

# Hot Design



Professorial lecture  
University of Sussex  
28<sup>th</sup> November 2006

## Design



The term design is popularly used to refer to an object's aesthetic appearance.

## Design



The word design comes from the Latin 'designare', meaning to designate or mark out.

## Design



Design generally begins with either a need or requirement or, alternatively, an idea.

It ends with a set of drawings or computer representations and other information that enables a product to be manufactured and utilised.

Here design is defined as ‘the total activity necessary to provide a product or process to meet a market need’ (Pugh (1990)).



MARKET

SPECIFICATION

CONCEPTUAL  
DESIGN

DETAILED  
DESIGN

MANUFACTURE

MARKET

## Agenda



- Principles of product styling
- Creativity
- Detailed design
- Rotating flow
- Conclusions/Global challenge

## Styling



Styling involves developing and giving a product an attractive visual form.

Although the appreciation of a product's aesthetic appeal is subjective and each person will judge it individually, there are a number of principles that are helpful in the development and realisation of style and form.

## Styling



The principles of product styling include:

- exploration of the design space
- consideration of human behaviour
- ergonomics
- technology selection
- colour
- metaphor
- use of organic and inorganic forms
- form follows function
- visual identity/branding
- material selection



## Styling



A product's visual form is a generated by the designer.

Visual form may be non-descript, inelegant or ugly.

Alternatively a design may produce an item of beauty and a product that is admired for its form rather than its function.

Styling is a means by which value can be added to a product without necessarily impacting on the function.

## Visual Perception



When an image is first seen, our brain will extract certain visual patterns and construct these into a meaningful image.

The process by which this is performed develops according to the visual stimuli that we are exposed to.

The Gestaltdt rules are the operational rules for this process of visual perception in our brains.



## **Rule of Proximity**

One of the most important factors determining the visual perception organisation of a scene is the proximity of the elements in it.

Items that are close together are grouped together.



## Visual Perception



The implication of the Gestalt rules for product styling is a tendency towards visual simplicity.

*Manifesto for minimalism*

## Visual perception



In contemporary product styling minimalism is a dominant theme.

Elegant simplicity is the aspiration of many modern designers.

Products however that are either too simple or too complex give rise to less feelings of attractiveness than those of an intermediate level of complexity.

## Visual perception



Visual perception is particularly refined in the detection of certain visual forms

- faces

Products can be made to smile, frown, be cross ....

# Visual perception





## Styling



Four main ways of making products attractive:

- Prior knowledge attractiveness
- Functional attractiveness
- Symbolic attractiveness
- Inherent attractiveness of visual form

## Creativity



An essential element of the design process is creativity

Creativity can be viewed as the ability to imagine or invent something new of value.

It is not the ability to create out of nothing, but the ability to generate new ideas by combining, changing, or reapplying existing ideas

## Creative Methods



There are 100s of creative methods available.

Some professionals tend to restrict their attention to less than 10 in their careers.

Creative approaches can be very useful in enhancing the generation and realisation of ideas.

## Creative Methods



Activating the Variables	Boundary Examination
Active Crisis Generation	Boundary Relaxation
AIDA	Boundary Shifting
Algorithmic Composition/Generation	Brain Sketching
Alternative Seeking	Brainstorming
Analogy	Brainwriting
Analytical Techniques	Brainwriting 6-3-5
Ask 'Why' Five Times	Brainwriting Game
Assumption Smashing	Browsing
Assumption Surfacing	Brutethink
Attribute Listing	Bud Listing
Attribute-Value Chain	Bullet-Proofing
	Bunches Of Bananas

## Creative Methods



Card Story Boards

Catwoe

Causal Analysis

Causal Mapping

Change Matrix

Charrette

Checklists

Cherry Split

Circle Of Opportunity

Clarification

Collective Notebook

Combination, Transformation,  
Exploration

Component Detailing

Concept Evaluation and Selection

Concept Variants

Concepts Fan

Consensus Mapping

Constrained Brainwriting

Context Modifying

Controlling Imagery

Copying/Parametric

Crawford Slip Writing

Creative Problem Solving

Creative Target List

Creativity Challenge

Creativity Template

Criteria For Idea-Finding Potential

Crossed Segmentation

## Creative Methods



### The Create Methodology Phases

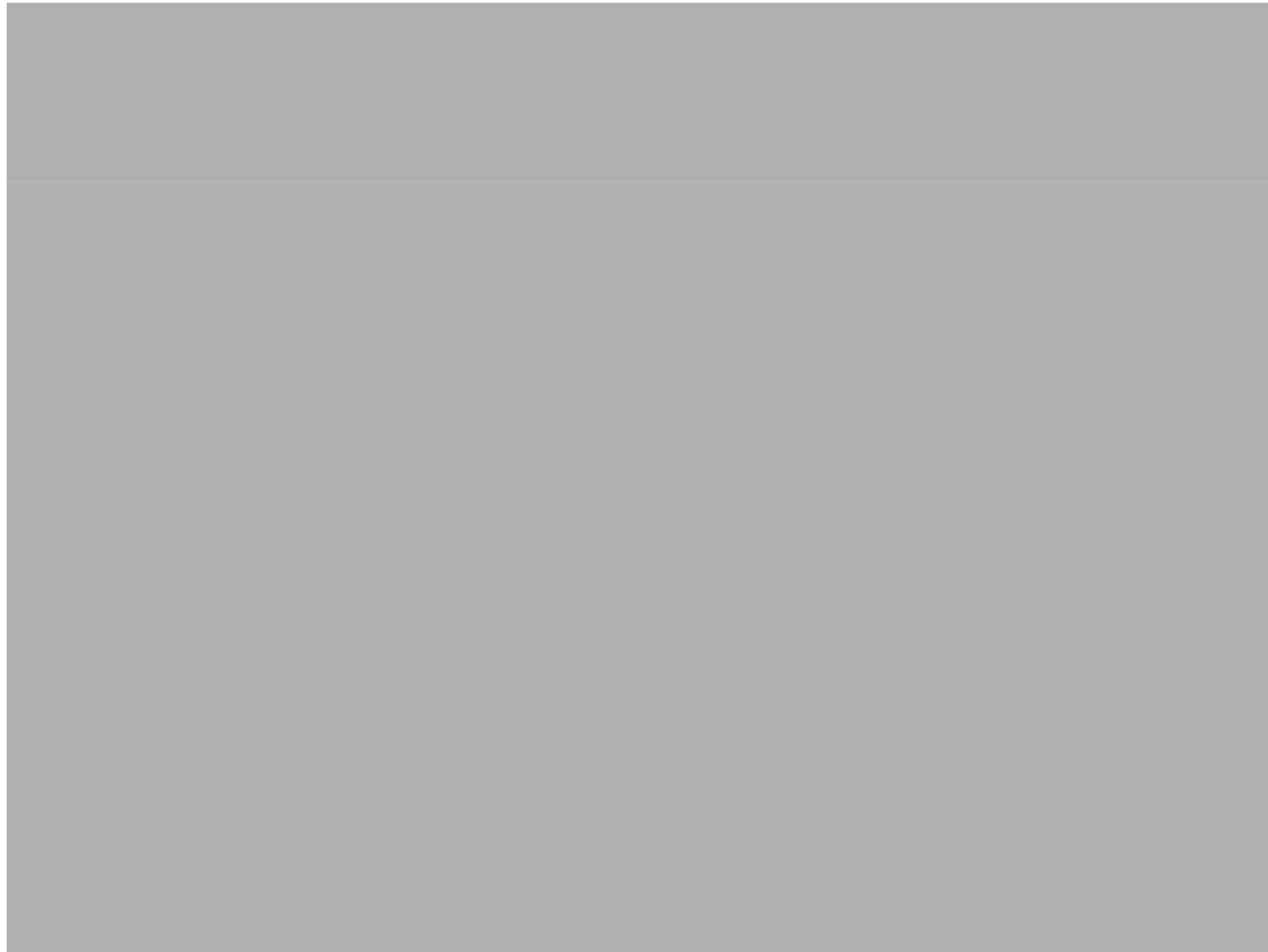
- Predisposition
- External mapping
- Internal mapping
- Idea generation
- Evaluation

