

# The Ronnie Shephard Memorial Address Before Uber:

Professor Nira Chamberlain CMath CSci FIMA FORS OBE  
Atkins Technical Fellow for Mathematical Modelling

**ATKINS**

Member of the SNC-Lavalin Group

# The Ronnie Shephard Memorial Address

Ronnie Shephard was a professor in the United Kingdom who had joined the Army Operational Research Group (AORG) in 1942. Over the next few decades Shephard amassed a large collection of documents relating to military operational research, primarily of post-1945 conflicts. At one time, Shephard held the Chair of Operational Research at the UK's Royal Military College of Science at Shrivenham. In 1984, he founded The International Symposium On Military Operational Research (ISMOR)



# Modelling Evolves every 10 years

1990's Engineering Mathematics

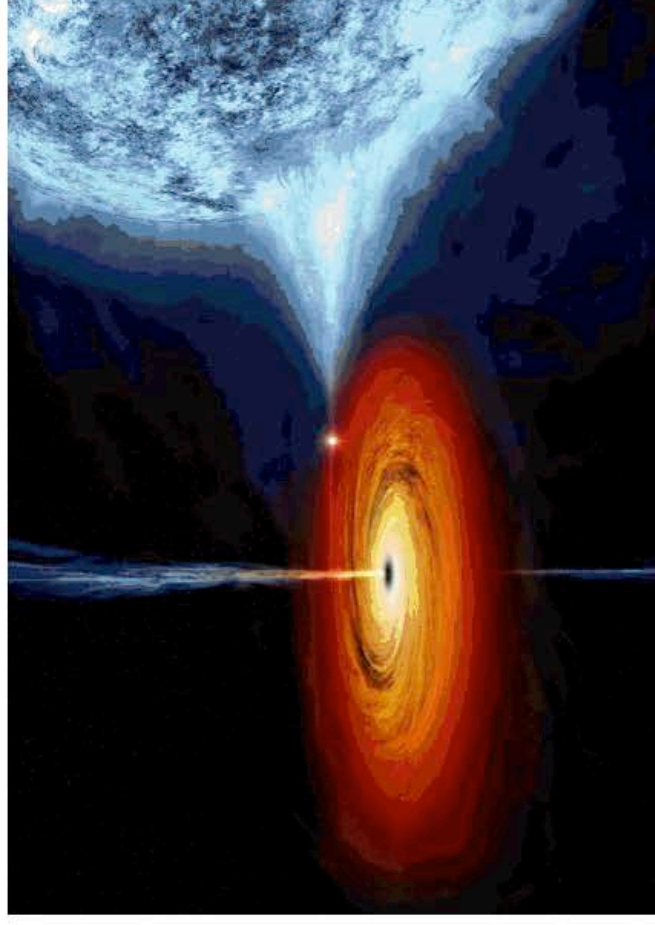
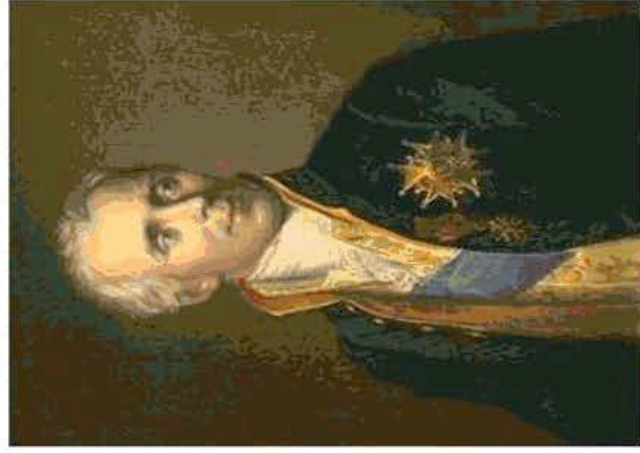
2000's Discrete Mathematics

2010's Data Science

2020's Generative AI?

# Threat of AI – is the Deskilling of Present and Future Modellers

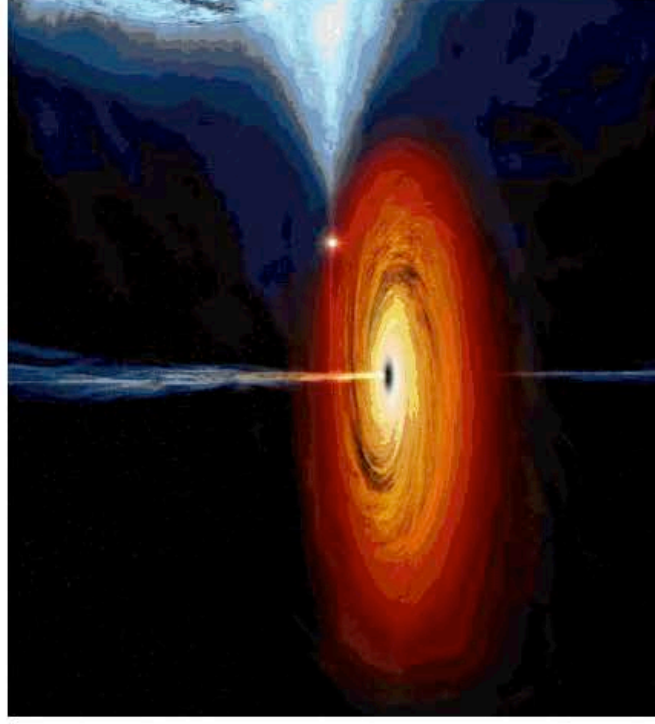
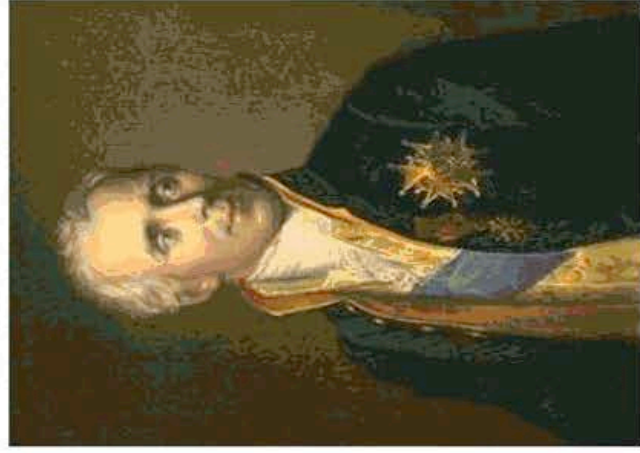
Pierre-Simon Laplace



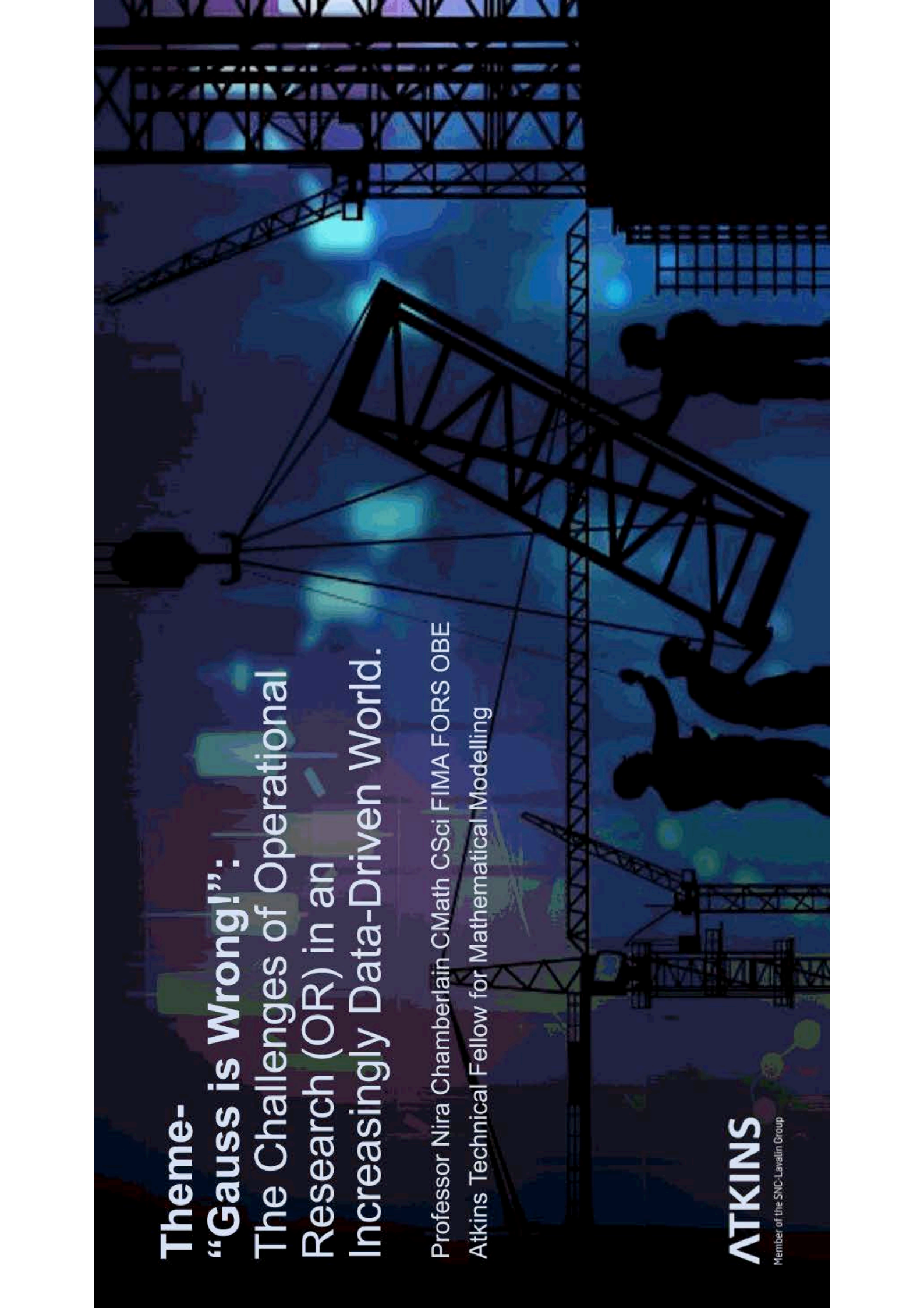
Without a Computer, Laplace found the Hidden Logic

# Threat of AI – is the Deskilling of Present and Future Modellers

Pierre-Simon Laplace



But by focusing purely on the Hidden Pattern (AI) do we risk throwing the baby out with the bath water!



**Theme-**  
**“Gauss is Wrong!”:**  
**The Challenges of Operational**  
**Research (OR) in an**  
**Increasingly Data-Driven World.**

Professor Nira Chamberlain CMath CSci FIMA FORS OBE  
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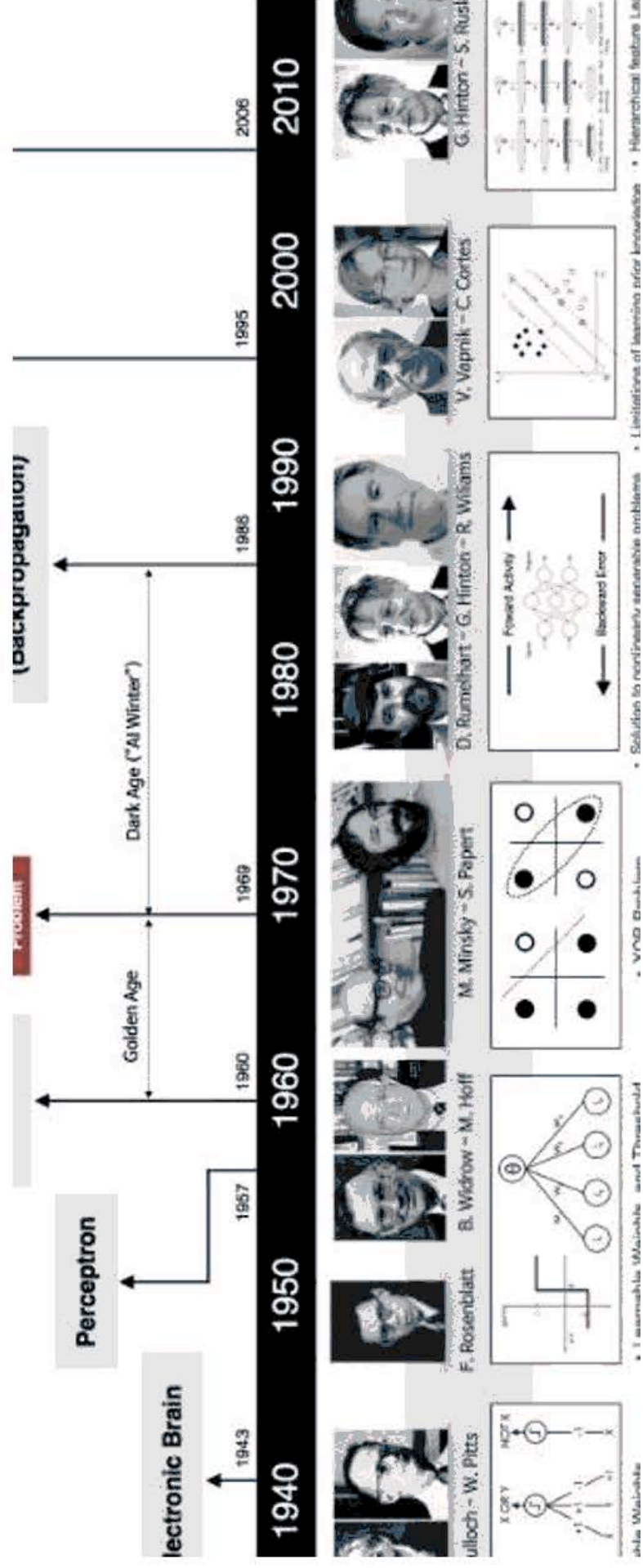
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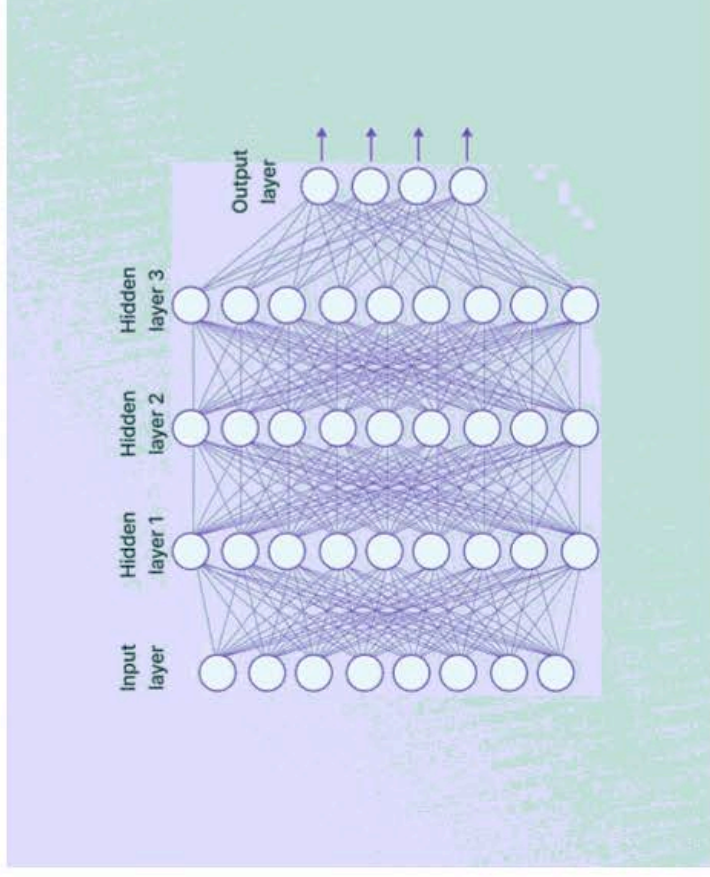
# The Summer of 2001 – 22 years ago – met two academics



