Rutherford BUSINESS INSTITUTE

engineering new zealand te ao rangahau

Te Ao Rangahau kei te heke mai

Foresighting Engineering 2050–2060

Summary

If you think for a moment about the climate issues, decarbonisation, sustainability, zero emissions, zero waste, resilience, declining biodiversity, massive species loss, significant changes to all food and the agriculture industry, loss of petrochemical and plastics industries and the massive changes to the automotive and transportation industry, new fuels ,Hydrogen, EVs or ammonia, continued climate heating, flooding, desertification, storms and cyclones the advent of AI, AGI and singularity and all of it shrouded in massive population increases (3.5 Billion extra by 2048) with housing, increasing inequality and declining food security issues then one can see easily that the global questions for the next several decades to 2050 and beyond is characterised by deep complexity of a degree and level we certainly have not seen since the green revolution in agriculture in the 1960s when the planet required a four-fold increase in food production. The production increases (volume as well rate) have researched indicate that we are entering a zone of unknown unknowns and we will have societal divisions on an unprecedented scale. The question we must ponder at the BlackRoom strategy meeting is where does the engineer fit in this future and what should their membership organisation be reshaped to or repurposed in order to remain relevant to these engineers. Engineers are generally across all sectors of the society from infrastructure, generation, transmission, buildings, hospitals, housing inequality and poverty, bio diversity loss, automation and autonomy etc. As such their impact going right up to 2050 is highly significant but we believe, substantially different from now in 2021. Engineers are characterised by their problem solving ability. In the future however as the research tells us they will be still problem solving but in the area of complex unknowable. This reality is the key to what the organisation (Eng NZ) will need to pivot to. We have done it before.

Because of the interconnectedness of engineers, its institutions to global engineering the scope of this work is large. For the last 90 days we have been collecting and cataloguing hundreds of papers and articles from around the planet as well as interviewing engineers and owners of major engineering companies in order to get a handle of where our profession and its membership Institution fits in the future both near and far. As the future is fast approaching in terms of technology we will be looking right out until 2070 but focusing the Strategic foresighting statements and backcasting on 2050 as this is still within the working life of the majority of our younger generation engineers. For any foresighting project the secret sauce is research, and this project where the Institution is subject to many sets of mega trends the research scans were widely set. A five month research program has investigated all the likely trends, disruption and impacts of systems development, the global future system state, climate, decarbonising etc, and the market's innovations from a futures point of view. Within the research documentation which is included for reasons of record in the appendices are the 2050 plausible scenarios of where the planet might be going from ARUP. ARUP is an originally Norwegian based engineering consultancy group and it seemed to us to be entirely appropriate that we are mindful of their superb work. This report will follow the research period. Post the comments period for the preliminary report a 'BlackRoom' was be held in early 2022 .

'In the decades ahead, waves of exponential technological advancements are stacking atop one another, eclipsing decades of breakthroughs in scale and impact. Emerging from these waves are a number of "Metatrends," likely to revolutionise entire industries (old and new), redefine tomorrow's generation of businesses and contemporary challenges. Among these meta-trends are augmented human longevity, the surging smart economy, AI-human collaboration, urbanized cellular agriculture, and high-bandwidth brain-computer interfaces, massive food demands just to name a few.' (Diamantis.com) The intervening decades to 2050 will be turbulent, destabilized both by technology disruptions that upend the foundations of the global economy and by system shocks from pandemics, geopolitical conflict, natural disasters, financial crises, and social unrest that could lead to dramatic tipping points for humanity including mass migrations and even war. In the face of each new crisis we will be tempted to look backward rather than forward, to mistake ideology and dogma for reason and wisdom, to turn on each other instead of trusting one another. If we hold strong, we can emerge together to create the wealthiest, healthiest, most extraordinary civilization in history. If we do not, we will join the ranks of every other failed civilization for future historians to puzzle over. Our children will either thank us for bringing them an Age of Freedom, or curse us for condemning them to another dark age. The choice is ours. This is Engineering NZ's Kodak moment. The members that attended the BlackRoom were unequivocal in their support of the Post Anthropocene engineering option. This strong approval which is evident throughout the Mural wall chart involves a totally new kind of engineering which is completely ahead of the current paradigm. Engineering New Zealand will need to establish an entity to pursue this kind of engineering at pace. In terms of climate change and the effect on the planet there i no time to lose. Post Athropocene engineering will take several decades to fully realise but in order to do so it must start now with the calculation of complex unknown unknowns immediately.

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Contents

Introduction

The World of Engineering

Because of the interconnectedness of engineers, its institutions to global engineering the scope of this work is large. For the last 90 days we have been collecting and cataloguing hundreds of papers and articles from around the planet as well as interviewing engineers and owners of major engineering companies in order to get a handle of where our profession and its membership Institution fits in the future both near and far. As the future is fast approaching in terms of technology we will be looking right out until 2070 but focusing the Strategic foresighting statements and backcasting on 2050 as this is still within the working life of the majority of our younger generation engineers. For any foresighting project the secret sauce is research, and this project where the Institution is subject to many sets of mega trends the research scans were widely set. A five month research program has investigated all the likely trends, disruption and impacts of systems development, the global future system state, climate, decarbonising etc, and the market's innovations from a futures point of view. Within the research documentation which is included for reasons of record in the appendices are the 2050 plausible scenarios of where the planet might be going from ARUP. ARUP is an originally Norwegian based engineering consultancy group and it seemed to us to be entirely appropriate that we are mindful of their superb work. This report will follow the research period (Draft for comment by the end of December 2021). Post the comments period for the preliminary report a BlackRoom will be held in early 2022 . The BlackRoom meeting will be held in Engineering NZ's Head Office in Wellington New Zealand.

The purpose of the BlackRoom is to deliver the following steps:

- Breakdown the scenarios (Possible, Probable, Plausible, Preferred)
- Deep thought analysis (multiple horizons views)
- Visualisation of the future system State (Steel Mann)
- Sensemaking and the Final Strategic Foresighting Statement (2050)

Post the workshop will be the production of the following in the form of a second final report:

- Strategic foresighting statement (From the BlackRoom)
- Backcasting from 2050 back to present (not included in this version)
- Final Roadmap.

Recommendations to ENG NZ Executive

Purpose and Aim

The purpose of this research project was to identify and describe global meta-trends, critical uncertainties, market's innovations and their implications that are likely to influence the business and sectors that Engineering New Zealand are currently involved with and to propose, given the meta-trends, new directions for the Organization in the coming decades. The Organisation's executive felt that with the astonishing rate of change in their sector that a view of the future was in order, so that the existing corporate paradigm did not become irrelevant to its members.

The aim of the project is to provide a set of recommendations that the organisation should pivot to a role that would be relevant to its members in the coming decades.

Structural Framework

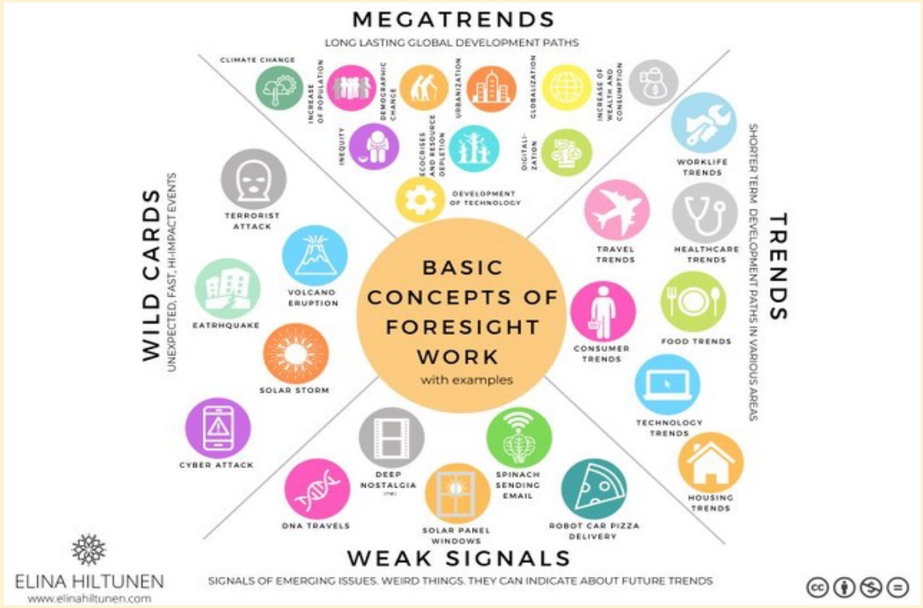
One of the key challenges with a project of this breadth and magnitude is how to organise all the analysis into a story that is coherent, integrated, and forward looking. We constructed this report around two central organising principles: identifying and assessing broad forces that are shaping the future strategic environment, and then exploring how populations and leaders will act on and respond to the forces. Based on those organising principles, we built the analysis in four general sections.

First, we explore structural forces in four core areas: demographics, environment, economics, and technology. We selected these areas because they are foundational in shaping future dynamics and relatively universal in scope, and because we can offer projections with a reasonable degree of confidence based on available data and evidence. The analysis in this section involves a higher degree of uncertainty because of the variability of human choices that will be made in the future as the ARUP 2050 scenarios show us and as we have embodied them into Waves of change depending on how they play out.

The second section examines how these structural forces interact and intersect with the engineering sector on a world basis to affect emerging dynamics at multi levels of analysis: individuals and society, states, and the international system which are depicted as waves of change scenarios. We focus on identifying and describing the key emerging dynamics at each wave, including what is driving them and how they might evolve over time.

The third section identifies several key uncertainties regarding the professional engineer and uses these to create five future "Waves of Change" for the professional engineering world in 2040. These Waves of change scenarios are not intended to be predictions but to widen the aperture as to the possibilities, exploring various combinations of how the structural forces, emerging dynamics, and key uncertainties could play out.

The fourth section explores the long-term future of the institution while being mindful of the Waves of change from the first three sections. another challenge is choosing which issues to cover and emphasise, and which ones to leave out. We focused on global, long-term trends and dynamics that are likely to shape communities, countries and the international system for decades and to present them in a broader context.



Research Methodology

There are six methods to the Engineering NZ Research Literature Review and the results (and themes) are summarised in this report. The research material is derived by the six methods shown on the facing page and are further arranged into themes. The Appendices hold the lists of the literature sources. This research has been conducted from the view point that it is the 'Market' that generates innovations not necessarily individual enterprises. The final organising themes are fully synthesised, summarised into 5 key themes and and these are translated into "Waves" of Change across the four structural sections and taken through to the BlackRoom for consideration. The ten Organising themes in each of the four structural sections summarising the Basic themes are shown below as Findings.

In generating the Engineering NZ's view of the future we have applied a traditional Literature Review approach but fashioned it around futures thinking. The future of business is uncertain the face of increasing change. The speed of change over time is constantly accelerating across technological, societal and geopolitical settings. Alongside this, governments, companies and decision makers require relevant up to date information to better understand the future opportunities, threats and potential disruptions at both global and local levels. Many sophisticated methods are being utilised to capture this data and turn this into readily available information.

Despite this, the world over seems to be constantly disrupted with unknown and unpredicted technology, business models, economics, politics, or natural events in an era of hyper-competition, technology disruption and increased customer power. The resulting knee-jerk reactions from government and business alike when surprised by a new 'mega-trends' or "an inevitable evolution leading to a change [within] society, business economics or [the] environment" is unsatisfactory.
In fact, it is rapidly becoming clear that the historical ways of thinking based on "our ways of working and the assumptions and models upon which we have structured our organisations are no longer useful or relevant".

Looking at the combinations and interactions of these existing mega-trends is a useful exercise for governments and organisations to understand impacts and opportunities. In order to successfully analyse these trends, an effective approach is required to make sense of all the data to turn this into a form which is effective for decision making. This involves gathering, analysing and interpreting trend intelligence, and integrating it into strategy and planning. Some approaches of utilising big data and mega-trends are continuous scanning, using models and simulations, moving from static data gathering to dynamic reconnaissance, foresighting tools and utilising integrated intelligence service providers.

The next step for governments and organisations is to then turn the resulting information into process to transform the way they conduct day to day business. The resulting outcome of this is an end to end process which integrates future thinking, planning and strategising into the business as usual mindset. Our approach suggests a way which this end to end process could look like incorporating future thinking.

LITERATURE RESEARCH

The purpose of the literature research was to identify the key themes and current engineering sector issues as well as all the future issues associated with AI and AGI. The source documents are listed in the appendices.

STEEP ANALYSIS

The early stage of the project consisted of identifying the drivers of change by means of five comprehensive STEEP Analysis reports, which cover Social, Technological, Economics, Environmental and Political trends around the world using sources such as WEF ARUP and others.

INTERVIEWS

Significant confidential interviews were conducted by **email** and phone around the world to ascertain the level of current AI and AGI development within the Engineering sectors areas. In addition this technique was used to identify the market levels and strengths.

SCENARIOS

The purpose of scenarios is to differentiate and describe the elements that make up possible, probable and preferable future. Scenarios are especially useful as they can illustrate the many possible drivers of change in the global environment to 2050 and beyond. For this project extensive use has been made of the ARUP 2050 Scenarios.

