INNOVATING & INTEGRATING for SUSTAINABILITY

Presented to SB08 24 March 2008

Technology and Tools Improving Sustainability in Design

Presented to SB08 24 March 2008

Peter Bowtell
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industry revolution

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complexity

embedded cost

evaluation

optimisation

explanation

senses

planning

operations

energy

COMMUNICATION

Approaches to Interdependency: Early Design Exploration across the architectural and engineering domains

(Dr) Paul Nicholas

"Interdependency"

A relationship through which parties can constructively explore their differences and search for solutions that go beyond their own limited vision of what is possible

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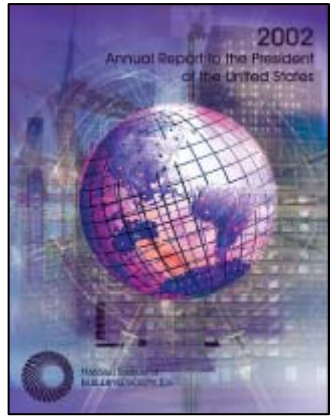
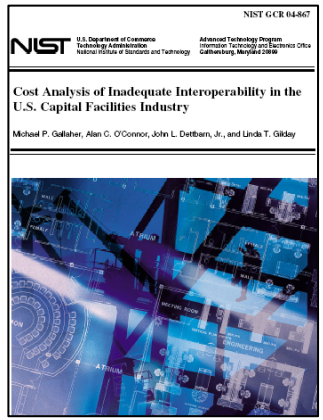
Annual Report of the National Institute of Building Sciences (USA)

"It has been estimated that 30% of the cost of construction today is spent on gathering, entering, exchanging and re-entering data and information used by the different sectors involved in a facilities' planning, design, construction, and operation and maintenance.



US National Institute of Standards and Technology (USA)

“estimates the cost of inadequate interoperability in the U.S. capital facilities industry to be $15.8 billion per year.”


NIST GCR 04-867

NIST U.S. Department of Commerce Technology Administration National Institute of Standards and Technology — Advanced Technology Program Information Technology and Electronics Office Gaithersburg, Maryland 20899

Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry

Michael P. Gallaher, Alan C. O'Connor, John L. Dettbarn, Jr., and Linda T. Gilday

Sustainable buildings

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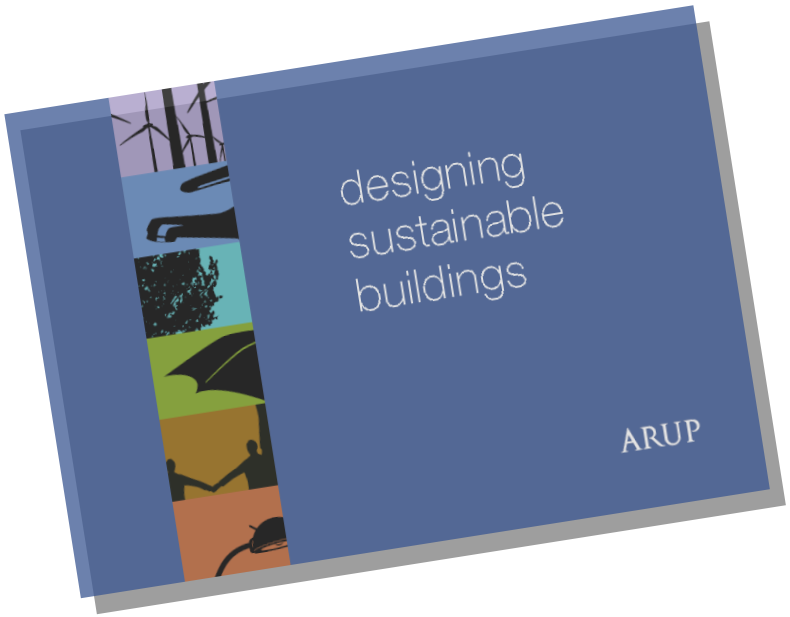
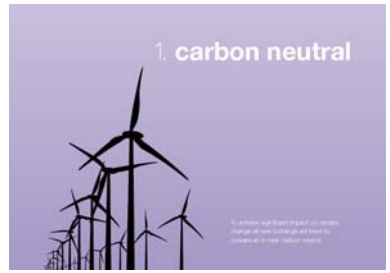

designing
sustainable
buildings
ARUP


1. carbon neutral


2. self-sufficient
by collecting and
re-using water


3. built using
sustainable
materials


4. able to cope
with future
climate change


6. sustainable
in operation

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Assessing Green Building Performance

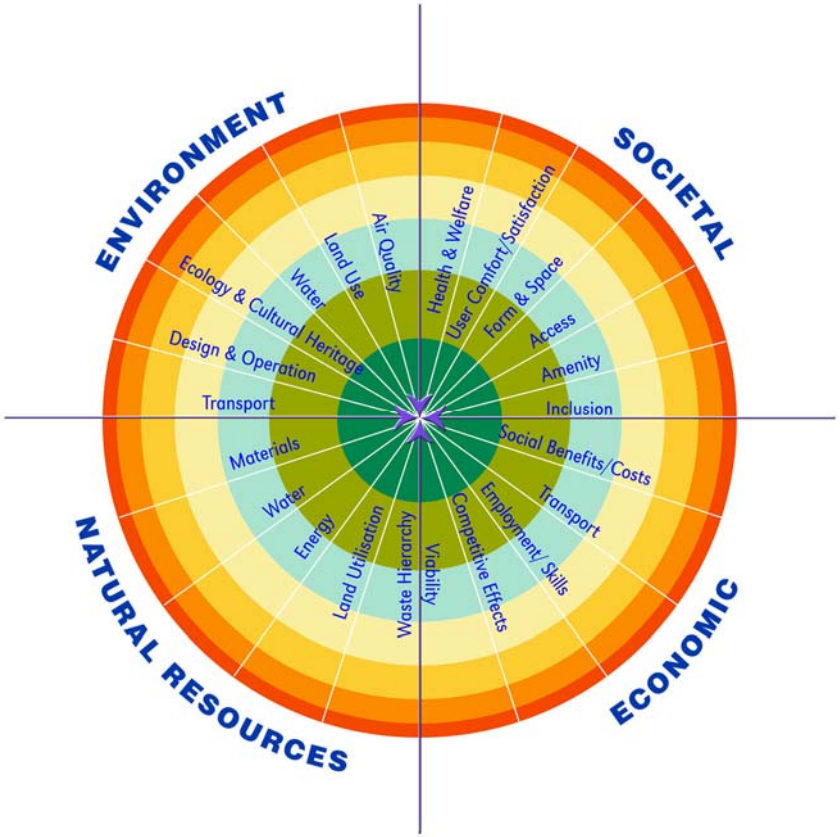
A post Occupancy Evaluation of 12 General Services Administration Buildings

26 % less Energy Use

13% Lower maintenance Costs

27% higher Occupant Satisfaction

33% less CO2 Emissions


ENVIRONMENT
SOCIETAL
NATURAL RESOURCES
ECONOMIC
Air Quality
Land Use
Water
Ecology & Cultural Heritage
Design & Operation
Transport
Materials
Water
Energy
Land Utilisation
Waste Hierarchy
Viability
Competitive Effects
Employment/ Skills
Transport
Social Benefits/Costs
Inclusion
Amenity
Access
Form & Space
User Comfort/Satisfaction
Health & Welfare

SPeAR

MaterialOptimisation

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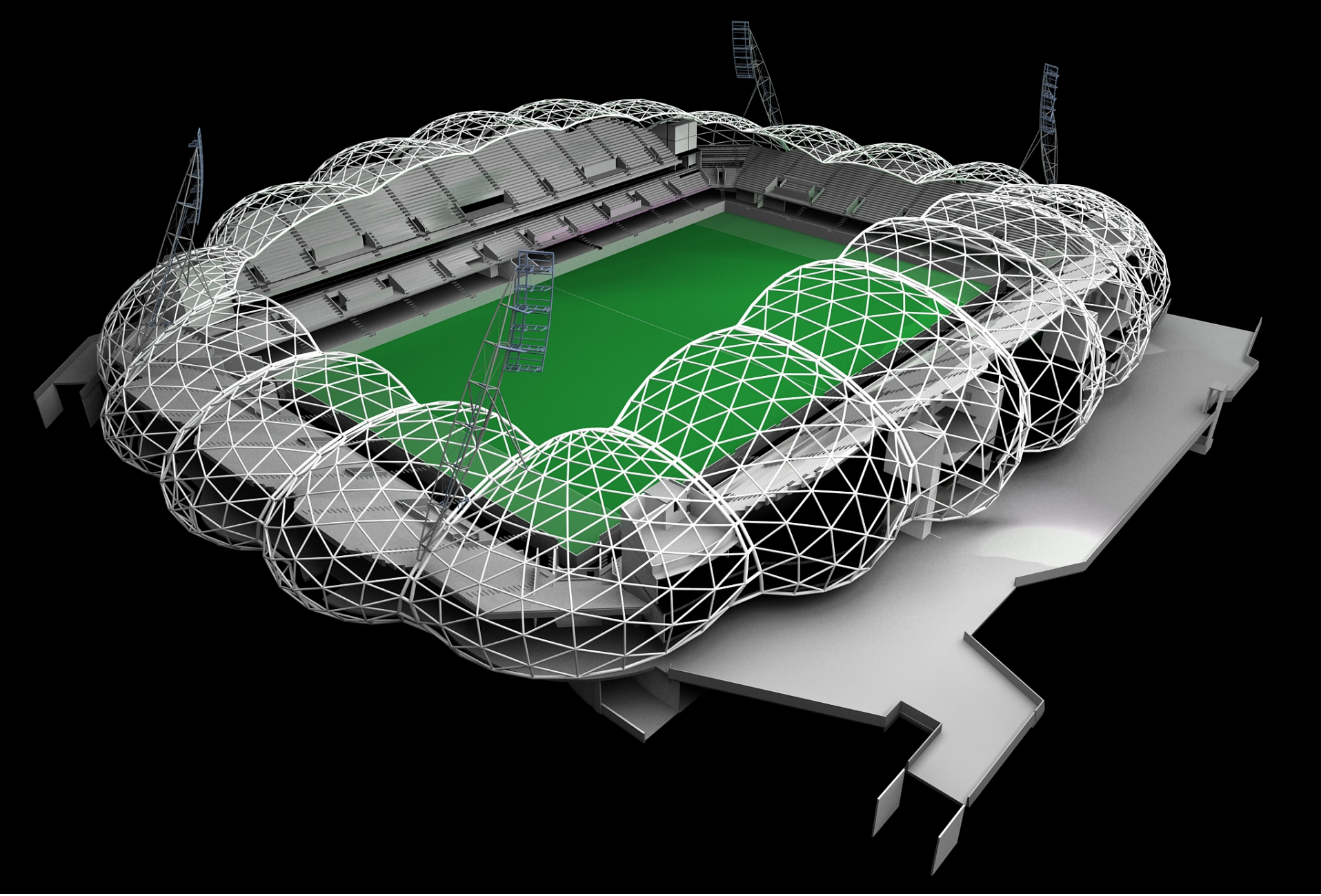

