Specialist Consultants for Lightweight Structures

TENSYS
Engineering • Analysis

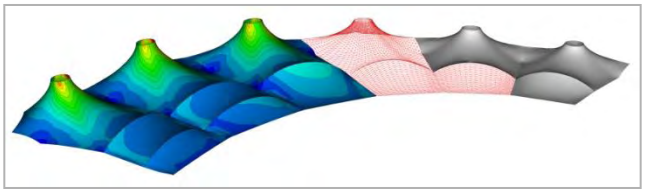
Burj al Arab Dubai

Daegu World Cup Stadium Korea

Clarke Quay Singapore

- Shape Finding
- Load Analysis
- Patterning
- Installation Studies
- Design
- Detailing
- Supervision
- Project Management
- Review & Checking

Hybrid Air Vehicle



Incheon World Cup Stadium Korea

National Space Centre UK

Marsyas Sculpture Tate Modern London

1 St Swithins Yard
Walcot Street
Bath BA1 5BG
United Kingdom

T +44 1225 321950
F +44 1225 321969
E mail@tensys.com

7/340 Gore Street
Fitzroy
Victoria 3065
Australia

T +61 3 9416 0066
F +61 3 9416 3766
E mail@tensys.com

www.tensys.com

BC Place Replacement Roof Vancouver

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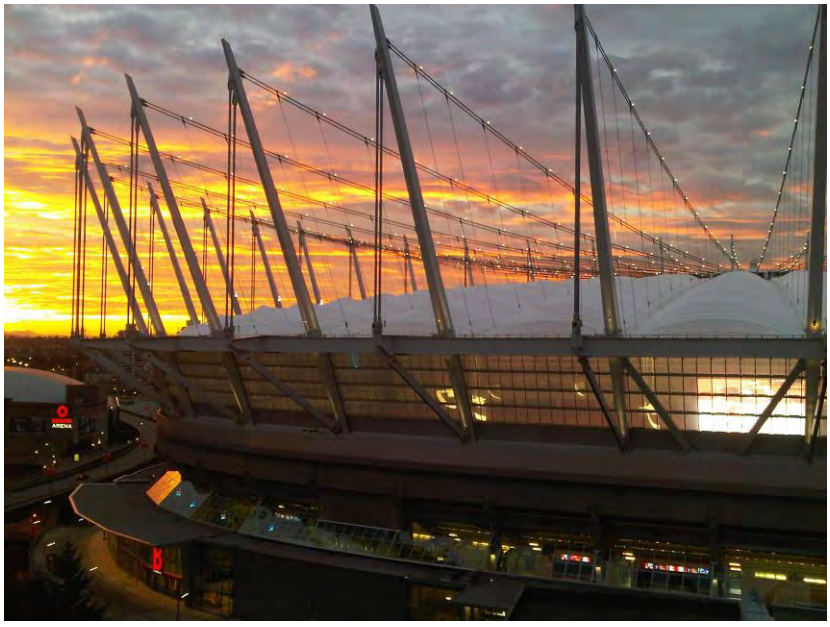

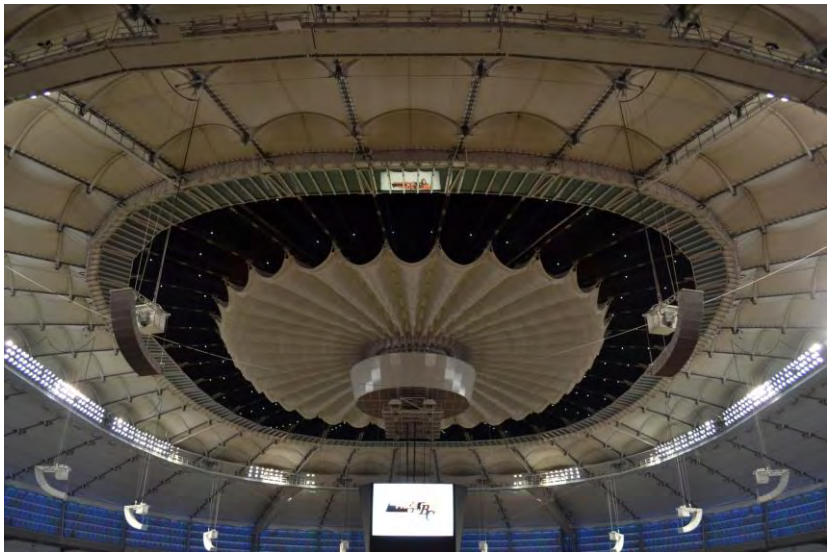

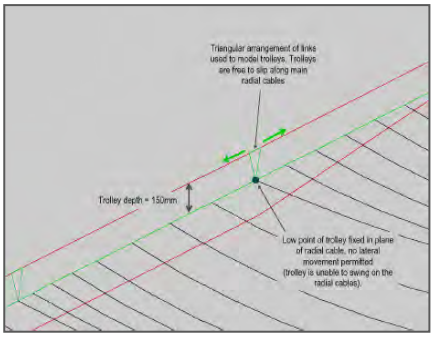

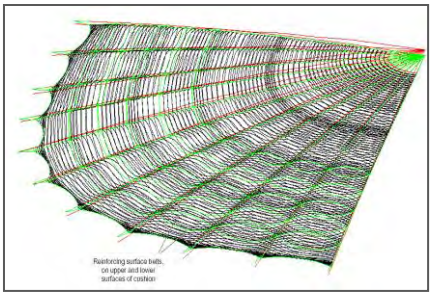

BC Place Vancouver

AELTC Wimbledon : Centre Court

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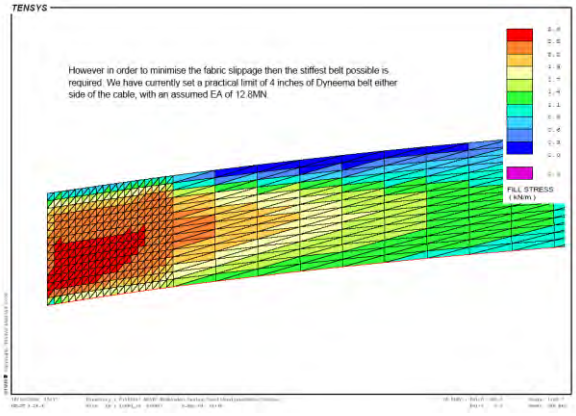
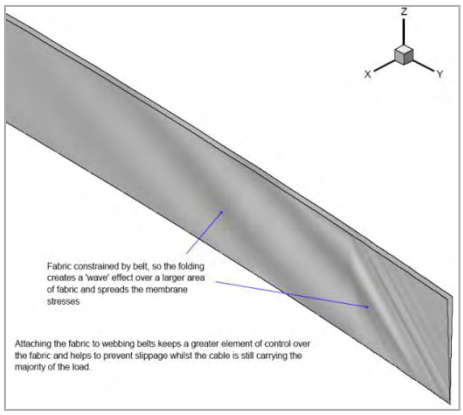
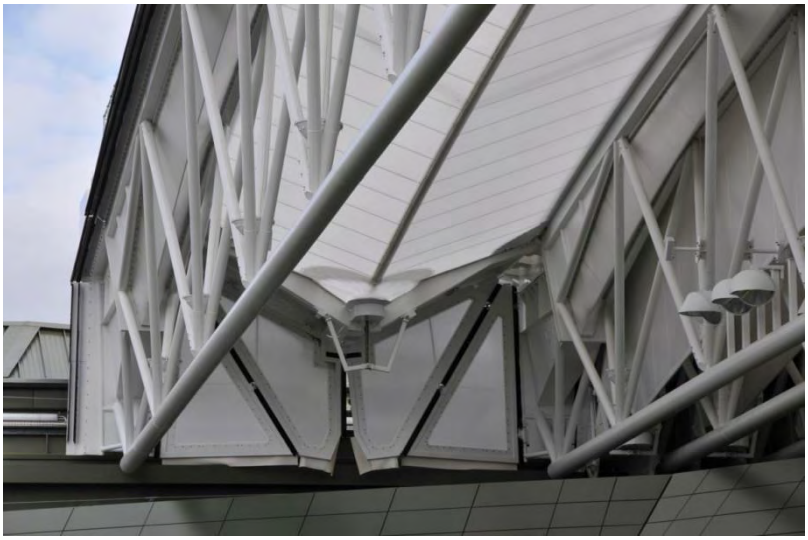
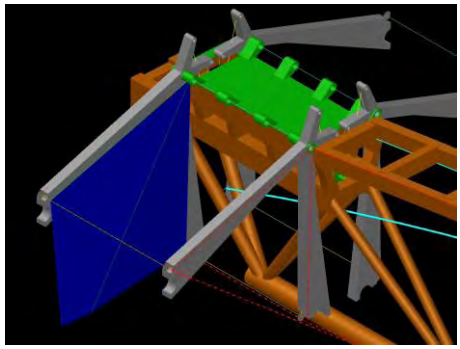
Centre Court
AELTC Wimbledon









National Stadium Warsaw

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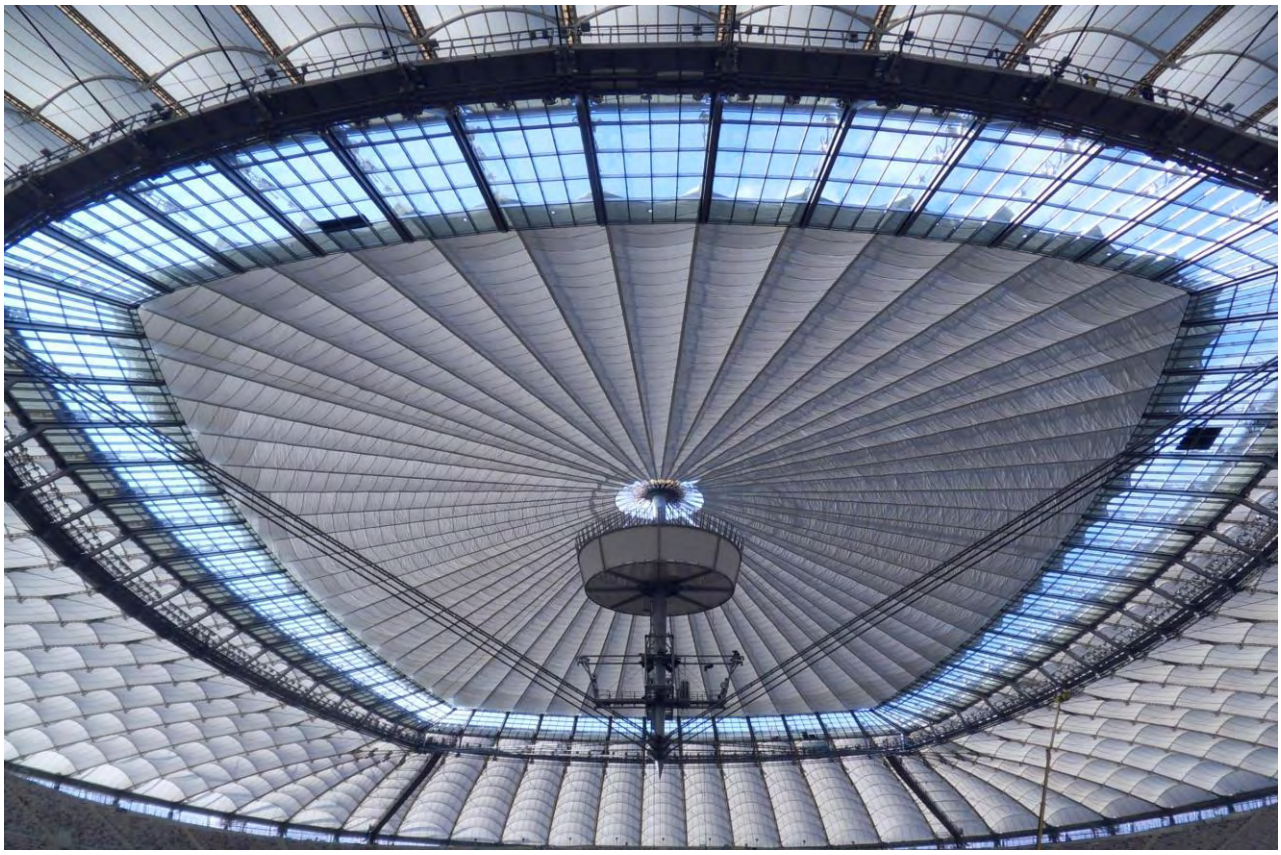

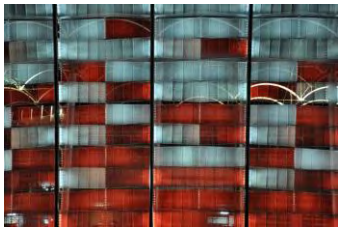

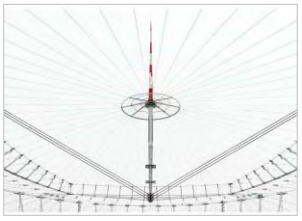

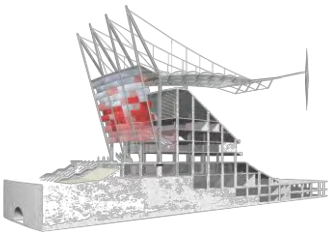

National Stadium Warsaw

Olympiastadion Berlin

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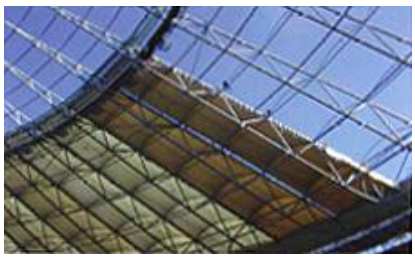
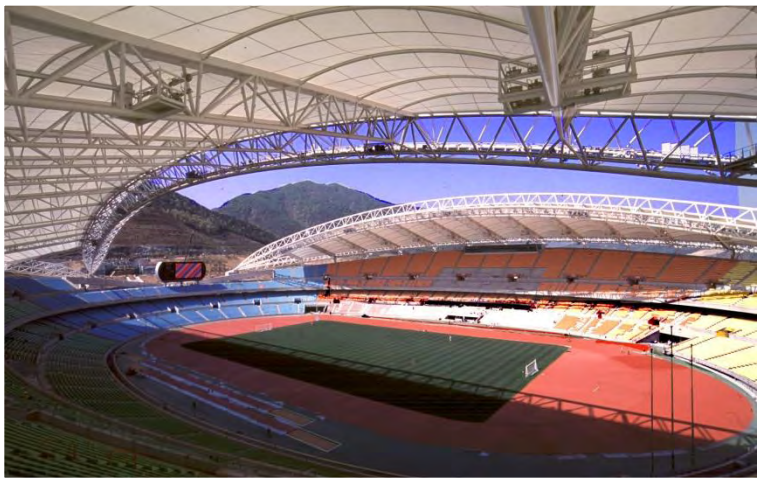


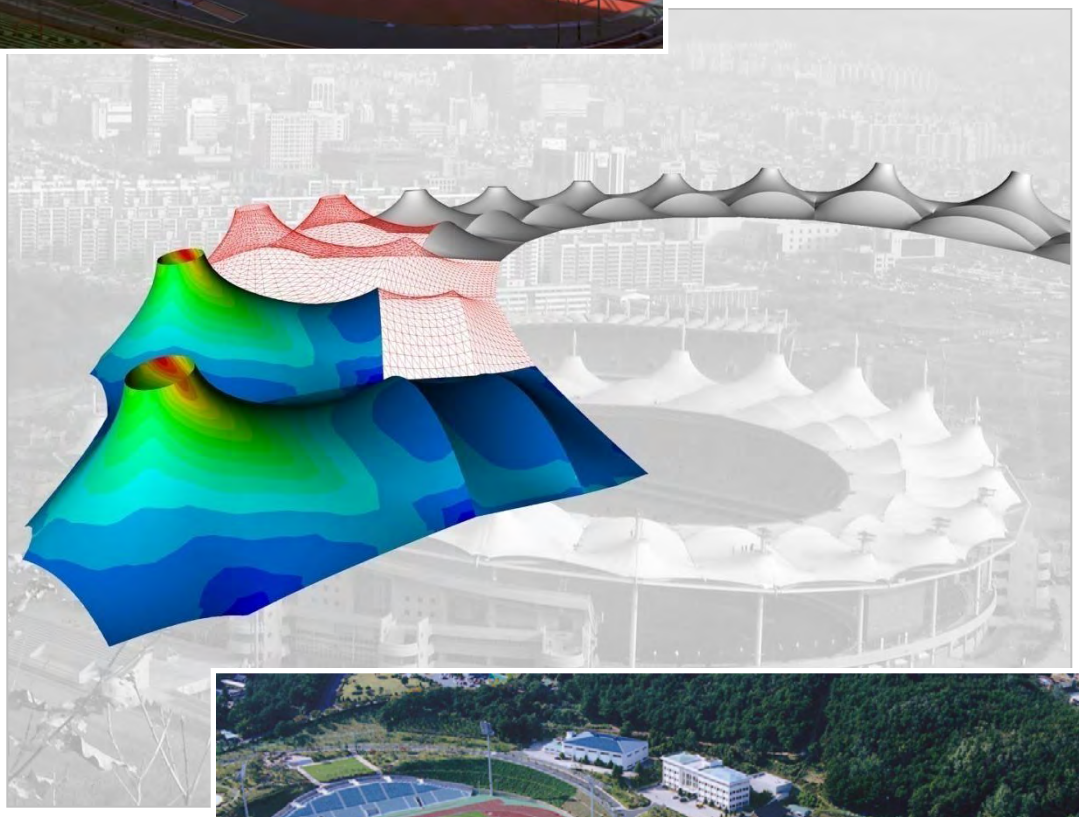
Olympiastadion Berlin

Stadiums: Korea



Daegu

Goyang



Incheon

Busan

Stadiums: Retractable Roofs

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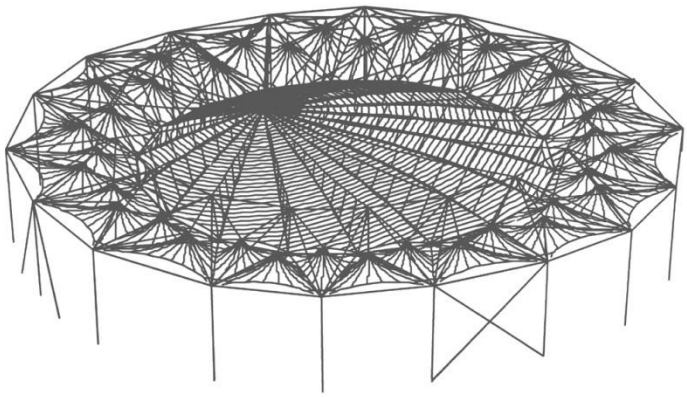
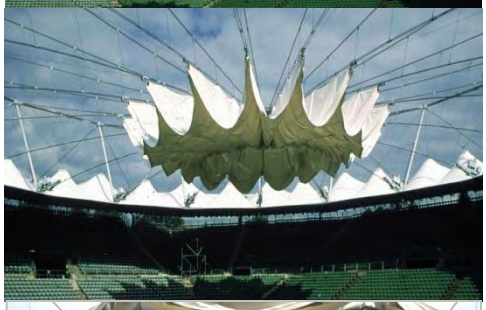
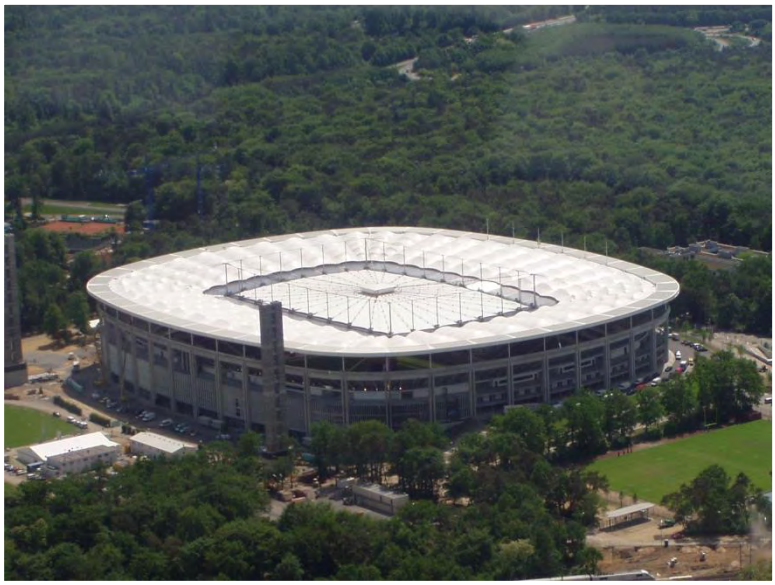
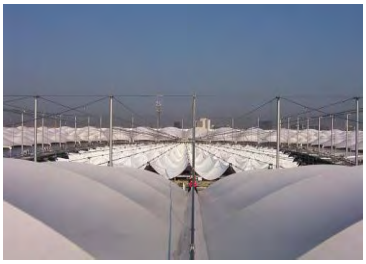




Rothenbaum
Hamburg



Waldstadion Frankfurt



Sports Facilities: UK

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Hampshire County Cricket Ground Southampton

