Optimising optical component performance

The significance of opto-mechanical design

or

Why the wrong opto-mechanical design can ruin your day

John Oliver
Glyndwr Innovations Ltd

glyndŵr INNOVATIONS

What do we do?

Services

- Ultra-precision optical engineering
- Design & manufacturing consultancy
- Customised one offs
  - Components or Sub-systems

Located at:

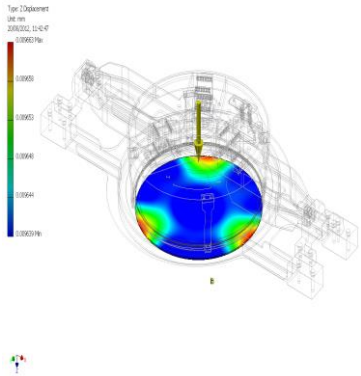
The OpTIC Centre
St Asaph, North Wales

glyndŵr INNOVATIONS

Precision Engineering

Design

- Analytical sciences instrumentation sub-systems
- Opto-mechanical and opto-electronic systems
- Precision actuation systems;
- High performance components



Assembly/Integration/Test

- opto-mechanical components
- assembly of sub-systems

glyndŵr INNOVATIONS

Trends

1. Increasing demand for larger optics
2. More complex optics
3. Improve quality: reduce wavefront error
4. CNC “super polishing "processes

glyndŵr INNOVATIONS

Historically

1. Make sure the optical surface is a precise as possible
2. Make sure the optical surface is a precise as possible
3. Make sure the optical surface is a precise as possible

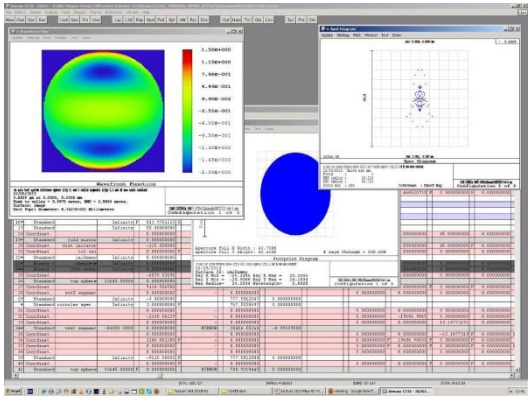
But that's not all the story…how you **mount** it effects performance

glyndŵr INNOVATIONS

Optomechanical system design

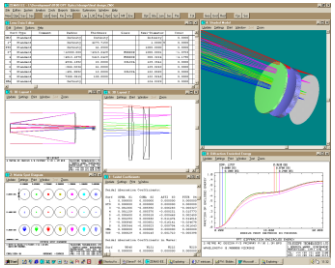
- Ensure final assembly is to the correct tolerances
- Must maintain correct tolerances under
  a. environmental change (e.g. temperature, humidity)
  b. load

  Process: combination of subjective techniques + computer-based methods

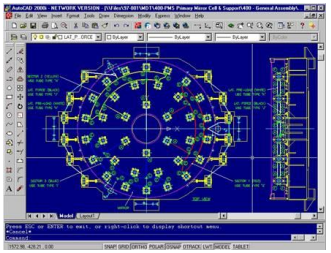


glyndŵr
INNOVATIONS

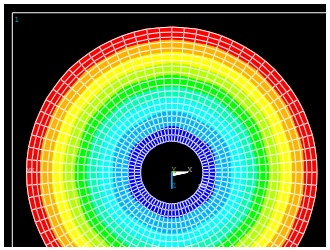
Design Process



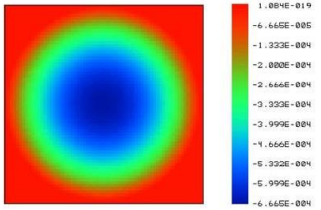
Optical Design
(Zemax)



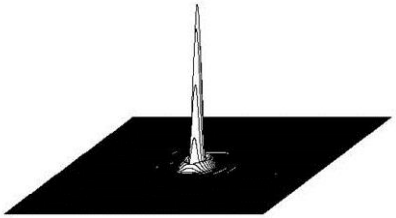
Design support system



FE analysis



Insert deformation of
mirror profile into optical design software



Assess optical performance

glyndŵr
INNOVATIONS

Opto-mechanical design process:

- **Principle:**
  Support optic around its CoG to minimise bending forces
- **Only a tool**
- **Iterative process**
- **Still an art**
- **Most valuable for larger mirrors & lenses**
  less so for beamsplitters/prisms etc

Not new……just not always fully appreciated!

glyndŵr INNOVATIONS

Key variables that can changed

Size ✔

Mass (mirrors) ✔

Where & how to support? ✔ ✔ ✔

glyndŵr INNOVATIONS

Where & how to support the optic?

Main support options:

- Fixed
- Wiffle tree
- Astatic

Points of contact

The case for flexures?

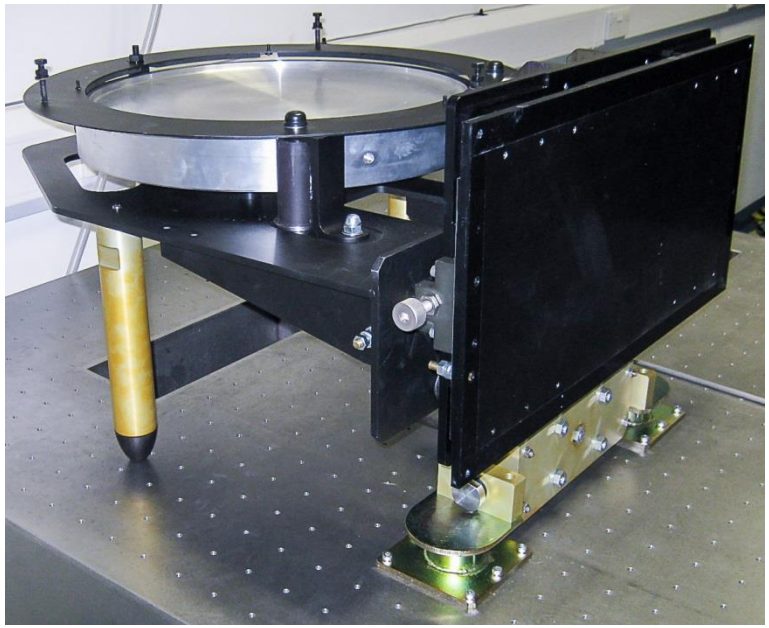
glyndŵr INNOVATIONS

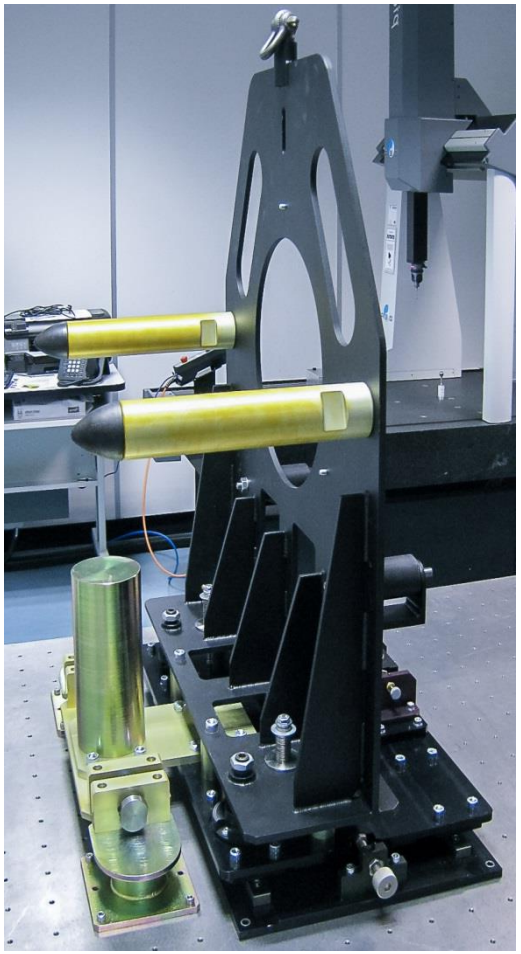
Where & how to support the optic?
1. Fixed supports

