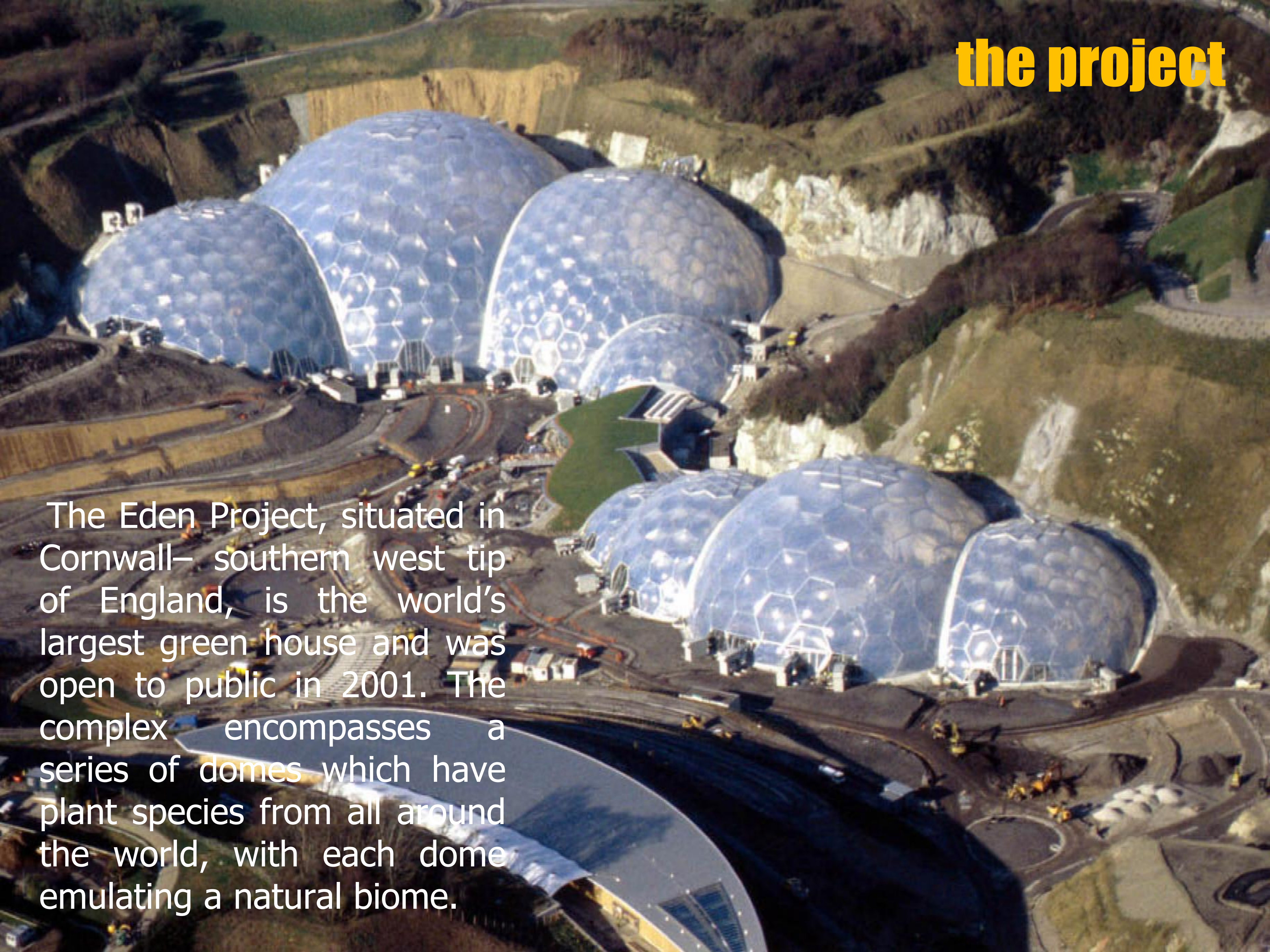

the eden project



the project

The Eden Project, situated in Cornwall– southern west tip of England, is the world's largest green house and was open to public in 2001. The complex encompasses a series of domes which have plant species from all around the world, with each dome emulating a natural biome.

Client: **The Eden Project**

Size: **23,000 sq.m / 247,480 sq. ft**

Completion: **March 2001**

Cost: **£ 160 millions / $ 239 millions**

Structural Engineer: **Anthony Hunt Associates**

Services Engineer: **Arup**

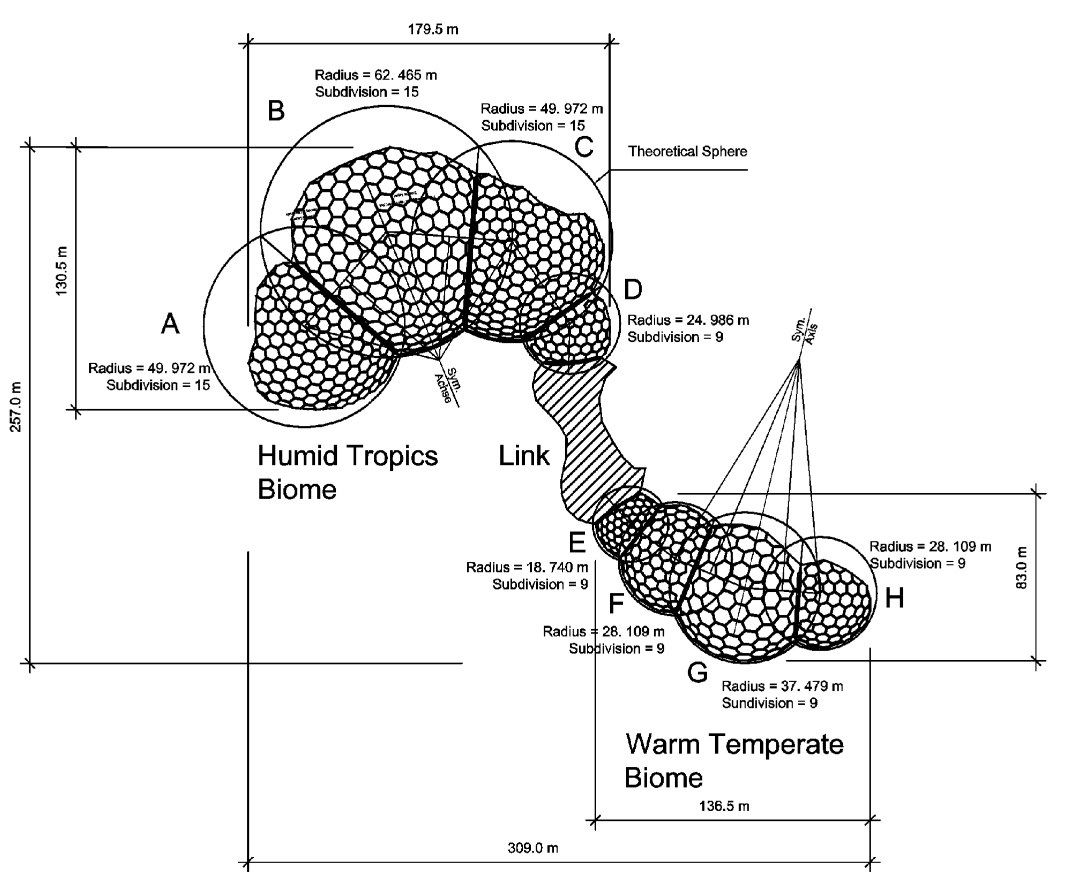
Cost Consultant: **Davis Langdon and Everest**

Main Contractor: **McAlpine Joint Venture**

fact file

The complex consists of:

- Entrance and the visitor centre
- Humid topic Biome (HTB)
- Warm Temperature Biome (WTB)
- The Link



