DESIGN

AI for Augmented Intelligence

RAMBØLL

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Prologue:

“Technology is our friend”

The story of our separation from the natural environment is closely entangled with our journey of technology development and adoption. Biological life on planet earth is as old as 3 billion years.

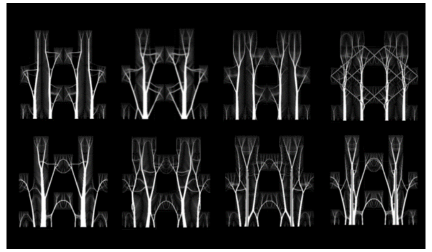
As recently as 1 billion years ago, the highest form of intelligence on the planet were the forerunners to our beautiful and hardworking earth worms. In such timescales stretching billions of years, the 250 thousand or so years that we, the homo-sapiens, have been on this planet is minuscule. It is literally 0.00008333 times the duration of biological life on earth.

This has been likened to the measuring scale “yard”; which has its origins in the distance between the tip of the stretched arm of the emperor and his nose. If life on earth is as long as a yard, the entire time the sapiens have been on the planet will be wiped off with a single file on the nail of the emperor’s index finger!

While we were fully integrated into the natural environment up until as recently as 10 to 15 thousand years ago, we now are totally and sadly isolated from it, with the devastating outcomes of climate change, loss of biodiversity and other huge environmental challenges we are grappling with. It is widely believed that the origin of such separation and disenfranchisement is firmly embedded in that first piece of stone our ancestors sharpened, and used as a tool.

The sharpened stone, which was the tip of our technological advancement at the time, has put a gap between us and other species, and empowered us to pull ourselves outside of the food chain, and instead, to command, colonise and exploit the natural environment as a resource.

While the cutting-edge technology of the time, and since, empowered us to separate from the natural environment, it is ironic that this very technology is now a major catalyst to help us integrate back into the natural environment and become an active member of the community of life, in the best interest of all living and non-living forms.



Topological Optimization
Unlocking natural efficiency for an unwrapped elevation of a high-rise building façade structure

Innovating:

For which future?

Embracing a World of Possibilities
Amidst the challenges we face, we recognize that technology holds immense potential. It is up to us, as stewards of innovation, to harness its power for positive transformation. With responsible actions, we can shape a thriving future—renewing our planet and venturing into uncharted cosmic realms—ensuring our survival and advancement.

The construction industry stands at a crossroads, grappling with its carbon footprint while striving to meet the growing demands of a burgeoning global population. As aspirations for improved living conditions surge, sustainability becomes an imperative. In this race against time, innovation is paramount to secure a prosperous future for humanity.

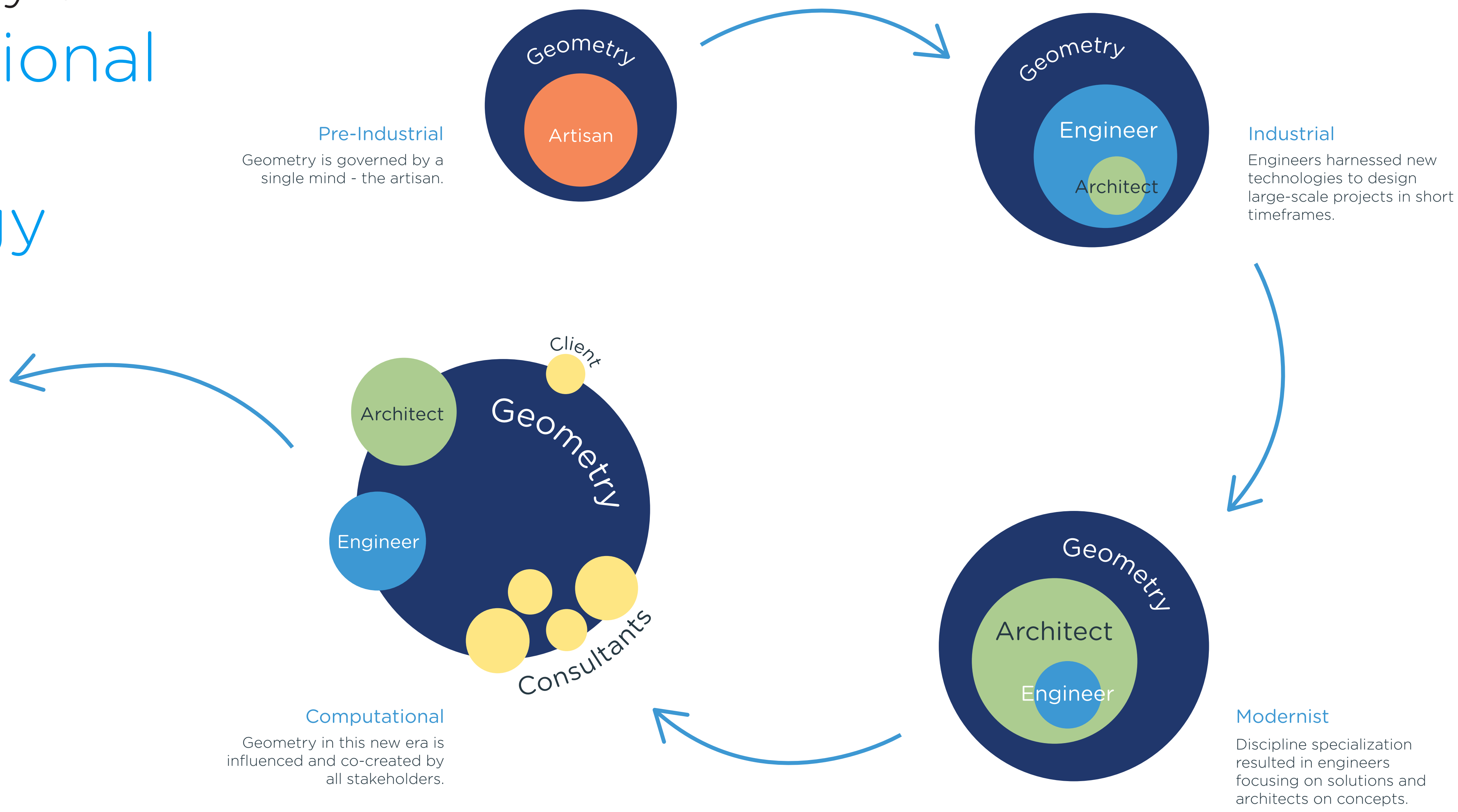
Within the Architecture, Engineering, and Construction (AEC) industry, Computational Design Technology (CDT) serves as an essential key to keeping pace with the rapidly changing crises – climate, environment, waste, water, security, and food (to name a few).

Penang South Islands, Malaysia (Bjarke Ingels Group (BIG), Hijjas Architects and Planners)
In a masterplan entitled BiodiverCity, its focus is not just on liveability, economy and quality of life but critically on creating an environmentally-rich, biodiverse and regenerative developments that would be a first in the region.