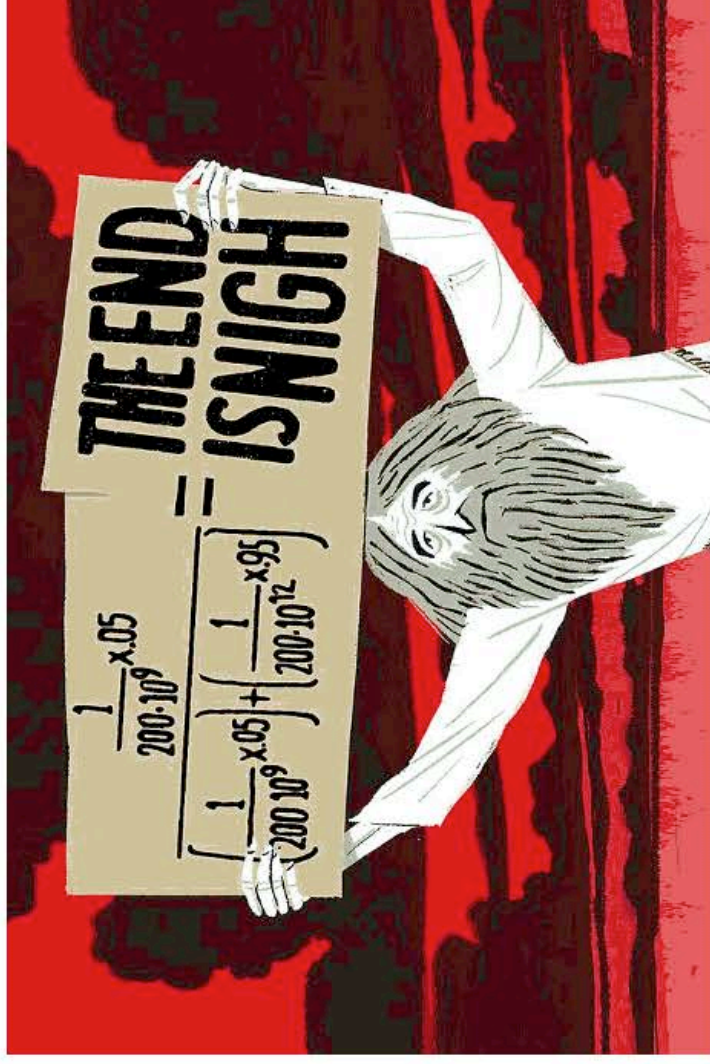
# The History of Machine Learning



# The rise and greatness of convolutional neural networks!



# The end of OR and Mathematical Modelling!



2023 – 22 years later.... We are still here!



THE  
OPERATIONAL  
RESEARCH  
SOCIETY



Institute of  
mathematics  
& its applications

2045 – 22 years from now....What challenges will we face?...



THE  
OPERATIONAL  
RESEARCH  
SOCIETY



Institute of  
mathematics  
& its applications

2045 – 22 years from now.... What challenges do we face....

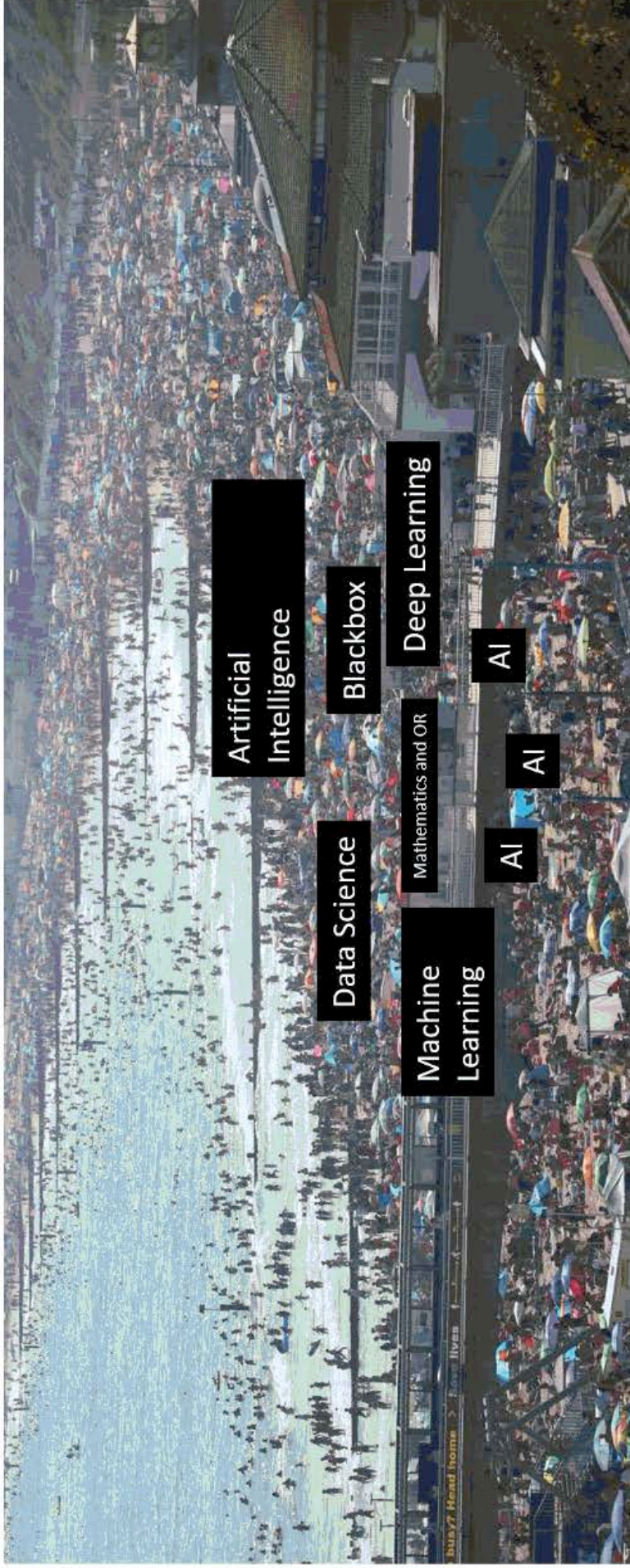


## Game Over for Maths A-level



The combination of ChatGPT with its Wolfram plug-in just scored 96% in a UK Maths A-level paper.

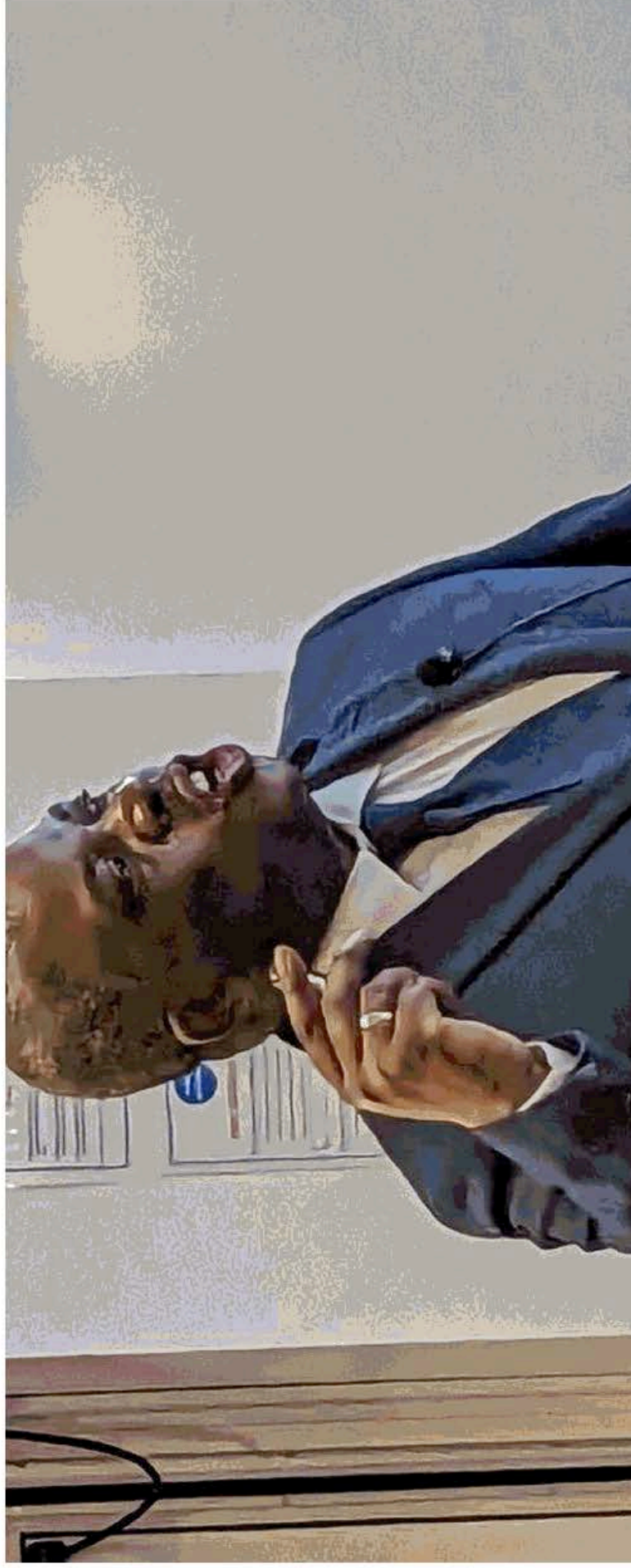
# Is there a danger of being crowded out?



Or can with counter this by thinking more strategically?



My name is... This is my story



I wear many hats



Technical Fellow  
For Mathematical  
Modelling



Past President



Executive Committee



Current President



# The hat I'll wear today

**ATKINS**

Member of the SNC-Lavalin Group

Technical Fellow  
For Mathematical  
Modelling



Past President

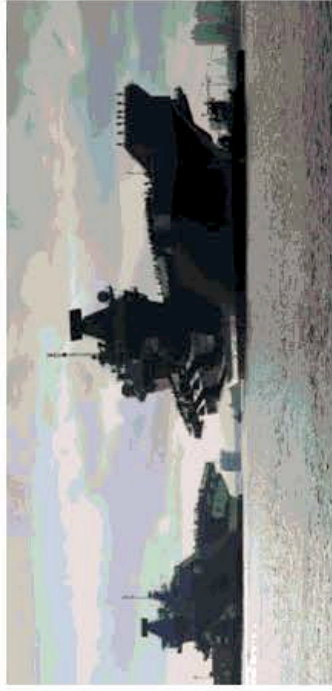


Executive Committee



Current President

# Reflections – mixture of technical and personal opinions based on my experience so far



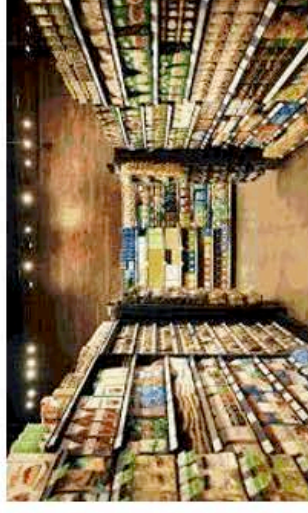
Defence



Energy and Utilities



Automotive



Retail



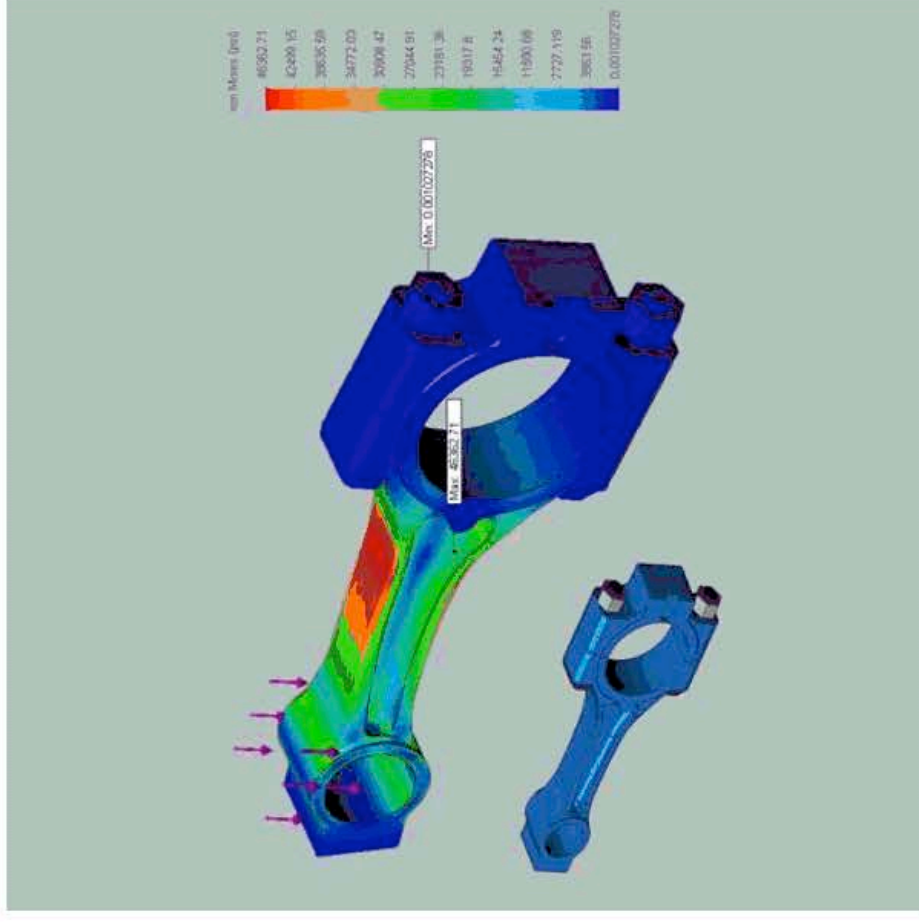


## Question

Did the rise of theoretical physics signal the end of experimental physics?