the complex

structural concept

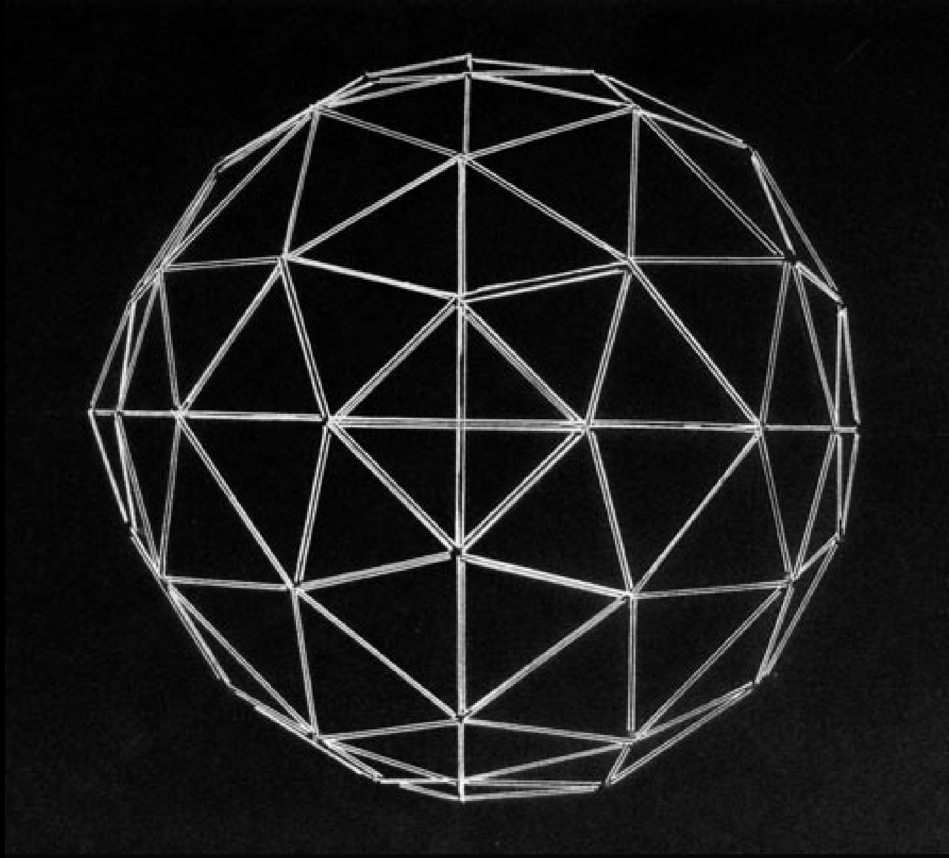
geodesic dome

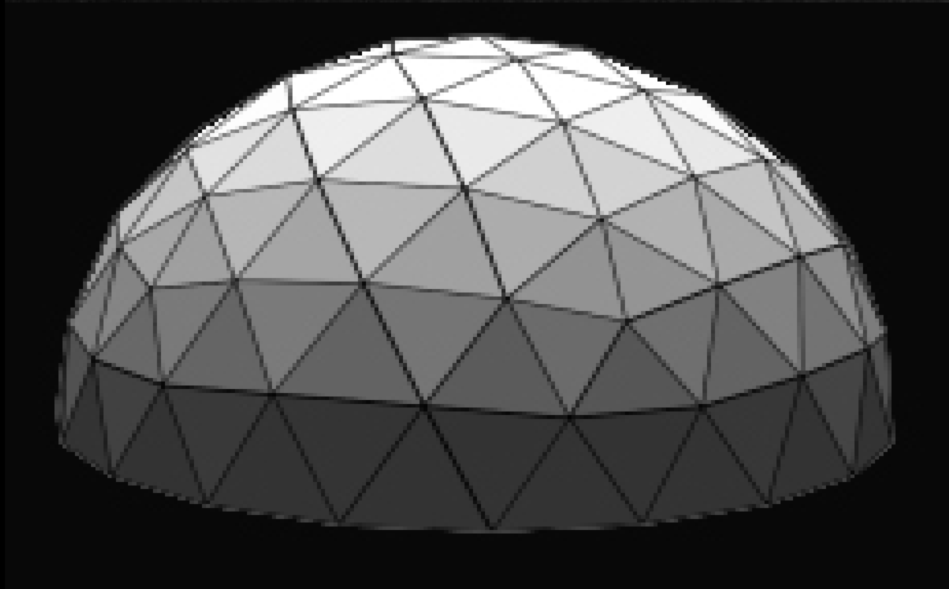
Geodesic Dome is a spherical space frame which transfers the loads to its support by a network of linear elements arranged in a spherical dome.

All the members in the geodesic dome are in direct stress (tension or compression).

The geodesic dome is developed by dividing platonic polyhedrons.

The loads are transferred to the support points by axial forces (tension and compression) in the frame members.



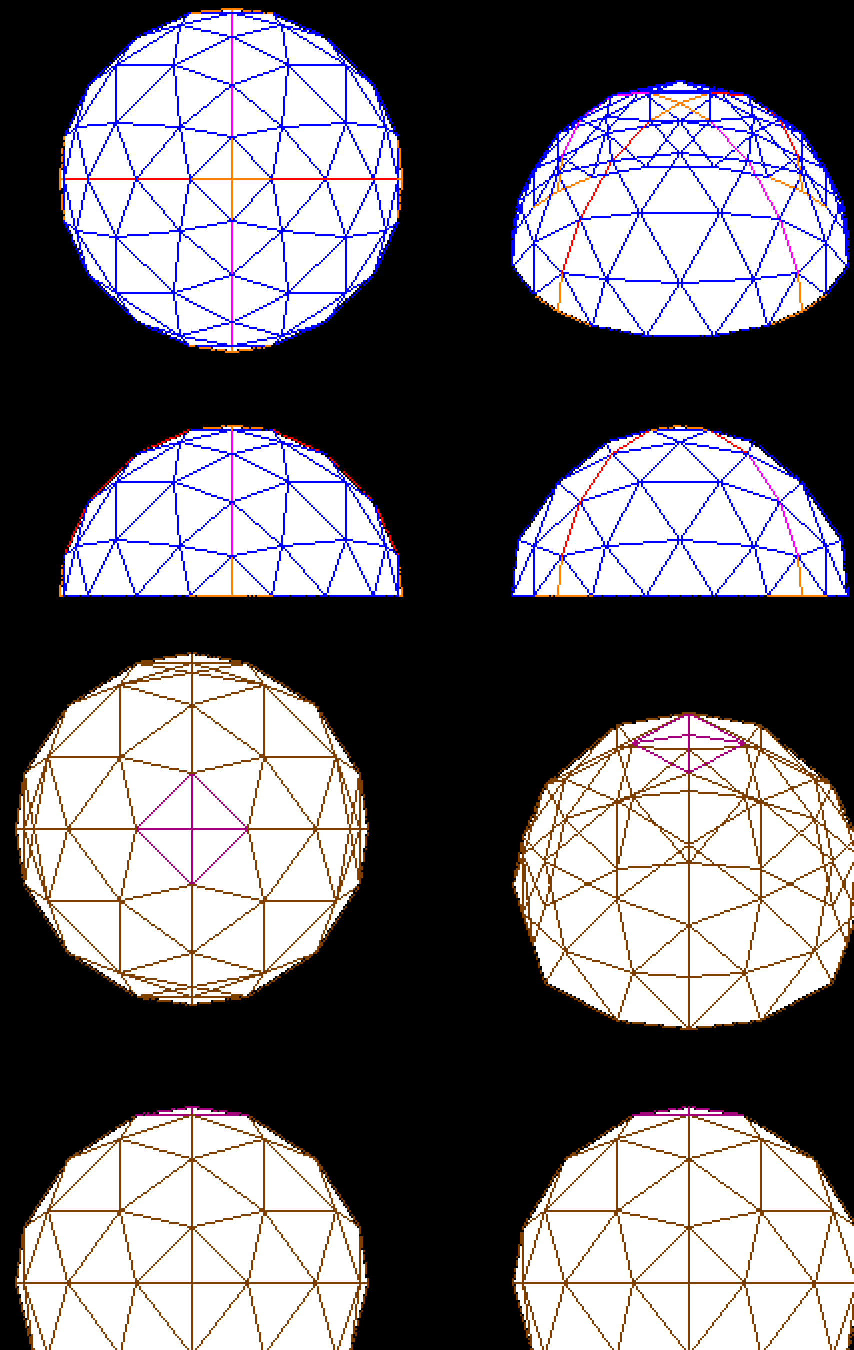


Under uniform loading in a hemisphere geodesic dome, all upper members those about approx 45 degrees will be in compression, lower near horizontal members will be in tension, while near vertical members will be in compression.

Hemisphere domes generate a small amount of outward thrust.

Quarter sphere domes generate considerable outward thrust that must be resisted by buttresses or a tension ring.

Three quarters sphere domes develop inward thrust which must be resisted by the floor slab or a compression ring.



The layout of the project was based on significant criteria like column free space, maximum sunlight intake, optimum volume for required function and visual appearance.

The geodesic domes fulfilled all these criteria and were also best suited to fit the structure on the undulated site surface.