A brief history of Computational Design Technology

Design Through the Ages.
Over time, geometry has been controlled by practitioners who are best-placed to influence design language. In the new Computational Design Age, geometry is co-created by design 'influencers' who develop intelligent design DNA using augmented parametric processes to enable wide-ranging objectives.

Geometric Influence across design ages



The origins of computational design can be traced back to the early days of Computer-Aided Design (CAD) in the 1960s. Initially, computers were used to automate drafting and documentation processes, providing architects and engineers with greater precision and speed. However, as technology progressed, so did the capabilities of Computational Design Technology (CDT).

In the 1990s, parametric modeling and Building Information Modeling (BIM) emerged, allowing designers to create complex digital models with intelligent relationships between elements. This breakthrough marked the first step towards integrating computation into the design process. As computational power increased and algorithms became more sophisticated, designers could explore multiple design options and simulate real-world scenarios with ease.

In recent years, the capabilities of computational design technology have skyrocketed, thanks to advancements in machine learning, artificial intelligence, and data-driven algorithms. Designers can now generate design solutions that were once inconceivable, harnessing the power of algorithms to optimize building performance, analyze energy consumption, and enhance sustainability.

CDT's integration with generative design has been particularly transformative. By setting parameters and constraints, designers can let algorithms explore vast design spaces, generating countless alternatives and identifying optimal solutions based on predefined objectives. This iterative process allows for design exploration on an unprecedented scale, facilitating faster and more informed decision-making.

The Computational Design Age

With the widespread adoption of computational design technology, we are witnessing the dawn of the Computational Design Age. This era represents a fundamental shift in how we approach design challenges and unlock the full potential of our built environment. It emphasizes the symbiotic relationship between human ingenuity and computational power, enabling us to tackle complex problems with greater precision, efficiency, and sustainability.

Within the AEC industry, the rapid evolution of CDT has brought about a paradigm shift. What was once considered an emerging tool has now become an intrinsic part of leading practitioners' processes, revolutionizing the way we approach design. The rise of CDT has given birth to a new era, aptly named the Computational Design Age, where the fusion of human creativity and machine intelligence propels us into uncharted territories of innovation and efficiency.

As we enter the Computational Design Age, we must embrace this transformative wave of technology and harness its potential to create innovative and resilient spaces. Designers, architects, engineers, and construction professionals must continue to push the boundaries of computational design, exploring new frontiers and constantly challenging the status quo.

Ignite a world of possibilities by harnessing Computational Design Technology for positive transformation

Parametric Design:

Disruptive? Evolutionary? or both?

Parametric design is not new. One of the co-authors of this edition of Ramboll DESIGN wrote a paper on a parametric research project back in 1988. As designers, we have been parametrizing, both consciously and subconsciously, to seek innovative concepts and creative solutions to stretch the envelope of possibilities.

Indeed, parametric design may simply be the applied science of human curiosity – i.e. testing and tweaking parameters to develop more optimal systems. However, the evolutionary model of parametrics we have observed in the past 30 years has leapt forward by the revolutionary modern tools with which we now collaborate.

Previously unthinkable horizons have been crossed and dream-like possibilities have been realised, all in the 'evolutionary' blink of an eye.

Kistefos Museum, Norway (Bjarke Ingels Group)

An iconic museum building that functions as a bridge and an elegant sculpture. Parametric modelling techniques were used to assess, inform and optimise various architectural design options.

Future Parametric :

Researchers, academia and other professionals are constantly developing new parametric tools and improving existing ones to enable the exploration of ideas at the edge of our cognitive ambitions.

We are now empowered to test the most extreme ideas which, until recently, our psyches might have subconsciously suppressed considering them impossible to realize.

Furthermore, these new parametric collaborators are daring us to think beyond our current cognitive horizons. The open-platform nature of these tools further enables established design disciplines such as architecture, engineering and sustainability to further collaborate and co-create together.

We are now empowered to carry out super-early-stage combined parametric studies with holistically conceived geometries.

In a short article we wrote as recently as February 2019, we wrote:

"At some point in the future, we envisage that buildings will be "generated" from optimisation algorithms by using a comprehensive set of weighted design parameters.

Some (and clearly not all) of these design parameters could be aesthetics, size, efficiency, cost, speed of construction, aerodynamics, structural performance, heat gain, daylighting, code and authority requirements. This range of new possibilities together with the rapid advancement of additive manufacturing, will eventually generate its own design typology whereby material can be minimised through the freedom of form.

The "economy" in material usage and the "generosity" in form can be borrowed straight from the playbook of the oldest and most masterful of all builders – i.e. nature itself."

This future scenario imagination is already upon us, beyond proof of concept!

With currently ongoing and further development of such ideas, a bespoke and exciting design environment awaits us all and in particular, those of us who wish to shape it. Such design ideas further extend into manufacturing and construction fields with speed and at scale.

The future is now

Most of these futuristic-feeling tools and ideas are already developed, and are being further explored. So far, we have found that the solutions they present have already challenged our preconceived notions of effective structures.

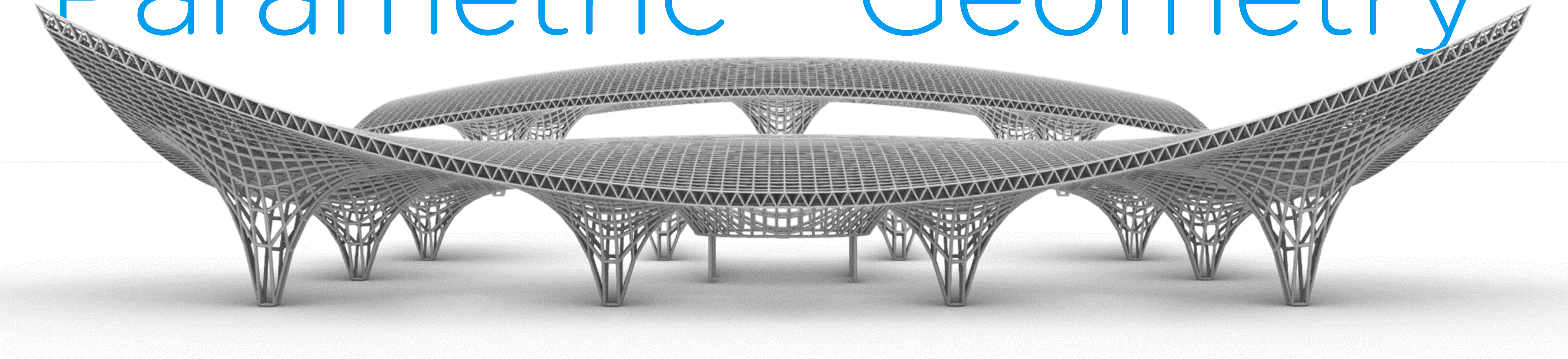
Counterintuitively, we now know that inclined columns are more efficient than their vertical cousins and that geometric optimisation is independent of scale. Curves are more efficient than straight lines and bespoke is more cost-effective than modular and standardized.