Amenity Centre Inland Revenue Nottingham

Stadiums: Australia

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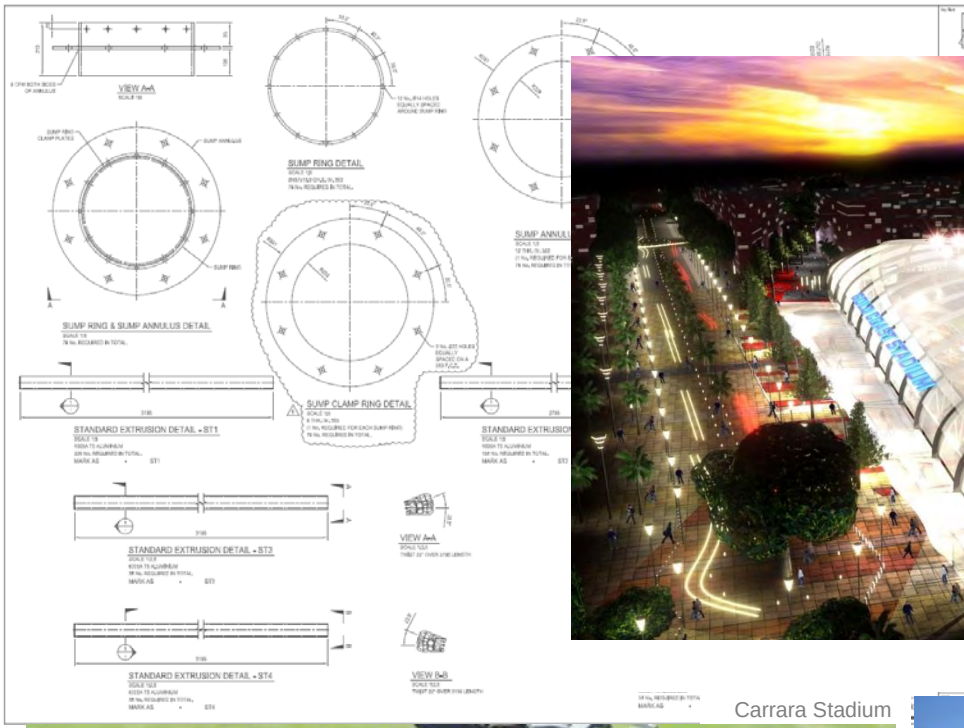
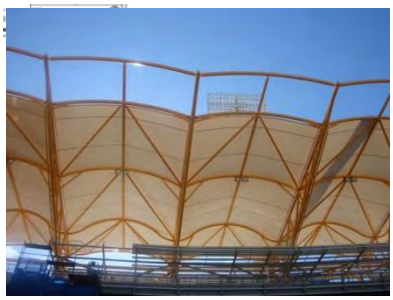
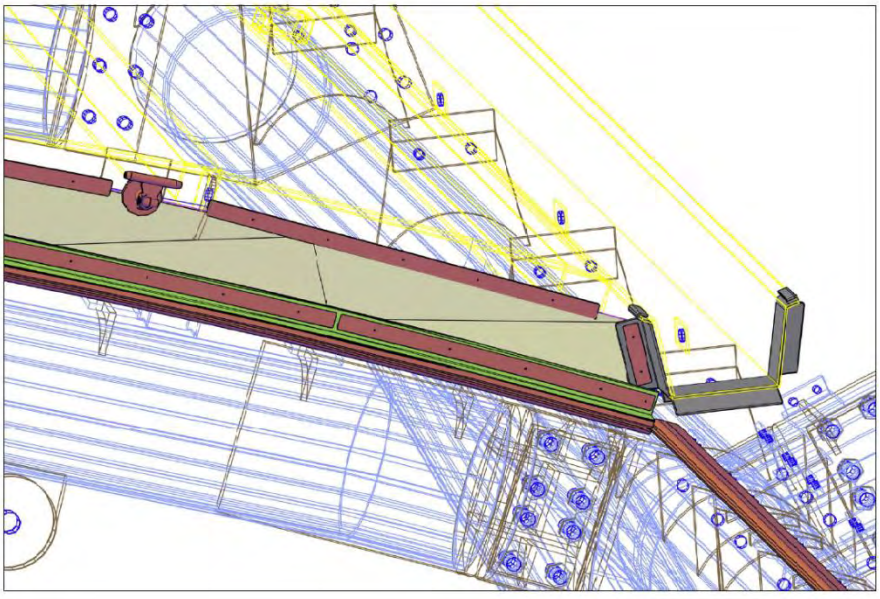
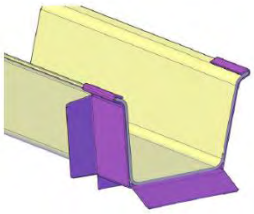


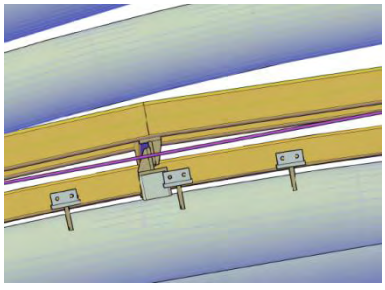
Robina Stadium

Carrara Stadium









Carrara Stadium: Australia

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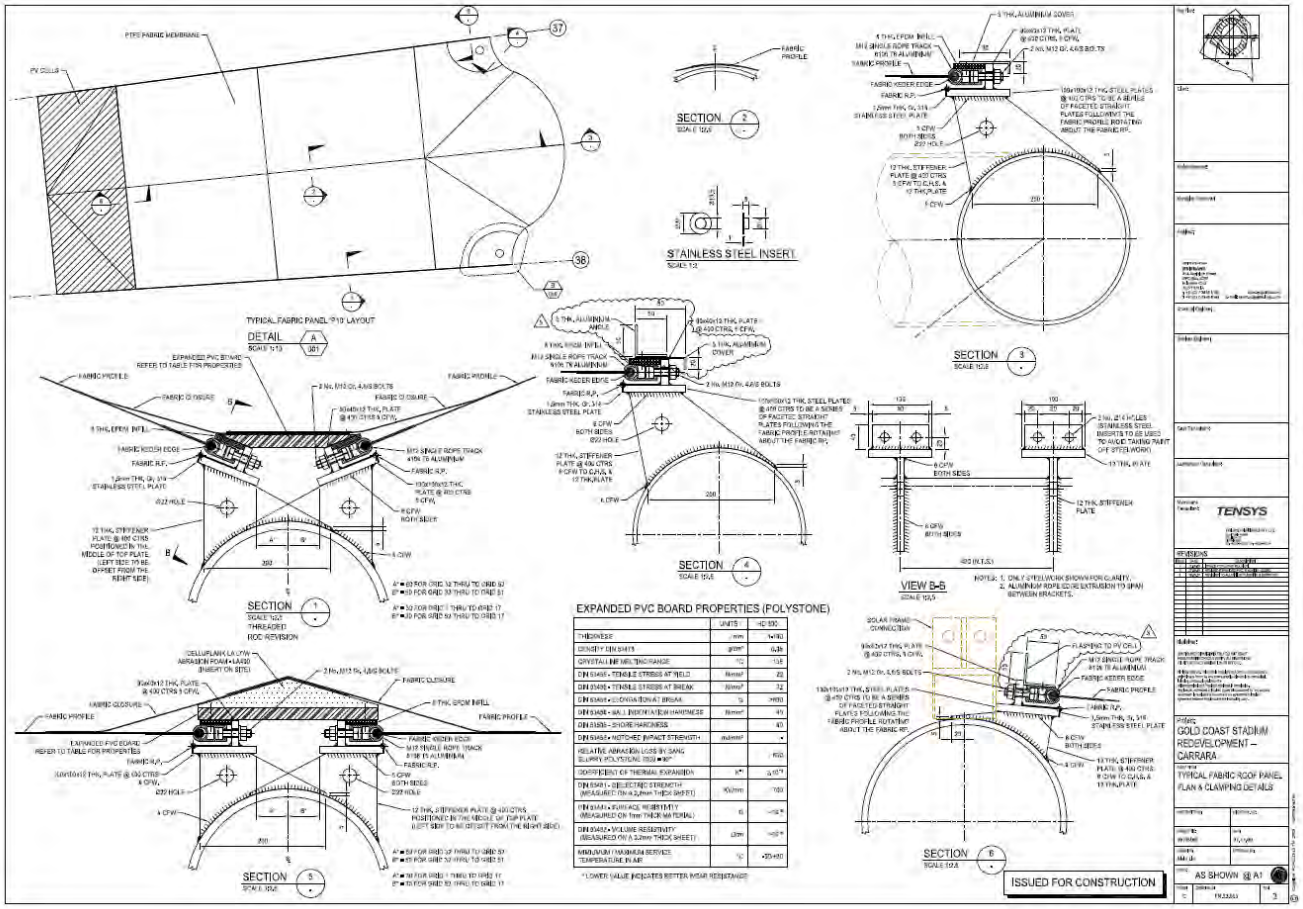
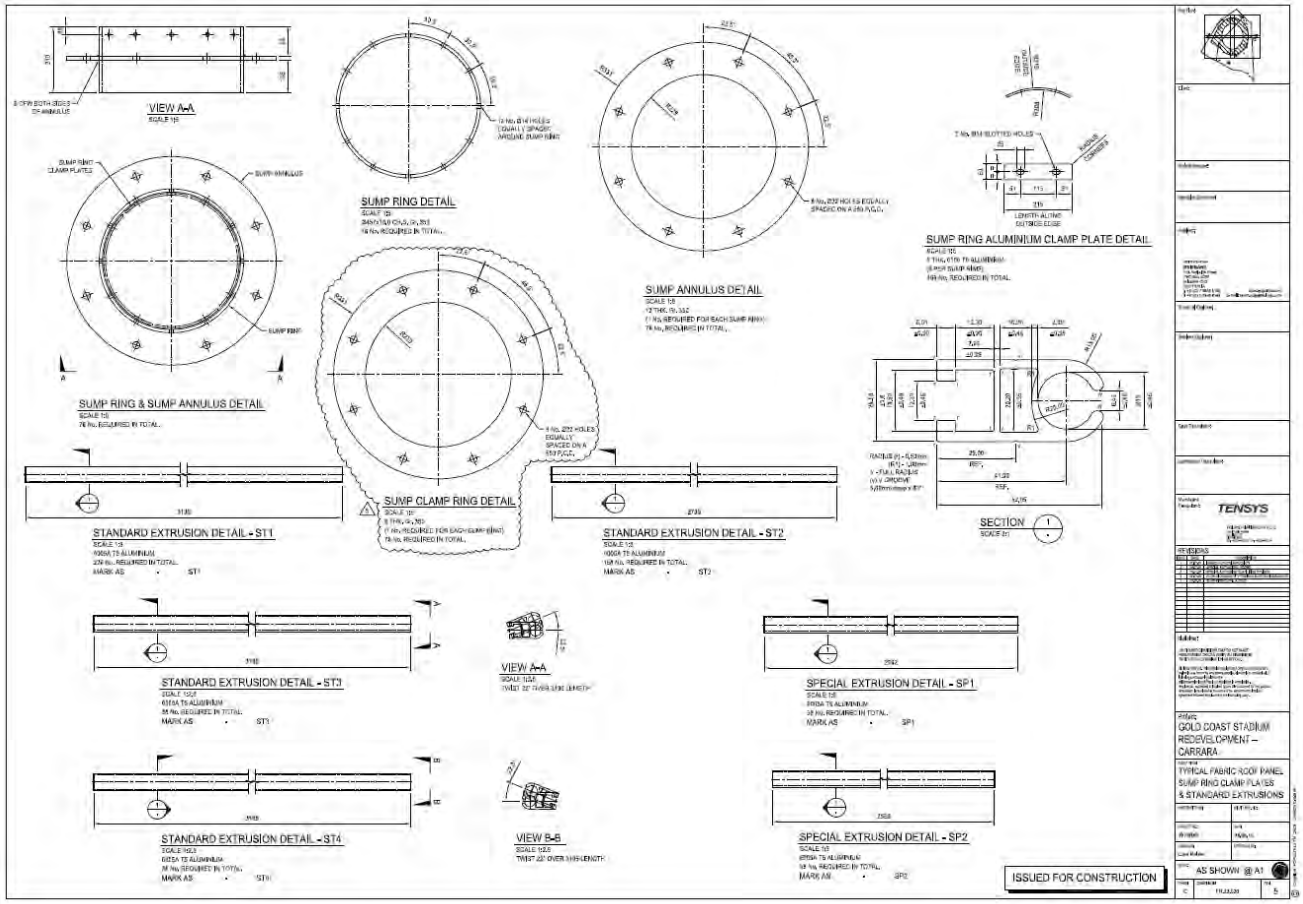


	UNITS	HD 930
THICKNESS	mm	1•180
DENSITY DIN 53479	g/cm³	0,59
CRYSTALLINE MELTING RANGE	°C	158
DIN 53455 - TENSILE STRESS AT YIELD	N/mm²	23
DIN 53455 - TENSILE STRESS AT BREAK	N/mm²	32
DIN 53455 - ELONGATION AT BREAK	%	>100
DIN 53456 - BALL INDENTATION HARDNESS	N/mm²	41
DIN 53505 - SHORE HARDNESS	-	65
DIN 53453 - NOTCHED IMPACT STRENGTH	kJ/m²	•
RELATIVE ABRASION LOSS BY SAND SLURRY POLYSTONE 930 = 80*	-	100
COEFFICIENT OF THERMAL EXPANSION	K⁻¹	5,0*10⁻⁵
DIN 53481 - DIELECTRIC STRENGTH (MEASURED ON 1,2mm THICK SHEET)	kV/mm	>30
DIN 53482 - SURFACE RESISTIVITY (MEASURED ON 1mm THICK MATERIAL)	Ω	>10¹⁴
DIN 53482 - VOLUME RESISTIVITY (MEASURED ON 3,2mm THICK SHEET)	Ωm	>10¹⁴
MINIMUM / MAXIMUM SERVICE TEMPERATURE IN AIR	°C	-20/+60

* LOWER VALUE INDICATES BETTER WEAR RESISTANCE



Abdullah bin Khalifa Stadium Doha Qatar

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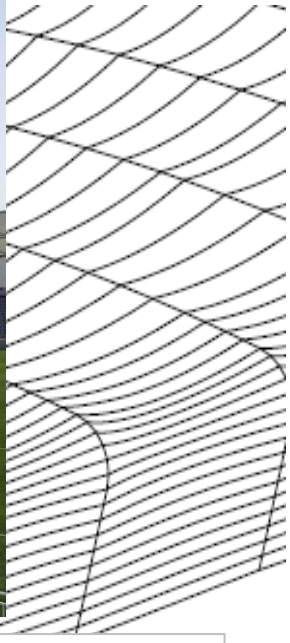
Engineering • Analysis



MGM City Centre: Las Vegas

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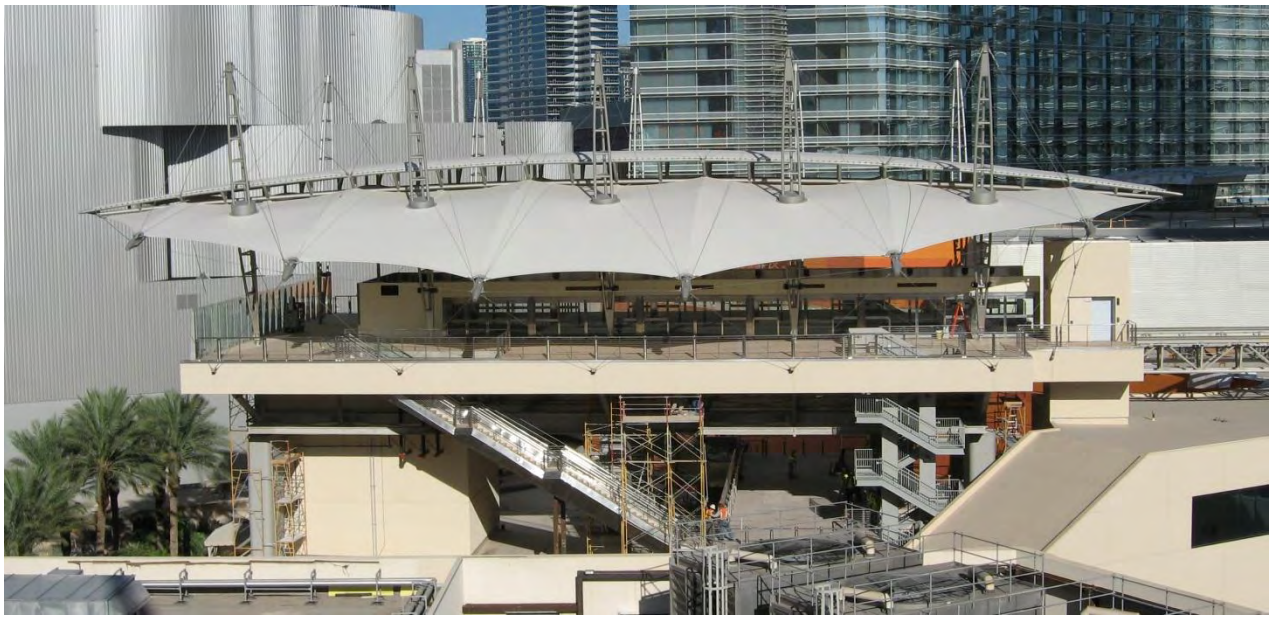
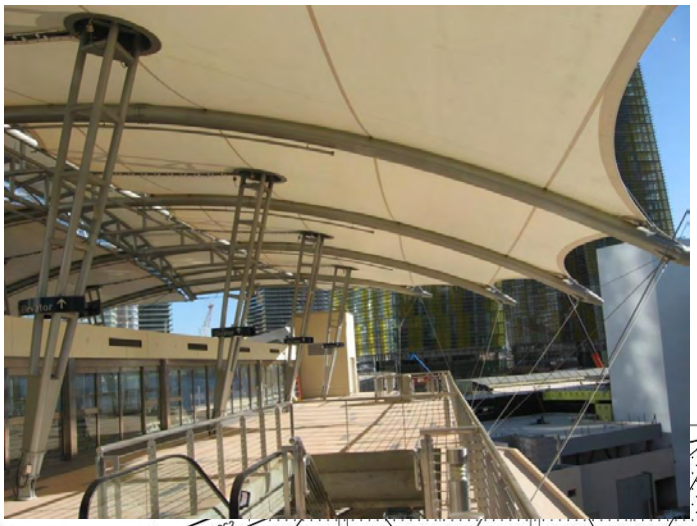
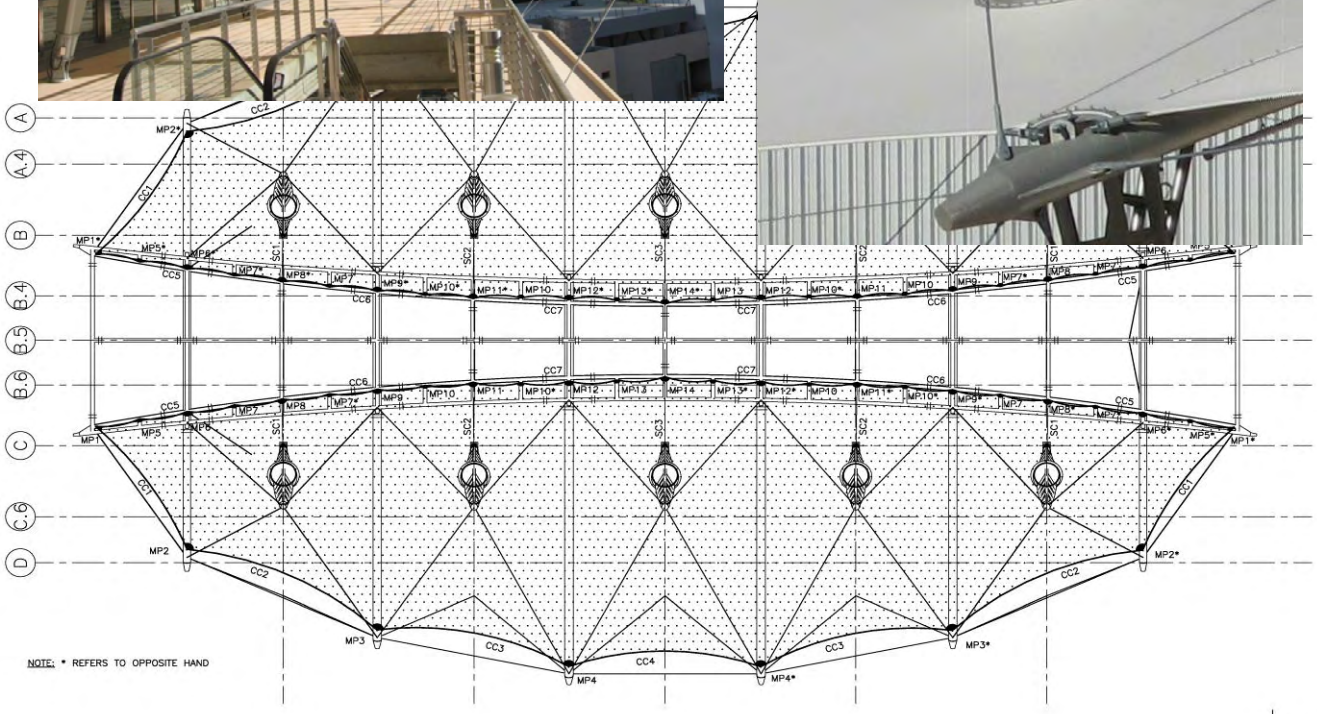
Engineering • Analysis