The primary design for the project was single layered domes. But some preliminary studies showed that the single layered structures of the given project dimensions would be uneconomical and also had large deformations.

the eden biomes

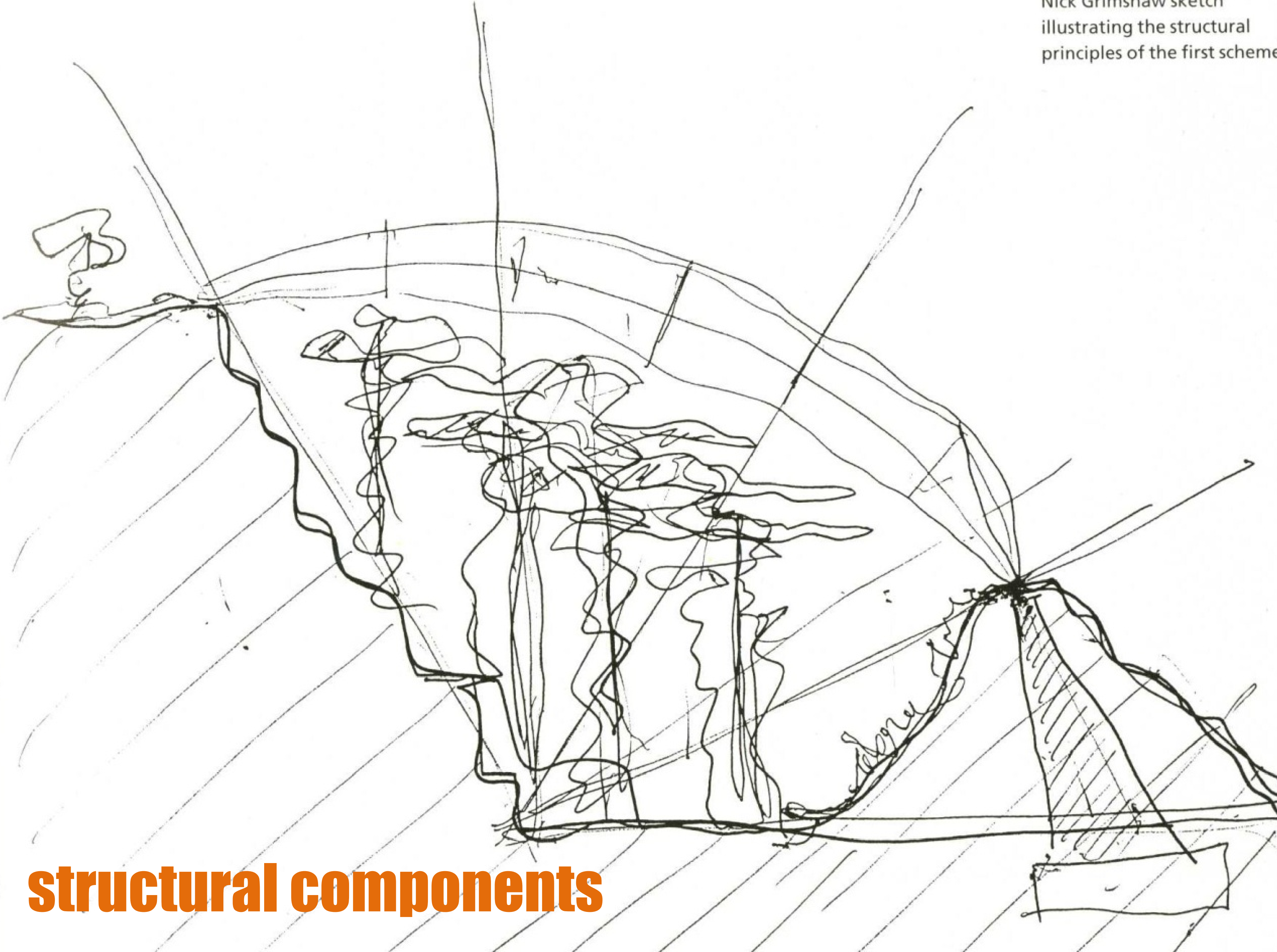
The structural network of a dome consists of two concentric spherical networks with a radius difference between them. This radius difference is connected by diagonal struts thus creating a dual layered three dimensional load carrying network.

The external face consists of hexagons and pentagons whereas the internal one is made up of hexagons and triangles. The external layer is referred as “Hex-Net” and the internal is the “Tri-Hex-Net”. The Tri-Hex Net shows similarity with the molecular structure of silicates, which exhibits the characters of minimal path and minimal material consumption.

To have a continuous column free space, the series of geodesic domes are connected by a truss at their intersection. The trusses transfer the load to their foundation. The domes also partly transfer the load to the strip foundation along its perimeter.

The external skin is made of ETFE triple layered pillow filled with air pressure. They act as good insulators and optimizes the light penetration.

Nick Grimshaw sketch illustrating the structural principles of the first scheme.

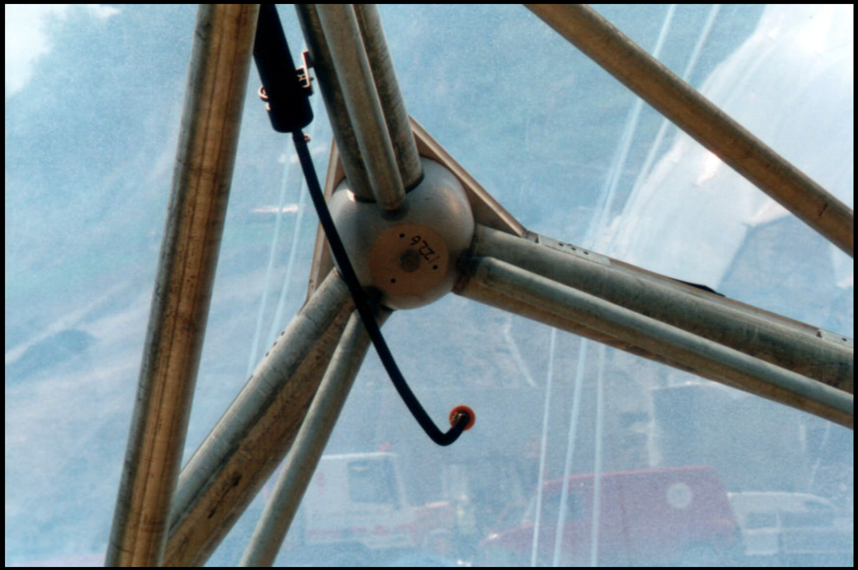


structural components

ETFE

- Ethelene tetra-fluoro-ethelene
- Trade name “Tefzel”
- High corrosive resistance
- Three times larger load carrying capacity
- Bears 400 times its self weight
- Compared to glass, ETFE is 1% the weight
- Transmits more light
- Installation cost reduced by 24% to 70%
- Self cleaning and recyclable
- Ability to stretch to three times its length without loss of elasticity

- Three layered pillow
- each pillow attached to air supply system
- Inside pressure is about 300 pascals
- Maximum height of inflated pillow is 10-15% of the maximum span

