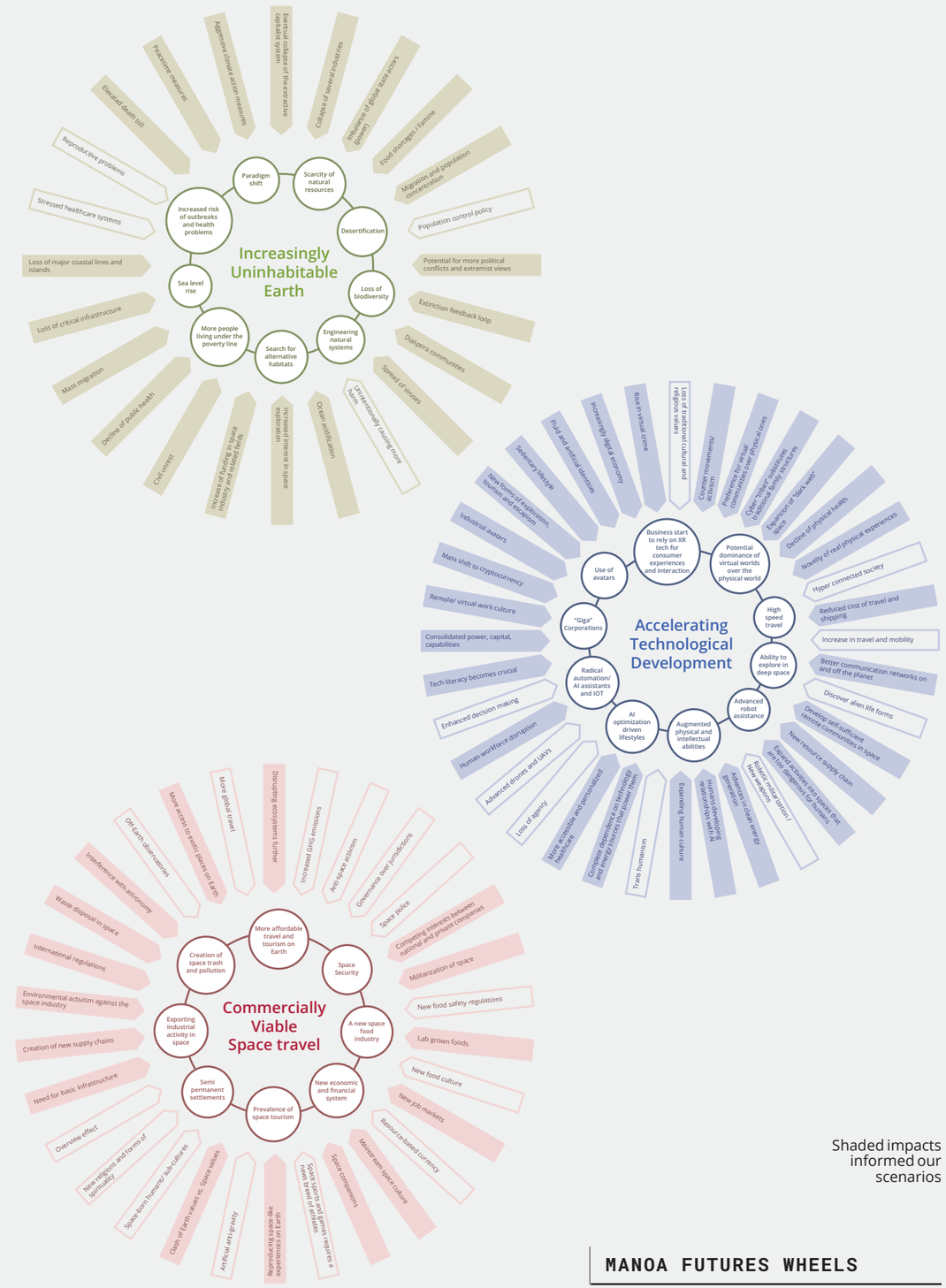
Our group selected the Manoa method because it highlights the impacts of drivers that are present in the current day. Upon reflecting on the state of space technology today, the group saw three main underlying drivers that would loom large in the coming decades. These drivers include climate change, the rate of technological development, and the commercialization of space travel. We also noticed that these three drivers and their second and third-order impacts have several interaction points that would yield leverage points and implications for the future. It was around these interaction points that we developed the ideas for our initial scenarios. We each created a broad concept for our scenario and some of the main drivers and impacts informing the scenario. Next, we used the "generic images of the future" archetype grid to refine them further. We incorporated this method to ensure a diversity of scenario "worlds," each with a consistent internal logic. The worlds we chose include growth in technology, a decline in ecological conditions, and a transformation of societal values. Finally, we shared these scenarios and discussed where they would fit within a futures cone of plausibility and each scenario's approximate time scale.

We believe the Manoa wheel made for a richer scenario generation process with support from the "generic images of the future" archetype grid. As the SpaceTech group, we were aware of the colossal impact that the direction and maturity of technological developments will have on the context of each scenario world. Furthermore, how the climate crisis plays out and its effects on our global society will also influence how technology develops. The values of the governments, individuals, and institutions in which research and development occur also impact the types of problems researchers decide to solve and the solutions they generate.

For example, a more utilitarian society would value functionality and practical usage over leisure. The types of value propositions companies would have to develop in response to this paradigm shift would focus more on their customer segment's basic needs.

Conversely, a more techno-utopian, cosmopolitan society might value luxury, experience, and entertainment. In this case, technologists must ensure that they cater to their potential users' comfort, knowing that cost would not be an issue.

Finally, the "generic images of the future" grid allowed us to develop values and conditions in the worlds in which our scenarios exist. As a group, we found our personal biases and sensibilities seeped into each of our scenarios' tones. Our group's diverse experiences and perspectives (and associated biases) generated a range of optimistic and pessimistic future conditions. Some of our scenarios offer contrasting outlooks on specific conditions such as the state of wealth inequities or technological developments at different points in time. The one consistency between all of our scenarios is the expectation of an overall decline in Earth's ecological conditions.

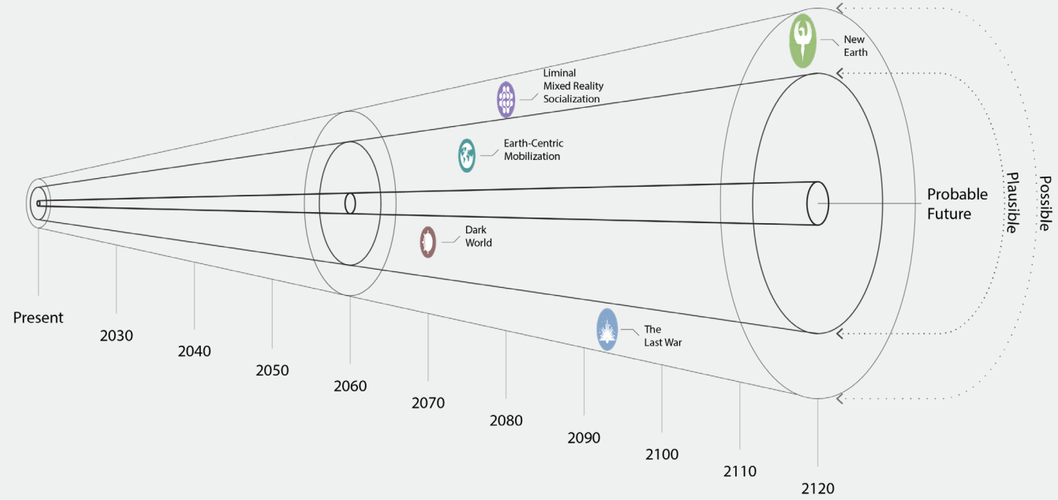


Shaded impacts informed our scenarios

MANOA FUTURES WHEELS

FUTURE PROMPTS	GROW	COLLAPSE	DISCIPLINE	TRANSFORM
Biology	Biological Magnification	Extinction	GMOs	Evolution
Economy	Tech-driven	Extreme Inequality	Controlled	Circular
Energy	Diverse	Scarce	Renewable	Infinite
Environment	Urbanization	Uninhabitable	Regulated & Utilitarian	Planetary Rejuvenation
Governance	Corporate	Anarchy	Centralized	Participatory
Health	Accessible	Palliative & Pandemics	Preventative	Regenerative & Immortal
Population	Increasing	Infertility	Restricted	Cloning
Sociocultural	Diverse	Isolation	Norms & Rules	Multiverse
Technology	Breakthroughs	Extensive Hacking	Focused	Biologically Embedded
Work	Disruption	Survival	Duty	Purpose
Space Exploration	Accelerating Growth	Earth Inc.	Government-aligned	Omnipresent

DATOR'S FUTURE ARCHETYPES



CONE OF PLAUSIBILITY

SCENARIOS & TIME MACHINES

SCENARIOS AT A GLANCE

DARK WORLD

This growth/collapse scenario explores the degradation of environmental conditions and political stability in parallel with accelerating technological development.

EARTH-CENTRIC MOBILIZATION

This discipline/transform scenario explores the possibility of humans being unable to leave earth to address climate change. A transformation of governance structures and societal values highlights this world.

LIMINAL MIXED REALITY SOCIALIZATION

This growth/transform scenario explores socialization in a technologically advanced world highlighted by paradigm-shifting technologies and transformational governance structures.

THE LAST WAR

This growth/collapse scenario explores the conditions at a flashpoint in the future when the amplified effects of runaway capitalism, technological development, and widening wealth inequality lead to war.

NEW EARTH

This collapse/transform scenario explores a world where large technology conglomerates dictate climate progress and industrial activity. The mistakes of the past loom large in this future world as its participants consider if they are doomed to repeat them.

Image source: (Mcnew & Reuters, 2019)

Timeframe:
2070's

Likelihood:
Plausible

Archetype components:
Grow/collapse

DARK WORLD

Climate change, resource depletion, and biodiversity loss have put Earth's ecological and social systems on the brink of collapse. Economic pressures derailed efforts to mitigate an unsustainable path in favour of growth. Billions of people lack food and water security due to being climate refugees. The world's poor have experienced the worst effects of climate change: sea-level rise, extreme temperatures, and livelihood loss.

Prosperous, northern countries notice the sustainability problem's severity and prioritize resource accumulation and investments in space infrastructure and exploration. There is a race for space on Earth, in orbit, and on the Moon. Nations, massive corporations and trillionaires pursue settlements beyond Earth. Terraforming Mars is the ultimate goal, but the technology and market are still nascent.

Developments in satellites and networking capabilities enable ultra-high bandwidth everywhere on Earth. For most, it's easier to access reliable internet than food or water. Unbearable temperatures force southern countries to conduct most activities indoors and remotely. Worldwide internet access enables people to pursue opportunities and leisure that are unfeasible locally.

Advances in automation, artificial intelligence and robotics have changed the nature of work. Countries start adopting a universal basic income due to the decreasing value of labour. Basic income also acts as a means to manage resource scarcity. Governments and political system failures in poorer countries have undone earlier progress towards reducing poverty. Lacking income, a social net and public safety, much of the developing world adopt remote work. Loss of confidence in governments and the rise of online virtual worlds and marketplaces has accelerated the use of cryptocurrencies.

In failed states, governance and politics have become more local and disorganized. Criminal enterprises take over smaller regions due to weak governments and corruption. Organized criminal enterprises operate at scale through encrypted and clandestine networks. The complete anonymity of the online Dark World enables a global marketplace for illicit drugs, crypto fraud, counterfeits goods, gambling, and sex work. The mental, physical and economic anguish of climate refugees leads them to these more desperate income sources. The infinite opportunities offered by online worlds versus resource-limited local regions propels further integration in online communities. All of this increased computing power, networking capabilities, and dependence on crypto usage places growing demand on energy grids.

Political instability and the more significant threat of nuclear attacks impedes nuclear adoption. Renewable power expands in adoption and spread, especially solar. Newly inhospitable lands provide large vacant areas for solar panels and wind turbines. However, energy storage remains an underfunded industry as battery technologies have not sufficiently revolutionized. Most forms of mass transport and travel by sea and air remain fossil fuel-based. Rare earth mineral shortages also impact the proliferation of higher capacity batteries.

As biodiversity rapidly declines, there is a race to capture the remaining DNA and genetic data of flora and fauna. Genetic modification and biomimicry techniques have heightened demand for the remaining plants and animals. Both resources and organisms are traded illegally in the Dark World. The ban on wet markets due to disease transmission risk has also unintentionally skyrocketed exotic wildlife prices.

Most regular people conduct their interactions and activities online due to environmental hazards, crime and poor infrastructure in the real world. Wealthier populations access more hospitable regions and climate-controlled superstructures that are heavily secured.

Fortunately, ubiquitous broadband and mature XR technology allow most people to socialize seamlessly and remotely, giving the illusion of physical presence online and in-person. Mass migrations and greater emphasis on remote relationships expand familial bonds and friendship structures. The growth of virtual avatars, human augmentation, and artificial personas broaden societal norms to be more open to designer identities and human/AI relationships.

KEY TRENDS, DRIVERS & IMPLICATIONS

Climate Change: Food and water security plague many countries due to several crises;

loss of lakes, rivers, groundwater, soil erosion, peak phosphorus, and lack of high-quality fertilizer. The rapid decline of biodiversity creates cascading effects in other processes that humans critically depend on - pollination, flood mitigation, fisheries, and pest control.

Political Instability: There is a lack of transparency and loss of citizen rights in many lower-income nations. Low-income groups are at the mercy of their corrupt governments due to subsistence payments. Throughout the latter half of the 21st century, there has been continual political and social collapse due to climate pressures. Significant international conflict arises due to energy, food and water scarcity. Affluent countries and individuals are scrambling to accumulate the remaining critical natural resources, reigniting neo-colonist projects and missions overseas.