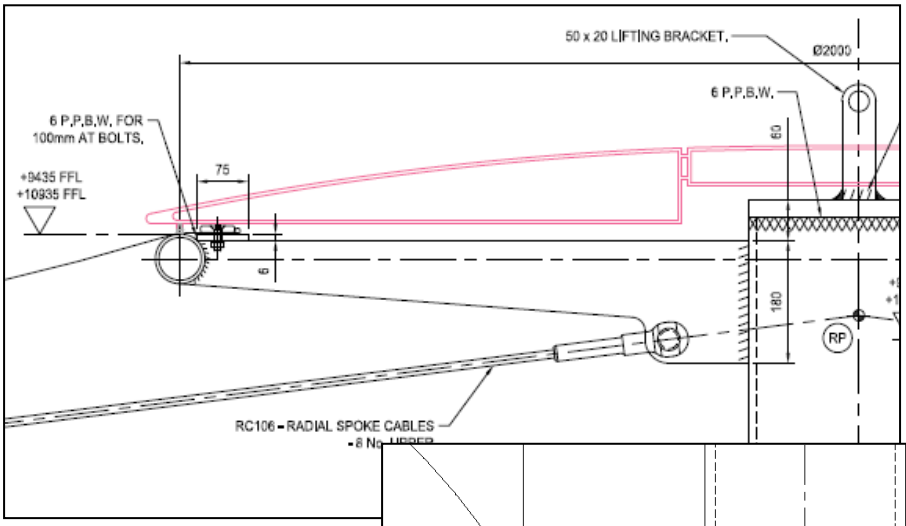


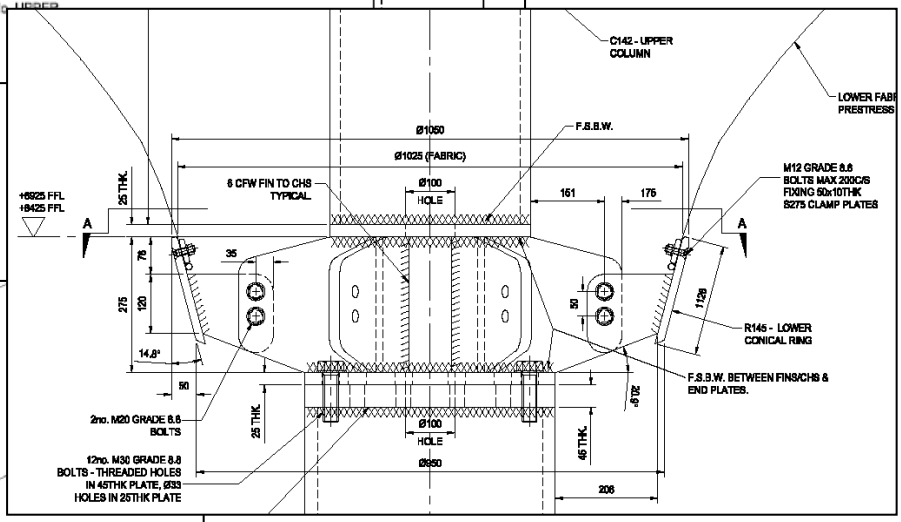


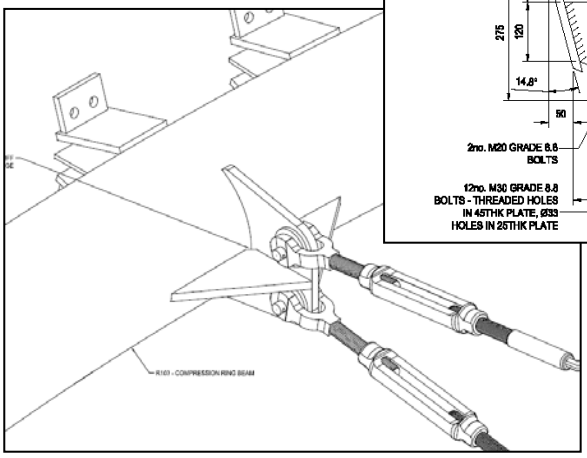
MEMBRANE PLATE PLAN LAYOUT
1/8" = 1'-0"

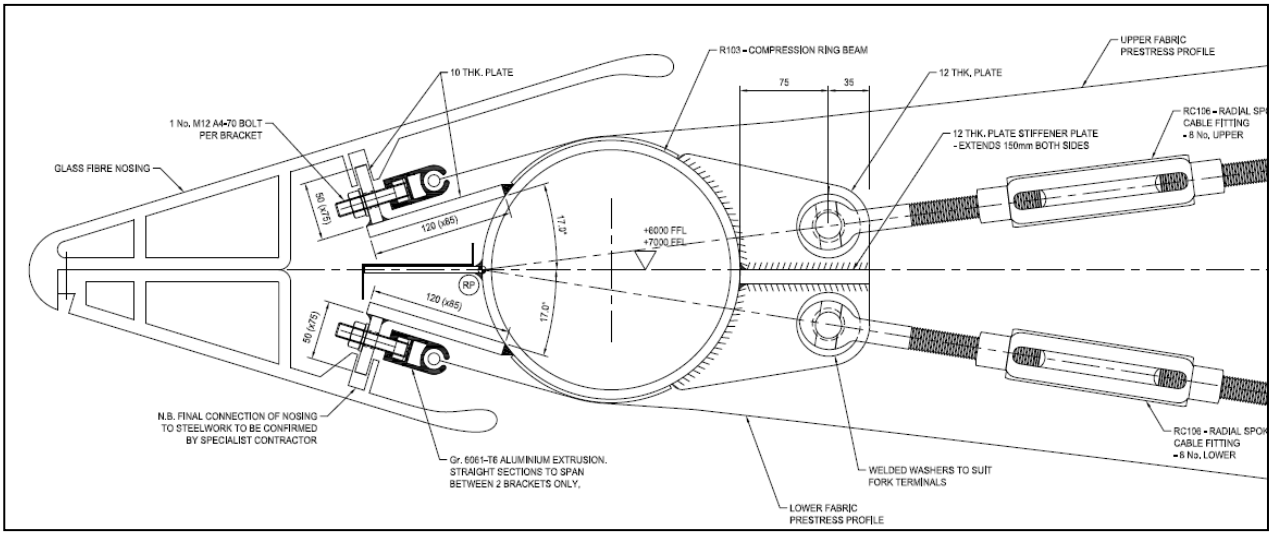
Design + Detailing

TENSYS
Engineering • Analysis









ETFE

Clarke Quay
Singapore

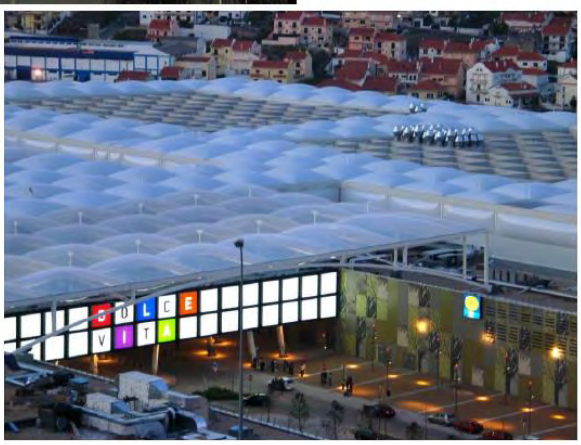
Vista Alegre Madrid

Prienavera Germany

Yas Island F1 Abu Dhabi

UK National Space Centre

ETFE

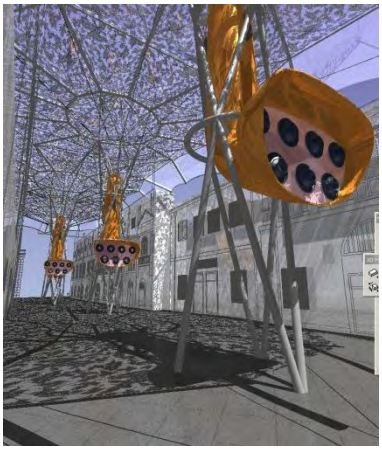


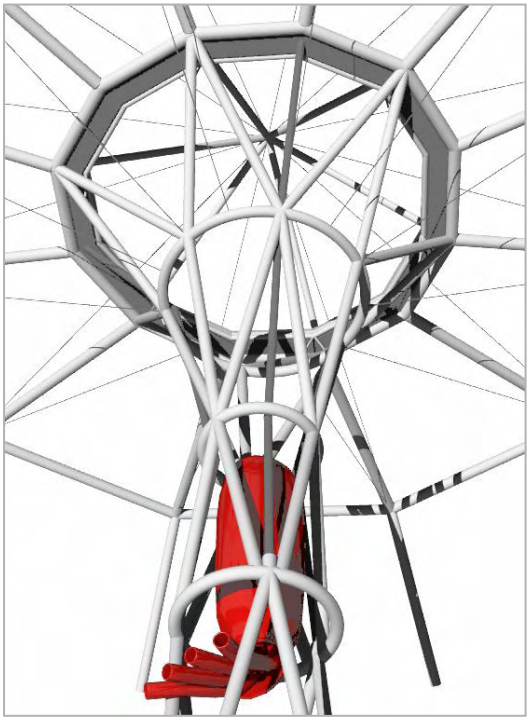
Dolce Vita Portugal

ExCel : London Exhibition and Conference Centre

Clarke Quay: Singapore

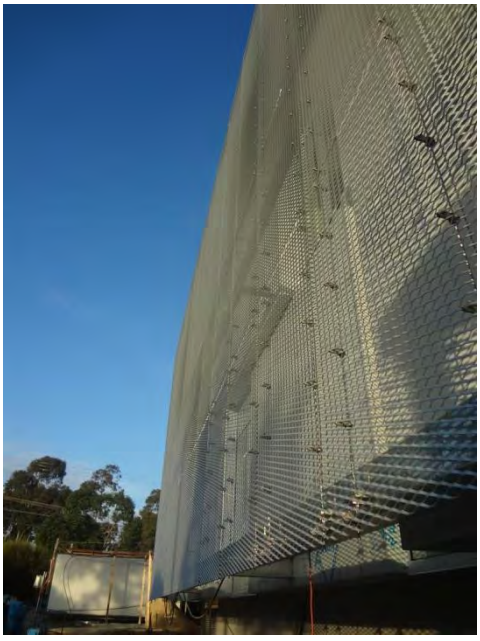
TENSYS
Engineering • Analysis

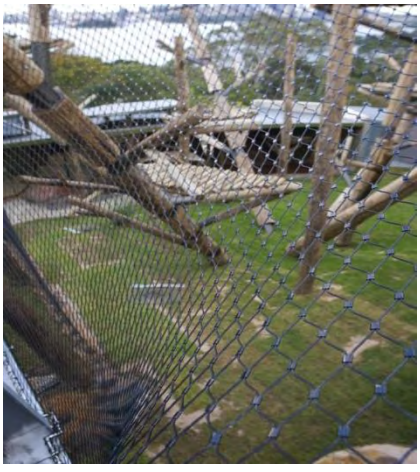




Cable Mesh & Net Systems

TENSYS
Engineering • Analysis





Brisbane Wintergarden Facade

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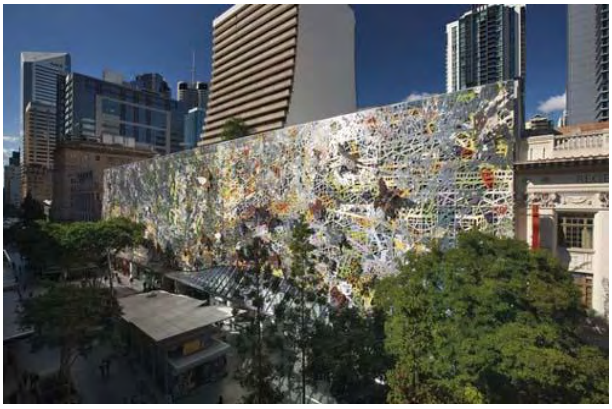
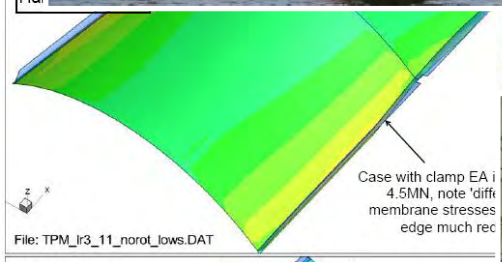
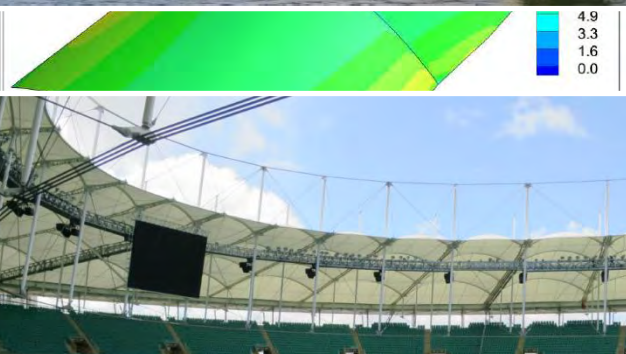
Engineering • Analysis

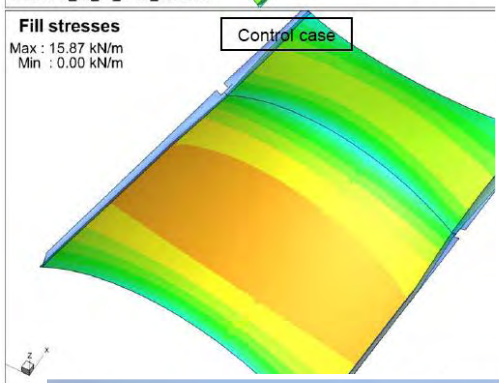


Checking Engineers

TENSYS
Engineering • Analysis



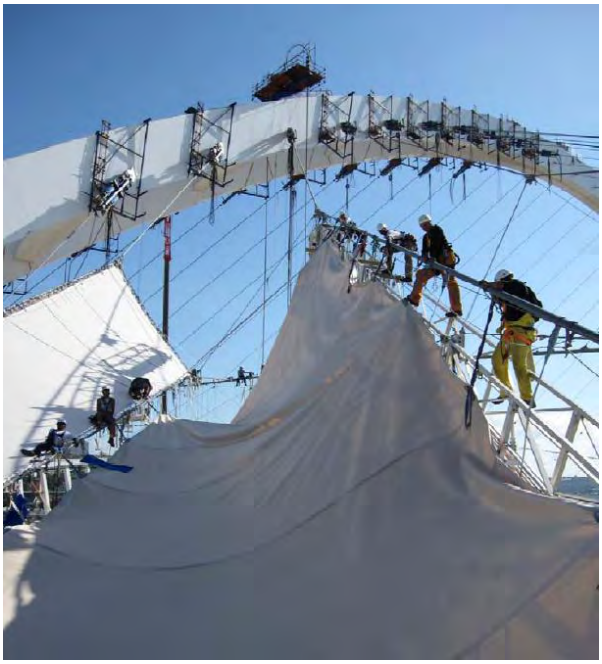




World Cup 2014 Brazil
Fonte Nova Stadium
Salvador

Checking Engineers

TENSYS
Engineering • Analysis

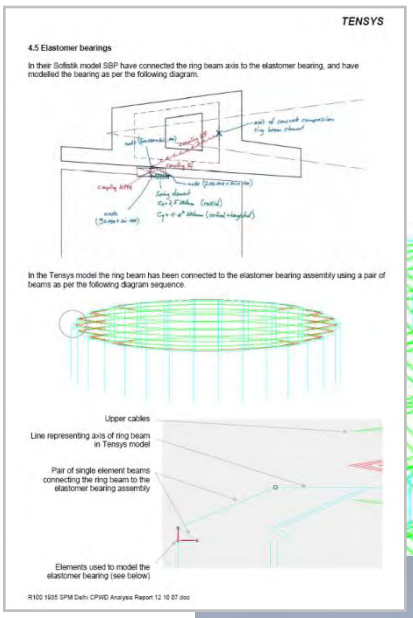


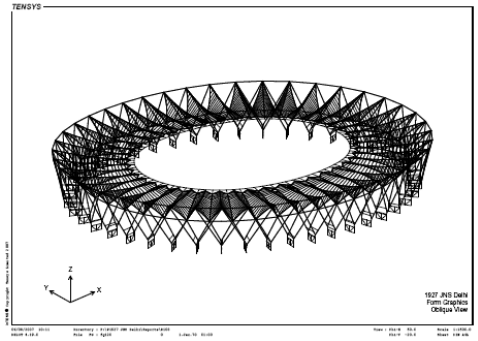
World Cup 2010 South Africa
Moses Mahbida Stadium Durban

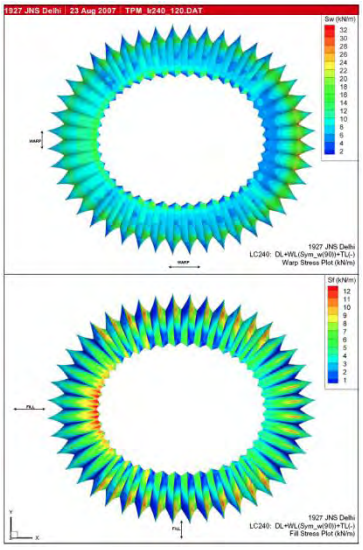
Checking Engineers

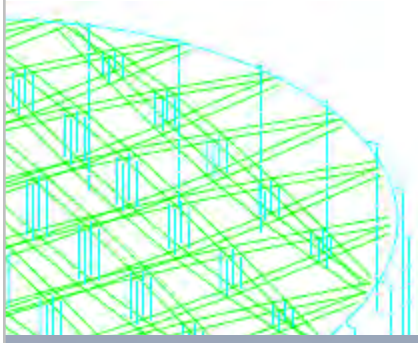
TENSYS
Engineering • Analysis

Commonwealth Games 2010 New Delhi
Jawaharlal Nehru Stadium

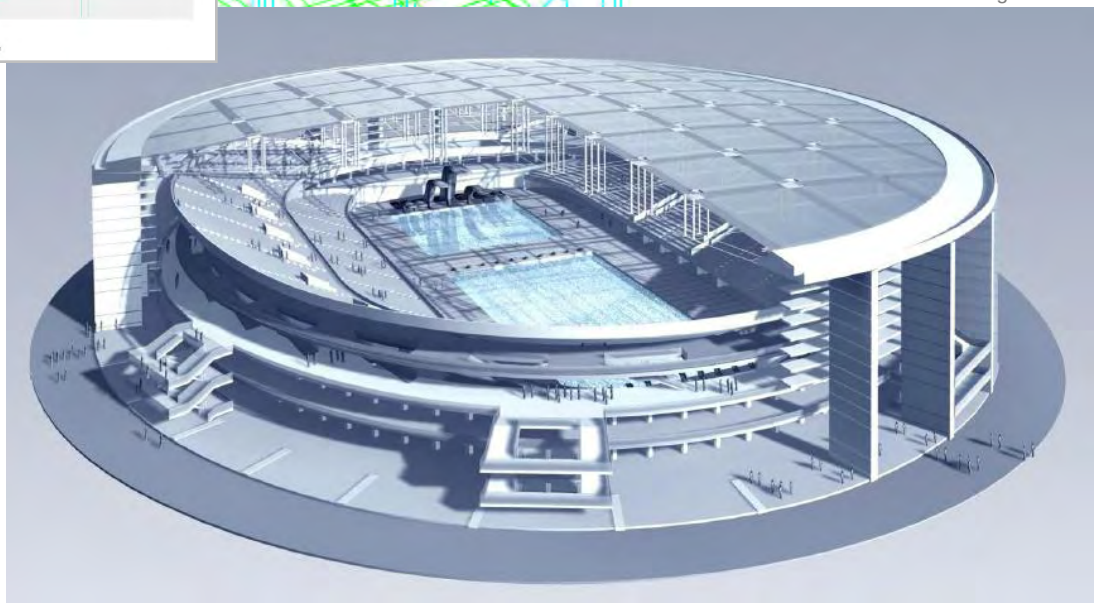






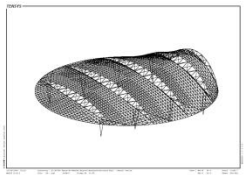


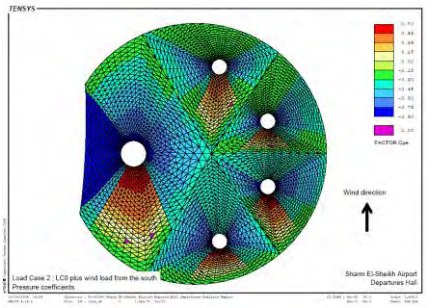
Commonwealth Games 2010 New Delhi
SPM Swimming Stadium