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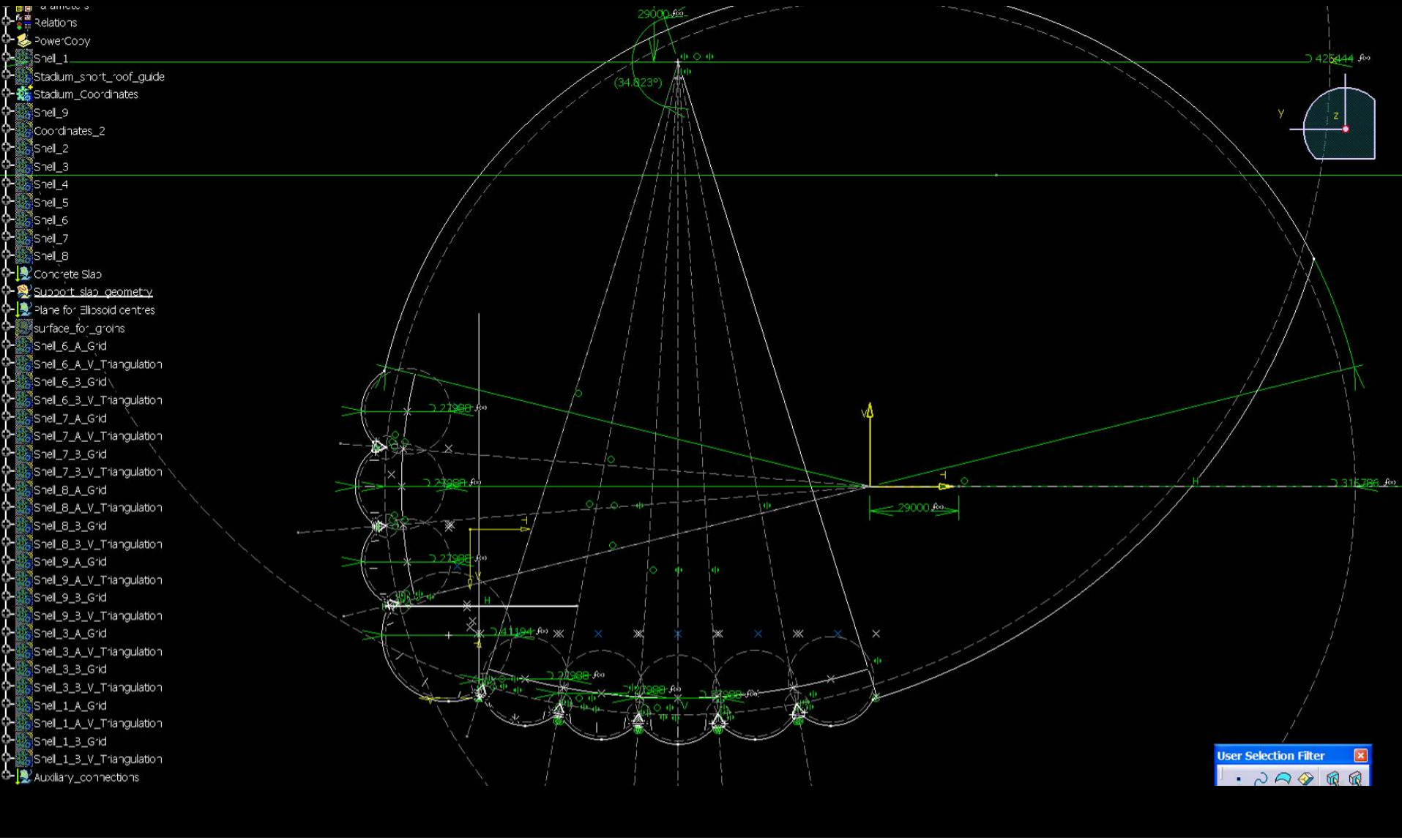
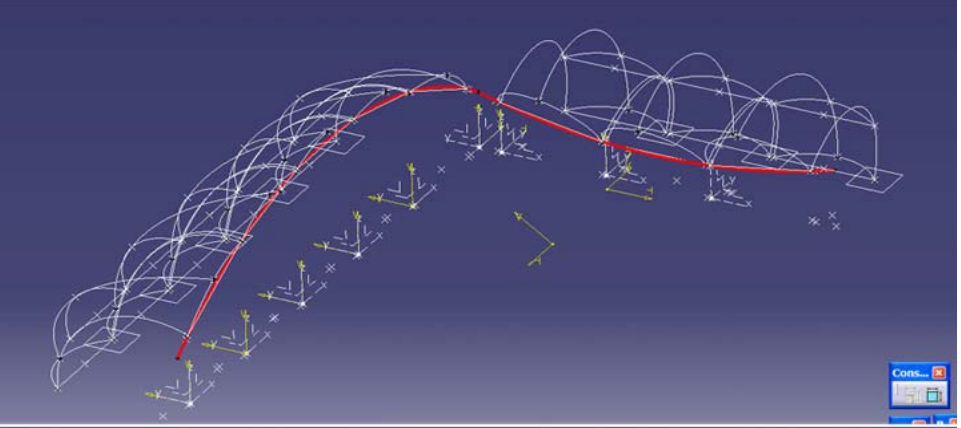
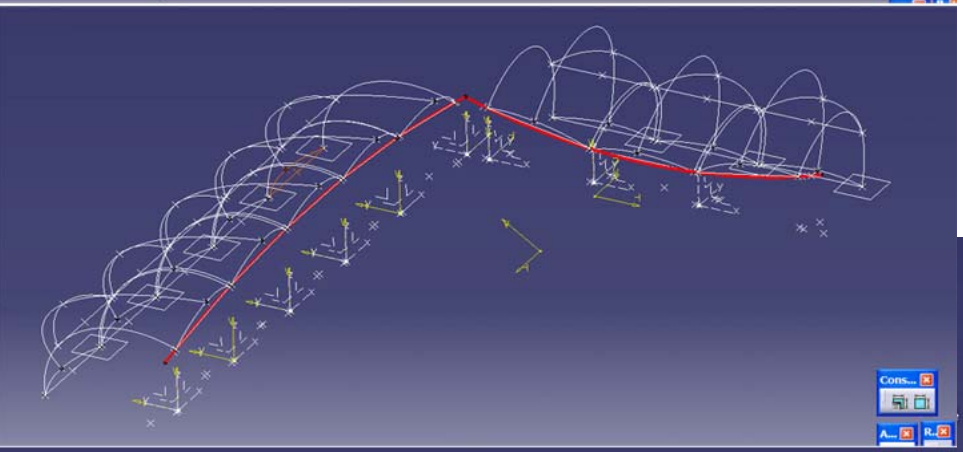
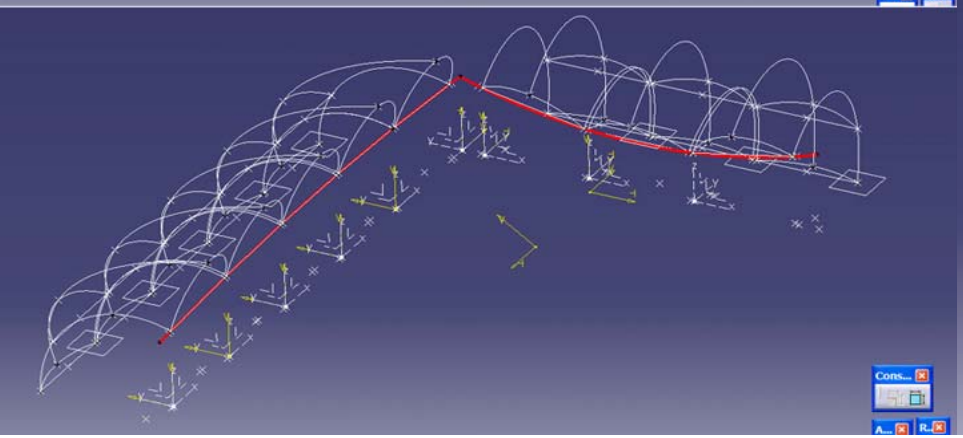
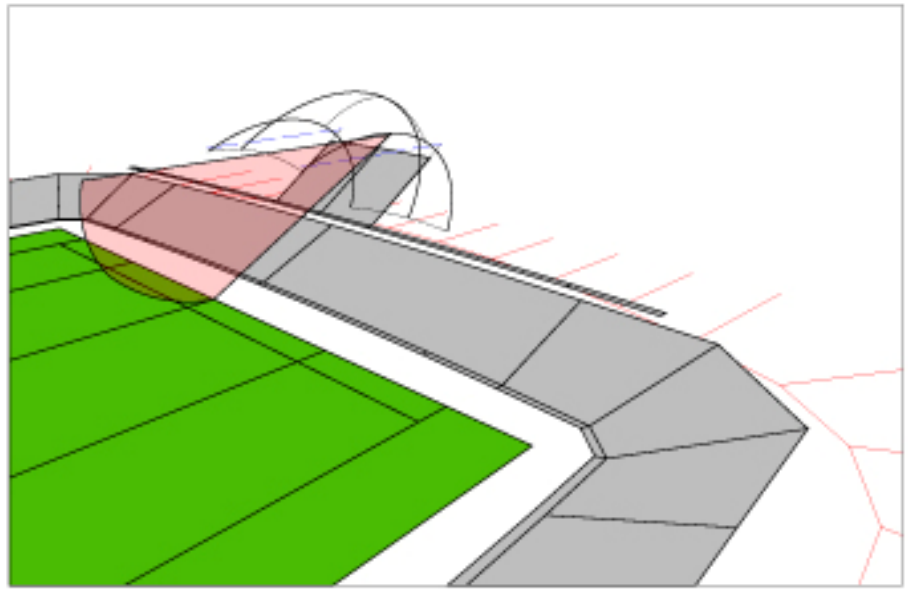
Melbourne Rectangular Stadium

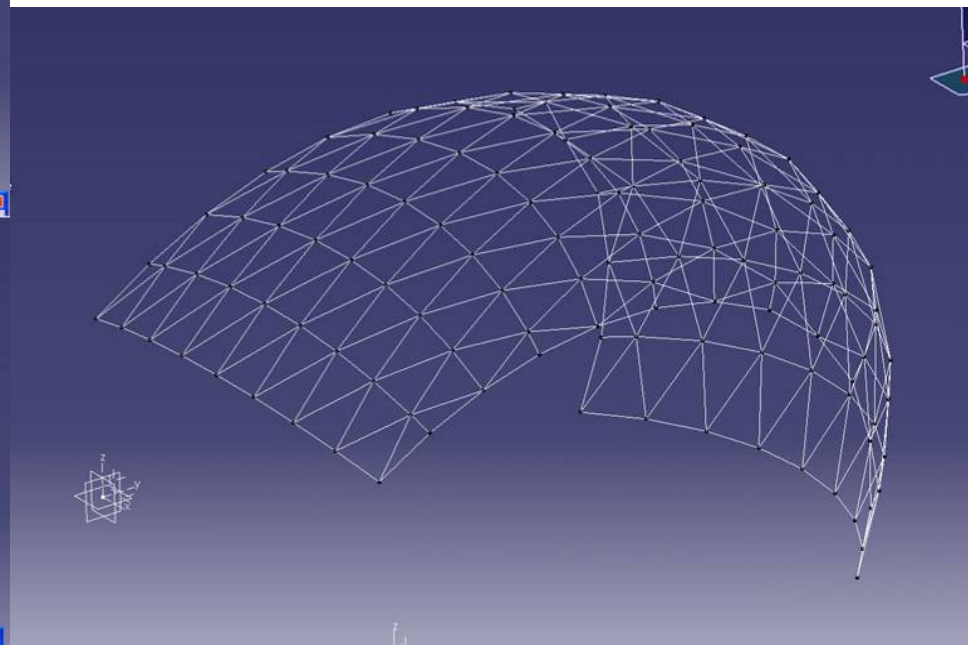

Relations
PowerCopy
Shell_1
Stadium_short_roof_guide
Stadium_Coordinates
Shell_9
Coordinates_2
Shell_2
Shell_3
Shell_4
Shell_5
Shell_6
Shell_7
Shell_8
Concrete Slab
Support_slab_geometry
Plane for Ellipsoid centres
surface_for_groins
Shell_6_A_Grid
Shell_6_A_V_Triangulation
Shell_6_3_Grid
Shell_6_3_V_Triangulation
Shell_7_A_Grid
Shell_7_A_V_Triangulation
Shell_7_3_Grid
Shell_7_3_V_Triangulation
Shell_8_A_Grid
Shell_8_A_V_Triangulation
Shell_8_3_Grid
Shell_8_3_V_Triangulation
Shell_9_A_Grid
Shell_9_A_V_Triangulation
Shell_9_3_Grid
Shell_9_3_V_Triangulation
Shell_3_A_Grid
Shell_3_A_V_Triangulation
Shell_3_3_Grid
Shell_3_3_V_Triangulation
Shell_1_A_Grid
Shell_1_A_V_Triangulation
Shell_1_3_Grid
Shell_1_3_V_Triangulation
Auxiliary_connections
29000
(34.823°)
29000
User Selection Filter

