

# BCS Cumbria

AI Presentation  
16<sup>th</sup> May 2019

# Introductions

- Steve Lawless – CEO Purple Griffon

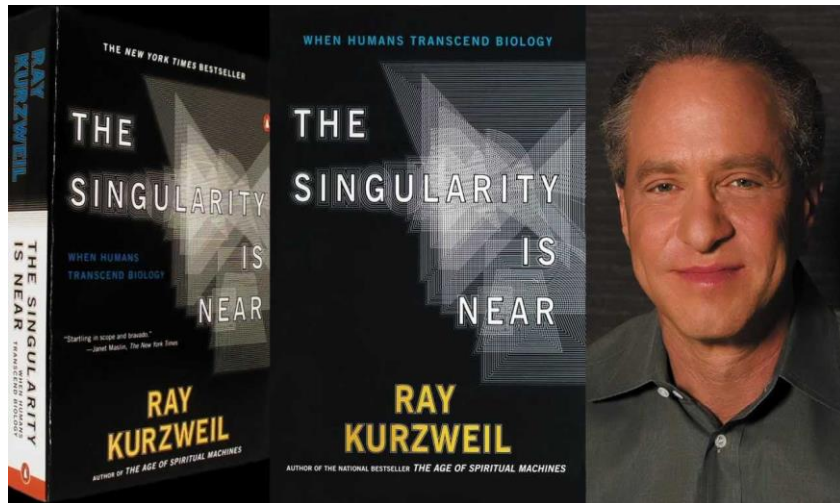


- Dr Andy Lowe – Artificial Intelligence SME



# How the idea started

Blame... Ray Kurzweil (The father of AI) and Kendal Snowsports Club



# What we are going to cover...

What actually is Artificial Intelligence?

Separating the hype from the facts

A look at some current practical uses of AI

Why we all need training in AI

How organisations can get started and use AI

Why AI Ethics and sustainability is so important

What the future holds for humans and AI

Q&A



What actually  
is Artificial  
Intelligence?

# JOURNEY HOME - SO WHAT!

1. The Fourth Industrial Revolution will make us re-imagine every aspect of life.
2. It's about 'learning from experience' – Building Intelligent Entities
3. It is NOT a Silver Bullet.
4. Machine Learning needs good quality DATA and good algorithms.

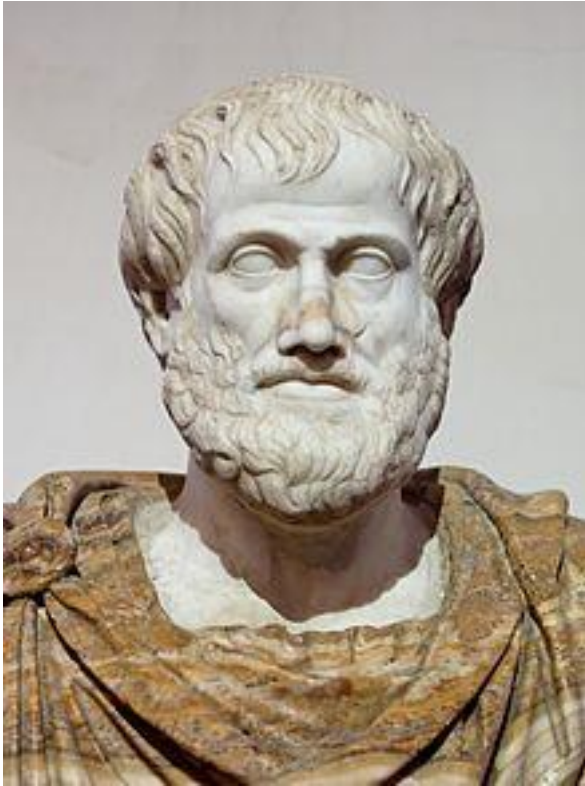
# Dictionary Definition of Intelligence – IQ & EQ

- The Concise Oxford Dictionary : *'quickness of understanding; wisdom. The collection of information.'* -
- Cambridge International Dictionary of English : *'the ability to understand and learn and make judgements or have opinions that are based on reason.'*
- *Wikipedia : Problem Solving, Reasoning, Self Awareness, Creativity, Emotional Knowledge*

## **Good Essay and video**

- <https://www.britannica.com/science/human-intelligence-psychology>
- Learn From Experience, Adapt, Understand and handle abstract concepts, manipulate our environment.

# Aristotle



364BC to 322BC – Father of Western Philosophy

First to write about OBJECTS and laid the foundations of:

- Ontology – The Natural of Being, Knowledge Engineering,
- The Scientific Method.

Today, we teach:

- Natural Science,
- Data Science,
- Computer Science,
- Social Science,
- Artificial Intelligence – A Universal Subject ???