Checking Engineers

TENSYS
Engineering • Analysis





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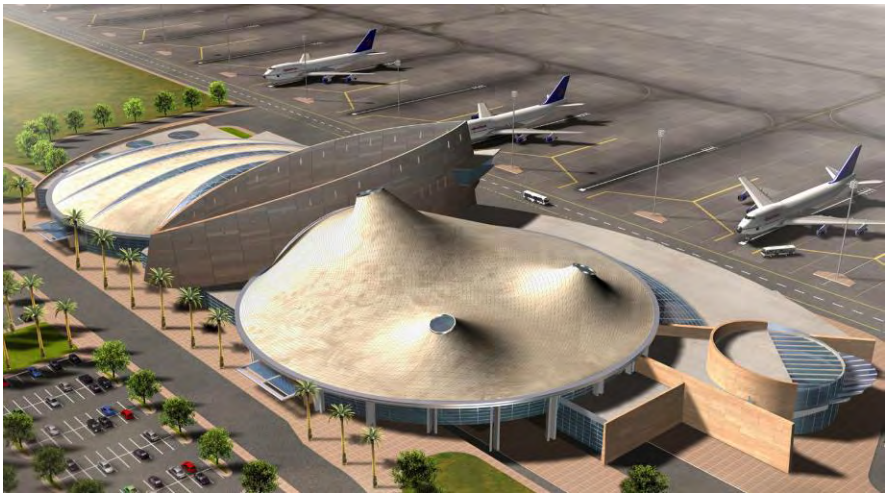
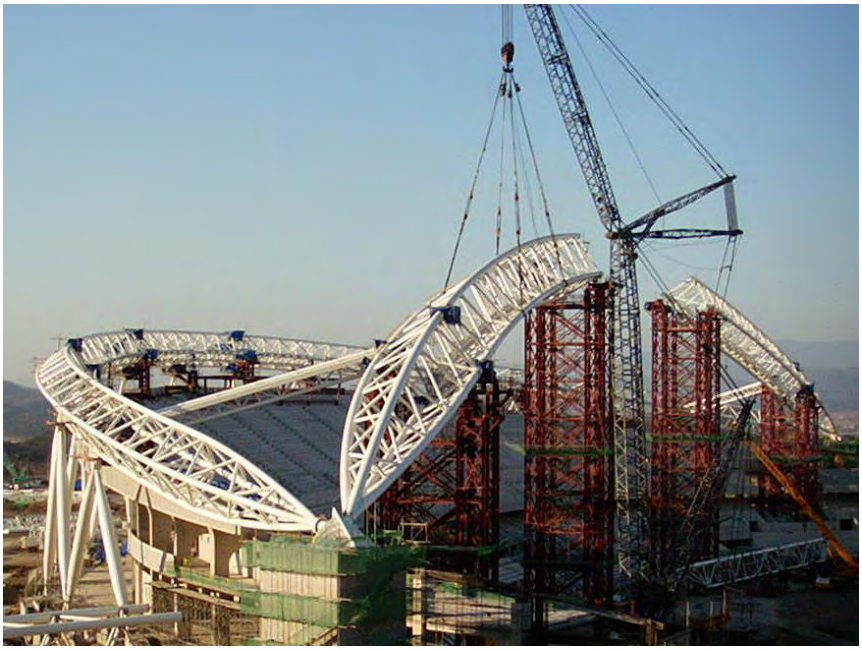
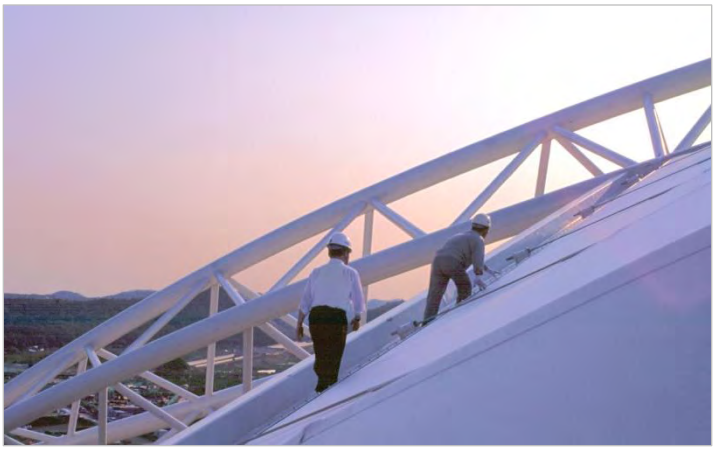




2002 World Cup Japan /Korea
Daegu Stadium



Marsyas: Anish Kapoor Tate Modern

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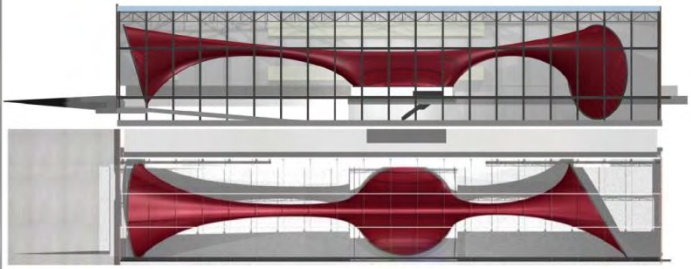

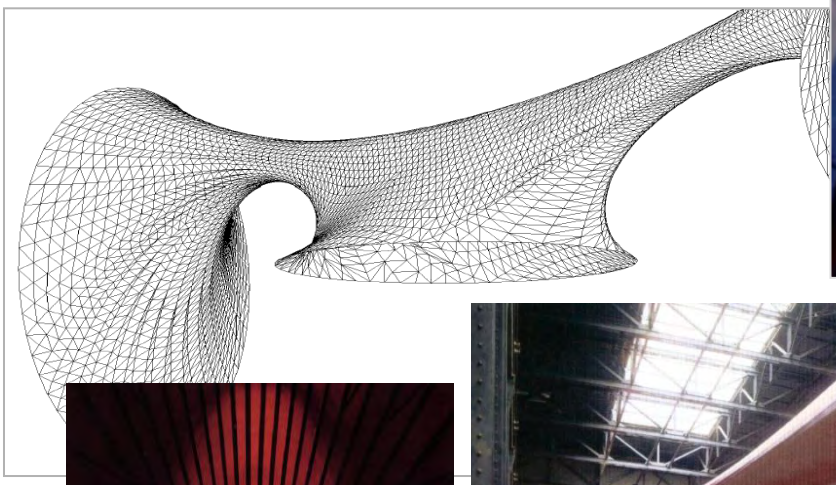

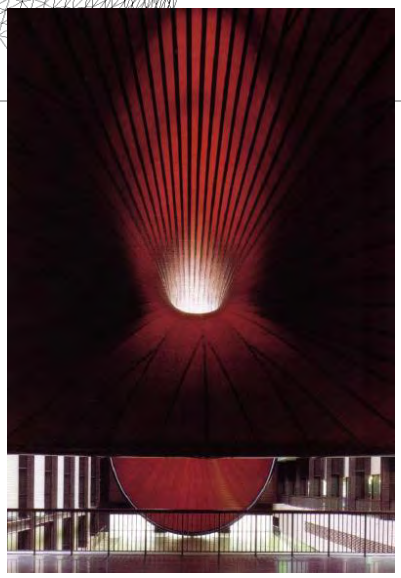

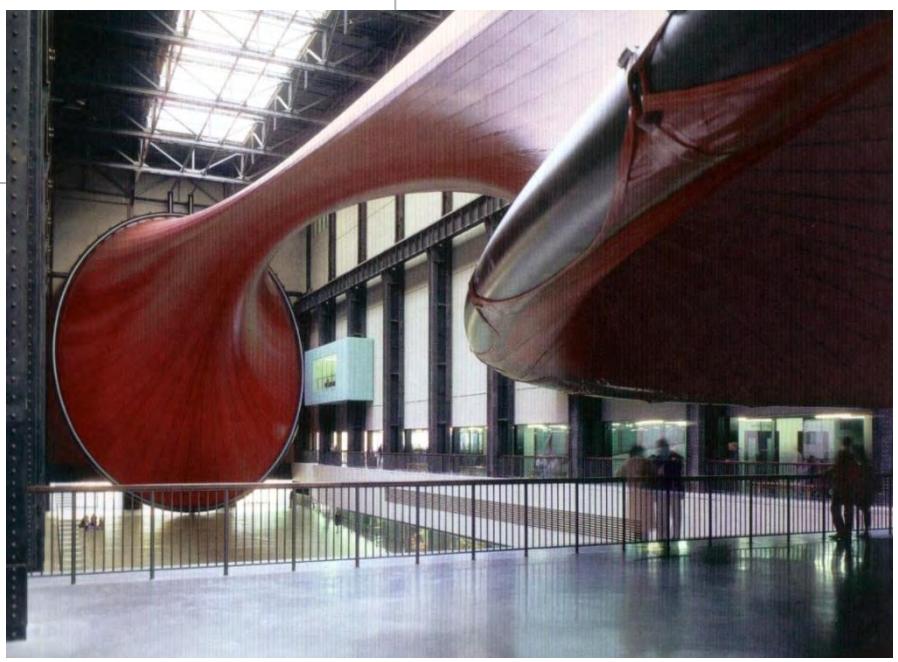

Leviathan: Anish Kapoor Paris 2011

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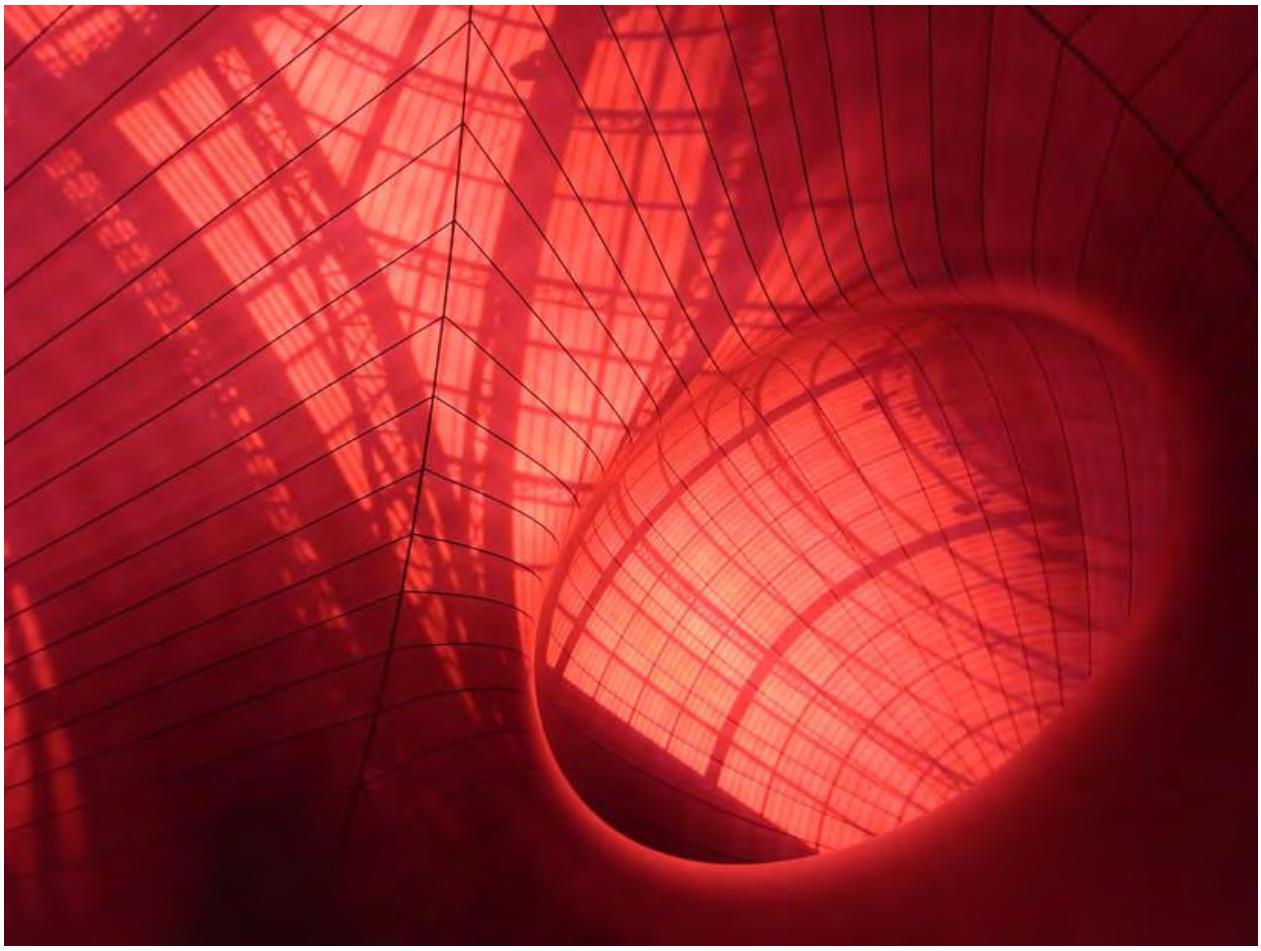

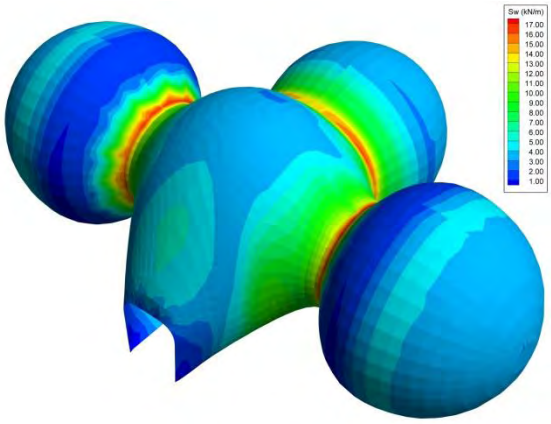

Ark Nova: Anish Kapoor Japan 2013

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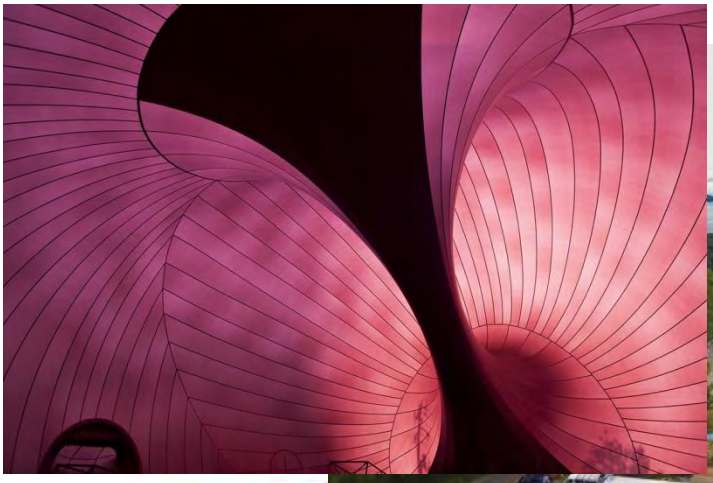
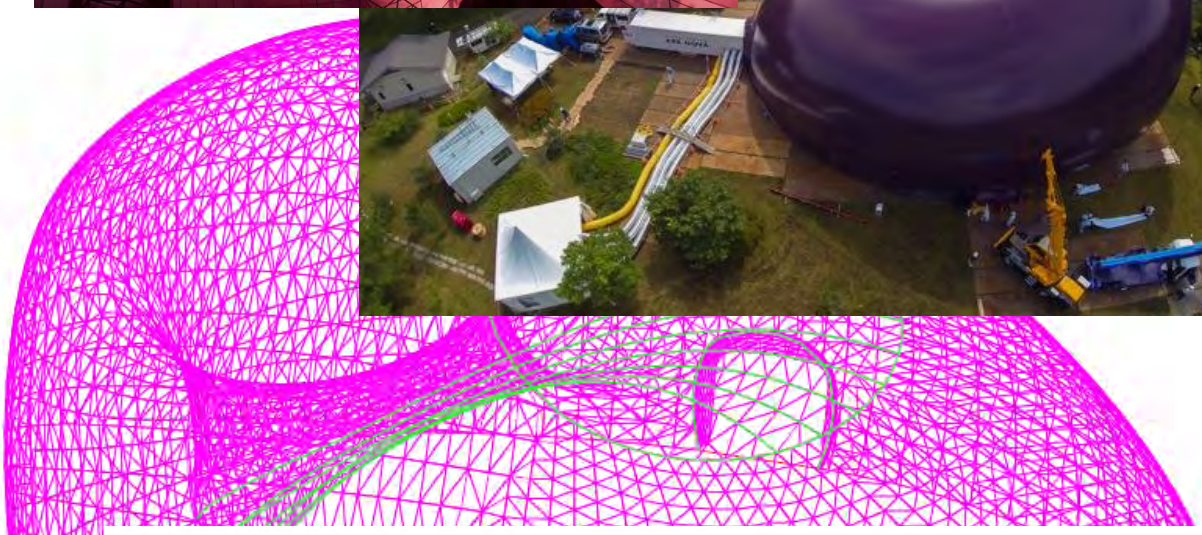
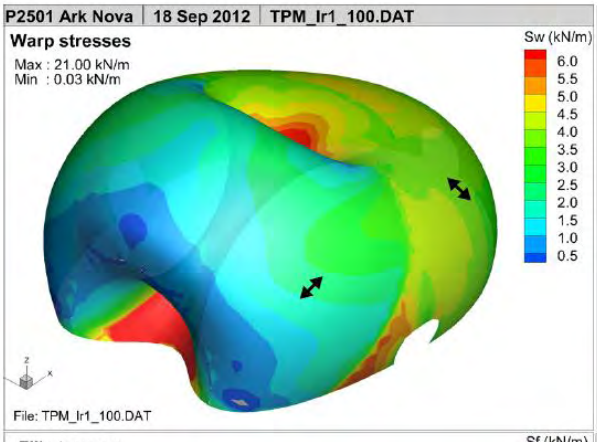
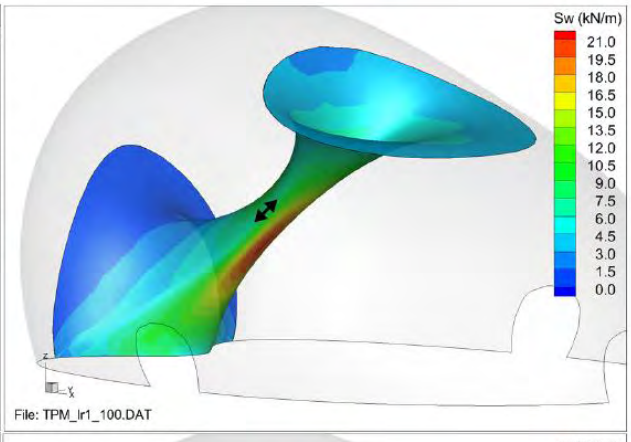
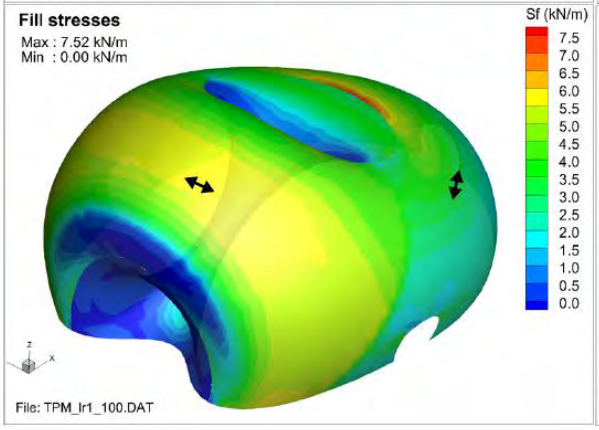
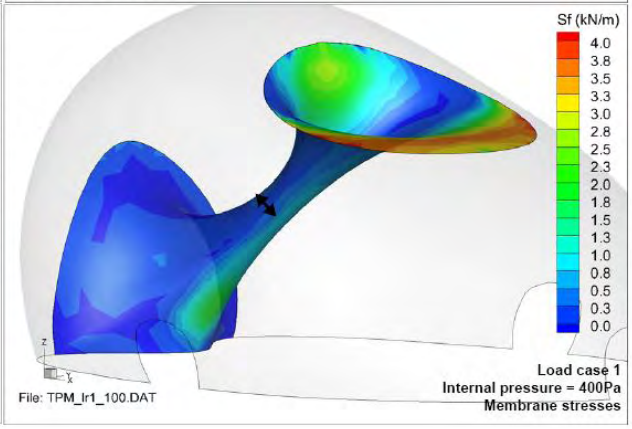