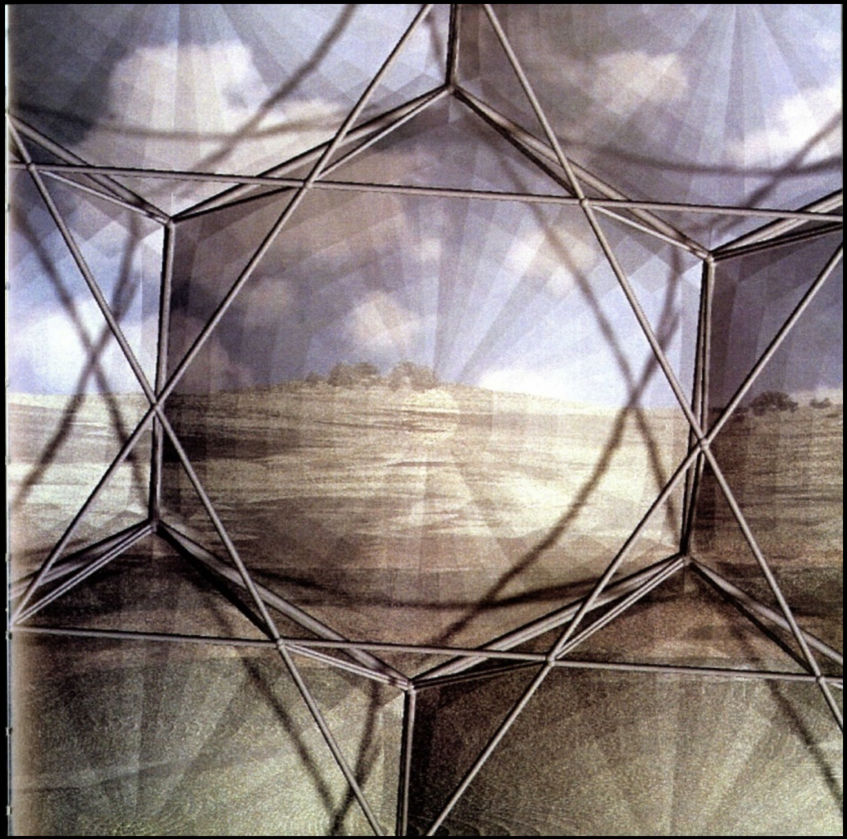


hex - net

Grid consists of series of hexagons and pentagons

Rigid connections through bowl nodes

Maximum grid span is 11 m, member size is 193 mm dia

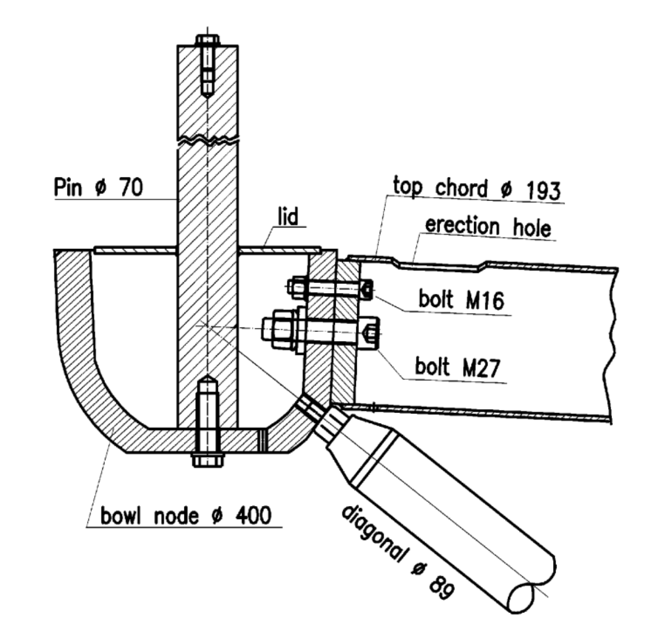


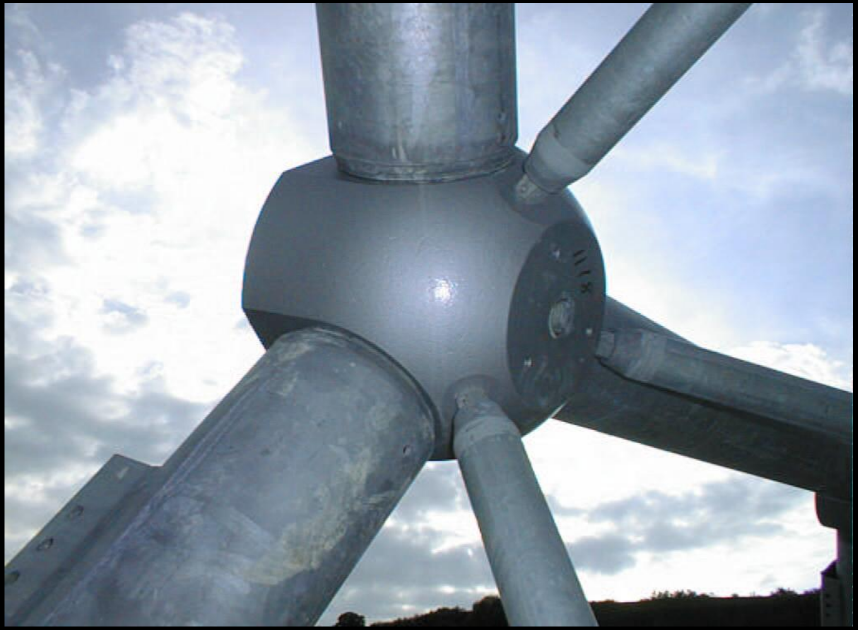
tri - hex - net

Single layer domes are restricted to a span of approximately 100ft. (30m). Domes greater than this span employ a double layer space frame configuration for greater stability and rigidity.

The Bowl node:

Rigid connection for the Hex Net members.
Hinged connections for the Tri - Hex Net members.
No tolerances





connectors

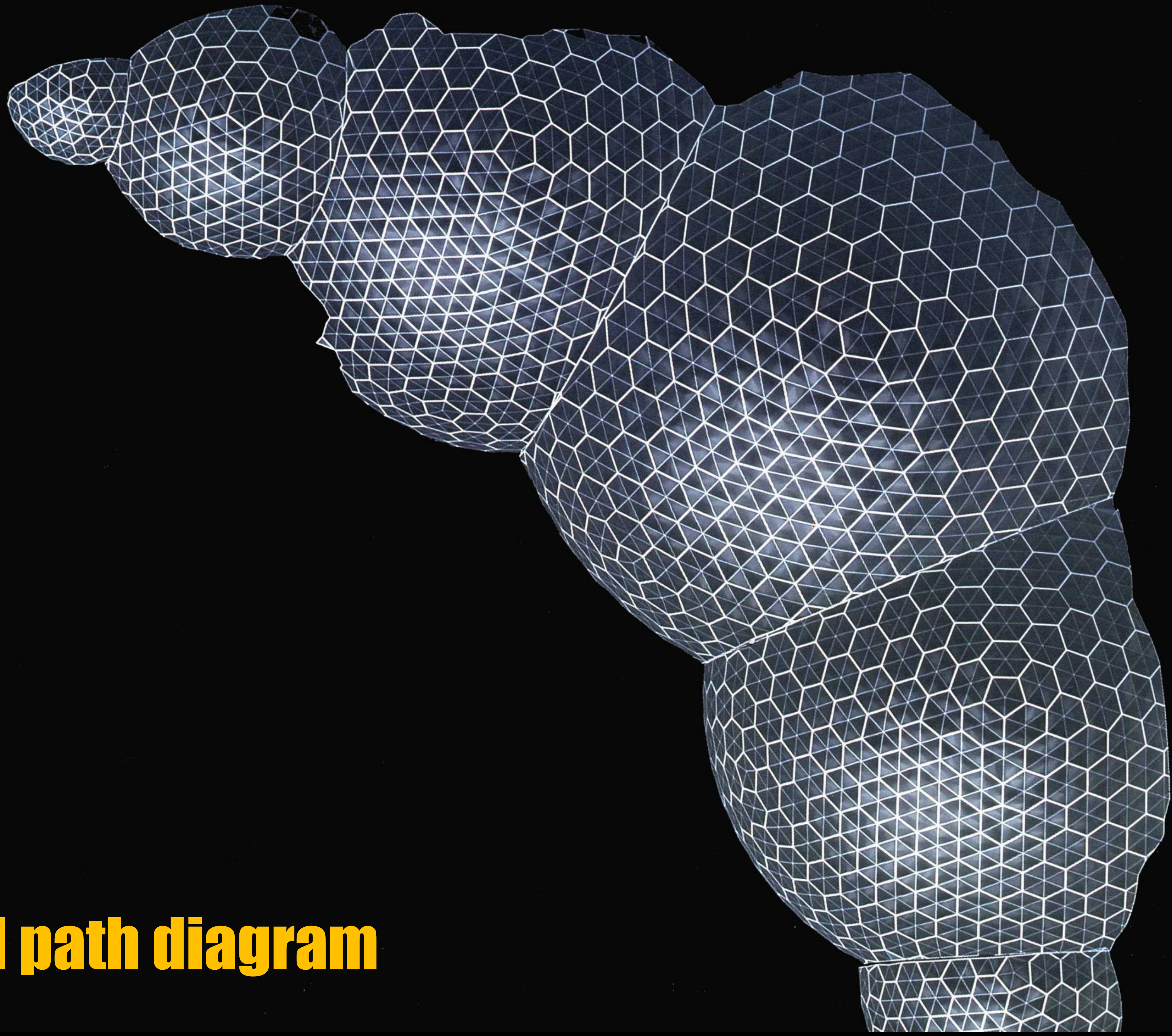
Hinged connections for Tri Hex Net layer.