Technological Development: Computing, communications and network technology have progressed significantly despite environmental failures. There has been innovation in energy use and production but continued reliance on fossil fuels for flights and shipping. Massive corporations possess more power than some nations. These entities push the pace of innovation and product research and development in space exploration and settlements. Blockchain utility is essential in virtual markets, but due to its reliance on electrical grids, its associated carbon footprint looms large. The rise of sedentary lifestyles drives declines in public health, intensifying the harms caused by pollution and malnutrition.

Economic Pressure: There is rampant inequality, especially in southern nations, as inhospitable temperatures and the environmental decline have eliminated critical industries like agriculture and fishing. Land in more temperate northern regions is highly sought after for residential purposes. The financial markets are unstable due to on-going supply chain interruptions creating significant volatility and inflation. In unstable nations, resource scarcity catalyzes rampant theft locally and online.

Implications for the future of space technology development: The increasing concern for the long-term survival of human civilization will lead nations towards building backup colonies and genetic data vaults on the moon and eventually Mars. Resource scarcity may fuel both the militarization of space and the pursuit of non-terrestrial resources. Technological advances are widening the inequalities between individuals and nations. Those with the latest XR technology can remotely explore and work in remote areas of Earth and space. Similarly, development in asteroid mining could boost the economies of space-faring nations. Lastly, due to cascading financial crises and lack of opportunities, skilled labourers from developing nations may pursue some of the most dangerous and life-threatening jobs in space.

TIME MACHINE

Artifact Description

Economic and growth issues thwarted efforts to avert an unsustainable route. As a result of being climate refugees, billions of people lack access to food and water. The nature of work has changed due to advances in automation, artificial intelligence, and robotics. The ultimate goal is to terraform Mars, but the technology and market are still in their infancy.

There is a race to capture the remaining DNA and genetic data of flora and fauna as biodiversity declines. The demand for surviving plants and animals has increased as a result of genetic modification and biomimicry methods. On darknets and the virtual underground, both resources and species are illegally traded.

Real-Time Globe

In this photo, Obie Garba uses a holographic display and extended reality interface to communicate with his family and manage his work duties. He primarily uses the real-time digital model of the Earth to map his route to a national wildlife preservation park. On the 3D map, we can see Obie is leaving Abuja, Nigeria and heading southeast towards central Africa. Using satellites and advanced drones, Obie can monitor endangered species such as black rhinos in real-time.

On the map, we can see warnings of extreme heat and drought. These intense weather events occur more frequently as the planet has significantly warmed due to greenhouse gas emissions. Despite the concurrent global crises of climate change, wealth disparity and resource scarcity, digital technology has continued to progress unimpeded. Remote communications and surveillance are essential tools and services for navigating this treacherous world.

Obie's wife and daughters are virtually in the background of the scene. They seek to maintain a close bond and daily interactions with their husband and father despite him being on the other side of the world. Ubiquitous ultra-high-speed networks and mature XR technology enable remote presence and conferencing almost anywhere on the planet.

Obie's map data reveals that climate change effects will render former population centers inhospitable due to desertification and soil erosion. The warning of raiders in the region demonstrates that legal and political authorities have collapsed under the weight of ecological and socioeconomic stress. Foraging bands and organized criminal activity shows a lack of development opportunities and financial collapse in vulnerable regions.

REAL-TIME GLOBE

Image source: ([AI Space Factory website's homepage header depicting their 3D printed habitat concept], n.d.)

Timeframe:
2070's

Likelihood:
Plausible

Archetype components:
Discipline/
transform

EARTH-CENTRIC MOBILIZATION

Climate change reached a tipping point in this future world. Each region is experiencing the effects of an increasingly hostile Earth differently. Extreme heat, forest fires, and droughts ravage southern regions near the equator. Coastal regions experience severe storms, earthquakes, mudslides, and flooding. The loss of biodiversity due to species being unable to adapt to rapid changes has drastically affected how we grow and produce food. In this world, countries with a geographical advantage combined with advanced technological resources have fared the best, but not without its share of loss in human lives, infrastructure destruction, and ecological degradation. Populations living in developing countries or located in heat or flood zones have either been forced to evacuate indefinitely or have perished. Every organization, corporation, and business that survived was able to do so because they quickly pivoted and mobilized to align with the Primary Mission: protecting life on Earth.

An accelerating rate of technological advancements, driven mainly by techno-nationalism and a race to commercialize space, led up to this future. While these conditions were conducive to innovation in all sectors, competing priorities and national interests led to a lack of coordination in the fight against climate change. Advanced technology allowed humans to become better at monitoring and predicting weather patterns. So, when it became apparent that humans could no longer reverse climate change, society started to adapt.

The harshness of mother nature does not account for social constructs in this world. Traditional notions around countries, borders, and nationalist interests would fade as new flexible borders around safe-zones and host-regions emerge. Small frontier habitats would also exist on the Moon and Mars, working towards growing self-sustaining communities. Climate change would force the previous capitalist construct into a gale of creative destruction. Society would have generally adopted a new techno-ecological worldview under which the previous extractive capitalist system would be replaced by a natural capitalist system.

This natural capitalist system functions around the Primary Mission. All of Earth's ecological problems have significantly increased the value propositions of any groups or individuals addressing the Primary Mission. Consumption and consumerism no longer drive the economy, as ecological damage from the past several generations have shifted this remaining human society's collective values towards regenerative practices, preservation, and decentralized sharing economies. They would use their collective knowledge and technology to balance fear with mission-driven discipline and productivity - aimed at survival and regeneration.

Technology paired with new incentive systems, values, and policy would keep regional markets working within planetary boundaries. Central governance councils would be responsible for defining, uniformalizing, and institutionalizing targets and measures of success aimed at maximizing natural capital output with the goal of regenerating Earth's ecosystems. Each region would monitor their ecosystems closely and update their progress with the council. Development on and off-Earth would align with the Primary Mission and supporting technologies would garner the majority of investment capital.

The space industry sets a precedent for Earth-based workforces as autonomous robots would principally execute manual labour in all sectors with human technicians and operators supervising. Meanwhile, humans would be busy interpreting data and developing new technologies to move us forward on our common goals. This society focuses its training efforts on critical tasks ensuring social welfare, disaster mitigation, infrastructure and sustainable resource management, and most importantly, efforts to regenerate regional ecologies. Space-tech plays a central role in developing and supporting Earth-centric missions by:

- Creating new self-sustaining cities.
- Developing robust communication networks.
- Establishing renewable energy grids.
- Studying and monitoring climate patterns.
- Developing and deploying fleets of land remediation bots.

Life on Earth would increasingly mirror frontier habitats on the Moon and Mars, with humans and artificial intelligence working synchronously to create self-sustaining habitats. Society would be under strict population control and distributed proportionally in designated international host-regions, located above sea level, mainly in northern geographic regions. Existing cities would be adapted for density, rendering living spaces compact and utilitarian. New communities would be constructed- nestled underground, in excavated mountains, or on elevated dome-sheltered platforms, to protect against harsh climates.

This society trains its members to be disciplined and cooperative, rallied under a Primary Mission, to adapt to living under constant threat. But this type of stress is not sustainable, which is why health and wellness would become increasingly important to factor into daily activities. This aspect is also paramount to keeping peace and order. Thanks to technology, a new work-leisure balance would become the norm. Health systems would closely monitor people's biological vitals, and key indicators would prescribe leisure regimens. XR experiences would become the main tool to facilitate leisure activities when access to outdoor space is limited.

KEY TRENDS, DRIVERS & IMPLICATIONS

Climate Change: Its consequences, having reached a critical point, could provoke the current capitalist system to collapse.

Activist movements: Climate activist movements are growing as a response to reckless human behaviour. With extractive practices continuing beyond planetary boundaries and being potentially diverted off-world, these movements could expand to drive a transformational paradigm shift towards an ecological worldview.

Techno-nationalism: Techno-nationalism could be defined as a race between nations to amass technological prowess and use it as an instrument of geopolitical power. This competitive power dynamic promotes accelerated growth in all technology sectors, including AI, robotics, orbital communications, energy, space travel, XR, and health. These advancements could also give humans the tools to adapt to a changing environment.

Space Tech legacy: Space research and development has a long tradition of informing human understanding of the planet and contributing to our socio-technical evolution. Moreover, many technologies developed for space continue to have practical applications for life on Earth.

Implications for the future of space technology development: The space industry could be mobilized to help develop and support missions aimed at monitoring, mitigating, rebuilding and regenerating our planet. New policy could compel this industry to change its sourcing and manufacturing practices and shift its R&D priorities towards more earth-centric applications. Furthermore, environmental degradation could have impacts on critical infrastructure supporting industry development on and off the planet.

TIME MACHINE

Artifact Description

Welcome to the Earth-Centric Mobilization world. In this future world, climate change has reached a tipping point. Society would have generally adopted a new techno-ecological worldview. A natural capitalist system would replace the previous extractive capitalist system. Every organization, corporation, and business that survived did so because they quickly pivoted and mobilized to align with the Primary Mission: protecting and regenerating life on Earth. In this world, sophisticated ecosystem maps are generated using biological samples collected by specialized micro drones. These maps are analyzed and used to determine appropriate regeneration strategies.

ERTF Mapping

The humble time machine drops you off in the year 2078, where you will find Ridley, a junior biologist and member of the Earth Regeneration Task Force (ERTF). She is onboard a high-speed hovercraft headed towards Barren Valley on a field assignment to collect ecological data that will be processed into a map. Ridley will then use this map to generate remediation strategies suited to the bio-region's environmental context.

Upon arrival, Ridley receives coordinates from headquarters in her earpiece. She treks a few miles before reaching her destination. Ridley sets down her gear and pulls a latch from her backpack, which immediately inflates into a small dome-shelter. She then opens her briefcase to reveal a portable lab equipped with a laptop and holding case filled with dozens of insect-like micro field drones. Ridley types in a few commands on the laptop and activates the drones. These specialized drones collect samples and transmit biological data remotely. They work together, optimized for canvassing vast regions in relatively little time. Ridley steps outside the shelter to deploy the drones. They swarm into the distance and disperse to begin their work. Meanwhile, Ridley monitors their progress on her laptop, receiving real-time visualized data on a detailed map. Once the drones have returned, Ridley processes the final map and transmits it to HQ. From there, senior biologists run the map data through software that generates tailored regeneration strategies. The project team would then review these before developing an action plan. Mission accomplished. Ridley receives confirmation that she can pack up and wait for the hovercraft's arrival at the original drop-off location.

ERTF MAP

Image source: (Pazani, 2018)

Timeframe:
2080's

Likelihood:
Possible

Archetype components:
Grow/transform

LIMINAL MIXED REALITY SOCIALIZATION

In 2080, we are living in a hyper-tech age. Society is highly globalized due to new XR (AR and VR) variations based on social media, and citizens are more aware and participative. All nations have faced the brunt of the climate crisis due to pollution and mindless exploitation of resources. An era of deep reflection nudges human communities towards a new normal of living frugally and sustainably. Meanwhile, people mostly live their lives in XR for both recreational and vocational purposes. This society has established luxury sub-orbital colonies for vacations, and Mars has small settlements for human and robot scientists. Virtual social worlds are inhabited not just by humans but also by artificially intelligent robots that may or may not exist in physical form. For example, one of the successors of the Mars Perseverance Rover was both artificially and emotionally intelligent. Some people could have intellectual conversations with it through a variety of social XR platforms.

Socialization in the hyper-tech age is almost entirely on virtual platforms. People meet, live and work in the digital intersections of XR and AI. These worlds include humans, AI beings, and digital pets (including avatars of extinct species or entirely new creations

stemming from the human mind's creativity). New cyber-tribes, religions, and cults have emerged. Indigenous and marginalized groups now have a strong voice in society. There has been significant progress in gender and ethnic diversity in STEM fields, allowing for more meaningful and holistic progress in science, technology and economies.

XR, the Internet of Things (IoT), and AI-powered technology such as artificial assistants, robots, cars, factories, and services have become ubiquitous. A specific class of intelligent AI (like Sophia the robot) has rights, citizenship, and laws across different nations. The gender dynamics, societal beliefs, and culture of individual nations also impact these rights. The way people interact with technology has changed significantly, as interactions shifted from touch to implantable brain-machine interfaces and contactless gesture control systems (Neuralink's descendants).

A highly-skilled human and robot population established a small settlement on Mars. The night sky gives sight to a lot of space debris and satellites. "Interplanetary families" now exist, and regular communication between civilians of both planets is standard. There is a reduction in travel and tourism on Earth due to environmental and commercial reasons and consequently more focus on providing novel commercial XR experiences.

The climate crisis is more evident than ever before. Consequently, the need for survival and the need for socialization of the human race in this crisis is one of the critical drivers of this society's innovation. There is a scarcity of water and arable land in an increasing number of places across nations. Research in technologies for the artificial provision of clean air and water on Earth receives a growing amount of attention and investment.

Governance is more participatory, decentralized, and democratic. Several futurists believe that democratic socialism represents the future of global governance. The participatory government creates incentives to encourage citizens to adopt more sustainable practices like mandatory rainwater harvesting, subsidies for solar panels, limits to water pressure and supply, and subsidies for lab-grown meat. As the economy is highly digitized, cybercrime and privacy laws are more robust, with more dedicated teams to tackle complex challenges.

Advancements in medical technology and AI-augmented healthcare have made health systems more resilient to unexpected situations like pandemics. Telehealth is easily accessible to all, and the quality of mental health services have vastly improved. Advanced body augmentation is technologically and medically viable for people with disabilities and those looking to enhance their human capabilities in both digital and physical realms.