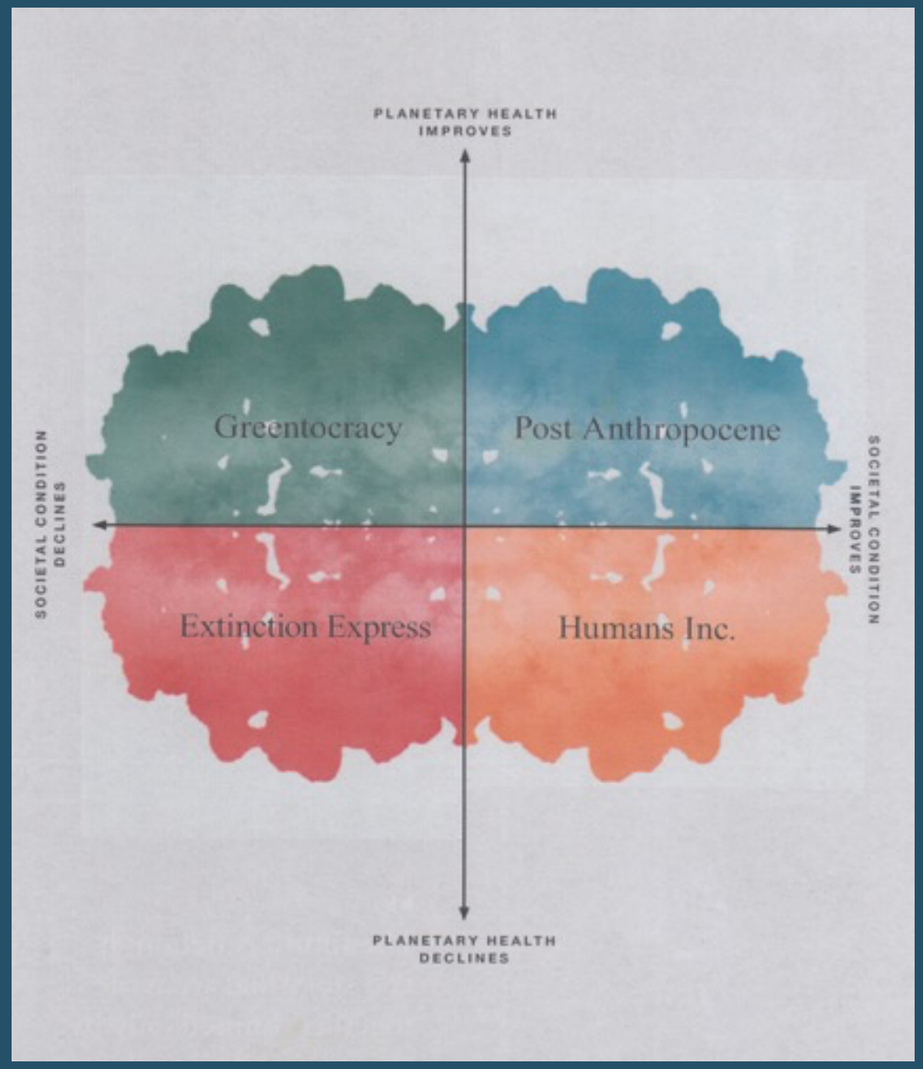
THEMES

A thematic analysis is a common way to organise interview data into descriptive categories. The research utilises Basic, Organising and Key themes as a way to integrate the data into recurring, meaningful patterns and concepts. A basic theme is the lowest-order theme, which details a recurrent experience. Basic themes are then placed into coherent groupings to construct categories at a more conceptual level, forming the organising themes - the mega trends. This construct is shown on the Transition Maps in the Findings section.

FORESIGHTING

Lastly, the organising themes are then grouped into the overall Waves of change key themes, which form the basis of the foresighting statement driven by the ulitmate BlackRoom considerations.

ARUP 2050 Plausible Futures



- Post Anthropcene Both people and planet are on the path to a regenerative world. Society consumes resources at a rate at which they can be replenished, populations are diverse, and societal structures are balanced.

- Greentocracy. Climate action and biodiversity recuperation are the top line of every national and transnational agenda. The results of the global efforts have been unprecedented for the environment, but not without significant sacrifice from people who are realizing the trade-offs didn't quite work out for them. Humanity now lives in self imposed servitude to the environment under the mantra happy planet happy people.

- Extinction Express Climate change and the inexorable consumption of earth's resources has resulted in fundamental destabilization of natural systems. Resource, energy, water and food shortages are pervasive across the world. Environmental consciousness is largely non-existent.

- Humans Inc. For most people life is as good as it's ever been. The planet on the other hand is not as healthy. In many ways, this period reflects a business –as –usual trajectory from 2020. The condition of humanity has continued to improve at the expense of the environment.

Foresighting

The systematic examination of the future in the sense of modern futures research is not a recent phenomenon "it can be traced back to the end of World War II…. futures research per se emerged as a quasi-formal discipline [during] this period…" (Von der Gracht, Vennemann, & Inga, 2010) During the 1950s, futures methodologies, such as the scenario or Delphi technique, were developed. In the late 1970s, Strategic Issue Management (SIM) emerged as a method to support the corporate planning process and to cope with uncertainty in the business environment (Von der Gracht, Vennemann, & Inga, 2010).

Since the late 1980s the term 'foresight' has increasingly been used. It describes an inherent human activity used every day by individuals throughout society and business and draws on wider social networks than 'futures studies' view foresight less as a technical and analytic process, but as "a human process permeated by a dialectic between the need to know and the fear of knowing" Corporate foresight has become the prevalent term used by many companies for their futures research activities (Von der Gracht, Vennemann, & Inga, 2010).

Foresighting has been defined as "the learned thinking capacity to explore possible futures to inform decision making today" (Conway, About Foresight - Thinking Futures, N.D). Foresighting is a way of future thinking which is open, long term, collaborative and expansive. It moves beyond mainstream, short term, strategic, cross disciplinary and cross industry current thinking into long term patterns which take notice of changes focuses, interactions and patterns (Conway, About Foresight - Thinking Futures, N.D). Using foresighting as a planning tool allows for proactive responses to issues and problems, rather than a reactive, subjective and emotive response to change. Using foresighting helps drive strategic future thinking around long term future change. Such as "what changes are coming that will undermine our current business model, or who will our clients be in 10-20 years…" (Conway, About Foresight - Thinking Futures, N.D).

Foresight is first and foremost a state of mind that determines how you think about the future (Conway, Foresight: An Introduction, 2014). It is a way of doing and thinking that is unlike current conventional strategic planning. It is essentially a new mindset which is required by organisations to anticipate and prepare for the future. A mindset that embraces individualism, collaboration and innovation. A mindset that addresses societal and environmental, as well as economic, imperatives. Above all, a however, a mindset that can tackle complexity, uncertainty and change (Ratcliffe, 2008).

Foresighting done well expands future options available and enhances the operational context of the strategy. It uses new ideas and options to develop into proactive responses to change. Done less well, it results in an "interesting experience but there is little change to how strategy is developed or the understanding of the scope of change shaping the organisation's future" (Conway, Foresight: An Introduction, 2014).

The main principals of the foresighting approach according to Ratcliffe is to:

-"Look far way, as prospective is a long term activity;

-To look breadthways, in order to examine interactions;

-To look in-depth, so as to become aware of the most important trends and issues;

-To take risks, because new adventures can lead to the change of long-term plans; and

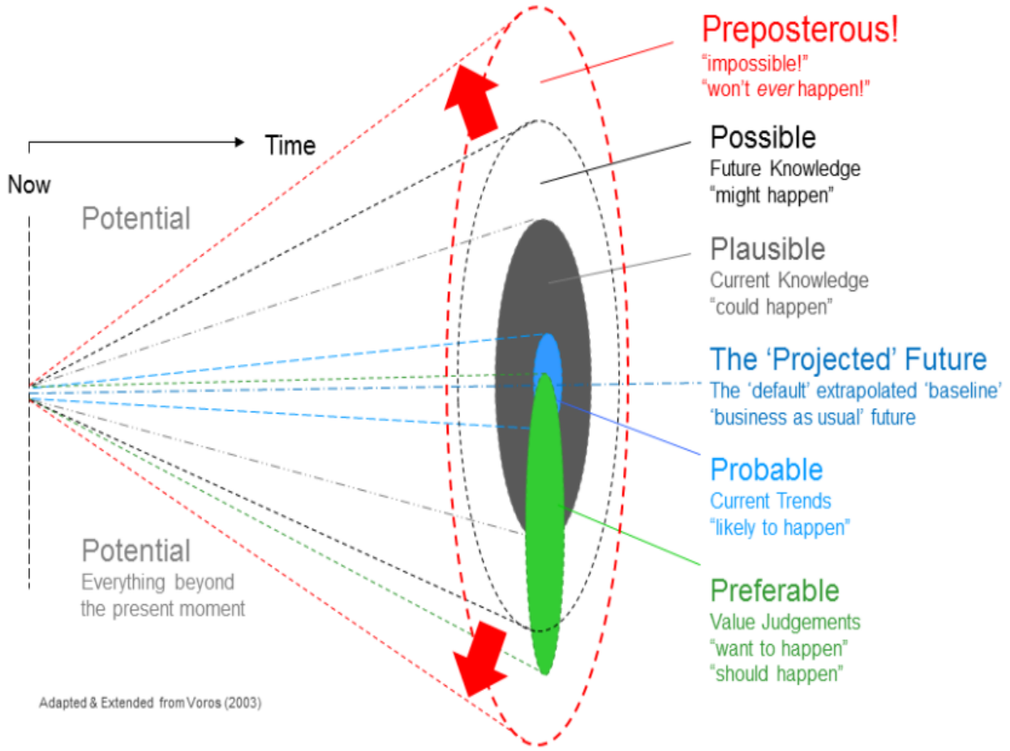
-To take care of humanity, as prospective should fundamentally be concerned with implication for people". (Ratcliffe, 2008)

However major challenges do face decision makers in adopting a futures orientated approach as a result of fragmented, unstructured and bias information. Ratcliffe's suggestion to overcome these challenges is to adopt the five key fields: "fostering a culture of foresight, envisioning change, exploring creativity, communicating futures, and championing prospectives" (Ratcliffe, 2008).

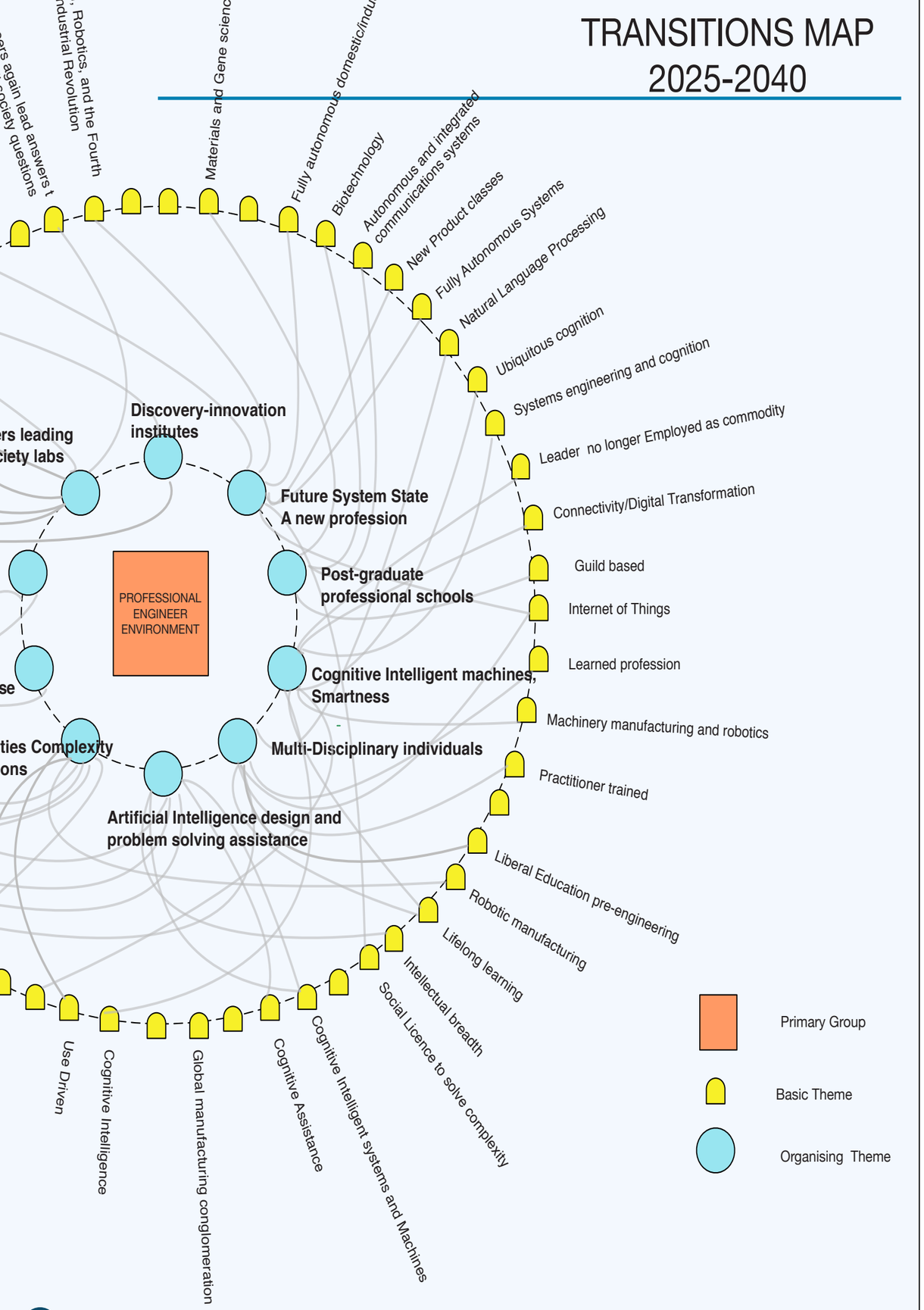
Further to this Ratcliffe believes that "we can shape the future if we can first imagine it" and then by having a value – driven system that fosters the evolution of the socially sustainable organisation.