## Creative Methods

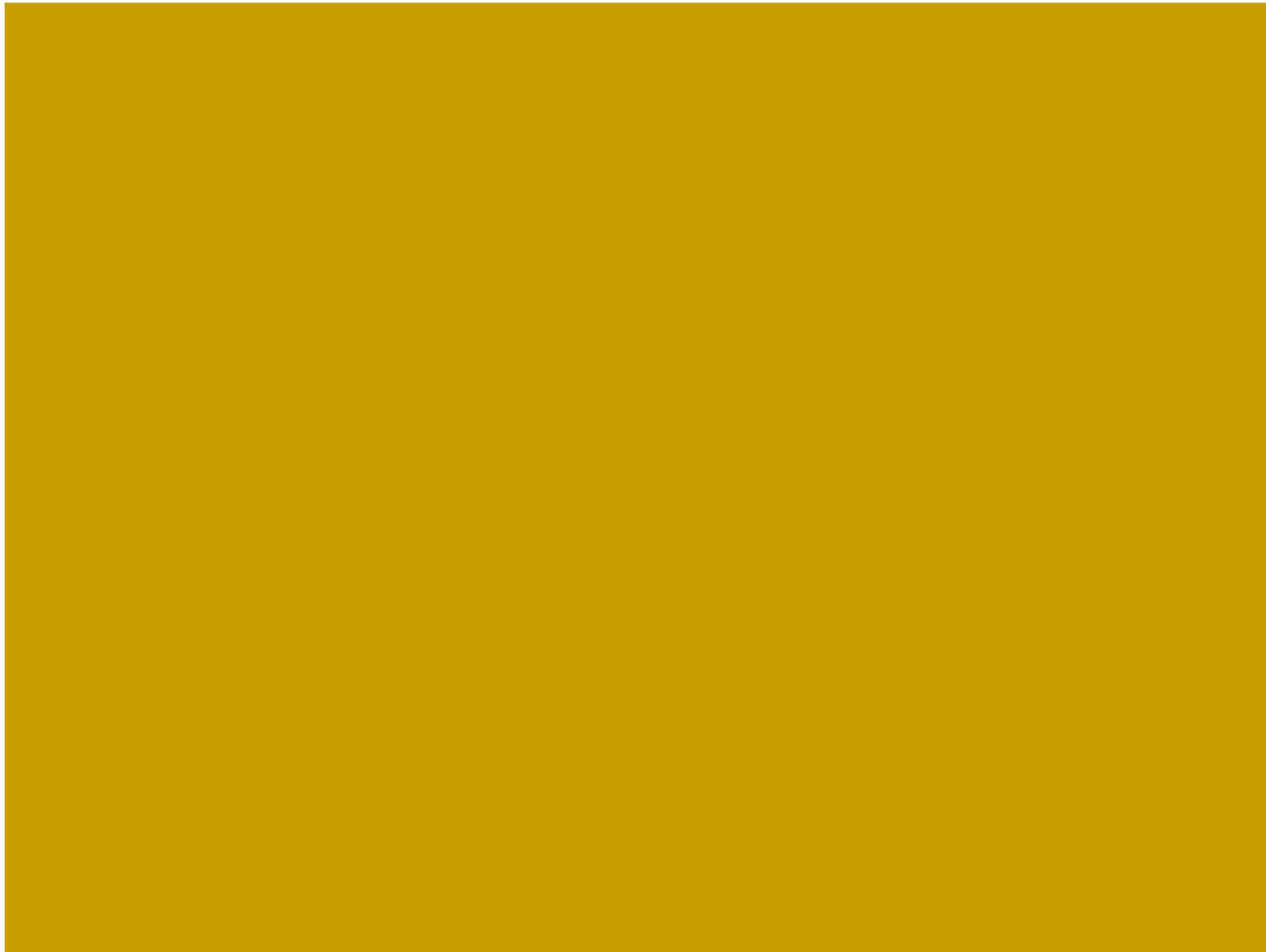


### Techniques/Methods?

- Predisposition - Training
- External Mapping – Attribute value chain
- Internal Mapping – SWOT analysis
- Idea Generation - Brainstorming/Morphological analysis/Synectics/TRIZ
- Evaluation – Criteria Matrix/Six Hats







## Creativity



The Higher Education Funding Council for England has recently awarded about £4.1 million to the University of Sussex and the University of Brighton to set up InQbate, the Centre of Excellence in Teaching and Learning (CETL) in Creativity.



## Creativity zones



The centrepieces of the CETL in Creativity are two Creativity Zones, one at the University of Sussex and one at the University of Brighton.

Although physically separate, these are networked to enable individuals to interact within a range of shared physical and virtual spaces, each embedded with appropriate technologies and communication infrastructure.

## Creativity zones



The zones draw their inspiration from operating theatres associated with the explosion in understanding of surgeons, by comprising observation capability, enabling students to experience the activity under way.

## Creativity zones



Educational spaces are long term resources and their design needs to be:

- Flexible – to accommodate both current and evolving pedagogies
- Future-proofed – to enable space to be re-allocated
- Bold – to look beyond current technologies and pedagogies
- Creative – to energise and inspire learners and tutors
- Supportive – to develop the potential of all learners
- Enterprising – to extend capability for different purposes

JISC

## Creativity zones



**Creativity**





## Creativity zones





## Creativity zones



## Creativity zones



## Creativity zones



## Creativity zones



## Time to do ....



Any one who has ever been to one of my lectures or teaching sessions will know that I cannot resist the opportunity of getting everyone to do something ....