KEY TRENDS, DRIVERS & IMPLICATIONS

XR technology includes augmented reality, virtual reality and mixed reality. The XR devices of the future will consist of more personalized experiences and be accessible to broader populations. As technology advances, XR experiences will be more realistic and immersive. Artificial Intelligence (AI) will act as a prominent driver in every industry as its synthesis with Big Data, the Internet of Things (IoT), and robotics impact: media, healthcare, manufacturing, education, customer services, transportation, and space travel. AI can benefit humanity

if appropriately and ethically implemented. For example, by designing AIs against race and gender bias. Technology for emotionally intelligent AI is also emerging, showing the possibility of new kinds of relationships with technology explored in the future.

Climate change will make most of Earth uninhabitable. An escape to XR will enable human creativity to flourish- creating new worlds or reviving old ones. These include virtual national parks with extinct animals and flora. The major drivers for innovation globally would be goals such as more sustainable futures and making communities more resilient to climate change challenges by uniting them together instead of dividing them.

These developments would greatly impact the space industry. Remotely accessing real-time viewpoints on Mars for vicarious space travel experiences in XR will be possible. Before there is a human colony on Mars, there will be intelligent robot colonies. Exploring Mars with XR and working together with the robots present could be a genuine possibility. More space missions involving AI robots will be deployed either as emotionally intelligent crewmates for the astronauts or on solo missions. The ways humans will socialize and work will become much more immersive through developments in XR. They will have both real humans and AI bots as inhabitants, interacting and learning from each other. Social media XR platforms will be the liminal spaces connecting all humanity in different forms across celestial bodies in space.

TIME MACHINE

Artifact Description

At a technological epoch and constant environmental hazards, humans now live most of their lives in immersive media and mixed reality. Hence finding new visions for humanity's future is the next frontier and discourse of excitement in popular culture. New forms of socialization and communication emerge. Meanwhile, the Dark Energy Spectroscopic Instrument (DESI) has mapped the entire observable universe. Data from DESI enables a complete, open-source 3D map of space.

Cosmic Traveller

A social media and space exploration platform where people can explore space virtually and share new paths and maps. Users can come to the map's VR space and make studies, explore connections, and derive new insights for research and exploration purposes. These paths and discoveries are open for public commentary. Users can upvote paths to become viral or popular, prompting more visitors to access these virtual spaces. Cosmic Traveller also supports user-generated XR games, movies, and environments on its platform.

Cosmic Traveller is very transparent about the path-building process and notifies users if a VR space they are viewing is under development. The company acknowledges inaccuracies and invites users to suggest discoveries or corrections to the map. Cosmic Traveller enables this co-creative process with its users with partnerships and plugins from Minecraft.

AI bots act as tour guides in popular locations such as the Moon and Mars. Based on interactions with experts and visitors, these bots will learn and become more knowledgeable. Some Earth-based nations have added geofencing to areas in space which they claim as part of their national strategic interests. Visiting these VR spaces now requires a digital passport to access the platform.

COSMIC TRAVELLER

Timeframe:
2090's

Likelihood:
Possible

Archetype components:
Growth/collapse

Image source: ([HAVOC Venus Airship Concept], n.d.)

THE LAST WAR

The seeds of conflict are beginning to germinate as governments worldwide grapple with the effects of a raging climate crisis while trying to maintain order in a drastically inequitable society. Technology is both keeping the fabric of society together and one of the forces ripping it apart. Big Tech has exponentially grown since its first post-pandemic boom and dominates the global economy. Alphabet and Amazon both exert more geopolitical power than most nations due to their economic positioning, value as job-creators, incredible scale, and advanced quantum AI. Both companies own several subsidiaries, including Google, SpaceX, Tesla, Blue Origin, and Uber. Both exert significant presence in space - due to their partnership with the United States government and, specifically, the Department of Defence (of which NASA is now a part). With the help of their multinational partnerships, the US controls orbital space much like they controlled global shipping lanes between the late-20th and early-21st century.

On Earth, waves of populism have resulted in several uprisings and failed coup attempts in many developed nations. And as the disparity between the wealthy (now almost entirely technology-driven) class and the rest of the world increases, the growing tension between Nationalists (nation-focused former "working-class") and Globalists (space-focused techno-class) brew within and across borders. It seems that the threads that held nations together

(culture, language, etc.) are now a relic that only Nationalists uphold. A new ideological and tech-centric culture has emerged with the wealth and prosperity of the Globalists.

The driving forces of climate change, wealth inequities, and technological advancement have finally clashed as the global economic order collapses. Entire nations go bankrupt and struggle to maintain order. The US soon enters a state of hyperinflation wherein its dollar becomes severely devalued. Big Tech is the sole entity on Earth that profited from the collapse, and its "partnership" with the US has become more like an acquisition as they formed the Alphazon-USA Coalition (AUSAC).

As the resources on Earth begin to fade, the techno-class - a group of wealthy knowledge workers and tech owners - can abandon their homelands in favour of advanced Space Living Capsules (SLCs) provided by Amazon and Google. These SLCs are modular and combine to form larger self-sustaining colonies anywhere on Earth (including oceans) and space.

For people outside of the technology industry, the collapse was devastating. For years preceding the crash, they had been increasingly dependent on the government's Universal Basic Income. However, when hyperinflation devalued their currency, they had no assets, no more income sources, and droves of worthless digital USD coins. The economic collapse was a breaking point for these folks, many of whom were actively engaged in populists movements that regularly arose around the world. These populist movements fragmented into bands of guerilla-style hunting parties which sought to live off scarce resources and "take" what they could through violence. These groups posed no real threat to the Big Tech - US coalition until they began organizing by reviving defunct Ham radios and communicating outside of Big Tech's purview. They were able to form a significant militia and covertly partnered with recently-fallen nuclear powers. This new partnership enabled the Nationalist militia to deliver an unexpected blow to a floating Google server farm, which wiped out all their services for a whole week. Nationalists followed this up by locating and raiding several SLC colonies and killing hundreds of innocent Globalists.

The Dark Week - as the Globalists called it - was a setback for AUSAC. However, they were back up after a week and determined to complete their transition to a fully space-based, multi-planetary civilization. But first, they had to wipe out the remaining Nationalist Militias to ensure no further setbacks occur. The Last War had begun...

KEY TRENDS, DRIVERS & IMPLICATIONS

Climate change is driving the trend of escalating political instability due to resource scarcity. Growing climate migration agitates rising populism within developed nations which further drives civil unrest. The middle class' decline in socio-economic power also impacts this unrest as increasing wealth inequities drive the consolidation of power towards a small minority.

Economic insecurity is further entrenching inequities between and within developing and developed nations. Increasing public debt in developed nations and inflationary practices are reducing the purchasing power of national fiat currency. Wealth is becoming concentrated as the economic barrier to becoming an asset owner rises. Wages have stagnated relative to inflation, so the middle class cannot "catch up" to afford skyrocketing housing and post-

secondary education costs. These enormous costs drive many to rely on debt financing. This debt makes banks wealthier as they collect interest payments. However, the increased risk of defaults adds risk and volatility to the market and makes for economic instability.

Low operating costs relative to their scale, large amounts of capital, and exponentially increasing computing power reinforce Big Tech stakeholders' growth and influence. The private sector can travel to space at a fraction of the cost that governments can. Their immense resource capabilities, specifically concerning knowledge workers in R&D, enable them to progress on projects much faster than governments.

The above drivers within this scenario affect the space technology domain by showcasing the possible ramifications of unbridled growth and development in technology, concentrated wealth, economic instability, and climate change. Actors in this domain should remain mindful that their actions in space should benefit humanity and add value to humans living on Earth. StarLink (space-based broadband internet), from SpaceX, is an example of one such dual-benefit application of cutting-edge technology. Big Tech stakeholders moving into space should be cognizant of the unintended consequences of some of their grand ambitions on Earth (ex. social media misinformation).

TIME MACHINE

Artifact Description

Welcome to the world of The Last War. Today you'll be taking a trip with me to 2093 where the wealth disparities, polarization, and technological growth that dominated the early 21st century have accelerated to unprecedented levels. The techno-utopic Globalists and the nomadic Nationalists live in two different, clashing worlds within and around the same planet. The concept of maps as a reflection of their values and priorities aptly highlights the contrast between these two populations.

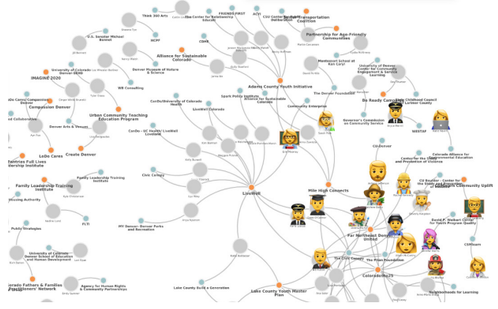
MindMap

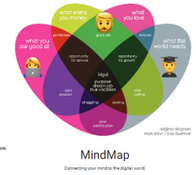
Context: For Globalists, "IRL maps," as they call it, are an antiquated form of spatial reference. Since much of their lives occur in modular units, or remote space stations, knowing where to go physically is irrelevant. Instead, they map out where their minds or interests go. These maps enable users to share the thematic location of their minds. A neural-link device tracks your thoughts, categorizes them, and shares them on the MindMap platform. Users can find and connect with like-minded communities by navigating through MindMap.

MindMap is a global subsidiary of Alphabet, which leverages its company Google's AI expertise to encode one's thoughts and perceptions into data used to support the MindMap platform. Advertisers also pay trillions of dollars to access these data and take a peek inside their customers' minds to "better serve" their needs.

MindMap's "ikigai" function uses biological data and live-encoded brainwave data to orient one's actions, thoughts, or work relative to one's most profound reasons for being. This tool helps many Globalists, who live and work in isolation, with the endless possibilities of

the virtual world, find purpose in their lives. Google uses their advanced AI to find insights from the biological and live-thought data. These insights are immediately shared with the end-user and compiled by Google to predict potential future opportunities to mobilize purpose-driven employees in ventures that support Google's mission.





MIND MAP

Great-great grandfather's Map

Context: These maps are utilitarian, but hold historic and sentimental value as connections to their users' familial roots.

Nationalist squad leader X-90 keeps his cherished map close by as a survival tool and to remain connected to his roots. This particular map is a family heirloom that his father gifted him before the Great Collapse. It was a map of their local terrain, hand-drawn by his grandfather as part of a scouting mission during WW2. The rough terrain, largely untouched by humans, especially after the Second World War, enabled the Nationalists to survive off the land in small settlements. X-90's map helps his squad find the best locations to trap food and get some rest. Since it's a physical map, it remains entirely out of Globalists' purview, so maps like these and paper-based mapping and communications are a thriving medium within Nationalist militias. These maps are crucial to mission-planning, sharing intel, and navigating. X-90's map was especially significant since it helped him coordinate the first of many attacks on Globalist modular colonies that were land or sea-based.

GREAT-GREAT GRANDFATHER'S MAP

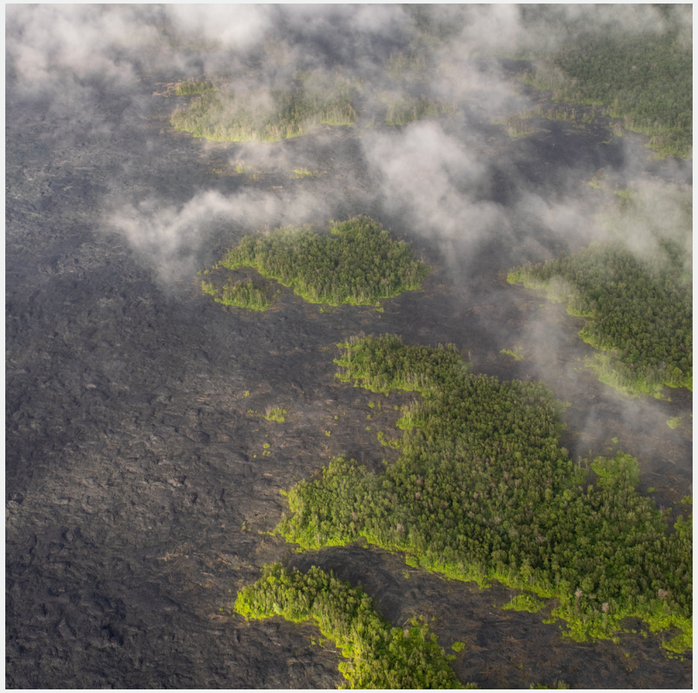


Image source: (Wallstabe, n.d.)

Timeframe:
2120's

Likelihood:
Possible + wild card

Archetype components:
Collapse/transform

NEW EARTH

Climate change has resulted in irreversible damage to the global ecosystem. Rising sea levels have submerged whole cities. Large portions of land are infertile and uninhabitable. Diseases and famine have wiped out a large number of the world's population. Historically thriving regions are now abandoned ruins - except for a few wealthy and technologically-advanced metropolises.

The current global population includes the surviving inhabitants of abandoned cities and those living in large metropolitan areas. Some of the former inhabitants of abandoned cities managed to migrate and integrate into the metropolises' social fabric. Others formed nomadic tribes roaming the outskirts- aided by technology salvaged or traded with metropolises. The metropolitan populations have managed to survive during the global climate crisis, but their lives have significantly evolved. Although metropolises used to enable techno-utopian lives, they sourced their critical resources (energy and raw materials) from lands now impoverished by drought. Moreover, the influx of climate refugees has exacerbated a resource shortage. Although everyone contributed to the global climate crisis, large metropolises were the most significant contributor. However, their inhabitants were also the least affected by its devastating consequences. It is for this reason that nomadic survivors resent metropolitan survivors.

Research and development institutions spent many difficult years developing alternatives for the lost natural and human resources. While the crisis interrupted developments in leisure and entertainment technology, the need for survival accelerated development in other technological sectors.

Photography, video footage, 3D renderings, virtual reality environments, and gene synthesis have partially digitized the state of Earth before the climate crisis. These data have been synthesized into a global vision, an ideal future of Earth: The Lost Paradise.