Foresighting can be used in two different situations where it can add to the innovation process. The first is before the idea is born and the second is when the idea is already established. In the first situation, foresighting is applied as a concept to inspire and create new ideas for innovation or services. In the second situation, foresighting can help to assess either the commercial and technological viability and/or to adjust or abandon the innovation process (Von der Gracht, Vennemann, & Inga, 2010). There are in addition a range of tools within foresighting which can be utilized to strengthen the foresighting process and cut through the sheer volume of raw data at part of the innovation process. Milojevic and Inayallullah believe foresighting focuses not on the veracity of the future—is a future true or false—but on discovering and creating new stories that better meet needs and desires of the preferred/wished for future (Milojevic & Inayatullah, 2015).

Furthermore, Milojevic et al. believe; the foresighting concept balances between the empirical, interpretive, critical, and action learning concepts of futures studies. It uses the forecasts of the empirical but recasts them as possible stories. That is, unlike the empirical approach of futures studies, which sees narratives or qua data as accurate and a precise description of an objective reality and sees reality as being constantly negotiated by stakeholders. Like the critical, it challenges assumptions and interests but does so to transform or enrich the worldview of the questioner, not just to disrupt the categories of that which is being questioned. Action emerges from this deep questioning of data, meaning, worldview and metaphor (Milojevic & Inayatullah, 2015).

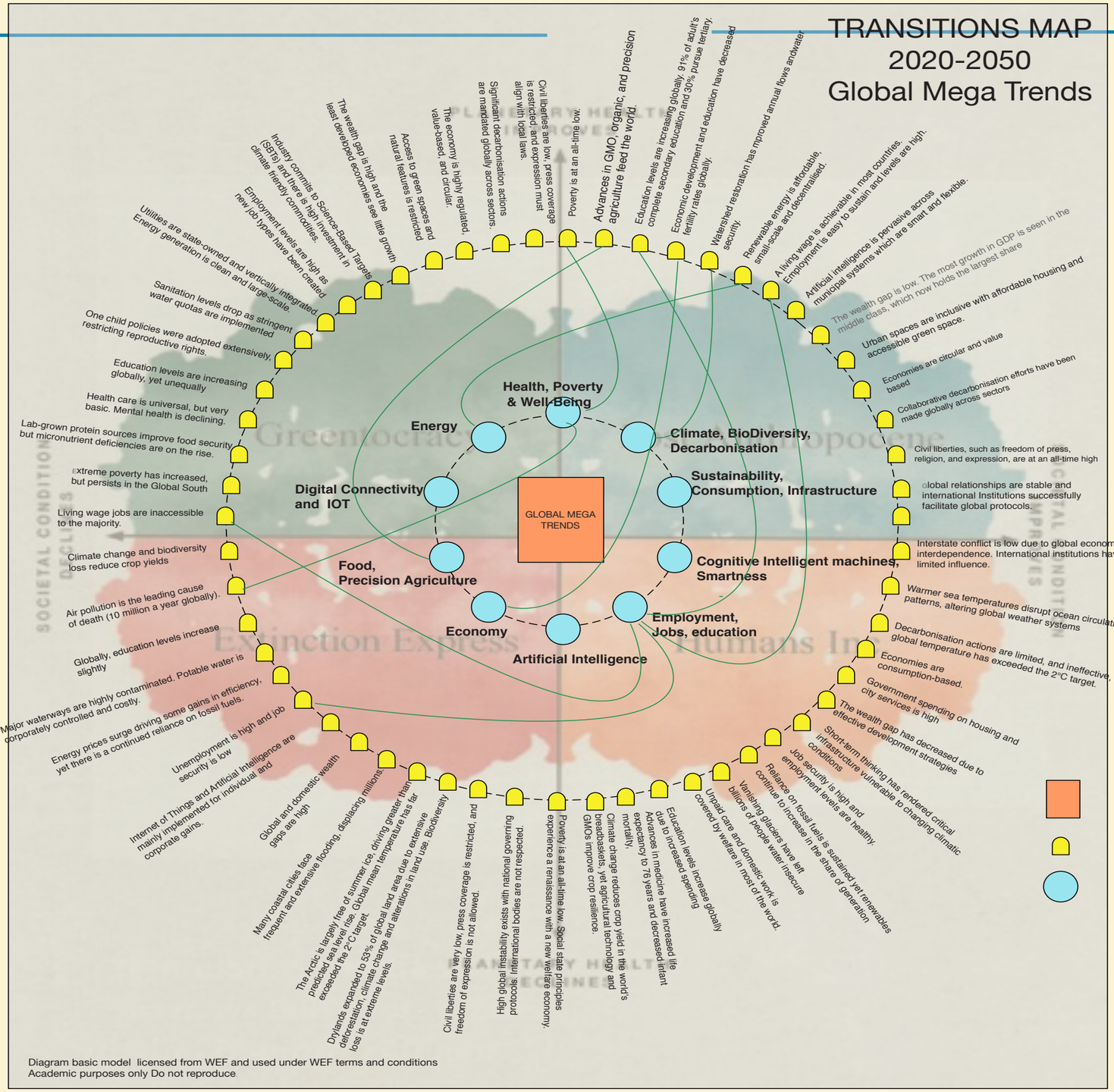


TRANSITIONS MAP 2025-2040



FINDINGS
Global Mega-Trends

FINDINGS
Global Waves of Change



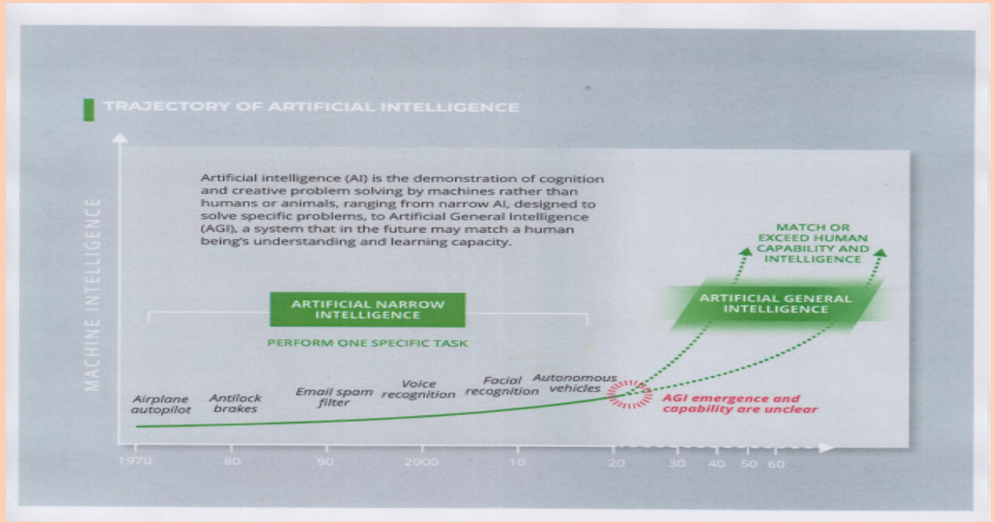
FINDINGS
Global Mega-Trends

A number of trends finally emerged from the findings, which highlight the responses from the participants of the study, literature research, STEEP and research interpretations along with the excellent work done by ARUP . Each Basic Theme was treated with the same level of importance, including critical uncertainties and predetermined aspects, and therefore are not differentiated by the number of references. The Basic Themes were formed into Organising Themes which were then collected together as Key or Mega/Meta Trends. The basic themes will be placed within this report for completeness within the appendices. The Basic Themes are presented on a Transitions Map in this section. The Transitions Map follows the World Economic Forum Mapping concept.

The Meta-trends (key themes) are taken into the BlackRoom for consideration by the research team as disruptive "Waves of Change". The BlackRoom process is described below. The developed "Waves of Change" are taken from the Meta-trends into the BlackRoom and the final Strategic Foresighting statement derived during the BlackRoom deliberation. The resulting Foresighting statement and the backcasting with road maps is the subject of the final report. For the overall Global Waves of change we have referenced the ARUP four plausible 2050 scenarios and the waves that will affect out businesses, organisations, countries and people are noted below.Jo Da Silva ARUP Fellow and Director puts it like this. " It is now recognised that human systems are putting our planetary systems under significant stress. Thus, we thought it appropriate to consider four worlds in which these two systems would be juxtaposed as the axes. The world today is marked by rapid change. Some trends point towards human progress, others indicate an increasingly perilous outlook for the planet Each of the resulting scenarios are compelling for different reasons: from a world in which both the societal systems and natural systems move towards collapse, to one where sympathetic symbiosis is the baseline for all activities on our planet. We believe that these four worlds are consistent, coherent and plausible. Indeed, there are indications that each scenario can already be found somewhere on Earth.

Wave One: We live in a world characterised by increasing complexity and uncertainty. Climate change, biodiversity loss and resource scarcity threaten future generations and will require urgent global action and collaboration over the next decade. Meanwhile, digital technology, urbanisation and changing demographics will impact communities, businesses and economies, radically affecting every aspect of our lives. The future, 2050 and beyond, will be determined by our ability to address today's environmental challenges and social changes to meet the needs of nearly ten billion people who will be primarily living in urban areas.

Wave two: Both people and planet are on the path to a regenerative world. Society consumes resources at the rate at which they can be replenished, populations are diverse, and societal structures are balanced. Humanity is well on its way towards a shared consciousness and an understanding of Earth's limited resources – that production and consumption are intrinsically linked to the natural environment. There is no 'away' to throw discarded things. Global ecosystem services are recognised and valued, helping to improve the quality of both planet and society. Circular processing measures are in place and most nations abide by them. Full life-cycle and ecological resource assessments are mandatory for all new products. Global biodiversity loss has halted, and protected areas are seeing ecosystem recovery. Everyone has, and knows, their carbon quota and daily spend; AI provides daily updates, and state governments penalise overspend. The multi-stakeholder vision for an equitable and thriving future has prevailed. All global leaders are proud to wear the 'thriving planet = thriving people' symbol showing their support for the drive towards the post-Anthropocene epoch. Cities around the world have transitioned from being in conflict with nature to something approaching symbiosis.



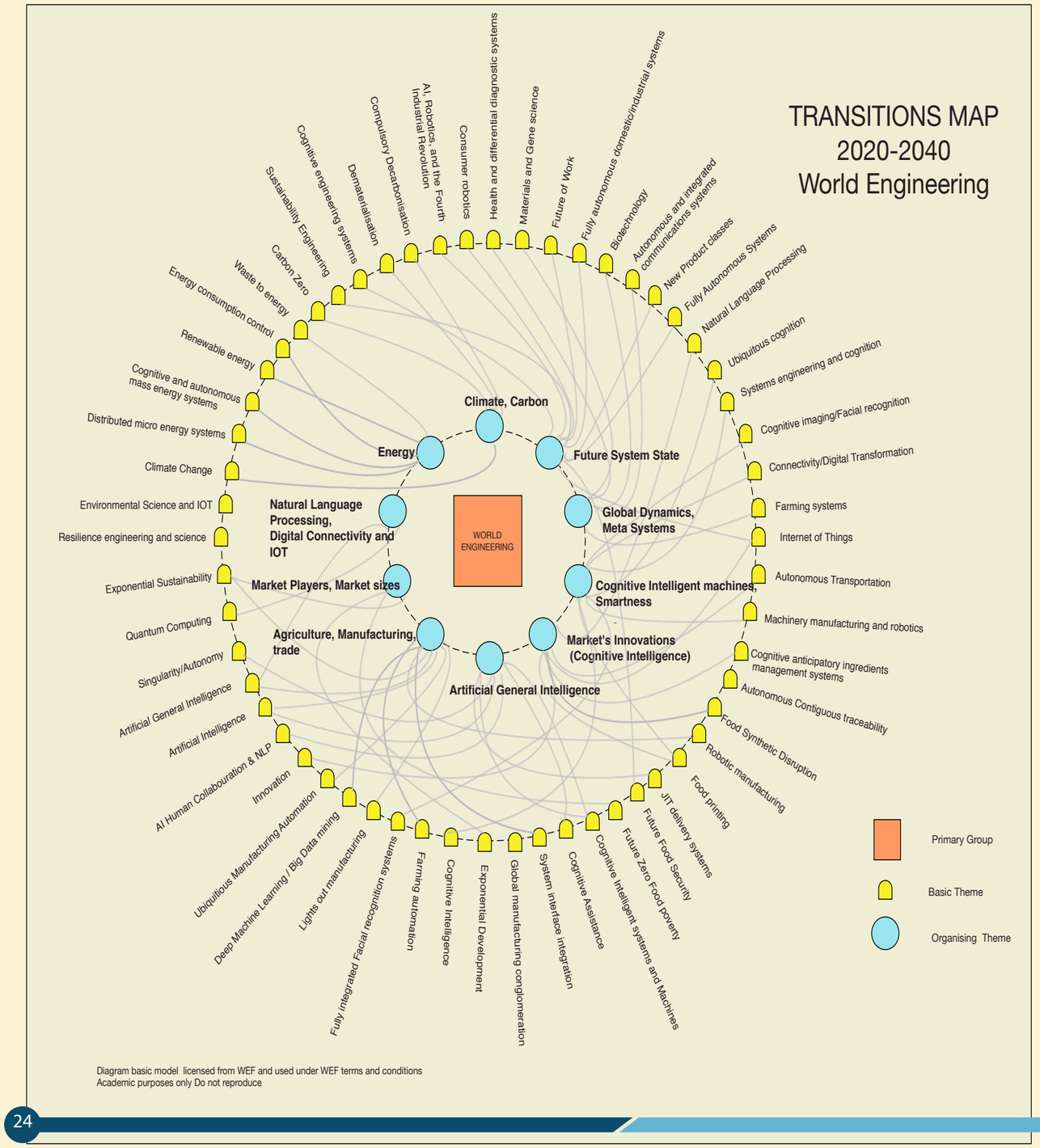
FINDINGS
Global Waves of Change (Scenarios)