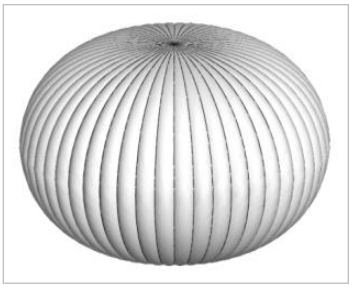


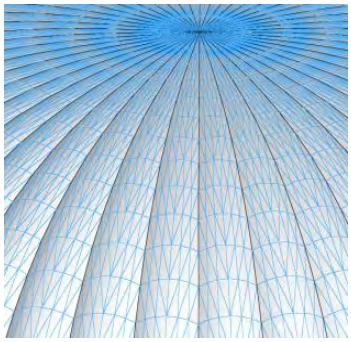


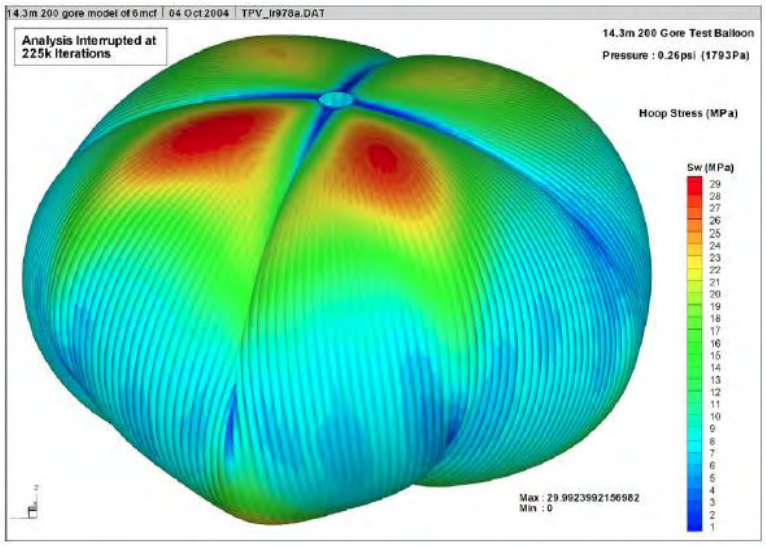


NASA : Ultra Long Duration Balloon Program

TENSYS
Engineering • Analysis







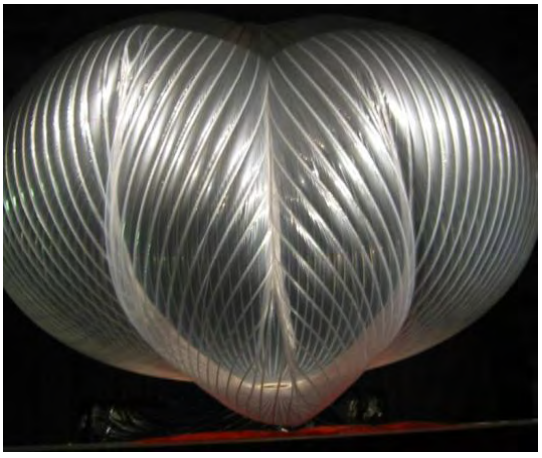
Shape Finding

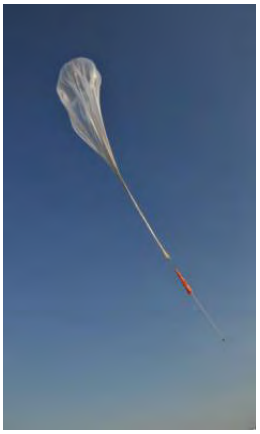
Load Analysis

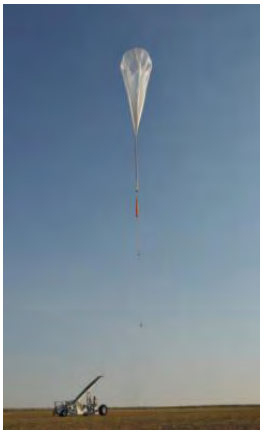
Stability Studies

Viscoelastic Modelling

Flight Duration Simulation







2mcf Test Balloon Launch Ft Sumner NM July 08

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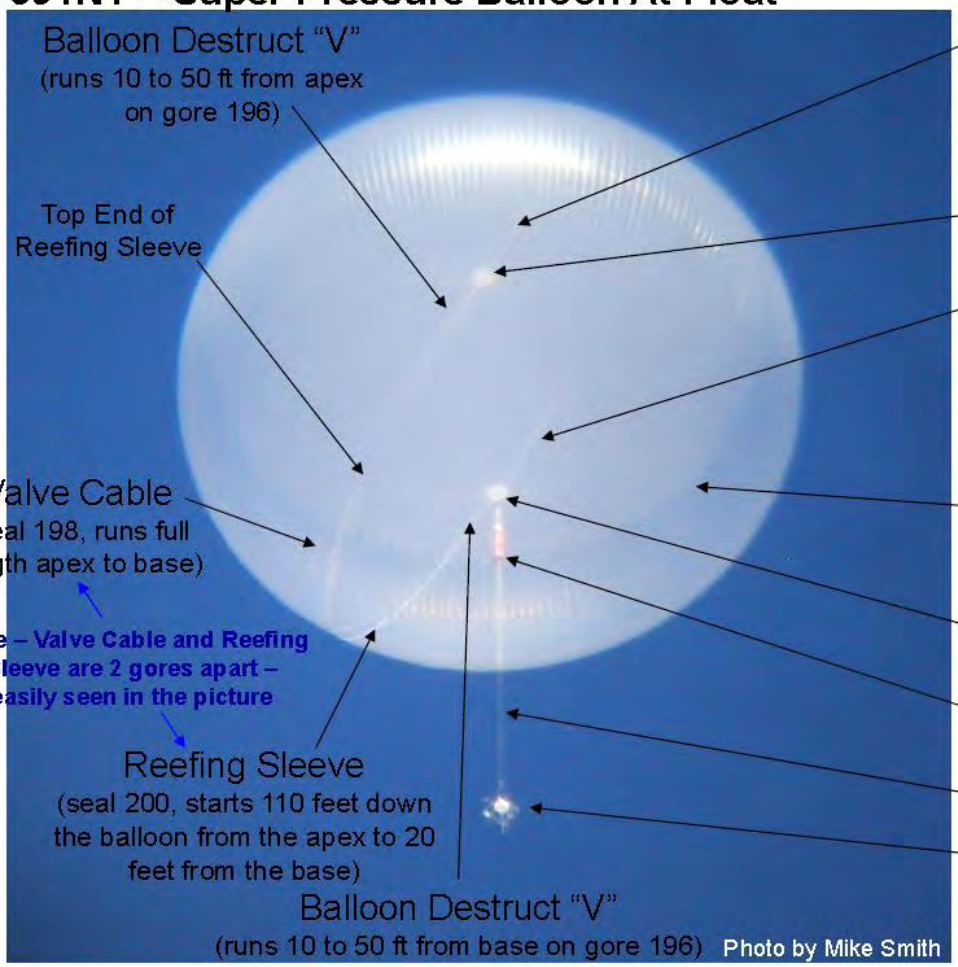
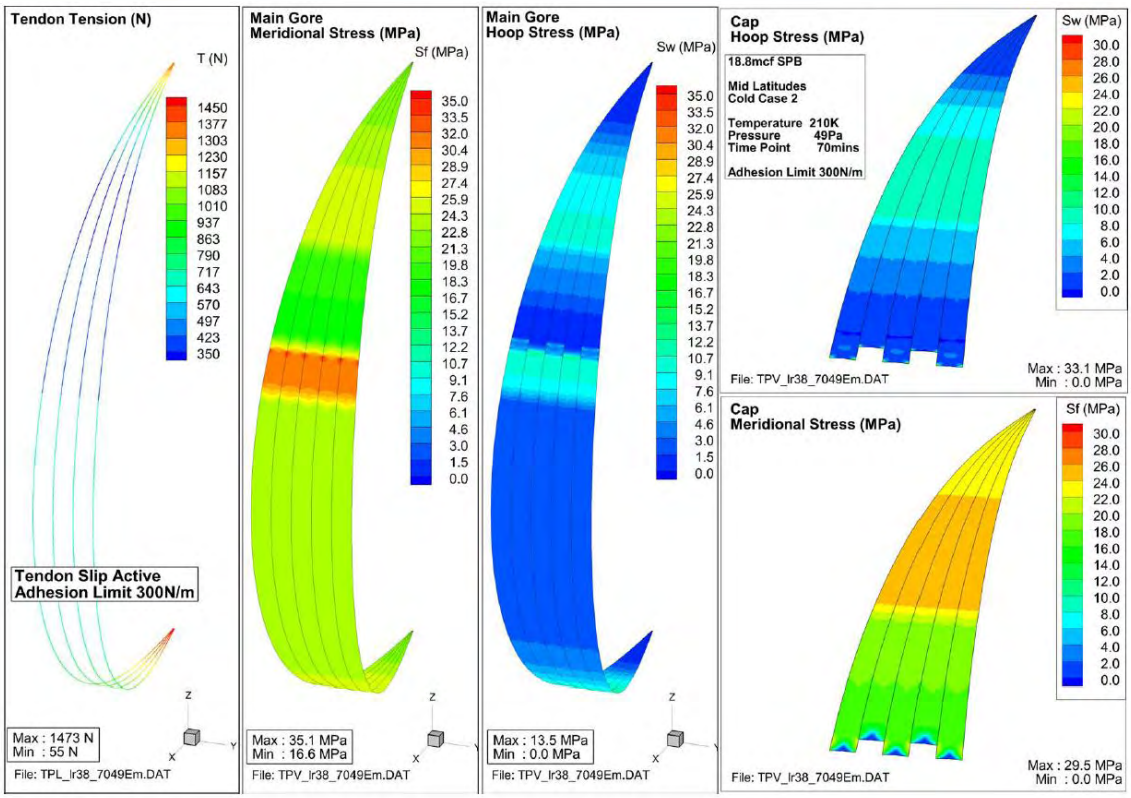
591NT – Super Pressure Balloon At Float



Inflated Dimensions
Height 49.9 m (163.61 ft)
Diameter 82.8 m (271.60 ft)



NASA : Ultra Long Duration Balloon Program

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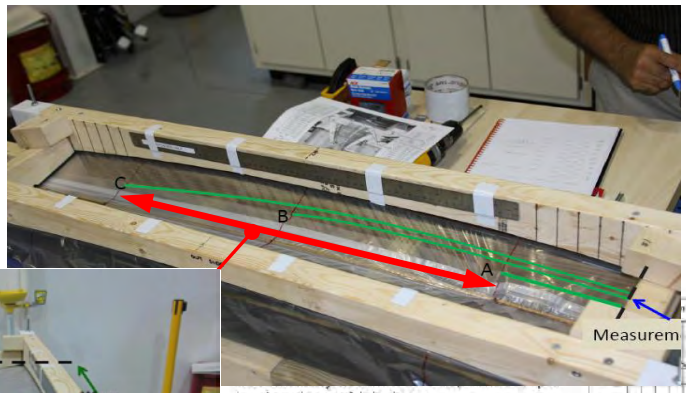
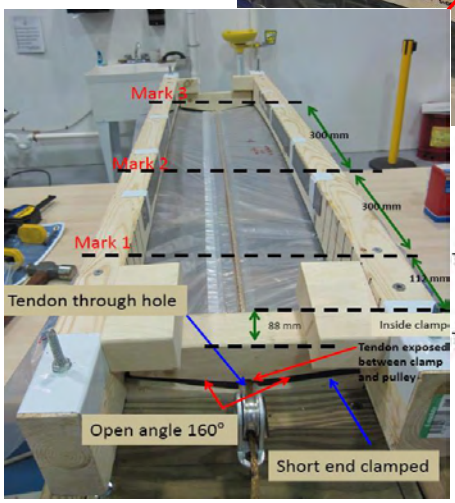
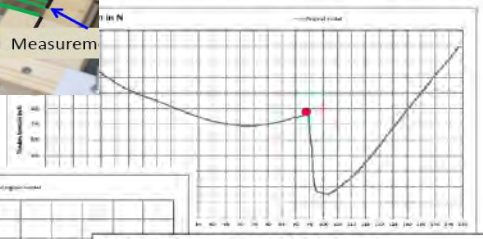
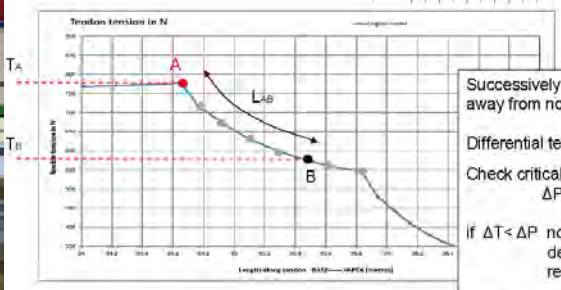




Enhanced Debonding Studies

tension change/high shear





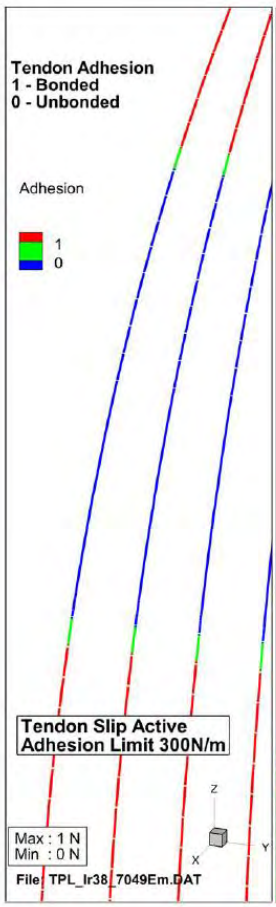
Successively examine nodes B moving away from node A:

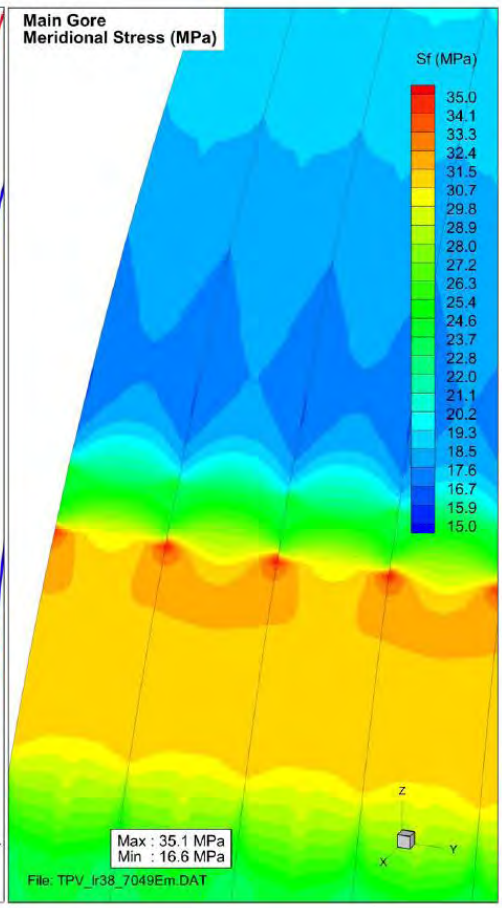
Differential tension $\Delta T = T_A - T_B$

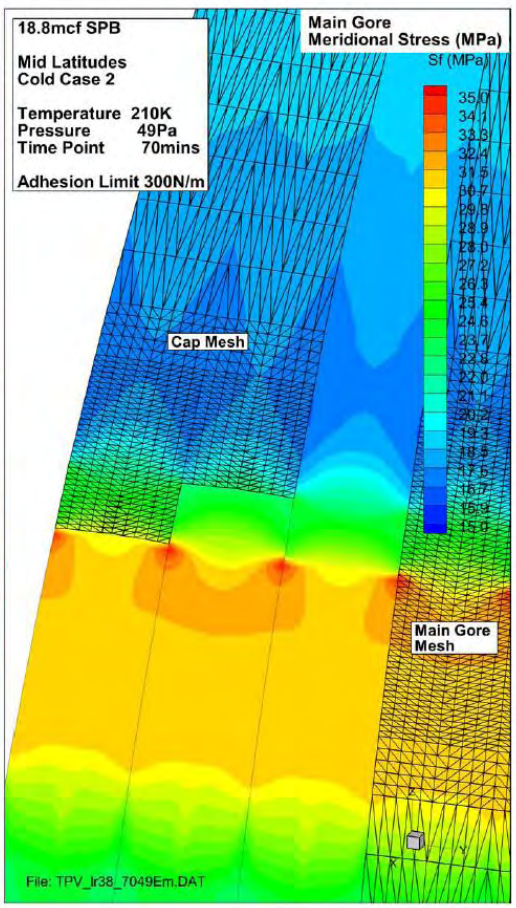
Check critical differential load for debonding
$\Delta P = f(L_{AB}, \text{Temperature})$

if $\Delta T < \Delta P$ no debonding at B
debond from A to previous node B-
restart search from next node A

if $\Delta T >= \Delta P$ debonding from A->B
continue to next node B+ and repeat







Hybrid Air Vehicles and Aerobots

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Engineering • Analysis

Lockheed Martin P791 HAV Demonstrator

WORLD NEWS & ANALYSIS

SKUNKS WORKING

Quietly built airship makes unannounced spin above the desert

MICHAEL A. DORNHEIM/LOS ANGELES

Lockheed Martin Advanced Development Projects is making perhaps the first realistic tests of a hybrid airship—a concept that dates back many decades but that is just now being tried at a significant scale.

The Skunk Works had secretly built the craft and hoped for a quiet first flight at its Palmdale, Calif., facility, but a few passers-by noticed the strange object in the sky.

The Defense Dept. is showing interest in two categories of airships—those that can carry large cargo at low altitudes, exemplified by the Defense Advanced Research Projects Agency (Darpa) Walrus program, and those that can operate at high-altitude low-wind conditions and remain on station for long periods of time. The configuration of the Skunks Works ship indicates it is the former—a hybrid heavy-load carrier.

The interest is across the services and the notional applications are diverse, ranging from logistics—delivery of an integrated fighting unit within theater, for example—to sensor, communications and even laser-weapon relay platforms.

But airships aren't there yet. Major unresolved issues could derail the airship dream, such as their traditional delicate ground handling, and possibly prohibitive economics and vulnerability. These issues have been debated endlessly on paper, and now Lockheed Martin, a prime airship proponent, is investing to seek real answers.

A hybrid airship derives most of its lift by being filled with a lighter-than-air gas such as helium. Overall, it is heavier than air and gains the final 20% or so of lift by flying like an aircraft, but with slow takeoff and landing speeds that allow operations from short unprepared strips.

The Skunk Works made the first flight of its "P-791" testbed on Jan. 31 at its facility on the Palmdale Air Force Plant 42 airport. The manned flight was about a 5-min. circuit around the airport in the morning and appeared to be successful. The company did not announce or want to discuss the flight.

The P-791 is not part of a government contract, but rather an independent research and development project by the Skunk Works to better understand airship capabilities and technologies, such as materials, a company official says. However, it may also be a quarter-scale prototype of a heavy-lifter.

TO GAIN MORE SPAN TO ACT LIKE a wing, the P-791 is three pressurized lobes joined together. An observer of the first flight says it was about the size of three Fuji blimps blended together. The Fuji blimp, a Skyship 600 model, is 200 ft. long. That suggests the P-791 would have a gross lift of roughly 3-5 tons.

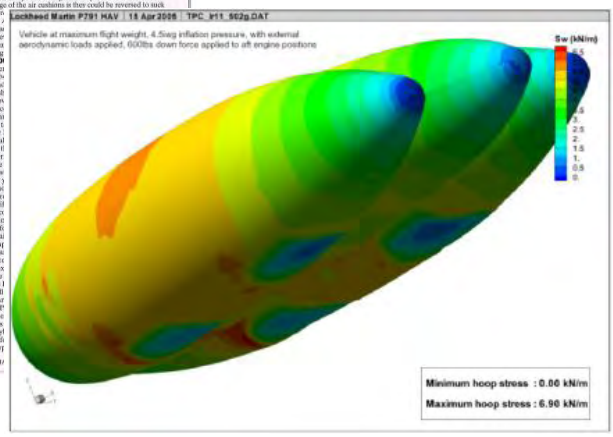
The observer saw the craft performing very tight 360-deg. turns while taxiing. It made a brief takeoff roll, climbed to a low altitude, made a few banks—including a long sweeping turn—then came back and landed. The landing approach had a nose-down body attitude that leveled for the flare. The flight was very smooth, the observer says. The craft was flown by P-791 Chief Test Pilot Eric P. Hansen.

The speed of the testbed was estimated at about 20 kt. A full-scale version would be able to go much faster, over 100 kt. Lockheed Martin has long proposed a large transport airship, at one time called the Aereocraft, which was halted around 2000 (AW&ST Feb. 22, 1999, p. 20). That design was about 800 ft. long and was to carry 1-1.2 million lb. at 125 kt. The Skunk Works was one of two contractors to receive one-year, $3-million Darpa contracts in August 2005 to study Walrus. The second Walrus phase would be a three-year demonstration effort.

Hybrid airships have a long history. The Aereon Corp. in New Jersey started experiments in the late 1950s, but they were small scale (see www.aereoncorp.com). The company tested the "dirhoid aerobody" shape, also called a flattoid pumpkinseed, with a 1,200-lb.-manned demonstrator in 1970-71. That was followed by several studies funded by the military at less than $1 million. In the U.K., the Advanced Technologies Group built a 40-ft.-long unmanned SkyKoncept hybrid airship and flew it in 2000 (AW&ST Sept. 25, 2002, p. 30). Nothing in the field has progressed to the size or apparent sophistication of the Skunk Works testbed.