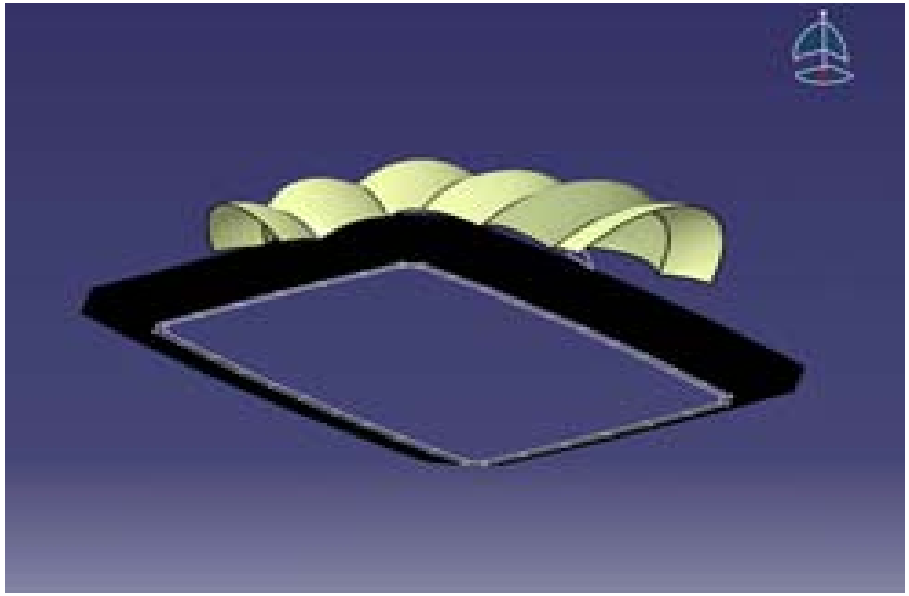


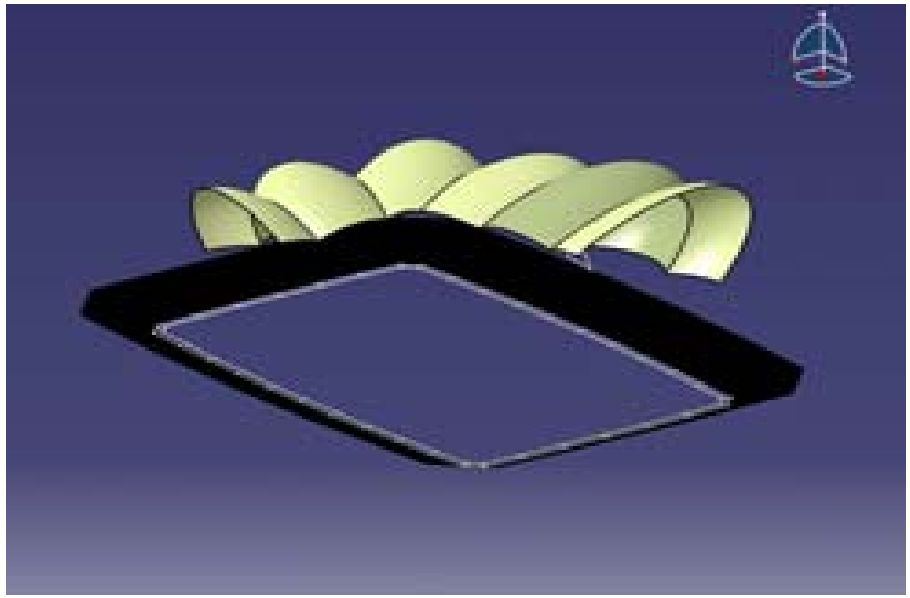


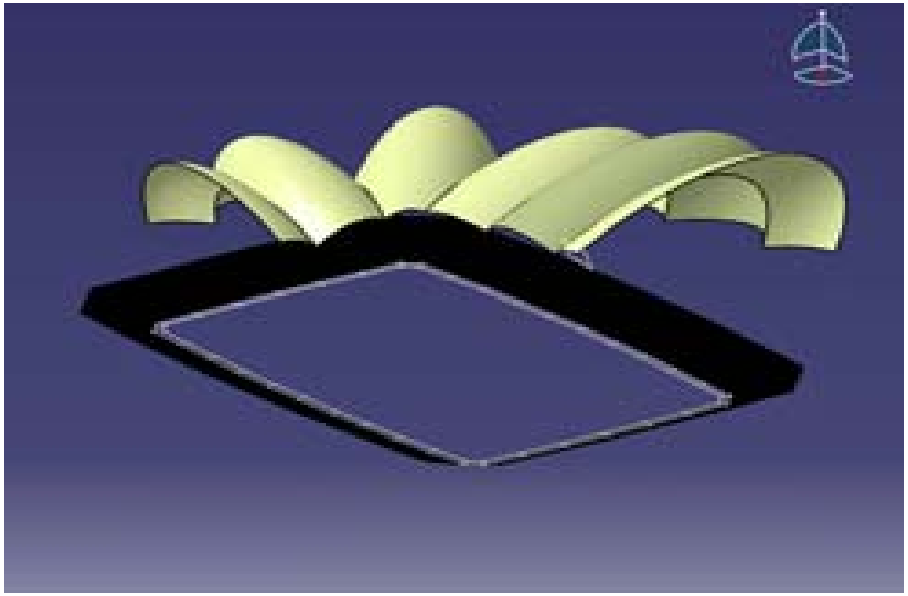


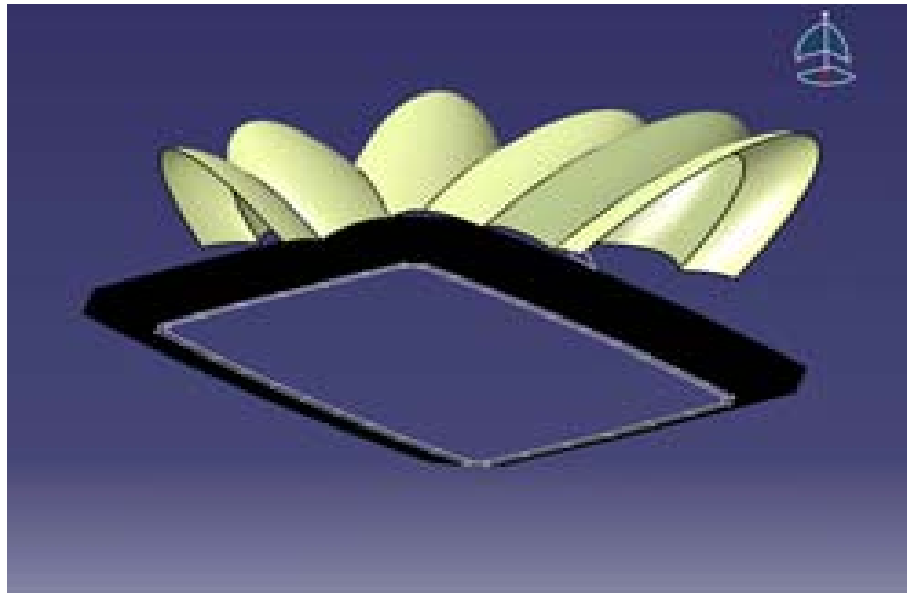












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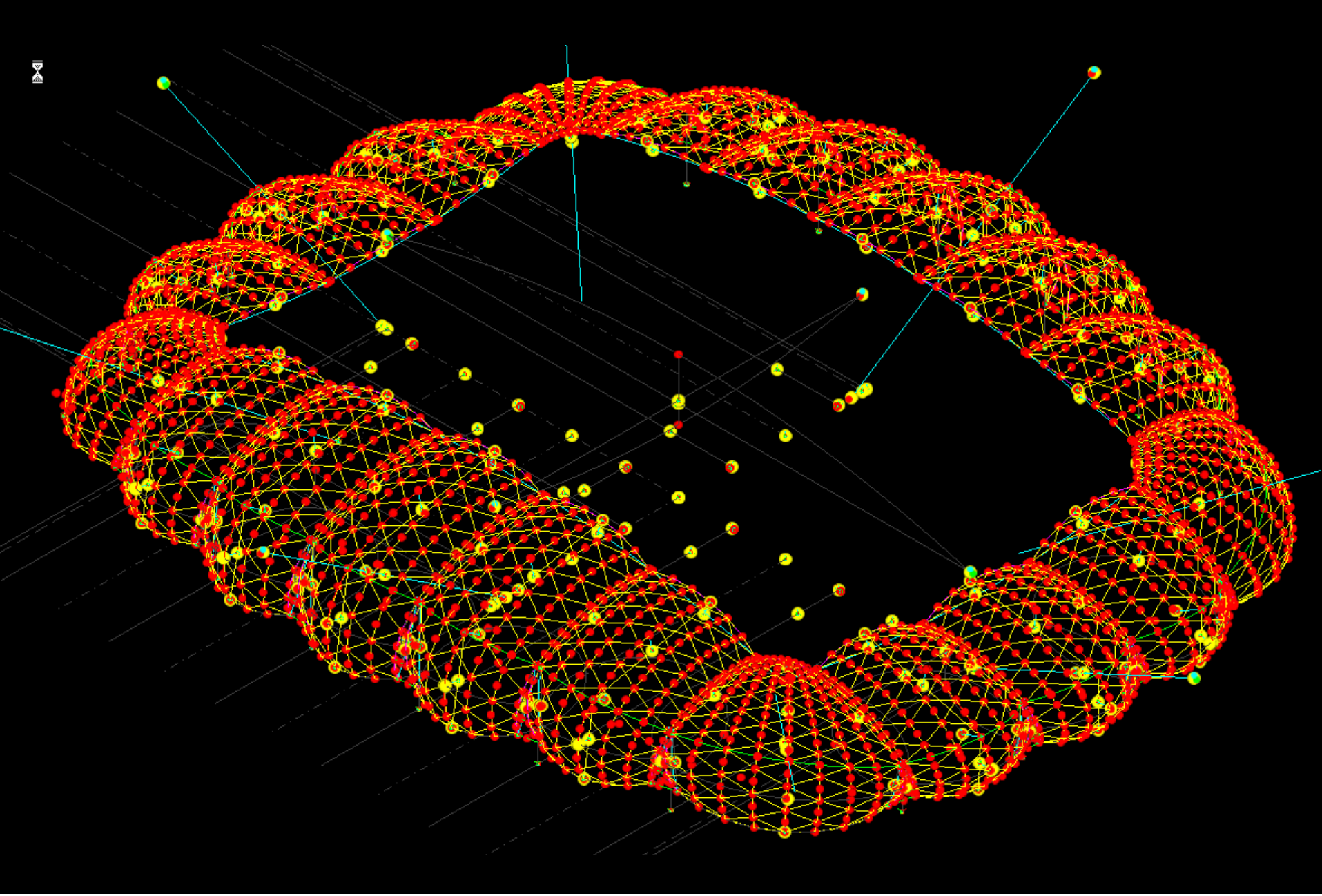

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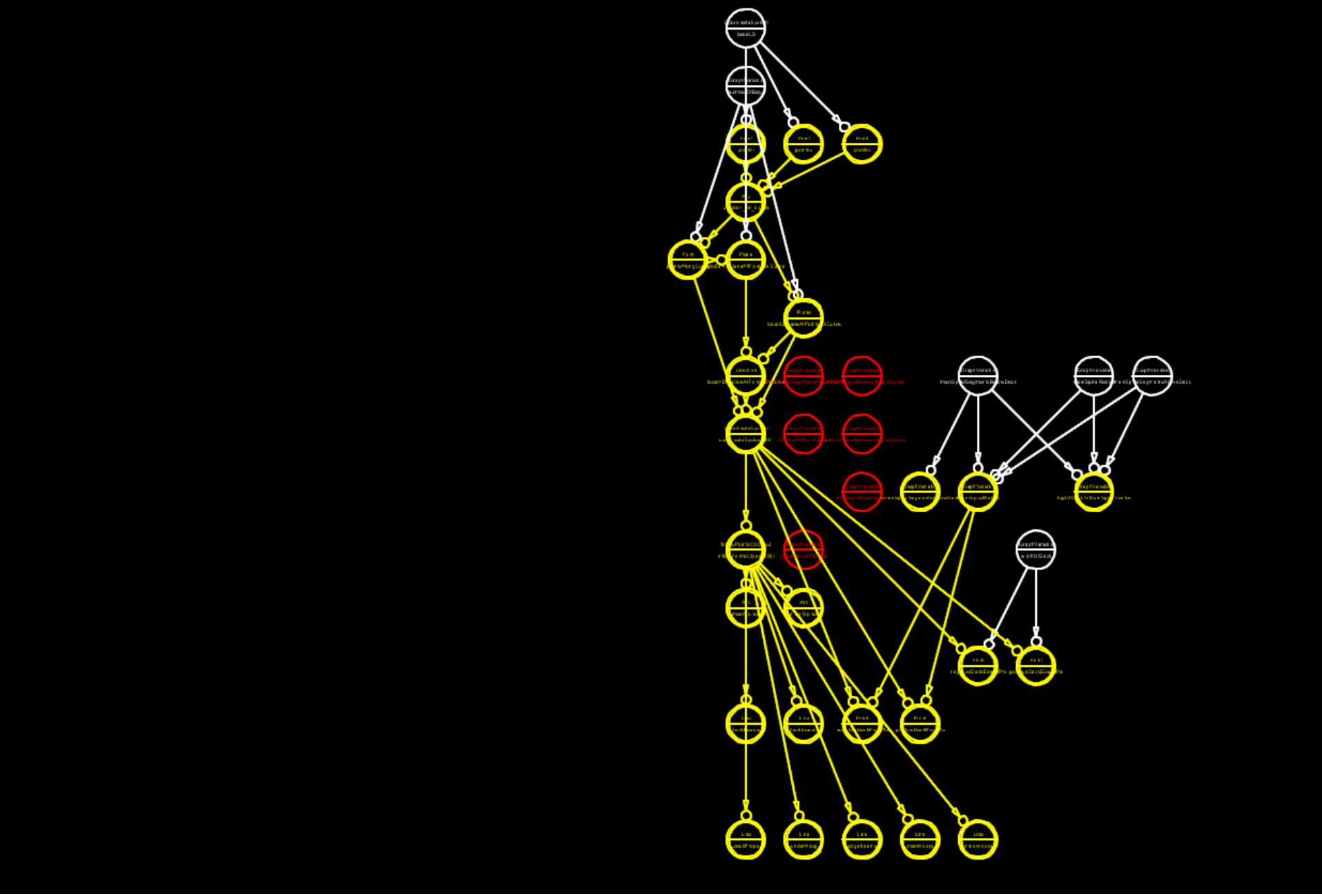
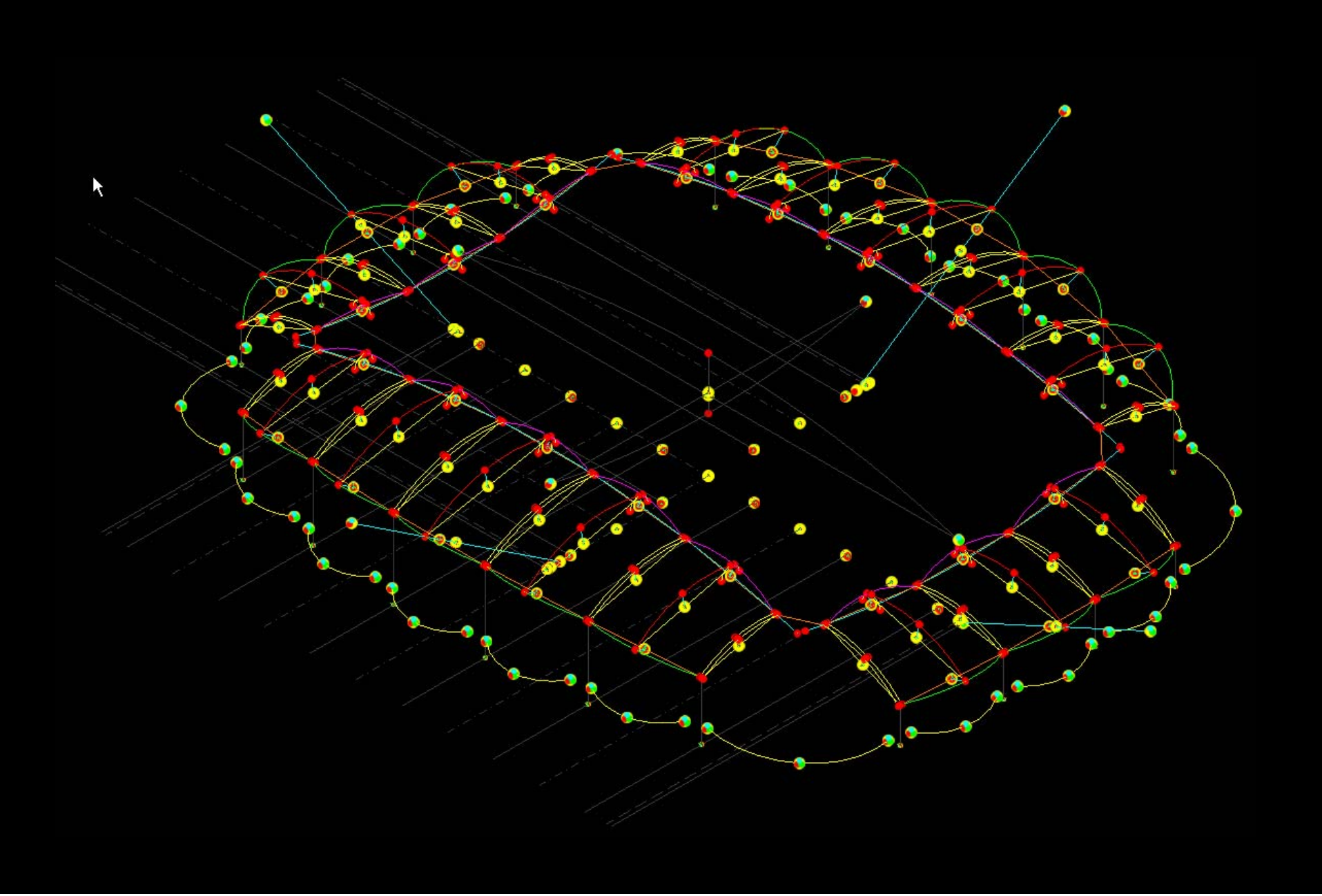
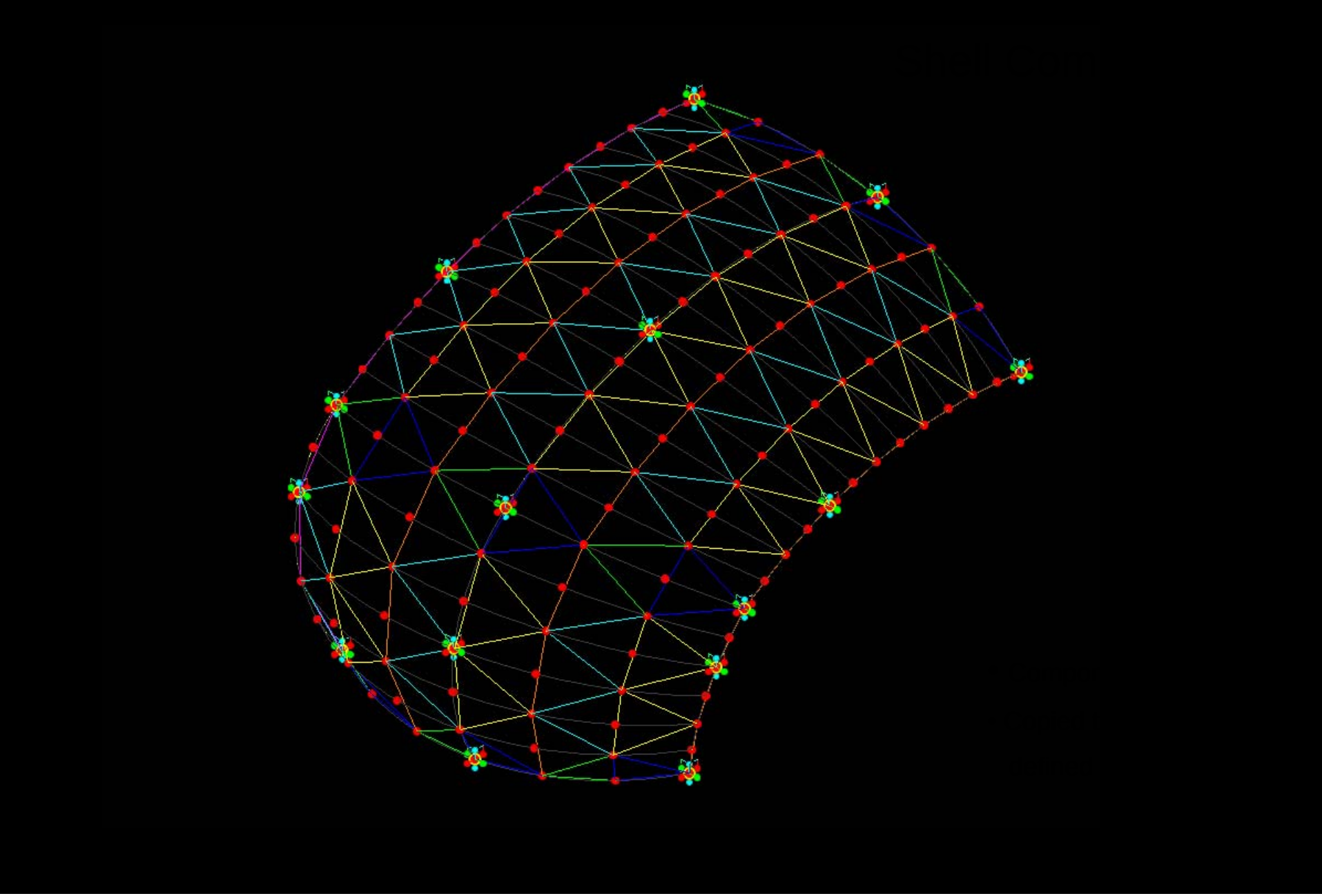
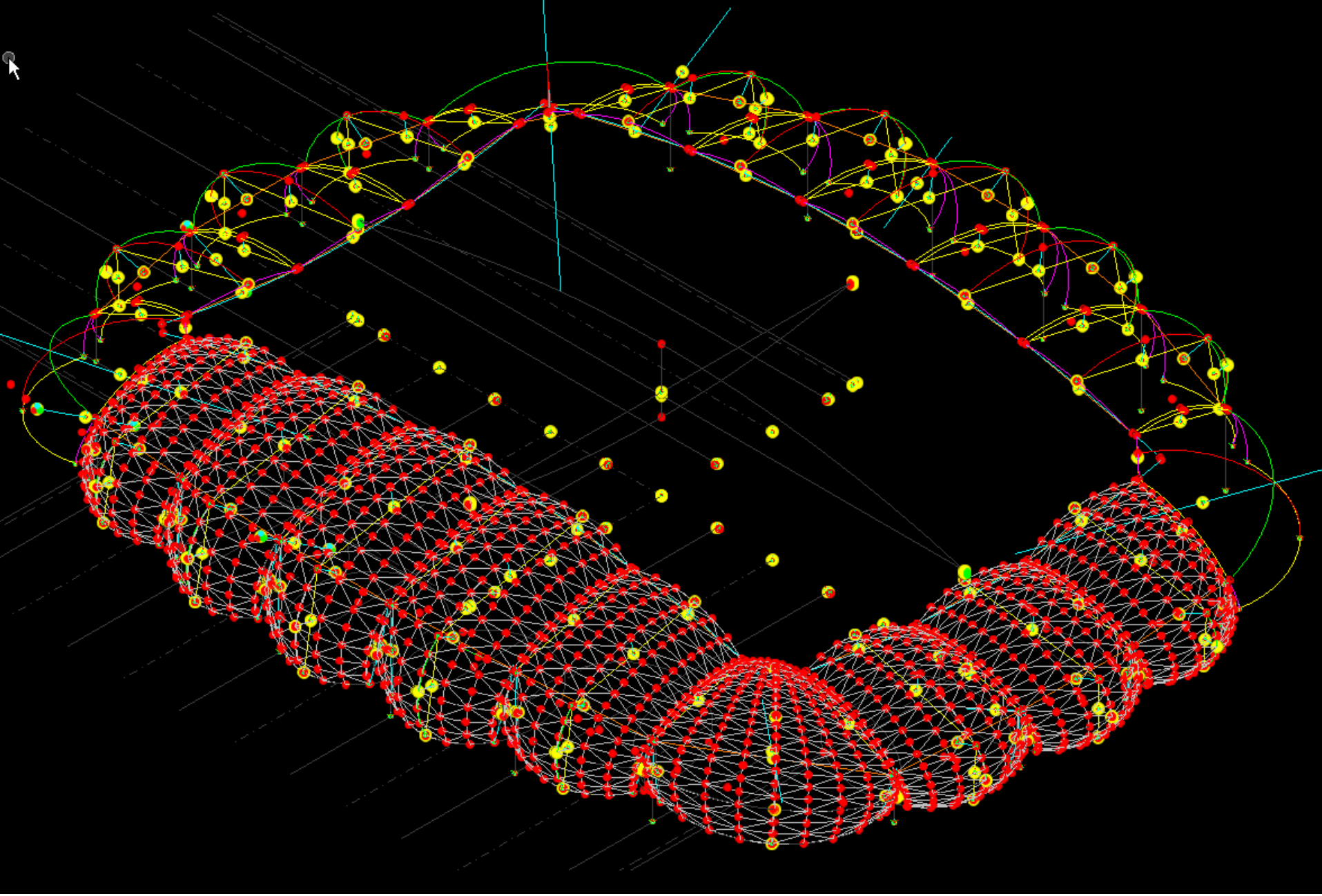
Melbourne Rectangular Stadium