You have two post-it notes:

- 1) On the pink one write down up to three of the biggest challenges facing the World.
- 2) On the green one write up to three of the best things about the World.

## Six hats



The six hat technique was developed by Edward de Bono to assist in applying a range of perspectives routinely in decision making and evaluation.

Each hat is symbolic of a particular approach and way of thinking.

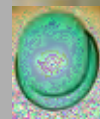
White hat - neutral and objective. It is concerned with facts and figures.

Red hat - gives the emotional point of view.

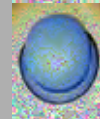
Black hat - cautious and careful. It is critical and identifies weaknesses in an idea.



Yellow hat - sunny and positive and gives positive and optimistic points of view.



Green hat - indicates creativity and new ideas.



Blue hat - represents control and organisation of the other hats.





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DEFINITION

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## Gas Turbine Engines



A particularly challenging application in today's society demanding the highest levels of sophisticated detailed design is the gas turbine engine used for power generation and aircraft.

Essential to the functioning of a gas turbine engine is the internal air system.

**Internal air systems** The gas turbine engine internal air system provides cooling



## Internal air systems



In order to supply the internal air system flow requirement, up to 20% of the engine core flow is extracted from the compressor.

This can consume up to 5% of the fuel and it is therefore important to minimise the quantity of air required for the internal air system whilst maintaining functionality of the engine, acceptable component life, robustness and acceptable manufacture costs

## Internal air systems



For a large passenger aircraft a 1% reduction in specific fuel consumption could save 560 tonnes of fuel per annum and

## Internal air systems



A typical internal air system will include a compressor bleed take off, transfer tubes and passages to deliver the cooling and sealing air to critical components and use of differential pressure across disc surfaces to balance bearing loads.

Image courtesy of Rolls-Royce plc

# Internal air systems



Image courtesy of Rolls-Royce plc

# Internal air systems

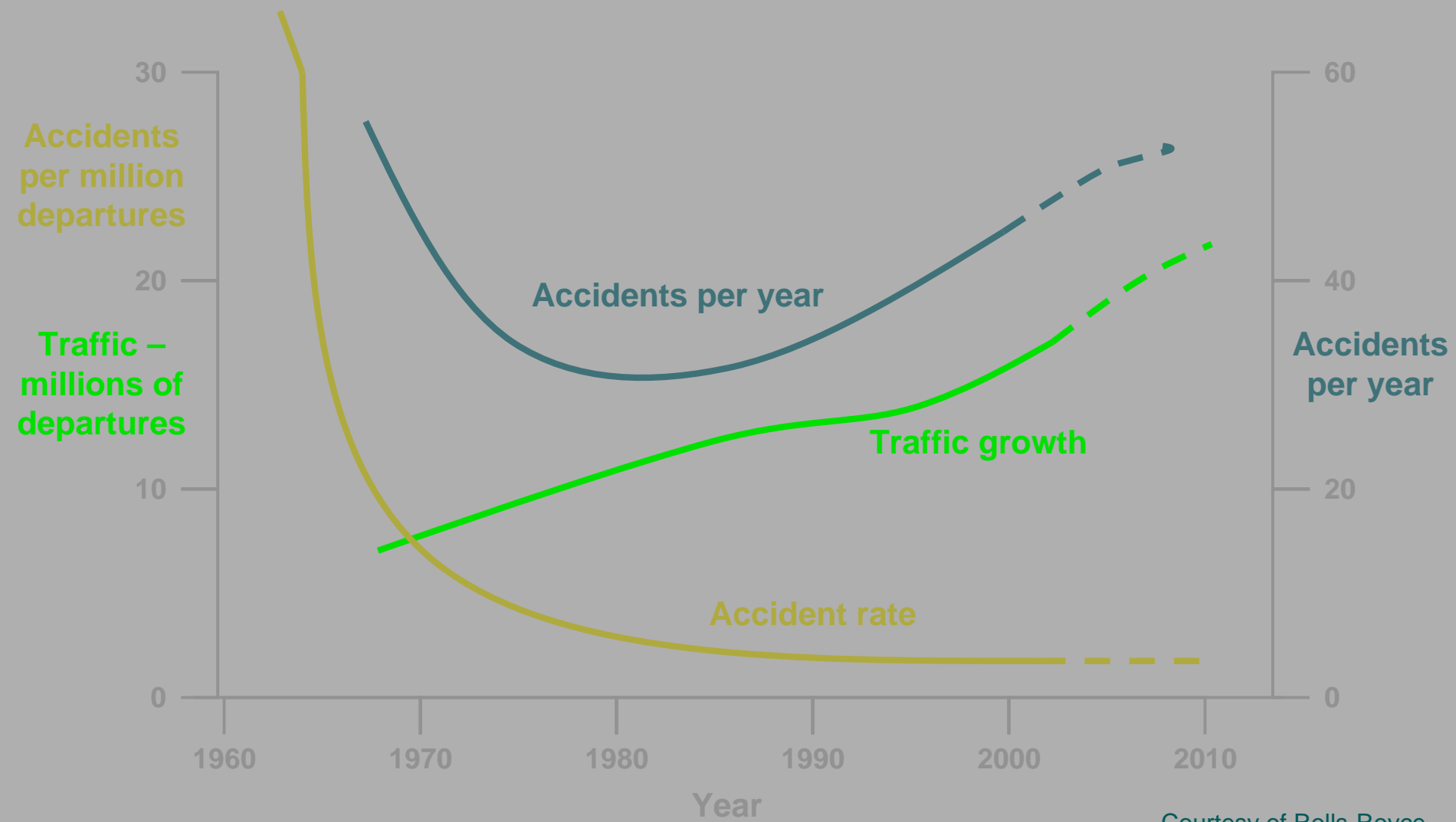


Imags courtesy of Rolls-Royce plc





# Annual Accident Statistics



Courtesy of Rolls-Royce

## Rotating flow



There are fundamental differences between rotating and linear flows and it is the Coriolis terms that are responsible for the differences between the dynamics of non-rotating and rotating fluids.

These give rise to complex flow phenomena that are often non-intuitive.

It is these flows that make the subject area interesting and an on-going challenge despite advances in modelling and data available.

## Internal air system



A gas turbine engine generally comprises a series of discs for the rotating blades and a stationary casing and support structure.

A common feature is the cavity formed between coaxial rotating and stationary discs, which is known as a wheelspace or a rotor-stator cavity.