Did the rise of finite element signal the end of continuous mathematical modelling?

Did the rise of computational fluid dynamics signal the end of fluid dynamics



## Question

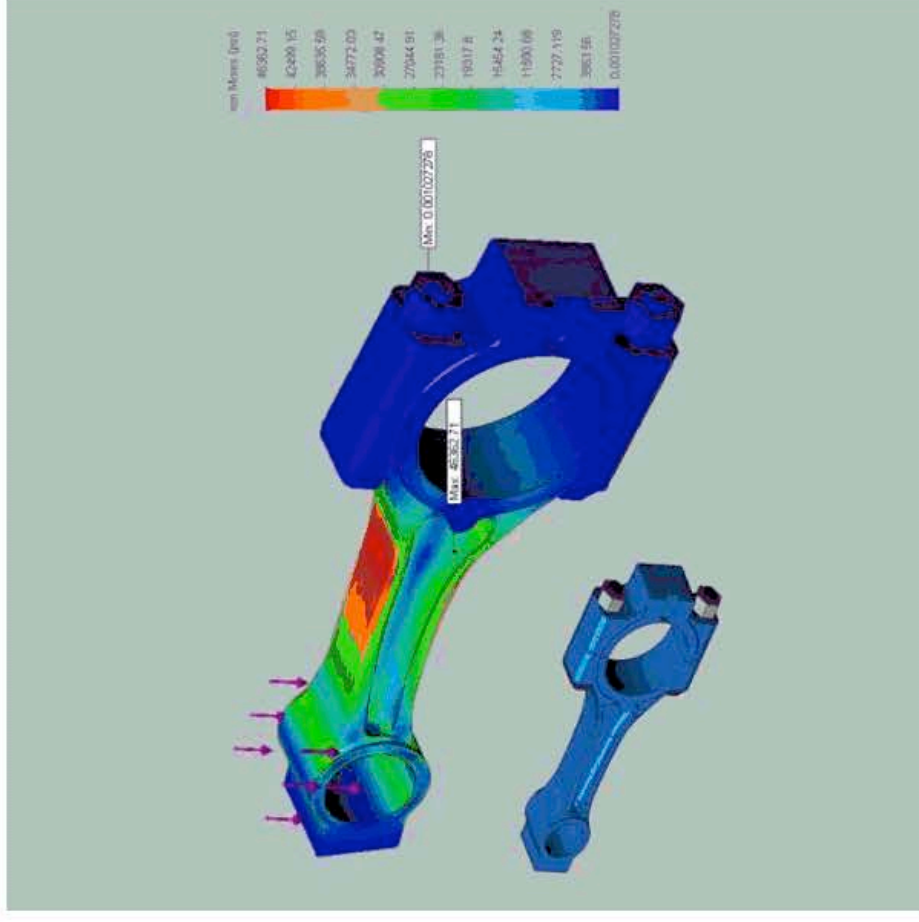
Did the rise of theoretical physics signal the end of experimental physics?

Did the rise of finite element signal the end of continuous mathematical modelling?

Did the rise of computational fluid dynamics signal the end of fluid dynamics

**NO – Both disciplines evolved and enhanced each other**

**Cooperation not competition.**



# Numerical Simulation versus Analytical Approximation

For my PhD

Numerical Simulation was not used to  
replace an Analytical Approximation

but both techniques were used in  
tandem to enhance understanding  
of the problem.

EXTENSION OF THE GAMBLER'S RUIN  
PROBLEM PLAYED OVER NETWORKS

THE THESIS IS SUBMITTED IN PARTIAL FULFILMENT OF  
THE REQUIREMENTS  
FOR THE AWARD OF THE DEGREE DOCTOR OF  
PHILOSOPHY  
OF THE UNIVERSITY OF PORTSMOUTH.

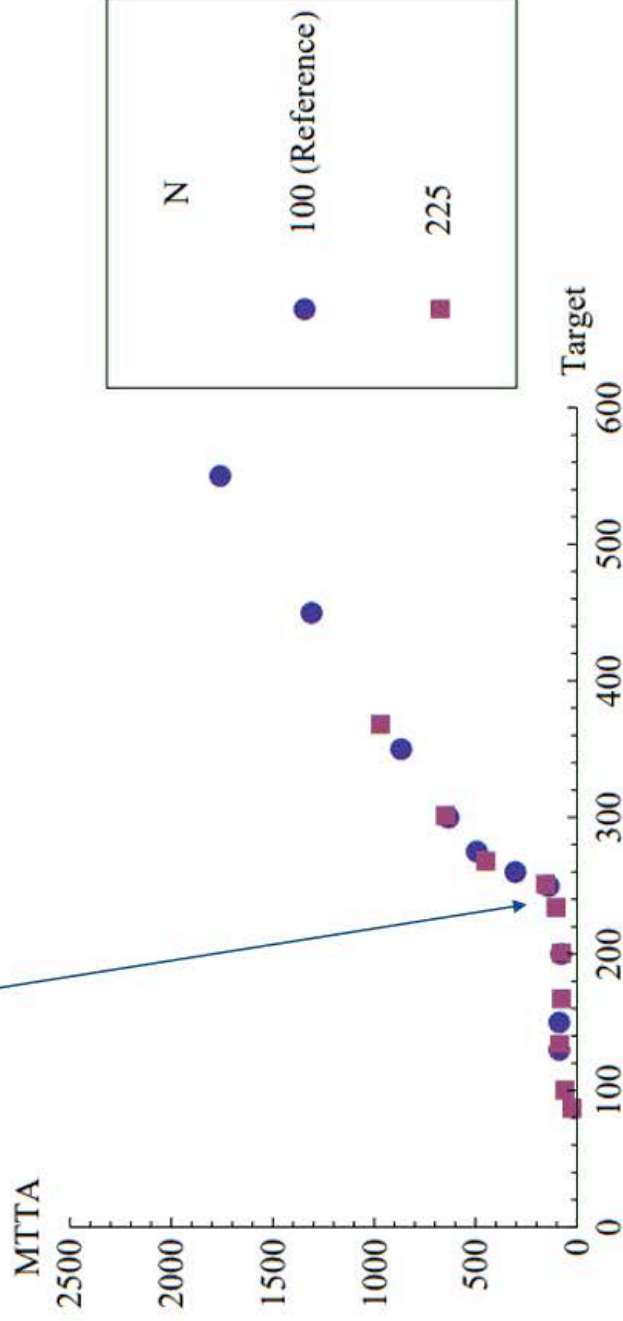
December 30, 2013

By  
Nira Chamberlain

Department of Mathematics



# What influences the position of the Critical target



# Analytical approximation and Numerical Simulation

$$N \frac{I}{T} \times (C - 1) \times k = T - I. \quad (5.3.2)$$

The variables are:

$N$  - the initial size of the network.

$I$  - the initial resources of each player.

$T$  - the target for each player.

$C$  - the number of offspring of an achiever.

$k$  - the degree of the offspring player.

$T - I$  - the estimated size of the kudus population. There is the assumption that

Rearranging the above expression, the critical target can be approximated by:

$$T^* \approx \frac{1}{2} \times \left( I + \sqrt{I^2 + 4 \times N \times I \times (C - 1) \times k} \right). \quad (5.3.3)$$

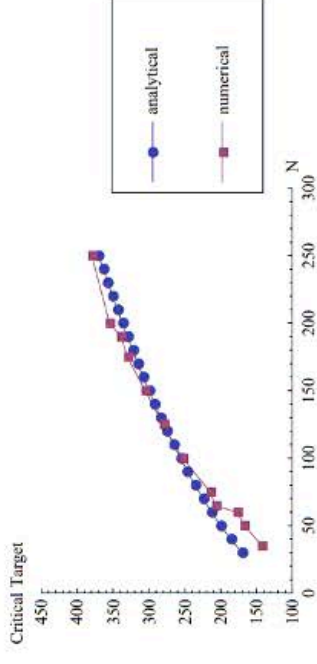


Figure 75: Critical target estimate comparison between the numerical simulation model and the analytical approximation. The initial resource is fixed at 100 units; offspring entrance degree = 2; 10,000 rounds. Result averaged over 50 histories for the numerical simulation.





## Katherine Johnson on the rise and fall of subjects

“We will always have STEM with us. **Some things will drop out of the public eye and will go away**, but there will always be science, engineering, and technology. And there will always, always be mathematics...**[and operational research]**.”



# Artificial Intelligence, ML etc....

In an increasing Data Driven world  
this very much in the public eye and  
will continue to be so....

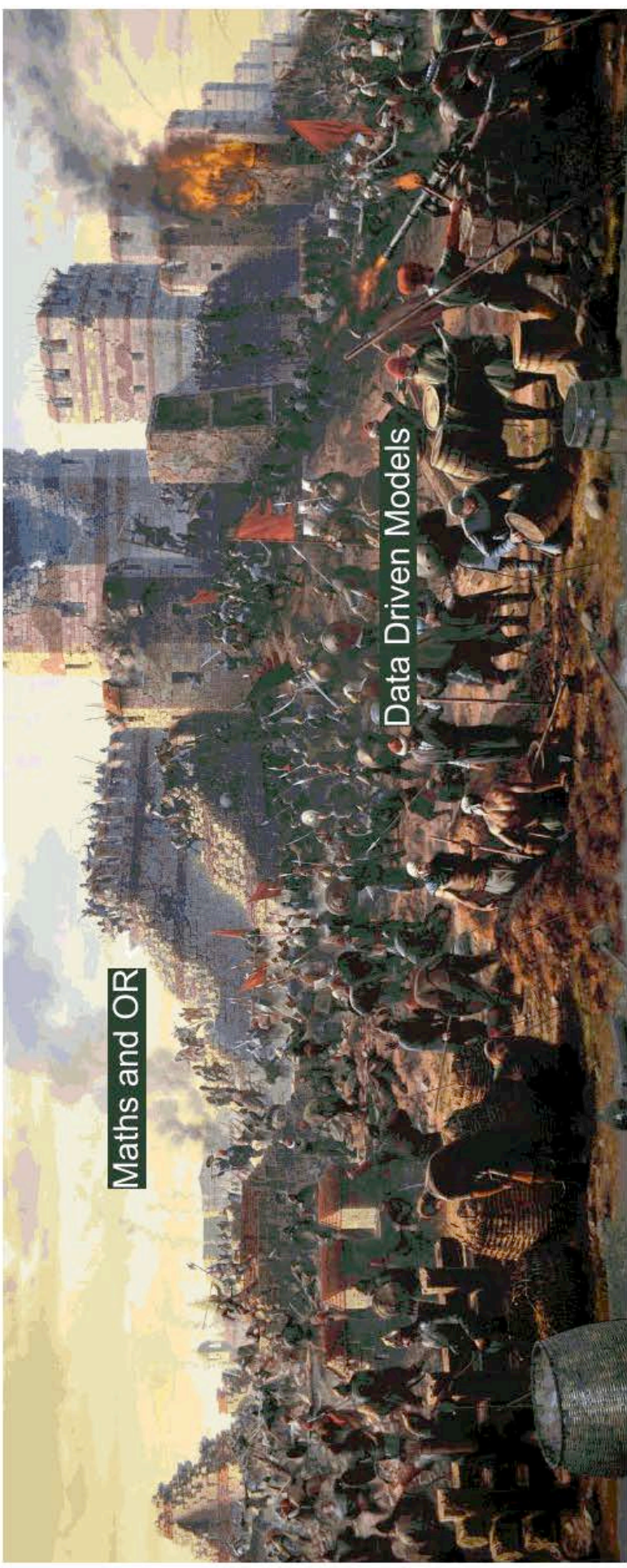


# Artificial Intelligence, ML etc....

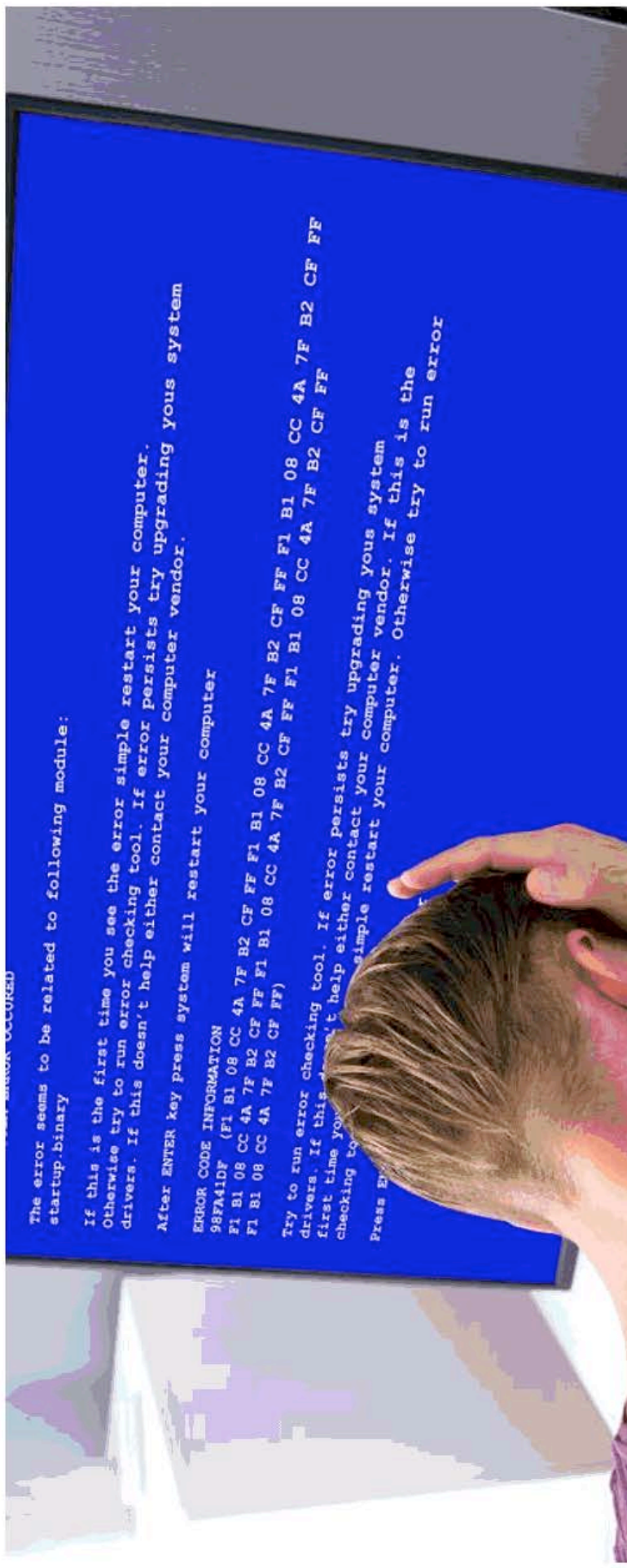
It is powerful and its potential  
is immense!