Mega technology conglomerates control booming economic sectors, governments, and militaries. The Earth Regeneration Sector employs most knowledge workers. The Space Resource Development Industry serves as the second primary economic sector. Its principal activities include extracting resources, manufacturing, and waste disposal. Bots and automated machinery carry out land scanning, assessment, and remediation.These technologies also detect and extract resources from abandoned and submerged cities. Carbon sequestering materials trap and transport atmospheric carbon to planets deemed uninhabitable on high-speed spacecraft powered by renewable energy sources. These spacecraft also transport nuclear waste to space disposal sites. Industrial bots mine planets containing resources deemed valuable for regenerating Earth. These resources are then processed and manufactured in space facilities before being transported back to Earth for further processing or direct use.

When direct human supervision is needed, space colonies with artificial gravity house staff that supervise space disposal and manufacturing plants.

Information and communication technologies act as the critical infrastructure supporting all vital economic and social activities. Protocols that prohibit carbon emissions and the use of weapons on Earth govern the collaboration and competition between these large conglomerates. Only digital warfare is allowed on Earth as a measure to preserve the scant livable territories still available. There are no such strict protocols in space yet.

While there has been tremendous progress in space exploration for the past few decades, humans have yet to find a planet entirely suitable for long-term habitation. Meanwhile, Earth's remediation and regeneration are more financially and technologically plausible than terraforming other planets from scratch. Space is now more fitting for industrial and waste disposal activities.

Alongside the splendid vision of the pre-crisis state of the Earth, recorded history shows the darker side of humanity in those days. Out of mindless and thoughtless greed, humans have used nuclear bombs, released excessive amounts of carbon into the atmosphere, and disposed of their waste into the oceans. These collective actions ejected them out of a paradise and into the ruins of a world where they must toil to rebuild. People are starting to wonder how many paradises they have lost before recorded history. And so, ecological activists warn of greedy and tunnel-visioned technology conglomerates repeating past mistakes by disposing waste into territories that seem far and insignificant, and of the delusion that there is a way to escape the consequences of thoughtless intervention. The mechanistic technology conglomerates dismiss those warnings as mere myths from timid and unambitious activists. Meanwhile, holistically-minded activists accuse corporations

of disregard and ignorance of the connectedness of the universe. Whether there will be room to explore the paradox of responsible growth is still unknown.

KEY TRENDS, DRIVERS & IMPLICATIONS

Climate Change: If left unchecked, climate change would lead to large portions of Earth being uninhabitable due to droughts, floods, rising sea levels, melting polar ice, and biodiversity loss. These changes would lead to variable impacts on populations based on their access to resources and geographical locations—mass migrations from uninhabitable regions would ensue due to increasing deaths caused by diseases, droughts and famines.

Space Exploration: Despite the evidence for the increasing commercial viability of space travel, the potential for long-term space habitation is still unknown in terms of possibility and timeline. In this scenario, when climate change reached its tipping point, long-term human habitation of space was not yet possible. The world has to deal with the climate crisis on Earth, utilizing space in any supporting way, except for long-term habitation.

Mega-Tech Rules: Mass communication and social media have gained substantial power and influence over geopolitical, economic, and social structures. Technology dependence has permeated all aspects of civil society. Social media's influence on government elections, revolutions, stocks, and currency values are a few examples of the power these Mega-Tech corporations have amassed in the past couple of decades. This power would only increase as society becomes more and more integrated with technology.

Environmental Awareness: Understanding the impact of human intervention on the ecosystem is growing. Addressing climate change is on many organizations' and individuals' agendas, yet their general approach is not holistic. While it aims to reduce carbon emissions, the carbon credit market only shifts the location of carbon emissions, which hints at a paradigm that does not acknowledge the ecosystem's interconnection.

Implications for the future of space technology development: Space is becoming the exit strategy from the climate change crisis. The majority of Futures work is starting to take for granted the near-term establishment of long-term human-friendly space habitats. Organizations would benefit from considering the possibility of not having space as an escape route from the climate crisis. These organizations must develop technologies to address this problem wholly on Earth.

TIME MACHINE

Artifact Description

Welcome to New Earth, the year 2121 AD, where technology conglomerates have developed a series of maps of their territories, documenting their current conditions and future regeneration visions. These maps have an ecological focus, providing a wealth of information on the flora, fauna, and microorganisms that these conglomerates will introduce into each territory. This time machine will take you on a tour of a virtual career fair in New Earth.

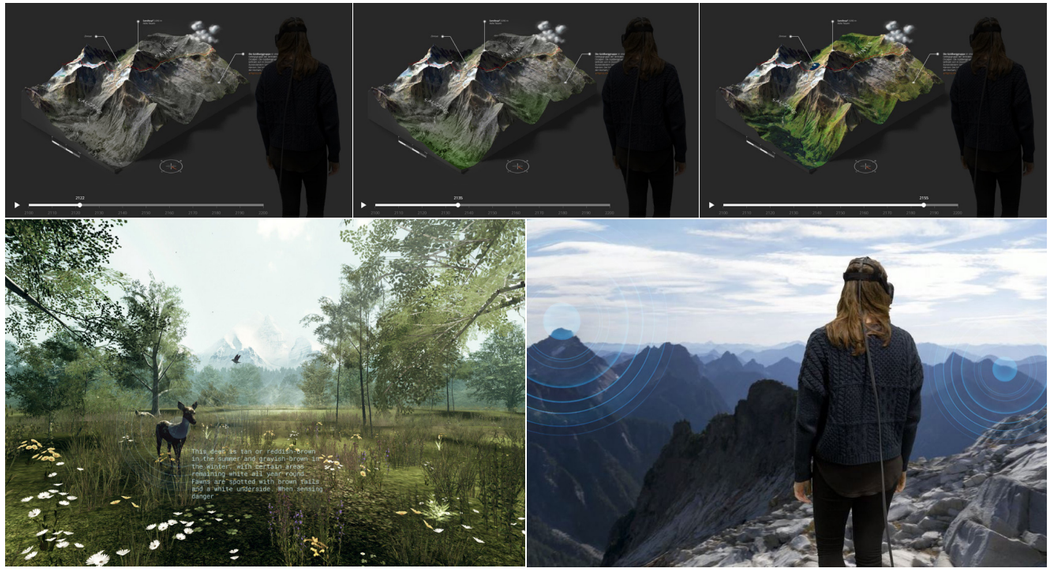
New Earth Maps

"Welcome to Gaia Collaborative, Earth's first regeneration group. We're moving forward on our promise to expand our regeneration activities to cover over 30% of the land area on Earth, and we want you to be part of our vision.

You now have open access to maps of all lands targeted for regeneration in the next century. Feel free to roam and explore these lands through history and discover how we have met our regeneration targets in the past decade. For a future-oriented exploration, check out the many possibilities we have identified as viable routes for further regeneration and the flora and fauna that will soon inhabit those lands. Your preferred regeneration route counts, so make sure that you endorse the projects that matter to you most, and keep an eye out as we continue to add more lands and projects.

You also have access to maps of our space bases, orbits, extraction and processing plants, and Earth remediation fields. Here, you can learn more about the processes and standards that support our responsible space stewardship initiatives.

We look forward to welcoming you to the Gaia Collaborative family."



NEW EARTH MAPS

3.0 STRATEGY DEVELOPMENT

INTRODUCTION

Space Technology is an emerging market that benefits from the recent reduction in space travel costs. This new reality provides opportunities for other technology companies to leverage their innovative capabilities to push the space market's frontiers. This dossier will consider the intersection of Deep Biotech and space exploration by developing a robust set of strategies for our persona client, Gaia, over a 50-year time horizon.

AUDIENCE: PERSONA CLIENT, GAIA

Gaia is a young startup led by a team of founders with professional and research specializations in Data Science, Evolutionary Biology, and Bioengineering. The organization has acquired significant amounts of capital through private investments, their founders, and research grants. The team is currently limited to its four founders.

The senior leadership team of Gaia (founders), who possess a long-term growth mindset, requested strategic foresight consultation for their new startup, Gaia. They seek a robust set of strategies such that their company can move towards their ambitious long-term (100-year) vision of recreating Earth's biodiversity on a different planet. This strategic advice will inform their resource allocation and decision-making to support the following high-level strategic goals over the next 50 years:

- Build scalable data infrastructure with user-friendly front-end development and deep learning capabilities.
- Develop strategic partnerships with entities possessing large sets of biological data.
- Acquire genetic bioengineering capabilities.
- Establish a strong network of researchers, government officials, and technology firms.
- Secure partnerships with space transportation and settlement organizations.
- Preserve Earth's genetic data off-world.

DOMAIN: DEEP BIOTECH

Deep technologies refer to technologies that develop innovative products with paradigm-shifting effects on their industries.

Artificial Intelligence, Blockchain, and Biotechnology are three current emerging Deep Tech fields to which Gaia can direct research efforts. In doing so, Gaia will develop a self-reinforcing value chain that accelerates growth in a future where scarce biodiversity will amplify biological data's value.

Artificial Intelligence is a quickly-growing field in which machine-learning algorithms operate on large data sets that enhance BioTech research through its application within bioinformatics. This field can drive bio evolutionary and genomic research.

Deep technology investments in artificial intelligence and biotech can induce transformative innovations in current bioengineering techniques and harness the power of Earth's biological data to support interventions that seek to preserve biological life in the most inhospitable environments.

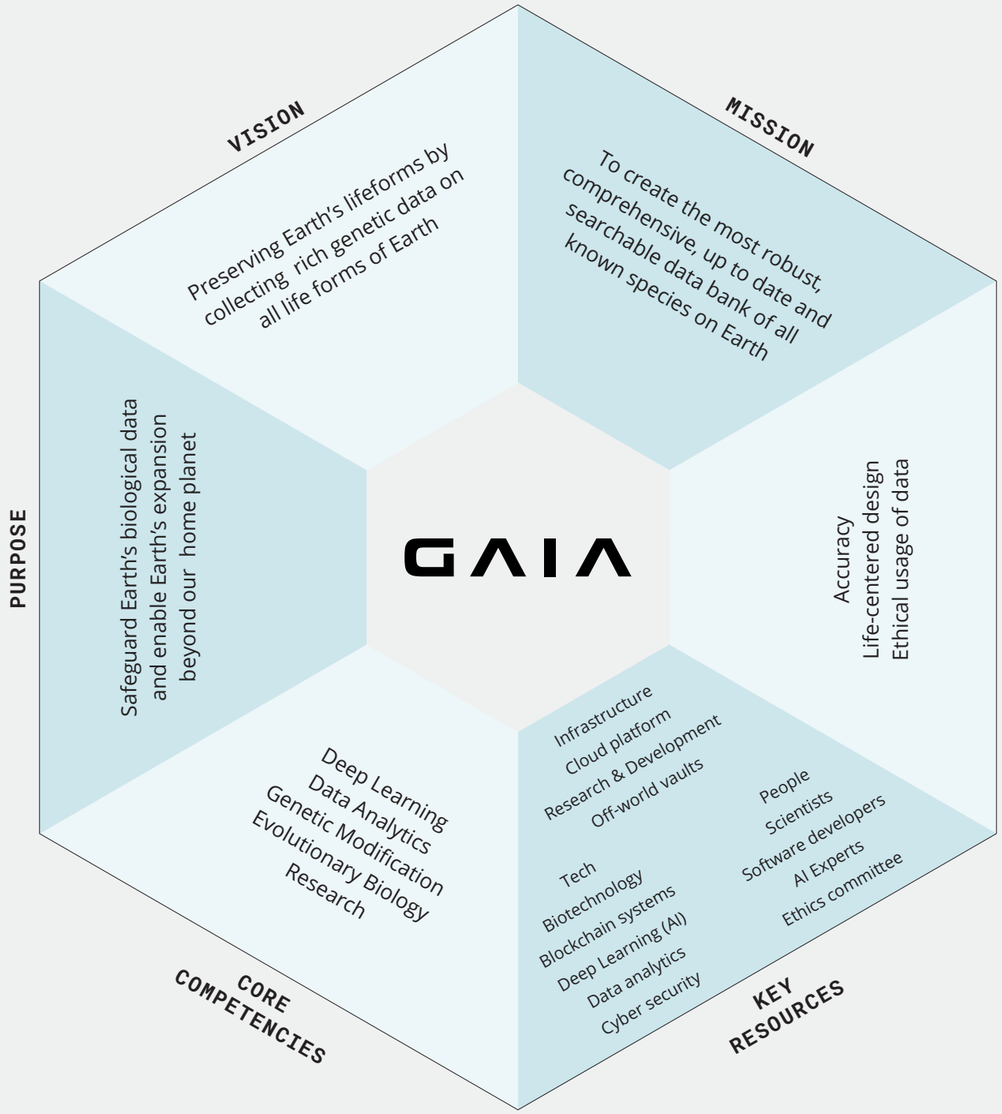
These technology innovations are crucial to supporting long-term or permanent space settlements and expeditions. The ability to preserve, modify, and adapt Earth's biology in a range of extreme conditions will set the preconditions for mass-human migrations into space.