The P-791 uses four air cushions as landing gear, located on the outer lobes. Taxiing the vehicle could be like flying a hovercraft, except one with greater exposure to winds. An advantage of the air cushions is they could be reversed to suck the air

Lockheed Martin's P-791 hybrid airship climbs out on its manned maiden flight from the Palmdale, Calif., airport last week. The company built the craft in secret and did not want publicity for the flight. Rear view on closeout shows triple-lobed wide shape that provides aerodynamic lift. One of the side-mounted propellers is visible at right. Before takeoff (top inset), the airship displays Skunk Works logo on vertical tail, and partners including TCOM on the side. Note dark structure at rear that transmits tail engine loads into the inflatable structure, and appears to be shaped to allow thrust vectoring. In a side aspect (middle inset), the fore and aft air cushion landing pads at the bottom of each outboard lobe are readily seen. One estimate of the size is roughly 300 ft. long. Front view on approach (bottom inset) shows nose-down angle to return to the ground, and reveals cockpit located under middle lobe.

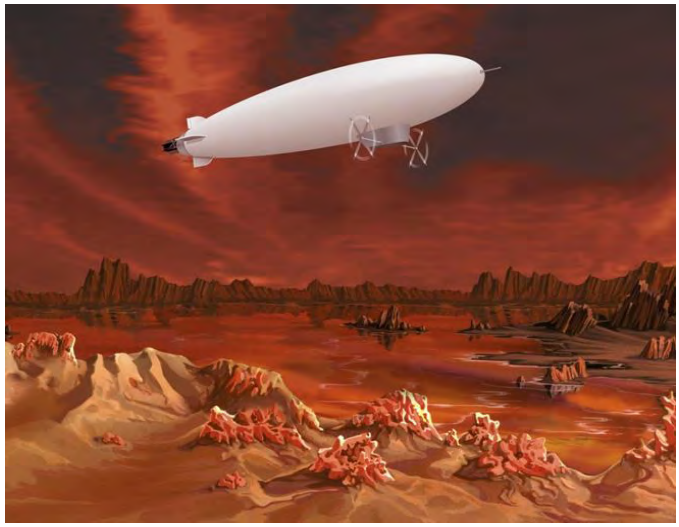


Shape Finding

Load Analysis

Patterning

Design Consultancy



NASA JPL : Titan Exploration Aerobots

Hybrid Air Vehicle : LEMV

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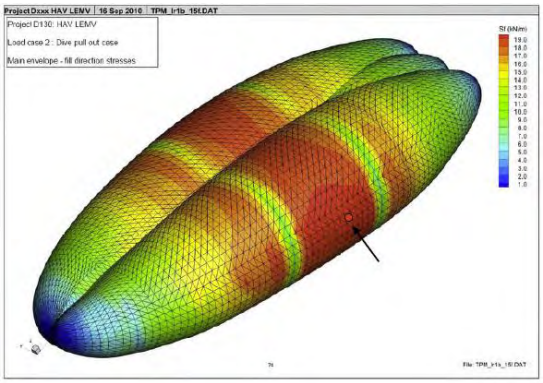

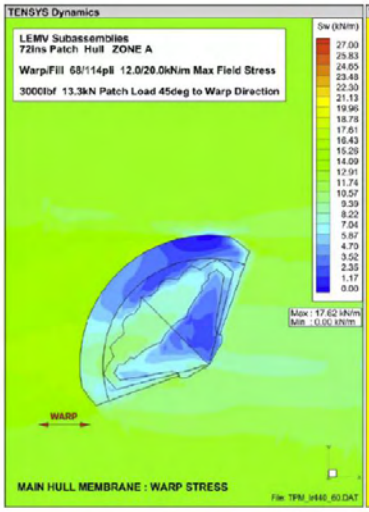

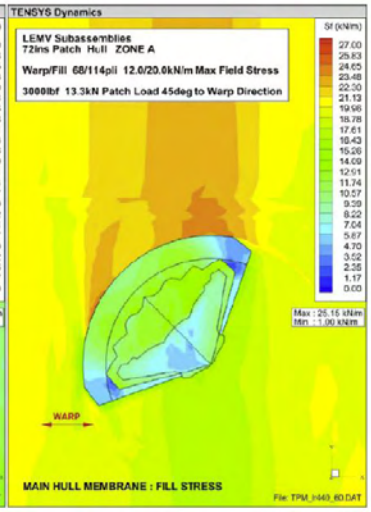

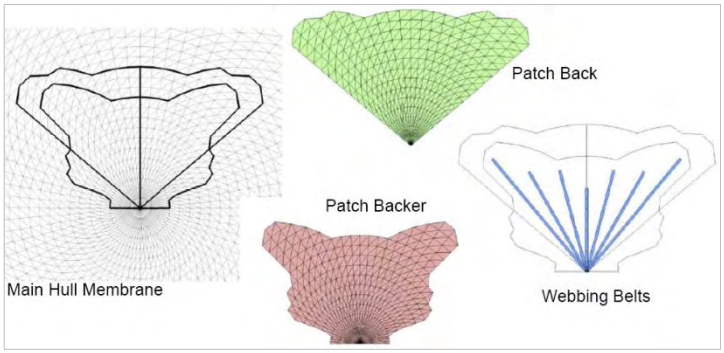

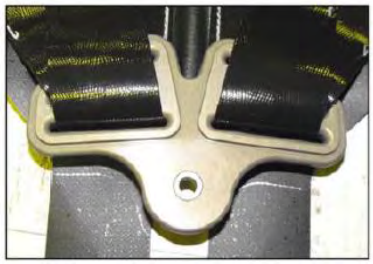

Detail Analysis

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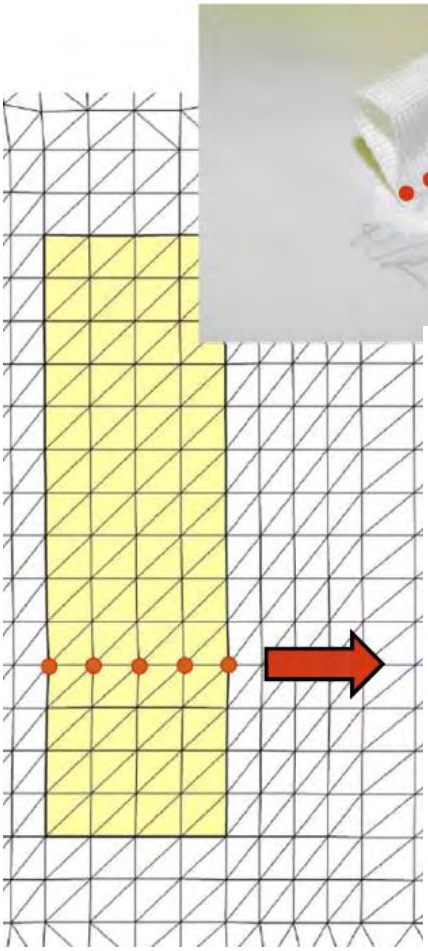

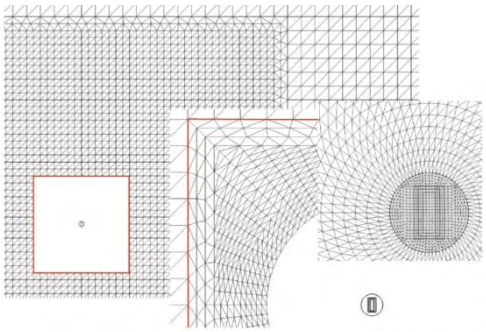

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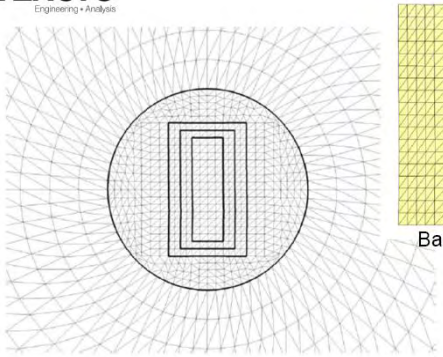
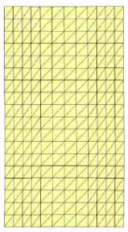
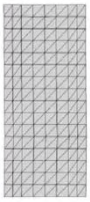
Model Build Up





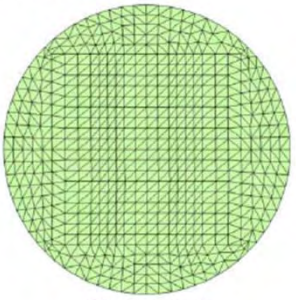
Backer



Reinforcement

Belt

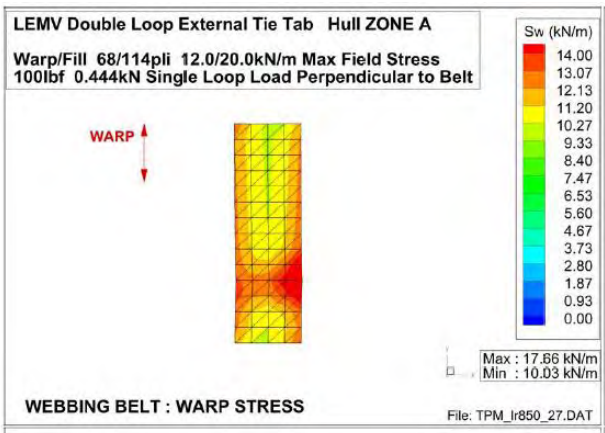
Main Hull Membrane

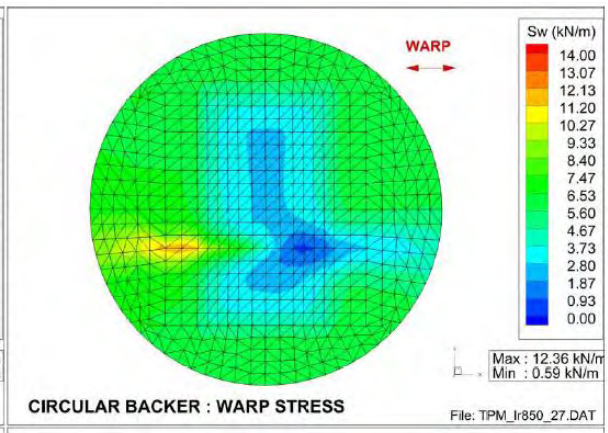


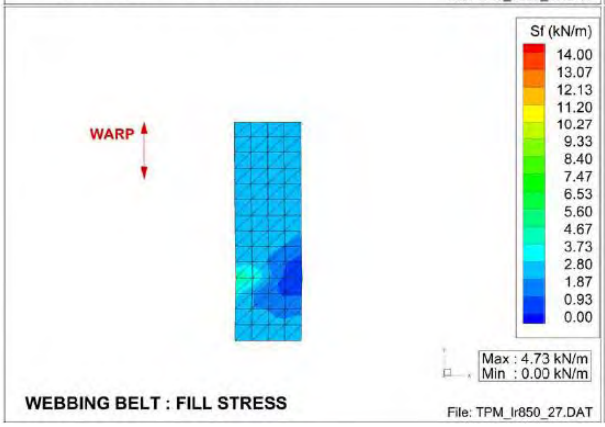
Circular Backer

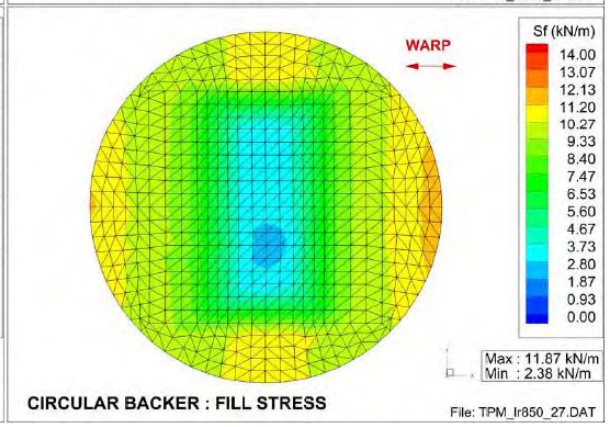
Separate triangular membrane elements are used for each material layer, connected with common nodes to model the composite nature of the construction.

The webbing belts are also represented by membrane elements.



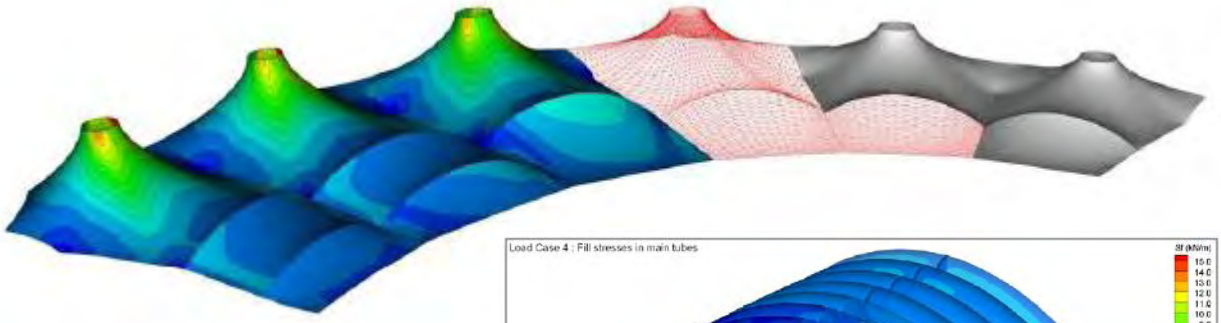


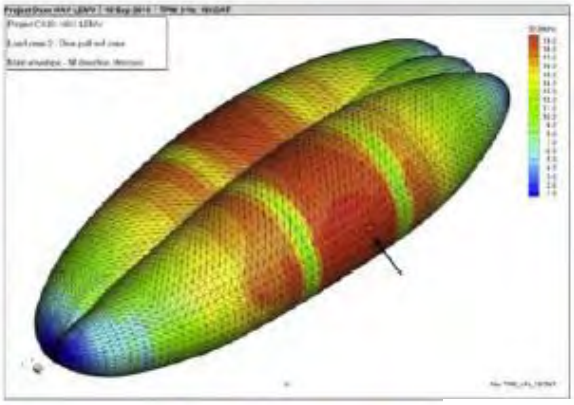


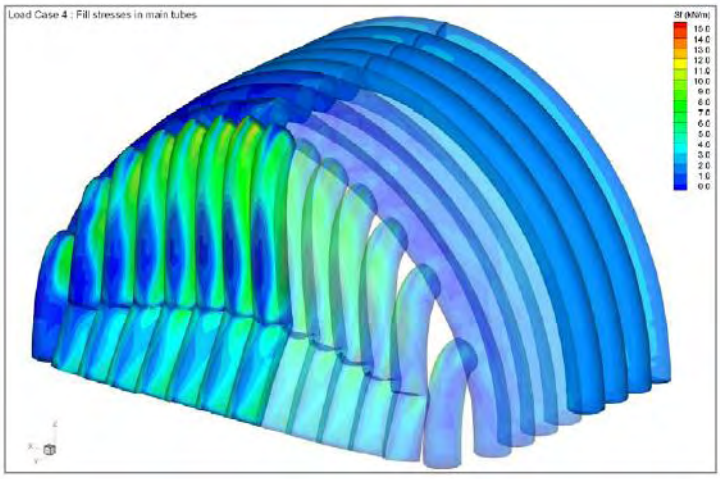


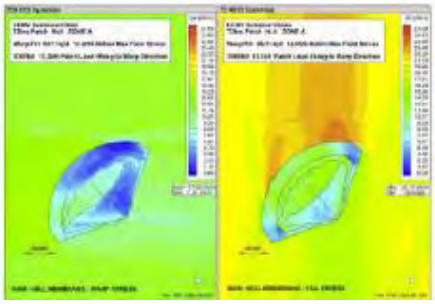
inTENS : Integrated Software for Tensile Structures Design