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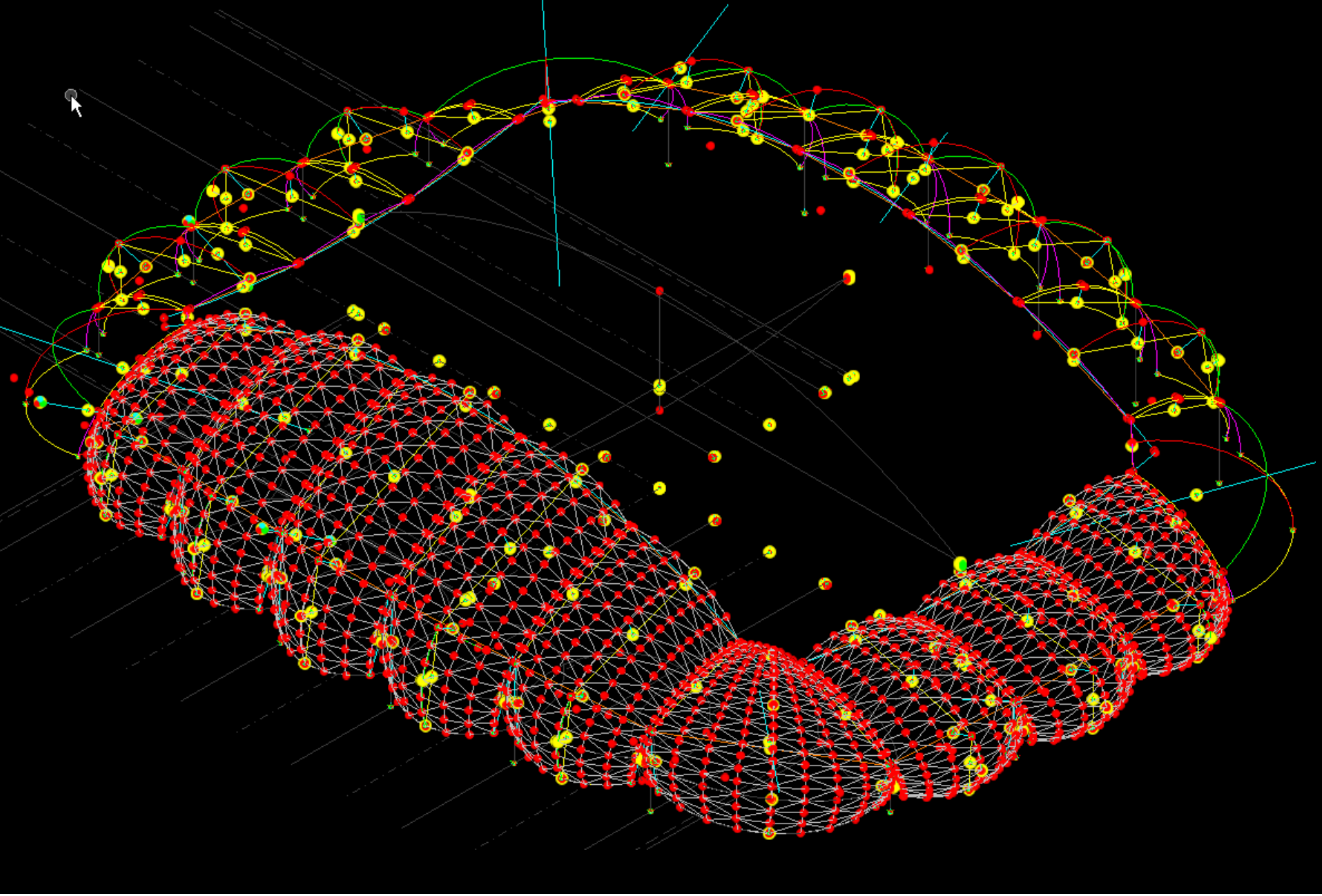