# If our subjects fall – what could happen?



# Possibility of Future Real World Applications not being Sustainable



## Warning: When the maths can no longer sustain an application Lesson Learnt from the World of Engineering



Many Engineering applications use Mathematics and OR in the right way.

However, when we remove scientific and mathematical foundations in some cases, it could lead to **compromising and/or corruption of the solution.**



## The story of the Reynold's Equation

$$\frac{\partial}{\partial x} \left( \frac{\rho h^3}{12\mu} \frac{\partial p}{\partial x} \right) + \frac{\partial}{\partial y} \left( \frac{\rho h^3}{12\mu} \frac{\partial p}{\partial y} \right) = \frac{\partial}{\partial x} \left( \frac{\rho h (u_a + u_b)}{2} \right) + \frac{\partial}{\partial y} \left( \frac{\rho h (v_a + v_b)}{2} \right) + \rho (w_a - w_b) - \rho u_a \frac{\partial h}{\partial x} - \rho v_a \frac{\partial h}{\partial y} + h \frac{\partial \rho}{\partial t}$$



Osbourne Reynolds



Piston Dynamics & Lubrication

Personally saw cases where the mathematical and scientific principles were abandoned and the solution were bent and twisted to fit the customer's desired outcome.

$$Load = \iint p(x, y) dx dy$$



# The story of the Reynold's Equation

$$\frac{\partial}{\partial x} \left( \frac{\rho h^3}{12\mu} \frac{\partial p}{\partial x} \right) + \frac{\partial}{\partial y} \left( \frac{\rho h^3}{12\mu} \frac{\partial p}{\partial y} \right) = \frac{\partial}{\partial x} \left( \frac{\rho h (u_a + u_b)}{2} \right) + \frac{\partial}{\partial y} \left( \frac{\rho h (v_a + v_b)}{2} \right) + \rho (w_a - w_b) - \rho u_a \frac{\partial h}{\partial x} - \rho v_a \frac{\partial h}{\partial y} + h \frac{\partial \rho}{\partial t}$$



Osbourne Reynolds

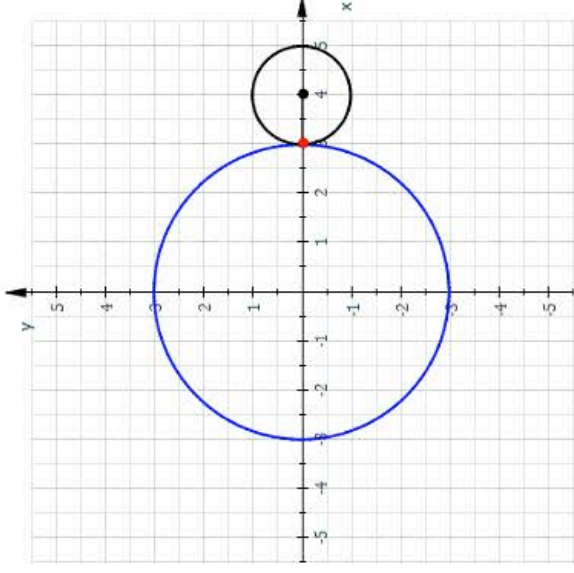
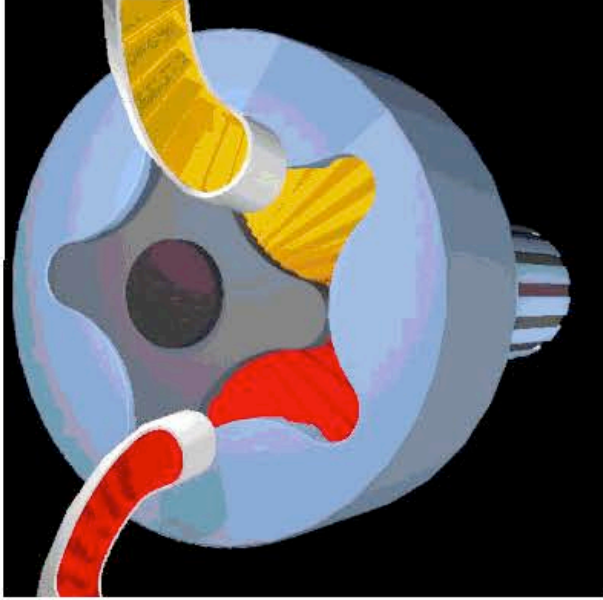


Piston Dynamics & Lubrication

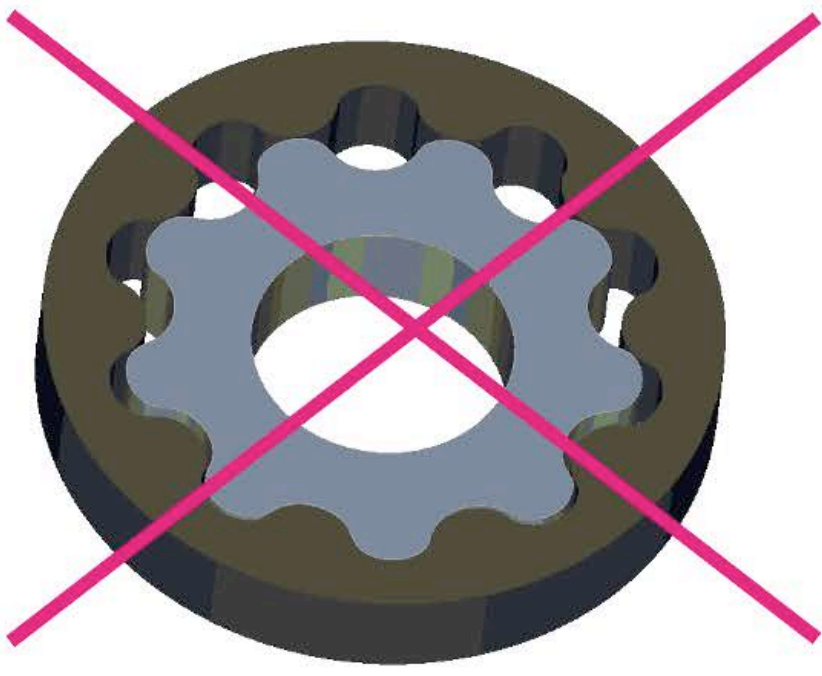
Personally saw cases where the mathematical and scientific principles were abandoned and the solution were bent and twisted to fit the customer's desired outcome.

$$Load = 100 \times \iint p(x, y) dx dy$$

# Designing a Gerotor and the misuse of Vector analysis



$$x(\theta) = r(k+1)\cos\theta - r\cos((k+1)\theta)$$
$$y(\theta) = r(k+1)\sin\theta - r\sin((k+1)\theta).$$



# The science of better decision making in a complex world

## OPERATIONS RESEARCH: THE SCIENCE OF BETTER®

TIME-STARVED EXECUTIVES ARE MAKING BOLDER DECISIONS WITH LESS RISK AND BETTER OUTCOMES. THEIR SECRET: OPERATIONS RESEARCH.

WHAT'S YOUR TOUGHEST, MOST COMPLEX PROBLEM?  
RECOVERING FASTER

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### OPERATIONS RESEARCH:

Lucent Technologies makes major strides in inventory management. Lucent Technologies strives to fill customer orders quickly, reliably, and economically while coping with the uncertainty inherent in forecasting. Using operations research, Lucent developed an inventory requirements planning system to track inventory of parts, avoid bottlenecks, and maintain tip service. The company saved \$55 million at one plant alone.

## The Science of Better

Using Professor G. Keith Still's principles there are three Modelling Outcomes:



# THE BIGGEST OPTIMISATION PROJECT IN THE WORLD

Prof Dr. G. Keith Still

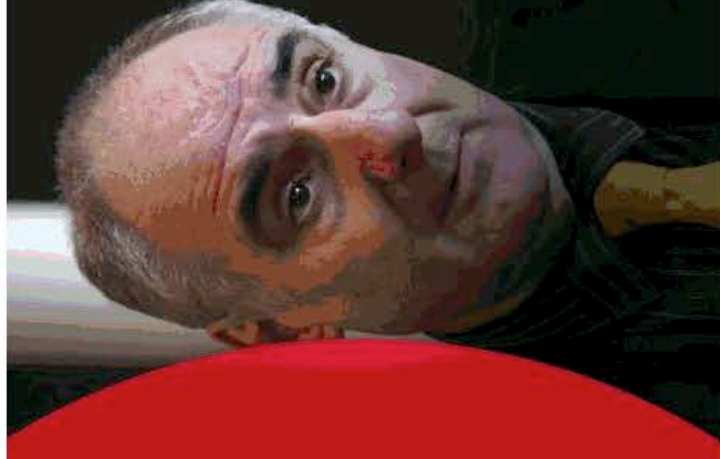
## The Science of Better

Using Professor G. Keith Still's principles there are three Modelling Outcomes:

To understand

# THE BIGGEST OPTIMISATION PROJECT IN THE WORLD

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## The Science of Better

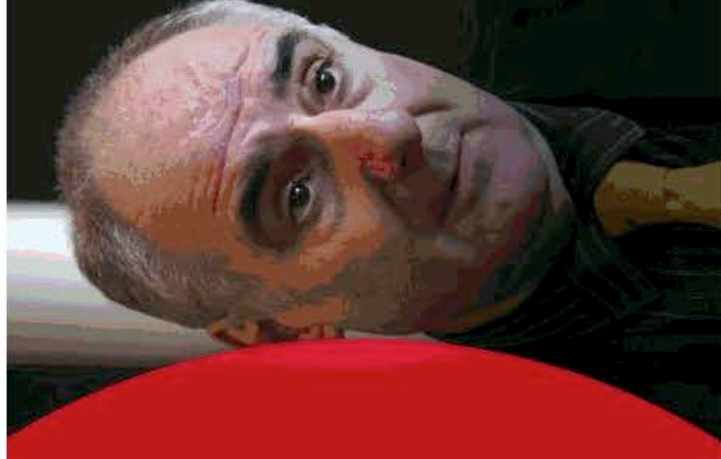
Using Professor G. Keith Still's principles there are three Modelling Outcomes:

To understand

To predict

# THE BIGGEST OPTIMISATION PROJECT IN THE WORLD

Prof Dr. G. Keith Still



## The Science of Better

Using Professor G. Keith Still's principles there are three Modelling Outcomes:

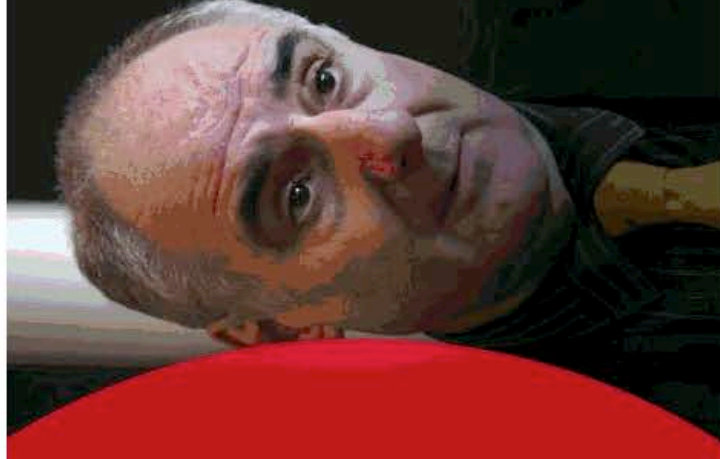
To understand

To predict

To influence

# THE BIGGEST OPTIMISATION PROJECT IN THE WORLD

Prof Dr. G. Keith Still



## But for certain Data-driven methodologies

Using Professor G. Keith Still's principles there are three Modelling Outcomes:

~~To understand~~

To predict

To influence

# THE BIGGEST OPTIMISATION PROJECT IN THE WORLD

Prof Dr. G. Keith Still



## Using a Data Driven AI Tool that predicts, influences but we do not understand the problem

Involves a lot of calculations.

These calculations can go into many layers of depth with different numbers and combinations of numbers carrying various meanings.