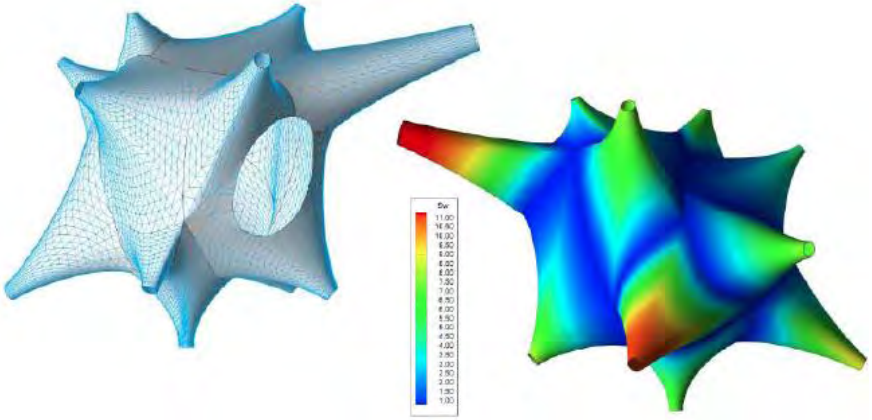
TENSYS
Engineering • Analysis

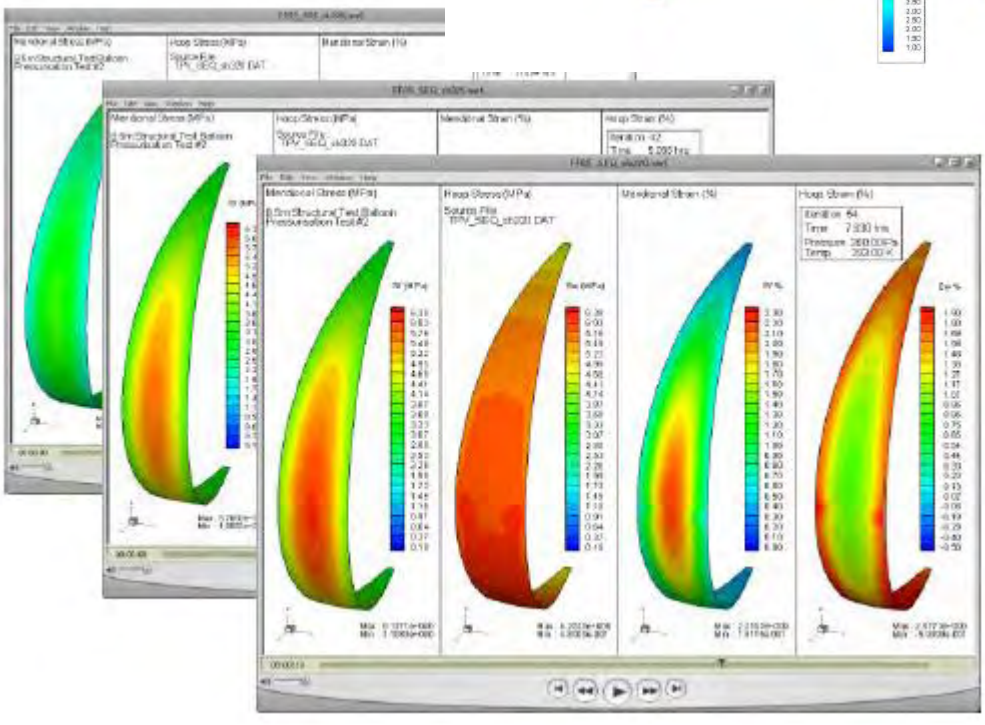






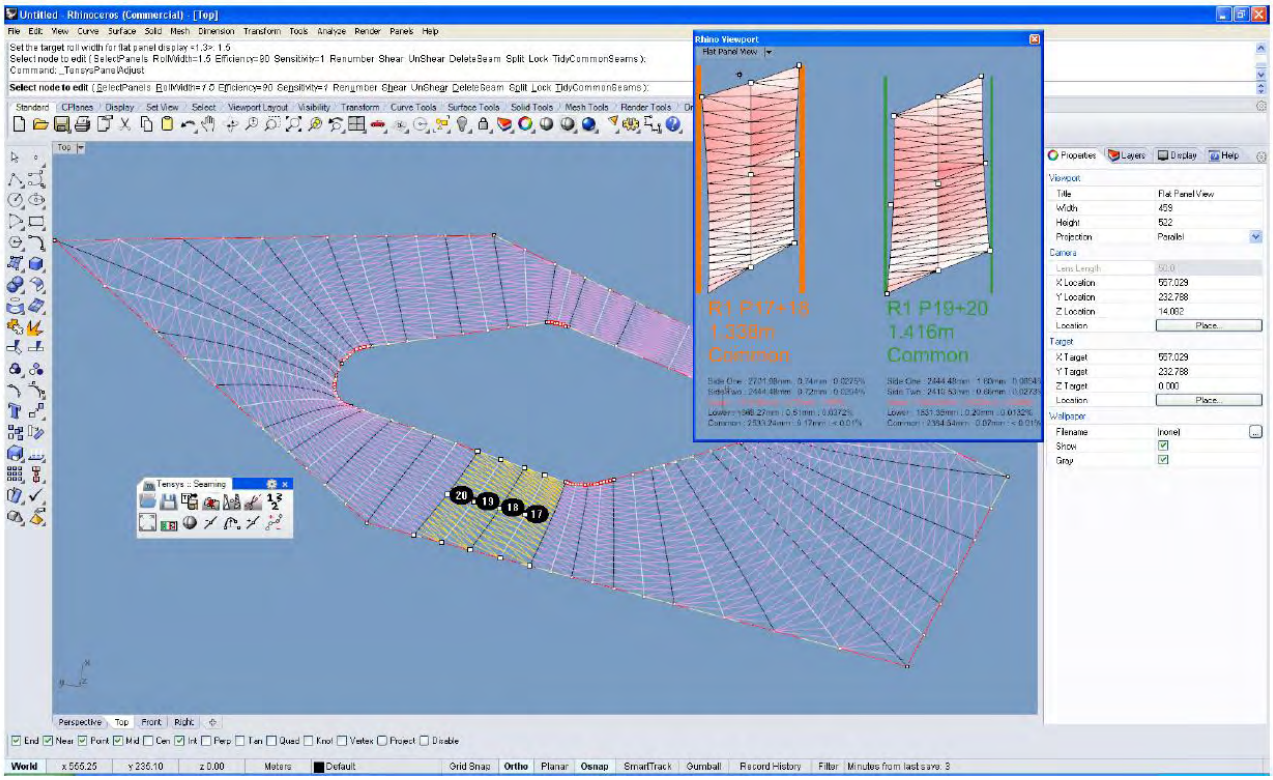




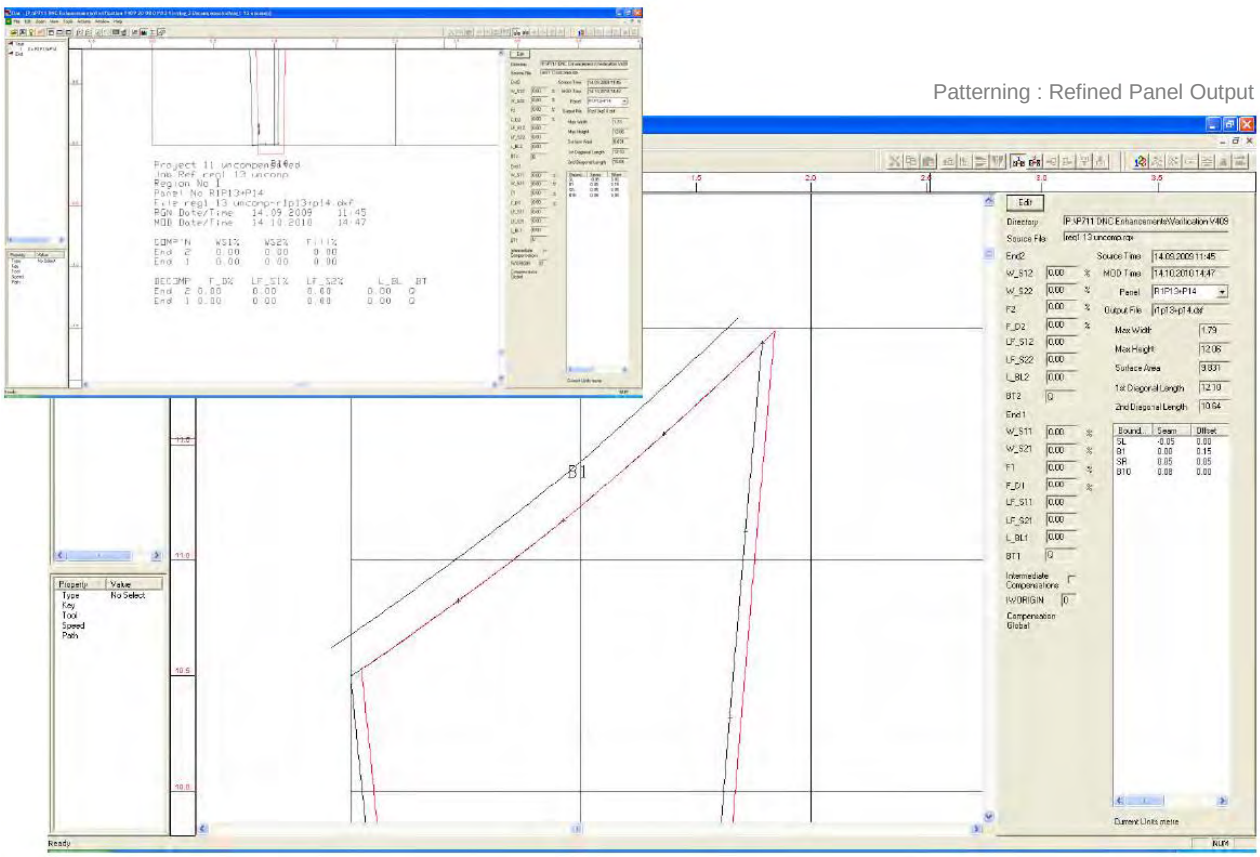


inTENS : Integrated Software for Tensile Structures Design

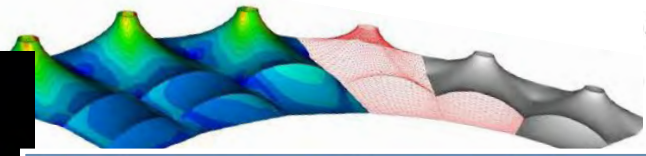
TENSYS
Engineering • Analysis



Patterning : Interactive Panel Width Adjustment



Patterning : Refined Panel Output



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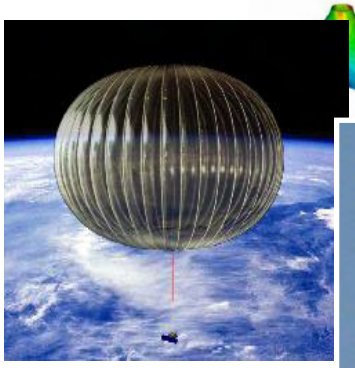
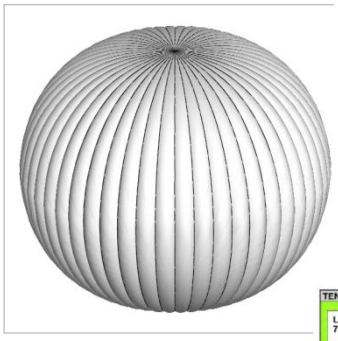
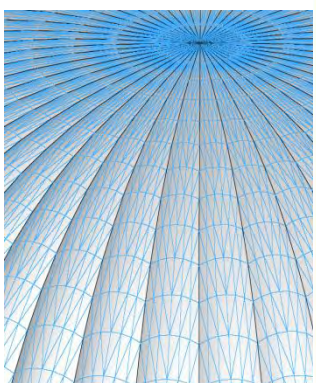
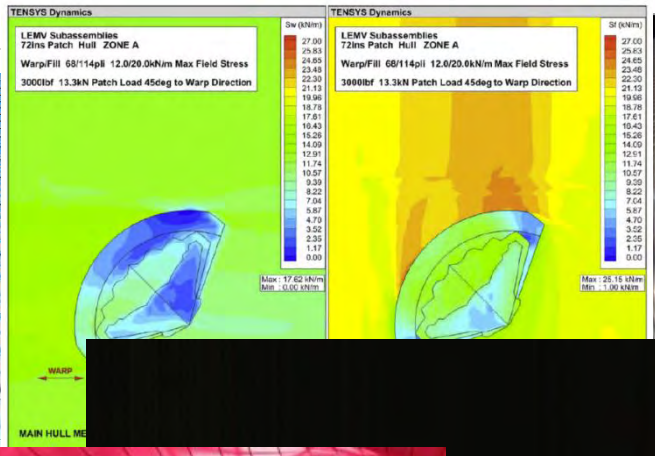
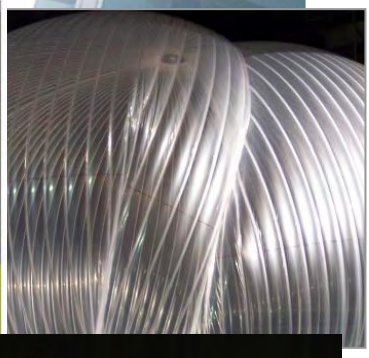
Engineering • Analysis

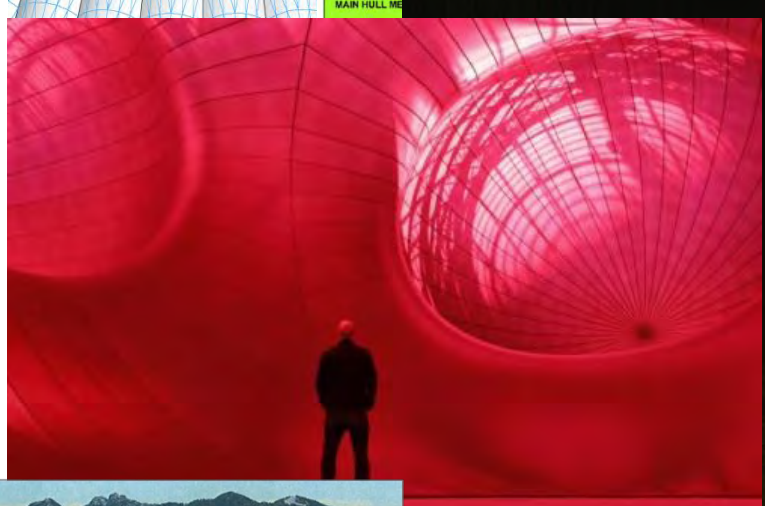


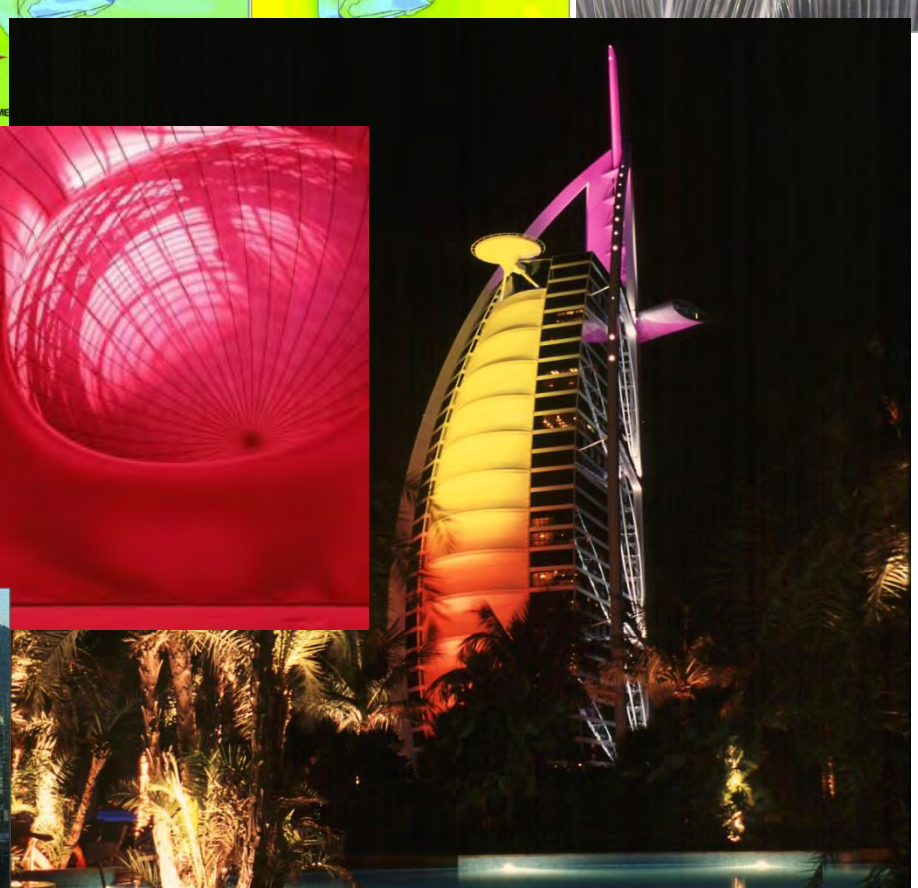












Company Profile

Tensys are structural engineering consultants providing specialist services for the design and construction of lightweight stressed membrane structures. We have offices in the historic city of Bath in the West of England, and in Melbourne, Australia.

These consultancy services are founded upon **inTENS**, our Integrated Tension Structures Design Software, which is under continuous development in-house. Our aim is to provide effective and practical solutions to geometric and non-linear analysis problems under the time and other pressures of real projects.

Tensys Consultants offers form-finding, load analysis, patterning and erection analysis support to Contractor and Consulting Engineer clients throughout the world. Over 2500 projects have been completed since Dr David Wakefield founded Tensys in 1990.

Current and recent projects include the Burj–al-Arab Hotel in Dubai, World Cup stadia in Korea and Germany, Commonwealth Games stadia in India and the New Bangkok International Airport. Projects with retractable roofs include the Centre Court at the AELTC Wimbledon, the National Stadium in Warsaw and the new roof for BC Place, Vancouver.

Tensys Dynamics is active in airship design and associated areas. Combining our established analysis capability with over 25 years of practical LTA industry experience enables us to offer full in-house capabilities for airship envelope design and overall project coordination. We are currently involved in development projects for several major aerospace corporations.

We are structural analysis consultants to the NASA scientific balloon program, undertaking numerical investigations of the stressing and geometric stability of their high-altitude super pressure balloon designs. Built hybrid airship projects include the Lockheed Martin P791 demonstrator and the Northrop Grumman LEMV.

Tensys Engineers operate from our offices in Melbourne, Australia. With many years of design experience from a tension structures contracting background, this team offers the full range of consultancy services from concept design, detail design and analysis, contract document preparation through to project management and contract supervision and control.

Their current workload includes major projects in Singapore, Indonesia and the Middle East.

With ISO9001 accreditation, we are committed to the highest quality of both work produced and relationships with our increasing client base world-wide.

Further details of our activities may be found on our website.

Tensys Ltd
1 St Swithins Yard
Walcot Street
Bath
BA1 5BG UK

T +44 1225 321950
F +44 1225 321969
E mail@tensys.com

W www.tensys.com

Contact:
David Wakefield

Tensys Engineers Pty Ltd
7/340 Gore Street
Fitzroy
Victoria 3065
Australia

T +61 3 9416 0066
F +61 3 9416 3766
E engineers@tensys.com

Contact:
Peter Lim

Dr David Wakefield
BSc PhD CEng MIStructE MIASS

Director, Tensys Limited

Nationality : British
Date of Birth : 31st August 1952

Education : Leeds Grammar School
City University, London — BSc Civil Engineering
PhD 'Dynamic Relaxation Analysis of Pretensioned Networks supported by Compression Arches'

Professional Affiliations : Member of Institution of Structural Engineers
Member of International Association of Shell and Spatial Structures
Associate Fellow of American Institute of Aeronautics and Astronautics

Experience :

1990- TENSYS LIMITED Bath, UK and Melbourne, Australia
Consulting Engineers specialising in the Analysis and Design of Lightweight Structures
Founder and Director:

Development of inTENS tensile structure design and analysis software suite.

Responsible for Analysis and Patterning of over 2000 Architectural Membrane Structure Projects including :

German National Pavilion, EXPO'92 Seville
Burj-al-Arab Hotel Facade, Dubai
Mina Tent Project, Mecca, Saudi Arabia
Daegu World Cup Stadium Korea
Hauptbahnhof Dresden
Incheon World Cup Stadium Korea
Second Bangkok International Airport
Olympic Stadium Berlin
Marsyas Sculpture Tate Modern London
Ascot Racecourse Grandstand Roof
AELTC Wimbledon Centre Court Retractable Roof
JNS and SPM Stadia Commonwealth Games 2010 Delhi
BC Place Stadium Roof Renewal Vancouver
National Stadium Warsaw

1998- TENSYS DYNAMICS LIMITED Bath, UK
Consulting Engineers specialising in the Analysis and Design of Lighter-than-Air Vehicles
Founder and Director:

Previous and current projects include:

CargoLifter Airship Project
Lockheed Martin Aerocraft
ATG SkyCat 20 Hybrid Air Vehicle Demonstrator
TCOM Aerostat Design Consultancy
Lockheed Martin P791 Manned Hybrid Air Vehicle Demonstrator
Lockheed Martin DARPA Walrus Project – Heavy Lift Vehicle Design Studies
NASA Super Pressure Balloon Program – Stress and Stability Analysis
NASA JPL – Design Studies for Autonomous Airship Exploration of Titan
Northrop Grumman LEMV Hybrid Air Vehicle

1978-1990 BURO HAPPOLD, CONSULTING ENGINEERS

Director of Computing :

Development of CAD techniques for analysis, design and fabrication of membrane and cable net structures. Supervision of application to over 100 tensile structure projects, including

Pier 6 Music Pavilion, Baltimore
Tsim Sha Tsui Cultural Centre, Hong Kong - inverted lattice shell
Royal Welsh National Eisteddfod - demountable theatre
Calgary Olympic Coliseum - proof engineering and erection analysis
Diplomatic Club, Riyadh - cable net and membrane structures
ADF Sports Complex, Jeddah
CFAN Gospel Tent, Africa - 12000sqm demountable structure
Isle of Wight Music Pavilion, Maryland
New York Philharmonic, Metropolitan Opera - Performance Facility
Imagination Ltd Headquarters, London - atrium roof enclosure

Site Engineer :

Florida National Pavilion, Jacksonville
Diplomatic Club, Riyadh

Expert Witness :

On behalf of owners of Minnesota Metrodome, Minneapolis

Minitec Limited:

Director of Buro Happold associated company, with responsibility for the development of tensile structures software and for international licensing and support in Australia and USA.

Dr David Wakefield BSc PhD CEng MIStructE
Director, Tensys Limited

Chartered Engineer
Member : Institution of Structural Engineers
Member : International Association of Shell and Spatial Structures
Associate Fellow : American Institute of Aeronautics and Astronautics

'Dynamic Relaxation Analysis of Pretensioned Networks with Flexible Boundaries'
IASS World Congress, Madrid, 1979

'Dynamic Relaxation Applied to Interactive Form Finding and Analysis of Air Supported Structures'
jointly with M.R.Barnes
I Struct E Conference on Air Supported Structures, Bristol, 1984

'Computer Aided Design, Analysis and Patterning of Fabric Structures'
International Conference on Architectural Fabric Structures, Orlando, 1984

'Reconstruction of the CFAN Mission Tent'
jointly with W.I.Liddell, M.J.Cook
International Conference on Lightweight Structures, Sydney, 1986

'The Development of an Integrated CAD System for Stressed Membrane Structures'
International Conference on Lightweight Structures, Sydney, 1986

'Inverted Latice Shell Roof, Tsim Sha Tsui Cultural Centre, Hong Kong : Design'
jointly with T.A.Ealey, P.Kelly
International Conference on Non-Linear Structures, London, 1987

'Practical Numerical Modelling of Complex Structures'
International Conference on Non-Linear Structures, London, 1987

'Form Finding, Analysis and Patterning of Surface Stressed Structures'
jointly with M.R.Barnes
I Struct E Oleg Kerensky Memorial Conference, London, 1988

'Interactive Graphic CAD for Tension Structures'
jointly with M.R.Barnes, C.F.Ong
International Conference on Civil and Structural Engineering Computing, London, 1989

'Membrane Engineering : The Role of the Specialist Engineer in the Design and Construction Process'
Techtextil, Frankfurt, 1995

'Membrane Engineering : Principles and Applications'
IASS Asia-Pacific Conference on Shell and Spatial Structures, Beijing, 1996

‘Membrane Engineering : Current Project Examples’
IASS International Symposium on Shell and Spatial Structures, Singapore, 1997

‘Numerical Modelling in Tension Structure Design and Construction’
LSA98 : Lightweight Structures in Architecture, Engineering and Construction, Sydney, 1998

‘Engineering Analysis of Tension Structures : Theory and Practice’
Engineering Structures, Special Issue - Tension Structures, Volume 21 Number 8 Aug 1999

‘Computer Aided Design of Tensile Structures’
TechTextil North America : Architectural Applications in Technical Textiles, Atlanta, 2000

‘Structures, Cladding and Airships – Some Recent Inflatable Membrane Projects’
Membranes ’03 : Textiles Composites and Inflatable Structures, Barcelona 2003

‘Marsyas – A Large Fabric Sculpture : Construction Engineering and Installation’
jointly with A Bown
Membranes ’03 : Textiles Composites and Inflatable Structures, Barcelona 2003

‘Numerical Modelling of Pumpkin Balloon Instability’
COSPAR International Conference on Space Research, Paris 2004

‘Numerical Modelling of Pumpkin Balloon Instability’
AIAA 16th Lighter-Than-Air Systems Technology Conference and Balloon Systems Conference, Arlington VA, September 2005

‘Nonlinear Analysis and the Design of Pumpkin Balloons: Stress, Stability and Viscoelasticity’
jointly with JL Rand
COSPAR International Conference on Space Research, Beijing 2006