Paradigms will continue to shift, and progress will further accelerate. We can only wonder and imagine with a sense of excitement, respect and awe what will be achieved in the next 30 years, but there can be no doubt that the developing field of computational design will be intrinsic to the way in which the built environment is shaped to deliver innovative and efficient forms by solving the challenges of their day.

The future is now.

Founders Memorial, Singapore (Kengo Kuma & Associates + K2LD Architects)
A visionary landscape that highlights Singapore as a 'City in a Garden'. This bold and sustainable design blends organically with Gardens by the Bay. The Memorial aims to commemorate Singapore's independence and inspire Singaporeans to unite in shaping the nation's future.

Parametric Geometry



Parametric geometry stands as a cornerstone of computational design, empowering architects and designers to unlock new realms of creativity and redefine the possibilities of architectural expression. At its core, parametric geometry harnesses the power of algorithms and data-driven processes to generate intricate, adaptable, and dynamic design solutions.

By embracing parametric geometry, architects can transcend traditional design limitations, breaking free from the constraints of standardization and embracing a world of limitless possibilities. The flexibility inherent in parametric geometry allows for the creation of complex, non-linear forms that were once thought to be unattainable. It enables the exploration of organic and biomimetic structures, inspired by the beauty and efficiency of nature itself.

The true power of parametric geometry lies in its ability to respond and adapt to varying design criteria. Through the manipulation of parameters and inputs, designers can generate a multitude of design iterations, each with its own unique set of qualities. This iterative process not only facilitates exploration and experimentation but also enables designers to optimize their designs based on specific performance goals, such as structural efficiency, energy consumption, and occupant comfort.

Moreover, parametric geometry empowers designers to create highly customized and site-specific solutions. By integrating site data and environmental factors into the design process, architects can shape structures that harmonize with their surroundings, optimizing solar exposure, ventilation, and views. The result is architecture that seamlessly integrates with the environment, creating a sense of harmony and enhancing the overall user experience.

In the realm of computational design, parametric geometry serves as a catalyst for innovation, pushing the boundaries of what is possible in architecture. It offers a transformative approach that combines mathematical precision, design intuition, and technological advancements to reshape our built environment. By embracing parametric geometry, architects can navigate uncharted territories of design, creating awe-inspiring structures that captivate the imagination and shape the future of architecture.

Parametric Long-span
Newtonian gravitational laws were applied to architectural surfaces to generate an efficient long-span airport terminal geometry. The full geometry is defined via 2 # surfaces and 1 # formula.

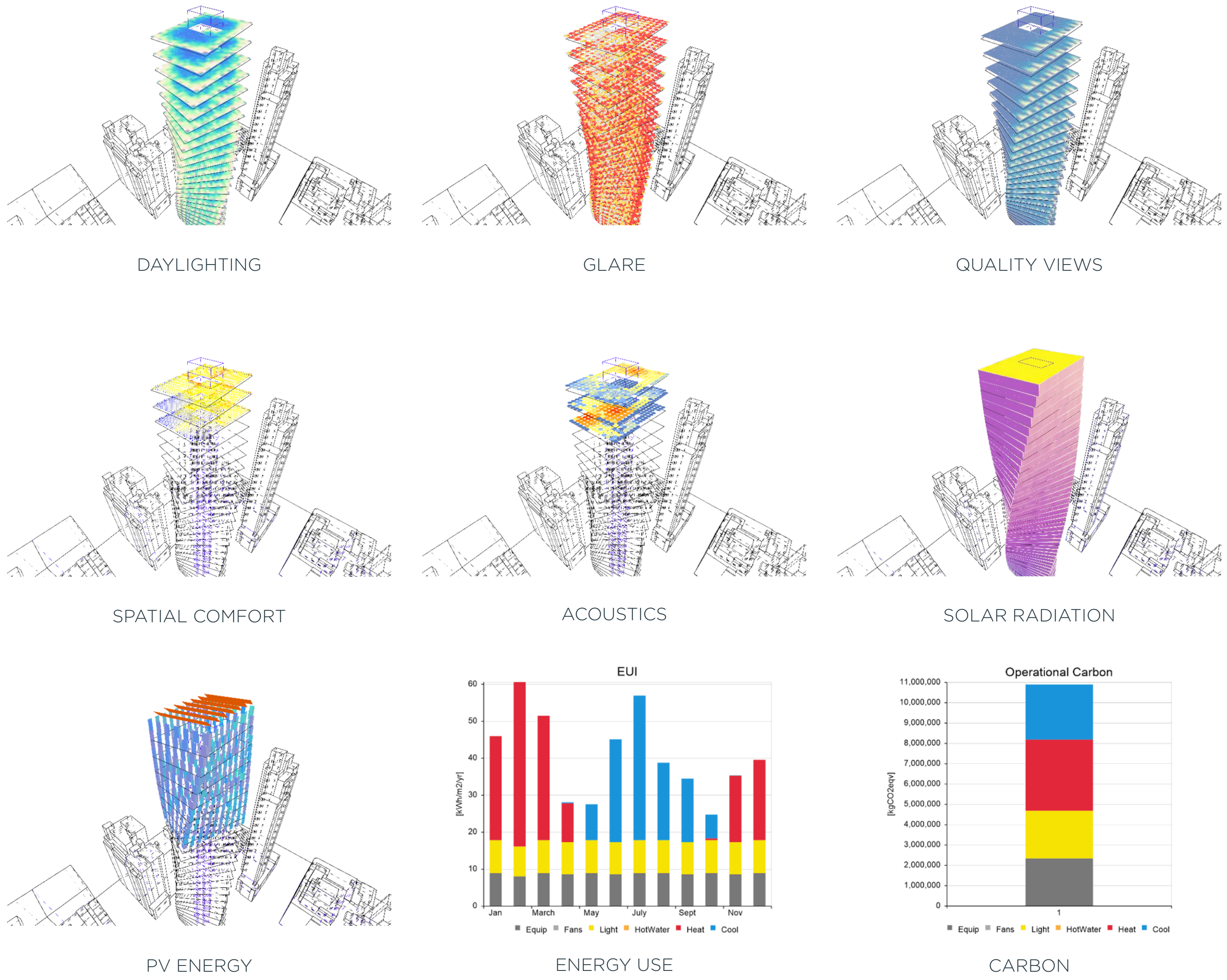
Informative Design

In this captivating image, we witness the marvel of Building Environment Analysis (BEA) employed for a parametric tower, unlocking a new era of architectural intelligence. Through a revolutionary one-click simultaneous analysis, this cutting-edge approach enables multiple assessment attributes to be seamlessly evaluated.