Wave three: Climate action and biodiversity recuperation are the top-line of every national and transnational agenda. The results of the galvanised global efforts have been unprecedented for the environment, but not without significant sacrifice from people who are realising the trade-offs did not quite work out for them. Humanity now lives in self-imposed servitude to the environment under the mantra of 'happy planet, happy people.' For most of the last two decades, the Earth and its health have enjoyed the highest priority in the public consciousness. The scale and speed of environmental degradation of the first quarter of the century, with extreme weather events, rising urban air pollution and climate migration, drove governments and major global cities to act swiftly, and strictly, on climate action. Popular unrest and ardent civil demand led to unanimous agreement that everyone must help the planet to heal. Protected lands have expanded worldwide, and significant resources have been allocated to restoring ecosystems. The extinction curve is flat and many species previously on the brink of extinction are regenerating. The effects of climate change can still be felt and sea levels continue to rise, yet the impacts are less severe than expected. Achievement of the targets came at a much greater expense to society than expected. The changes to where people lived, what they ate and how they travelled were sudden and extreme. They permeated every aspect of daily life. A myriad of new job types was created but most were dangerous and undesirable, as workers were tasked with cleaning up environmental pollutants and processing materials for re-use. Extreme urban densification, driven by urban growth boundaries for land-use regeneration, led to a premium on space. Pervasive carbon taxation and individual carbon allowances have severely slowed consumerism for the aspiring global middle-class. To save on their carbon allowance, people regularly repurpose used items and upcycling is at an all-time high, with a thriving 'Do Everything Yourself (DEY)' culture. In many countries, rubbish collection and prospecting are a reliable income stream.

Wave Four: Climate change and the inexorable consumption of Earth's resources has resulted in fundamental destabilisation of natural systems. Resource, energy, water and food shortages are pervasive across the world. Environmental consciousness is largely non-existent. The established world order has shifted, and the global centre of power has moved to the East. China has a strong economic presence and position globally and dominates the research and manufacturing of technologies. The incentive to reach and operate in these inaccessible and inhospitable locations is greater than ever; access means the ability to harvest rare materials and resources that are increasingly scarce on Earth. While the USA, China, Russia and Europe conduct the vast majority of extractions, Japan, India, Indonesia, Iran, Brazil and others are expanding their presence, leading to an increase in resource conflicts. Natural resources that were previously taken for granted and considered basic human rights – such as water, air, ozone, land and the oceans – are now genuine commodities. Water sources are highly regulated with restricted access; corporations now hold a monopoly over the majority of the global water supply. Those who can't afford to pay for the premium cost of water must rely on localised, often contaminated water sources. Similarly, clean air is accessible only to those who can afford it. Agricultural systems suffer extensively from the transformed climate and regularity of extreme weather. Geo-engineering and GMO crop development are the only way to feed the global population.

Wave Five: For most people, life is as good as it's ever been. The planet, on the other hand, is not as healthy. In many ways, this period reflects a business-as-usual trajectory from 2020: the condition of humanity has continued to improve at the expense of the environment. Climate considerations have come third, subordinate to economic development and societal wellbeing. When coordinated action continued to falter on a global level, the super-economies settled for ambitious adaptation programmes. Future-proofing their own critical infrastructure while protecting their populations is a priority. A sense of urgency for climate action is palpable, but "Why should we go first?" or "Not in My Backyard" dominates the dialogue. Thus, most national governments hesitate or delay the needed large-scale actions. The Netherlands, most of Scandinavia and Germany are a few places that have started trying to mitigate their impacts on the planet by introducing carbon-free transport weeks complete with penalties and fees for those who do not comply. Norway, Finland, Singapore, Costa Rica, and California have implemented Personal Carbon Limits. Many cities are taking an active role in developing urban agriculture in an attempt to secure their populations' food supplies and reduce reliance on surrounding areas. Despite these localised efforts, the exploitation of planetary resources continues almost unabated.

FINDINGS
World Engineering Trends



FINDINGS
World Engineering Waves of Change

As can be seen from the previous page the themes from the research were grouped into organising themes which were further grouped into Key themes or meta-trends. These mega-trends are translated into the "Waves of Change" that will affect all business and industry sectors over the period 2020 to 2050. The Waves of Change with their explanations are as below:

The Waves of Change - World Engineering

Wave One : Hyper Velocity Automation

In the decade ahead, waves of exponential technological advancements are stacking atop one another, eclipsing decades of breakthroughs in scale and impact. The speed of this activity exceeds the exponential pace most were expecting and is called hyper-velocity by this report. Applying advanced intelligence and cognitive technologies enables organisations to respond dynamically to changes in demand and customise product, ensure high product quality, and optimise production processes in real time. Autonomy for all systems is the end game and all process manufacturing companies need to start on this journey now. Cognitive intelligent networks are ubiquitous and fully integrated within and across all sectors. Congregation of Industrial 4.0 and big data systems.

Wave Two : Deep Sector Disruption

Severe disruption of all manual and people operations of all processing and harvesting industries as cognitive automation is applied from 2025. Within the Food industry and many others this is acute and has already commenced and will be intensified over the next two decades. A driver of this disruption is the COVID 19 pandemic. Food supply over the next three decades, given the extreme volumes required, will be hyper-efficient and artificial general intelligence and autonomous systems are required to make it happen. Wherever possible humans will be removed from the production lines.

Wave Three : Interdependent Synchronous Innovation

At a pace never seen before the market demand for synchronous and interdependent automation development is unprecedented. Funding for Natural Language Processing, Artificial General Intelligence and Cognitive intelligent systems to be developed synchronously is at a level not seen before in automation development. In the next decade massive funding of start-ups in this area will be astonishing. Much of the development will be open-source given the speed and synchronicity of it. Most autonomous systems will be open source.

Wave Four : Mandated Carbon Neutrality

Climate change, carbon neutrality will be fully mandated against all manufacturing companies worldwide over the next two decades starting immediately. Sustainability will be the market entry price for many jurisdictions. As the planet moves to a Hydrogen or electric economy manufacturing will move with it.

Wave Five: Cognitive Collabouration

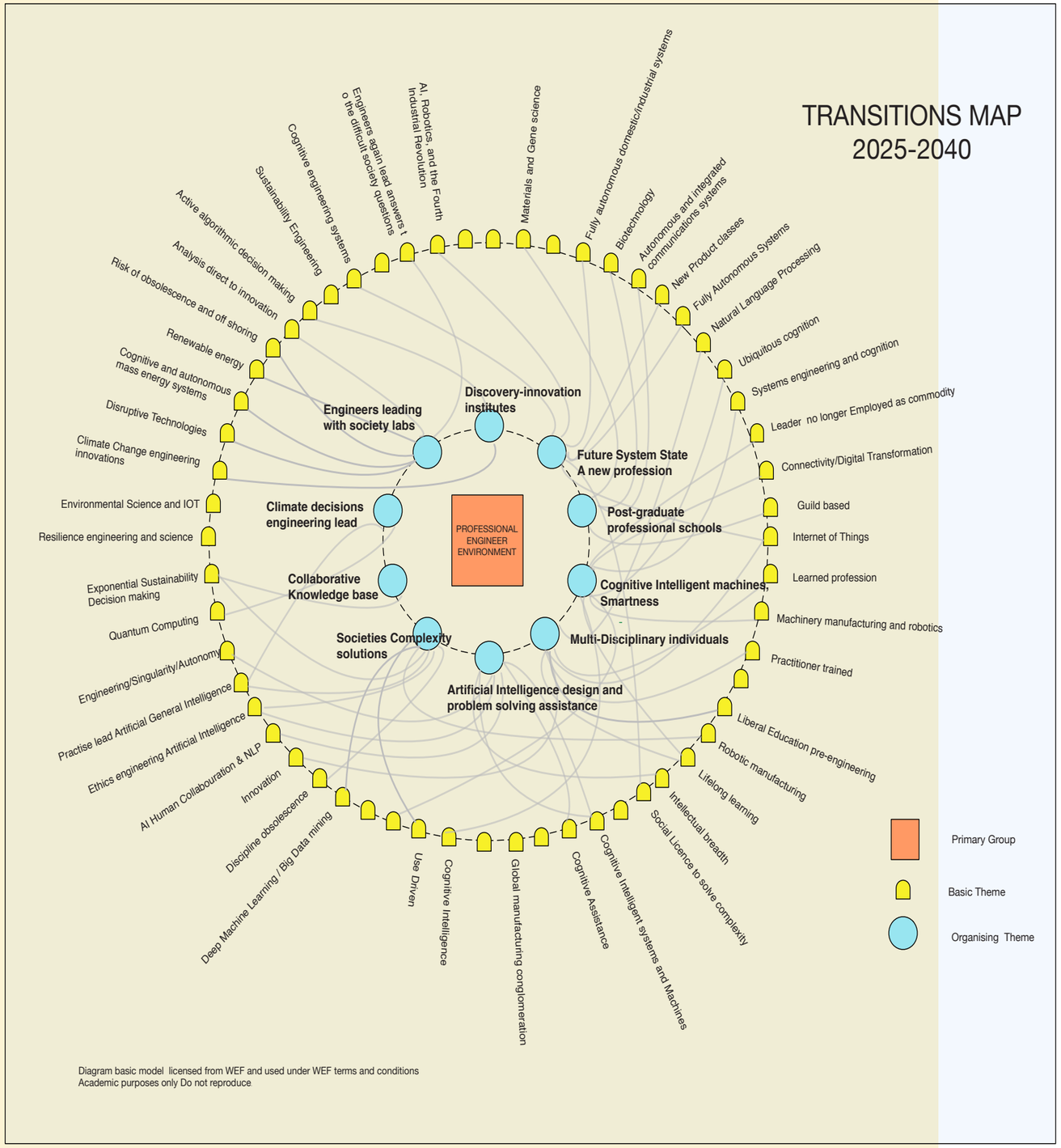
As Natural Language Processing is fully developed the demand for cognitive intelligence collabouration will occur with rapid application for all human-machine interfacing. Consumer demand for this facility will drive system design for all consumer systems. All consumer facing systems by 2050 will be autonomous. All retail and commercial operations will be light out along with most manufacturing. There will be no human operators in call centres, information facilities, banks, insurance, local government, super-markets, etc.

This mega-trend is driven by the convergence of: low-cost space launches, hardware advancements, 5G networks, artificial intelligence, materials science and surging computing power, the convergence of: digitalization, demonetization and democratization, and the convergence of: various biotechnologies (CRISPR, Gene Therapy), genome sequencing, and

Wave Six : The Perfect Storm

For Engineering NZ all of the above 'Waves of Change' are in a state of flux with all the elements happening at the same time. All these elements occur as the world population and food demand goes exponential and the imperative of climate change along with the need for cognitive intelligence, sustainability, resilience in manufacturing 6.0 and big data.

FINDINGS
Professional Engineer Trends



FINDINGS
Professional Engineer Waves of Change

As can be seen from the previous page the themes from the research were grouped into organising themes which were further grouped into Key themes or meta-trends. These mega-trends are translated into the "Waves of Change" that will affect all business and industry sectors over the period 2020 to 2050. The Waves of Change with their explanations are as below:

The Waves of Change - Professional Engineer

Wave One : Design systems Automation

Applying advanced intelligence and cognitive technologies enables engineers to respond dynamically to changes in demand and customise product, ensure high product quality, and optimise production processes in real time. Autonomy for all systems is the end game and all engineers of all disciplines need to start on this journey now. Cognitive intelligent networks are ubiquitous and fully integrated within and across all sectors.

Wave Two : Sector Disruption

Severe disruption within engineering consultancy groups at all levels , large and small. Consolidation not only of practices but also of type. Examples include Fire consultancy taking over building design and starting with AI assisted passive materials design before the structure is designed. BIM will be AI assisted for all services and design and may indeed not involve engineers as we know them. A new class of technologists will evolve. as cognitive automation is applied from 2025 and will be guild based. Within the Food industry and many others this is acute and has already commenced and will be intensified over the next two decades. Food supply security over the next three decades, given the extreme volumes required, will be hyper-efficient and artificial general intelligence and autonomous systems are required to make it happen. The scale of this phenomenon is so vast that it can only be done by AI an AGI assist.