GAIA'S BUSINESS MODEL CANVAS

Key partners	Key activities	Value propositions	Customer relationships	Customer segments

• Private space exploration companies
• Cloud storage developers
• Government space agencies
• Biotech research labs
• Earth Biogenome Project
	• Collection and storage of genetic data
	• Development of blockchain data storage
	• Research publication
	• Outreach
	• Development of artificial intelligence and machine learning algorithms
	
	Key resources
	• Tech
	  • Artificial intelligence, machine learning & deep learning algorithms
	  • Blockchain systems
	• Infrastructure/Processes
	  • Cloud platform
	  • Off-world vaults
	• People/expertise
	  • Scientists, Tech developers and specialists
		• Genetic data backup & preservation
		• Genetic insights gathered from big data analytics
		• Preservation of Earth's life-forms
		• Extending the reach of Earth's life-forms beyond Earth
		• Research incubation & sponsorship
		• Highly functional and robust database interface
			• Accessible database for research purposes
			• Personal touchpoint for individuals
			• At project milestones
			
			Channels
			• Website
			• Cloud database
			• Physical storage
			• Conferences, seminars, & exhibitions
			• Research universities
				• Research institutes & the scientific community
				• Private space exploration companies
				• Governments space agencies
				• Biotech companies
				• Foundations & philanthropes
				• Private investors (individuals)

Cost structure R&D, Building data infrastructure, Data collection and storage, Marketing & showcases, acquisition of genetic datasets			**Revenue streams** Database access subscriptions and licenses, Individuals' genetic data storage fees, Institutions' data storage fees, Government contracts, Sponsorships, grants & donations	



GAIA'S INTERNAL LANSCAPE

EXECUTIVE SUMMARY

The strategic foresight process resulted in five strategic recommendations (below) addressing key strategic options for Gaia over the next 50 years. Two evaluation matrices on pages 65 and 72 tested these recommendations in a diverse set of scenarios.

CAPABILITIES STRATEGY: DEEP TECH ACQUISITION

- Deep Learning capability by seeking out personnel and resources with the Deep Tech fields of Artificial Intelligence and Biotechnology.
  - First, develop Deep Learning capabilities by acquiring access to large biological datasets and hiring a Machine Learning team.
  - Next, develop Biotechnology capabilities by building a BioTech team of experts in genetic engineering, evolutionary biology, bioinformatics, and biorobotics.
- Scale based on revenues and the competitive landscape in a phased approach.

DATABASE ACCESS STRATEGY: VALUE-REGULATED TIERED ACCESS

- Gaia will offer tiered access to its genetic databases. This model will provide free access for contributors (partners) and paid access for non-contributors (subscribers).
- Partners and subscribers will require alignment with Gaia's core mission, vision, and values to gain access through either tier. Gaia will formalize these values in a manifesto of principles that encode Gaia's ethical values in the company's DNA.
- An external ethics committee will use this manifesto to approve potential partners and network members.
- Develop a Gaia blockchain capable of maintaining the unique data security and access restriction requirements of the Gaia database.

DATABASE INFRASTRUCTURE STRATEGY: HYBRID DATA INFRASTRUCTURE

- Adopt a hybrid cloud database to achieve the best of both on-premise and public cloud infrastructures- flexibility, cost-effectiveness, safety, and dependability.
- Gaia would store classified and confidential genetic data and make it accessible exclusively on Gaia's network on and off-world. In contrast, Gaia's public and declassified data will be accessible on enterprise cloud solutions such as AWS.
- Invest in private security infrastructure to protect Gaia's critical infrastructure on Earth.
- Create redundancies of all critical assets on off-world locations.
- Incorporate self-destruct features within on-world sites to enable a fail-safe if a hostile attack could corrupt or steal Gaia's data or biological samples.

SPACE EXPANSION STRATEGY: PRIVATE PARTNERSHIPS PAVE THE WAY TO SPACE

- Secure private space transportation partnerships to develop off-world genetic database storage vaults safeguarding Earth's life forms from disasters that could compromise Gaia's Earth databases' integrity.
- Invest later stage R&D into developing an indestructible "SpacePod" capable of dual applications on Earth and space. This technology can provide an additional revenue stream through partnership agreements with space transportation companies.

ORGANIZATIONAL CULTURE STRATEGY: VALUE-DRIVEN GLOBAL EXPANSION

- Gaia will establish an influential global presence that transcends national and political interests and agendas.
- Gaia's vision, mission, and values will inform its strategic decisions through an external ethics board and a public engagement campaign focusing on leading the way on biotechnological ethics.

STRATEGY

PROCESS

The Seven Steps to Strategy Making (Laflay et al., 2012) provided the framework for developing the strategic direction for Gaia. From there, we followed an iterative process in developing those strategies, which consisted of the following steps:

1. **Internal scan:** we conducted an internal scan of Gaia's collective ambition and identified Gaia's purpose, mission, vision, and core values. This scan was essential in determining where the organization wanted to go. We also scanned Gaia's core competencies, resources and organizational capabilities, which helped us identify how Gaia could reach that destination.

2. **External scan:** multiple models organized findings from scanning Gaia's domain. SWOT, PESTLE, and a Five Forces analysis provided a broad view of the organization's competitive landscape and market.

3. **Strategic choices:** throughout the internal and external scans, a pattern of issues and decision points about Gaia's structure and operations began to emerge. Gaia's founders already made some of these decisions, and others were points still under debate within the organization. We identified seven categories under which Gaia must make decisions and defined two mutually exclusive options that would address the issues under each of the following categories:

    - Corporate structure: should Gaia remain privately owned, or should it go public?
    - Growth: should Gaia expand its capabilities through outsourcing or joint ventures and acquisitions?
    - Raising capital: should Gaia consider NFT's to raise capital?
    - Database ownership and access: should Gaia keep its genetic databases exclusive or open source?
    - Database structure: should Gaia own its internal database, or should it use cloud storage services?
    - Space access: should Gaia align with national space agencies or commercial space companies to access space?
    - Establishing presence and reach: should Gaia operate within a national boundary, or should it pursue a global presence?

4. **Decision making:** after identifying these strategic decision points, we conducted a second iteration of trends, internal and external scanning to support or discredit each decision under each strategic issue.

5. **Implications:** we then identified the conditions for each of these strategic decisions' success and the implications for Gaia's business model and future operations.
The following is a brief overview of the strategic options and key findings generated in the first strategy development phase. A detailed discussion of these strategies' implications and rationale will be presented in a later section of this dossier under Wind Tunneling, Round 1, Strategic Directions Revision.

KEY FINDINGS

BLUE SKIES
Gaia's substantial startup capital allows its founders the freedom to design the organization's structure and strategies around their vision and values without public shareholders' influence. Gaia has the potential to venture into emerging opportunities and business territories without the pressure to maintain short-term revenue growth.

DEEP BIOTECH
Gaia's founders have a unique mix of Data Science, Evolutionary Biology and Genetic Engineering expertise. This mix reinforces Gaia's strategic positioning as leading experts in Deep BioTech.

PROTECTORS OF THE REALM
Gaia's founders are committed to life-centred, socially responsible, environmentally conscious values and ethics. These values are the inspiration and drive behind Gaia's vision of preserving all of Earth's life forms. This strong commitment can be a barrier to pursuing lucrative opportunities in the BioTech field that do not align with their values. However, it's also one of Gaia's crucial differentiators.

SAVED BY SPACE
There is growing interest in space as a potential refuge from the detrimental consequences of irreversible climate change. Gaia should consider the utilization of space for long-term storage and safeguarding of Earth's biological data and be involved with space projects aiming to make space more hospitable to humans and all of Earth's life forms.

BLOCKCHAIN
The developments in blockchain technology add value to Gaia by decentralizing, protecting, and securing valuable data. Blockchain can enable additional revenue streams through NFT's (non-fungible tokens) or an ICO (Initial Coin Offering). The carbon footprint of mainstream blockchains is a concern that Gaia should address.

BIG -NOT SO FRIENDLY- TECH GIANTS
Large technology companies have resources and incumbency advantages when it comes to machine learning. A Big Tech (Google/Alphabet, Amazon, Facebook) entry into genetic data poses a risk to Gaia's potential market share without strategic differentiation or advantages.

WE'RE NOT ALONE
There are many genetic data banks around the world, some of which are publicly available.

These data banks are focused on specific biological species or domains. They do not target the preservation of all life forms. Gaia has an opportunity to differentiate its databases from the existing offerings through its expansive database.

STRATEGIC DIRECTIONS

CORPORATE STRUCTURE: GAIA WILL REMAIN UNDER PRIVATE OWNERSHIP FOR AT LEAST THE NEXT FIVE YEARS
Going public through an IPO or a SPAC could provide additional funding. However, the possibility of a market downturn poses a threat to that funding, particularly for recent IPOs. A surge of high-growth technology stocks and high valuations drive current "bubble-like" conditions (Ganti, 2021; Reuters, 2020). These conditions and the increase in bond yield rates from the US federal reserve (Pisani, 2021) are trends that point towards this potential market downturn. With the initial investments and grant funding providing substantial short-term financing, Gaia should maintain its current private ownership structure. This structure empowers its founders to design the company's activities and focus around the core vision and maintain consistent funding for its research and development teams over the next five years. After five years, going public through an IPO or SPAC will remain options as Gaia grows into a more established company.

GROWTH: GAIA WILL EXPAND ITS BIOENGINEERING CAPACITY THROUGH ACQUISITIONS AND MERGERS
Gaia's strategic focus is to grow its database and acquire genetic bioengineering capabilities geared towards preserving and replicating Earth's life forms. Outsourcing bioengineering capabilities would allow Gaia to focus on its core competencies while offloading its non-core functions to external partners. However, insourcing would allow for better control and management over projects and timelines. Expanding and building new parts of a business has more upfront costs. However, these costs are recovered over time as an organization develops a skilled team and expands its revenue-generating activities. Expanding Gaia's bioengineering capacity by bringing R&D in-house aligns with the organization's short and long-term goals and vision. Additionally, Gaia will ensure a competitive edge in a rapidly growing market by expanding its core competencies, resources, and genetic sequencing and engineering activities.

ALTERNATIVE FUNDRAISING: GAIA WILL NOT PURSUE NFTS AS A MEANS OF FUNDRAISING
Gaia's R&D in blockchain technologies will focus exclusively on developing secure data storage infrastructure and will avoid producing NFTs due to their current energy-intensive validation processes (Calma, 2021; Fairly, 2019; Nano, n.d.). The ethical implications of offering "authentic" genetic data as NFT tokens run counter to Gaia's values. An Initial Coin Offering (ICO) will remain an open possibility in the future once Gaia develops its own blockchain.

DATABASE ACCESS: GAIA WILL OFFER TIERED ACCESS TO ITS GENETIC DATABASE

Gaia will enable access to its comprehensive genetic database of all Earth's known species through a tiered access model. This model will cater to two customer segments: contributors to Gaia's database (free access) and non-contributing institutional subscribers (paid access). Thus, Gaia establishes partnerships with BioTech stakeholders and fosters a community of specialized researchers supporting their mission by contributing research findings to grow and develop Gaia's database. Additionally, Gaia will leverage access to its database as a steady revenue stream that can help finance its operations.

DATABASE STRUCTURE: GAIA WILL PURSUE A HYBRID CLOUD NETWORK AND STORAGE MODEL

While private servers and on-premise computing hardware enable enhanced security, they have added upfront cost and complexity. Public cloud infrastructure allows for more flexibility, lower startup costs, and greater scalability. However, public clouds require an always-on connection and are less secure than an internal network. Security and reliability are central to Gaia's data preservation policy, so exclusively private or cloud-based networks would entail a greater risk of data loss. Gaia will adopt a hybrid cloud infrastructure to achieve the best of both networking worlds; low cost and elastic while also safe and dependable. Classified genetic data would be accessible exclusively on Gaia's private network on and off-world. Gaia's public and declassified data will be accessible on enterprise cloud solutions such as AWS.

TRANSPORTATION TO SPACE: GAIA WILL SECURE PRIVATE SPACE TRANSPORTATION PARTNERSHIPS TO ENABLE OFF-WORLD GENETIC STORAGE

Space transportation is essential to Gaia's vision of preserving Earth's biological data off-world. Suppose Gaia partners with government agencies to secure space transportation. In that case, it might have to align its mission with these agencies' national space mandates. This obligation could impact Gaia's control over its genetic payload and threaten its vision to benefit all of humanity. Gaia cannot cost-effectively develop rockets without pivoting the company focus. So, Gaia will partner with private space transportation companies to secure cost-controlled and reliable transportation enabling Gaia to focus on its core mission.

ORGANIZATIONAL CULTURE: GAIA WILL ESTABLISH A STRONG GLOBAL PRESENCE THAT TRANSCENDS NATIONAL AND POLITICAL INTERESTS AND AGENDAS

Gaia's vision of expanding human presence beyond Earth and preserving Earth's life-forms necessitates a global presence. Gaia must establish relationships and partnerships with international BioTech labs, genetic data banks, NGOs, research institutes, and private spaceflight companies. This strategy establishes a global presence and prevents attachment to specific national interests. Gaia will also engage smaller local research teams preserving endangered life forms. In doing so, Gaia will form a web of branching roots that can draw data from broad sources and develop a body of knowledge sufficient to preserve all of Earth's biodiversity.

WIND TUNNELLING

OVERVIEW

Wind tunnelling (also known as strategy stress-testing) is the process of considering the viability, strengths, and weakness of business ideas within various future scenarios (Van der Heijden, n.d.). Trends and drivers relevant to Gaia's business space laid the foundation of our scenarios. Hence they offer a rich testing ground to evaluate each option's performance when measured against specific criteria.

Our team adopted an iterative wind tunnelling approach. We continued to work on each strategy and change its component mix until the options seemed robust enough to be run through a wind tunnelling exercise. As a result, we conducted two rounds of wind tunnelling and subsequent strategic revisions. During round one, we were interested in the impact of the strategies on attaining the primary organizational goals of survival and growth. We used a tiered ranking system to evaluate the seven strategic options' overall performance in each scenario. Based on the results, we reworked the strategies to form a set of 5 adapted options. These were evaluated in the second round of wind tunnelling using four criteria and a ranking system. During round two, we were interested in the value these options would offer in each scenario world. We used the evaluation criteria to evaluate each option against financial performance, risk performance, strategic fit, and cultural fit.

ROUND I

WIND TUNNELING MATRIX

We plotted our seven strategies on the y-axis against the scenarios on the x-axis. We then discussed and rationalized strategic implications to assess each scenario's viability on a "good," "moderate," and "bad" scale.