Foundation connectors for the Hex Net and Tri Hex Net Membrane

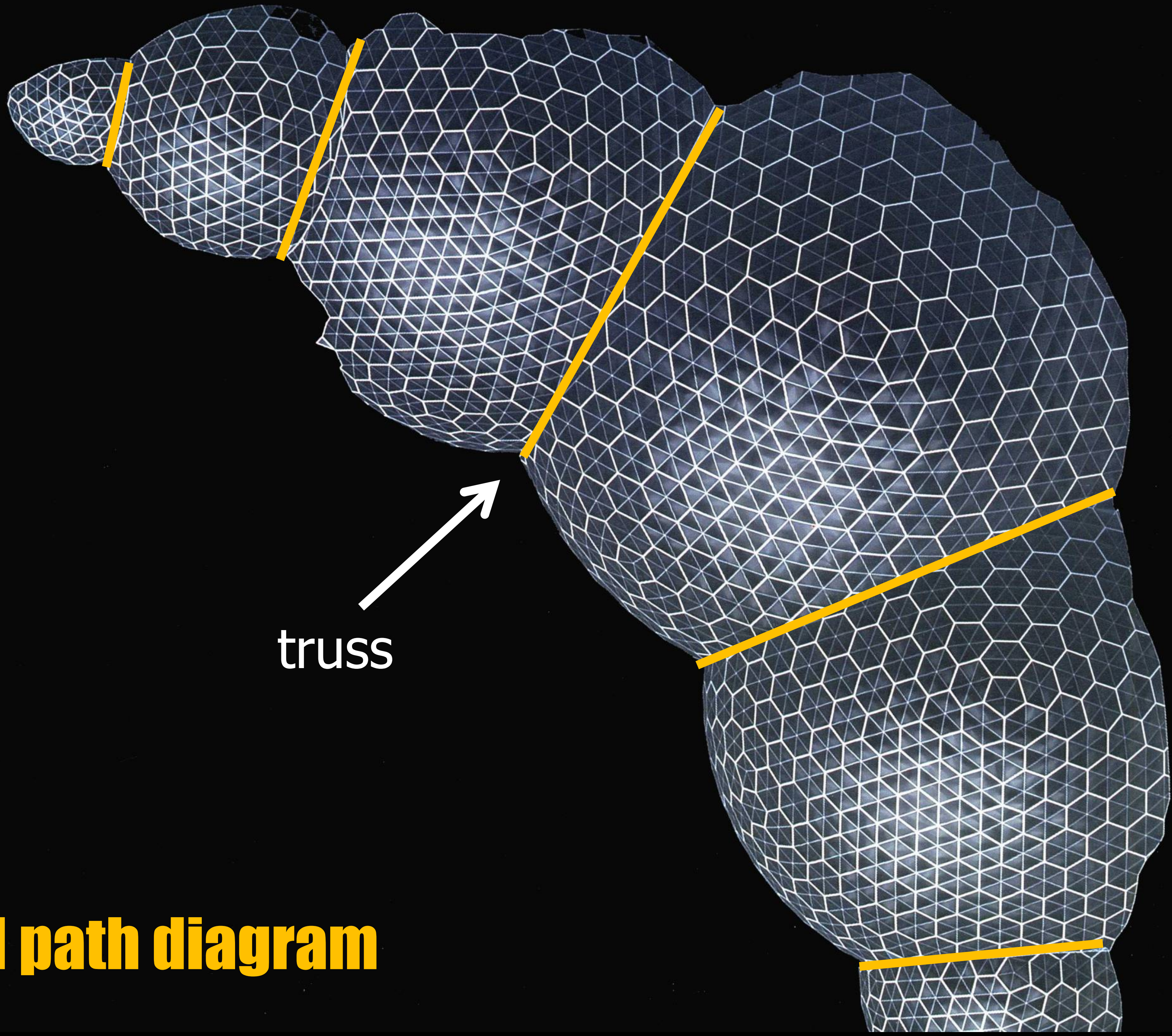
connectors

truss

The Hex-net and tri-hex-net of the domes meet the top chord and the bottom chord of the triangular truss



load path diagram



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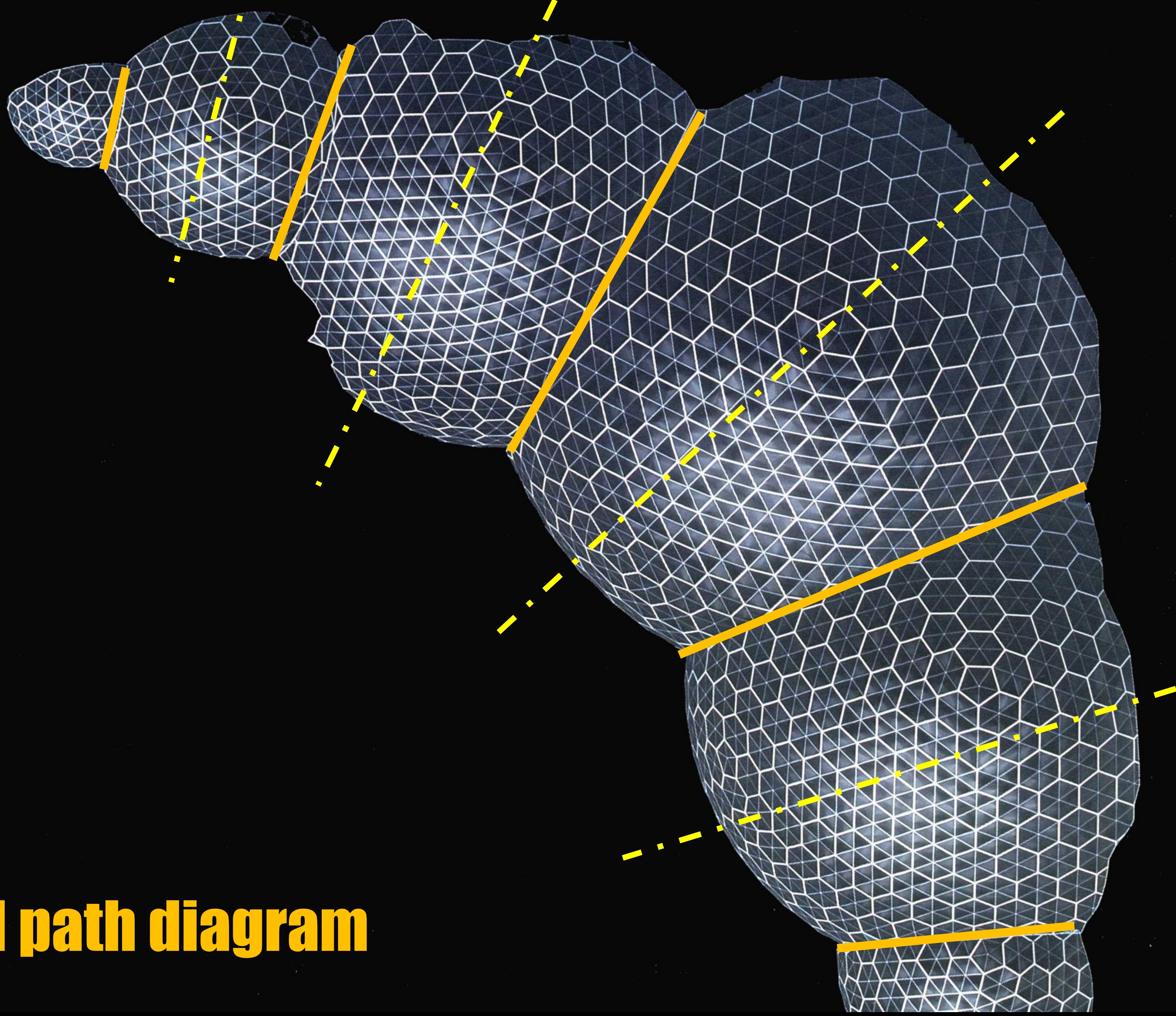

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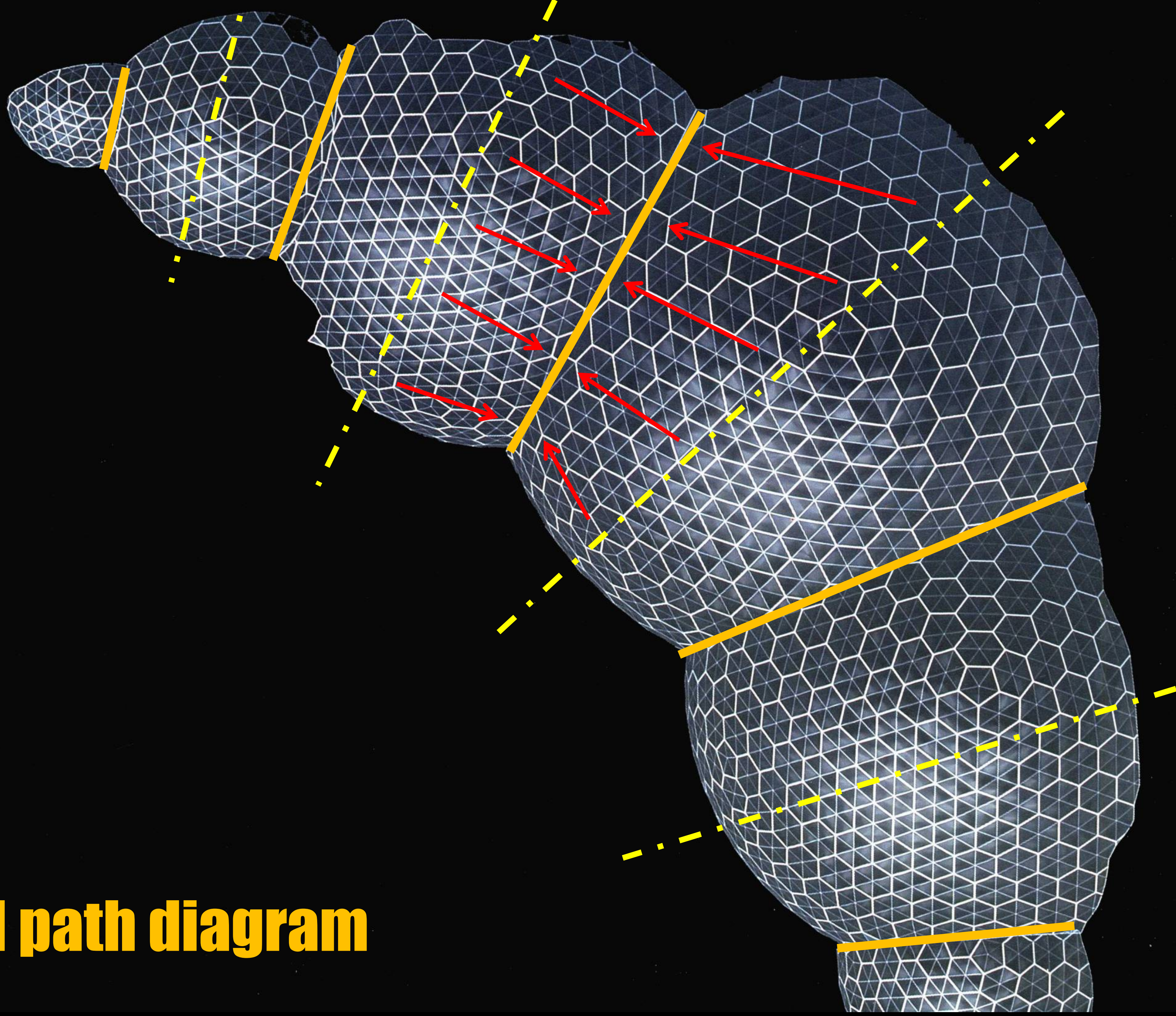