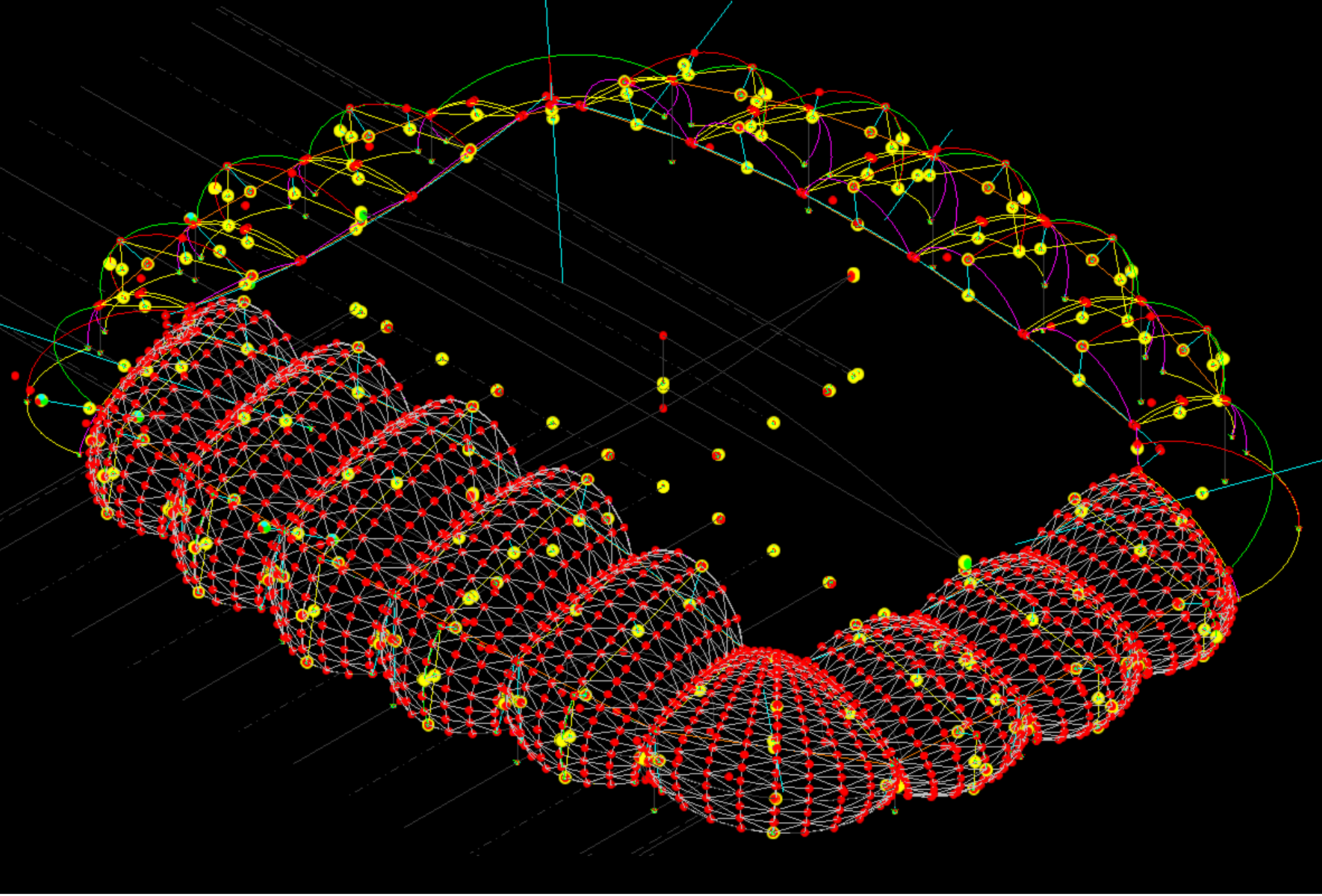

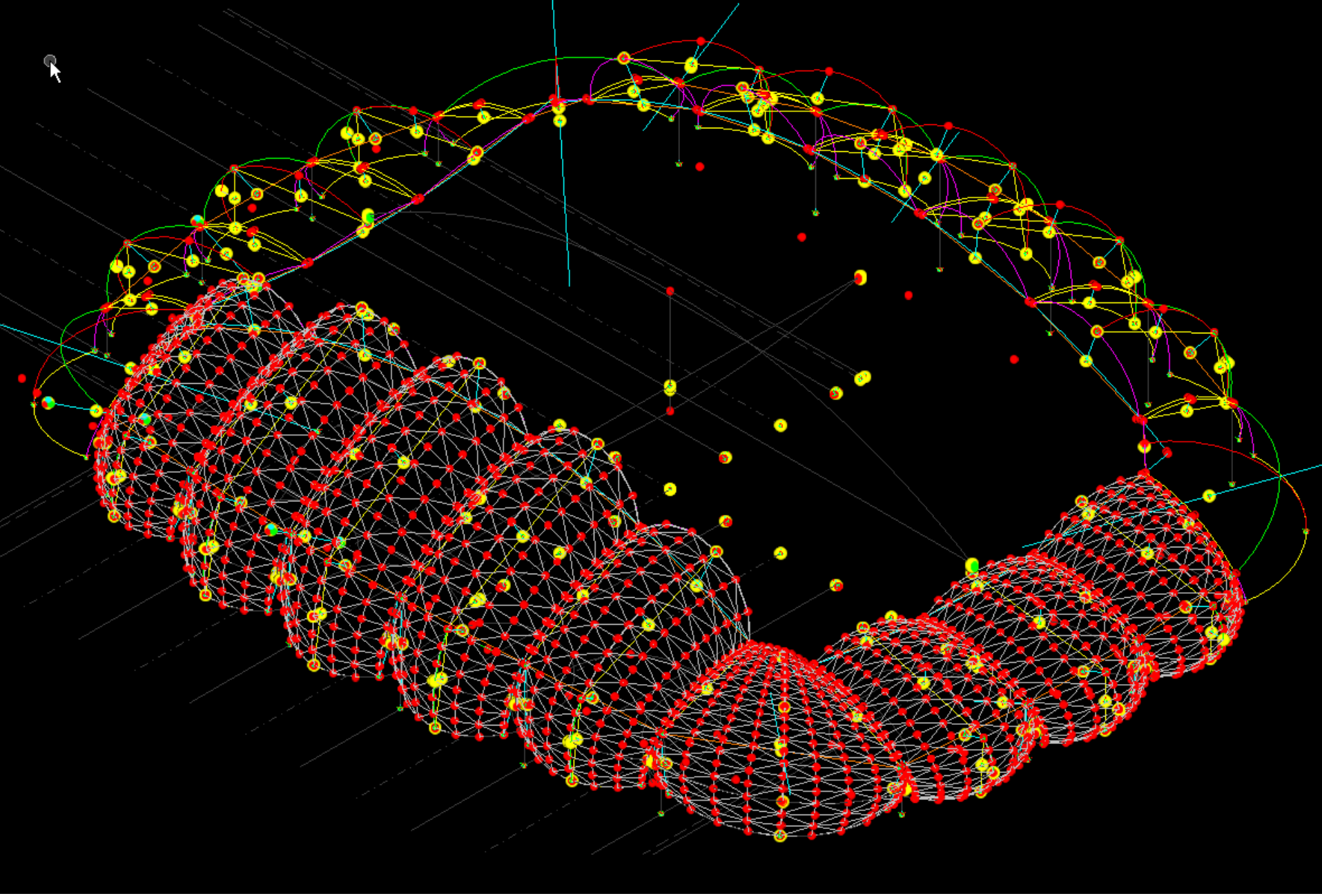

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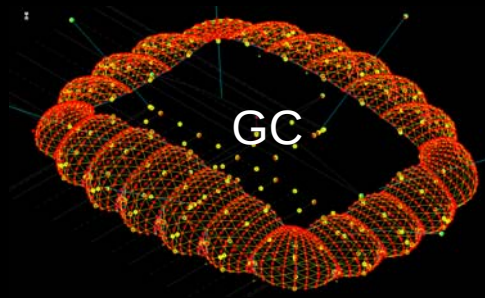
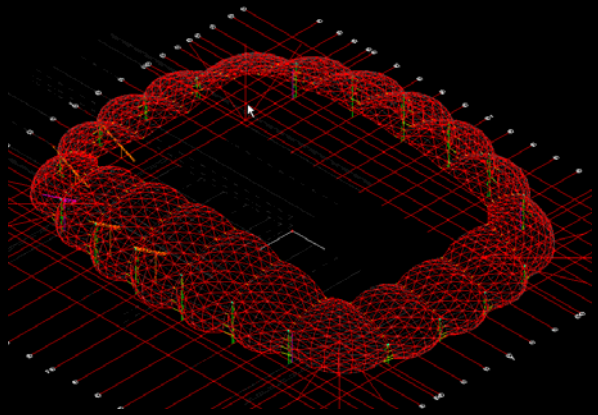
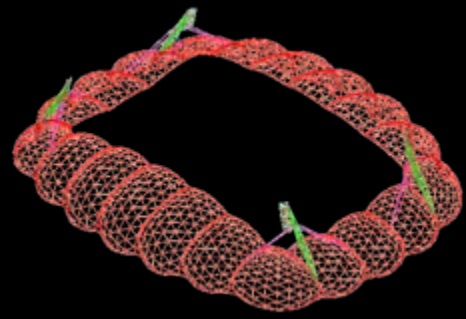
Melbourne Rectangular Stadium





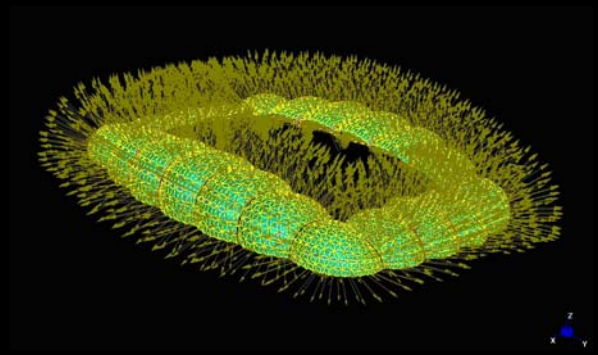
Fabrication

Wireframe



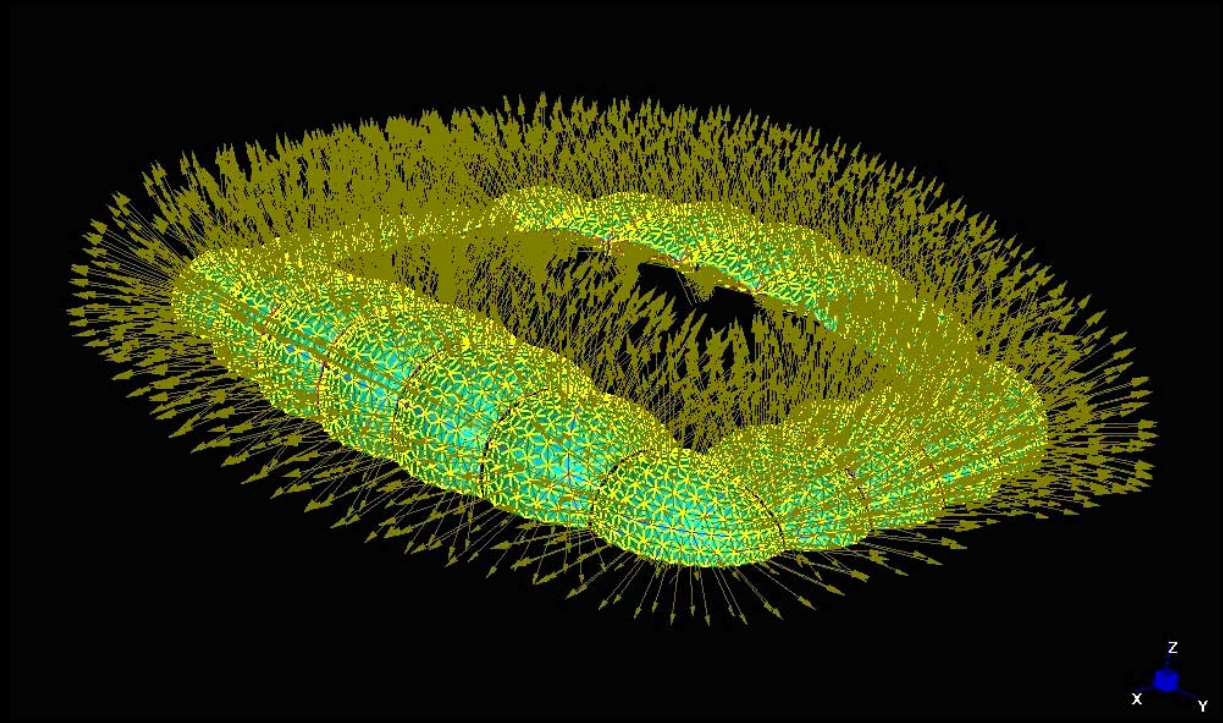
Bentley STF

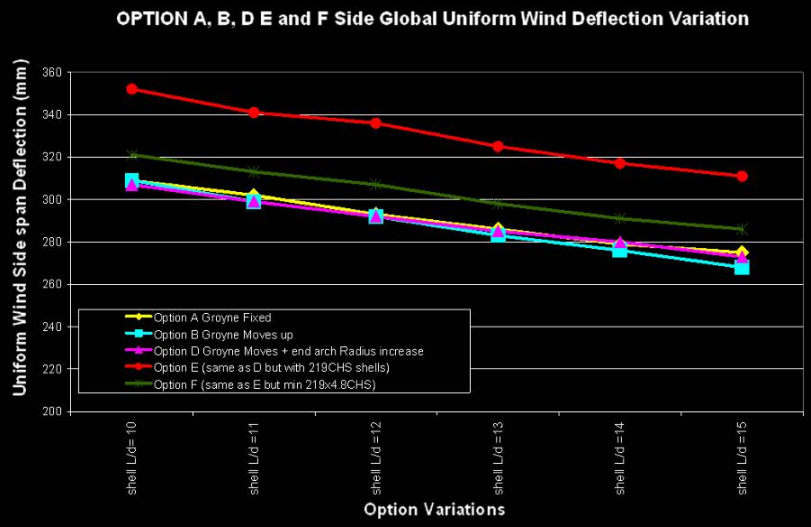
Model

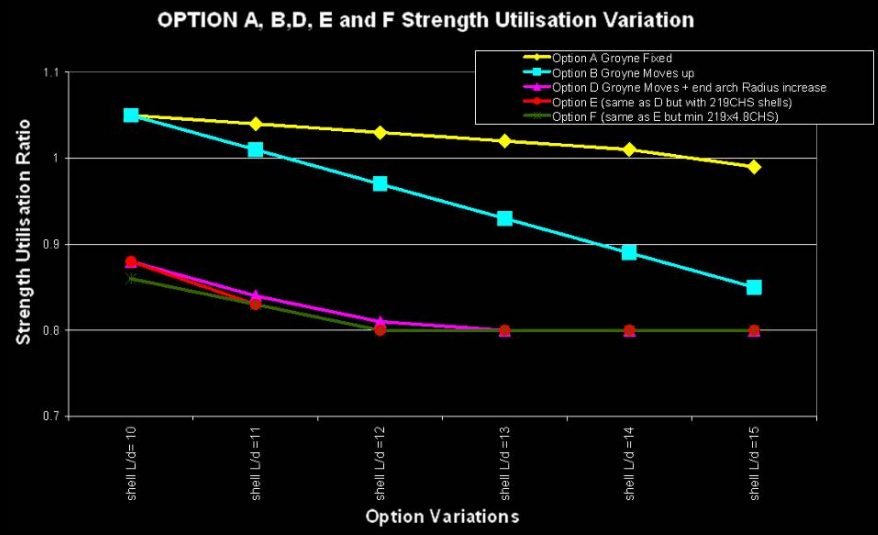


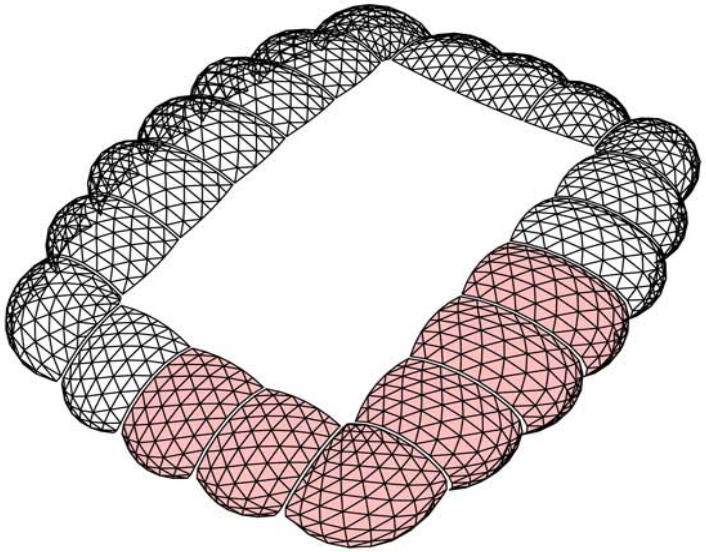
Strand

Analysis


Z
X
Y


OPTION A, B, D E and F Side Global Uniform Wind Deflection Variation
Uniform Wind Side span Deflection (mm)
360
340
320
300
280
260
240
220
200
Option A Groyne Fixed
Option B Groyne Moves up
Option D Groyne Moves + end arch Radius increase
Option E (same as D but with 219CHS shells)
Option F (same as E but min 219x4.8CHS)
shell L/d= 10
shell L/d =11
shell L/d =12
shell L/d =13
shell L/d =14
shell L/d =15
Option Variations