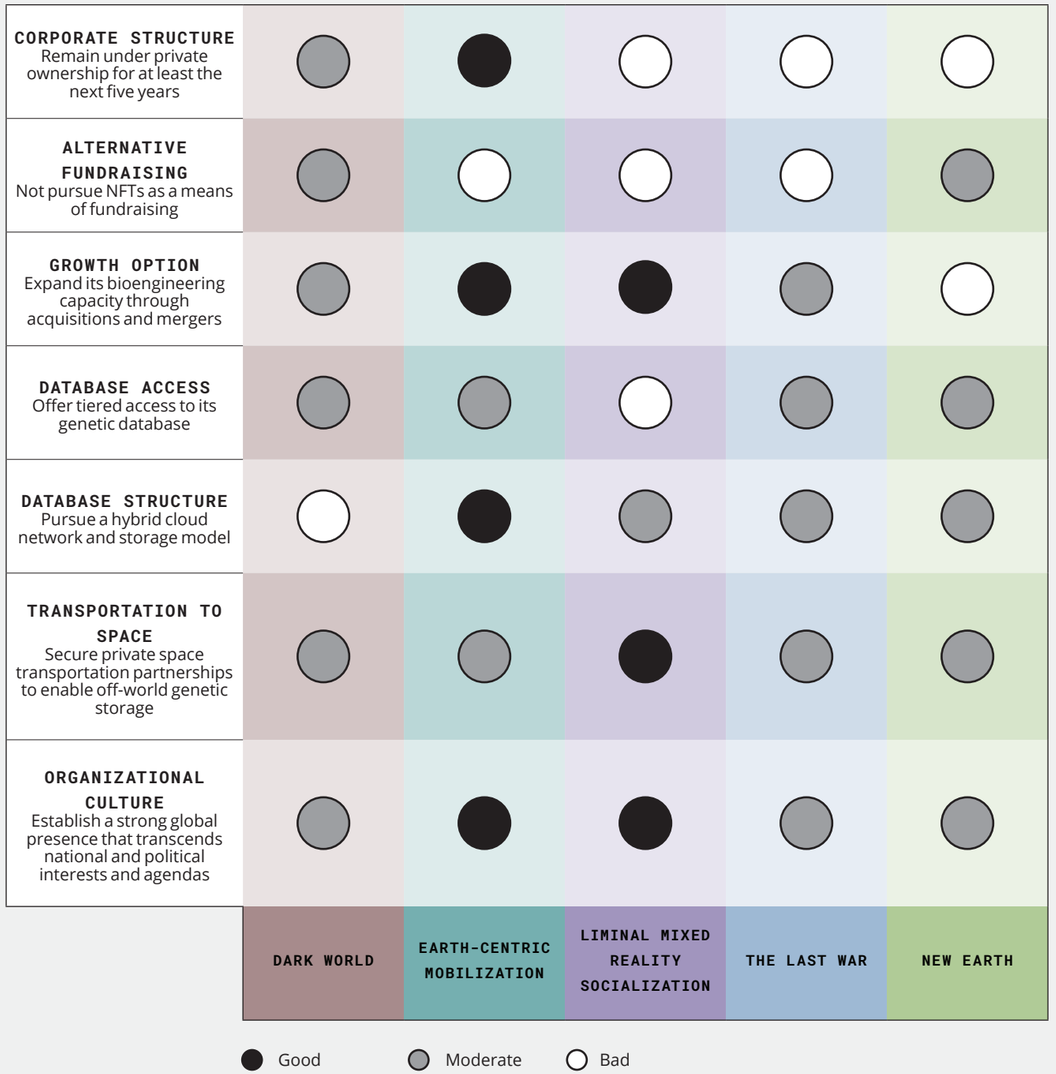
STRATEGIC CONVERSATIONS

> The wind tunneling approach is based on the assumption that there is always room for improvement in the design of strategic options. This involves an ongoing search for options that are more robust across the scenarios. Most optional strategies tend to show rather different perceived performances depending on the scenario in which they are being tested. (Van der Heijden, n.d.)

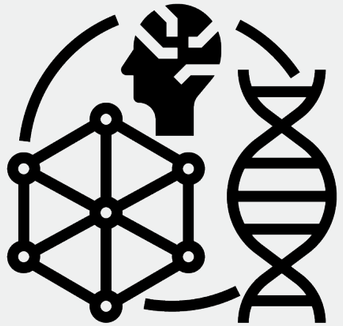
Initial activities must strengthen the organization's core competencies before exploring new business options. After the first round of wind tunnelling, our team noticed several options lacked focus and compromised Gaia's ability to survive or grow across the different scenarios. Part of the problem was the viability of these options' time frames. We recognized that new business options aimed at immediately widening revenue opportunities were not beneficial at the early stage of Gaia's life cycle.

Furthermore, the level of uncertainty highlighted in each scenario required us to adopt a hybrid approach to strategy development, combining robust and flexible strategies. Robust because Gaia seeks to maintain a viable position while concentrating its efforts on building the capacity to accommodate new business options. Flexible because it recognizes a high level of uncertainty in the future, which requires decision-makers to remain vigilant to spot signals of change and quickly respond with new business opportunities.

This first round of wind tunnelling was useful in triggering ideas used to brainstorm five adapted strategic options. These new options, outlined in the following section, were then run through the second round of wind tunnelling.



WIND TUNNELING ROUND I MATRIX



CAPABILITIES STRATEGY: DEEP TECH ACQUISITION

Sign Posts:
- The growth of the Deep Technologies ecosystem
- Growing demand for Deep Technology applications to complex biological data, such as Ginkgo Bioworks lab
- Genomics projects focused on preserving biodiversity
- The growing threat of climate change on biodiversity

Timeframe:
Immediate + ongoing

Gaia will build its internal capabilities by focusing on acquiring and developing resources that fit best with its long-term vision and competitive landscape. Initially, this focus will bring in resources, experts, and partnerships that bolster Gaia's Deep Technology capabilities in Artificial Intelligence, Blockchain, Robotics, Photonics, Electronics, and Quantum Computing. In the next phase of Gaia's long-term strategy, this focus will shift to building up its Biotechnology and Synthetic Biology capabilities by hiring experts and partnering with institutions.

RATIONALE

Expanding internal capabilities has significant upfront costs. Still, these costs are recovered over time as organizations build a team of experts to grow their revenue-generating activities. This route would also give Gaia more control over project delivery and timelines. Combining Deep Technology capabilities would afford Gaia the needed resources for innovation in building its genetic database and utilizing this database to regenerate endangered and extinct life forms in the later phase of the organization's strategy.

RISKS & CAVEATS

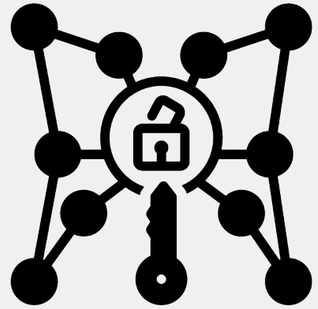
Large BioTech companies have an advantage in the bioengineering market and the acquisition and application of Deep Tech to genetic data and engineering. Gaia will have to contend with prominent players and differentiate its offering to gain significant market share.

MEASURES OF SUCCESS

- Number and quality of acquisitions, mergers, and partnerships
- Database size and quality of data
- Funding, research grants, and awards acquired

STRATEGIC FIT – CAPITALIZING ON STRENGTHS

Vertically integrating genetic data storage with synthetic biology is crucial to Gaia regenerating extinct and endangered life forms, thus bringing Gaia closer to fulfilling its core vision of preserving all of Earth's life forms.



DATABASE ACCESS STRATEGY: VALUE-REGULATED TIERED ACCESS

Sign Posts:
- Prevalence of recurring revenue model in Big Tech
- Software as a service (saas)
- Crowdsourcing
- The growing market for Biotech, Fintech, and Cleantech
- Growing demand for Deep Tech applications to complex biological data
- Genomics projects focused on preserving biodiversity

Timeframe:
Beginning when Gaia's database grows large enough to facilitate Deep Learning (within two years).

Gaia will offer tiered access to its genetic databases. This model will provide free access for contributors (partners) and paid access for non-contributors (subscribers). Partners and subscribers will require alignment with Gaia's core mission, vision, and values to access either tier. Gaia's founders will formalize these values in a manifesto of principles that ensure the ethical use of genetic data. An external ethics committee will use this manifesto to approve potential partners and network members.

RATIONALE

Enabling Gaia to grow its database while providing contributing partners free access to its database and insights is mutually beneficial. Subscriptions offer Gaia dependable revenue streams from non-contributing members. Applying machine learning algorithms to large genetic datasets can have unintended consequences. Therefore, an external ethics review process protects Gaia, its partners, and subscribers from the risk of these algorithms' unforeseen consequences.

RISKS & CAVEATS

Harmful use of genetic data may not always be predictable. Gaia must ensure a manifesto of data use principles and guidelines balances these risks while driving innovation.

MEASURES OF SUCCESS

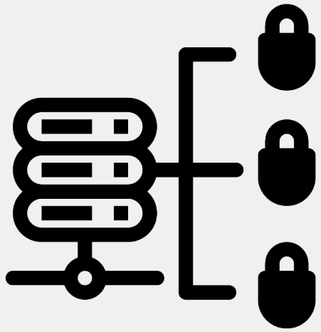
- Number of Gaia's contributing partners
- Revenue from Gaia's non-contributing subscribers
- Size and quality of the database
- Scientific community engagement (e.g. invitations to conferences, workshop attendees, journal publications and number of citations)

STRATEGIC FIT – MINIMIZING THREATS

Gated value-based access ensures Gaia's resources and capabilities do not support life-endangering uses that run counter to Gaia's life-centric vision.

Sign Posts:
- Software as a service (SAAS)
- Satellites as a service
- LEO satellites
- 5g+
- Genetic data banks

Timeframe:
Immediate + ongoing



DATABASE INFRA-STRUCTURE STRATEGY: HYBRID DATA INFRA-STRUCTURE

Gaia will adopt a hybrid cloud database to achieve the best of both on-premise and public cloud infrastructures - flexibility, cost-effectiveness, safety, and dependability. Gaia would store classified and confidential genetic data and make it accessible exclusively on Gaia's network on and off-world. In contrast, Gaia's public and declassified data will be accessible on enterprise cloud solutions such as AWS.

RATIONALE

Gaia's database is one of its primary key resources. The security and reliability of these database servers are central to Gaia's data preservation policy. Therefore, a purely on-premise or cloud-based network would significantly risk data loss and security compromisation.

RISKS & CAVEATS

Data security is of utmost importance in an organization like Gaia. Standard security measures often fail in an increasingly connected world.

MEASURES OF SUCCESS

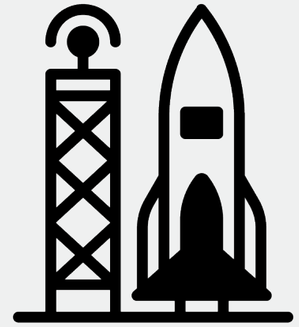
- Database security reports
- Database maintenance costs

STRATEGIC FIT - MINIMIZING THREATS

Threats to data security and conservation would directly compromise Gaia's vision of preserving Earth's life forms. Therefore, this strategy is key to minimizing risks and threats to Gaia's data integrity.

Sign Posts:
- Low-cost space transportation
- Increasing competition in private space transportation
- Governments relying on private companies for space transportation
- The growing threat of climate change on Earth habitability
- The ever increasing interest in expanding life beyond Earth

Timeframe:
To be launched in 5-7 years + Long-term



SPACE EXPANSION STRATEGY: PRIVATE PARTNERSHIPS PAVE THE WAY TO SPACE

Gaia will secure private space transportation partnerships to safeguard Earth's life forms' on off-world genetic databases and expand them to other planets. Gaia will consider joining particular government missions on a case-by-case basis depending on feasibility and alignment with Gaia's values and vision.

RATIONALE

Commercial space transportation is the most economically viable option to access space and the most aligned with its core values. Depending on government agencies to access space might compromise Gaia's autonomy and vision to benefit all of humanity. Building a space fleet would take years of resources and investment and shift its focus from its core activities.

RISKS & CAVEATS

Expanding Earth's life forms beyond Earth is an attractive vision. However, a lack of awareness and knowledge about the impact of such interference on other life forms and ecosystems not yet known presents a risk and possibly a violation of Gaia's life-centric vision.

MEASURES OF SUCCESS

- Space transportation costs
- Ease of access to off-world vaults for database upgrades and maintenance

STRATEGIC FIT - CAPITALIZING ON OPPORTUNITIES

This strategy draws on the opportunities provided by the commercialization of space transportation to preserve Earth's biological data beyond Earth. Thus, it brings Gaia closer to its goal of preserving all of Earth's life forms.

Sign Posts:
- International collaboration in Biotech
- Commercialization of space
- Climate migration

Timeframe:
Immediate + ongoing

CULTURE STRATEGY: VALUE-DRIVEN GLOBAL EXPANSION

Gaia will establish an influential global presence that transcends national and political interests and agendas. Gaia's vision, mission, and values will inform its strategic decisions to maintain its organizational culture and presence.

RATIONALE

Gaia's vision of expanding human presence beyond Earth and preserving Earth's life-forms necessitates a global presence. To preserve all life forms on Earth, Gaia will need to collect genetic data from all ecosystems worldwide. The organization must establish strong relationships with institutes, labs, genetic data banks, and individual researchers to establish a global culture and facilitate this collaboration at scale. Moreover, natural disasters and the impact of climate change pose a threat to data servers' safety and integrity, and having multiple server locations around the world would further safeguard Gaia's databases.

RISKS & CAVEATS

In a world where national governments support the majority of space programs and many research institutes, Gaia might miss out on some opportunities and support by avoiding alignment with national governments.

MEASURES OF SUCCESS

- Number of international partnerships and collaborations
- Sustained international collaborations
- Diversity of data in Gaia's database
- Database maintenance costs

STRATEGIC FIT – CAPITALIZING ON OPPORTUNITIES

Global collaboration provides Gaia with access to diverse resources, datasets, and locations to store its databases. Thus, fulfilling both sides of its vision; comprehensiveness of databases and secure preservation of life forms.