In addition cavities are also formed between co-rotating discs

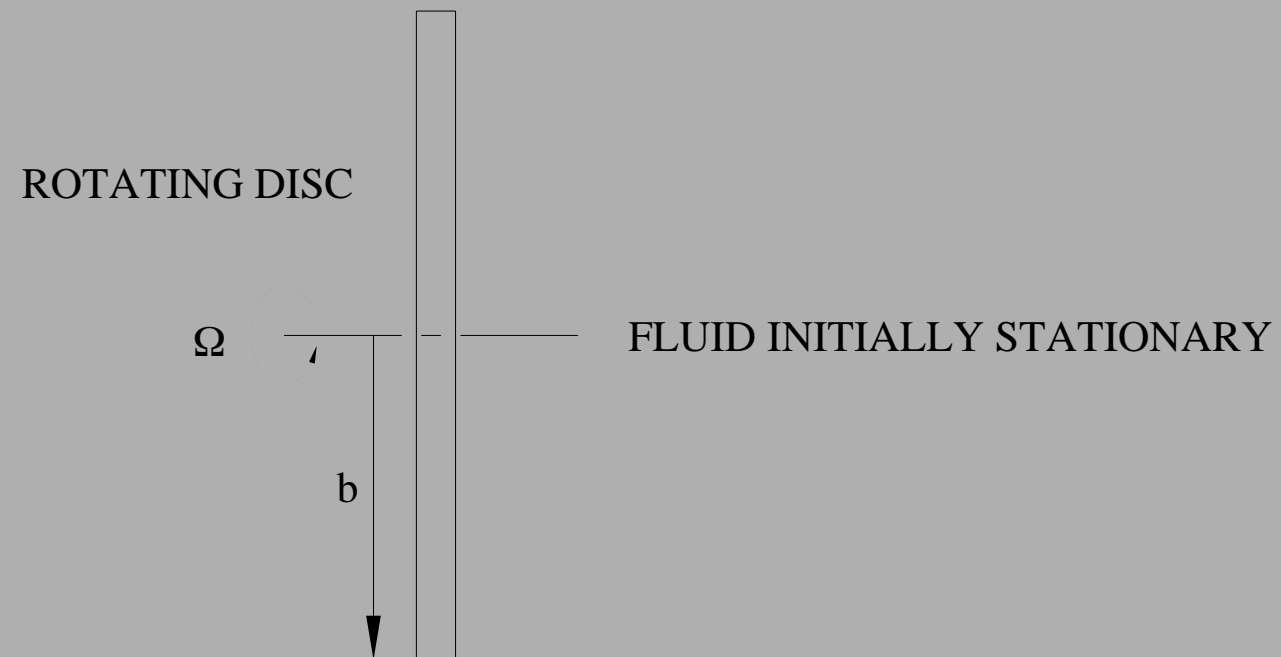
Image courtesy of Rolls-Royce plc



## Free disc



The case of a single disc rotating in an initially stationary fluid is known as the 'free disc'



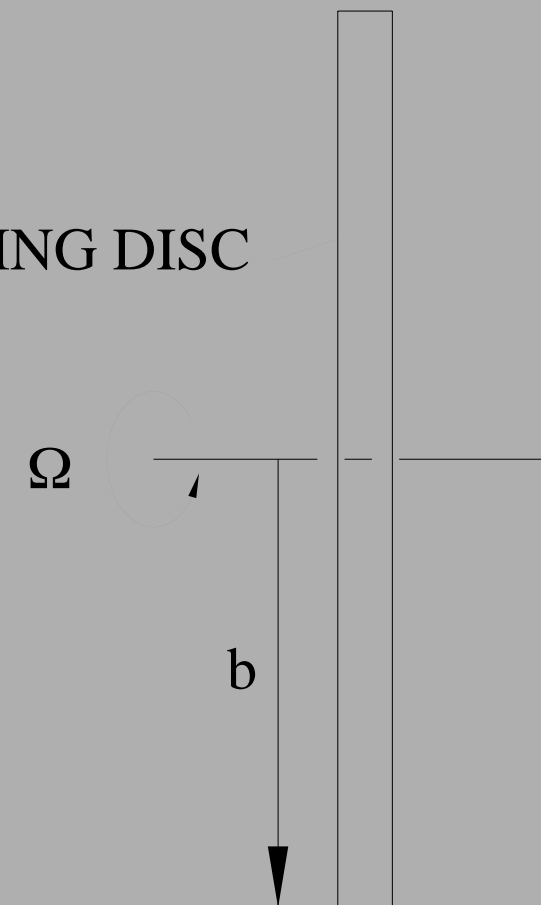
## Free disc



The 'centrifugal forces' generated by the shear between the rotating disc and the fluid cause a radial flow of fluid in the boundary layer.

As the radial component of velocity is zero at the disc surface and is also zero in the free-stream, in order to satisfy conservation of mass and provide the radial outflow, fluid must be entrained axially into the boundary layer.