OPTION A, B.D, E and F Strength Utilisation Variation
Strength Utilisation Ratio
1.1
1
0.9
0.8
0.7
Option A Groyne Fixed
Option B Groyne Moves up
Option D Groyne Moves + end arch Radius increase
Option E (same as D but with 219CHS shells)
Option F (same as E but min 219x4.8CHS)
shell L/d= 10
shell L/d =11
shell L/d =12
shell L/d =13
shell L/d =14
shell L/d =15
Option Variations



analysing panel area sizes from 3D model

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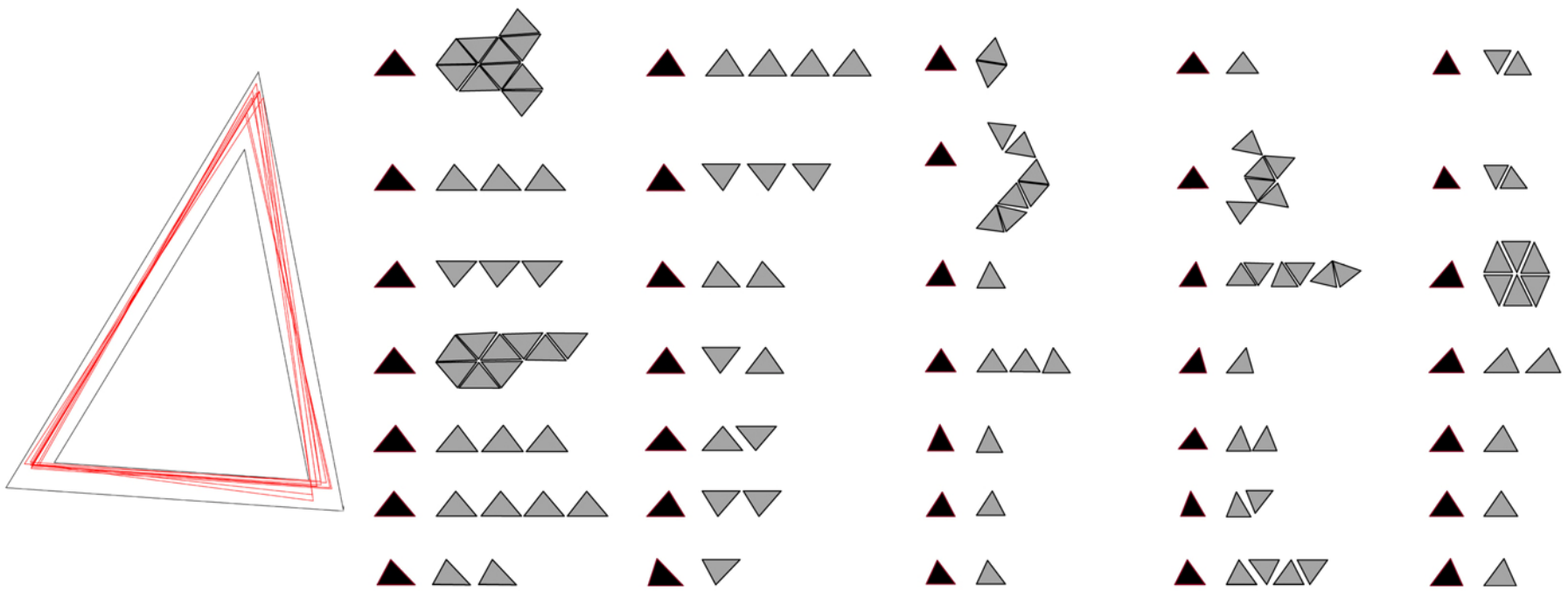
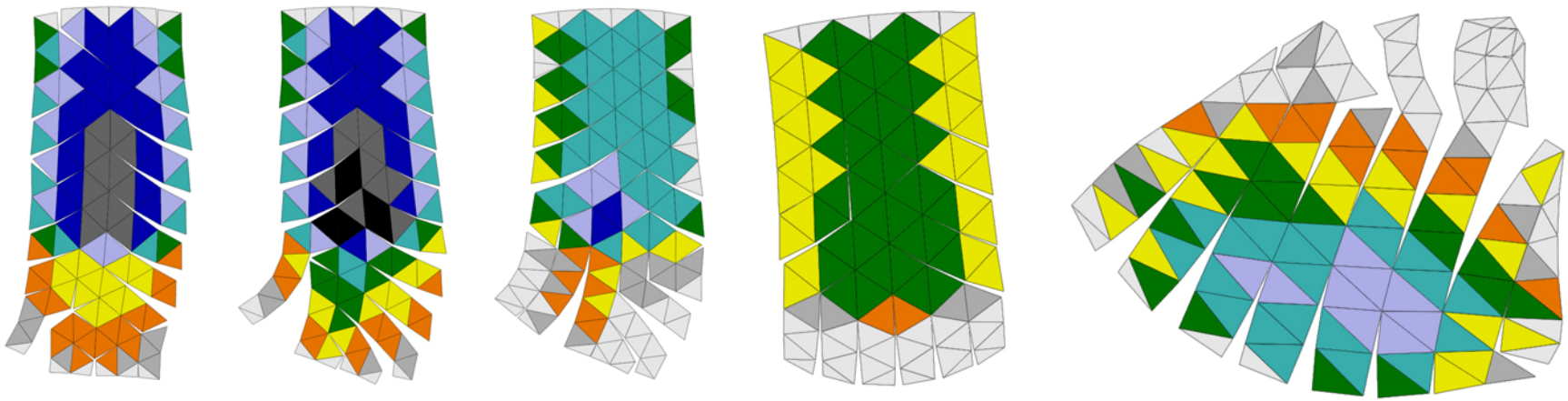
Melbourne Rectangular Stadium



extracting similar shapes



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Building Performance

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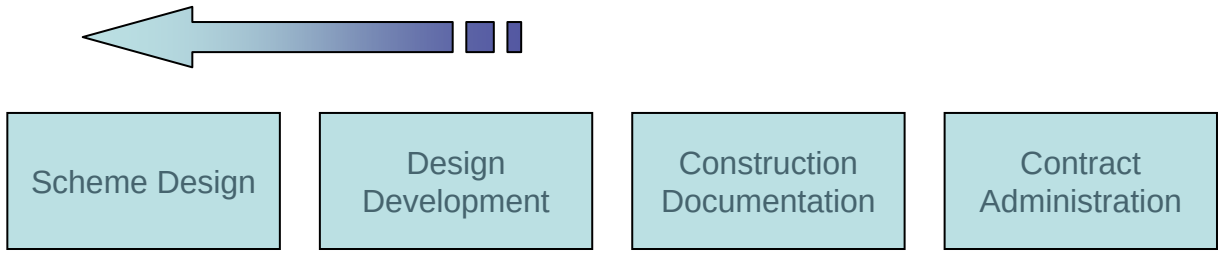

Scheme Design
Design Development
Construction Documentation
Contract Administration

Q: Does my building look good in this?

Not a photo montage

Visually accurate against city backdrop

Full 3D render to visualise scheme

Radiance

Perl

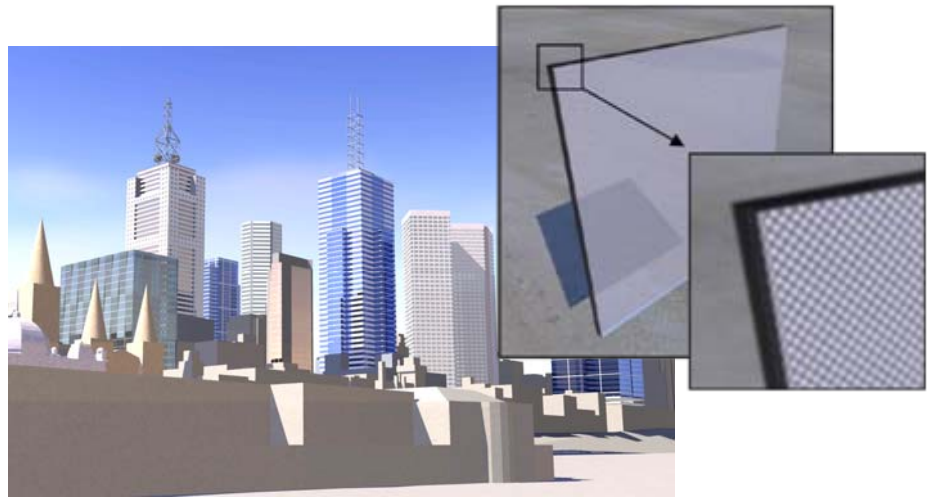
Rhino

Solution process

Build a 3D city model

Accurately determine and specify glass properties (frit + coatings)

Simulate using physically accurate ray-tracing



Solution features

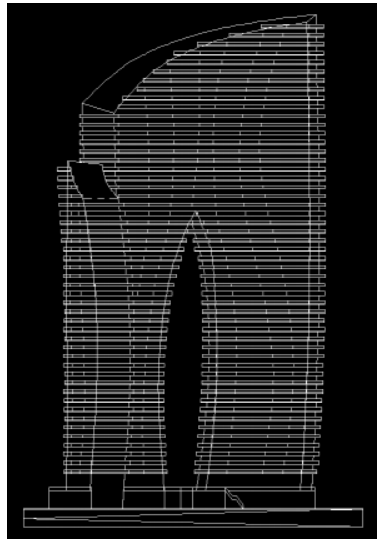
Scheme + surrounds

Simplification of fritted DGU

Facade systems input using formulas

Q: Can this be a low energy building?

Complex building form
Limited information (plans and elevations)
Short timeframe
Unfamiliar solution process



DesignBuilder

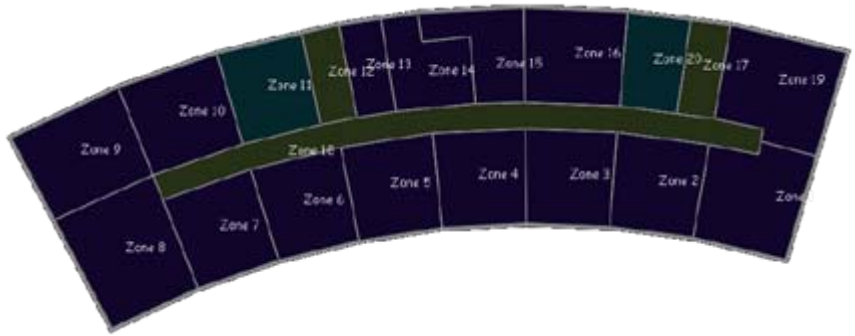
EnergyPlus

Excel

Perl

Solution process

Simplify the building
Construct an energy model and test options
EnergyPlus simulation model +
custom Excel spreadsheet =
reasonable answer



Solution features

Modelled ~ 1/20th of the building
Model geometry very different to actual building
Flexible model

Q: Will outdoor glass pavilions in Singapore be comfortable?

4 different pavilions, some overshadowing

PMV, SET*, PET ? (direct sun)

3D CAD (xrefs, complex geometry)

AutoCAD

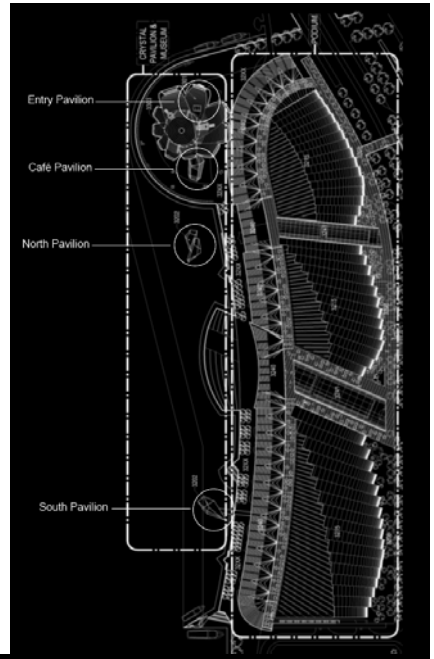
DesignBuilder

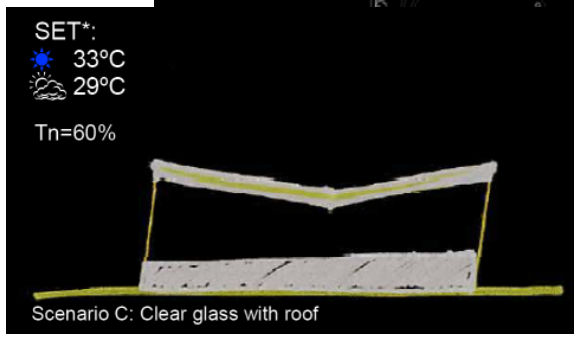
Rhino

EnergyPlus

Excel

Radiance





Solution process

Build a representative thermal model to test facade options

Define targets

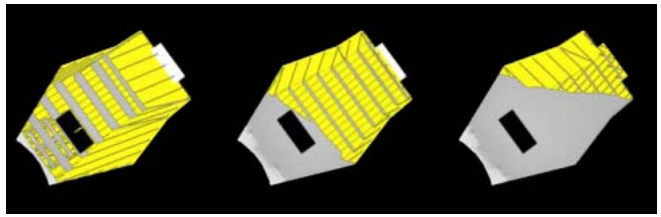
Generate sun plots to predict direct sun

Thermal model + sun model + SET* spreadsheet = reasonable answer ?

Solution features

Modelled 1 representative pavilion

Qualitatively combined sun-plots with comfort results



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Q: How do I design a low-energy villa in Dubai?

Plans, elevations, sections
Mech. & elec. Specifications
Free to modify fabric, shading, internal loads

Solution process

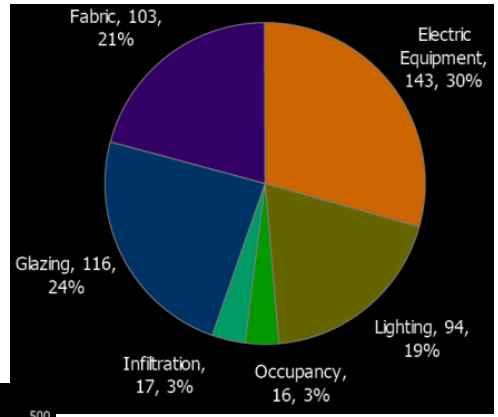
DesignBuilder

EnergyPlus

Perl

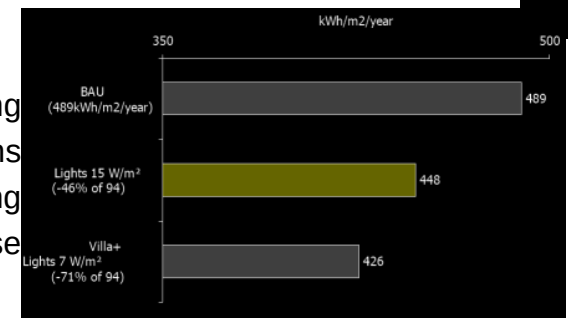
Excel

Construct energy model
Test various design options
Identify and rank potential improvements



Solution features

Model represents actual building
Scripts to automate multiple simulations
Scripts to automate reporting
Model templates for re-use



Q: Will these louvers provide adequate smoke ventilation?

Identify prevailing wind direction & speed

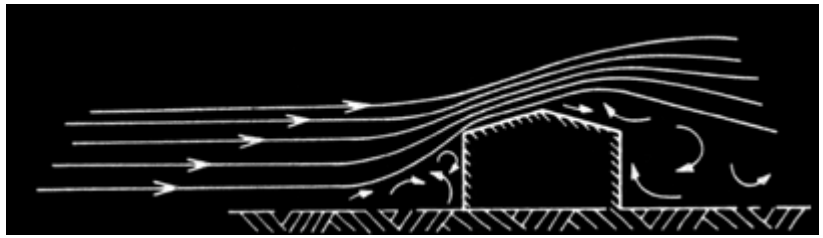
Determine typical fire scenarios & rate of smoke production

Size louver openings to provide smoke clearance and safe escape

Solution process

Rhino

CFX

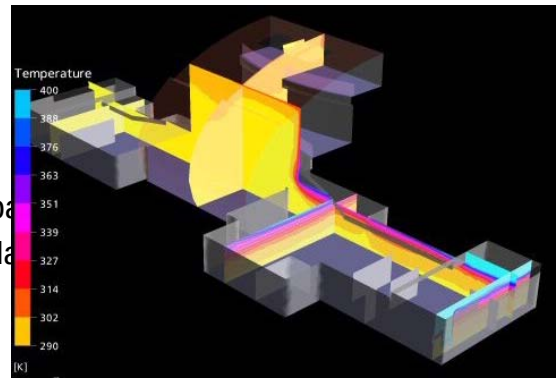


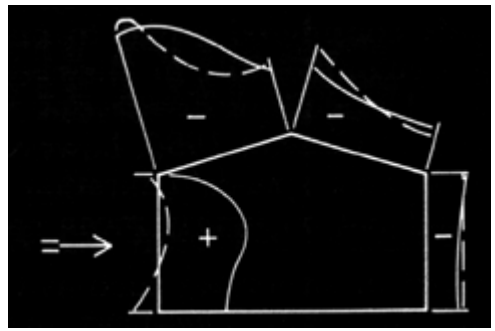
Generate mesh from 3D cad

Determine Cp from wind tunnel

Simulate range of scenarios using CFD

Solution features



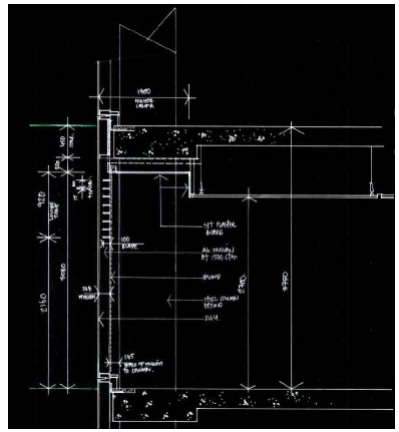


Modelled internal spa

Artificial domain bounda

Inputs from experimental

Q: How will my facade system perform in terms of daylight/glare/reflections/comfort ?