Image from:

<https://en.wikipedia.org/wiki/Aristotle>



# The Scientific Method - Objective

- Empirical way we acquire knowledge :
  - careful observation,
  - rigorous skepticism,
  - formulate hypothesis,
  - test with experiments,
  - and refine our hypothesis.
- Iterative and cyclical, we build on our results and we *'learn from experience'*.
- We publish our results so others can check ( peer review, transparency, reproducible )
- The Scientific Method and Learning From Experience led to Machine Learning (ML) - it's helping us daily.
- Further reading  
[https://en.wikipedia.org/wiki/Scientific\\_method](https://en.wikipedia.org/wiki/Scientific_method)

# Emotional Intelligence – EQ - Subjective

- Our ability to understand our own and the emotions of others.
- To use this understanding to adapt to and change an environment.
- To empathise and make a judgement
- The hardest problem in AI is Consciousness!
- Current scientific research is building our understanding.

BUT, social science is using the scientific method in:

- Economics, Politics, Geography, Health, Sociology, psychology, marketing ...

- Further reading

[https://en.wikipedia.org/wiki/Emotional\\_intelligence](https://en.wikipedia.org/wiki/Emotional_intelligence)

# The Industrial Revolutions

- First : 18<sup>th</sup> & 19<sup>th</sup> Century – Europe and US – Steam Engine, Rural Societies became urban and industrial.
- Second : 1870 to 1914 – Electricity allowed mass production and technological advances such as the Internal Combustion Engine, Telephone and Light bulb.
- Third : 1980's – Digital, ICT { Information and Communications Technology } is embedded into society, personal computer, internet and automation.
- Fourth : Today, exploits the digital revolution and is disruptive, driven by AI, Robotics, IoT { Internet of Things }, Plastic Printing, Nano-technology, Bio-engineering Autonomy....
  - Named by Klaus Schwab – Founder of the World Economic Forum.

THE FOURTH INDUSTRIAL REVOLUTION IS CHANGING EVERY AREA OF OUR LIVES – See the Reading list.

# Universal Design – design for all

- We can now design for all of whatever ability and age

Human plus a Machine ( Robot, Computer, System.. )

- It's about being more human, improving us as humans:
  - Performance
  - Socially

We are going to reimagine every area of our lives – Daugherty and Wilson

Further Reading :

- [https://en.wikipedia.org/wiki/Universal\\_design](https://en.wikipedia.org/wiki/Universal_design)

Motivational Example { Makes People Cry }:

- <https://developer.apple.com/videos/play/wwdc2017/110/>

# Artificial Intelligence

Intelligence Demonstrated by Machines

Computer Science View:

- ‘*Intelligent Agents*’ perceiving their environment and taking actions to achieve a goal.\*
- Some Traditional goals are sometimes called narrow or weak AI:
  - Reasoning, planning, learning, natural language processing, image recognition,...
- Artificial General AI, sometimes called strong AI:
  - Perform a full range of human abilities,
  - Some predict it will be 2050 before we can achieve this.
  - WE ARE NOT SURE IF WE WILL EVER UNDERSTAND CONSCIOUSNESS

\* [https://en.wikipedia.org/wiki/Artificial\\_intelligence](https://en.wikipedia.org/wiki/Artificial_intelligence)

# History of AI and Machine Learning

- 18<sup>th</sup> Century      Mathematical development of Statistics ( Bayes Theorem ) and the first computer description and algorithm – Ada Lovelace
- 1950's              Turing Test – Paper, '*Computing Machinery and Intelligence*' ,  
Machines play draughts. Dartmouth College first use of the term  
Artificial Intelligence – John McCarthy
  - Electronic Neural Net
- 1973                Resources withdrawn from AI research – Sir James Lighthill's Report
  - <https://www.youtube.com/watch?v=03p2CADwGF8>
- 1980's              David Rumelhart and James McClelland Parallel Distributed  
Processing and Neural Network Models
- 1997                Deep Blue ( 100 GFLOPS ) beats world chess champion – won by  
searching 200,000,000 moves per second – iPhone 7 ( 400 GFLOPS )
- 2016                Google Deep Mind Alpha Go beats Lee Sedol at Go



[https://en.wikipedia.org/wiki/Ada\\_Lovelace#First\\_computer\\_program](https://en.wikipedia.org/wiki/Ada_Lovelace#First_computer_program)

Separating the hype  
from the facts

# Machines Learn From Data

- Machines learning from experience is gained by analysing data
- Machine learning is a scientific way of analysing data – data scientist, data mining
- Machine learning helps engineers, scientists, marketing, doctors ...
- Machine learning gives us super human capability – searching of WWW in seconds, surgical robots, identifying patterns in lots of data, ...
- Machine learning can give disabled / older people more independence - voice control, home automation, autonomous vacuum cleaners and lawn mowers, drone delivery, ...
  - WE ARE REIMAGINING ALL APECTS OF OUR LIVES
- Machine Learning is focused on computers learning from data – AI is about systems ( machines ) that display human intelligence.