- > Answer questions concerning job and career choices
- > Offer in-depth personal analysis of personality and behaviour patterns
- > Discuss the trend of events to come
- > Assist with personal growth and self-evaluation
- > Propose a selection of dates for special events
- > Help to choose a professional name, business name, or stage name



# No it is a Numerology Tool!



- > Answer questions concerning job and career choices
- > Offer in-depth personal analysis of personality and behaviour patterns
- > Discuss the trend of events to come
- > Assist with personal growth and self-evaluation
- > Propose a selection of dates for special events
- > Help to choose a professional name, business name, or stage name

# Prediction without Understanding

## Data Driven Modelling

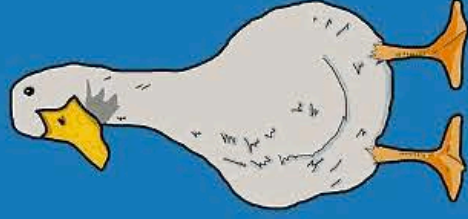
1. Collect data
2. Make Predictions
3. To Influence Outcome

## Numerology

1. Collect Data
2. Make Predictions
3. To influence Outcomes



If it looks like a duck, swims like a duck, and quacks like a duck, then it probably is a duck.



In an increasing Data Driven World  
which direction do we wish to move  
more towards



# Blackbox or being just Blind



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Member of The SNC-Lavalin Group



# Blackbox or being just Blind

“Machine Learning  
algorithms are the  
Modern-day Prophet?”

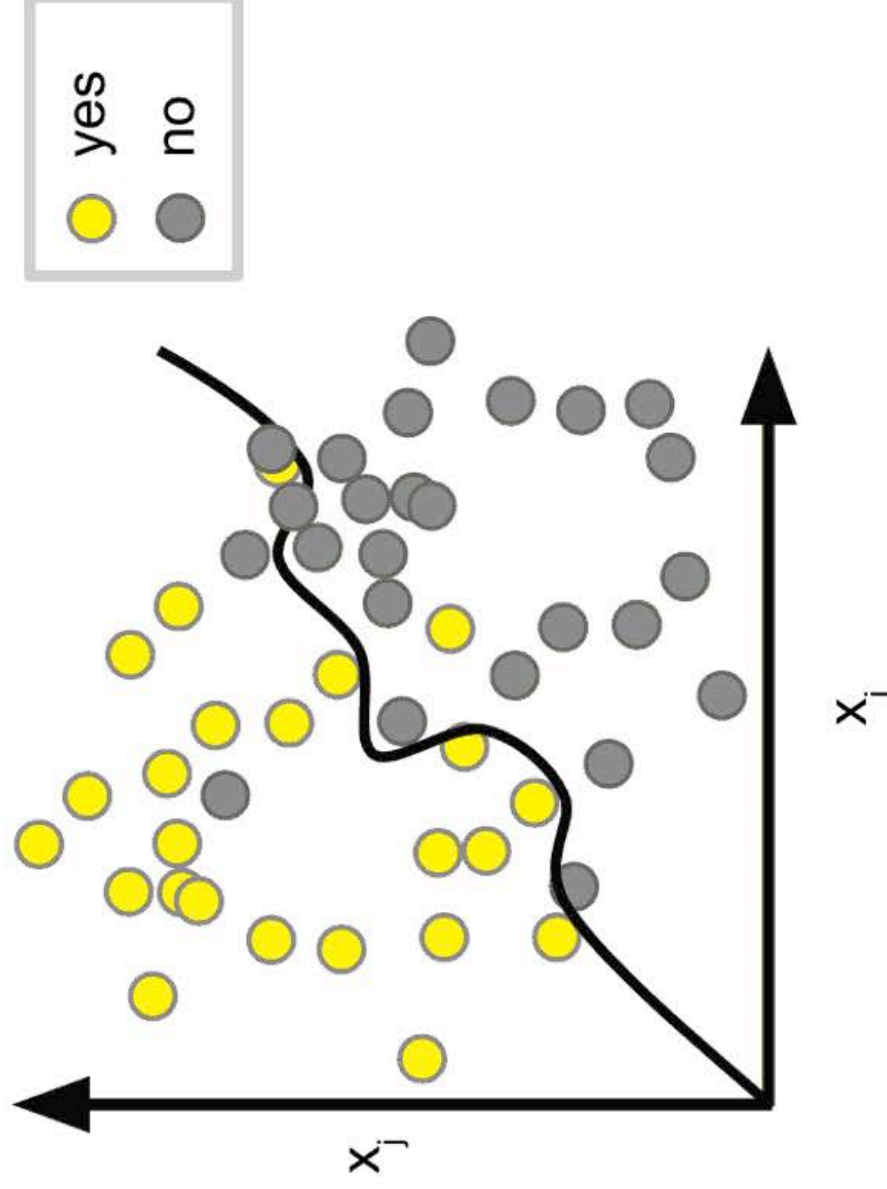


## Classifications

Retail Business Blackbox advocate wanted to use a new AI algorithm to do classifications

Challenge – I understood the underlying mathematics I wasn't sure that the objectives were achievable

Decided to run with the AI algorithm but undertake a statistical test of the results



# Carl Friedrich Gauss



Carl Friedrich Gauss

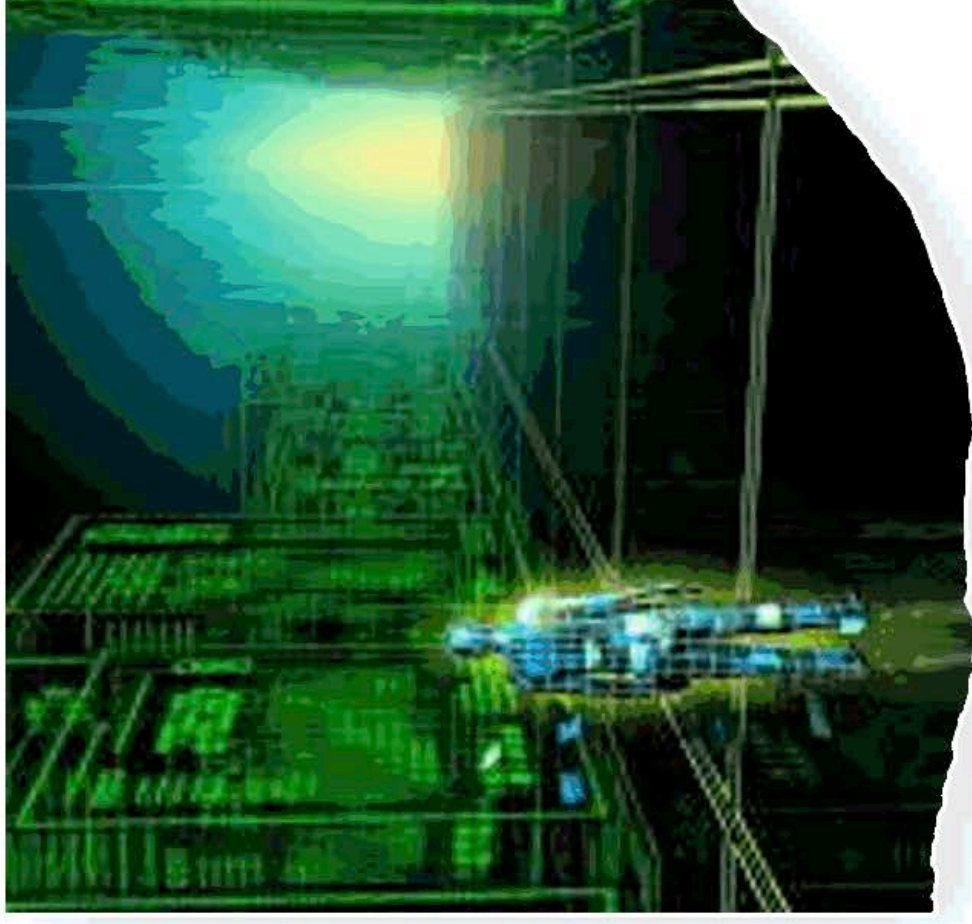
“Well Gauss is wrong!”  
- Machine Learning Expert



## In an Increasing Data-Driven World

The role of OR and Mathematical  
modelling is not to decline

NO

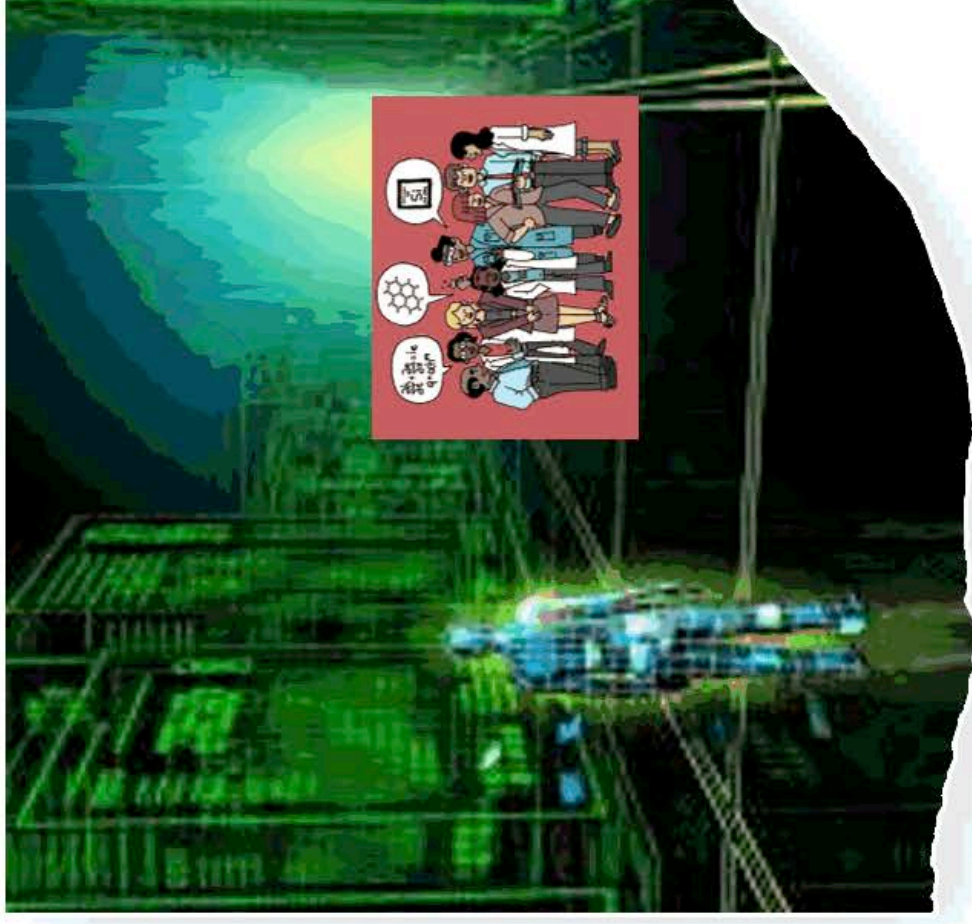


## In an Increasing Data-Driven World

The role of OR and Mathematical  
modelling is not to decline

NO

But to become the Strategic Modellers  
and the Scientists in the room!



# May 2017 - When AlphaGo beat the Go World Champion

**Everybody talked about  
the Deep Learning –  
Artificial Neural  
Network algorithm**



## May 2017 - When AlphaGo beat the Go World Champion

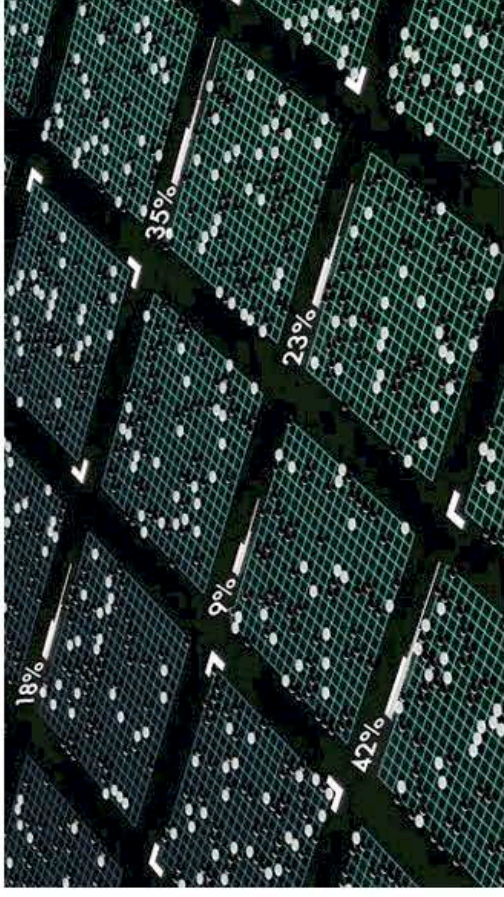
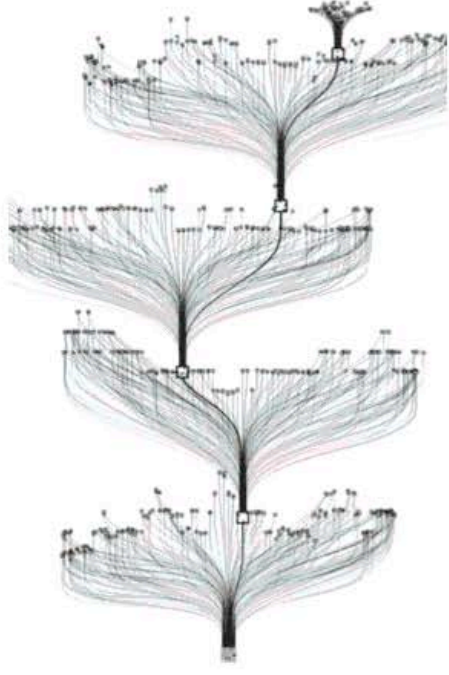
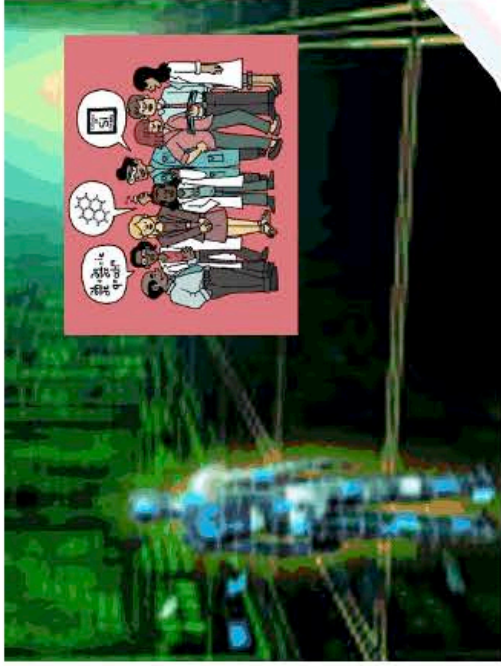
**Everybody talked about the Deep Learning – Artificial Neural Network algorithm**