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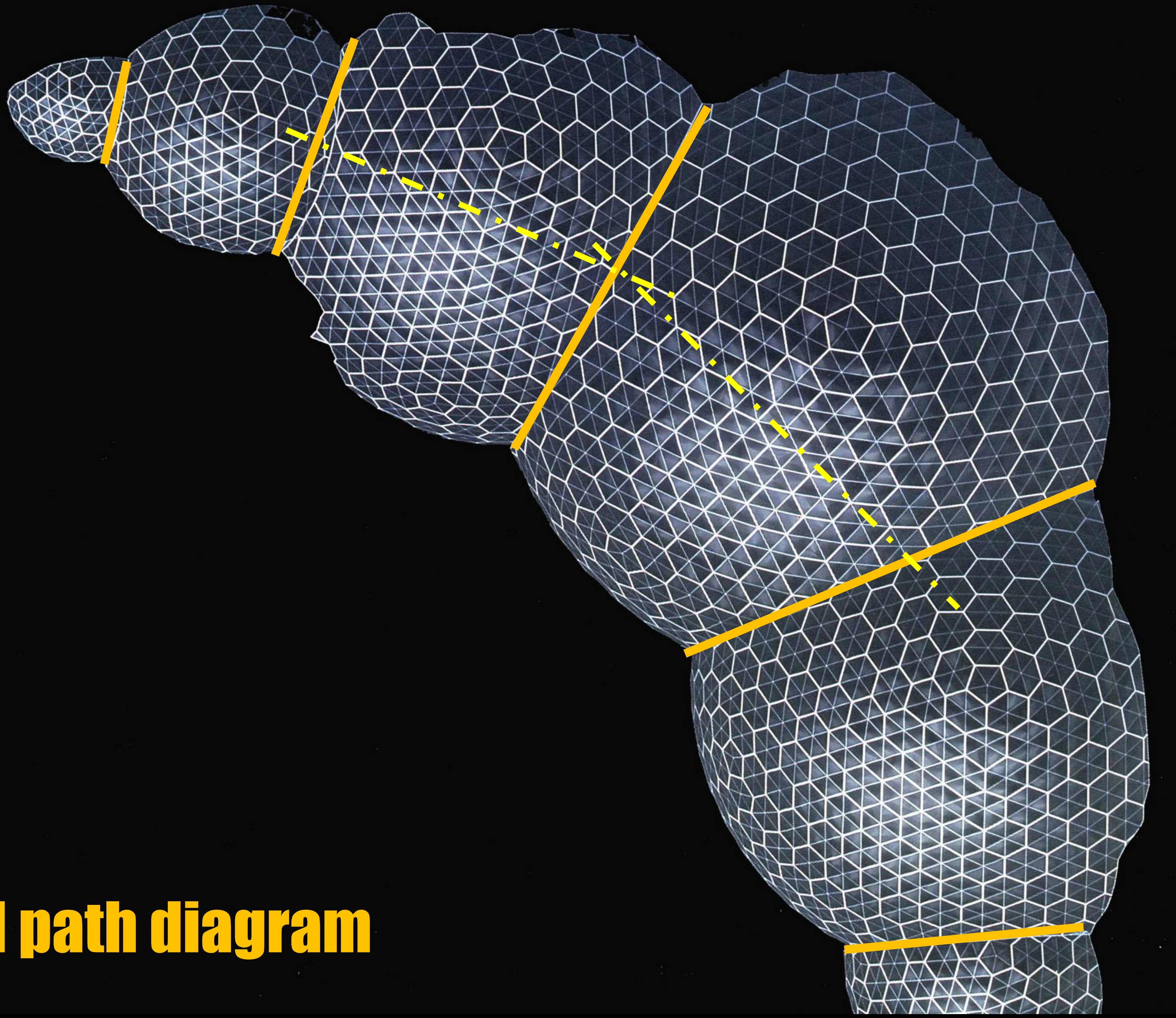

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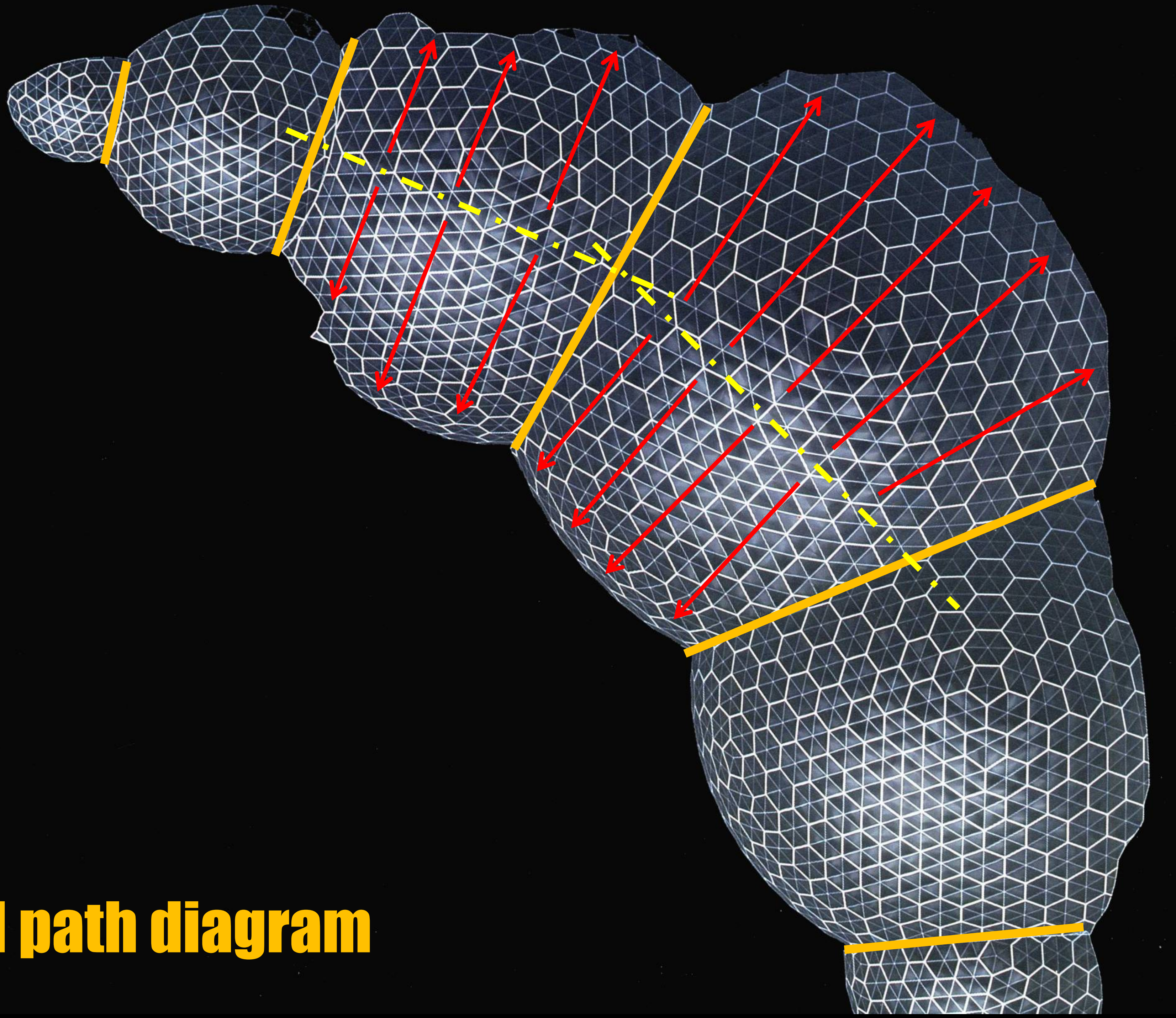