- **Smaller/simpler optics**
- **Minimal/no movement**

glyndŵr INNOVATIONS

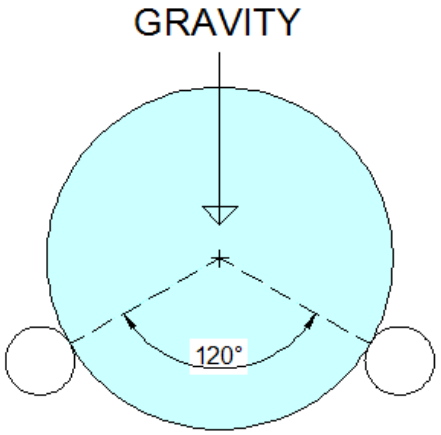
Fixed supports
(pre & post final assembly support)

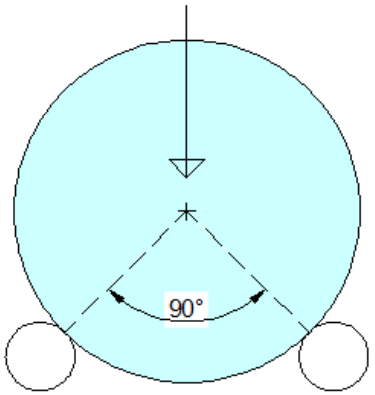




glyndŵr INNOVATIONS

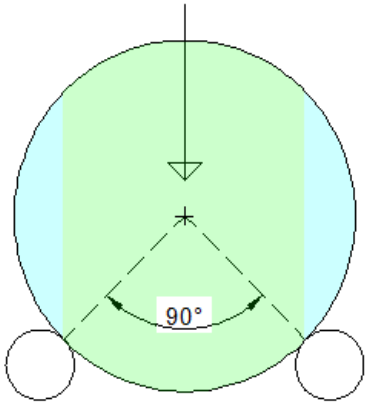
Fixed: Lateral supports
120 v 90 degrees