ROTATING DISC



**Free disc** AXIAL  
FLOW

A

D



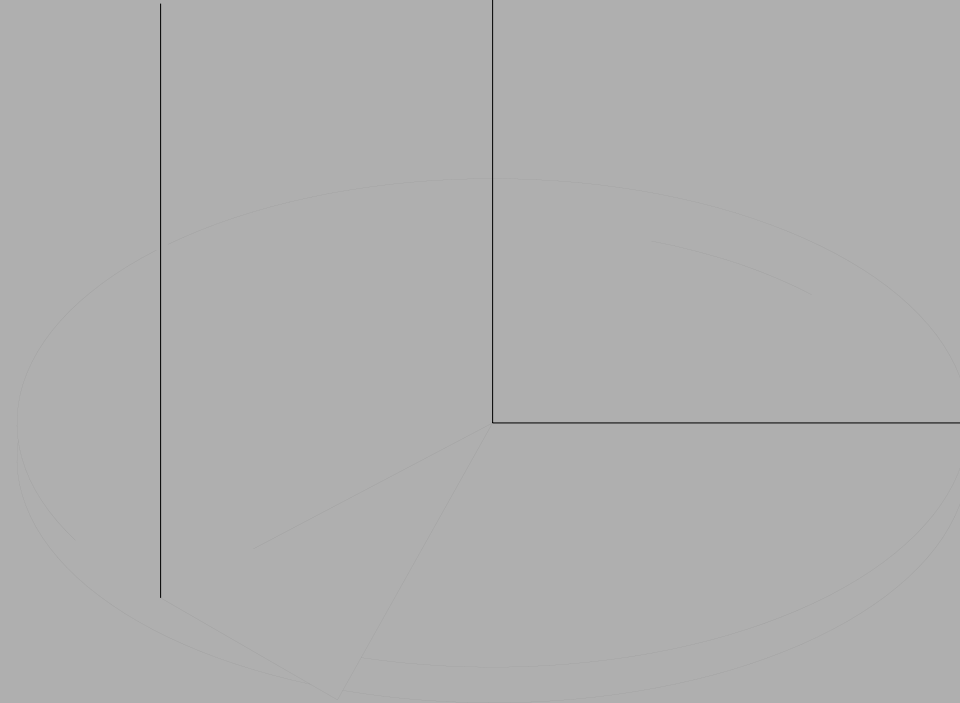
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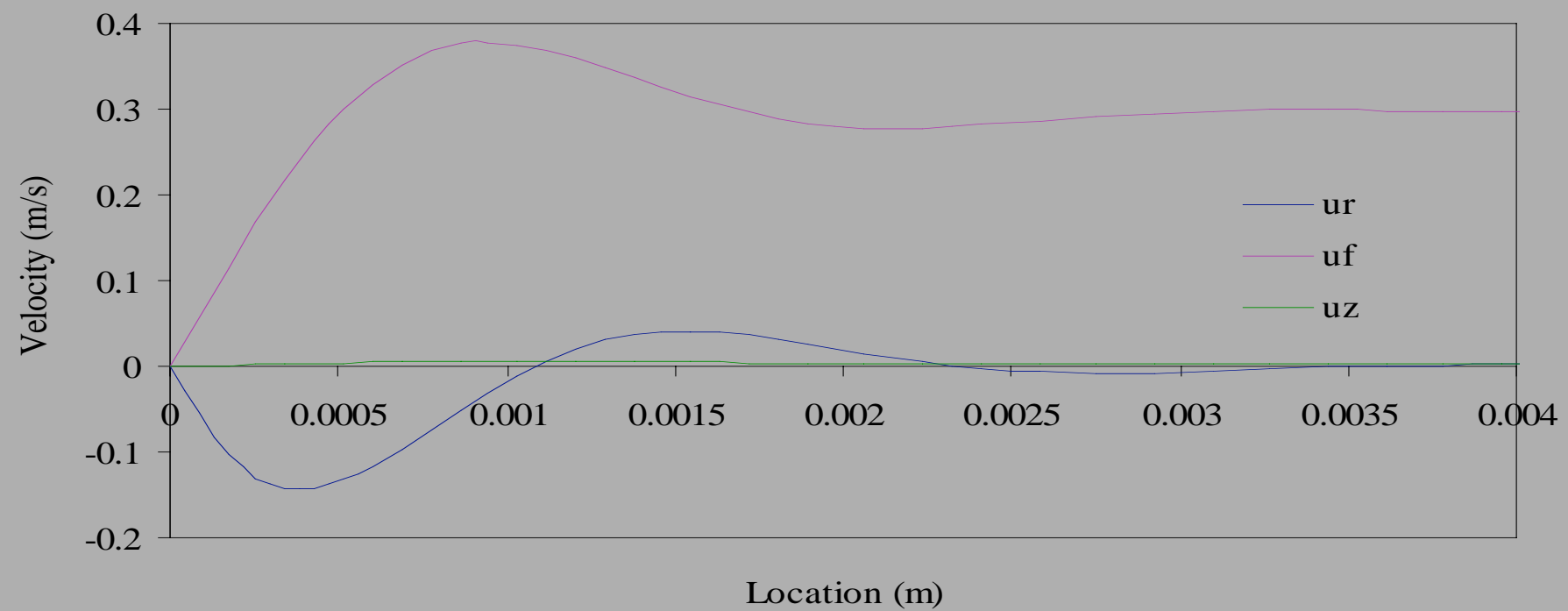
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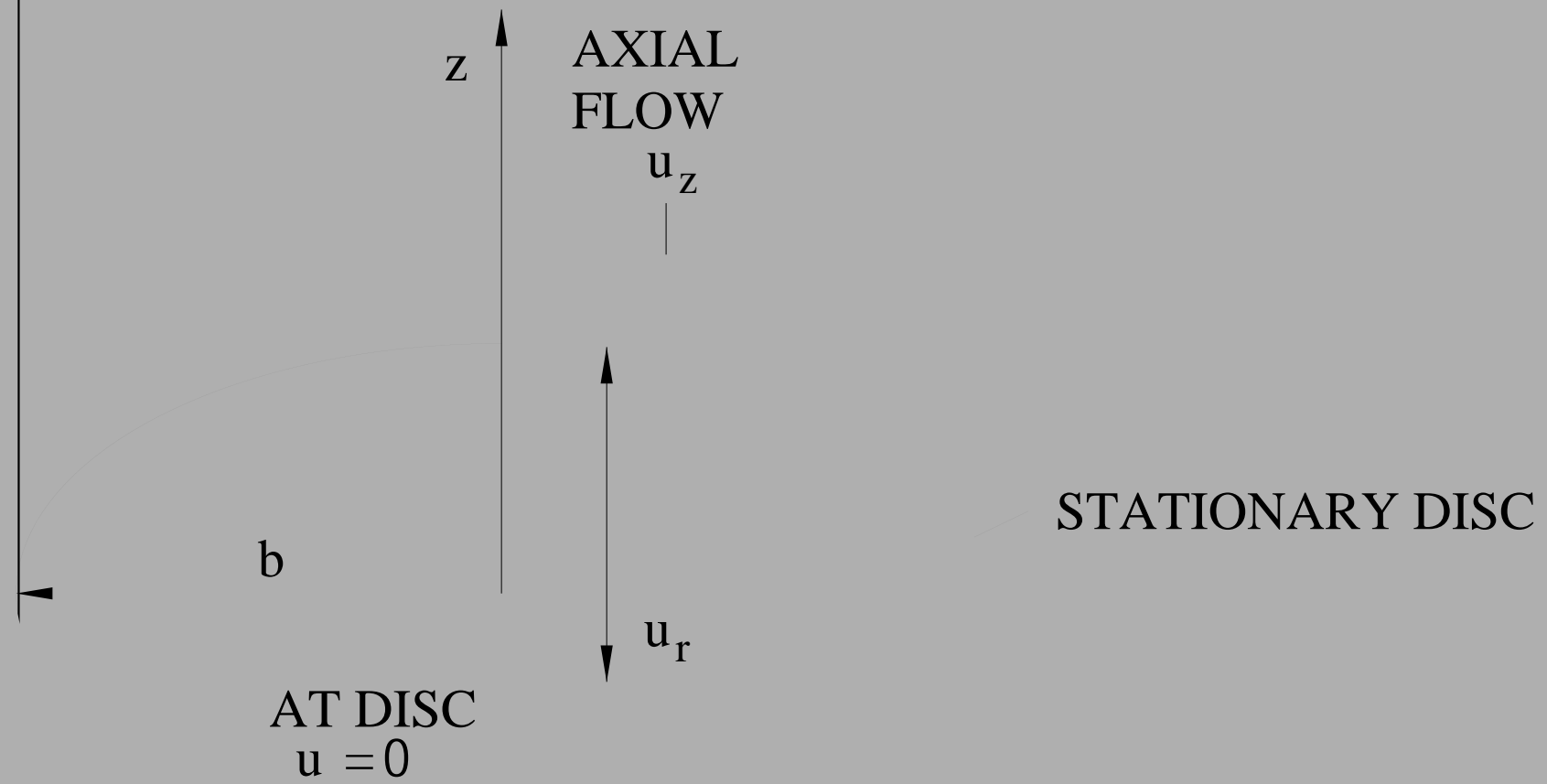