# Formal Tom Mitchell Definition of ML

Samuel Arthur IBM ( 1959 ) first used the term 'Machine Learning.'

Tom Mitchell definition is more widely quoted:

‘ the field of machine learning is concerned with the question of how to construct computer programs that automatically improve with experience;’

‘ a computer program is said to learn from experience,  $E$ , with respect to some class of tasks,  $T$ , and performance measure,  $P$ , if its performance at tasks,  $T$ , as measured by  $P$ , improves with experience,  $E$ .’

# Heuristic – sometimes works

*‘Heuristic is a strategy derived from previous experiences with similar problems.’*

In Machine Learning Heuristic means a technique for solving a problem more quickly where classical techniques are too slow – a bit like a short cut, rule of thumb, trade offs, developed using trial and error, discovery and experimentation ...

- experts teach a ML algorithm how they do it, transform a problem into a simpler form which is easy to work with ( e.g. reduction )

# A Human Being is more than IQ and EQ

ML can give us super human skills and improve the quality of our life, BUT

- We are feeling, emotional and conscious beings...
- Our brain has a conscious and sub-conscious capability
  - it interacts with chemical and electrical signals from our physiology, our environment, our memory, other people
  - it has developed over evolutionary timescales – evolution has chosen sight, smell, hearing, taste and feeling as our data collectors
  - as well as the less well know e.g. balance and acceleration ( vestibular ), pain, internal ( hunger )
- Intuition often helps us make decisions, motivate us – ‘What’s your GUT feeling?’ – Our stomachs and hearts have brains - literally!

# Go with your gut feeling – Magnus Walker

<https://www.youtube.com/watch?v=KDQrMoksJ4Q>



- TACIT Knowledge : Knowledge that we pass on without being able to write it down, without being explicit – Example we remember a face not its features, hard to put into words!

# The Digital Human

Computer simulations are used to understand the whole human body

- Ergonomics ( reduce fatigue, improve well-being, improve performance, reduce errors ... )
- Drug testing – modelling the physiological response to drugs
- Brain function – electro chemical, response to drugs, hormones, dehydration
- Sense function – how we see?
  - Imagine if we could assess the evolutionary effect of food, exercise and medication on the human body

# Human brain inspired AI – ‘*Deep Learning*’ ( DL )

Deep Neural Networks ( DNN ) are used in:

- Speech recognition;
- Image recognition;
- Medical diagnosis;
- Natural Language Processing ( NLP ) – Echo, Siri, Alexa, Cortana,...

Inspired by the physiological construction of the human brain and today is widely thought to have revolutionised AI – WHY?

It closely matches the AI intelligent agent concept.

# What have we learned

Artificial intelligence is a diverse, fascinating, complex and rich subject and it is growing and learning

The Fourth Industrial Revolution has the potential to change every aspect of our lives – make us more human

‘Learning from experience’ can be enhanced by Machine Learning – Toolkit to re-imagine every area of our lives

Machine Learning and AI is driven by the scientific method and needs good quality data

# A look at some current practical uses of AI



# Engineers Build Models Everyday

*Top University Engineering Departments build models EVERYDAY*

*AI can help engineers build better models which means:*

*better engineering - > better products - > better society*

*Engineers use partial differential equations, experiments, computational physics and simulations, statistics.... Models models models*

*Patrick Winston MIT -> AI is the modelling of representations that support models targeted at thinking, perception and actions*

### 3 AI Examples Simple to Complex – Low Hanging Fruit to Complexity...

- 1. Learning from waste decay data to optimise a Nuclear Intermediate Level Waste Store*
- 2. Modelling of Atmospheric Turbulence 500 Year Problem – Da Vinci to the Red Spot on Jupiter*
- 3. Sellafield the most complex nuclear decommission problem in the world*

# *1. Learning from waste decay data to optimise a Nuclear Intermediate Level Waste Store – Operational Research*

Used operational research to optimise the contents of an encapsulated waste Store with two vaults