‘Numerical Investigations of Pumpkin Balloon Deployment Stability’
AIAA 19th Aerodynamic Systems Systems Technology Conference and Balloon Systems Conference, Williamsburg VA, May 2007

‘Inflatable Membrane Structures in Architecture and Aerospace – Some Recent Projects’
Membranes ’07 : Textiles Composites and Inflatable Structures, Barcelona 2007

‘Numerical Investigations of Pumpkin Balloon Deployment Stability’
COSPAR International Conference on Space Research, Montreal 2008

‘Non-Linear Viscoelastic Analysis and the Design of Super-Pressure Balloons: Stress, Strain and Stability’
AIAA Balloon Systems Conference, Seattle 2009

‘Structures, Cladding and Airships – Some Recent Inflatable Membrane Projects’
Membranes ’09 : Textiles Composites and Inflatable Structures, Stuttgart 2009

‘Non-Linear Analysis of the NASA Super Pressure Balloons: Some Detailed Investigations of Recent Antarctic Flight Balloons’
AIAA Balloon Systems Conference, Virginia Beach VA, September 2011

‘Inflatable Membrane Structures in Architecture and Aerospace: some Recent Projects’
jointly with Adam Bown’
IASS International Symposium ‘From Spatial Structures to Space Structures’, Seoul, May 2012

‘Non-Linear Analysis of the NASA Super Pressure Balloons: Refined Modelling
jointly with Adam Bown’
AIAA Balloon Systems Conference, Daytona Beach FL, March 2013-04-02

Nick Gibson
BSc DipEng

Director, Tensys Limited

Nationality : British
Date of Birth : 2nd April 1962

Education : Kirkham Grammar School
Southampton University — BSc Civil Engineering
Diploma of Engineering

Experience :

1995- TENSYS LIMITED Bath, UK and Melbourne, Australia
Director:

Responsible for Form and Stress Engineering and Patterning of a variety of Membrane Structure Projects including :

Swindon Parade
Lego Park, Windsor
Julie Rose Grandstand, Ashford
Mid-Kent Radiotherapy Centre
Munich Airport Centre
Toll Gate, Japan
Burj-al-Arab Hotel Facade, Dubai
Yapi Kredi Bank, Turkey
Saga Amenity Building, Folkestone
Mina Tent Project, Mecca, Saudi Arabia
Tour de France Podium
Butlins Skyline Pavilions
Spirit Zone, Dome, London
National Space Centre, UK
Ascot Racecourse Grandstand Roof, UK
Goyang Stadium, Korea
Hauptbahnhof, Dresden
Olympic Stadium, Berlin
AELTCC Wimbledon Centre Court Retractable Roof
BUGA 2005 Federal Garden Show Pavilions, Munich
Street and Riverfront Canopies Clarke Quay, Singapore
Queen Mary School of Medicine and Dentistry – Spikey Pod, London
Sharm El-Sheikh Airport, Egypt
Temenos Sculpture, Middlesborough
National Warsaw Stadium
JNS and SPM Stadia Commonwealth Games 2010 Dehli
BC Place Replacement Retractable Roof
2012 London Olympic Stadium Wrap

1989-1995 APEX STORAGE SYSTEMS LTD

Design Office Manager:

Responsible for technical support to sales/estimating and design of numerous highbay warehouses and racking systems.
Product development from concept through to launch, including development and documentation of technical specifications.
Implementation of CAD and structural analysis systems within the Engineering department.
Development of computer based design suite for determination of storage system configurations.

1985-1989 OVE ARUP AND PARTNERS, CONSULTING ENGINEERS

Engineer:

Assisted in development of FEA based soil/structure interaction analysis system and subsequent analysis of silo/raft systems.

Structural design of tubular steel atrium structure, turn of the century department store refurbishment and site supervision experience of office development in Central London.

Peter Lim
BE (Civil) MEngSc MBA CEng MIEAust

Director, Tensys Engineers

Education : Melbourne University BE (Civil)
University of New South Wales MEngSc
Melbourne University MBA

Professional Affiliations : Member of Institution of Engineers Australia
Member of American Society of Civil Engineers
Member of International Association of Shell and Spatial Structures
Vice President Lightweight Structures Association of Australasia

Experience :

2002- TENSYS ENGINEERS PTY LTD
Director
Project development, management and design

Projects involved include

Second Bangkok International Airport, Bangkok Thailand
Goyang Stadium, Seoul Korea
Tampines Mall, Singapore
Clementi Pedestrian Bridge, Singapore
Infineon Asia Pacific Headquarters, Singapore
Melbourne Central Refurbishment, Melbourne Australia
Medan Selera Putrajaya Precinct 9, Putrajaya Malaysia
Granville Swimming Pool, Paramatta Australia
Waterfront City Tension Structures, Melbourne Australia
Hsinchu Amphitheatre, Hsinchu Taiwan
BP Solar Icon Structure, Shenzhen China
Istana Kuta Galeria Shopping Centre, Bali Indonesia
Republic Polytechnic University, Singapore
Clarke Quay Riverfront Canopy, Singapore
Clarke Quay Streetscape Canopy, Singapore
Al Manshar Shopping Centre, Kuwait City
Melbourne Docklands Icon, Australia
RAS Pavilion Structure, Melbourne Australia

1999-2001 SKYSPAN (PACIFIC) PTY LTD
Director
Project development, management and design

Projects involved include

Rockwell Tennis Court Roof, Manila Philippines
Eunos Amphitheatre, Singapore
MPSJ Medan Selera, Food Court, Kuala Lumpur
Yomaguichi Coal Cover, Japan – 34,000sqm
NgeeAnn Polytechnic, Singapore
Sunway Pyramid Oasis Walkways, Kuala Lumpur Malaysia
GE India, Bangalore India
United Square Building Refurbishmnet, Singapore
Cathay Pacific Sails, Hong Kong

Taman Maluri Hawker Centre, Kuala Lumpur
EcoCentre, Scottsdale, Tasmania
Aspley Shopping Centre (9,000sqm) CarPark, Brisbane Australia
Palms Country Club Tennis Court roof, Manila Philippines
Booval Shopping Centre (8,000 sqm) CarParks, Brisbane Australia
Pattaya Aquarium, Bangkok Thailand
Yam O MTRC Station, Hong Kong
Kuwait Marina Cable Structure
Sydney Aquarium Animal Enclosure Cable Net

1988 – 1999 SPACETECH PTY LTD
(Lightweight Structures Design/Construct Company)
Director (since 1990)

Project development, management, design and R&D

Projects involvement include:

Moonee Valley Racecourse 'The Silks ' Bar, Melbourne Australia
Shell West Gate Bridge Structures, Melbourne Australia
Penguin Parade, Philip Island Australia
Sea & Island Expo Hiroshima 1989, Hiroshima Japan
Keysborough Gold Club, Melbourne Australia
Pavilion Hotel Atrium, Canberra Australia
Eltham Leisure Centre, Melbourne Australia
BMW Australia corporate demountable structure, Australia
Ivanhoe Girls Grammar School Arthouse, Melbourne Australia
Lake Macquarie Council demountable stage, Australia
Signal Processing Research Institute Atrium, Adelaide Australia
VATC Caulfield Betting Ring Arena, Melbourne Australia
Central Park Development Space Frame, Perth Australia
Aquashell floating stage structure, Sydney Australia
Kuching Waterfront, Kuching Malaysia
Victoria Market Food Court, Melbourne Australia
Bridge View Hotel Space Frame, Bangkok Thailand
Esso Headquarters, Melbourne Australia
Dandenong Market, Melbourne Australia
Melbourne Tennis Centre, Melbourne Australia
Spastic Special School , Hong Kong
Forrest Centre Space Frame, Perth Australia
Thai Farmer Bank Amphitheatre, Bangkok Thailand
Central Chidlom Shopping Centre Atrium, Bangkok Thailand
Eyton on Yarra Winery Amphitheatre, Melbourne Australia
Citrus Café, Kuala Lumpur Malaysia
IT Entrance structure, Kulim, Malaysia
Ho Man Tin Spectator Stand, Hong Kong
Singapore Turf Club Parade Ring, Singapore
Hakurrahurra Resort, Maldives
Shatin Park Amphitheatre, Hong Kong

1989 - 1999 SLIDE A WAY SYSTEMS PTY LTD
(Manufacturing and fabrication company)
Director
Management and design

1986 – 1988 MARJON DEVELOPMENTS PTY LTD
Design Engineer & Project Manager

Adam Bown
BEng
Director, Tensys Ltd.

Nationality : British

Date of Birth : 12th January 1972

Education : University of Aston, Birmingham – BEng Civil Engineering
New College, Swindon (A-levels), Kingsdown Comprehensive, Swindon

Experience :

June 1998 - TENSYS LIMITED Bath, UK and Melbourne, Australia
Director

Responsible for form finding, stress engineering and patterning of a variety of architectural fabric structures, sculptures and lighter than air vehicles:

Architectural structures:

- BC Place Stadium Roof, Vancouver, Canada.
- SPM Swimming stadium, Delhi, India
- Munich Olympic Hall, Munich Germany
- M11 Monument, Madrid, Spain. Inflated ETFE sculpture
- Second Bangkok International Airport, Bangkok, Thailand
- Waldstadion Frankfurt, Frankfurt, Germany
- Munich International Swimming Pool, Munich, Germany

Fabric sculptures (by artist Anish Kapoor):

- 'Ark Nova' - Japan
- 'Leviathan' - Grand Palais, Paris
- 'Marsyas' in the Turbine Hall of the Tate Modern, London
- 'Melancholia' at the Grand Hornu Museum, Belgium
- 'Membrane sculpture' at Brescia, Italy.

Lighter than air vehicles:

- Analysis support to ongoing program of design and development for medium sized high altitude pressurized communication balloons.
- Ongoing analysis and investigation work to support NASA's ULDB high altitude, long duration, super pressure balloon program.
- Fabrication and stress analysis for Hybrid Air Vehicles 'LEMV'.
- Fabrication and stress analysis work on the Lockheed Martin's P791 half tonne hybrid air vehicle demonstrator.
- Stress analysis work on Lockheed Martins' P794 hybrid air vehicle
- Static calibration analysis of the ACLS Ltd 1:4 scale air cushion landing system model.
- Analysis to support the US governments DARAP Walrus program to develop a hybrid air vehicle.

Other : Quality Manager, responsible for the implementation and maintenance of the Company Quality Management System

July 1994 to June 1998 - Site Engineer working for Tilbury Douglas Construction Ltd and Gleeson Ltd on a variety of large civil engineering projects around the UK.

Stadia and Sports Facilities

AELTC Indoor Courts Wimbledon
Don Valley Athletic Stadium Sheffield
Grandstand Roof Misano Italy
Birkenhead Cricket Club Pavilion
Gottlieb Daimler Stadium Stuttgart Analysis Verification
National Hockey Stadium Milton Keynes
Olympic Club Barcelona
Amenity Building New Inland Revenue Centre Nottingham
Retractable Roof Gary Weber Tennis Centre Halle
Yacht Club Nansei Japan
Hurlingham Covered Tennis Courts
Daegu World Cup Stadium Korea
Rothenbaum Stadium Hamburg
Goyang Stadium Korea
UNIDome Replacement Roof USA
Millennium Stadium Cardiff Installation Analysis
Olympic Stadium Montreal Investigation of Failure
Hampshire County Cricket Club
Kuwait Stadium
Waldstadion Frankfurt
Busan World Cup Stadium Korea
Faro Stadium Portugal
Da Kwan Basketball Stadium Taiwan
Incheon World Cup Stadium Korea
Stadium Abuja Nigeria
Olympic Stadium Berlin
Huaibei Stadium China
Beckham Football Centre London
Ascot Racecourse Grandstand Roof
AELTC Wimbledon Centre Court Retractable Roof
Khalifa Sports City Feasiblity Study, UAE
Mound Stand Lords Cricket Ground London
UK National Tennis Centre Roehampton
Munich Olympic Swimming Pool
Jawaharlal Nehru Main Stadium Commonwealth Games Delhi
Swimming Stadium Commonwealth Games Delhi
Weightlifting & Wrestling Stadia Commonwealth Games Delhi
Skilled Stadium Queensland Australia
BC Place Stadium Vancouver
F1 Grandstands Yas Island Abu Dhabi
Scotstoun Stadium Scotland
Durban World Cup Stadium South Africa
Green Point Stadium Cape Town South Africa
National Stadium Warsaw
Pune Cricket Stadium India
Chepaul Cricket Stadium Chennai India
Carrara Stadium Queensland Australia

Expositions and Exhibitions

Expo'92 Seville German National Pavilion
Oleada and Diadema Entrance Structures
Singapore National Pavilion
Heuereka Swiss National Science Exhibition Zurich
Ebbw Vale Garden Festival
Press Centre World Economic Summit Munich
Exhibition Halls Munich Exhibition Grounds
Expo'93 Taejon S Korea German National Pavilion
Exhibition Stands BMW Reuters BNFL Philips Peugeot
Thai Farmers Bank Viglen Ford Audi
GCC Conference Centre Kuwait
Philips Pavilion Bavaria Film Park
BMW Pavilion IAA'95 Frankfurt
BMW Clear Energy Pavilion
EXPO 2000 Hanover Hermes Umbrellas and Expo Walkway
BUGA 2005 Federal Garden Show Munich Pavilions and Flower Halls
Royal Agricultural Showground Pavilion Melbourne
Excel Exhibition Centre London
Qatar exhibition Canopy

Entrances Walkways and Shade Structures

Expo'92 Seville European Avenidas
Royal Chelsea and Westminster Hospital
Walkway Canopies Dusseldorf Airport
Botanischer Garten Graz Austria
Mid-Kent Radiotherapy Centre
Lampstandards Esch Luxembourg
Train Station Euro Disney Paris
Shade Structures Port Canaveral Florida
Entrance Canopies Glyndebourne Opera House
27 Broadley Terrace
J Sainsbury Marsh Mills Plymouth
Lords Hill Southampton
Hilton Beach Club Dubai
The Piazza Huddersfield
Bradford Transport Interchange
Millennium Piazza Greenwich
Union Square Torquay
Millennium Wheel Pier
Clementi Bridge Singapore
Street and Riverfront Canopies Clarke Quay Singapore

Leisure and Recreation Facilities

Rhyl Leisure Centre
Bristol Zoo Restaurant Tent
Colombo 500 Genoa
Retractable Roof Garsington Manor Opera
Radolfzell Gymnasium
EPCOT Centre Future World
Buckingham Palace Ticket Office
Lego Park Windsor Circus Tent Music Tent Puppet Show
Raubtierhaus Munich Zoo
Edo Museum Tokyo
Madagaskarhalle Zurich Zoo
Dolphinarium and Elephant House Duisburg Zoo
Royal Armouries Museum Leeds
Le Coco Beach Hotel Mauritius
Tak On Park Hong Kong
Schildkroetenhaus Munich Zoo
Swimming Bath Miramar Germany
SAGA Amenity Building UK
Warmbad Prien
Lei Yue Mun Museum Hong Kong
Krajil Racecourse Singapore
Tour de France Podium
Butlins Skyline Pavilions Bognor Regis Minehead Skegness
Bisley Clay Shooting Ranges
Villa Arena Madrid
Chene Park Detroit
National Space Centre UK
Al Ain Celebration Wedding Halls, UAE
Putrajaya Swimming Pool Malaysia
Alnwick Gardens Visitor Centre

Theatre and Performance Structures

International Eisteddfod Llangollen
Retractable Theatre Roof Wiltz Luxembourg
Rainbow Theatre Ebbw Vale Garden Festival
Entrance Tents Pier 6 Performance Facility Baltimore
Loro Parque Theatre Tenerife
Eilat Creative Arts Centre Israel
Stage Structures Michael Jackson Pink Floyd
Paul McCartney Rolling Stones
Shakespeare Theatre Stamford
Buddy Holly Theatre Hamburg
Spirit Zone Millennium Dome London
Nautica Performance Shell USA
Marsyas Sculpture Tate Modern London
Glyndebourne Opera Stage Set UK
Anish Kapoor Sculptures – Belgium and Italy
Stage Cover Oberammergau
Temenos Sculpture Gateshead UK
Leviathan Sculpture by Anish Kapoor Paris

Commercial and Industrial Applications

Herford Air-Supported Structures Toxic Waste Treatment
Docklands Bridges and Landing Stage
Health Clinic Masserberg
Swindon Covered Markets
Stratford Bus Station
New Inland Revenue Centre Nottingham
Swindon Parade
Water Treatment Plant Emscher
Stairwell Roofs BHS Cambridge and Solihull
Atrium Roof City Square Leeds
Renault Darlaston
Burj al Arab Hotel Atrium Wall Dubai
Yapi Kredi Bank Turkey
Dearne Valey College
Dun Laoghaire Ferry Terminal
Hospital Entrance Gaza
Munich Airport Centre
Amt für Abfallwirtscaft Munich
Retail Development Ashford
DBU Osnabruck Germany
Rathaus Vienna
Vodafone Headquarters UK
Hauptbahnhof Dresden
JR Shinjuku Station Tokyo
Okinawa Floating Pier Japan
Tampines Mall Singapore
Second Bangkok International Airport
Jiangxi Airport China
Sharm el Sheikh Airport Egypt
Damman Shopping Mall Saudi Arabia
Whitecity Retail Development
Industrial Gasholders

Airships and Balloons

CargoLifter 'Joey' Prototype
CargoLifter CL160 Heavy Lift Airship Prototype 1
ATG SkyCat Development Studies
TCOM Aerostat Consultancy
NASA Super Pressure Balloon Program
NASA JPL Titan Aerobot Consultancy
Lockheed Martin P791 Hybrid Air Vehicle Demonstrator
Lockheed Martin DARPA/WALRUS Consultancy
Northrop Grumman LEMV Hybrid Air Vehicle
BD2 Airship
Delhi Commonwealth Games Aerostat Design Review
Lockheed Martin SkyTug Hybrid air Vehicle

Architects and Artists

Anish Kapoor
Darryl Jackson Architects
Foster & Partners
Idea Image Institute
Michael Hopkins and Partners
Peddle Thorp Architects
Populous – Brisbane
SMC Alsop Architects
Sparch Architects

Consulting Engineers

Arup
Atkins
Bonacci Group
Buro Happold
Cardno Grogan Richards
Curtins Consulting
David Dexter Associates
Dewhurst Macfarlane
Mott Macdonald
Ramboll
Schlaich Bergermann
SKM
TY Ho

End Clients

Stadium Queensland
Department of Major Projects Queensland
University of Melbourne
Australian National University
Catholic University of Australia

General Contractors

Brookfield Multiplex
Fudo Construction
Galliford Try
Odebrecht
Probuild Constructions (including Contexx)
Shapoorji Pallonji
WATPAC

Specialist Contractors

Al Mirkaz
Architen Landrell
Base Structures
Birdair
Hardco
Hightex
Metalex
Obeikan Tension Structures
SEPA
Taiyo Europe
Taiyo Membrane Corporation – Australia
Taiyo Membrane Corporation – Middle East
Tiger Corporation
USA Shade
Velatex

Aerospace

Airship Technologies Group
Airships do Brasil
CargoLifter
Hybrid Air Vehicles
ILC Dover
Lockheed Martin
NASA Balloon Program
NASA JPL
Raven Aerostar
TCOM

Certificate of Registration

QUALITY MANAGEMENT SYSTEM - ISO 9001:2008

This is to certify that:

Tensys Limited
1 St Swithins Yard
Walcot Street
Bath
BA1 5BG
United Kingdom

Holds Certificate No: **FS 59559**

and operates a Quality Management System which complies with the requirements of ISO 9001:2008 for the following scope:

The design, development and numerical analysis of tensile structures.

For and on behalf of BSI:

Chair, Certification Body Management Committee.

Originally registered: **13/07/2001** Latest Issue: **22/12/2011** Expiry Date: **22/12/2014**

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This certificate was issued electronically and remains the property of BSI and is bound by the conditions of contract.
An electronic certificate can be authenticated online.
Printed copies can be validated at www.bsigroup.com/ClientDirectory

The British Standards Institution is incorporated by Royal Charter.
BSI (UK) Headquarters: Kitemark Court, Davy Avenue, Knowlhill, Milton Keynes MK5 8PP. Tel: 0845 080 9000

CERTIFICATE OF INCORPORATION

OF A PRIVATE LIMITED COMPANY

Company No. 4064405

The Registrar of Companies for England and Wales hereby certifies that

TENSYS CONSULTANTS LIMITED

is this day incorporated under the Companies Act 1985 as a private company and that the company is limited.

Given at Companies House, Cardiff, the 4th September 2000

REGISTRAR OF COMPANIES FOR ENGLAND AND WALES

THE OFFICIAL SEAL OF THE REGISTRAR OF COMPANIES

COMPANIES HOUSE

HC007A

CERTIFICATE OF INCORPORATION

OF A PRIVATE LIMITED COMPANY

Company No. 4064510

The Registrar of Companies for England and Wales hereby certifies that

TENSYS DYNAMICS LIMITED

is this day incorporated under the Companies Act 1985 as a private company and that the company is limited.

Given at Companies House, Cardiff, the 4th September 2000

REGISTRAR OF COMPANIES FOR ENGLAND AND WALES

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