Wave Three : Interdependent Synchronous Design

At a pace never seen before the market demand for synchronous and interdependent automation development is unprecedented. Funding for Natural Language Processing, Artificial General Intelligence and Cognitive intelligent systems to be developed synchronously is at a level not seen before in automation development. In the next decade massive funding of start-ups in this area will be astonishing. Much of the development will be open-source given the speed and synchronicity of it. Most autonomous systems will be open source. If engineers do not pivot to this reality with all design engineering they will not be participating at any level at all in a few years. BY 2030 all engineering design, calculation and analysis will be performed by AGI.

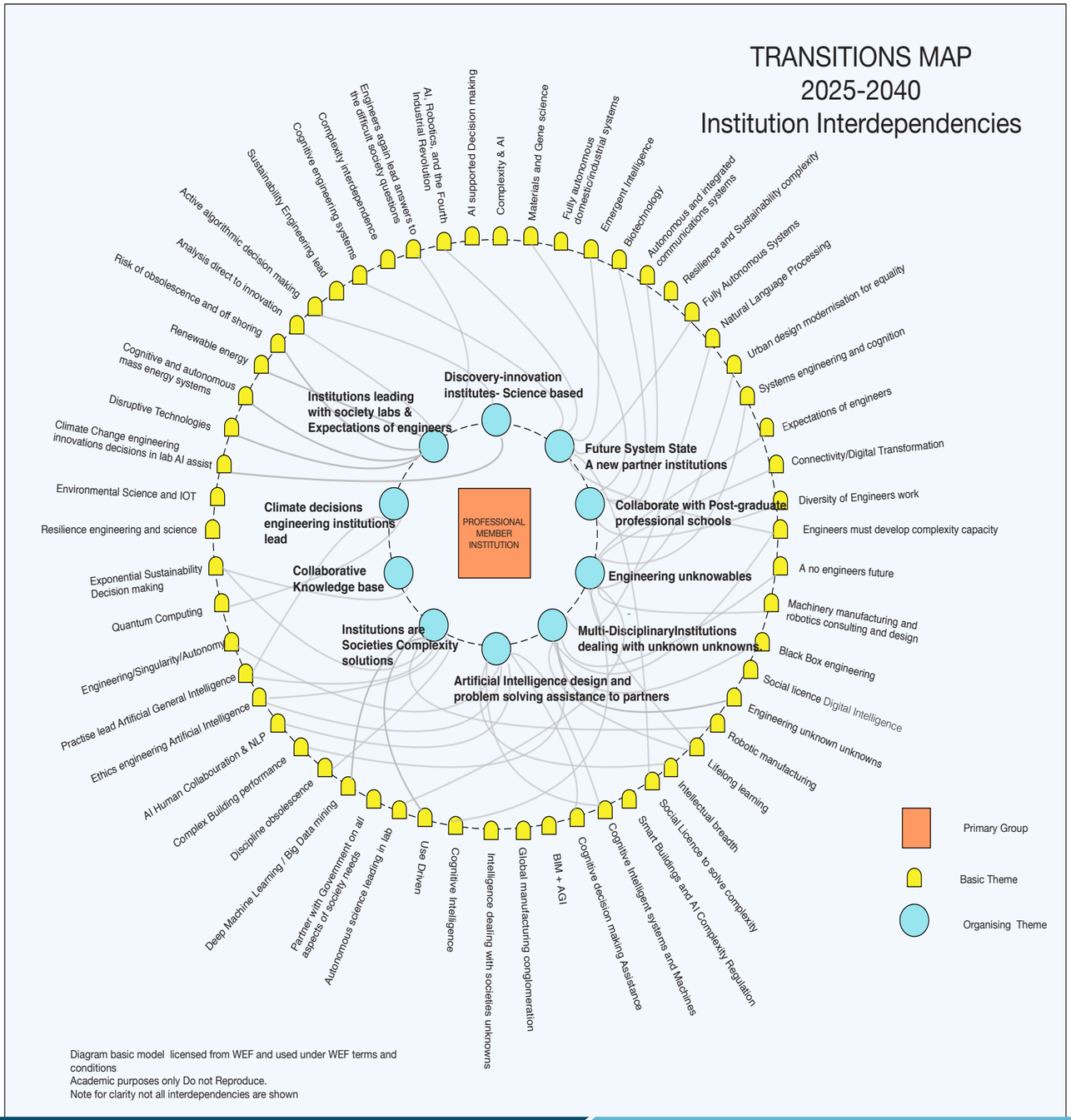
Wave Four : Mandated Carbon Neutrality

The big complex questions of unknown unknowns is the basis for all engineering beyond 2030. Climate change, carbon neutrality will be fully mandated against all manufacturing and energy companies and organisations worldwide over the next two decades starting immediately. Sustainability engineering and resilience and transition engineering will be the market entry price for many jurisdictions and will require complexity engineering at all levels The society expectation of engineers in this regard will peak around 2035 and the demand for engineers to answer the complex climate questions will never go away.

Wave Five: Cognitive Collabouration

As Natural Language Processing is fully developed by 2030 the demand for cognitive intelligence collabouration will occur with rapid application for all human-machine interfacing. Engineers must front this as there are a myriad of ethical questions within the complexity questions. Consumer demand for this facility will drive system design for all consumer systems. All consumer facing systems by 2050 will be autonomous. There will be no human operators in call centres, information facilities, banks, insurance, local government, super-markets, etc. Engineers will be deeply involved with job loss design and new job creation.

FINDINGS
Member Institution Trends



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Note for clarity not all interdependencies are shown

FINDINGS
Member Institution Waves of Change

The Meta-trends (key themes) are taken into the BlackRoom for consideration by the research team as disruptive "Waves of Change". The BlackRoom process is as shown below. The methodology of the BlackRoom is explained later in this report. The developed "Waves of Disruption" are taken from the Meta-trends into the BlackRoom and the final Strategic Foresighting statement derived during the BlackRoom deliberation. The resulting Foresighting statement and the backcasting with road maps is the subject of the final report.

The Waves of Change - The Institution

Wave One : Society Expectations

There is an unspoken expectation that engineers and their institutions must deliver for the planet in the same way they did back at the beginning of the industrial revolution in the 1800s and the green revolution in the 1960s. It is generally accepted that the near and far future have serious questions of complexity where many of the answers are in the realm of unknown unknowns and in fact may border the unknowable. Society expects that engineers will operate in this realm and provide answers to these difficult questions regarding Climate, decarbonisation, renewables, engineering transitions, AI, AGI and singularity. The faith that communities have towards engineers to solve these issues is far greater than for the science fraternity in general. Communities worldwide believe that all ethical considerations involving autonomy will be solved by engineers and their institutions. Autonomy for all systems is the end game and all engineers of all disciplines need to start on this journey now. Cognitive intelligent networks are ubiquitous and fully integrated within and across all sectors.

Wave Two : Decision making leadership for society

Decision making in the complexity field on 'unknown unknowns' will become the Institution's main future work. This will involve large scale AI assist algorithms initially and then the Institution will develop its own AGI to make these enormous decisions regarding autonomy and surveillance systems etc. If the Institution does not pivot to assume leadership of the complex unknown unknowns questions at a technical laboratory level, then engineering will dissolve into a mass of specialist guilds and all general engineering membership institutions will vanish by 2030.

Wave Three : Engineering Unknown unknowns leadership

At a pace never seen before the market demand for synchronous and interdependent automation development is unprecedented. Funding for Natural Language Processing, Artificial General Intelligence and Cognitive intelligent systems to be developed synchronously is at a level not seen before in automation development. If engineers do not pivot to this reality with all design engineering they will not be participating at any level at all in a few years. BY 2030 all engineering design, calculations and analysis will be performed by AGI. It is this reality that the Institution must lead.

Wave Four : Climate and carbon Neutrality leadership

The big complex questions of unknown unknowns is the basis for all engineering beyond 2030. Climate change, carbon neutrality will be fully mandated against all manufacturing and energy companies and organisations worldwide over the next two decades starting immediately. Sustainability Engineering and resilience and transition engineering will be the market entry price for many jurisdictions and will require complexity engineering at all levels The society expectation of engineers in this regard will peak around 2035 and the demand for engineering institutions to answer the complex climate questions and carbon neutrality will never go away.

Wave Five: Social licence

As Natural Language Processing is fully developed by 2030 the demand for cognitive intelligence collabouration will occur with rapid application for all human-machine interfacing. The Engineering Institution must front this as there are a myriad of ethical questions within the complexity questions. There will be no human operators in call centres, information facilities, banks, insurance, local government, super-markets, etc. Engineers will be deeply involved with job loss design and new job creation. To operate as engineers in this environment will require a new type of engineer and this must be set up, technically managed and supported by the Institution. It's possible that the standard four year engineering degree must be added to by a post graduate level professional qualification.

Foresighting Report

Preliminary

The 2050 Plausible Scenarios provided by ARUP Engineering and others have provided us with a basis to compress our thinking for this report into four main so called likely or plausible working scenarios. Given the very short time frame for this work we have used the ARUP 2050 report as our baseline document. ARUP call these scenarios Post Anthropocene, Greentocracy, Human Inc and Extinction express. All of these scenarios travel through the continuum of complexity from simple systems to complex systems and onto chaos. There many other scenarios that have been painted by a plethora of organisations but they are in the main of a similar base. The ARUP scenarios are useful for this report for ENG NZ in that they are from a world point of view rather generic and give a wide out picture of the world system in 2050. This helps us in that it allows us to visualise what Professional Engineers might be doing in 2050 if the environment is at least one of the ARUP four scenarios. The overall research we fall back on for this report has been gathered in 2020 and 2021 and is an extensive detailed understanding of world engineering , professional engineering, individual involvement and engineering organisations.

Primary Strategic Foresighting Report

If you think for a moment about the climate issues, decarbonisation, sustainability, zero emissions, zero waste, resilience, declining biodiversity, massive species loss, significant changes to all food and the agriculture industry, loss of petrochemical and plastics industries and the massive changes to the automative and transportation industry, new fuels ,Hydrogen, EVs or ammonia, continued climate heating, flooding, desertification, storms and cyclones the advent of AI, AGI and singularity and all of it shrouded in massive population increases (3.5 Billion extra by 2048) with housing, increasing inequality and declining food security issues then one can see easily that the global questions for the next several decades to 2050 and beyond is characterised by deep complexity of a degree and level we certainly have not seen since the green revolution in agriculture in the 1960s when the planet required a four fold increase in food production. The production increases (volume as well as rate) we have researched indicate that we are entering a zone of unknown unknowns and we will have societal divisions on an unprecedented scale. The question we must ponder at the BlackRoom strategy meeting is where does the engineer fit in this future and what should their membership organisation be reshaped to or repurposed in order to remain relevant to these engineers. Engineers are generally across all sectors of the society from infrastructure, generation, transmission, buildings, hospitals ,housing , inequality and poverty, bio diversity loss, automation and autonomy etc. As such their impact going right up to 2050 is highly significant but we believe, substantially different from now in 2021. Engineers are characterised by their problem solving ability. In the future however as the research tells us they will be still problem solving but in the area of complex unknowables. This reality is the key to what the organisation (Eng NZ) will need to pivot to. We have done it before.

It is clear to us that due to the extent of the research we have conducted, the next four decades will be characterised by complexity where the society expects the answers to be forthcoming from the Engineering sector as it has traditionally come from before. As major world activity and events occur, essentially simultaneously, the issues of complexity magnify and we very quickly get into the situation where all of our systems fall into the categories of known unknowns , unknown unknowns and the unknowable. For the Engineering NZ to remain relevant clearly they must reorganise ourselves into an organisation that studies, researches and solves the unknowable for all of engineering here in NZ and worldwide. As was shown above in the Findings section there are 'waves of change' coming from all four structural sectors for engineers and engineering that is clearly seen on the transitions maps. As these waves of change will be dynamic and very fast in their arrival and impactful in their effect and as a result the organisation must make a fundamental decision urgently. This decision should be made very soon as the system changes will arrive with breakneck speed. The decision that the institution must make is the degree to which the organisation wants to get involved with the new Scenarios eg Post Anthropocene. There are three strategic decisions points of which the organisation must pick one. Given the research and deliberation for this work we have assumed Eng NZ supports the ARUP 2050 Scenario Post Anthropocene and because of that we have assumed that Eng NZ will support "be the wave" as it's primary strategy. The other two options in our opinion are unsatisfactory in that they will render the organisation irrelevant in short order as they are simply business as usual.

Let the waves of change simply overwhelm us
Ride the waves for as long as we can
Be the wave.

So while it is clear to us what Engineering NZ must evolve into, rather than wait for the BlackRoom meeting to determine the Strategic Foresighting statement for the unknowable we will 'paint' a preliminary 'Steel mann' prior rather than expect attendees to develop this in the short period of the BlackRoom meeting because of the very complexity we are talking about. This must also make sense to our most reticent members and the writing of the strategic foresighting statement and the justifications and implications of complex systems and having (and your why) to be involved in resolving the unknowable must be written in a critical thinking sensemaking manner.

Next Steps

In order to develop a Strategic Foresighting statement (Steel Mann) for a distant time frame and in this case focussed on deep complexity and problem solving the unknowable within the Post Anthropocene we need to explore a bit of just what it is we are talking about when we use the expression 'unknowable'.