ROUND II

EVALUATION CRITERIA

Once we generated the adapted strategic options, their consequences were discussed and assessed using specific evaluation criteria. These criteria include:

Adapted from Van der Heijden, n.d.:

Financial Performance: How could this strategy provide value to customers in this world? What would be Gaia's advantage against its competitors if it implements this strategy in this world?

Risk Performance: Does this strategy equip Gaia with robust data security infrastructure and resources or work against it?

Strategic Fit: How does the strategy fit with the core competencies, resources and time frame for Gaia?

Cultural Fit: Does this strategy align with Gaia's vision and values? Will Gaia be walking on thin ice against their values?

WIND TUNNELING MATRIX

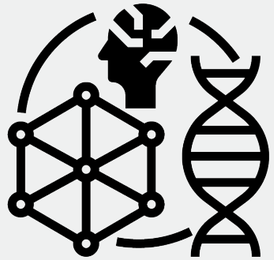
We plotted our five adapted strategies on the y-axis against the scenarios on the x-axis. We then discussed and rationalized the four evaluation criteria to assess the strategy's potency level in each scenario, ranked on a scale of "high," "moderate," "low."

	FINANCIAL PERFORMANCE	RISK PERFORMANCE	STRATEGIC FIT	CULTURAL FIT	FINANCIAL PERFORMANCE	RISK PERFORMANCE	STRATEGIC FIT	CULTURAL FIT	FINANCIAL PERFORMANCE	RISK PERFORMANCE	STRATEGIC FIT	CULTURAL FIT	FINANCIAL PERFORMANCE	RISK PERFORMANCE	STRATEGIC FIT	CULTURAL FIT	FINANCIAL PERFORMANCE	RISK PERFORMANCE	STRATEGIC FIT	CULTURAL FIT
DEEP TECH ACQUISITION	●	○	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
VALUE REGULATED TIERED ACCESS	●	○	●	○	○	○	◉	◉	●	◉	●	●	●	●	◉	●	◉	○	●	●
HYBRID DATA INFRASTRUCTURE	●	○	●	○	●	●	●	●	●	◉	●	●	●	●	●	●	●	●	●	●
PRIVATE PARTNERSHIPS PAVE THE WAY TO SPACE	●	●	●	○	●	●	◉	◉	●	●	●	●	●	●	◉	●	○	○	●	○
VALUE-DRIVEN GLOBAL EXPANSION	○	●	●	●	●	●	●	●	●	●	●	●	○	●	◉	●	●	●	●	●
	DARK WORLD				EARTH-CENTRIC MOBILIZATION				LIMINAL MIXED REALITY SOCIALIZATION				THE LAST WAR				NEW EARTH			

● High potency ◉ Moderate potency ○ Low potency

WIND TUNNELING ROUND II MATRIX

RESULTS AND STRATEGIC RECOMMENDATIONS



DEEP TECH ACQUISITION

Overall, this strategic option performed well across all scenarios. It received a single low score for its risk performance in Dark World. Here, the concern was that if Gaia didn't grow its R&D capabilities fast enough, it could lose important data due to environmental degradation. Conversely, if Gaia scales too quickly, they risk financial stress if revenue-generating activities don't also scale accordingly.

Adapted Direction
Develop Deep Learning capability by seeking out personnel and resources with the Deep Tech fields of Artificial Intelligence and Biotechnology. Scale based on revenues and the competitive landscape in a phased approach. Monitor the burn rate and financials to ensure that prohibitive debt is not what spurs growth.

Roadmap

1. Build data infrastructure.
    - Hire personnel capable of developing Machine Learning algorithms and multilayered neural networks to enable Deep Learning insights from large datasets. Potential hires should have a strong background in Artificial Intelligence, Data Science and their intersections (Machine Learning).
    - Acquire data relevant to sustaining biological life.
        - Pursue partnerships with institutions possessing specific and inaccessible data.
        - Partner with genetic databanks.
2. Build BioTech team.
    - Hire SMEs in genetic engineering, evolutionary biology, bioinformatics, and biorobotics.

VALUE-REGULATED TIERED ACCESS

This option scored the lowest marks overall due to a shared concern for data security. It's clear that data security should drive Gaia's strategic orientations.

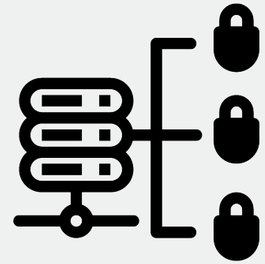
Moreover, this particular option assumes there could be a misalignment of values. Data could be compromised or used to harm an unregulated environment. But in a highly disciplined and regulated world such as Earth-Centric Mobilization, there is no need for this type of restriction. Furthermore, this world values cooperation and requires the free exchange of information. People would not value proprietary information in the same way we do today. Therefore, this revenue model holds no ground in this future. It would be beneficial for Gaia to explore other capabilities they could leverage as revenue-generating activities.

Adapted Direction

Develop a Gaia blockchain capable of maintaining the unique data security and access restriction requirements of the Gaia database.

Roadmap

1. Once Deep Learning capabilities are built, direct funding and resources towards accelerating blockchain development.
2. Hire personnel capable of developing secure blockchains that are energy efficient and impossible to corrupt.



HYBRID DATA INFRASTRUCTURE

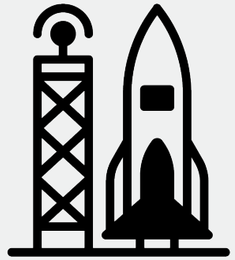
This option performed well across all five scenarios because it recognizes a need for robust storage to protect valuable data and samples. We highlighted a risk for data destruction in all five futures, whether digital (cyberattacks) or physical (environmental disasters or war). Protecting Gaia's data is fundamental to this organization's survival in the future.

Moreover, in the Last War world, conflicts between Nationalists and Globalists add the significant threat of violence as an important consideration. Data and samples' physical security will be as important as its security on digital platforms in this world. Gaia must consider the possibility of an armed attack on one of their facilities or data centres and must protect their critical infrastructure accordingly.

Adapted Direction

To mitigate the threat of attack:

- Contracting private security to protect Gaia's critical infrastructure.
- Moving Gaia's critical assets to off-world locations.
- Building security infrastructure around a large perimeter of Gaia's asset locations.
- Create redundancies of all critical assets on off-world locations.
- Incorporating self-destruct features within on-world locations enables a fail-safe in case of a hostile attack that could corrupt or steal Gaia's data or biological samples.



PRIVATE PARTNERSHIPS PAVE THE WAY TO SPACE

Both Dark World and New Earth cast doubt on this option's cultural fit due to value-alignment and transparency concerns associated with a profit-driven company with less public scrutiny.

Furthermore, in the Earth-Centric Mobilization world, the role of space-based missions is uncertain because most resources are dedicated to Earth-bound projects. Therefore Gaia should be prepared to re-orient its long-term space ambitions to Earth.

The wind tunnelling raised additional concerns about payload security during space transportation missions, highlighting a potential technology-development opportunity for Gaia. This new business opportunity (SpacePod) is discussed below.

Adapted Direction

- When exploring partnerships with private space transportation companies, perform comprehensive risk assessments considering ethics and payload safety.
- Adopt a phased and flexible approach to expanding R&D into space. Gaia should consider dual applications (Earth/Space) for any vault or pod technology it aims to develop.

SpacePod Opportunity

Develop an indestructible "SpacePod" capable of protecting Gaia's sensitive biological samples and data in extreme Earth or space conditions. Gaia can offer SpacePods to space transportation companies as an additional revenue stream and a mechanism to negotiate complimentary transport missions to space.

VALUE-DRIVEN GLOBAL EXPANSION

Here, two scenarios highlighted a financial performance weakness. As genetic data continues to be lost to human activity in the Dark World, nations may seek to capture genetic material in-house. Therefore, opting for political neutrality may limit Gaia's potential to garner lucrative BioTech contracts. In The Last War world, Alphabet or Amazon would likely acquire Gaia. The strategic alignment with the parent company's mission will determine Gaia's ability to maintain its rigid ethics process that excludes financial opportunities that compromise its values. This concern highlights the strategic importance of maintaining Gaia's public image and developing a loyal community of followers, contributors, and users. This large following and public image could be used as leverage to keep its value-based model intact in the event of a merger.

Adapted Direction

Gaia to become a global leader in BioTech ethics and sustainable practices.

- Embed BioTech ethics within its ethos by empowering its ethics board to ensure Gaia's growth efforts remain aligned with its values.
- Develop strategic partnerships within a committed BioTech ethics community of practice by connecting research institutions and national preservation agencies aligned with Gaia's commitment to BioTech ethics and environmental sustainability.
- Build favourable public perception by promoting transparency as a global leader in BioTech ethics. Gaia should be transparent about its strategic goals and use public feedback and contests to increase engagement and support.

OVERVIEW OF RECOMMENDATIONS

DEEP TECH ACQUISITION

Develop Deep Learning capability by seeking out personnel and resources within the Deep Tech fields of Artificial Intelligence and Biotechnology. Scale based on revenues and the competitive landscape in a phased approach. Monitor the burn rate and financials to ensure that prohibitive debt is not what spurs growth.

HYBRID DATA INFRASTRUCTURE

Prioritize cybersecurity as well as the physical safety of critical storage infrastructure.
Create redundancies of all critical assets in secure locations.

VALUE-REGULATED TIERED ACCESS

Develop a Gaia blockchain capable of maintaining the unique data security and access restriction requirements of the Gaia database.

VALUE-DRIVEN GLOBAL EXPANSION

Become a global leader in Biotech ethics and sustainable practices by:

- Empowering its Ethics board.
- Fostering a community of practice.
- Promoting transparency and investing in public outreach initiatives.

PRIVATE PARTNERSHIPS PAVE THE WAY TO SPACE

Utilize a comprehensive risk assessment with ethical and payload safety considerations embedded in the process when exploring partnerships with private space transportation companies. Adopt a phased and flexible approach to expanding R&D into space. Gaia should consider dual applications (Earth/Space) for any vault or pod technology it aims to develop.

SPACEPOD (NEW OPPORTUNITY)

Develop an indestructible “SpacePod” capable of protecting Gaia’s sensitive biological samples and data in the face of inhospitable environmental conditions on Earth or in space.

YEAR 1

YEAR 5

YEAR 20

4.0 CONCLUSION

This dossier covered our team's strategic foresight journey through its two elements- foresight and strategy.

The foresight process began with environmental and trend scanning. These trends and drivers fed into the Manoa scenario generation process to create potent future cross-impacts. Dator's Four Future's model enabled us to generate rich scenario details and sound internal logic (world-building). These scenarios stress tested organizational strategies inside the worlds built around the cross-impacts.

The strategy process started with an analysis of the persona organization, Gaia, and its competitive landscape. This information informed the development of the strategic goals, options, and adaptations tested within our scenarios using a wind tunnelling method.

Because of the two courses' structure (Foresight Studio and Strategy Development), we created the scenarios in isolation from the persona organization and the first round of strategic options. We recognize that the client would be part of the scenario-generating process under normal circumstances. Hence, our first round of wind tunnelling revealed a disconnect between our options and our scenarios, which was symptomatic of our somewhat siloed approach. Once our team engaged in the wind tunnelling process, the scenarios became an effective tool for generating new business ideas. This effect led us to adopt an iterative approach to wind tunnelling and option generating. Our strategic options became better adapted and more robust with each round of wind tunnelling. They converged upon a set of strategies that we believe will empower "Gaia" to achieve its vision and maintain the agility to adapt to an uncertain future.

BIBLIOGRAPHY

FORESIGHT WORK

Glossary

BCG. (2019). The Dawn of the Deep Tech Ecosystem. Boston Consulting Group. https://image-src.bcg.com/Images/BCG-The-Dawn-of-the-Deep-Tech-Ecosystem-July-2019-R-3_tcm9-221024.pdf

Intro

BusinessWire. (2021, January 29). Global space tourism market trajectory report 2020-2027: Suborbital tourism is projected to account for $1.5 billion of the total $1.7 billion market. https://www.businesswire.com/news/home/20210129005293/en/Global-Space-Tourism-Market-Trajectory-Report-2020-2027-Suborbital-Tourism-is-Projected-to-Account-for-1.5-Billion-of-the-Total-1.7-Billion-Market---ResearchAndMarkets.com

Cuhls, K. (2019, November 24). Horizon scanning in Foresight – Why Horizon scanning is only a part of the game. Futures & Foresight Science, 2(1). https://doi.org/10.1002/ffo2.23

Deloitte. (2019). Tech Trends 2019: Space industry perspective. https://www2.deloitte.com/content/dam/Deloitte/us/Documents/public-sector/space-perspective-on-tech-trends-2019.pdf

IPCC. (2018). Summary for Policymakers. Global Warming of 1.5°C. An IPCC Special Report on the impact of global warming of 1.5°C above pre-individual levels and related global greenhouse gas emission pathways in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_SPM_version_report_LR.pdf

MorganStanley. (2020, July 24). Space: Investing in the Final Frontier. https://www.morganstanley.com/ideas/investing-in-space

NASA. (n.d.). Climate Change: How Do We Know? https://climate.nasa.gov/evidence/

Key Trends - Climate Change

Bowles, D., Butler, C., & Morisetti, N. (2015, October). Climate change, conflict and health. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4622275/

European Commission. (n.d.).Climate change and environmental degradation. https://knowledge4policy.ec.europa.eu/climate-change-environmental-degradation_en

Institute for Economics & Peace. (2020). Ecological threat register 2020: Understanding Ecological threats, resilience and peace - World. https://reliefweb.int/report/world/ecological-threat-register-2020-understanding-ecological-threats-resilience-and-peace