Heat generation limit the vaults capacity

Used statistical approach to predict waste heat generation

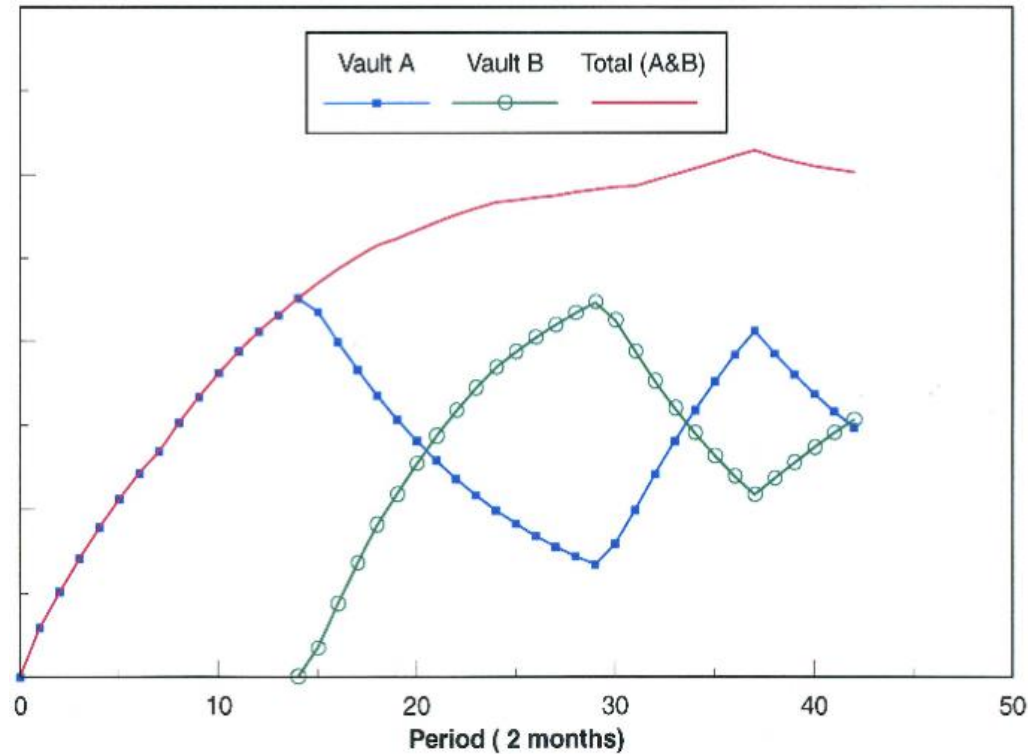
Showed only one store needed, saved 10's Millions pounds

Project Duration 6 Weeks

Project Diagnostics, Data Preparation, Solution and Report 2-4 Weeks



# *1. Learning from waste decay data to optimise a Nuclear Intermediate Level Waste Store – Operational Research*



## 2. Modelling of Atmospheric Turbulence – Da Vinci to the Red Spot on Jupiter



Turboleza Sketch, Leonardo da Vinci ( c. 1500 )

Big Data

Statistical Analysis

High Performance Computing

Generate the data as well as analyse it...

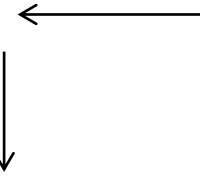
A Description of Turbulence: ‘ Non-linear, Enhanced mixing, Randomness (statistics) and Vorticity. ‘

MIT 1960's

## 2. Modelling of Atmospheric Turbulence – Da Vinci to the Red Spot on Jupiter



Assume that the potential energy from the fall ( 51m ) is transferred to kinetic energy and dissipated as heat.



Velocity at the bottom of the falls =  $31.63\text{ms}^{-1}$  (71 mph).

$\text{Re} \approx 3\text{E}+09$

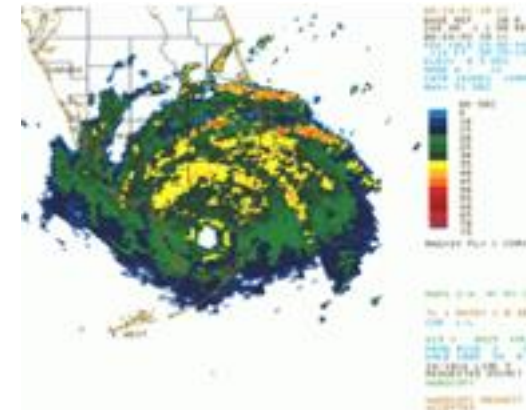
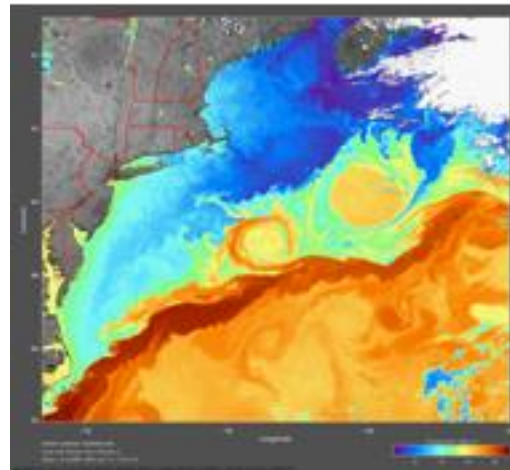
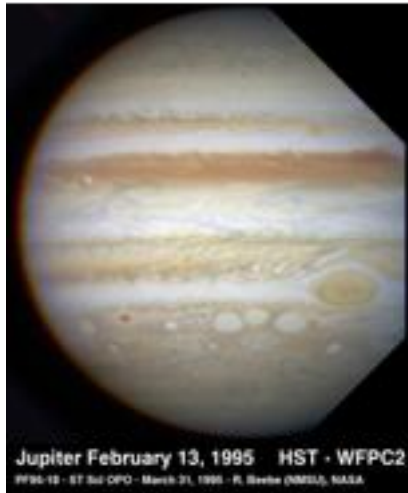
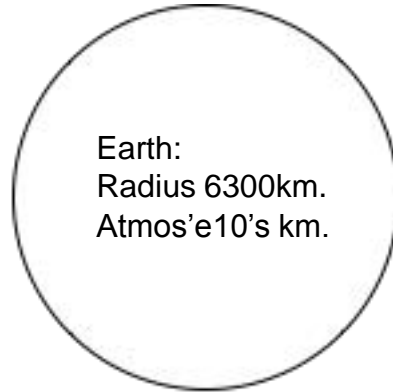
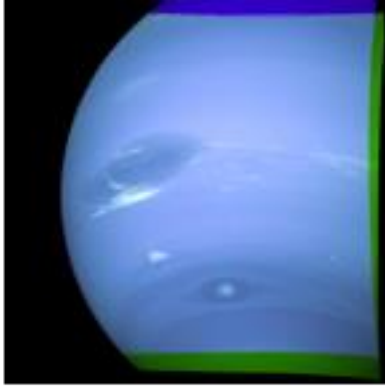
Smallest Length Scale ( Kolmogorov )