Simple contexts are characterised by stability and clear cause-and-effect relationships that are easily discernible by everyone. Often, the right answer is self-evident and undisputed. In this realm of "known knowns," decisions are unquestioned because all parties share an understanding. Areas that are little subject to change, such as problems with order processing and fulfilment, usually belong here.
Complicated contexts, unlike simple ones, may contain multiple right answers, and though there is a clear relationship between cause and effect, not everyone can see it. This is the realm of "known unknowns." While leaders in a simple context must sense, categorise, and respond to a situation, those in a complicated context must sense, analyse, and respond. This approach is not easy and often requires expertise: A motorist may know that something is wrong with his car because the engine is knocking, but he has to take it to a mechanic to diagnose the problem.
In a complicated context, at least one right answer exists. In a complex context, however, right answers can't be ferreted out. It's like the difference between, say, a Ferrari and the Brazilian rainforest. Ferraris are complicated machines, but an expert mechanic can take one apart and reassemble it without changing a thing. The car is static, and the whole is the sum of its parts. The rainforest, on the other hand, is in constant flux—a species becomes extinct, weather patterns change, an agricultural project reroutes a water source—and the whole is far more than the sum of its parts. This is the realm of "unknown unknowns,"
In a chaotic context, searching for right answers would be pointless: The relationships between cause and effect are impossible to determine because they shift constantly and no manageable patterns exist—only turbulence. This is the realm of unknowables. Ref David Snowden.

The research we have completed in the past year or so alludes to the global engineering situation going forward is in the realm of chaotic and as Snowden says this is where the unknowables reside. If Eng NZ is to 'be the wave' in this zone then the organisation must be reshaped to resolve critical decisions in the chaotic field much engineering will find itself in. It is because of this complexity that the Engineer will likely not have to tools of the complex decision making horsepower to be effective and he/she needs that from the membership organisation. It is also clearly society's expectation that it is engineers that will need to solve the unknown unknowns of the future and expect them to do so.

We are now confronting a complex network of interdependent global problems which we seem increasingly incapable of dealing with effectively at either the national or international levels, and arguably it is the very successes of human intelligence that have ratcheted the complexity of the challenges we face to a level that unaided human intelligence is now unable to cope with. What has changed in the last few decades? While the scale and urgency of the global problems we face have certainly intensified, what we have since learned in the germane fields of complexity science, evolutionary psychology, brain and behavioural science, and artificial intelligence, suggests that we may be close to another tipping point where we could possibly drive the emergence of advanced artificial intelligence systems that can effectively support human decision-making in managing such problems, by a combination of mitigating human fallibilities and complementing human shortcomings. The decision-maker needs to be able to give the system some initial direction about the problem, its scope, context, and goals and then develop them through dialogue, with intuitive visualisations presented by the interface to anchor and stimulate his participation. As these take shape the dialogue should extend to exploration of possible actions and their consequences, the development of courses of action, the building of necessary support from stakeholders and eventually monitoring the implementation of decisions made, and revising all above as more is learned and as the situation evolves. Ref Anne-Marie Grisogono

Since the interface is also the locus of the metacognitive support that the system can provide to the decision-maker, its design must be informed by an understanding of human limitations and shortcomings. Overall what is being described here is a cooperative system where learning and adaptation occurs at the levels of both the human and the AI support system. Importantly, it also occurs at the level of the combined system—the interface supporting the decision-maker's learning by setting the example of its own learning behaviour, in particular by continuously making predictions based on its current conceptual model, monitoring for the real world outcomes and revising its models in the light of what has been learned, and the human decision-maker being willing to expose their reasoning and ideas and subject them to analysis in their dialogue with the AI support system.

This combined advanced cognitive AI assisted decision making support system is what Eng NZ should evolve into. All Engineers in the next 30 years will need this to function at any level. Only this way will we be able to resolve the unknowables in this sector. The next section of this work builds on this part and proposes a Steel Mann. Make no mistake! to build an organisation with this capacity is both intense, focussed, time consuming and expensive.

Steel Mann

Explanation

Fundamentally a 'Steel Mann' is a more robust model than a 'Straw Man'. A 'Straw Man' models an opposing argument in a manner that is weak and can easily be knocked down and as such has significant flaws. A 'Steel Mann' model on the other hand is a strong argument or model that is based on the research brought forward with the idea that that the plenary strives to make the model universal and stronger. With this in mind the ultimate 'Steel Mann' is indeed the Final Strategic Foresighting Statement. Instead of substituting what someone else is saying with a lousy proposition, we'll do better by reinforcing their basic argument. This is known as the Steel Manning. Put simply, it's building the best form of the other side's argument and then engaging with it. It's being charitable and patching up the weaknesses in the other side's proposition so that they can bring the best counter-argument to your point of view. In this situation the other side is the "let the waves overwhelm us' rather than 'Be the wave'.

Steel Mann Methodology

People want to have their thoughts taken seriously and not brushed aside. The best way to do this is to show that you understand the thrust of their arguments by improving on the way the core idea is expressed. Anything less and you'll merely be attacking a weak manifestation of an idea, and not the idea itself.
Second, and more importantly, you need to constantly test our assumptions and beliefs in order to build a better mental model of the world. If you can't respond to the strongest argument from the other side, there's a good chance you're wrong. That's okay, as long as you're willing to adjust to the evidence and change your worldview. Otherwise, you'll be little different from someone who thinks that the sun revolves around the Earth.
One problem is that the best form of the argument often doesn't make sense to the other person. This doesn't mean he's stupid. An argument can make more or less sense to a person depending on his worldviews, values, and the premises that he works with. What this means is that we need to listen and understand where others are coming from. The best way to do this is what Bryan Caplan calls the Ideological Turing Test.
In a Turing test, a computer tries to pass off as a human:

> A human judge engages in a natural language conversation with one human and one machine, each emulating human responses. All participants are separated from one another. If the judge cannot reliably tell the machine from the human, the machine is said to have passed the test.

The Ideological Turing test is similar. If you can state opposing views as clearly and persuasive as your opponents, you pass. You're as good an emissary of that idea as anyone. That's the standard we should be striving for. As John Stuart Mill said, "he who knows only his own side of the case knows little of that."

Radical changes to present production and consumption systems, especially in the developed world, are required to achieve appropriate exponential development. These changes on a system level are referred to as industrial transformations, while also terms like sustainable system innovations or transitions towards sustainability are being used. Such system changes or transitions require combinations of technological, cultural, social, institutional and organisational changes, while affecting many stakeholders when diffusing into society and involving complex processes of social change on the long term. Engineers will be involved at all levels of this reality. However, system innovations (or industrial transformations or transitions) are very complex phenomena, due to the inherent uncertainty of the future and the inherent ambiguity of stakeholders having different value sets and mental frameworks. As we have iterated within this report the future is characterised by deep complexity. The Engineering Institution organisation required by the future does not exist at present.

The model we paint here is a deliberate fabrication of what we expect an engineering membership organisation will look like if it survives and maintains relevancy. Given the expected degree of complexity in 2050 it will be an entirely new model that has no precedence in the world never mind New Zealand. This Steel Mann is entirely new. It is based on months of intense Future System State research and analysis in the field of engineering in all four sectors. We make no apology that the proposed model (Steel Mann) is radical. If Engineering NZ wishes to avoid irrelevancy then in our opinion it has little choice but to adopt this radical approach as its members travel into what are largely unknown unknowns. The Steel Mann proposed here is taken into the BlackRoom and the attendees of the BlackRoom are then required to consider it and strengthen it. When discussing the Steel Mann there are no responses that are considered too radical or out of court, or too silly or not based on fact. All views are encouraged and indeed essential in fully establishing the Steel Mann and embedding it in order ti propose the Final Strategic Foresighting statement for Engineering NZ 2050.

2050 Steel Mann Model

In 2050 the global situation has entered the Post Anthropocene phase where both people and planet are on the pathway to a regenerative sustainable and resilient world and society consumes resources at a rate at which they can be replenished. Humanity is well on its way towards a shared consciousness and an understanding of Earth's limited resources – that production and consumption are intrinsically linked to the natural environment. Global ecosystem services are recognised and valued, helping to improve the quality of both planet and society. Circular processing measures are in place and most nations abide by them. Full life-cycle and ecological and carbon resource assessments are mandatory for all new products. Global biodiversity loss has halted, and protected areas are seeing ecosystem recovery. Everyone has, and knows, their quota and daily spend for critical planetary resources; AI provides daily updates, and state governments penalise overspend. The multi-stakeholder vision for an equitable and thriving future has prevailed. All global leaders are proud to wear the 'thriving planet = thriving people' symbol showing their support for the drive towards the post-Anthropocene epoch. Cities around the world have transitioned from being in conflict with nature to something approaching symbiosis.

It was understood by the Institution in 2022 that there was no chance, however, for these hopes to become a reality unless the technical means created by engineering are integrated toward a common global purpose. If our society was to mount an intelligent all-out attack on some of its most enduring and elusive problems, stronger engineering and technological influence and a better sense of technological possibilities were needed in the planning and execution of social interventions worldwide, both public and private.

It was realised by the board of Engineering New Zealand in 2022 that engineering has an unprecedented opportunity to exercise leadership in showing how technology can offer the means for creating a better world out of the ashes of collapsing or obsolete political and economic systems. The involvement of the engineer as a committed, scientifically knowledgeable problem solver and manager of nature is our best hope for solving the problems of poverty and hunger, for eliminating the atavistic recourse to war and violence, and for addressing the environmental climate problems.

In 2022 there was an expectation that engineers and their institutions must deliver for the planet in the same way they did back at the beginning of the industrial revolution in the 1800s and the green revolution in the 1960s. It was generally accepted that the near and far future at that time had serious questions of complexity where many of the answers are in the realm of unknown unknowns and in fact bordered on the unknowable. Society expected engineers to operate in this realm and provide the answers to these difficult questions. The big complex questions of unknown unknowns was the basis for all engineering beyond 2030. The society expectation of engineers in this regard peaked around 2035 and the demand for engineering institutions to answer the complex climate questions and carbon neutrality never went away.

By utilising the special character of New Zealand that was founded on the principles of Te Triti o Waitangi and Te Ao Maori the Institution was able to establish a unique high level socio-technical institution that by 2035 has broadened our social role and assumed the lead in developing more integrated socio-technological approaches to society's problems. Our Membership by 2035 are truly diverse, reflecting the make up of the society we serve and welcoming of engineering professionals from all disciplines and backgrounds. Te Ao Maori principles is integral in our cultural approach as we embrace members from all genders, cultures and beliefs.

Engineering NZ is by 2050 a global-focused international entity that has made a significant positive contribution to the realisation of the post anthropocene environment and a mature and sophisticated research and development facility that is fully engaged with the complex nature of the planet's business with respect to a sustainable, resilient, secure food system, balanced and equitable world, devoid of human division, poverty, famine, war and a stabilised climate.

2050 Steel Mann Model Continued

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Engineering NZ is the' go to' socio-technical society lab (STSL) facility by all engineers, government and society for solutions to the complex issues regarding the planet, materials and its people. The institution has by 2050 assumed the engineering leadership role in all aspects of the expectations of society with respect to providing answers to the questions of complexity that plague the planet. Members of the institution are a source of professional work with regards to complexity issues and where members are not able, then the institution with its international collaboration engages directly to provide the planet's solutions. While the institution operates in 2050 on an international basis, professional work on the complex unknown unknowns is made available to NZ engineers for research and development.

The members of the Institution not only comprise traditional engineers, but engineers who perform a valuable role of integrating technical solutions into the social and cultural expectations of society. Non-engineering members of society who adhere to the principles of Engineering NZ are encouraged to become members.

In 2050

Its members are engaged with critical decision making in all sectors, multiple levels of society, reflect society's diversity and are aligned with other like organisations around the world on the principles of post anthropocene. The institution has kept to its enduring visionary pillars established in the early 2020s, namely Collaboration, Credibility, Influence, Recognition and Thriving.

Many of society's critical decision making will be enabled by Engineering NZ's STSL facility using AI assisted complexity decision making AGI methodologies which it has developed itself over the last 30 years. The backbone of Engineering NZ's STSL facility was developed by its own engineers and members from big data capture and the development of IOT, AI, AGI and autonomous systems in the 30s and 40s since the time when society expectations became obvious to engineers and engineering.

The Engineering NZ STSL facility has reached the point in 2050 where it is now developing and leading critical decision making structures and systems for societal needs using its own version of singularity and is a major implementor of this technology throughout the world.

The organisation commenced the construction of its socio-technological society lab (STSL) with significant funding from Government in the late 20s after it had employed new technologists and creating its own big data systems and AI capability and with the establishment of its own Strategic Intelligence network.

Please note : This version of the Steel Mann model was discussed by the EPAC team who also attended the BlackRoom Session and they considered the 'argument' presented by the model and proposed a summarised version which appears on the page opposite. It is this version that is taken into the Final Foresighting Statement exercise and then the subsequent backcasting.

2050 Steel Mann Model post EPAC considerations

In 2050 Engineering NZ is a sophisticated, global focussed, pan engineering membership organisation that has made a significant positive contribution to the realisation of the post anthropocene environment. It is fully engaged with the complex nature of society's and the planet's challenges with respect to energy supply, resilience, environmental rehabilitation, economic circularity, a secure food system, and a balanced and equitable world, devoid of human division, poverty, famine and war. The backbone of ENZ's facilitation of it's work is through it's local and global connectivity, its role as a trusted advisor to government, and its close relationship with communities. Since realised, a critical contribution has been to lead the development of engineering capability to meet this goal.