At the super-early design stage, stakeholders are empowered with profound design intelligence. This transformative process allows for passive benefits to be seamlessly integrated into the very fabric of the tower's geometry. By harnessing the power of Computational Design, the true DNA of good design is unveiled, paving the way for maximum performative gains in terms of both environment and cost.

The BEA methodology embraces the essence of efficiency, streamlining the design process while magnifying its potential impact. Gone are the days of isolated and time-consuming analysis; now, a comprehensive understanding of the tower's environmental performance can be obtained effortlessly, thanks to the synergistic convergence of computational power and design finesse.

This image serves as a testament to the profound impact of computational design techniques. As the tower's intricate geometry unfolds, a symphony of insights emerges, illuminating the path towards a sustainable and optimized future. It exemplifies how the integration of advanced analysis tools at the earliest stages of design empowers architects, engineers, and stakeholders to make informed decisions that harmonize form, function, and environmental stewardship.



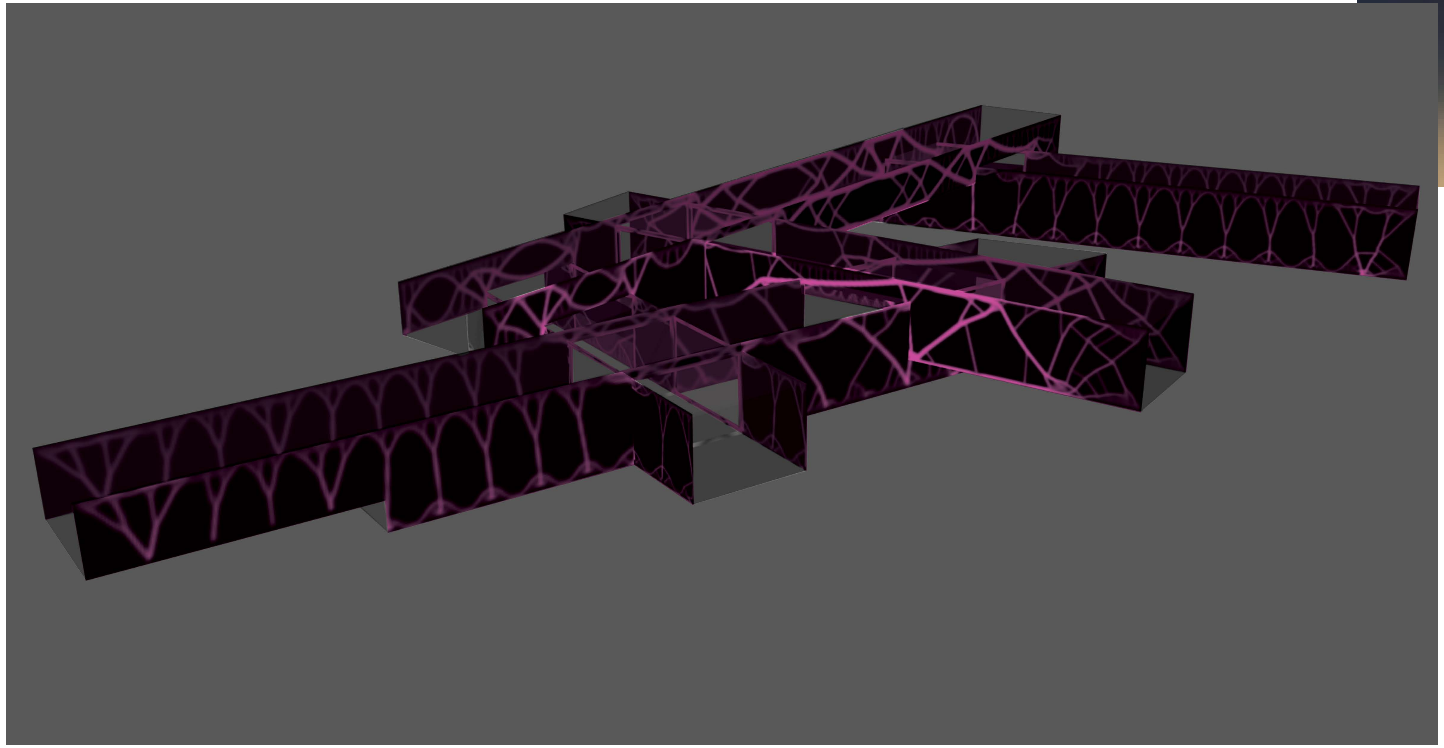
Early-stage insight with one-click simultaneous Building Environment Analysis (BEA)

Finding Form:

Learning from Nature's Playbook

Computational design has elevated structural form-finding to new heights, both at the building and elemental scale. No longer bound by rectilinear boxes, vertical columns, and horizontal beams, the freedom to explore geometric possibilities leads to greater efficiency. This borrowing from nature's playbook, embracing the freedom of form and frugality of material, allows for innovative structural solutions that optimize resource usage and minimize waste.

Computational design unlocks a realm where buildings take cues from the natural world, resulting in regenerative and aesthetically captivating architecture. These new techniques will inform a new design typology for the Computational Design Age.



Emulating Nature
Stress patterns in a cantilevered structure and in a cantilever wings of a dragonfly

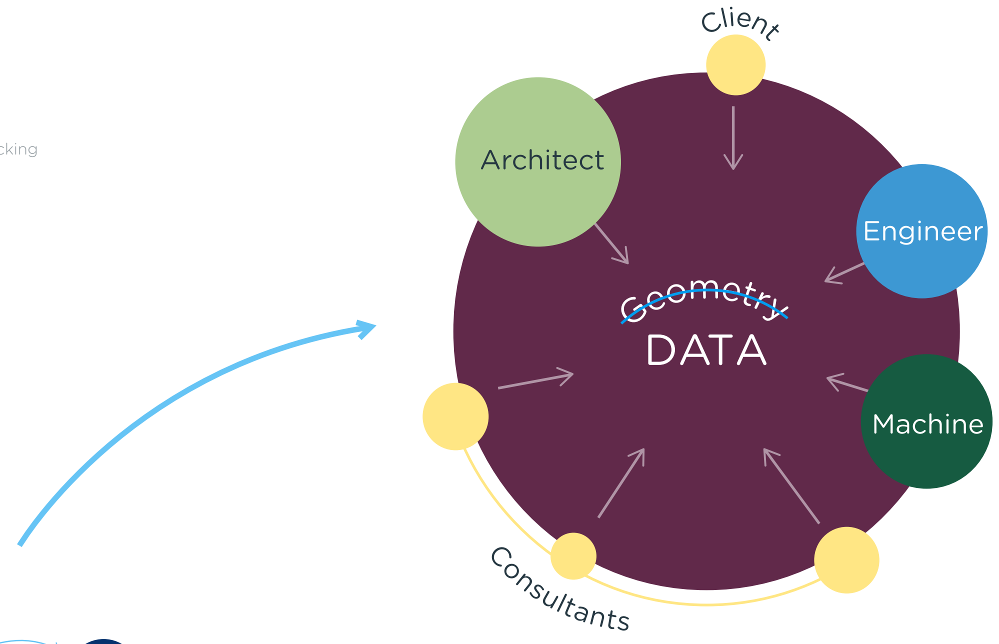
Dragonfly
Photo credit:
Maria Warner Wong

