ZHA, Zaha Hadid Architects

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Mathematics and its tools have always played a central role in the evolution of the human understanding of nature and the constructed world. Sir Isaac Newton's methods to derive the laws of gravitation, Henri Poincaré's extension of the Cartesian geometries to the planetary system and Lord Kelvin's use of the mathematical technique of curve-fitting to predict the tides, are just a few examples.

Mathematics provides the foundations of computing and of scientific methods of research within architectural practices. It has had a profound influence on architectural morphology and its origins, basing them on sound structural principles. The enhancement of the performative aspects of design with respect to the built environment, its manufacture and ultimately the comfortable navigation by people within these environments, forms an integral part of building on these foundations.

With historical training in geometric methods to understand morphology, architects are well positioned to contribute to this collaborative endeavour of delivering information-rich settings that support the complex needs of humans within the built environment.

A large proportion of our own work at ZHA emerges from our fascination with mathematical logic and geometry, with advances in design technology enabling us to rethink form and space. The fluid surfaces and structures of each project thus generated are defined by scientific innovations.

Our design for the *Mathematics Gallery* (2016) at the *Science Museum* in London represents a pertinent case. The successful flight of the *Handley Page* aeroplane (see Fig. 1) in the 1929 *Guggenheim competition*, with its short take-off and landing distances, represents a triumphal moment in the accessibility of aviation to ordinary men and women [1].

The spatial arrangement of the Gallery places a central emphasis on this important product of British aviation, and the transformational capacity of mathematics

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Fig. 1 Handley Page H.P.39 (1929)

and science, by taking inspiration from one of the key moments in the flight of the plane and the concepts of aerodynamics embodied within.

While mathematical logic and geometry can provide an intuitive model to understand, the natural world, computational tools allow us to examine scenarios that enable a nuanced understanding of the mechanisms of nature. Using the principles of a mathematical approach known as *computational fluid dynamics* that acts as an organizational guide, the layout of the *Gallery* allows for the virtual lines of airflow to be manifested physically. The positioning of the more than 100 historical objects and the production of robust arch-like benches using robotic manufacture, all embody the mathematical spirit of the brief. The resulting spatial experience created by these components within the *Gallery* enables visitors to see some of the many perceivable ways in which mathematics touches our lives.

However, these principles do not apply to the aforementioned project only. In facts, ZHA maintains a fully digital practice: all of our buildings are designed in 3D from the beginning, rather than being translated into 3D models at a later stage in the design process. Building on our expertise in 3D design, ZHA is using Building Information Modelling on a growing number of our projects such as the *Investcorp Building* (2015) at *Oxford University's Middle East Centre* and the *Serpentine Sackler Gallery* (2013) in *Kensington Gardens*, London.

Given the small complex site of the *Investcorp Building***,** it was critical that the building was efficient and that all building systems where coordinated with architectural elements. ZHA modelled the entire building in 3D to analyse and highlight problems within the design stage. The design team frequently exchanged 3D information to overlay the outputs of each discipline resulting in a highly coordinated building. Many of the design packages included 3D information to allow subcontractors to understand working zones, tolerances and to work with the design team as the design developed.

The irregular geometry of the *Serpentine Sackler Gallery* required close collaboration between us and the engineering teams to resolve any potential issue. The sinuous, fluid form of the *tensile* roof was achieved through specific 3D software. The roof curvature was then optimised to control and minimise the stresses in the fabric and avoid the risk of ponding. The structural and steel elements, such as the columns and the perimeter truss, were modelled in 3D in close collaboration with the structural engineer.

The late Zaha Hadid first became interested in geometry while studying mathematics at university. Mathematics and geometry have a strong connection with architecture and she continued to examine these relationships throughout each of her projects; with mathematics always central to her work. As Zaha said:

> When I was growing up in Iraq, math was an everyday part of life. My parents instilled in me a passion for discovery, and they never made a distinction between science and creativity. We would play with math problems just as we would play with pens and paper to draw—math was like sketching [2].

References

1. The Handley Page H.P.39 was a wooden biplane to compete in the competition proposed by the Daniel Guggenheim Fund for the promotion of Aeronautics
2. Z. Hadid, written for CNN, 17 November 2015

Mathematics: The Winton Gallery, Science Museum, London (2016)


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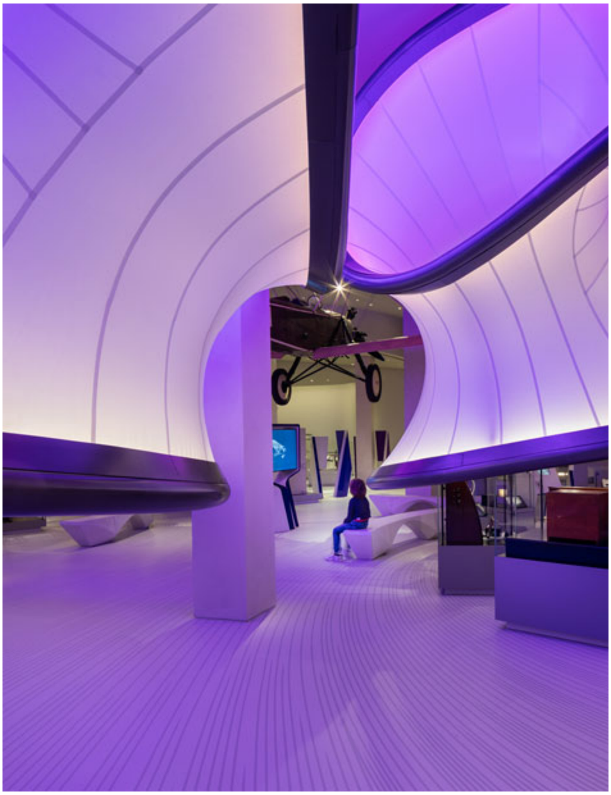