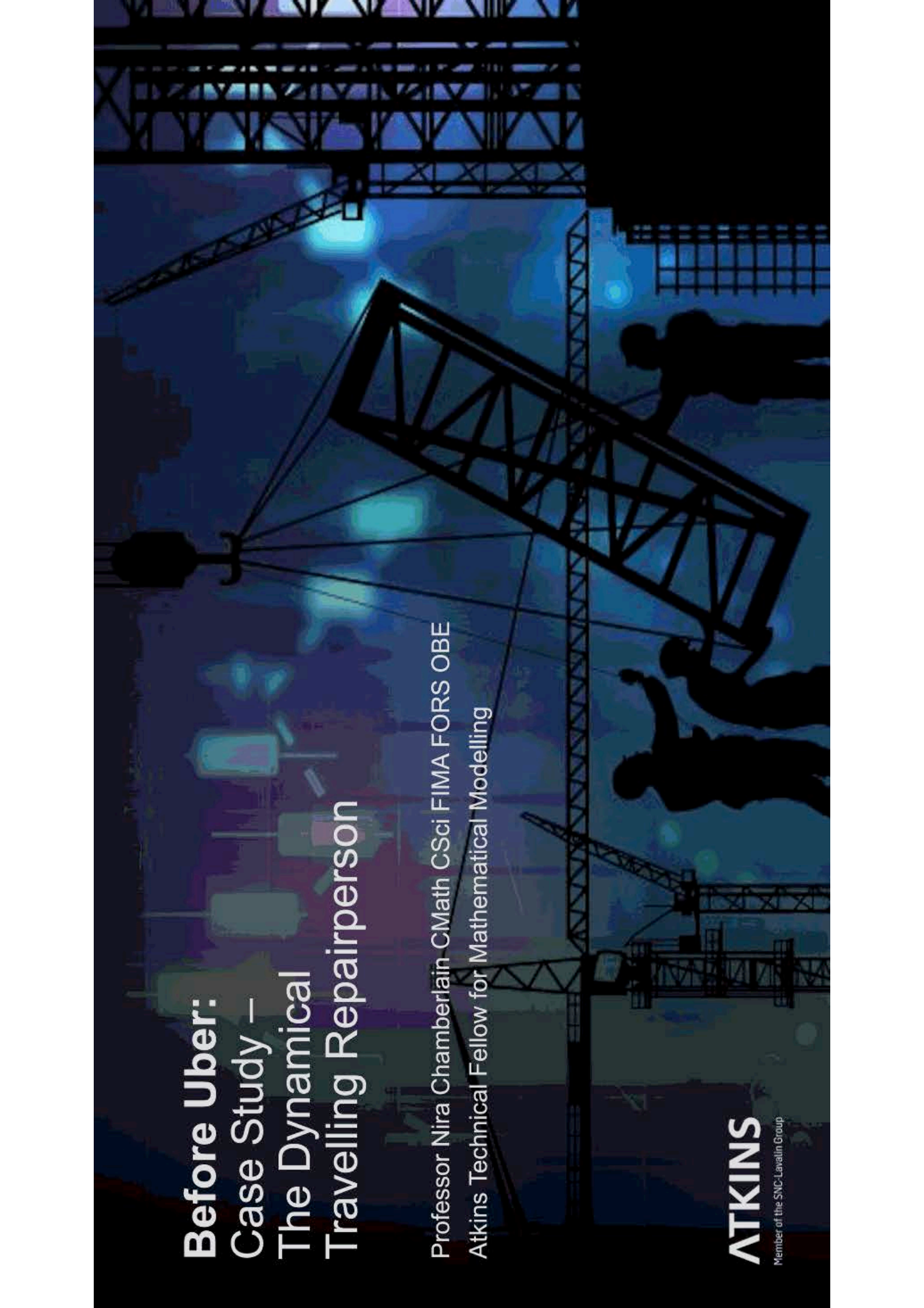
**But what about the OR modelling that was also part of the algorithm?**



# Monte-Carlo Tree Search

It would have been near impossible for AlphaGo to beat the World Champion purely on Machine Learning and **without OR mathematical algorithm**





# Before Uber: Case Study – The Dynamical Travelling Repairperson

Professor Nira Chamberlain CMath CSci FIMA FORS OBE  
Atkins Technical Fellow for Mathematical Modelling

**ATKINS**

Member of the SNC-Lavalin Group

## Before Uber – The Contract

The contract stipulates that 80% of problem that occurs any where in the world must be resolved within 48 hours



## Before Uber - Question

How many Engineers do we need in order to reach a problem any where in the globe within 48 hours and where should they be located?



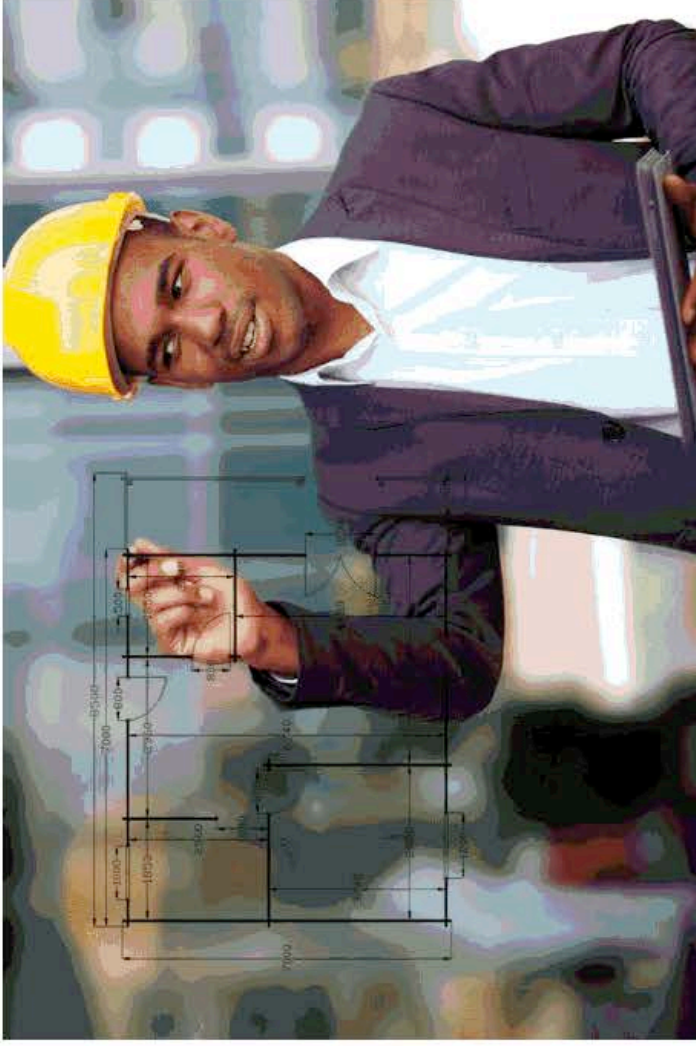
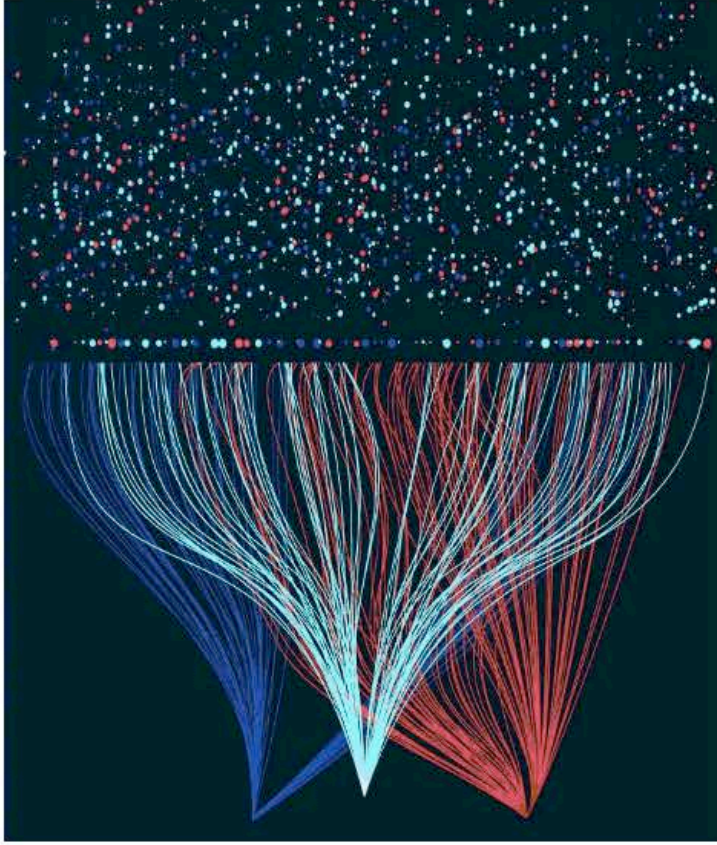
## Before Uber - Question

How many Engineers do we need in order to reach a problem any where in the globe within 48 hours and where should they be located?

**The answer is not infinity and everywhere!**



# After Uber – Hidden Pattern



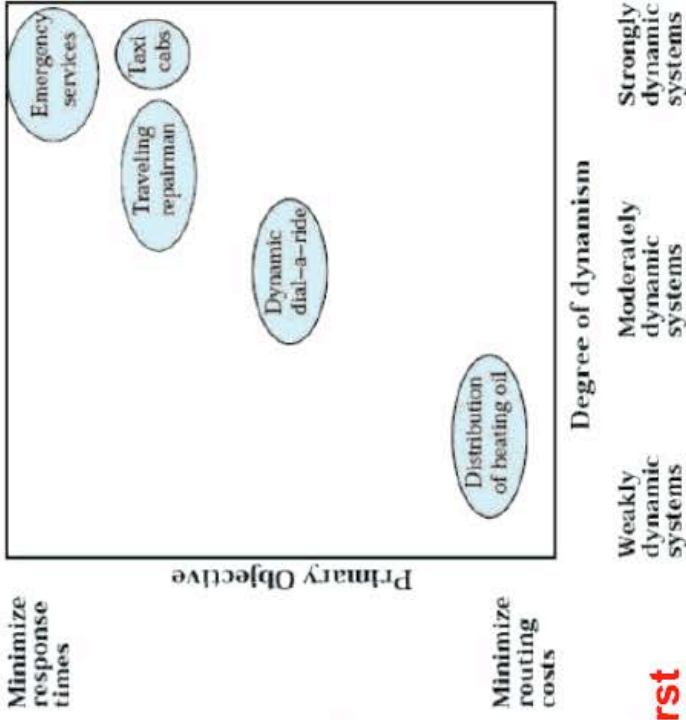
# Before Uber – The Hidden Logic

## The Dynamic Travelling Repairperson



# The Dynamic Repairperson Problem

Variation on the Travelling Salesperson Problem  
Looking to minimize time as oppose to distance.



## The Rule

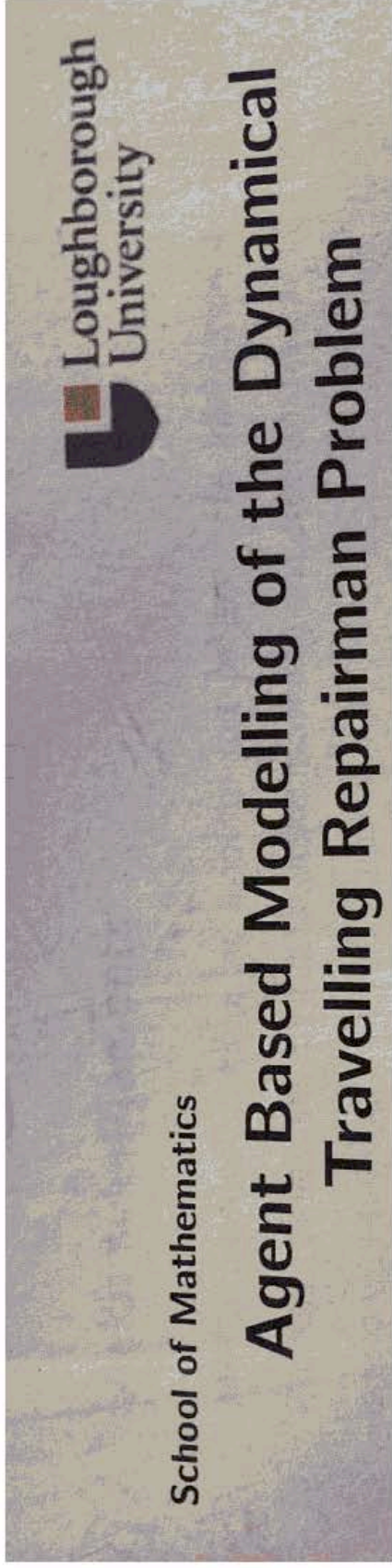
**The Engineer out of all the Engineers who can start the job first gets the job!**

# Before Uber – Hidden Logic

A finishes first  
 Time to finish (I) =  $f$  (Finish current job)  
 Time to finish (II) =  $(A_0[DepI] - 1) * MeanTime$   
 After A has left he has to go to I  
 Dynamical Array is  $\begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$   
 Next at time 4 another fault occurs at deployment  
 First question are there any unassigned issues at deployment I  
 $A_0(I) + B_0(I) > 0$  If the driver left  
 Found out who is there or is going there  
 It's A hence  $A_0[I] = A_0[I] + 1$   
 Time to finish (II) =  $f$  (Finish current job)  
 Dynamical Array  $\begin{bmatrix} 1 & 0 & 0 \\ 1 & 0 & 0 \end{bmatrix}$   
 Hence B will be sent

All fault comes in and must be resolved  
 At time 4 a fault occurs at I  
 A finishes  $A_0 = \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix}$   
 B finishes  $B_0 = \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix}$   
 It takes S hours for A to get to I  
 A finishes  $A_0 = \begin{bmatrix} 1 & 1 \\ 2 & 3 \\ 3 & 4 \\ 4 & 5 \\ 5 & 6 \end{bmatrix}$   
 Mean time to finish to finish

## Inspired MSc Projects

The slide features a textured, light-colored background. At the top left is the Loughborough University logo, which consists of a stylized 'U' with a red and blue square above it, followed by the text 'Loughborough University'. Below the logo, the text 'School of Mathematics' is centered. The main title, 'Agent Based Modelling of the Dynamical Travelling Repairman Problem', is centered and written in a large, bold, black font.