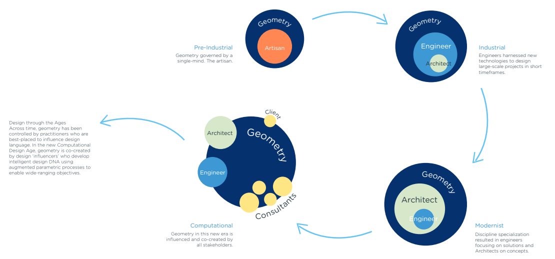
"The 'economy' in material usage and the 'generosity' in form can be borrowed straight from the playbook of the oldest and most masterful of builders.... Nature itself"

Cloud Simulation

Detaching processing power from design solutions

Computational - Next progression
Geometry is this new era but the key to unlocking ground breaking design is data visualisation.





External microclimates are critical for the comfortable use of outside space in large parts of the world. This is particularly important when targeting passive or low-energy strategies in more extreme environments for masterplans, projects of large scale or areas where the public realm is particularly sensitive.

Conventional assessments utilise intensive CFD, physical models and defined performance criteria (Pedestrian Wind Comfort–Lawson Criteria, etc.) These manifest in computationally heavy, detailed assessments carried out post-optioneering and architectural form finding. Wouldn't it be better if we understood and visualised these dynamic effects whilst developing the building massing? - this is where most negative impact is committed.

How do we make wind assessment as parametric as solar radiation analysis?

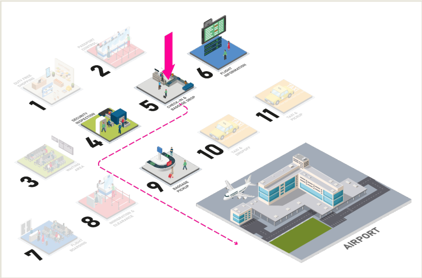
We can use a cloud-base CFD which is linked to parametric models that drive Universal Thermal Climate Index (UTCI) grids. This removes the inertia of local computation.

User Experience

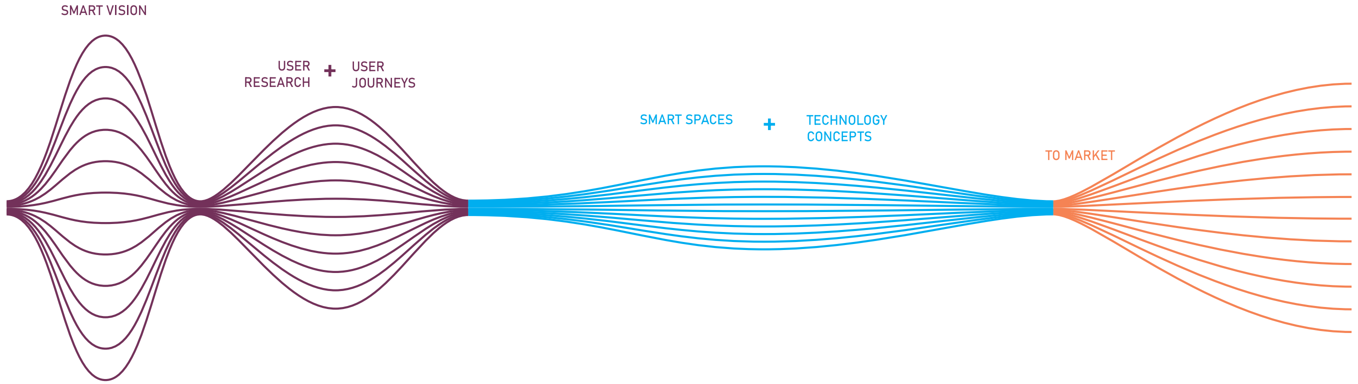
Technology underpins the way we live, work and interact. Demand for infrastructure that facilitates a seamless user experience and energy monitoring is accelerating - this must anticipate the needs of future generations. The growth of associated applications is almost exponential. The built environment and construction sectors, whilst historically slower in adoption of emerging technologies, are not immune. We see increasing complexity, requiring vast quantities of integrated systems.

Systems that manage the built environment are becoming truly sophisticated in the way they manage space, resources, and enhance user experience. Developments which combine a considered technology suite with an integrated design approach create new opportunities for innovation, interaction, and investment. SMART technology can be a tool to improve the health and well-being of users and reach new levels of liveability, sustainability and wellness.

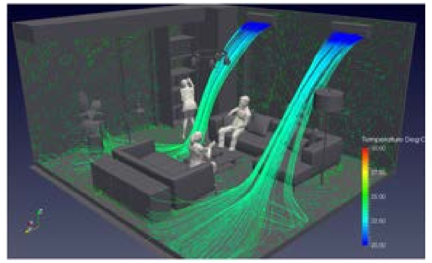
The future of SMART, does not only design a space. It designs a time, a series of moments that exist at the convergence of the physical, digital and psychological. The times where people find meaning and have purpose, all within a platform we call the SMART Future.



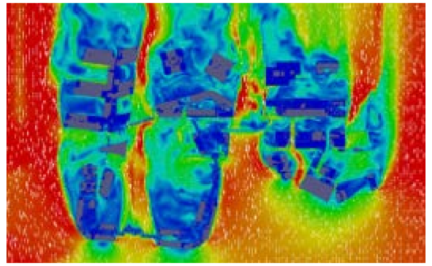
Key user journeys to inform the design and technology interventions for the project



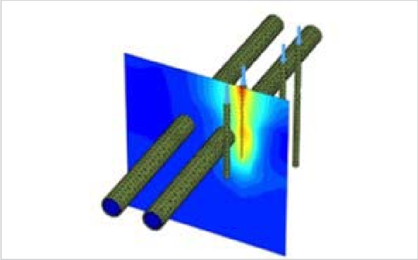
Everything Advanced Simulations



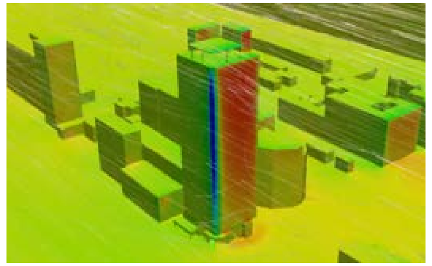
Thermal comfort study: CFD Simulation for ACMV flow