Jaggard, K., Qi, A., & Ober, E. (2010, September 27). Possible changes to arable crop yields by 2050. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2935124/

Lindsey, R. (2020, August 14). Climate change: Atmospheric Carbon Dioxide. NOAA Climate.gov. https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide

Medek, D., Schwartz, J., & Myers, S. S. (2017, August 2). Estimated Effects of Future Atmospheric CO2 Concentrations on Protein Intake and the Risk of Protein Deficiency by Country and Region. https://ehp.niehs.nih.gov/doi/10.1289/EHP41

NASA. (2021, January 22). Climate change evidence: How do we know? https://climate.nasa.gov/evidence/

NASA. (2021, January 26). Ice sheets | Vital Signs. https://climate.nasa.gov/vital-signs/ice-sheets/

Perkins-Kirkpatrick, S., & Gibson, P. (2017, September 25). Changes in regional heatwave characteristics as a function of increasing global temperature. https://www.nature.com/articles/s41598-017-12520-2

Sweet, W., Kopp, R. E., Weaver, C. P., Obeysekera, J., Zervas, C., Thieler, E. R., & Horton, R. M. (2017, January). Global and regional sea level rise scenarios for the United States. https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf

The Ocean Portal Team, & Bennet, J. (2018, April). Ocean acidification Smithsonian Institution. https://ocean.si.edu/ocean-life/invertebrates/ocean-acidification

Key Trends - Accelerating Tech

Eugenios, J. (2015, June 4). Ray Kurzweil: Humans will be hybrids by 2030. https://money.cnn.com/2015/06/03/technology/ray-kurzweil-predictions/index.html?iid=SF_LN

European Commission. (n.d.). Accelerating technological change and hyperconnectivity. https://knowledge4policy.ec.europa.eu/accelerating-technological-change-hyperconnectivity_en

European Commission. (n.d.). Developments and forecasts of accelerating technological change and Hyperconnectivity. https://knowledge4policy.ec.europa.eu/foresight/topic/accelerating-technological-change-hyperconnectivity/developments-forecasts-accelerating-technological-change-hyperconnectivity_en

Dobbs, R., Manyika, J., & Woetzel, J. (2018, February 9). The four global forces breaking all the trends. https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/the-four-global-forces-breaking-all-the-trends

Grand View Research. (2020, July). Artificial intelligence market size & Share REPORT, 2020-2027. https://www.grandviewresearch.com/industry-analysis/artificial-intelligence-ai-market

IFR. (2020, September 24). IFR presents World ROBOTICS Report 2020. https://ifr.org/ifr-press-releases/news/record-2.7-million-robots-work-in-factories-around-the-globe

Massey, R. & Pawczuk, L. (2019, November 1). The future of blockchain and market disruptors | Deloitte US. https://www2.deloitte.com/us/en/pages/consulting/articles/future-of-blockchain.html

Roser, M., & Ritchie, H. (2013, May 11). Technological progress. https://ourworldindata.org/technological-progress

Tilley, J. (2020, October 20). Automation, robotics, and the factory of the future. https://www.mckinsey.com/business-functions/operations/our-insights/automation-robotics-and-the-factory-of-the-future

Luxton, E. (2016, May 11). 4 billion people still dont' have internet access. Here's how to connect them. World Economic Forum. https://www.weforum.org/agenda/2016/05/4-billion-people-still-don-t-have-internet-access-here-s-how-to-connect-them/

Key Trends - Space Commoditization

Cobb, W. W. (2020, December 17). How SpaceX lowered costs and reduced barriers to space. https://theconversation.com/how-spacex-lowered-costs-and-reduced-barriers-to-space-112586

ESA.The cost of space debris. (2020, May 7). https://www.esa.int/Safety_Security/Space_Debris/The_cost_of_space_debris

Jones, H. (2018, July 08). The recent large reduction in space launch cost. https://ttu-ir.tdl.org/handle/2346/74082

Lappas, V., & Kostopoulos, V. (2020, July 22). A survey on small satellite technologies and space missions for geodetic applications. https://www.intechopen.com/books/satellites-missions-and-technologies-for-geosciences/a-survey-on-small-satellite-technologies-and-space-missions-for-geodetic-applications

Lewis, M. (2020, May 31). May 2020 – Commercial Crew Program. https://blogs.nasa.gov/commercialcrew/2020/05/

May, T. (2021, March 03). Japanese billionaire Seeks SPACE friends for a moon shot. https://www.nytimes.com/2021/03/03/world/asia/japan-spacex-moon.html

Morgan Stanley. (2020, July 24). Space: Investing in the final frontier. https://www.morganstanley.com/ideas/investing-in-space

Sheetz, M. (2020, September 26). How SpaceX, Virgin Galactic, Blue origin and others compete in the growing space tourism market. https://www.cnbc.com/2020/09/26/space-tourism-how-spacex-virgin-galactic-blue-origin-axiom-compete.html

SpaceX. (n.d.). Starship. https://www.spacex.com/vehicles/starship/

Drivers

Cardinale, B., Duffy, J., Gonzalez, A., Hooper, D., Perrings, C., Venail, P., . . . Naeem, S. (2012, June 06). Biodiversity loss and its impact on humanity. Nature, 486. 59-67(2012). https://doi.org/10.1038/nature11148

Coldewey, D. (2020, January 29). NASA finds real uses for VR and AR in astronomy and engineering. TechCrunch. https://techcrunch.com/2020/01/29/nasa-finds-real-uses-for-vr-and-ar-in-astronomy-and-engineering/

Fearson, R. (n.d.). Reusable rockets: Expanding space Exploration possibilities with Retrievable Spacecraft. https://www.discovery.com/technology/Reusable-Rockets

IBM. Big data analytics. (n.d.). https://www.ibm.com/analytics/hadoop/big-data-analytics

Lewin, H., Robinson, G., Kress, W., Baker, W., Coddington, J., Crandall, K., . . . Zhang, G. (2018, April 24). Earth BIOGENOME Project: Sequencing life for the future of life. Proceedings of the National Academy of Sciences of the United States of America. https://www.pnas.org/content/115/17/4325

NHGRI. (2019). What is genome editing? National Human Genome Research Institute. https://www.genome.gov/about-genomics/policy-issues/what-is-Genome-Editing

Pool, R. (2020, February 6). AR/VR/MR 2020: The Future Now Arriving. SPIE. https://spie.org/news/ar-vr-mr-2020_the-future-now-arriving?SSO=1

Reddy, V.S. (2018, June 1). The SpaceX effect. New Space, 6(2). https://doi.org/10.1089/space.2017.0032

Rayome, A.D. (2020, March 3). The future of Mars colonization begins with VR and video games. CNET. https://www.cnet.com/features/the-first-frontier-for-mars-colonization-video-games-and-vr/

Wall, M. (2019, November 06). SpaceX's starship may fly for just $2 million per Mission, Elon Musk says. https://www.space.com/spacex-starship-flight-passenger-cost-elon-musk.html

Scenarios

Curry, A., & Shultz, W. (2009, May). Roads Less Travelled: Different Methods, Different Futures. Journal of Futures Studies, 13(4), 35-60.

Dator, J. (2009, November). Alternative Futures at the Manoa School. Journal of Futures Studies, 14(2), 1-18.

Shultz, W. (2015, May). Manoa: The future is not binary. APF Compass.
https://www.researchgate.net/publication/275338406_Manoa_The_future_is_not_binary

Voros, J. (2003). A generic foresight process framework. Foresight 5(3), 10-21.

STRATEGY DEVELOPMENT

Calma, J. (2021, March 15). The climate controversy swirling around NFTs. The Verge.
https://www.theverge.com/2021/3/15/22328203/nft-cryptoart-ethereum-blockchain-climate-change

Fairly, P. (2019, January 2). Ethereum Plan to Cut Its Absurd Energy Consumption by 99 Percent. IEEE Spectrum.
https://spectrum.ieee.org/computing/networks/ethereum-plans-to-cut-its-absurd-energy-consumption-by-99-percent

Ganti, A. (2021, March 9). Tech Bubble. Investopedia.
https://www.investopedia.com/terms/t/tech_bubble.asp

Lafley, A.G., Martin, R.L., Rivkin, J.W., Siggelkow, N. (2012, September). Bringing science to the art of strategy. Harvard Business Review, 90(9), 56-66, 136.
https://www.researchgate.net/publication/230809241_Bringing_science_to_the_art_of_strategy

Nano. (n.d.). [Homepage] .
https://nano.org/

Pisani, B. (2021, February 25). Why stock investors are starting to really worry about rising bond yields. CNBC.
https://www.cnbc.com/2021/02/25/why-stock-investors-are-starting-to-really-worry-about-rising-bond-yields.html

Reuters Staff. (2020, December 3). Tech stock boom a 'bubble waiting to burst': Amundi CIO. Reuters.
https://www.reuters.com/article/us-investment-summit-funds-idUSKBN28D2LO

Van Der Heijden, K. (n.d.). "Scenarios, strategy, and the strategy process". Presearch, 1(1).

IMAGES

[AI Space Factory website's homepage header depicting their 3D printed habitat concept]. (n.d.).
https://www.aispacefactory.com/

Airbus. (2020). [CIMON-2 makes its successful debut on the ISS].
https://airbus-h.assetsadobe2.com/is/image/content/dam/products-and-solutions/space/human-space-flight/iss/CIMON-2-and-Luca-Parmitano-Copyright-NASA-ESA.jpg?wid=1920&fit=fit,1&qlt=85,0

Alex. (n.d.). [Template for science and technology presentation. Plexus style background]. Adobe Stock.
https://stock.adobe.com/ca/images/template-for-science-and-technology-presentation-plexus-style-background/288691510

[Digital artwork of a rotating torus habitat]. (2017).
https://medium.com/r3fl3ct1ons/could-we-actually-create-artificial-gravity-39cbcd9e6be1

ESA/ATG medialab. (n.d.). [Combining high-resolution and novel multispectral capabilities, a swath width of 290 km and frequent revisit times, the new Sentinel-2 mission offers views of Earth's changing lands in unprecedented detail].
https://www.esa.int/var/esa/storage/images/esa_multimedia/images/2015/02/colour_vision_for_copernicus/15250391-1-eng-GB/Colour_vision_for_Copernicus.jpg

[HAVOC Venus Airship Concept]. (n.d.).
https://www.planetary.org/space-images/havoc-venus-airship-concept

ITER. (2021). [The ITER project, shown during construction in February 2020, will be the first experiment to create a "burning," or self-sustaining, fusion plasma.]. POWER Magazine.
https://www.powermag.com/fusion-energy-is-coming-and-maybe-sooner-than-you-think/

Knssr. (n.d.). [3D Rendering of Artificial Intelligence hardware concept. Glowing blue brain circuit on microchip on computer motherboard. For big data processing, ai trading, machine learning, technology background]. Adobe Stock.
https://stock.adobe.com/ca/search?load_type=search&native_visual_search=&similar_content_id=&is_recent_search=&search_type=usertyped&k=3D+Rendering+of+Artificial+Intelligence+hardware+concept&asset_id=285865594

Mcnew, D., & Reuters. (2019, December 4). [A whirlwind of hot ash and embers tore through the Cave Fire in Santa Barbara, Calif.].
https://www.nytimes.com/2019/12/04/climate/climate-change-acceleration.html

Miroshnichenko, T. (2021, February 8.). [Black and White Circuit Board]. Pexels.
https://www.pexels.com/photo/man-person-smartphone-broken-6755081/

NASA/JPL-Caltech. (n.d). [This illustration taken from the Cassini Grand Finale movie shows Cassini's fly-through of the Enceladus plume in October 2015].
https://solarsystem.nasa.gov/internal_resources/1846

NASA. (2019). [Friday's All-Woman Spacewalk: The Basics NASA astronaut Christina Koch works while tethered near the Port 6 truss Friday's spacewalk will be the fourth for Christina Koch].
https://www.nasa.gov/sites/default/files/styles/ubernode_alt_horiz/public/thumbnails/image/iss061e006498.jpg

Offworld. (n.d.). [Artist's impression of OffWorld robots working in swarms on the lunar surface.].
https://cdn.mos.cms.futurecdn.net/5wAPVfM5nsSiL7fb3LsKaS-1024-80.png.webp

Pazani, A. (2018). [Photo Of Woman Wearing Turtleneck Top]. Pexels.
https://www.pexels.com/photo/photo-of-woman-wearing-turtleneck-top-2777898/

Pixabay. (2016, March 14). [Photo of Brown Bare Tree on Brown Surface during Daytime]. Pexels.
https://www.pexels.com/photo/photo-of-brown-bare-tree-on-brown-surface-during-daytime-60013/

Sokolovska,L. (n.d.). [Stars and galaxy outer space sky night universe black background]. Adobe Stock.
https://stock.adobe.com/ca/images/stars-and-galaxy-outer-space-sky-night-universe-black-background/141240657

SpaceX. (2015, December 30). [SpaceX]. Pexels.
https://www.pexels.com/photo/space-rocket-orbit-galaxy-23769/

SpaceX. (2017).[White Outer Space Satellite]. Pexels.
https://www.pexels.com/photo/white-outer-space-satellite-586056/

[Telexistence's Telesar V robot]. (2018).
https://www.geekwire.com/2018/beyond-avatar-xprize-ana-reveals-grander-vision-robotic-telepresence/

Wallstabe, J. (n.d.). [Stunning aerial drone helicopter view of lava fields and forests after a recent eruption of Kilauea volcano on the Big Island of Hawaii, USA]. Adobe Stock.
https://stock.adobe.com/ca/images/stunning-aerial-drone-helicopter-view-of-lava-fields-and-forests-after-a-recent-eruption-of-kilauea-volcano-on-the-big-island-of-hawaii-usa-cloudy-day-with-spots-of-sunshine-tourist-destination/244147977?asset_id=244148353