## Rotating fluid above a stationary disc



**Example velocity profiles for a stationary disc in a rotating fluid.  $b=0.035$  m,  $\omega=60$  rpm = 8.442 rad/s,  $\rho=1000$  kg/m<sup>3</sup>,  $\mu=0.001$  Pa s. Conditions equivalent to those for a stirred cup of tea**

# Rotating fluid above a stationary disc



## Your turn ...



- Working in small groups of two or three you should have a glass tumbler with some sugar water, a teaspoon and sachets of sugar.
- Empty a sachet of sugar into the water.
- Stir at 1 revolution per second (about 60 rpm) for about ten seconds.
- Remove the spoon.
- You should see the accumulation of a few granules of sugar near the centre of the tumbler at the bottom.
- This is a practical demonstration of the counter-intuitive nature of rotating flow.

# Cylinders and annulus flows





## Rim sealing



In aircraft and electric power generation gas turbine engines alike, it is common practice for the cavity formed between a rotating turbine disc and a stationary disc to be purged with coolant air.

This air reduces the thermal load of the disc and prevents the ingress of hot mainstream gas into the cavity between the rotating disc and the adjacent stationary casing.

## Rim sealing



However, use of this air is detrimental to engine cyclic performance, and turbine efficiency can be adversely affected by the seal air efflux into the main annulus.

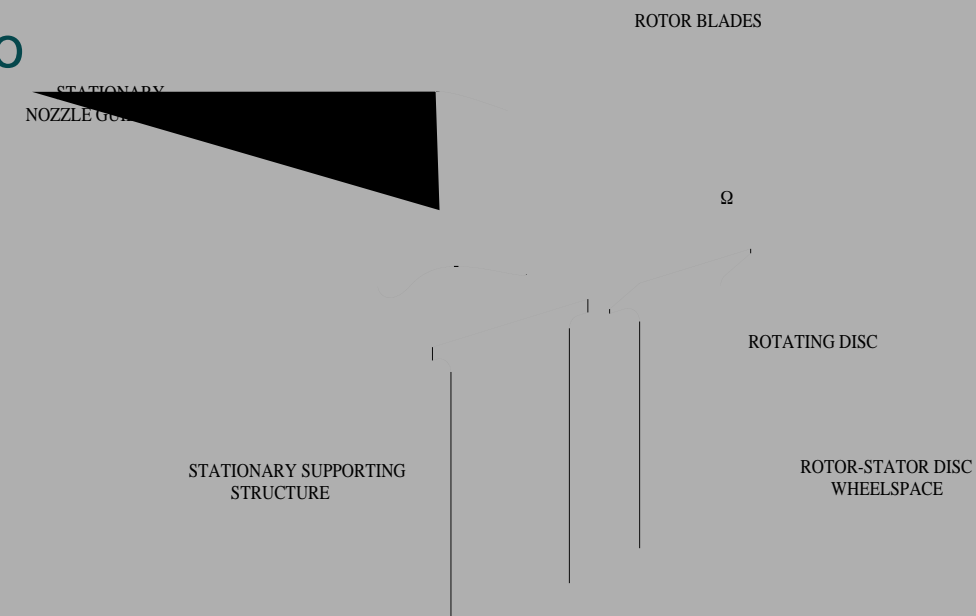
The lifetime of the rotor, and the cyclic and component performance of the engine are therefore dependent on the efficiency with which the cavity is purged.



## Rim sealing



Typically some form of peripheral rim seal is provided to limit the flow ingress or egress and limit mainstream annulus flow spoiling due to interactions with flow in the rim seal region.