Natural ventilation CFD analysis

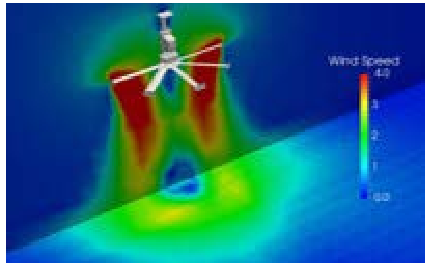


Tunnel settlement from consolidation of soils around loaded piles

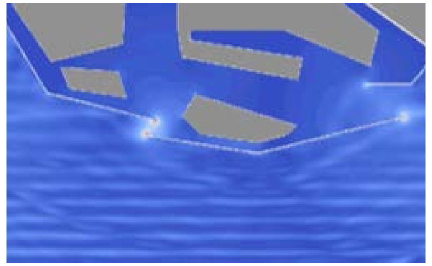


Wind pressure on building facade using CFD analysis

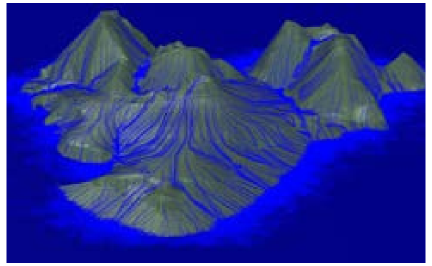
Wind-driven rain analysis



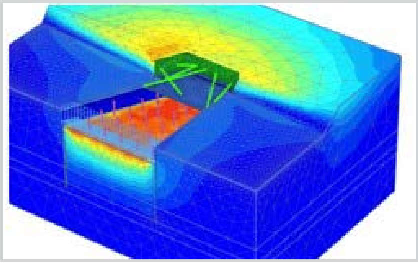
Thermal comfort study: CFD Simulation for fan air flow



Hydraulic CFD simulation on wave propagation



Hydrological analysis of rainwater on a hillside site or slope



Deep basement excavation soil deformation in top-down construction

Of Genes, Zebrafish & Net Zero

At Ramboll, we have developed a digital tool called Zebrafish.

It uses a mix of parametric and comparative modelling, cloud technology, bespoke analysis, and data visualisation to analyse hundreds of thousands of options for each building.

SETTING UP THE SIMULATION

Step 1 : Gather Information
In this initial phase, we gather a range of data, including weather data, geometrical measurements, fabric properties, room usage and occupancy information.

Step 2 : Set up a Baseline Model
A baseline model can be established depending on the project type: either for an existing building or a new construction. In the case of existing buildings, metered data can be gathered and correlated to the energy modeling results. This correlation ensures that the digital representation remains closely tied to real-world conditions.

Step 3 : Propose Interventions
A combination of numerous passive and/or system interventions can be proposed to create an exhaustive analysis that can be swiftly conducted during the early stages of the project.

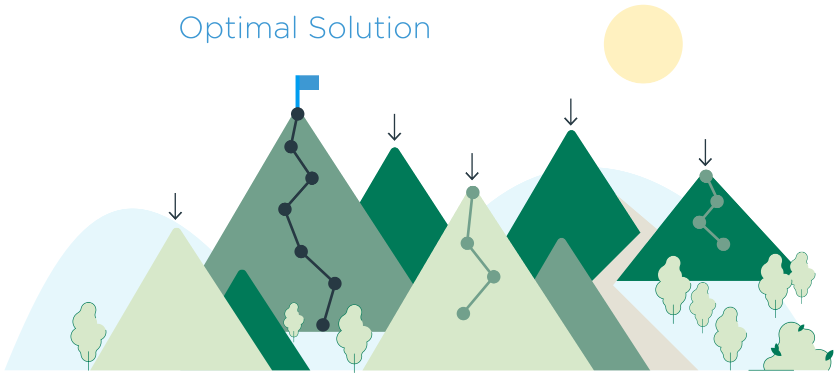
Results and Post-Processing

Step 4
Rapid Exploration

By considering many interventions, we can find the "sweet spot" where the maximum benefit can be achieved for the minimum cost and/or carbon investment.

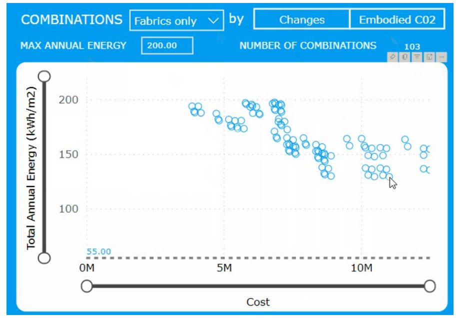
This approach enables us to efficiently explore a multitude of potential options.

Zebrafish helps scale decarbonisation of existing buildings



Step 5
Visualise and Interrogate the data

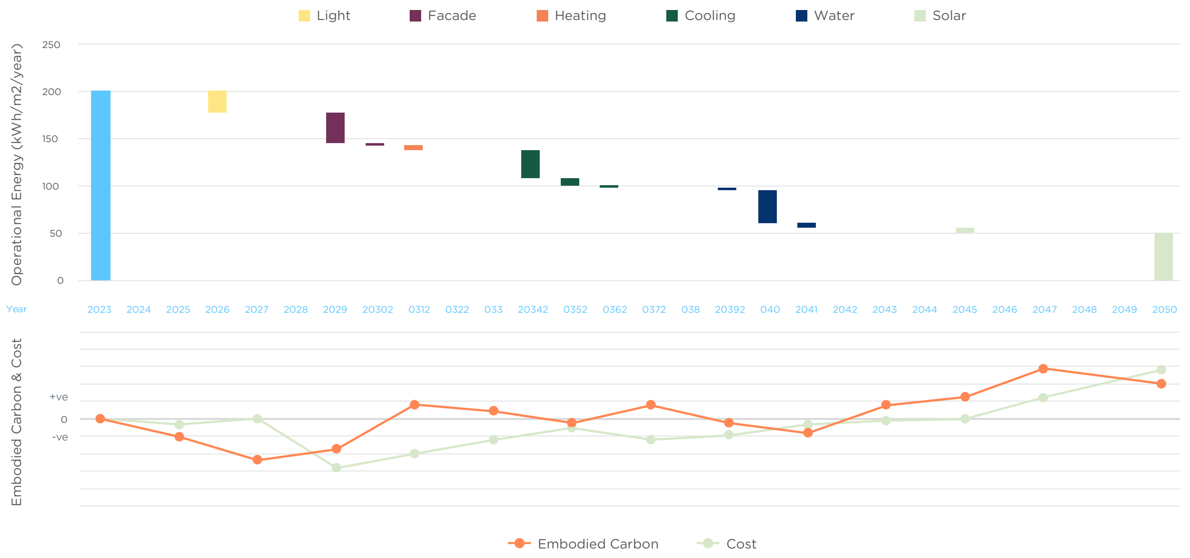
Interactive dashboards are used to outline and develop insights from the hundreds of thousands of data points which helps to inform decisions to be made.



Step 6
Create a carbon reduction roadmap

The ultimate result is a visual roadmap for asset owners on how clients can reduce the energy usage for their buildings and improve their energy ratings.