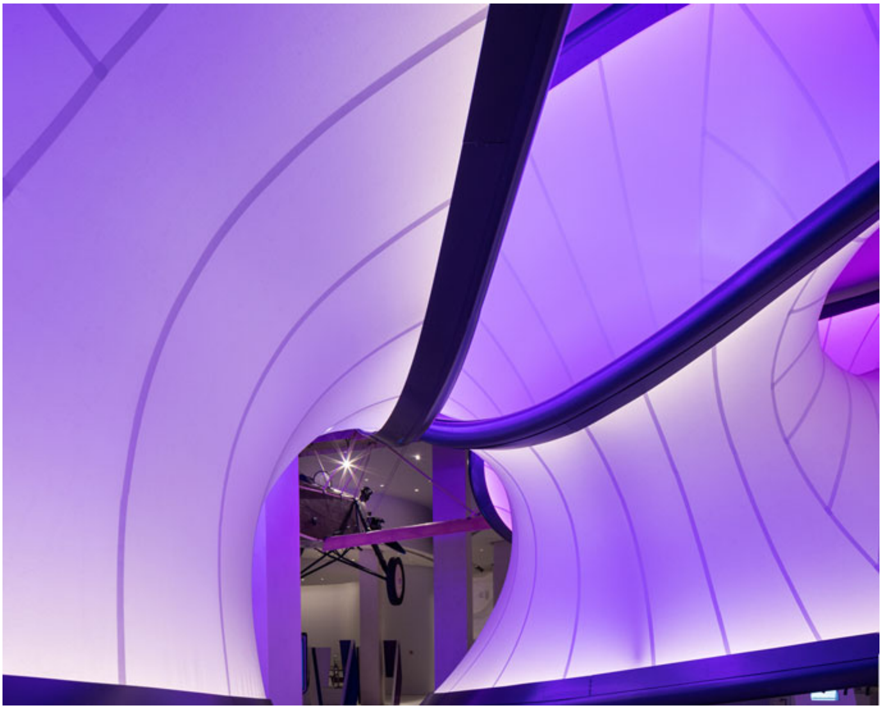

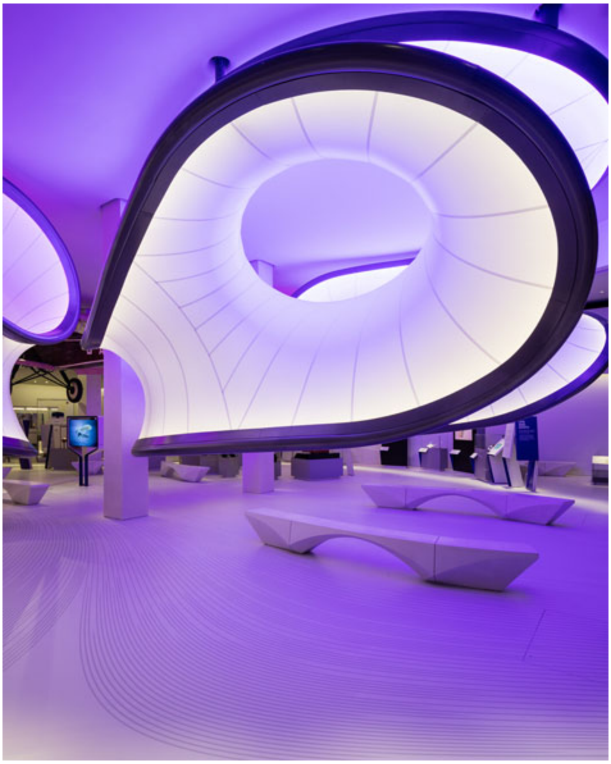


GLOBTIK TANKERS


LIFE
AND
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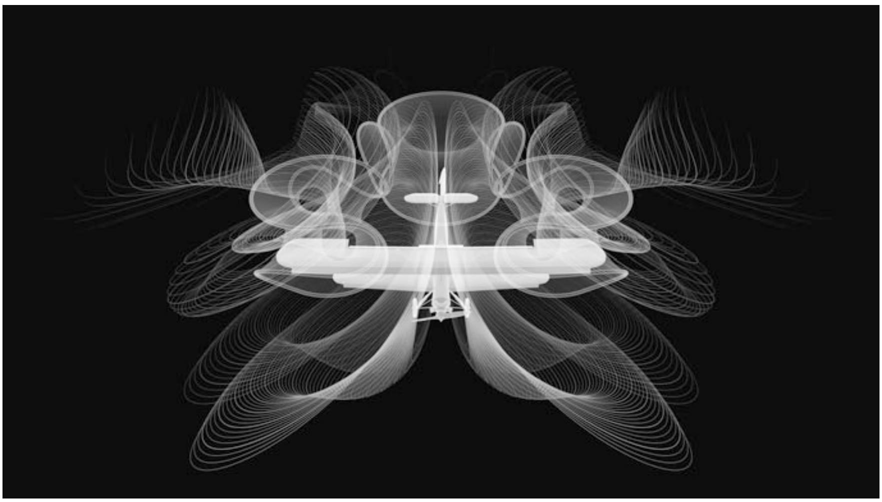

Serpentine Sackler Gallery, Royal Park of Kensington Gardens, London (2013)

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Investcorp Building for Oxford University's Middle East Centre at St Antony's College (2015)

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