Loughborough  
University

School of Mathematics

**Agent Based Modelling of the Dynamical  
Travelling Repairman Problem**

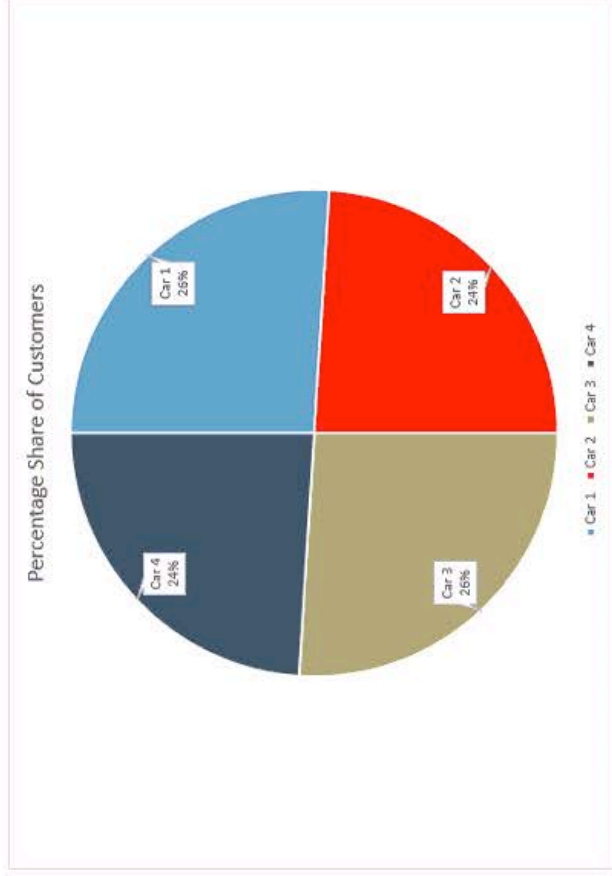
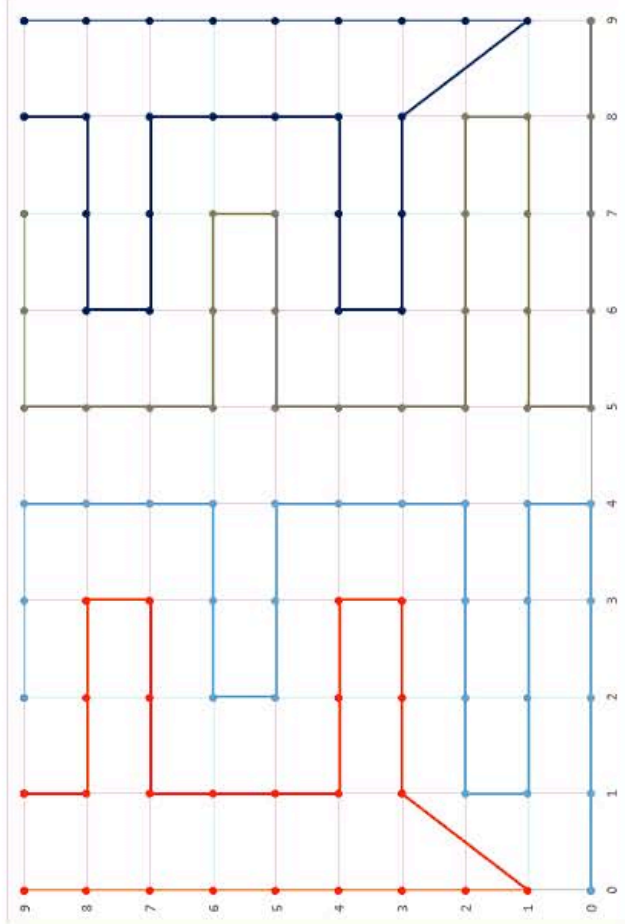
# Outreach

Status	Car 1	Car 2	Car 3	Car 4
Shift start	12	12	12	12
Base X location	0	0	9	9
Base Y location	0	9	0	9

Timestart	
0	

Simulation

Reset



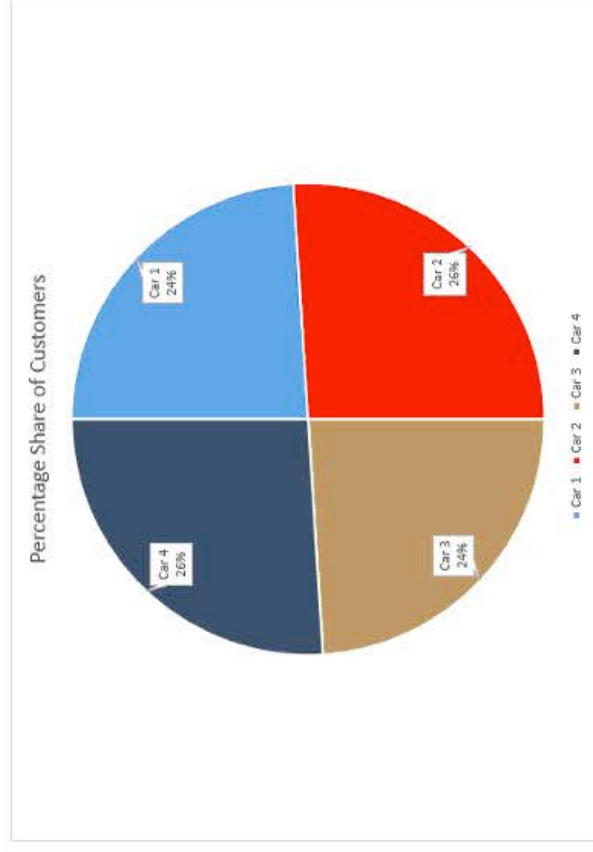
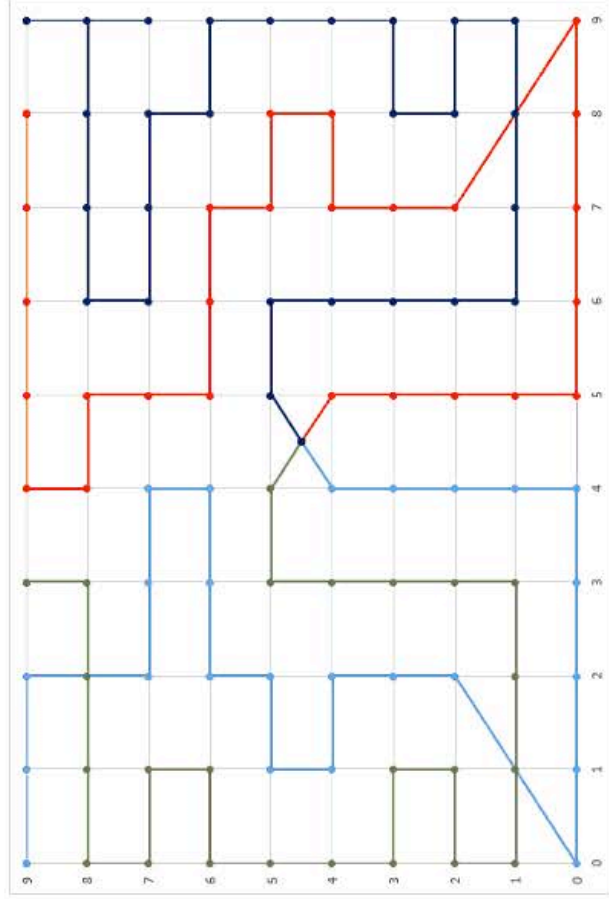
# Outreach

Status	Car 1	Car 2	Car 3	Car 4
Shift start	12	12	12	12
Base X location	4.5	4.5	4.5	4.5
Base Y location	4.5	4.5	4.5	4.5

Timestart	
0	

Simulation

Reset



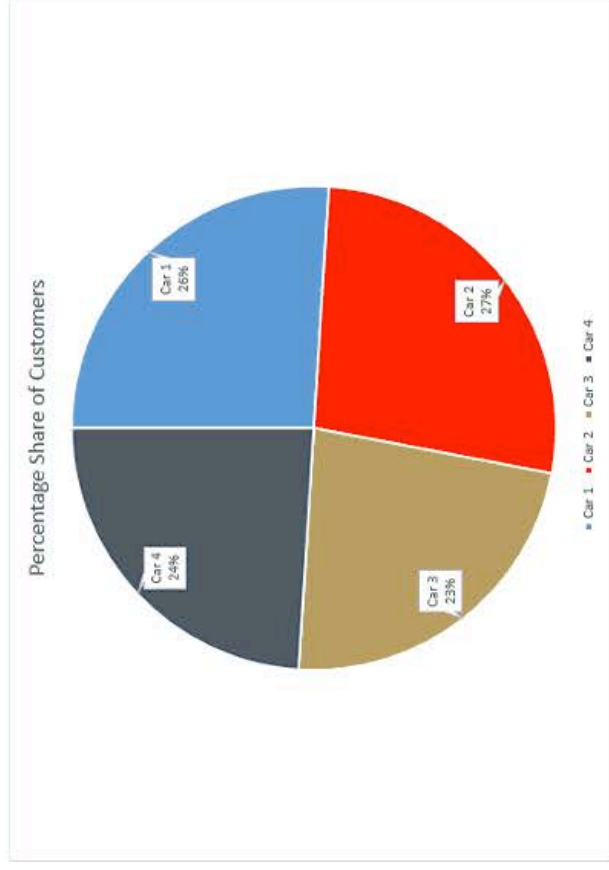
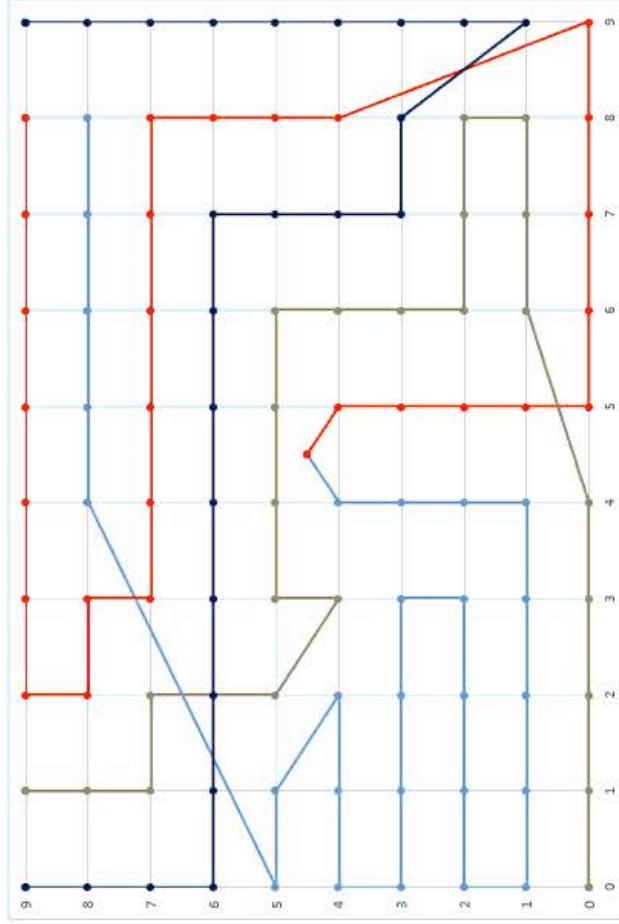
# Outreach

Status	Car 1	Car 2	Car 3	Car 4
Shift start	12	12	12	12
Base X location	4.5	4.5	0	9
Base Y location	4.5	4.5	0	9

Timestart	
0	

Simulation

Reset



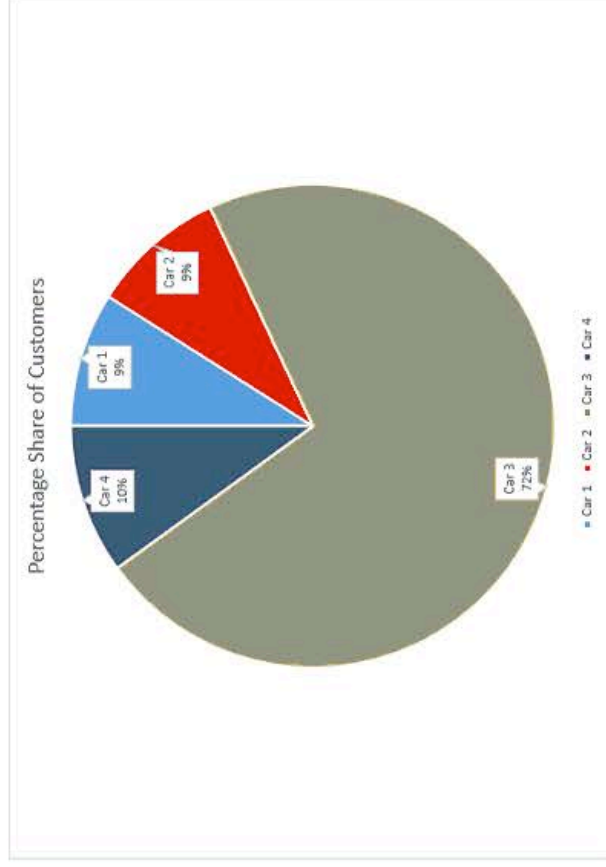
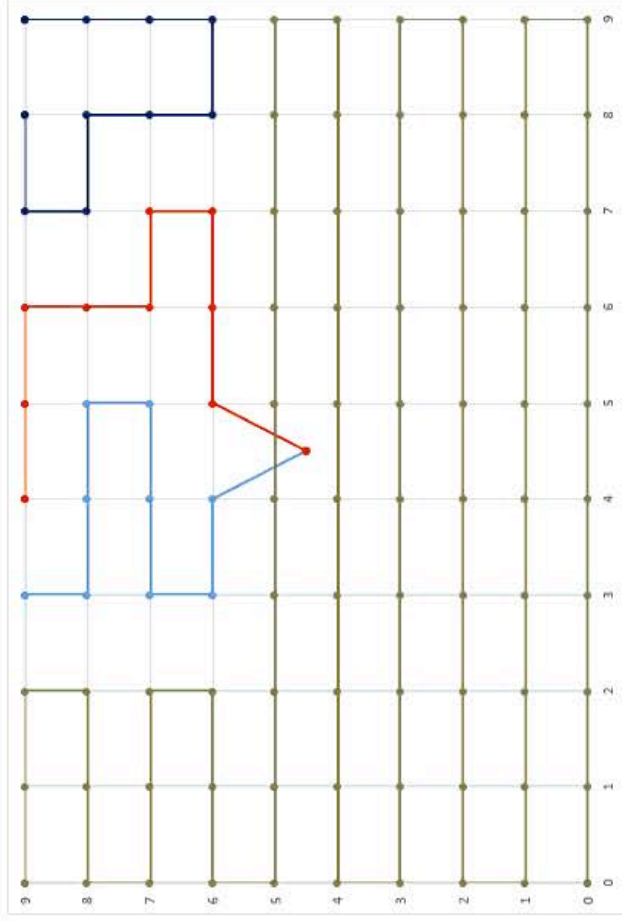
# Outreach