This sets out the pathway to decarbonisation and any interrelation-ships between interventions.



Immersive Interaction

In the realm of computational design, immersive interaction has emerged as a powerful tool, revolutionizing the way architects and designers engage with clients and stakeholders. By harnessing the capabilities of the latest film studio animation and video game rendering software, computational design teams are bringing projects to life with rich media interactivity, enabling unprecedented levels of co-creation.

The integration of advanced rendering software from the film and gaming industries allow computational design teams to create immersive experiences that transport clients into virtual environments. From interactive walkthroughs to real-time visualizations, these technologies provide a glimpse into the future of the built environment, offering clients a chance to experience spaces before they even break ground.

Through immersive interaction, clients can explore designs, interact with elements, and gain a deep understanding of the spatial qualities, materials, and ambience envisioned by the design team. This level of experiential engagement fosters collaboration and empowers clients to provide valuable insights and feedback early in the design process, enabling a truly co-creative partnership.

One of the key advantages of computational design is its ability to accelerate workflows, bringing high-end visualizations to clients and stakeholders from the project's inception. By leveraging computational power and advanced algorithms, design teams can rapidly generate and iterate on design concepts, integrating feedback seamlessly. This accelerated workflow not only saves time and resources but also enhances the decision-making process by allowing stakeholders to make informed choices based on realistic and immersive visualizations.

The convergence of computational design and immersive interaction heralds a new era of co-creation and client engagement. By immersing clients in virtual environments and providing them with the tools to interact and co-create, computational design empowers stakeholders to shape the trajectory of projects with a level of detail and realism never before possible.

In this dynamic landscape, computational design enables a transformative design process where collaboration and creativity thrive. Embrace the power of immersive interaction and computational design to redefine the boundaries of co-creation, shaping a future where client visions are seamlessly brought to life.

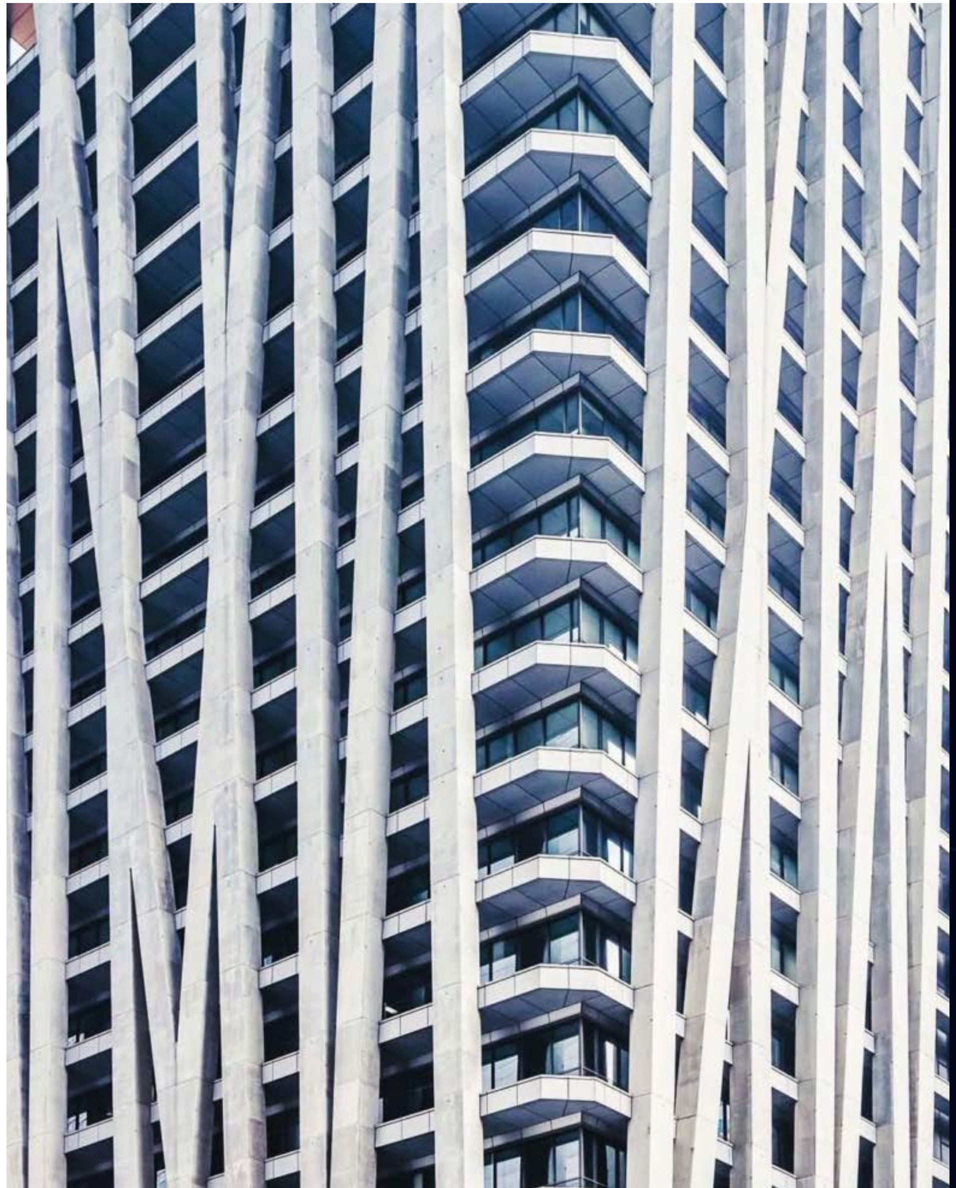
Reshaping the Future
and reducing carbon emissions

Computational design and technology hold immense promise in the battle against carbon emissions, offering a pathway to a regenerative future.

Through adaptable buildings, we can create structures that endure for centuries, reducing the need for frequent re-construction. By embracing organic materials, we tap into nature's toolbox, substituting environmentally harmful substances with sustainable and abundantly available alternatives.

Finally, the augmentation of human intelligence with AI empowers us to unlock new levels of innovation and efficiency.

As we embrace these transformative forces, we can pave the way for a regenerative future that harmonizes technological progress with environmental stewardship. It is through these synergistic efforts that we can reduce carbon emissions and shape a regenerative world for generations to come, and to become "**Good Ancestors**"...



Tokio Marine Centre, Singapore (CSYA)
A parametrically tuned structure

Augmenting Human Potential

The rapid advancements in AI tools and capabilities have sparked both fascination and fear. However, it is increasingly evident that the augmentation of human intelligence with AI can lead to ground-breaking new horizons.

By combining human creativity and intuition with computational power, we unlock the potential for innovative solutions to complex design challenges.

AI-powered algorithms and simulations enable designers to explore countless design possibilities, optimize energy efficiency, and reduce material waste.