glyndŵr INNOVATIONS

Fixed: Lateral supports
120 v 90 degrees

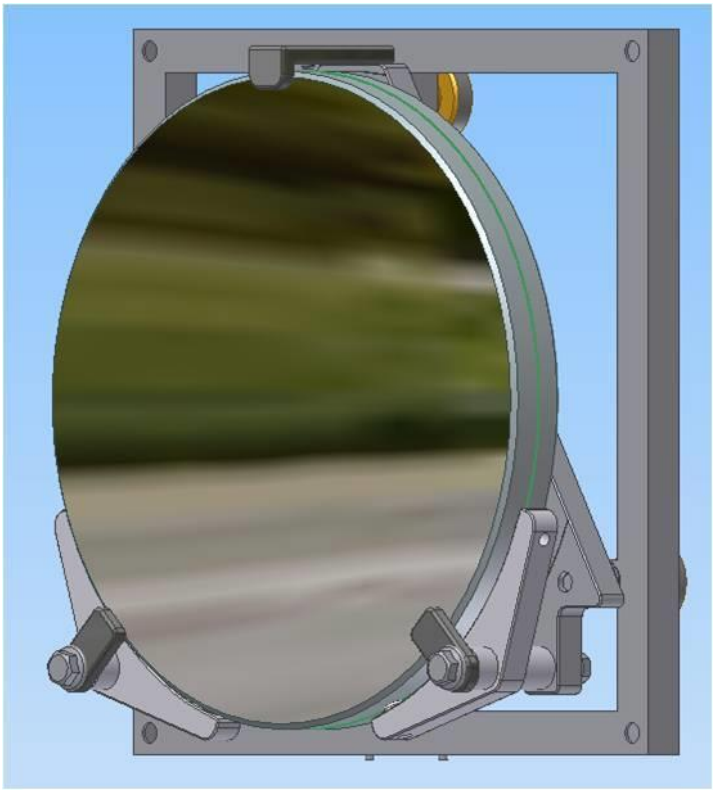


SOLID MIRROR

1) LOAD IS MORE EVENLY SUPPORTED
2) REDUCES ASTIGMATISM

glyndŵr INNOVATIONS

Vertical supports: 90 degrees

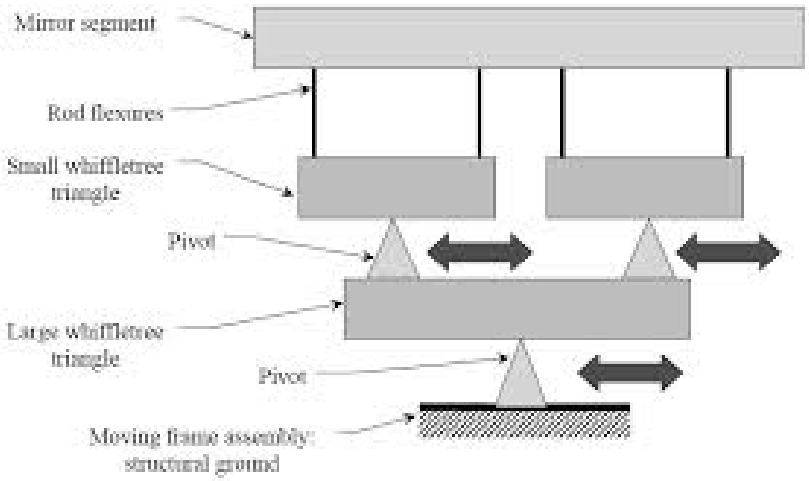


glyndŵr INNOVATIONS

2. The “Wiffle tree” concept

3 points of contact for stability

Distributed forces evenly

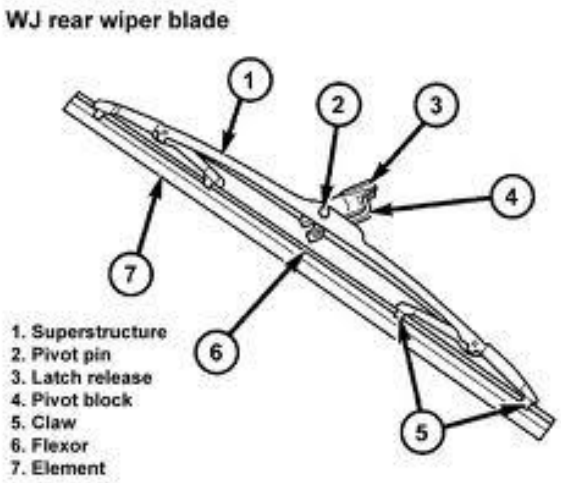


glyndŵr INNOVATIONS

The Wiffle tree concept – not new….