The members of the Institution not only comprise traditional engineers, but engineers who perform a valuable role of integrating technical solutions into the social and cultural expectations of society. Members of society who adhere to the principles of Engineering NZ are encouraged to become members.

Engineering NZ is the 'go to' socio-technical membership organisation for engineers, government and society, for solutions from its members to the complex issues regarding the planet, materials and its people. The organisation provides leadership and coordination of technical, ethical, and societal perspectives to provide solutions to the complex issues facing the planet. While the institution operates in 2050 on an international basis, professional work on the 'complex unknown unknowns' is carried out by NZ engineers including research and development.

By utilising the special character of New Zealand that was founded on the principles of Te Triti o Waitangi and Te Ao Maori the Institution has broadened our social role and assumed the lead in developing more integrated socio-technological approaches to society's problems. Te Ao Māori principles are integral in our cultural approach as we embrace members from all genders, cultures and beliefs. Our Membership is truly diverse, reflecting the make up of the society we serve and welcoming of engineering professionals from all disciplines and backgrounds.

Our members are engaged with critical decision making in all sectors, multiple levels of society. We reflect society's diversity and are aligned with other like organisations around the world on the principles of post anthropocene. The institution has kept to its enduring visionary pillars established in the early 2020s, namely Collaboration, Credibility, Influence, Recognition and Thriving.

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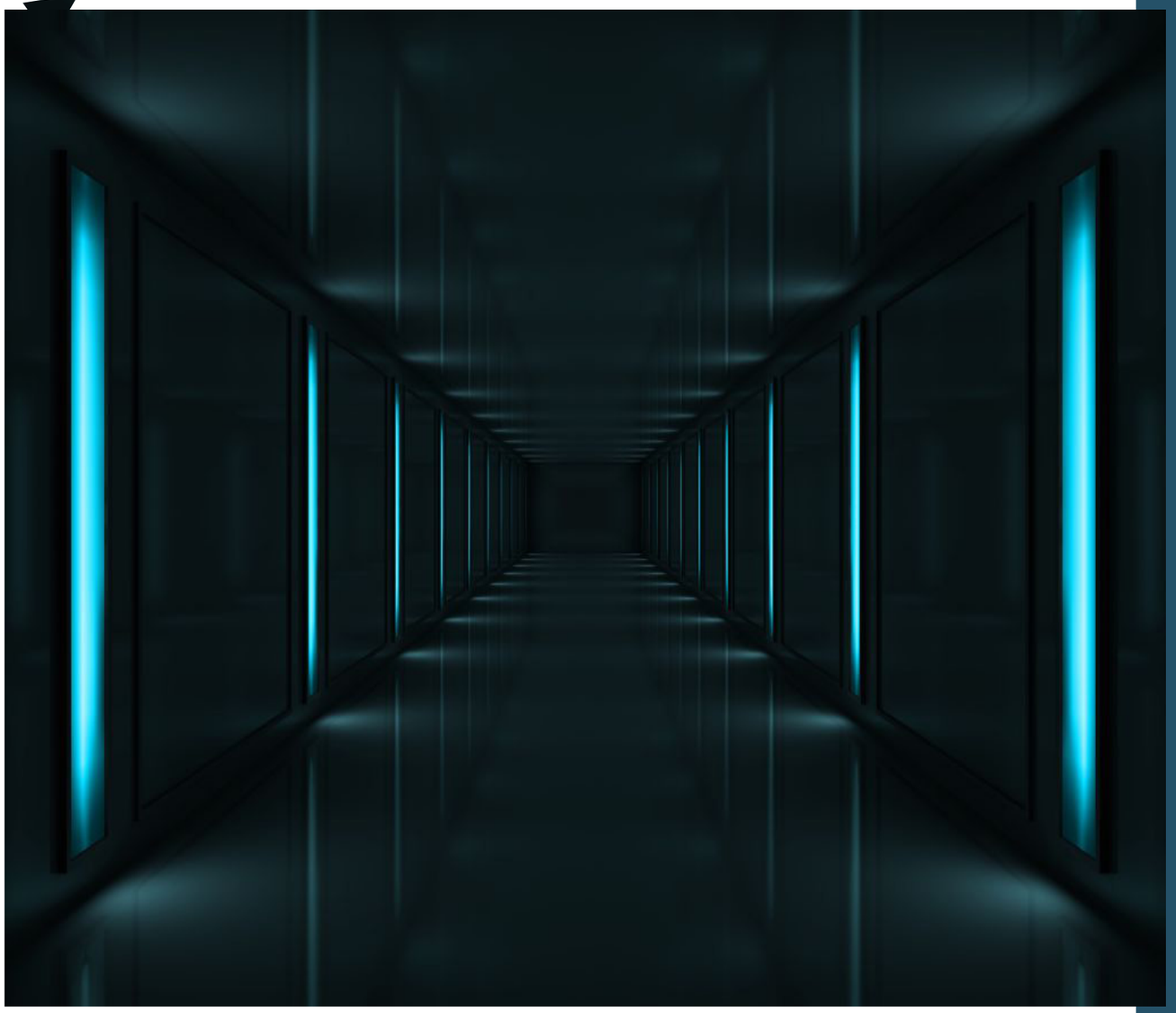


BlackRoom

BlackRoom Explanation

Fundamentally Black Rooming is about the notion of defining a future system state. The elements of a blackRoom are complex, integrated and indeed interdependent. When the sub-components of each element and their deeply connected interrelationships are taken into consideratio it is realised that both the global ecological, economic, and social meta-system and related sub-systems are in themselves complex systems. Even though the meta-system of global ecological, economic, and social relationships can be analysed in more manageable scales, any attempt to provide a definition of a future system state will be meaningless if this analysis is carried out by not taking these interdependent complex systems into account. It is into this environment we take the meta-trends discussed above and resolve exactly what Engineering NZ should be doing in the decades to come.

A blackRoom is: "Over the Horizon" strategic planning and product design tool and entails four fundamental futures planning tools that support strategic decision-making which enable firms to transition towards real levels of future product design. These are foresight, backcasting, scenario planning and most importantly the creation of "Black rooms" for research and development - protected spaces or niches working independently of current business activities involving innovative actors from a diverse range of sectors who develop and conceptualise alternative visions, agendas, and ideas for the industry sector.

To create the future one must first be capable of imagining it. Not predicting, not planning, not forecasting – imagining. A mindset that embraces individualism, collaboration and innovation. A mindset that addresses societal and environmental, as well as economic imperatives. Above all, however, a mindset that can tackle complexity, uncertainty and change.

Successful Future System State definitions depend on a combination of advances in scientific understanding, appropriate political programmes, social reforms and other institutional changes. Organisational and social innovations would always have to accompany any technical innovations and some would have to come first.

The one thing we can be sure of is when formulating Future System States that the world will emerge from the present arrangement of values, of beliefs, of social and economic structures, of political concepts and systems, indeed of world views, will all be different from anything anyone today imagines.

This implies a mindset that is oriented to process rather than to structure; that is ecologically driven rather than hierarchically driven; that is value added rather than competitive; that is holistic rather than functional; and that is collaborative and innovative rather than adversarial and derivative.

Radical changes to present production and consumption systems, especially in the developed world, are required to achieve exponential development. These changes on a system level are referred to as industrial transformations, while also terms like sustainable system innovations or transitions towards sustainability are being used. Such system changes or transitions require combinations of technological, cultural, social, institutional and organisational changes, while affecting many stakeholders when diffusing into society and involving complex processes of social change on the long term. However, system innovations (or industrial transformations or transitions) are very complex phenomena, due to the inherent uncertainty of the future and the inherent ambiguity of stakeholders having different value sets and mental frameworks.

A futures orientation, with strong foresighting capability and capacity, founded on flexible and adaptable systems, is the secret of success.

Furthermore….there should be three distinct phases in any "futures" exercise – divergence, emergence, and convergence and that far too many foresighting studies place too much emphasis on the present. The mega-trends researched in this project will form the agenda for the BlackRoom discussions. Questions have been raised about what kind of approaches could be applied to such complicated issues, how to identify attractive and desirable system changes (system innovations, industrial transformations or transitions), how to explore these, how to get these started and implemented in practice and about the role of different stakeholder groups and stakeholder co-operation.

Current models have all been designed to accommodate strategies derived from present business and usual practice driven from the base of today therefore only accustomed to short-term, current thinking influenced by past and present trends and events. The premise upon which the Over the Horizon model operates however is the exact opposite. Instead of using the current paradigm as the basis for future change, Over the Horizon starts by going out into the future to establish where success will be and then comes back to the present – a form of simulated hindsight that embraces long term planning and design.

Please Note: Because of the number of attendees and complexity of the BlackRoom we used the MURAL software. Each of the principles were discussed using Mural and the opinions and preferences of all the attendees was placed on the Mural graphics. At the end the murals were combined together in one graphical file and this appears on pages 46-47 below. A full five metre printout is available.

BlackRoom

BlackRoom Agenda

Day One - Scenarios (Breakout groups)		
Morning	4 Ps Scenarios Possible Probable Plausible Preferred as shown in final research report considered	Afternoon
Welcome, Introduction and research summary		Welcome and Summary
Group 1 Breakout "Global Future system state Scenarios"		Group1 Breakout "Global Plausible/preferred scenarios Implications to Engineering"
Group 2 Breakout "The profession's Future system state scenarios"		Group 2 Breakout "The profession's Plausible/ preferred scenarios implications to Engineering "
Group 3 Breakout "Engineer's Future system state Scenarios"		Group 3 Breakout "Engineer's Plausible/preferred scenarios implications to Engineering "
Group 4 Breakout "Institution's Future system state Scenarios"		Group 4 Breakout "Institution's plausible/preferred scenarios implications to Engineering "
Note : Breakout groups rotate after lunch. ie members of group 1 become Group 4 after lunch break etc. Each breakout group produces a single summary paragraph of its deliberations for use in subsequent sessions.		

Day Two - Plenary (ALL)		
Morning (ALL)	Morning Summary report presented to afternoon session	Afternoon (ALL)
Summary and discussion of Preferred Futures.		Open and free discussion of the 2050 System state Visualisation and production of the 'Strawman'.
Deep Thought Analysis (DTA) on Plausible/ Preferred scenarios and their implications		
DTA on The Multiple horizons and Black Swans and their implications		
DTA on Implications for engineering and institutions		

Day Three - Plenary (ALL)		
Morning (ALL)	Morning Summary report presented to afternoon session	Afternoon (ALL)
Deconstruction and Sensemaking of the 'Strawman'.		Final construction of the Strategic Foresighting statement 2050 and backcasting/milestone considerations and suggestions.
OUTPUT Strategic Foresighting Statement for 2050 Engineering NZ		

BlackRoom Mural - on Line Meeting

The purpose of this research project was to identify and describe global meta-trends, critical uncertainties, market's innovations and their implications that are likely to influence the business and sectors that Engineering New Zealand are currently involved with and to propose, given the meta-trends, new directions for the Organisation in the coming decades. The Organisation's executive felt that with the astonishing rate of change in their sector that a view of the future was in order, so that the existing corporate paradigm did not become irrelevant to its members.

Because of the interconnectedness of engineers, its institutions to global engineering the scope of this work is large. For the last 120 days we have been collecting and cataloguing hundreds of papers and articles from around the planet as well as interviewing engineers and owners of major engineering companies in order to get a handle of where our profession and its membership Institution fits in the future both near and far. As the future is fast approaching in terms of technology we will be looking right out until 2070 but focusing the Strategic foresighting statements and backcasting on 2050 as this is still within the working life of the majority of our younger generation engineers.

For any foresighting project the secret sauce is research, and this project where the Institution is subject to many sets of mega trends the research scans were widely set. A five month research program has investigated all the likely trends, disruption and impacts of systems development, the global future system state, climate, decarbonising etc, and the market's innovations from a futures point of view. Global knowledge and information-based environments require strategic-thinking leaders to utilise this knowledge to define their organisational and innovation strategy. This supports organisations in responding to changes in their environment, e.g. social, technological, market, regulatory, policy.

To this extent, it is necessary to isolate or synthesise data and information with high-confidence and to convert it into knowledge for driving strategic decisions. We (and others) call this process on which this document is based, 'Strategic Intelligence'. It is our view that Consulting Engineering practices are now in the midst of rapid exponential change and that they will not survive with-out performing regular Strategic Foresighting and establishing and utilising Strategic Intelligence (SI).

Within the research documentation which is included for reasons of record in the appendices of the draft report are the 2050 plausible scenarios of where the planet might be going from ARUP. ARUP is an originally UK based engineering consultancy group and it seemed to us to be entirely appropriate that we are mindful of their superb work.

Strategic Foresighting

The concept of strategic foresighting involves at the front end a substantial amount of research. This research is best described as Strategic Intelligence. In the usual way we researched basic themes in the engineering sector both global and local. There are some 20,000 basic themes which are arranged into hundreds of Organising Themes, placed onto transitional maps and then synthesised into disruptive Waves of change or scenarios.