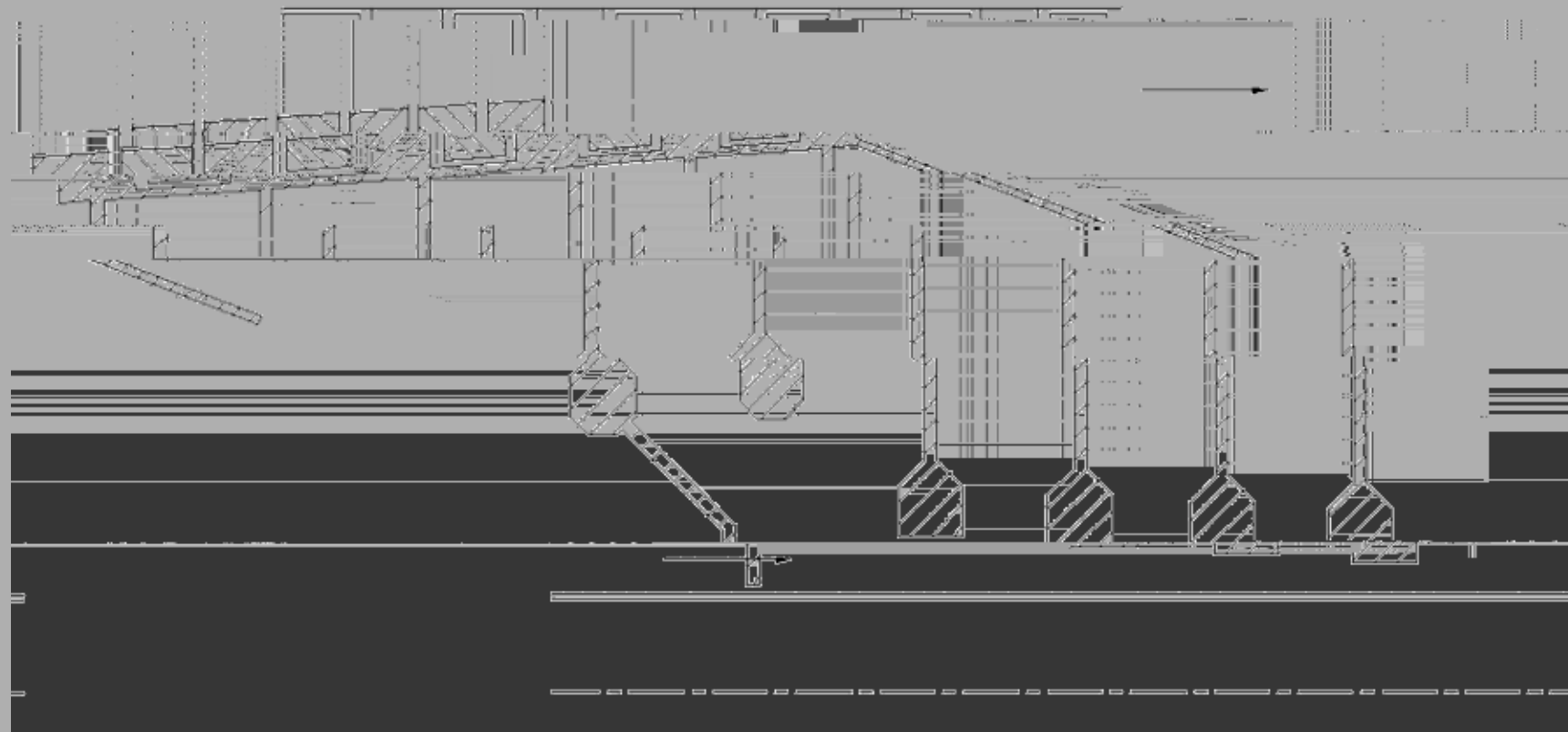
## Turbine stator wells



## Rotating cavities



Air extracted from the compression system for turbine cooling and rim sealing is often led through the annular passage formed between disc bores and a central shaft.





## Rotating cavities



The flow behaviour in a rotating cavity is strongly dependent on whether there is a throughflow of air in the cavity and on the relative temperature between the components.







## Rotating cavities



Practical engine geometric configurations can involve many rotating cavities with flow between successive rotating cavities and associated interactions.

Simultaneous measurements of the axial and tangential velocity components  $V_z$  and  $V_\theta$  have been made inside using Laser Doppler Anemometry (LDA) for a rig with four rotating cavities.

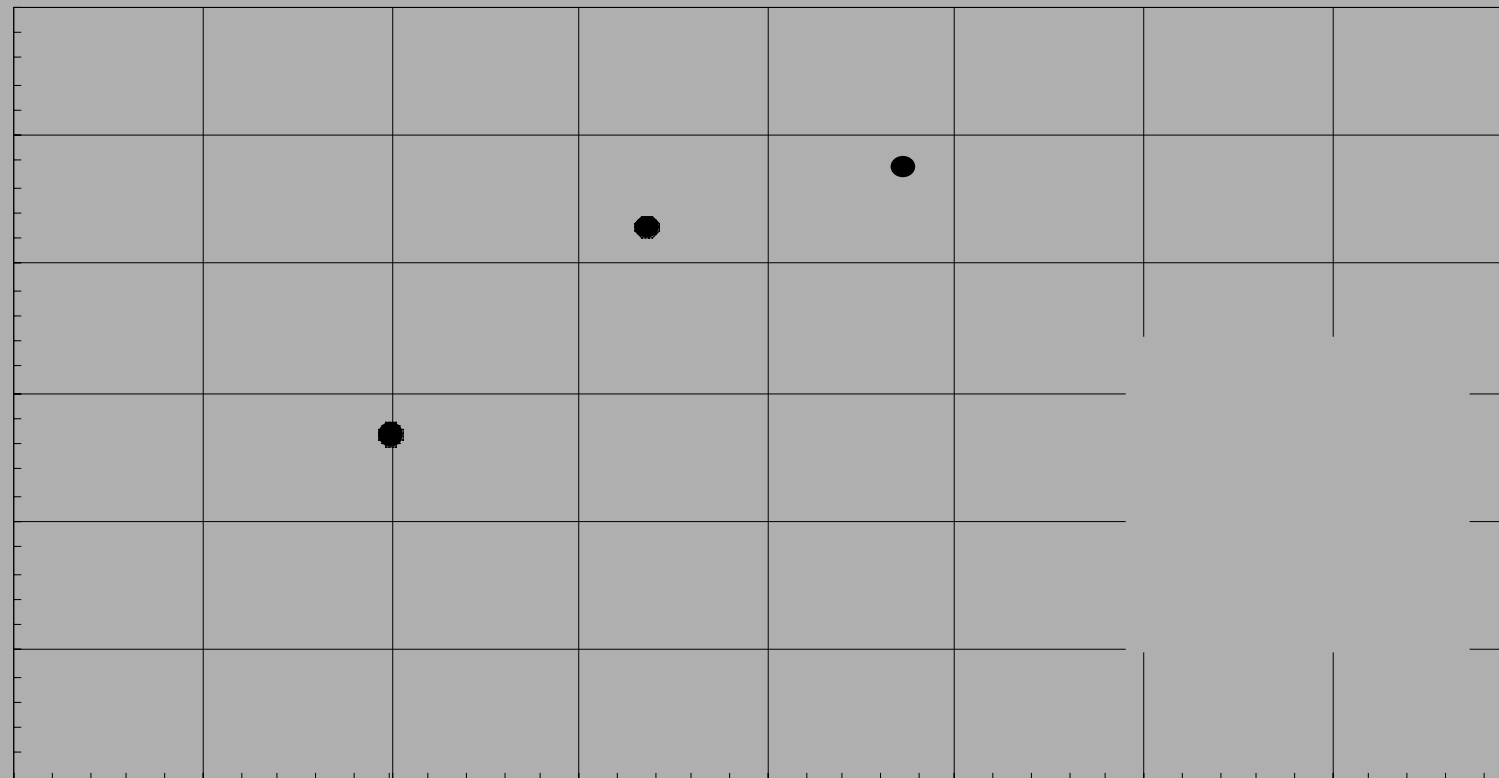
## Rotating cavities



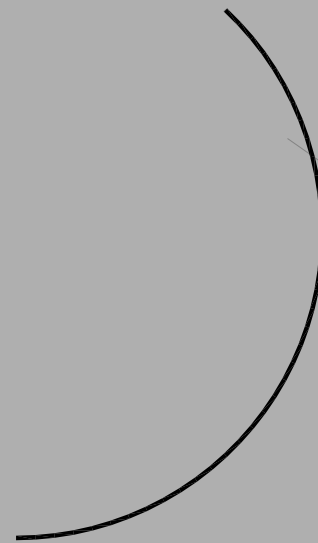
**Radial variation of dimensionless tangential velocity with Rossby number (*wide annular gap*)**



Radial variation of dimensionless tangential velocity with Rossby number (*narrow annular gap*)