$\zeta = 121.\text{Re}^{-3/4} \approx 0.01\text{mm}$

**Turbulence dissipates approximately 1500MW, enough to supply North Wales'.**

# Turbulence – Terrapin Point Horseshoe Falls.

## 2. Modelling of Atmospheric Turbulence – Da Vinci to the Red Spot on Jupiter





## 2. Modelling of Atmospheric Turbulence – Da Vinci to the Red Spot on Jupiter

Why study two-dimensional simulations:

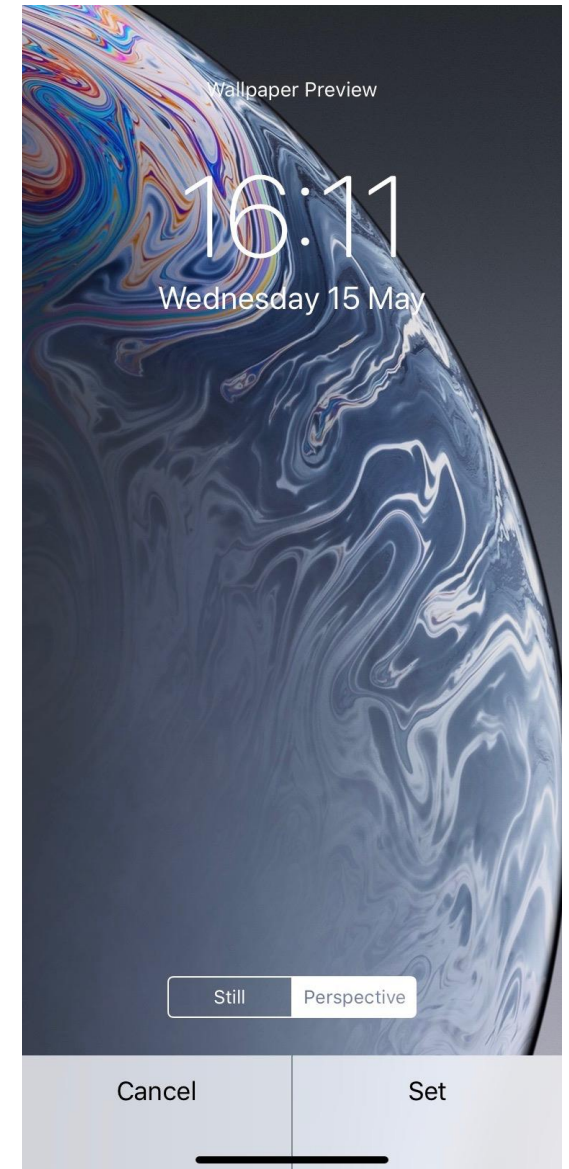
Good Approximation: - Ocean/Atmosphere (Interesting 2D/3D Blend ), MHD  
...

Simplifies the mathematics ( **does not simplify the physics** ) !

Large computer resources are required, large box ratios, lots of realisations and long simulations times ( 100's eddy turnovers ) !

2D CFD is used by Engineers everyday.

Batchelor 1969 ‘... means of testing plausible hypotheses.’