All this information is available within the Draft report issued in December 2021. When the reality of the future was known Engineering NZ was required to make and overall strategic decision either to 'ride the waves', allow them to overwhelm the institution or to "Be the wave". (See Fig 1. below) In the event Eng. NZ decided to "be the wave". It is with that imperative that we go forward to the next step - The BlackRoom. It is in the 'BlackRoom' that the researcher steps back and the members then take over to consider the implications of the researcher's conclusions, which are in the form of a 'Steel Mann'.

There are several steps to this project and we have now arrived at the penultimate step, the 'BlackRoom'. Because of the pandemic this exercise which normally would be conducted face to face , will be attempted on line using the software 'Mural.' along with an experienced facilitator.

BlackRoom Mural

The purpose of the BlackRoom is to deliver the following steps:

- Breakdown the scenarios (Possible, Probable, Plausible, Preferred)
- Deep thought analysis (multiple horizons views)DTA *
- Visualisation of the future system State (Steel Mann)
- Sensemaking and the Final Strategic Foresighting Statement (2050)

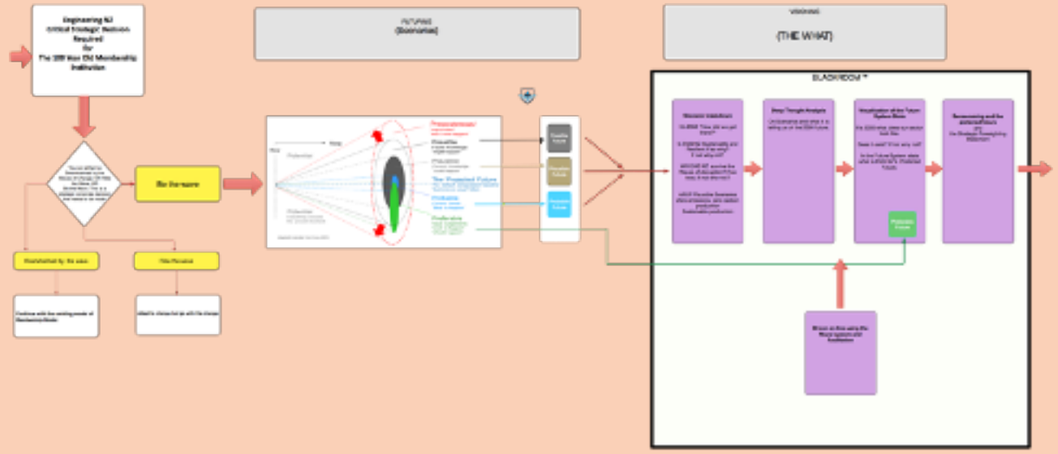
Post the workshop will be the production of the following in the form of a second final report:

- Strategic foresighting statement (From the BlackRoom)
- Backcasting from 2050 back to present

- Final Roadmap.

Final Recommendations to Engineering NZ Executive.

*DTA System 1, aka fast thinking, is essentially the frontlines of your perception and decision-making. It can also be described as superficial, intuition-based and norm-based.
System 2 , aka Slow thinking or DTA is our analytical consciousness. We use System 2 thinking to work through more complicated tasks, to think about ideas at length, and to flesh out the information retrieved by System1. System 1 sketches the outline of the world around us, and system 2 fills in the lines with colour. Ref: Danial Kahneman.



BlackRoom Mural

BlackRoomMural

Engineering NZ
Strategic Foresighting BlackRoom

INTRODUCTION

Welcome to the BlackRoom. Our objective over the three day workshop is to develop the 2050 Strategic Foresighting Statement which will underpin Engineering NZ's strategy and planning for the years to come. To do this forward looking exercise, we must remove ourselves from our current environment, use our imagination, and think critically about the possibilities the future may bring.

You can find more information about the BlackRoom and Strategic Foresighting Project in the Resources section of this MURAL.

AGENDA

DAY ONE: THURSDAY 17 FEBRUARY
GLOBAL FUTURE SYSTEM STATE

9.00am	Welcome and introduction	✓
10.10am	Ground rules and Autonomous Shuttle Bay	✓
11.00am	2050 Plausible Global Future System States	✓
2.00pm	Waves of change and implications	○

DAY TWO: FRIDAY 18 FEBRUARY
DRAFT STEEL MANN

9.00am	Welcome and recap	✓
9.15am	Waves of change and implications	✓
11.30am	Deep thought analysis	✓
1.30pm	A letter from our future (2050 Visualisation)	✓

DAY THREE: SATURDAY 19 FEBRUARY
STRATEGIC FORESIGHTING STATEMENT

9.00am	Welcome and recap	✓
9.30am	Set criteria to test the STEEL MANN	✓
11.30am	Strategic Foresighting Statement	✓
2.30pm	BlackRoom finishes	✓

RESOURCES

TIPS

Navigate

"It's like using Google Maps."

Zoom out to see the whole canvas. Zoom in to see the detail.

Using sticky notes

1. Double-click on the mural in the location you want to add a sticky note.

2. Alternatively, you can add a sticky note by select the text icon on the left-hand toolbar and dragging out your desired sticky note.

BLACKROOM ATTENDEES

FACILITATORS

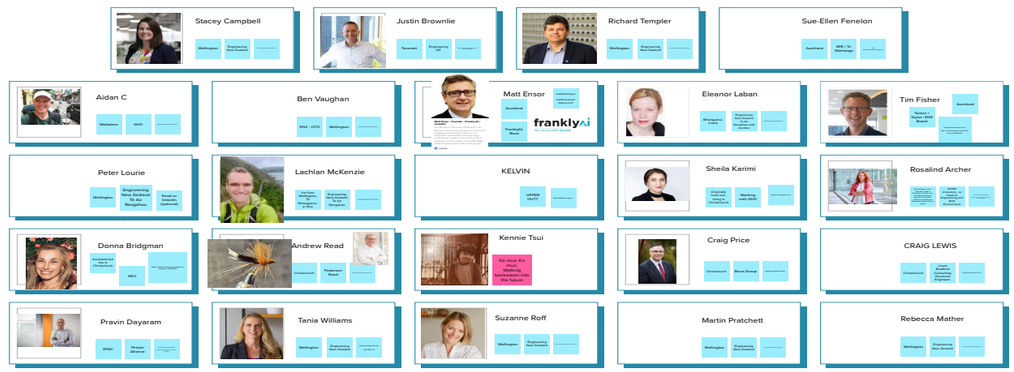
DR RON MCDOWALL ONZM

Ron is a Chartered Professional Engineer and a Professional Member of the Royal Society of NZ. Ron is a co-founder of Rutherford Business Group and its subsidiaries, teaches in the AUT MBA programme and is an adjunct Senior Lecturer at the University of Waikato. He has more than 30 years of industrial consulting engineering and management experience and was awarded the ONZM for services to science.

OLIVIA BURRELL

Kia ora. I'm a Wellington-based management consultant at MartinJenkins. I'm looking forward to spending the next few days with you, thinking outside of the box and far into the unknown. I'll be working alongside Ron, guiding you through the session and making sure we're achieving the objectives we've set out to do.

PARTICIPANTS



GROUND RULES

The five most-voted sticky notes from the brainstorm (left) were agreed as the BlackRoom's ground rules:

1. Approach this with an open mindset / positive mindset
2. Encourage creativity
3. Have fun!
4. Be bold
5. No wrong ideas

GLOBAL PLAUSIBLE FUTURES

Key points about ARUP's plausible global future system states.

The entire MURAL wall chart can be downloaded from the link below:. Note that the chart is 5 Metres long.

https://app.sugarsync.com/iris/wf/D131889_93036514_7537063

Explanation Strategic Foresighting Statement

The critical part of Foresighting preferred futures is the visioning of the 'future system state'. The quality of the visioning process is determined by the quality of the scenarios. Even though the meta-system of global ecological, economic, and social relationships can be analysed in more manageable scales, any attempt to provide a definition of a future system state will be meaningless if this analysis is carried out by not taking interdependent complex systems into account. This is normally performed as part of the BlackRoom. Once the pathways are verified then a Deep Thought Analysis (DTA) is required, and this may involve people outside of the Blackroom, and involves a reality check against the envisioned future system state as being likely or not. After the DTA has verified the veracity of the 'strand' then the backcasting exercise starts. In some cases, this proves may be conducted by a set of new people in the Blackroom rather than the visioning people. In some cases, of course a backcasting exercise can start with a single strand but with multiple pathways while further envisioning is being carried out by the original team. We sometimes call this sensemaking.

In summary the Blackroom concept is based on securing a future system state (foresighting) across many sector aspects and this is done by the Blackroom membership visioning in parallel, or perhaps in real future time and just in time visioning and using a multiple scenario and thinking systems. Essentially, and this is key, the visioning process is not a single one-way activity. It is a multi-strand interdependent process where the strands directly affect one and another and may oscillate backwards and forwards. While the concept of visioning out in the future is hard enough, doing it in multi-dimensions provides a significant challenge to the management and control of the Blackroom. The outcome of the blackRoom is a confirmation of the Steel Mann and the final strategic foresighting statement that is set in the future.

Below we see the Strategic Foresighting Statement as an example from the Auckland Counil Blackroom dlievered in 2012 about the 2030 Future.

Strategic Foresighting Statement from Auckland City Blackroom in 2012 involving a BlackRoom of 50 people.

> Auckland's compact, well designed and therefore accessible urban space has resulted in a resilient and integrated transport network, offering zero carbon transport choices (including active transport) for business, residents and visitors. Auckland's transport fleet is powered by a resilient and sustainable energy source. Smart technologies and information systems have enhanced the efficiency, speed and reliability of public and private transport (increasing comfort and convenience) and the efficient distribution of freight. Fossil fuel dependency has been significantly reduced due to the desire on the part of citizens for eco-efficiency and consumer response to market drivers and the availability of real time information enabling them to choose well among transport modes, including a rapid and frequent public transport system. Auckland has a safe, reliable and efficient public transport system which is interconnected across different transport modes including walking and cycling. The transport system readily connects residents to areas of greatest demand and facilitates the efficient distribution of freight whilst minimising its impacts on the transport network. Auckland's improved urban realm promotes walking and ensures that all parts of the public network can be used safely, easily and with dignity by all Aucklanders, including step free access. Auckland has taken the approach to the management off street space that takes account of the different roles of roads for neighbourhoods and road users in ways that promote public transport and other sustainable means of transport and a high quality public realm. EV recharging is part of an overall demand management system supporting a new energy aware culture. Enough households and businesses have invested in EVs over the last 30 years that they, and the Auckland economy, are avoiding the direct impacts of expensive fuels. Air quality has improved and Auckland's economic prosperity and clear air are attracting investment and inspiring feelings of confidence.

Dr William Pickering

William Pickering was a New Zealand born engineer who in 1962 was the senior executive of the Rocket Propulsion Laboratory at NASA. The President of the USA had just announced to the US congress that
"by the end of the decade of the 1960s the USA would be on the moon". Pickering translated this vision into what is now known as the "Moon Theory" Viz:

It's 1969 we are on the moon - how did we do it."
And thus the entire moon landing was backcasted
This is how we must imagine our "moon" and how did we get there.

The Engineering New Zealand Strategic Foresighting Statement

Our Moon

In 2050 Engineering NZ is a sophisticated, global focussed, pan engineering membership organisation that has made a significant positive contribution to the realisation of the transformed post anthropocene environment. Engineering NZ and its members are fully engaged with the complex nature of society's and the planet's challenges with respect to climate change, carbon sequestration, energy supply, resilience, environmental rehabilitation, economic circularity, a secure food system, and a balanced and equitable world, devoid of human division, poverty, famine and war.

How did we get there

We got there by establishing Engineering NZ as the 'go to' socio-technical membership organisation that provides leadership and coordination of technical, ethical, and societal perspectives to enable members to provide solutions to the complex issues facing the planet. While the institution operates in 2050 on an international basis, professional work on the 'complex unknown unknowns' is carried out by NZ engineers including research and development.

We got there by utilising the special character of New Zealand that was founded on the principles of Te Triti o Waitangi and Te Ao Maori thus the Institution has broadened its social role and assumed the lead in developing more integrated socio-technological approaches to society's problems. Te Ao Māori principles are integral in our cultural and intellectual approach as we embrace members from all genders, cultures and beliefs.

We got there because much of society's critical decision making was enabled by Engineering NZ's Socio-technical member resources/network using AI assisted complexity decision making AGI methodologies which it has developed itself over the previous decades. Because the backbone of Engineering NZ's facilitation of this work is through it's local and global connectivity, its role as a trusted partner to governments, and its close relationship with communities. A critical contribution has been to lead the development of engineering capability to meet this goal.

We got there because the organisation commenced the construction of its socio-technological member resources/network with significant funding from Government in the late 20s after it had employed new technologists and created its own 'big data' systems and AI capability and with the establishment of its own Strategic Intelligence network and the creation and implementation of the Post Anthropocene Engineer as a new engineering discipline.

The members of the Institution not only comprise traditional engineers, but engineers who perform a valuable role of integrating technical solutions into the social and cultural expectations of society. Members of society who adhere to the principles of Engineering NZ are encouraged to become members. Our members are engaged with critical decision making in all sectors, multiple levels of society. We reflect society's diversity and are aligned with other like organisations around the world on the principles of post anthropocene. The institution has kept to its enduring visionary pillars established in the early 2020s, namely Collaboration, Credibility, Influence, Recognition and Thriving.