## Rotating flow



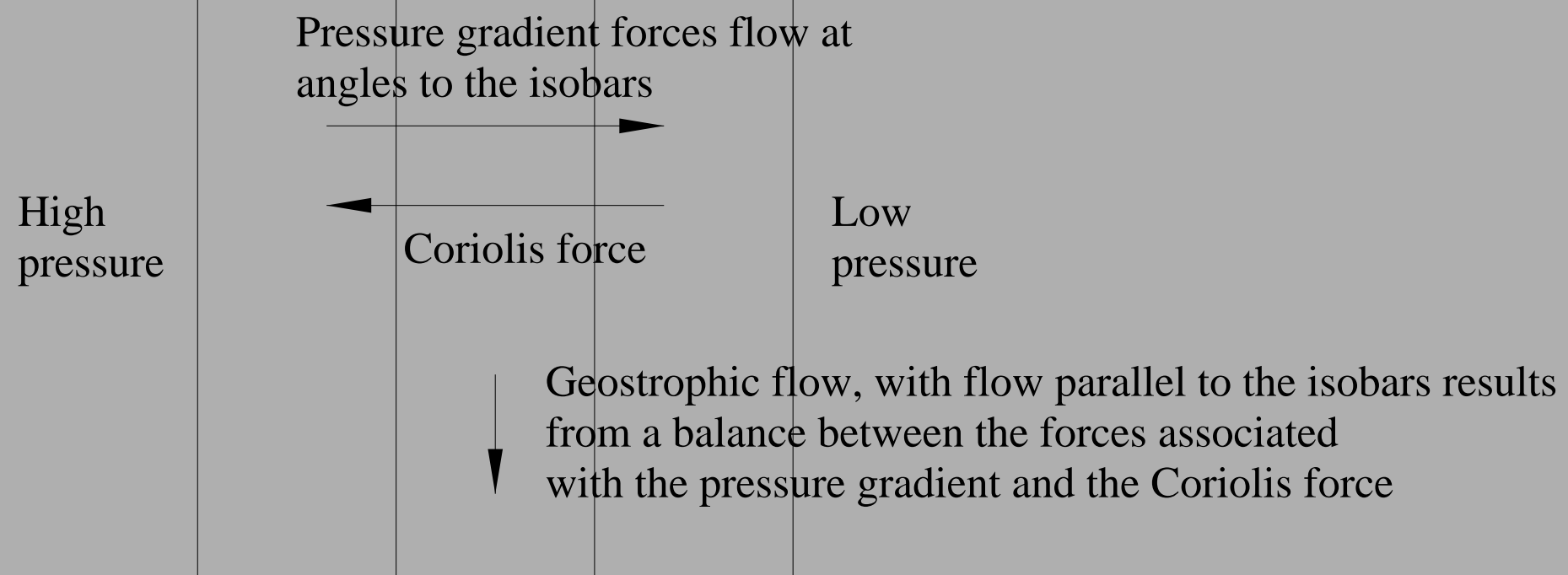
## Rotating flow

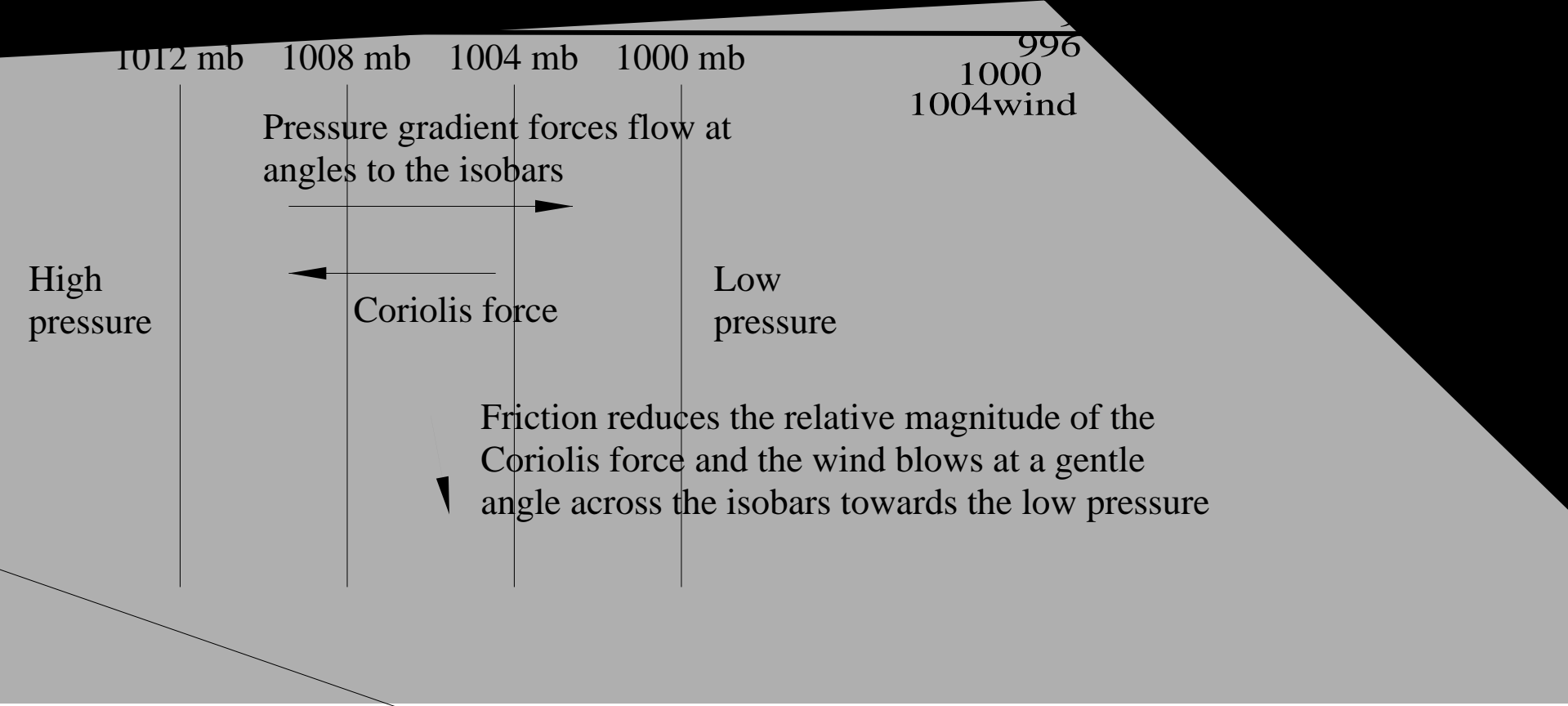


## Rotating flow



1012 mb   1008 mb   1004 mb   1000 mb







## Rotating flow



**Hurricane Katrina, 28th August 2005.  
Satellite image courtesy of NASA GSFC, data from NOAA GOES**

## Rotating flow



The energy involved in such a hurricane is massive and of the order of  $7.39 \times 10^{18}$  J

This can be compared with the explosive energy of the Little Boy atomic weapon, which was approximately  $6 \times 10^{13}$  J

A hurricane can therefore have approximately 120000 times more energy than that of an atomic bomb.

## Conclusions



- Design involves concept development, styling and attention to details.
- A wide range of creative methods are available and can be readily



Thank you