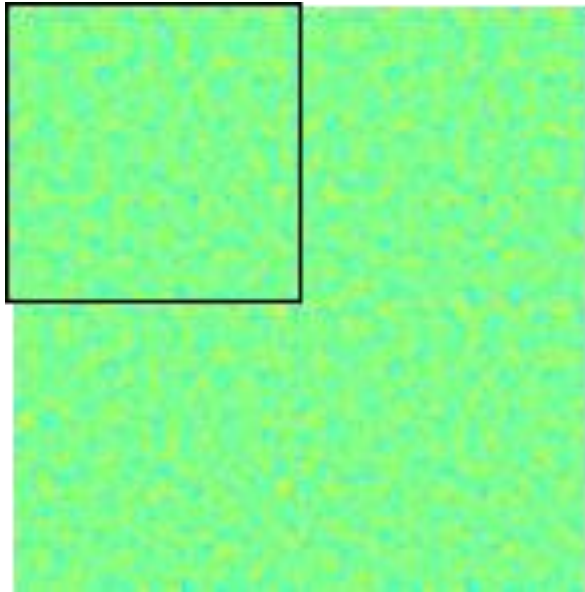




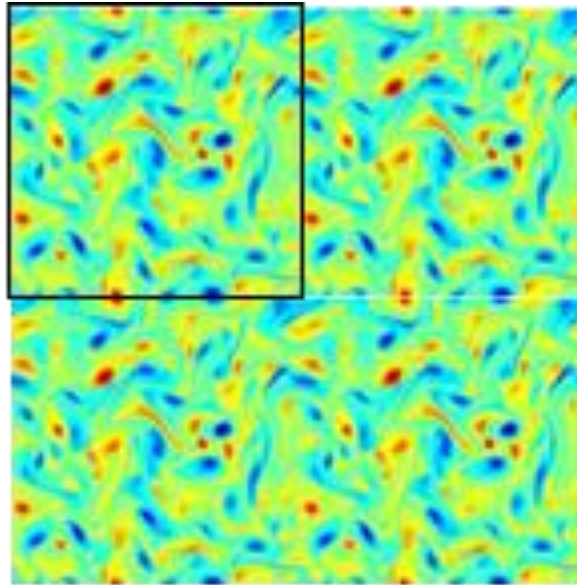
## 2. Modelling of Atmospheric Turbulence – Da Vinci to the Red Spot on Jupiter