glyndŵr INNOVATIONS

The Wiffle tree concept



glyndŵr INNOVATIONS

Wiffle tree – hexagonal or round mirrors

Good for lighter optics

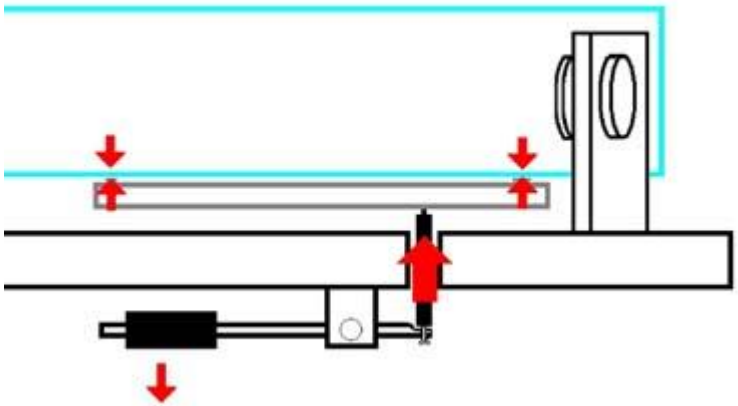
glyndŵr INNOVATIONS

3. Astatic supports

Essentially: balanced lever system

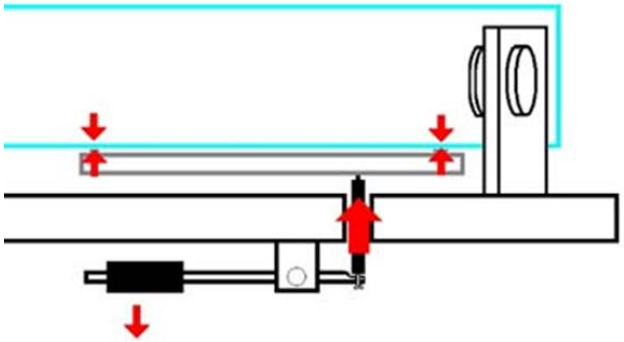
Good for: very big or heavy optics….ground based
Highly adjustable/moving optics

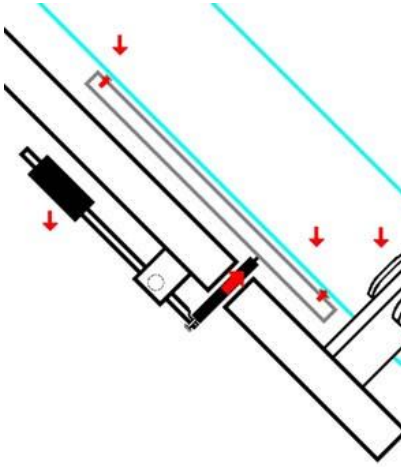
More expensive than wiffle or fixed

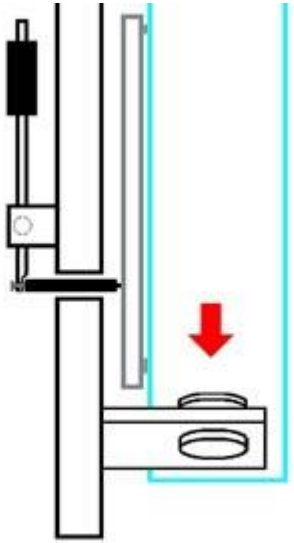


glyndŵr INNOVATIONS

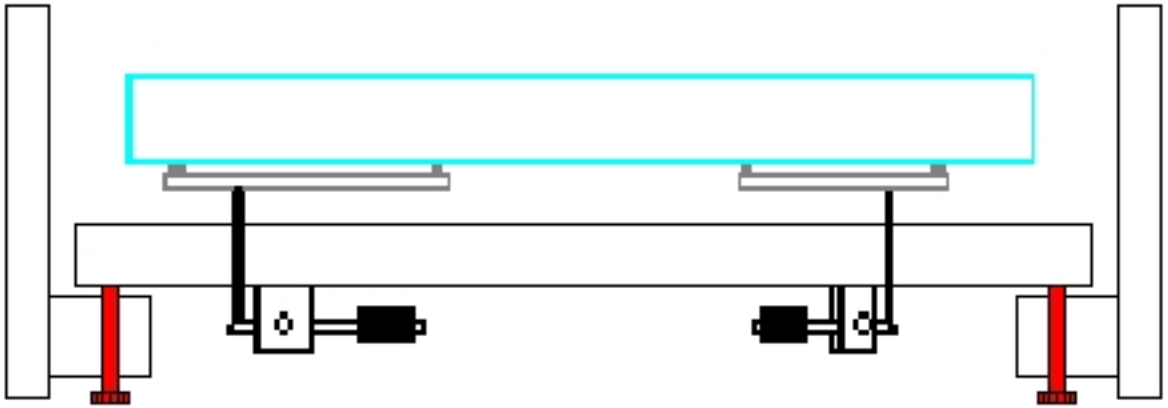
Astatic supports







Astatic supports



glyndŵr INNOVATIONS

Points of contact
Flexures v Conventional Bearings

The case for flexures

- **Bearing that allows motion by bending against a load**
- **Joins two parts**
  eg optic/pad + support mechanism
- **Repeatable flexed**

glyndŵr INNOVATIONS

Flexures

New CAD techniques

- Simple – single part
- Compact
- Lightweight

Limitations:

Range of motion

glyndŵr INNOVATIONS

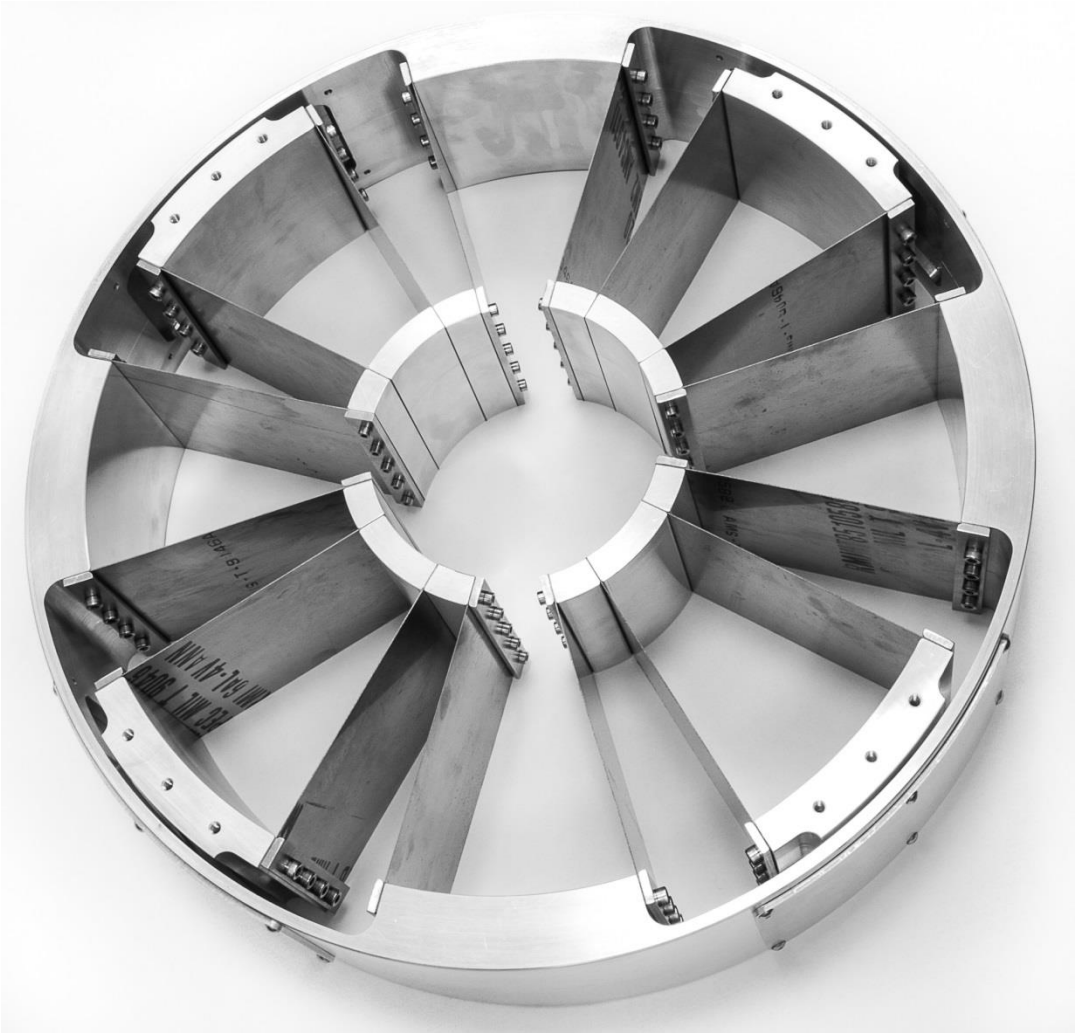
Flexures + WT mounting

glyndŵr INNOVATIONS

Flexures in Precision Actuation

Small angle turntable

Supports ½ tonne

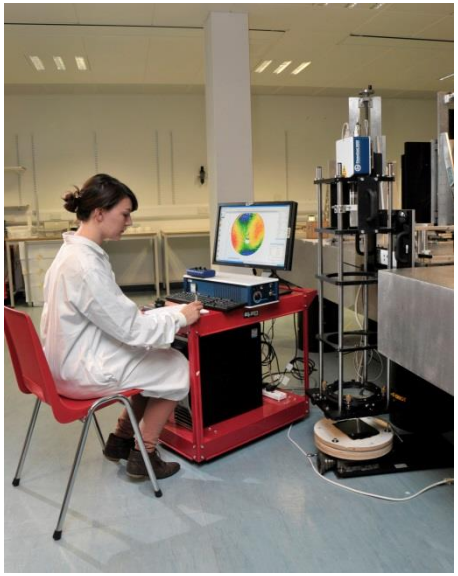


glyndŵr INNOVATIONS

During the manufacturing process

Check manufacture & test!

- Increasing use of CNC processes
- Machine support effects the final shape
- Solution
- Testing: support should mimic the final mechanism planned to be used