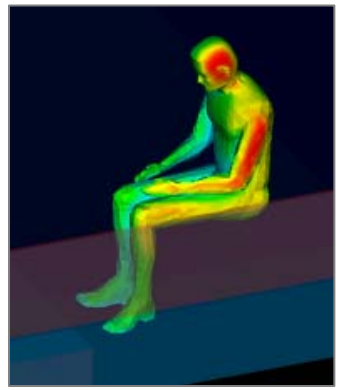
Assess proposed facade system

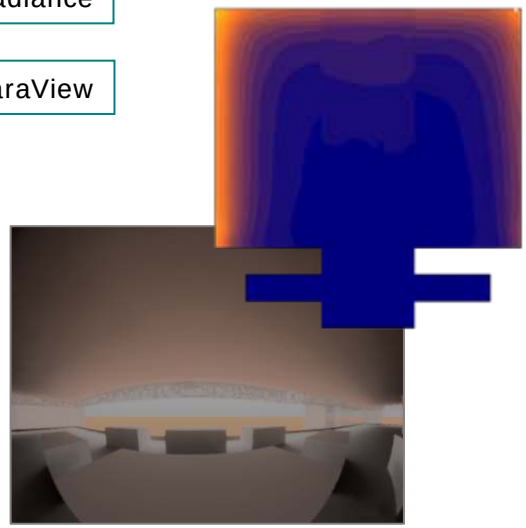
How does it compare with other buildings?

Solution process

Build range of analysis models
Determine targets
Simulate performance
Compare with GreenStar
Assess blind use, glare risks

Rhino
DesignBuilder
Excel
EnergyPlus
Radiance
Perl
ParaView



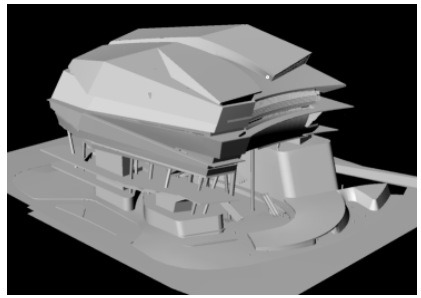


Solution features

Reflection model large uses mirror surfaces
Simplification of shading systems
Non-standard sky models
Non-standard glare models

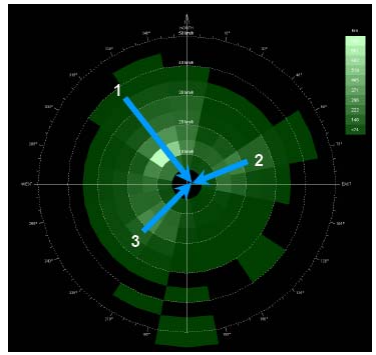
Q: Will I get wet in this ?

Predict wind-driven rain ingress
Determine requirement for canopy protection



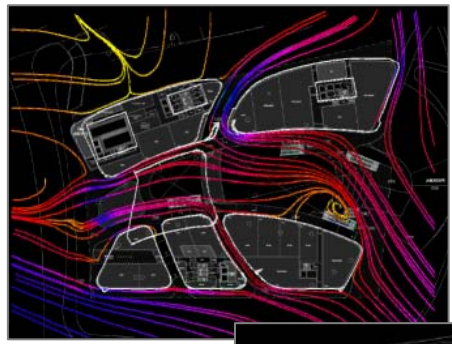
Rhino

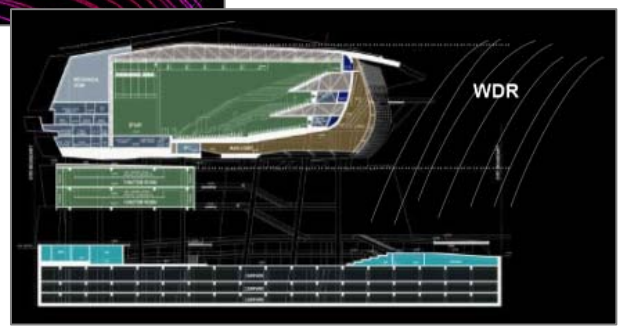
CFX



Solution process

Obtain combined wind and rain frequency data
Use CFD to simulate air movement
Add typical rain density (droplet size and distribution)
Predict droplet trajectory and wetting patterns





Solution features

Scheme + surrounds
Significant de-featuring for CFD
Special rain model (ASM)

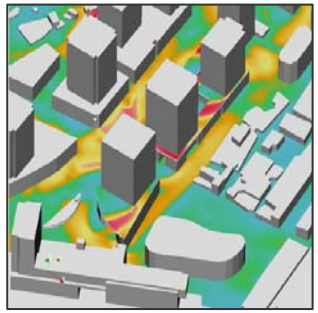
Q: Will this urban environment be comfortable?

Consider the local climate
Determine outdoor comfort conditions
Propose mitigation measures if required

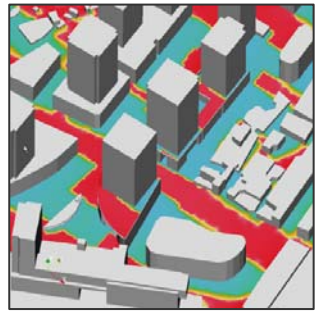
Solution process

Predict urban wind
Select characteristic summer/winter/mid-season days
Predict sun penetration
Combine data to predict SET* comfort temperature

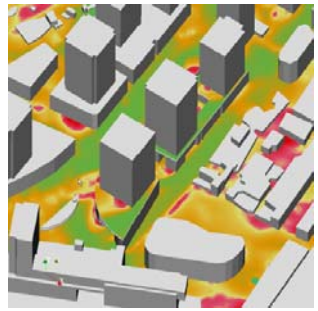
Wind speed



+ Radiation



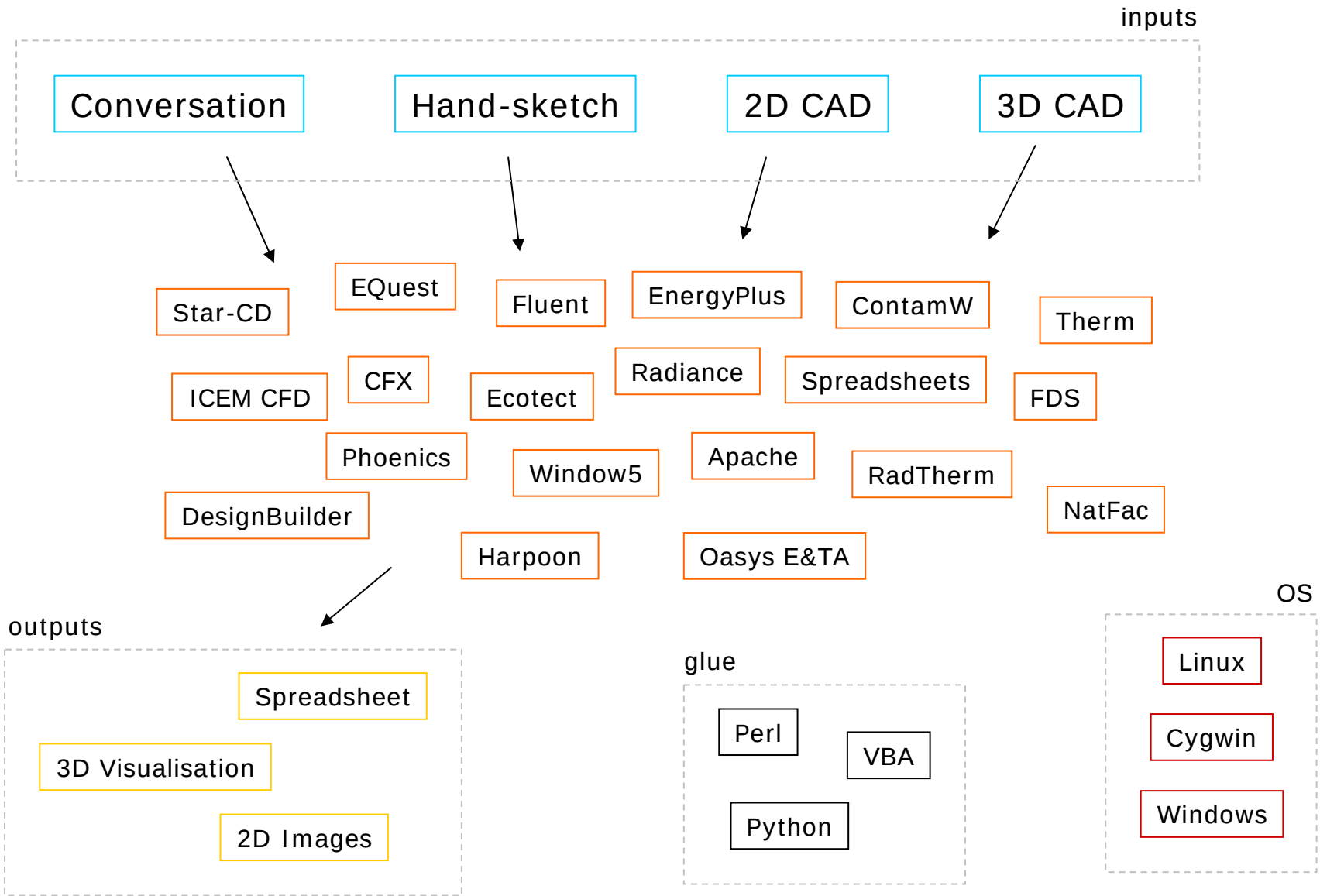
+ Humidity + Clothing + Activity = Comfort

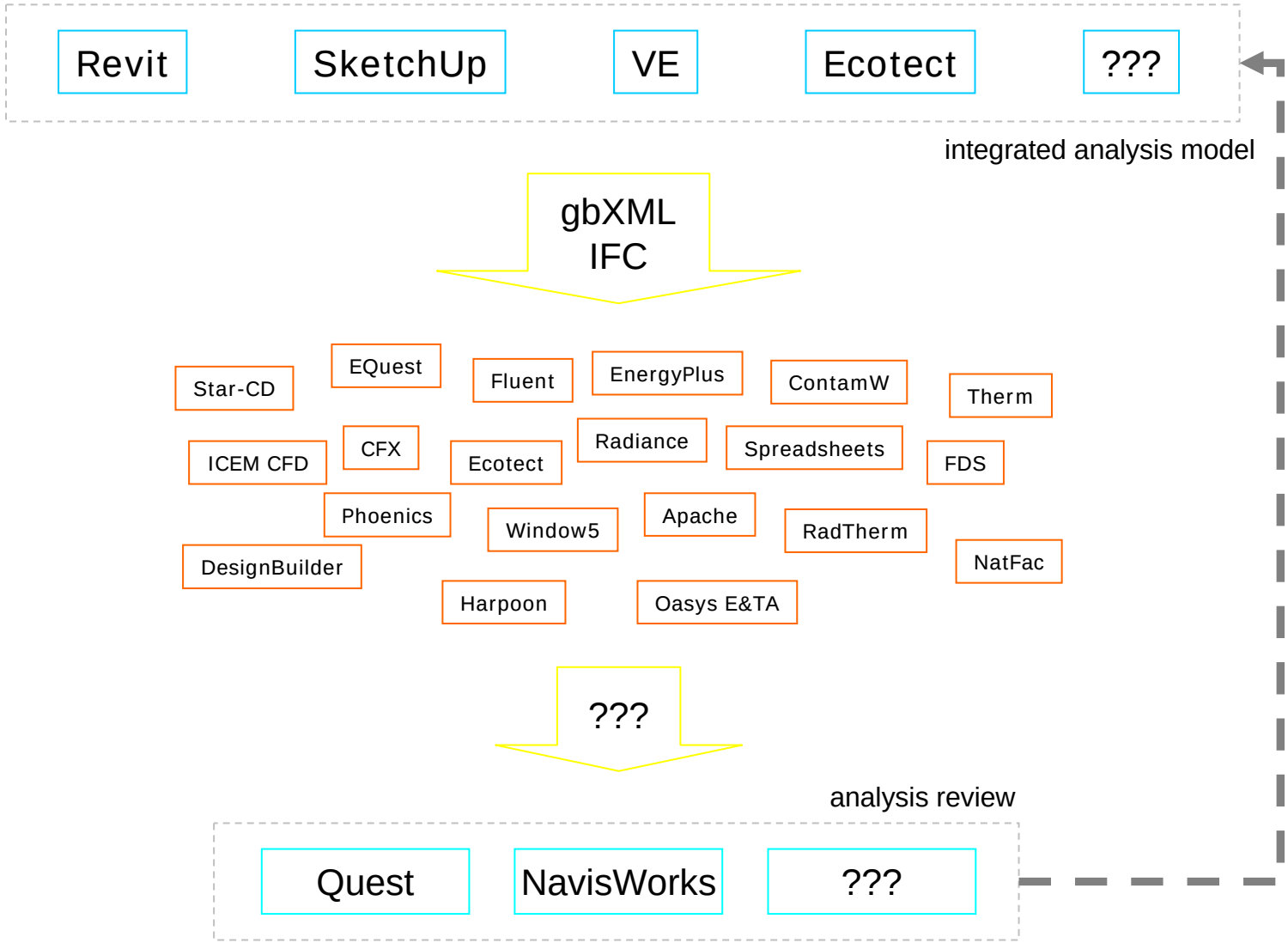


Solution features

Scheme + 500m surrounds
De-featuring to generate block models
Scripts to combine all the data
External function calls to comfort model

CFX
Paraview
Rhino
Spreadsheets
Radiance
Perl


inputs
Conversation
Hand-sketch
2D CAD
3D CAD
Star-CD
EQuest
Fluent
EnergyPlus
ContamW
Therm
ICEM CFD
CFX
Ecotect
Radiance
Spreadsheets
FDS
Phoenics
Window5
Apache
RadTherm
DesignBuilder
NatFac
Harpoon
Oasys E&TA
outputs
Spreadsheet
3D Visualisation
2D Images
glue
Perl
VBA
Python
OS
Linux
Cygwin
Windows


Revit
SketchUp
VE
Ecotect
???
integrated analysis model
gbXML
IFC
Star-CD
EQuest
Fluent
EnergyPlus
ContamW
Therm
ICEM CFD
CFX
Ecotect
Radiance
Spreadsheets
FDS
Phoenics
Window5
Apache
RadTherm
NatFac
DesignBuilder
Harpoon
Oasys E&TA
???
analysis review
Quest
NavisWorks
???