High Performace Computing – Worlds 10<sup>th</sup> Fastest super-computer

Generated Lots of Data ( 1000's of Gb ) most of it thrown away

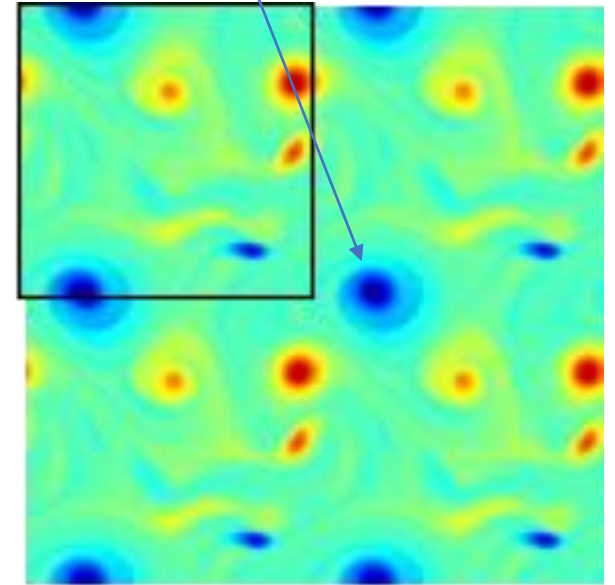


START



MATURING

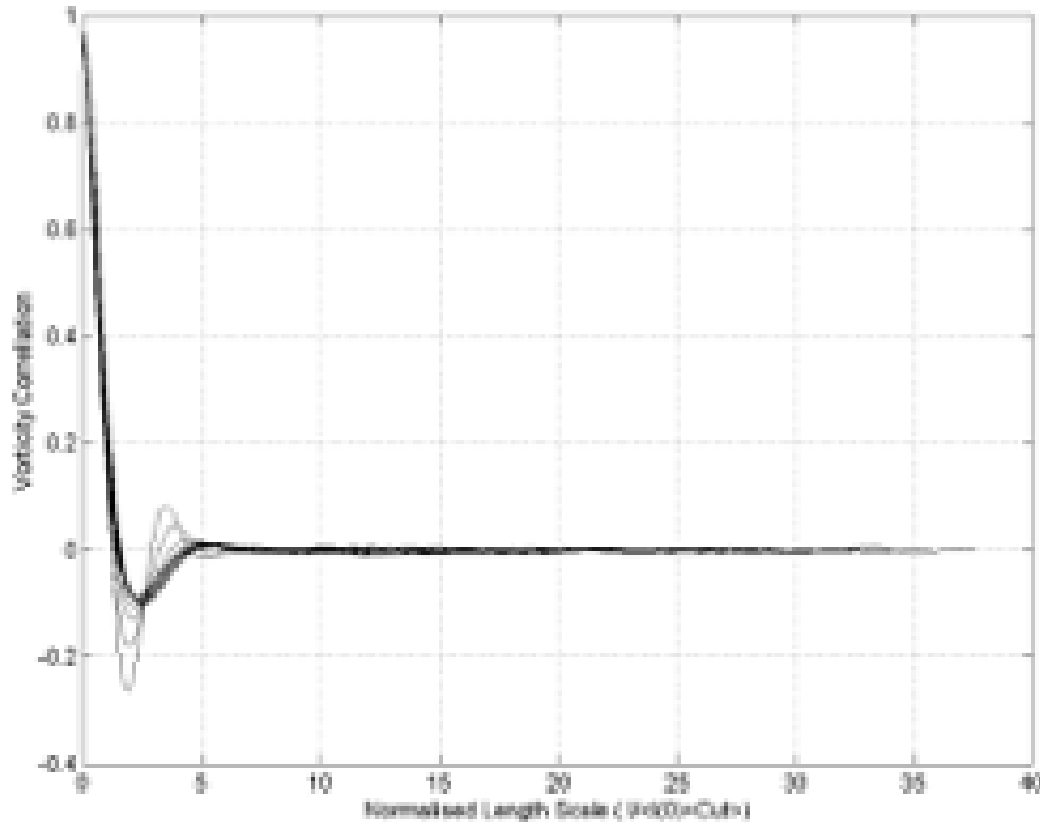
Large Scales  
- energy



MATURE

## 2. Modelling of Atmospheric Turbulence – Da Vinci to the Red Spot on Jupiter

2 Years of Preparing the Data led to this:

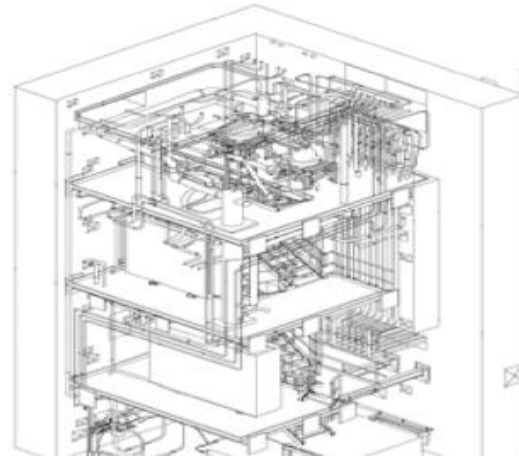


The Statistical Analysis took weeks

Perfect Example of Humans and  
Machines working in harmony!

Machines did the heavy lifting leaving  
Humans to build the hypothesis!

### *3. Sellafield the most complex nuclear decommission problem in the world*



Stakeholder Driven Decommissioning Process that:

Extreme chemical, radiological and personal safety environment.

Spans multiple generations – inter generational equity VERY important.

AI and robotic technology does not yet exist, but it's coming – WE HOPE SO.

NEEDED A DECISION ASSISTANT – easy to say very difficult to do...

### *3. Sellafield the most complex nuclear decommission problem in the world*

**Level 1** - Each step is a training module ( Professional Qualification ) - short term. Completed.

**Level 2** – ‘*What ifs*’ using Operations Research model - medium term. Pilot stage completed.

**Level 3** - Knowledge transfer / Learning From Experience - long term

- future proofing
- pattern recognition computing needed
- capture tacit
- LEARNING FROM EXPERIENCE AND INTERGENERATIONAL EQUITY...

### *3. Sellafield the most complex nuclear decommission problem in the world*

*Multiple Stakeholders differing needs meant we had a fundamental problem – There are TOO many permutations to analyse!*

*Led to too many unknowns, too much data to process and analyse*

*HOW DO WE REDUCE THAT DOWN SO WE CAN ALL UNDERSTAND IT*

*----- → Data scientist view, you just build a dash board!*

*WE HIT A PROBLEM – HOW DO WE BALANCE THE NEEDS OF ALL THE STAKEHOLDERS*

*PUT IT SIMPLY, WHAT DOES SUSTAINABLE DECOMMISSIONING  
LOOK LIKE!*

### *3. Sellafield the most complex nuclear decommission problem in the world*

*THIS COMPLEX ENGINEERING PROBLEM BECAME AN ETHICALLY DRIVEN SUSTAINABILITY PROBLEM*

*Sustainability is about balancing the needs of stakeholders:*

*Social  
Environmental  
Financial*

*UN now has 17 sustainability goals that we can use.*

*EU within the past few months has published the Ethical guidelines for AI – It links ethical AI to Sustainability and Universal Design.*

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# Why we all need training in AI



# Who needs training in AI

## A recent report from PwC said...

Artificial Intelligence (AI) and related technologies are projected to create as many jobs as they displace in the UK over the next 20 years, according to new analysis by PwC.