Status	Car 1	Car 2	Car 3	Car 4
Shift start	12	12	10	12
Base X location	4.5	4.5	0	9
Base Y location	4.5	4.5	0	9

Timestart	
0	

Simulation

Reset



# Agent Based Simulation and Visualisation of Emergency Relief Effort Strategies

By Dr Nira Chamberlain



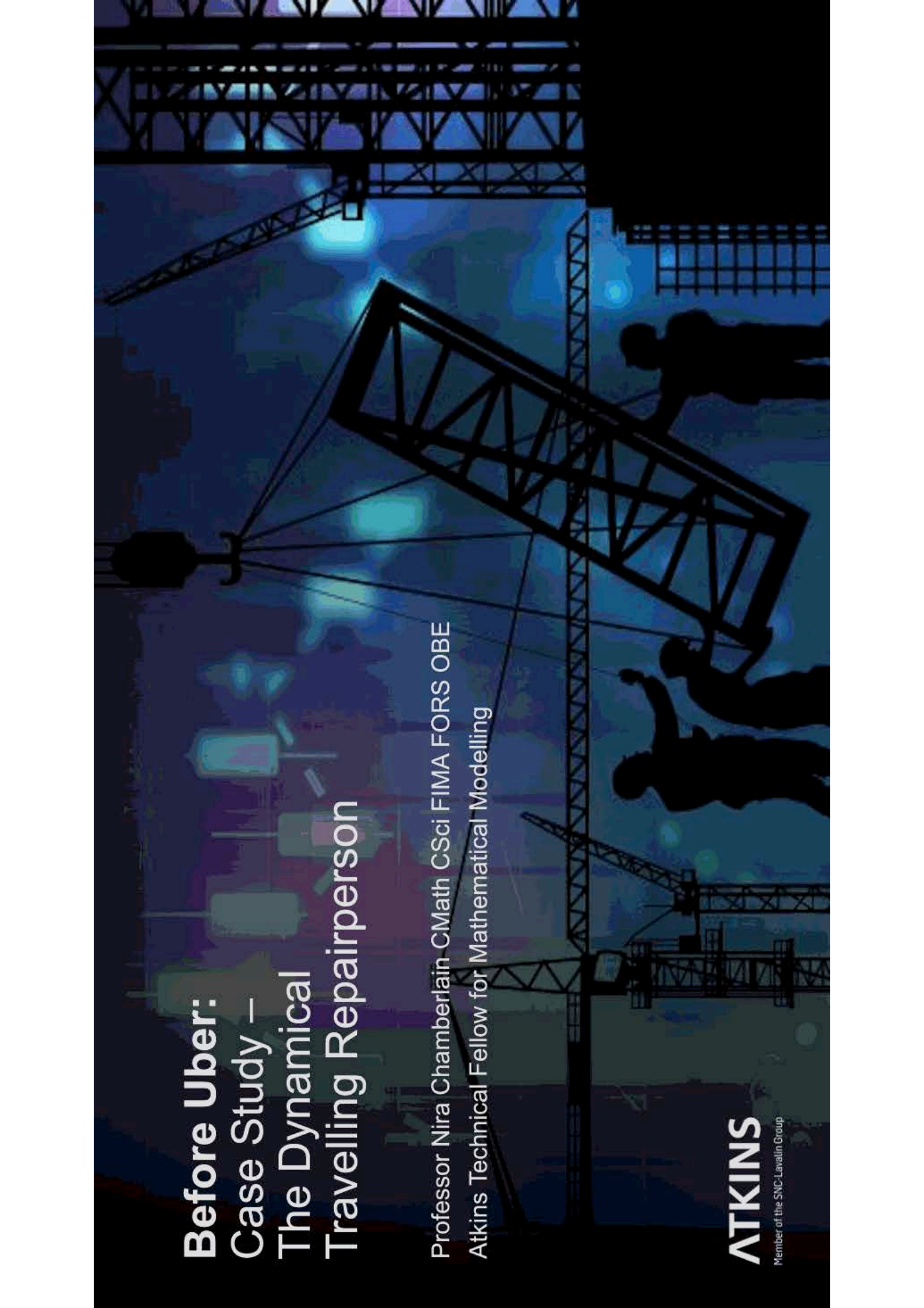
## Before Uber - Question

How many Engineers do we need in order to reach a problem any where in the globe within 48 hours and where should they be located?









# Before Uber: Case Study – The Dynamical Travelling Repairperson

Professor Nira Chamberlain CMath CSci FIMA FORS OBE  
Atkins Technical Fellow for Mathematical Modelling

**ATKINS**

Member of the SNC-Lavalin Group

# Alliance for Data Science Professionals

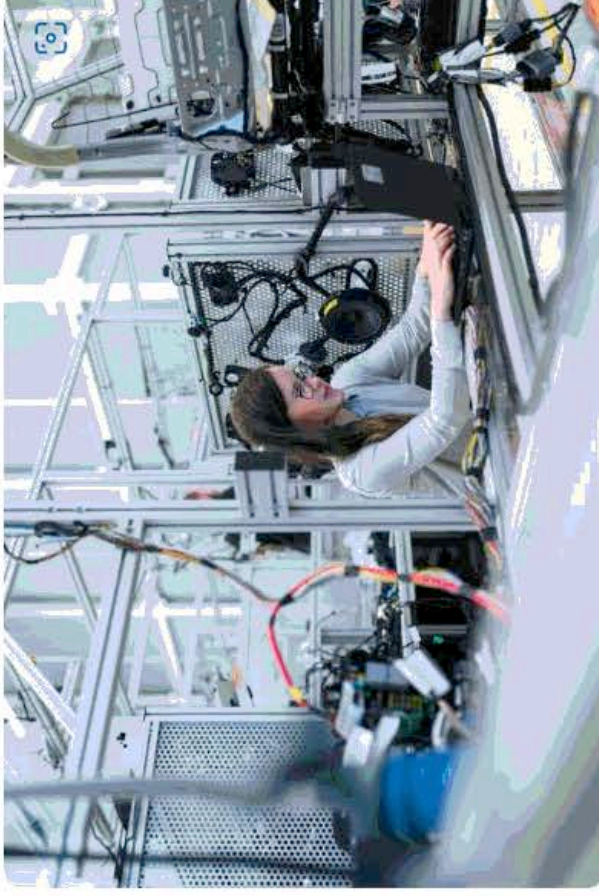
We are defining the standards needed to ensure an ethical and well-governed approach so the public, organisations and governments can have confidence in how their data is used.



## Get yourself certified

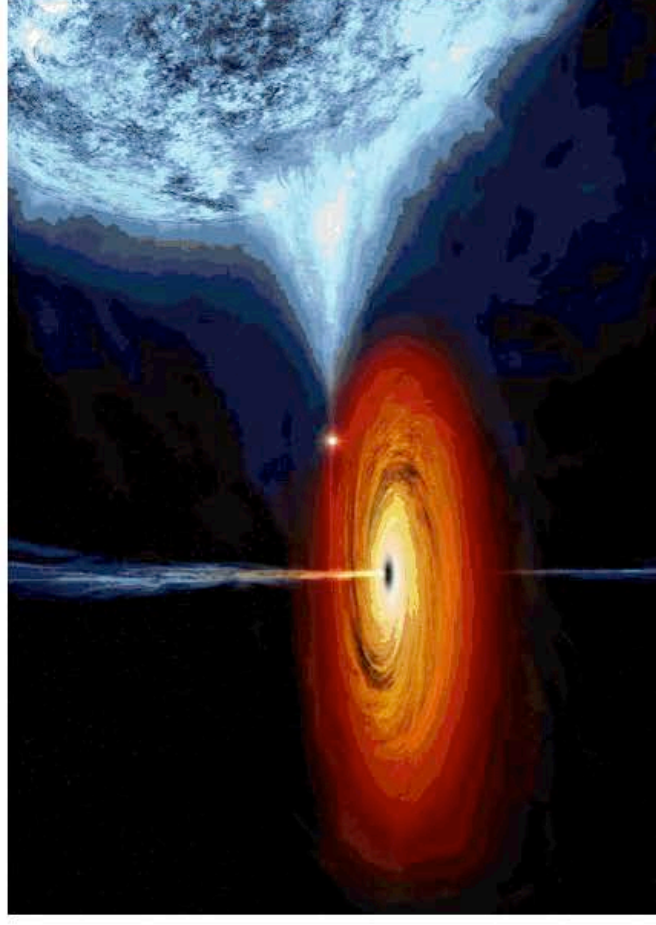
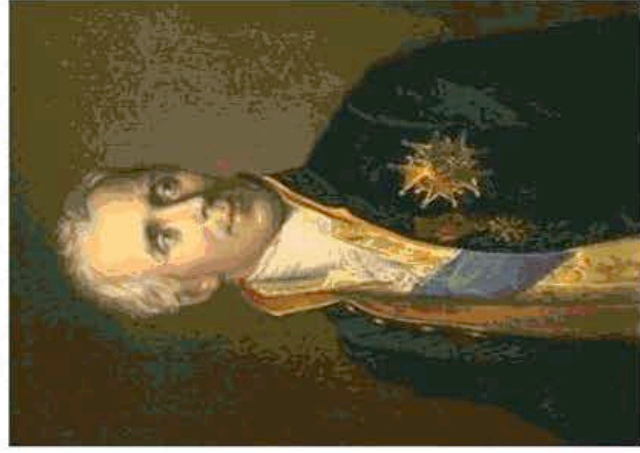
### We are committed to...

- ✓ Defining the standards of professional competence and behaviour expected of people who work with data which impacts lives and livelihoods. These currently include data scientists, data engineers, data analysts and data stewards.
- ✓ Delivering these standards as data science certifications offered by the Alliance members to their professional members, with processes to hold certified members accountable for their professional status in this area.



# Threat of AI – is the Deskilling of Present and Future Modellers

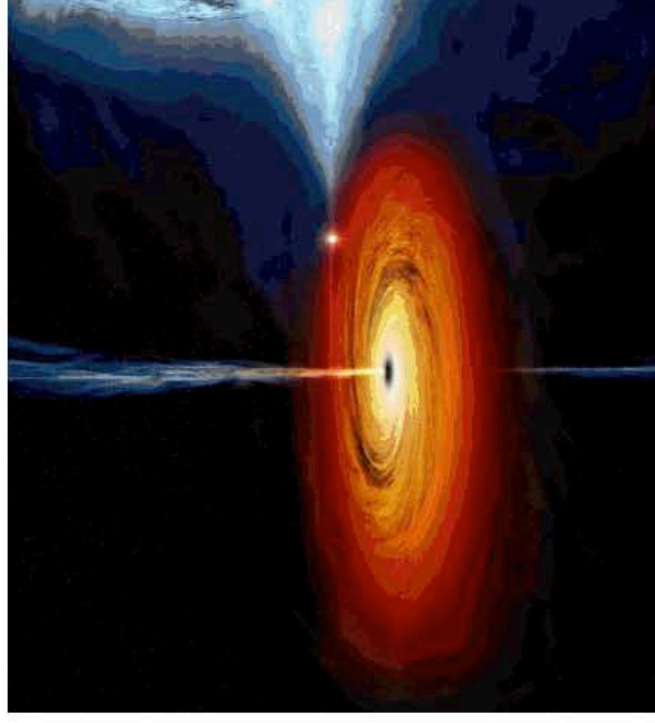
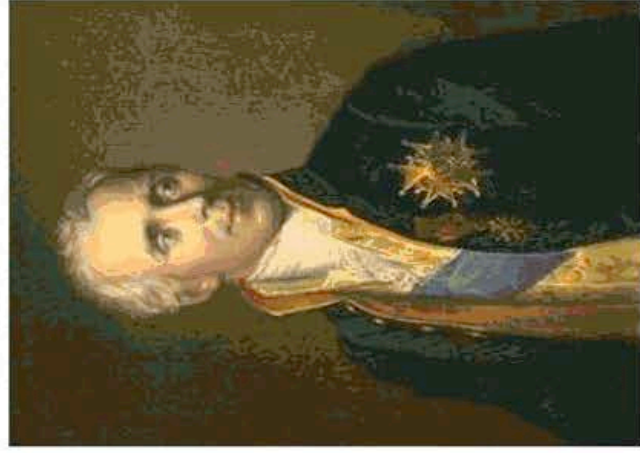
Pierre-Simon Laplace



Without a Computer, Laplace found the Hidden Logic

# Threat of AI – is the Deskilling of Present and Future Modellers

Pierre-Simon Laplace



But by focusing purely on the Hidden Pattern (AI) do we risk throwing the baby out with the bath water!



# The Ronnie Shephard Memorial Address Before Uber:

Professor Nira Chamberlain CMath CSci FIMA FORS OBE  
Atkins Technical Fellow for Mathematical Modelling

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