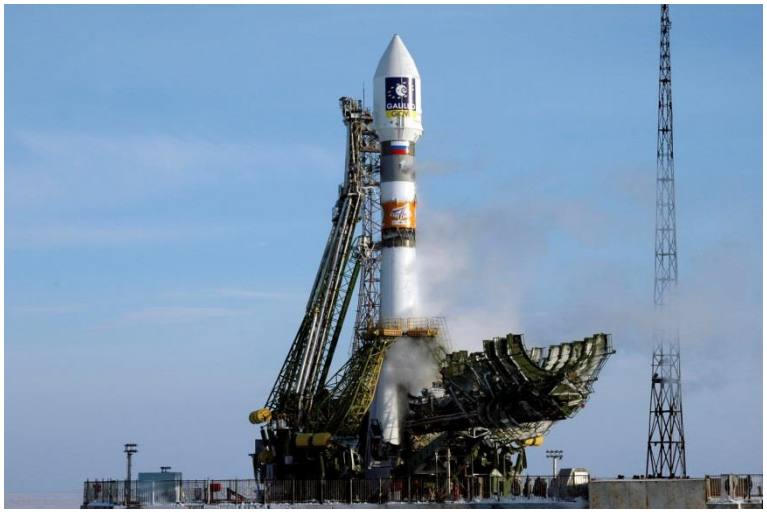


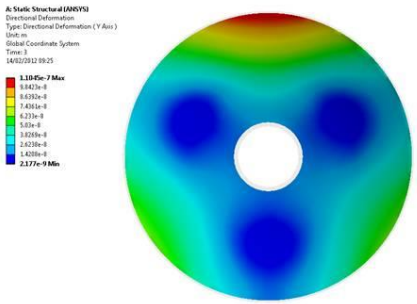
glyndŵr INNOVATIONS

Satellite optics

Launch: 60 to 90 g

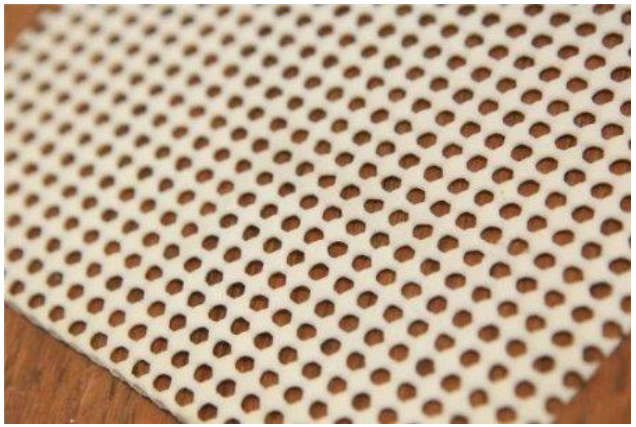
In use: Zero gravity





Testing – the low tech solution

“Soft air bags” mimic zero g



glyndŵr INNOVATIONS

Optimising optical component performance

Why the right opto-mechanical design can make your day

John Oliver

John.oliver@glyndwrinnovations.co.uk

01745 535100

glyndŵr INNOVATIONS