This symbiotic relationship between humans and AI may become our saviour, guiding us towards a regenerative future by leveraging the strengths of both human ingenuity and computational power.

Unleashing Synergy
Where the intricacies of human insight and AI computational might converge, weaving a tapestry of innovation for complex design endeavours

Ecology of Intelligence

"My more optimistic prediction is that we're moving towards an ecology of intelligence where artificial intelligence is becoming a new creature within this ecology, which is forcing us to adapt. In the end, we move to a higher level of complexity and value through the introduction of this new intelligence into the universe."

Richard Hassell
Founding Director,
WOHA Architects

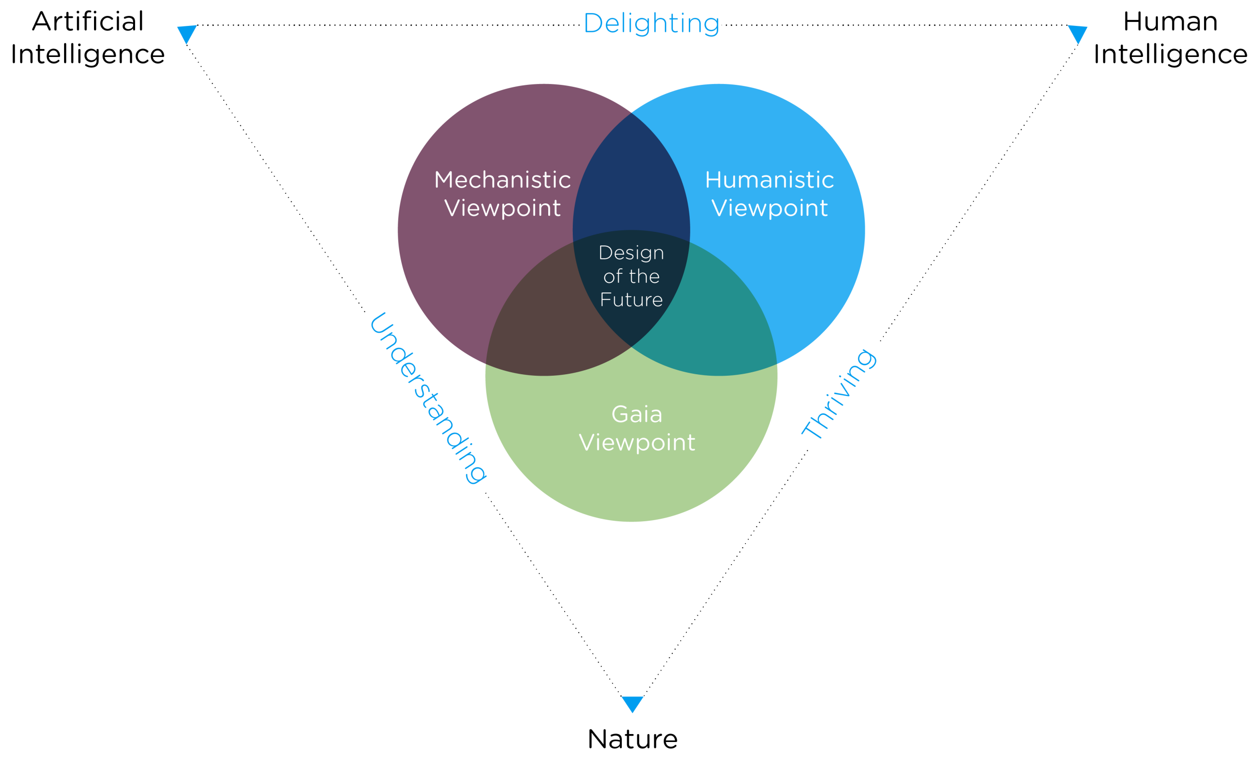


Image and idea: courtesy of Richard Hassell of WOHA Architects, Ramboll Design Excellence Forum 2022 (RDEF22)

Epilogue:an Etymology

Artificial Intelligence
an etymology

Artificial Intelligence is not yet another software to buy, nor an extension to current digitalization initiatives. AI is a completely new paradigm in which we have radically different attitude and relationship with technology compared to what we have hitherto had.

In an AI environment, machines are no longer mere tools that follow our instructions. Instead, they are real collaborators who not only bring to the table high levels of algorithmic and other computational power and prowess, but also contribute to the thinking and brainstorming process. The term Artificial Intelligence was coined 67 years ago back in 1956, when any level of autonomy by machines was seen by many in the context of Mary Shelley's "Frankenstein's monster"!

This perception, as old, flawed, and erroneous as it obviously is, still prevails in the minds of many. This needs to change. A change the lexicon is needed to reflect the positive impact that machines have brought to our lives, and how they can help co-create with us a better future for all.

The word computer is way older than the term AI. Surprisingly to many, it is over 400 years old! It was used, as far back as the 1600s, to describe the position of an assistant to accountants! One who would perform most of the detailed number crunching associated with keeping the books and accounts up to date.

The origin of the word comes from the 2 Latin words of "com" meaning "together", and "putare" meaning "to think". The literal meaning of the combined word "computer" is, therefore, to "think together".

AI, for the first time in our history, enables the true meaning of the name "computer" for some modern and powerful machines to be reflected in what they actually can now do; that is "to think together" with us.

"Artificial Intelligence is not yet another software to buy, nor an extension to current digitalization initiatives"

Punggol Digital District, Singapore (WOHA Architects)
The 50-hectare Punggol Digital District (PDD) is envisioned as the driver of Singapore's Smart Nation push through technology and ideas innovation.

PDD is the first district in Singapore to adopt an integrated masterplan of a business park, Singapore Institute of Technology's (SIT) new campus, an underground MRT station and other community facilities to create synergy and close integration between industry and academia and build strong creative communities.

Jiangxi River Park, China
(Henning Larsen, SADI and Ramboll)
This development is a linear riparian park acting as a vital regional ecological corridor for flora and fauna, playing a vital role in providing flood control & water storage for the new district. Our involvement in the project allowed layers of risks and vulnerabilities to be identified through iterative mapping, laying the foundation for the overall design and policy of the park.

Project visualisation from Henning Larsen

AI for Augmented Intelligence:

AI is about a complete paradigm shift in our relationship with the machine

"Hitherto, or until very recently at least, our imagination has been limited by our "natural" intelligence. With AI, this intelligence is augmented and multiplied many folds. This augmented intelligence empowers us to imagine things we would otherwise not allow ourselves to imagine; and to create things we would otherwise not imagine creating."

Hossein Rezai-Jorabi
Global Design Director,
Ramboll

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DESIGN is a periodical publication by the Design Excellence Board (DEB) within the Buildings Market in Ramboll.

The publication promotes and articulates latest ideas on matters relating to design, technology, environment and ethos within the design industry and the built environment, at large. It aims to address key issues facing contemporary design professionals, including our evolving relationship with the natural environment; as well as pressing political and social agendas for the built environment.

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