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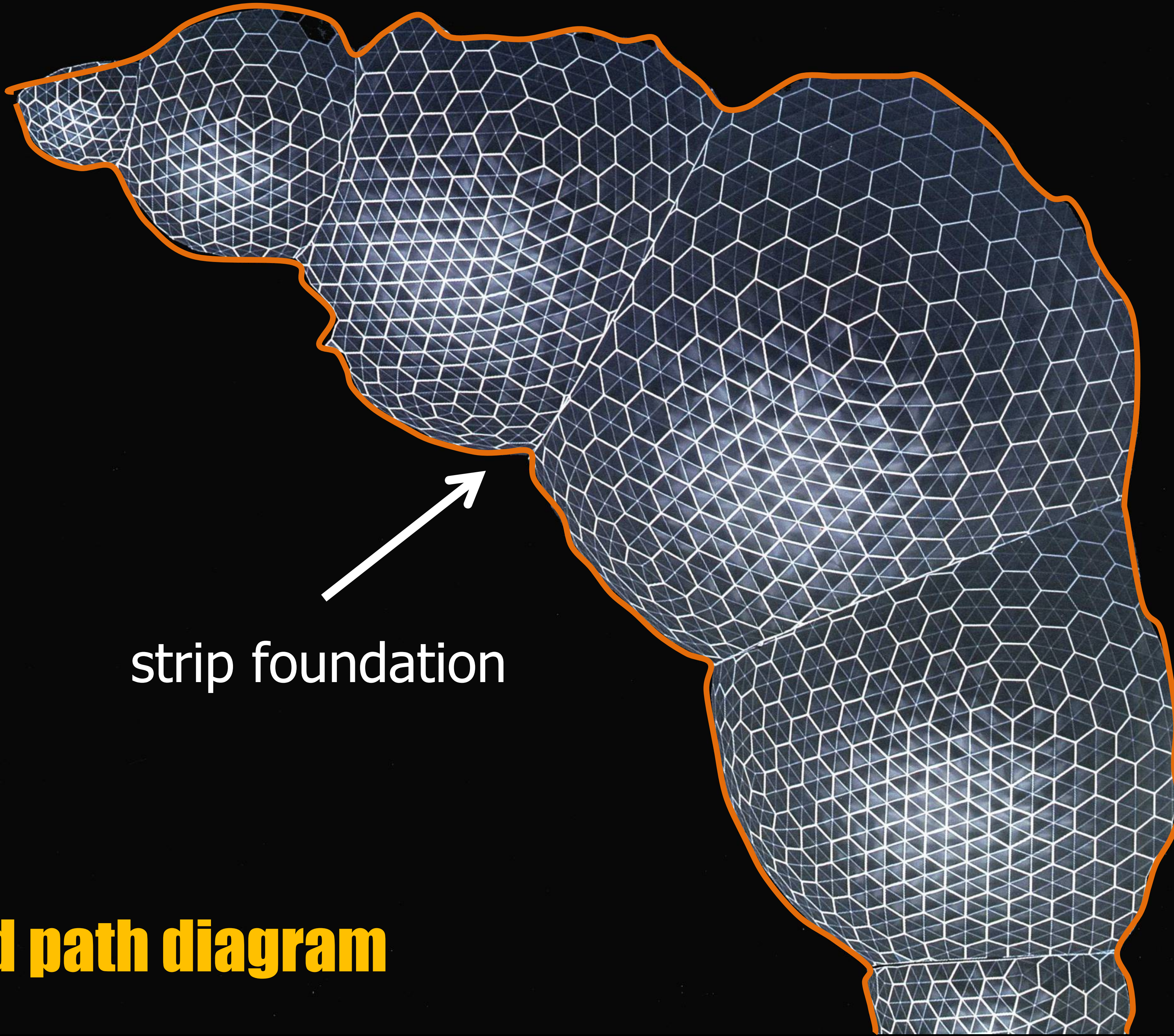

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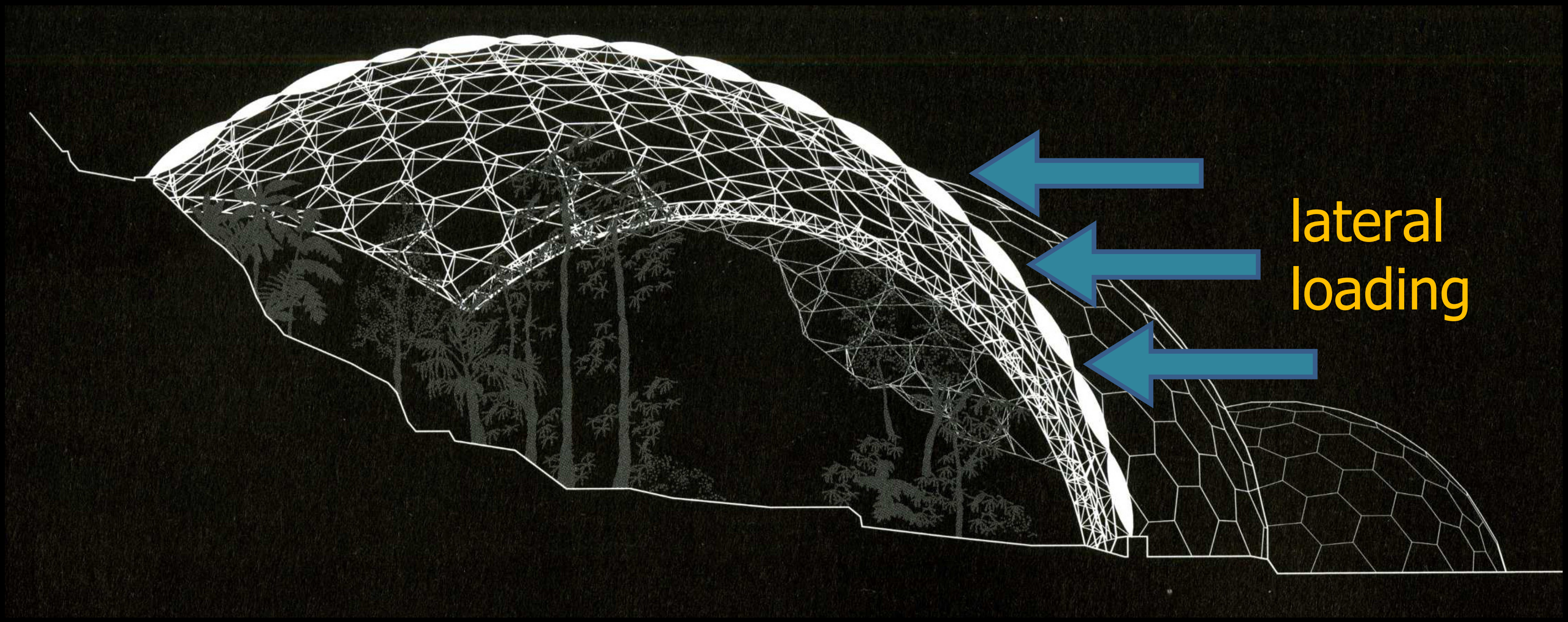

lateral
loading

STRUCTURAL FACT FILE

Total surface: 39.540 m^2

Total steel weight: 700 tons

Total length off all beams: 36000 m

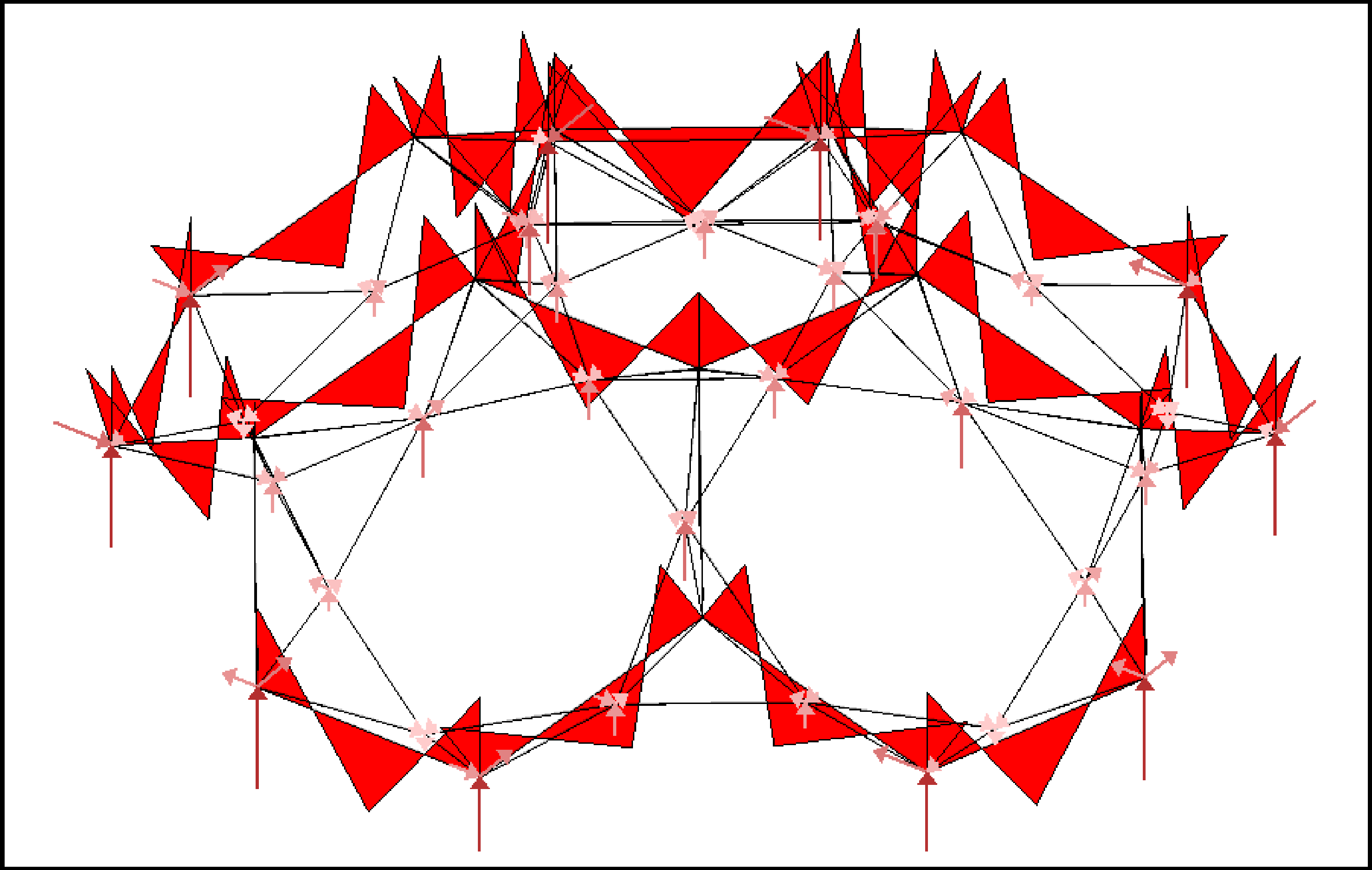
Steel weight per surface less than: 24 kg/m^2