Design Development (significant benefits)

General design advice

Green Star – Green Mark – LEED – Part L – ABGR

Model represents actual building

Can get away with less flexibility - repeat processes

Good for documenting performance

Less value ...

Scheme Design (smaller benefits)

Conceptual design advice

Broadening the design space

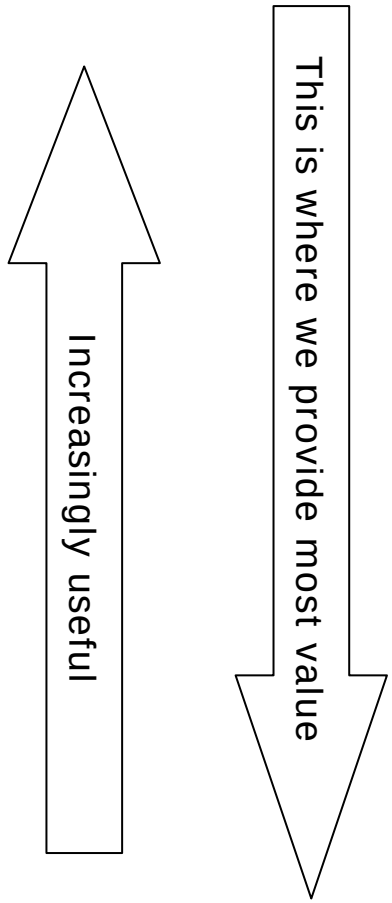
Focus on parametric design, scenario modelling, what-ifs ...

Model is an abstraction of actual building

Requires simplification, symmetry ...

Needs flexibility –novel processes

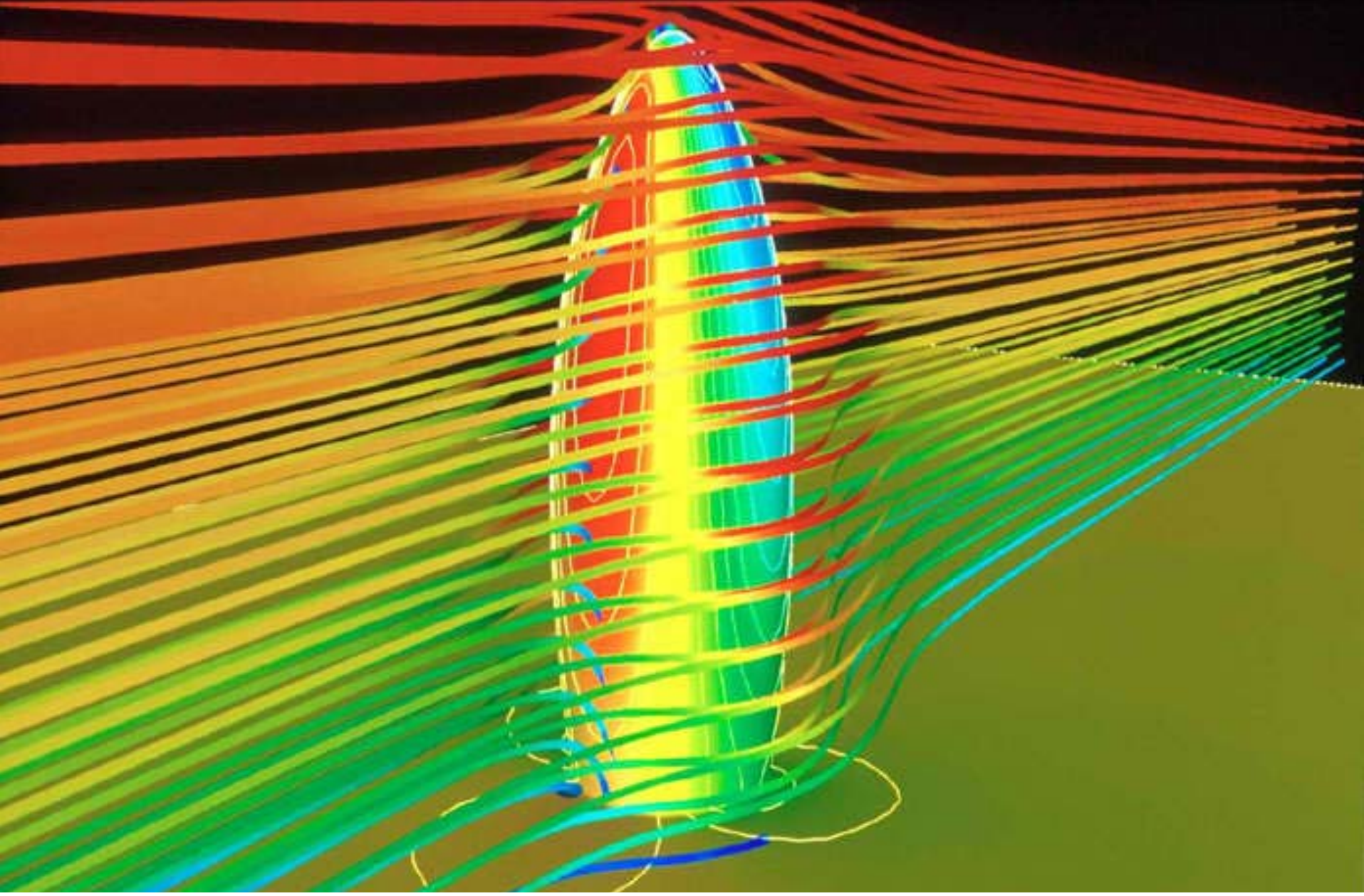
More value ...



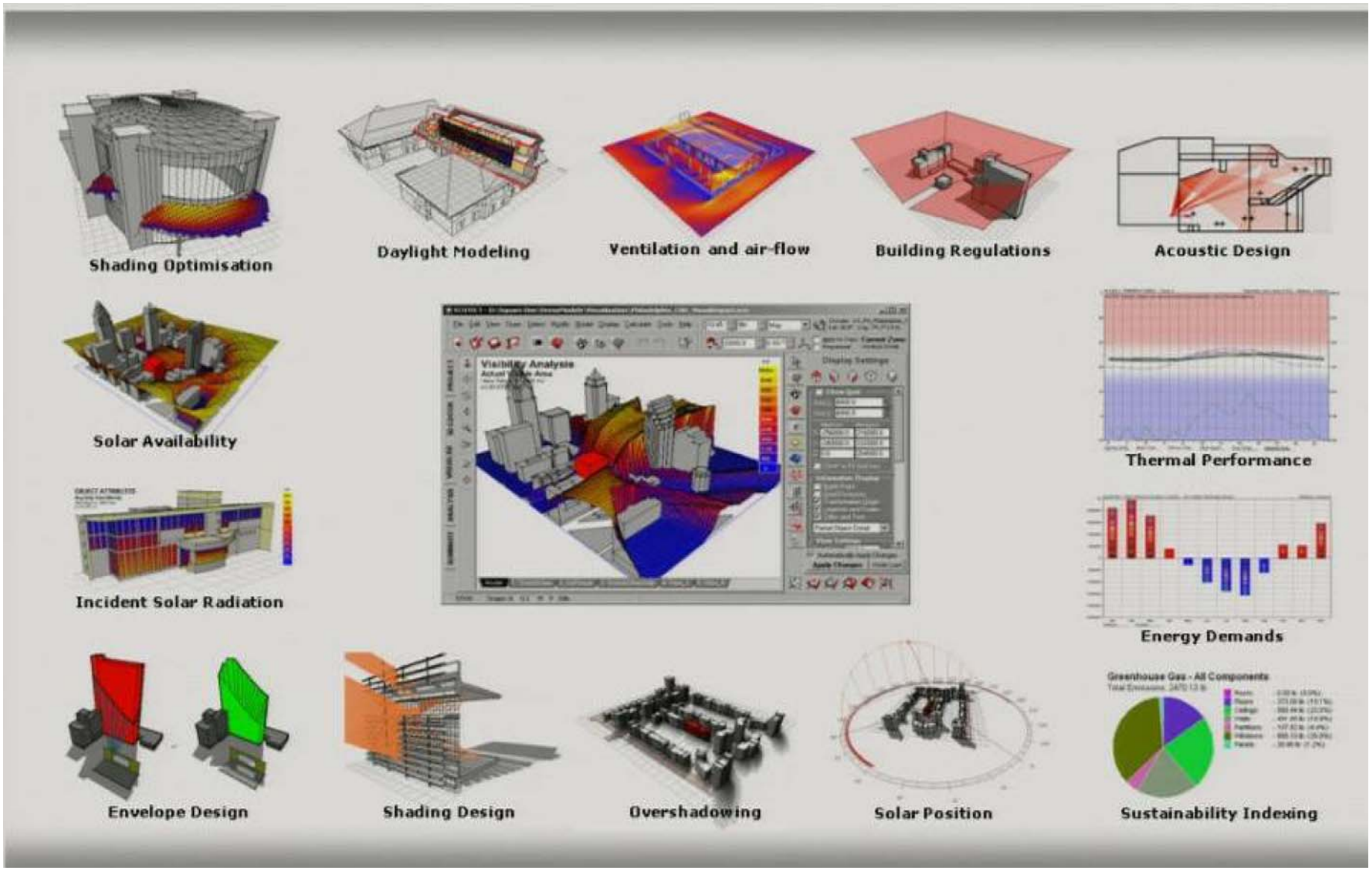
	Pros	Cons
SD Engineering & Modelling	Good starting point for further work Everyone on the same page	Parametric, simplification, abstraction? Loss of modelling skill (brute force over elegance & efficiency)
DD Engineering & Modelling	Faster throughput More time to look at options (within restricted design space)	Probably less choice of software If external model then possibly dependent on others for model updates etc. Reduced responsibility for inputs
Buildings	Integrated thinking Holistic design	
Reviewing / Checking	Integrated post-processing Consistent results formats Systematic errors	Systematic errors

linked up thinking?

ARUP

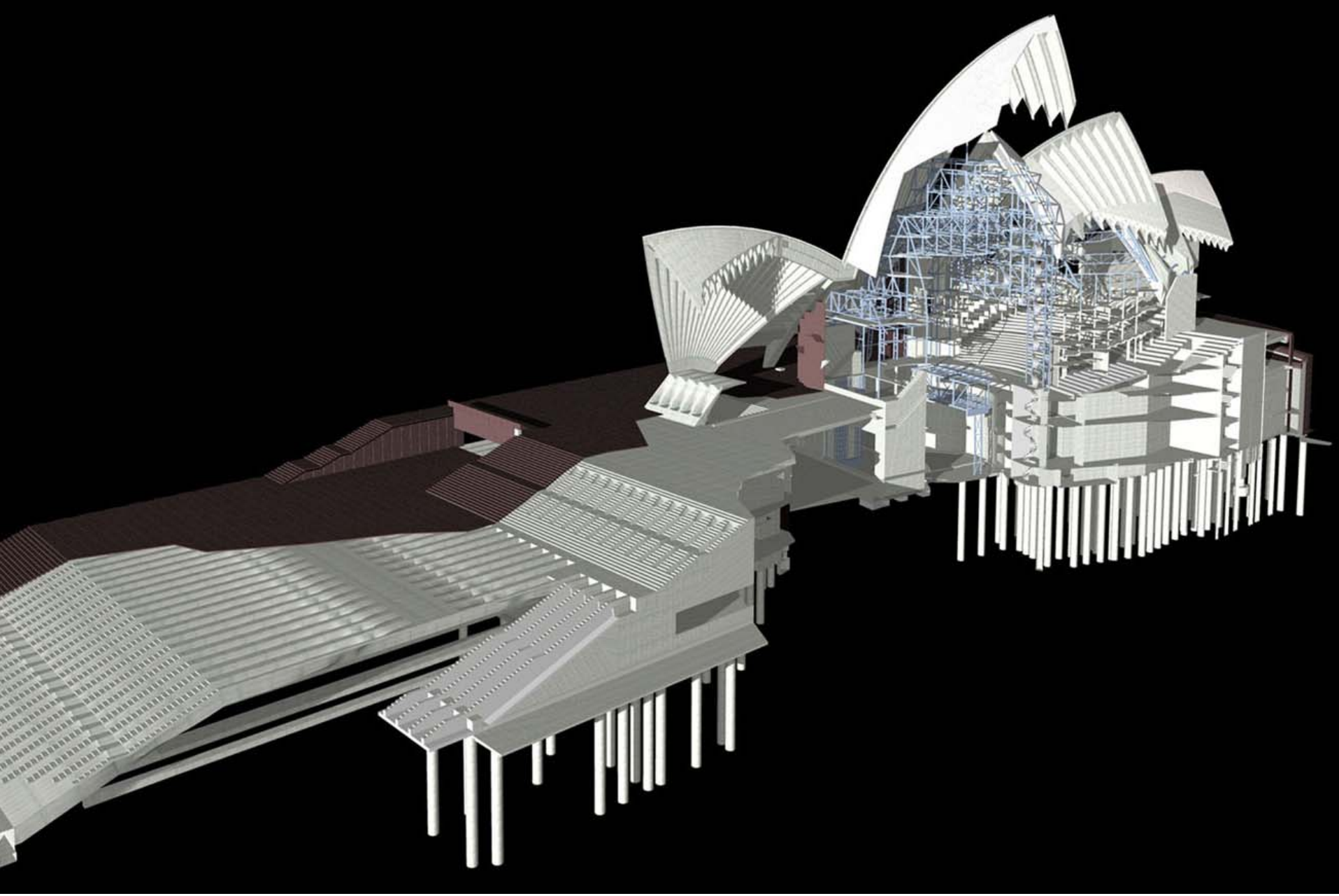


ARUP



ARUP

Autodesk Ecotect



ARUP

Where to next?

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THE ROTATING TOWER
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