Biggest hexagon area: 80 sq. m at a span of 11 m

Biggest dome diameter (dome B): 125 m

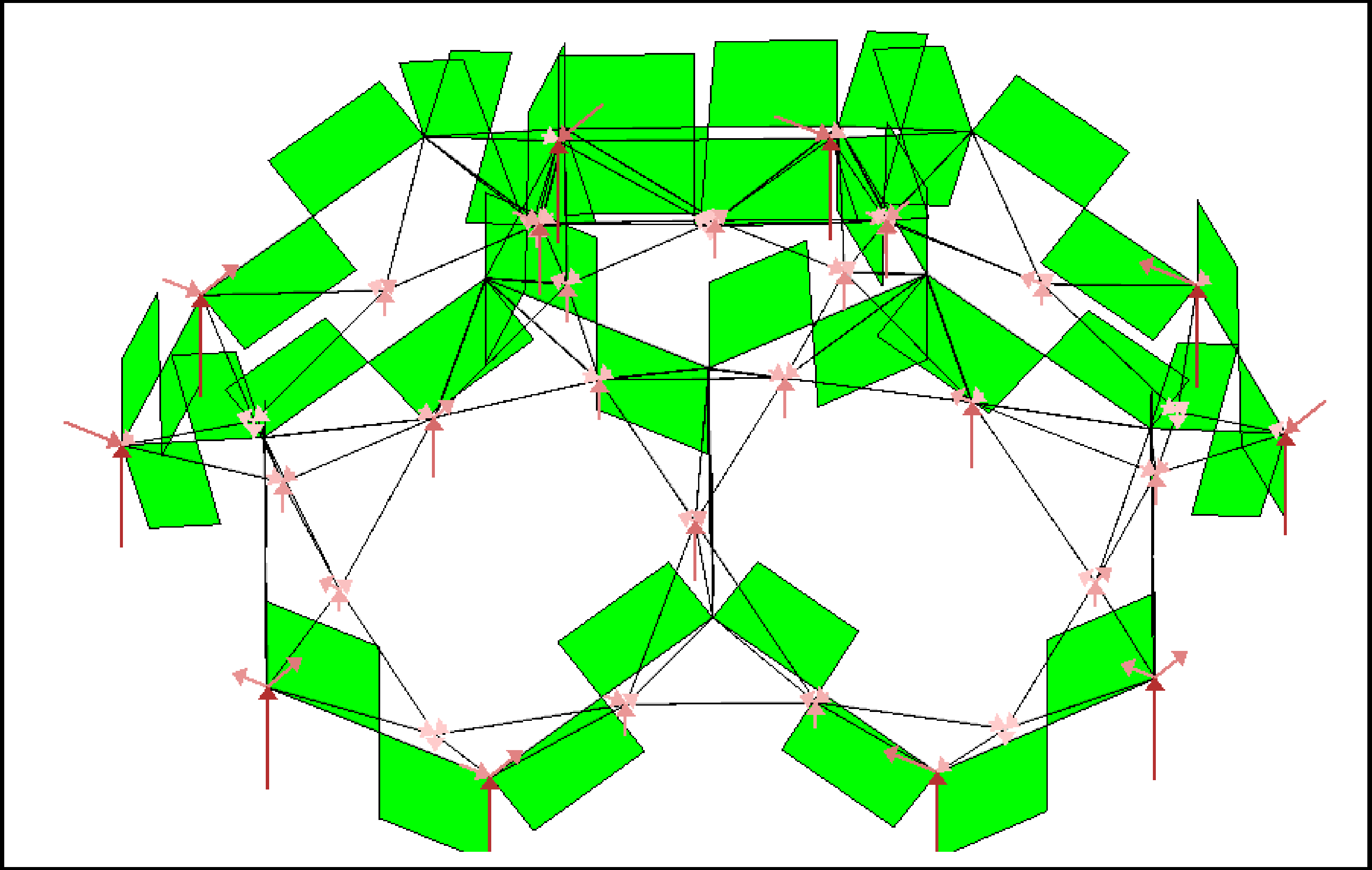
Column free area: 15590 m^2 WTB and 6540 m^2 for HTB

multi-frame analysis



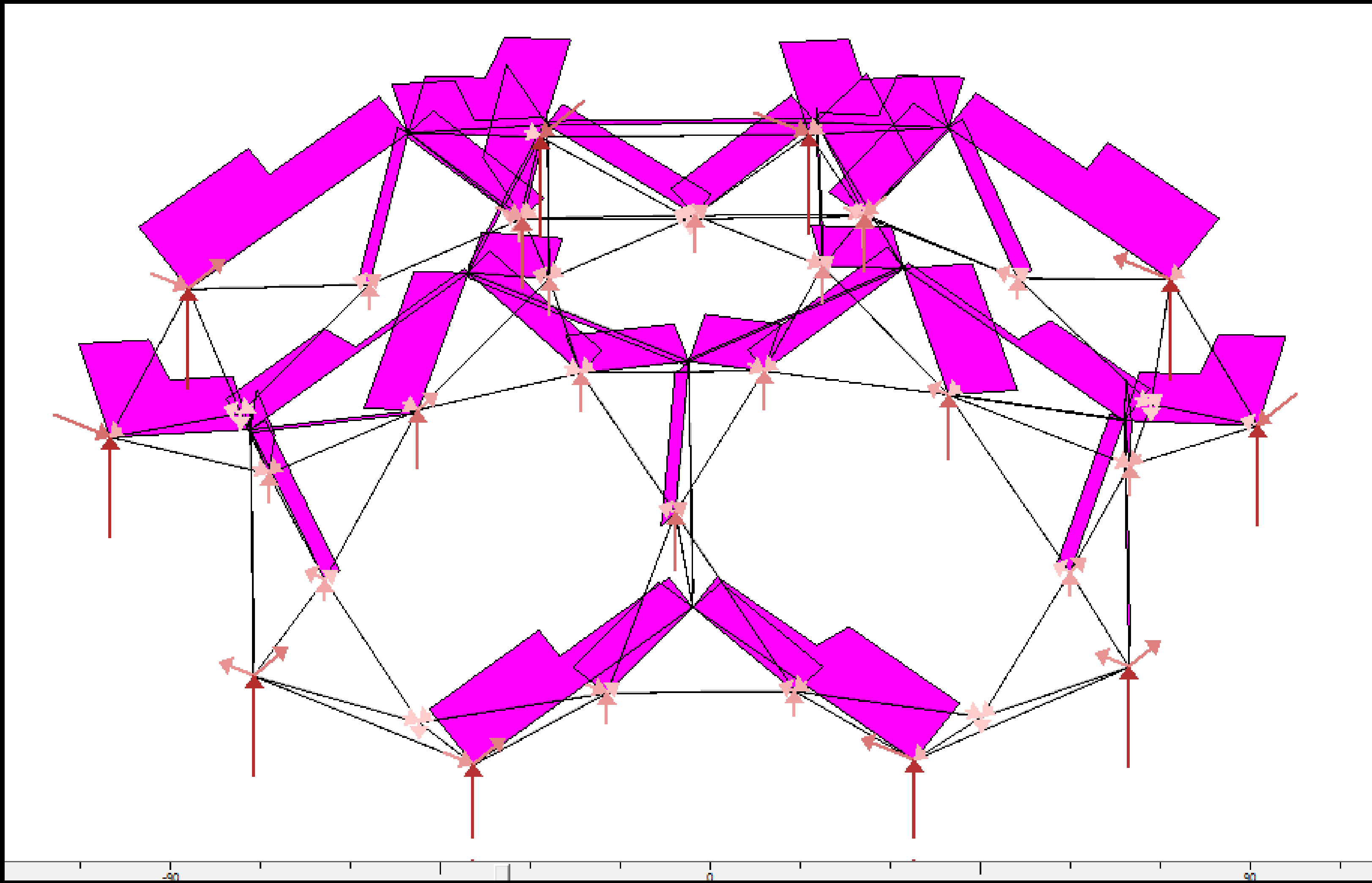
bending moment diagram

multi-frame analysis



shear force diagram

multi-frame analysis



axial loading

bibliography

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