In absolute terms, around 7 million existing jobs could be displaced, but around 7.2 million could be created, giving the UK a small net jobs boost of around 0.2 million.

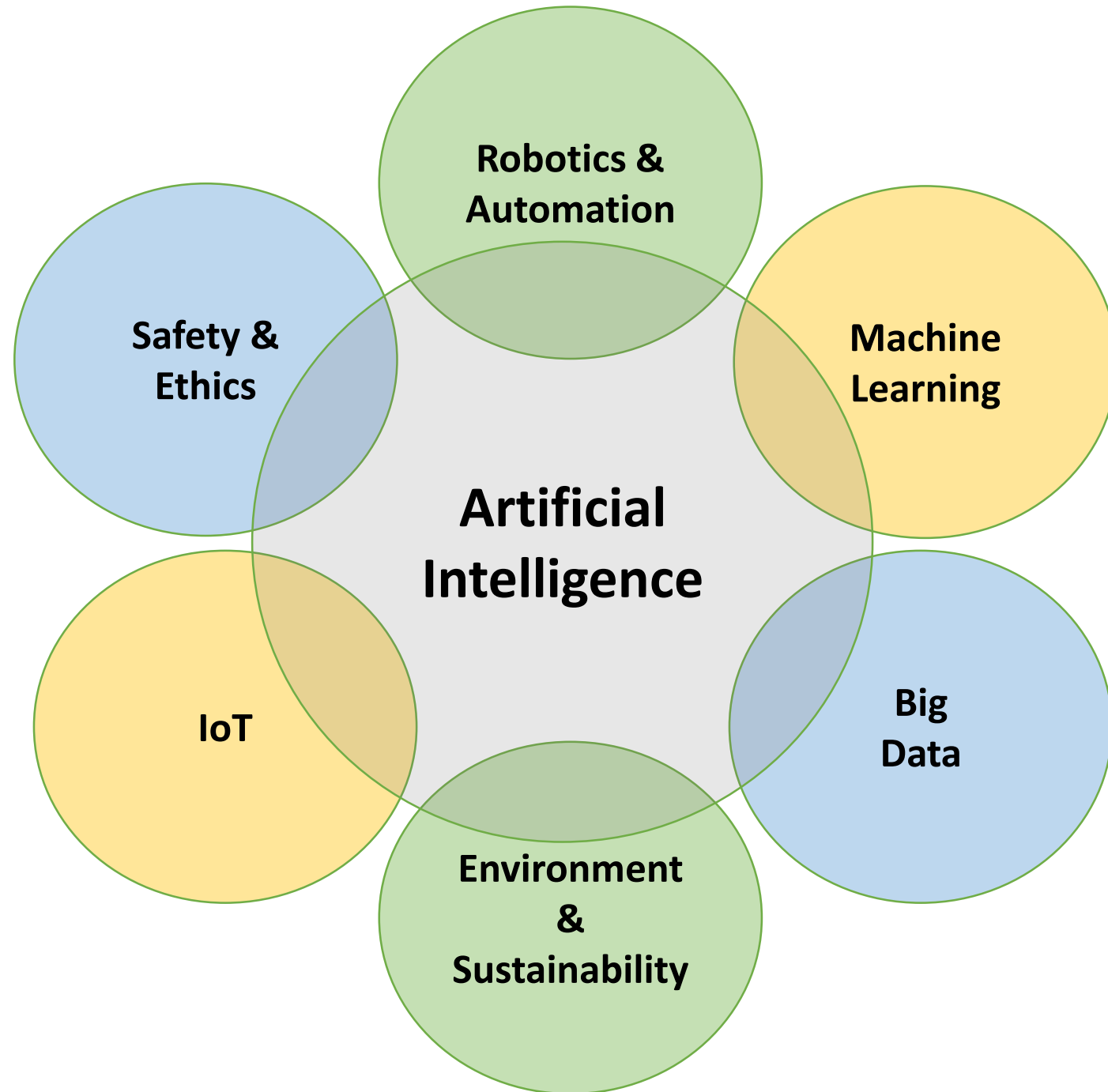
July 2018 PwC

65% OF CHILDREN NOW  
ENTERING PRIMARY SCHOOL  
WILL HOLD JOBS THAT  
CURRENTLY DON'T EXIST

\*ACCORDING TO THE WORLD ECONOMIC FORUM

**Digital Skills** - "It's likely that the fourth industrial revolution will favour those with strong digital skills, as well as capabilities like creativity and teamwork which machines find it harder to replicate."

# AI training is a sum of its parts



# Who is already training people in AI

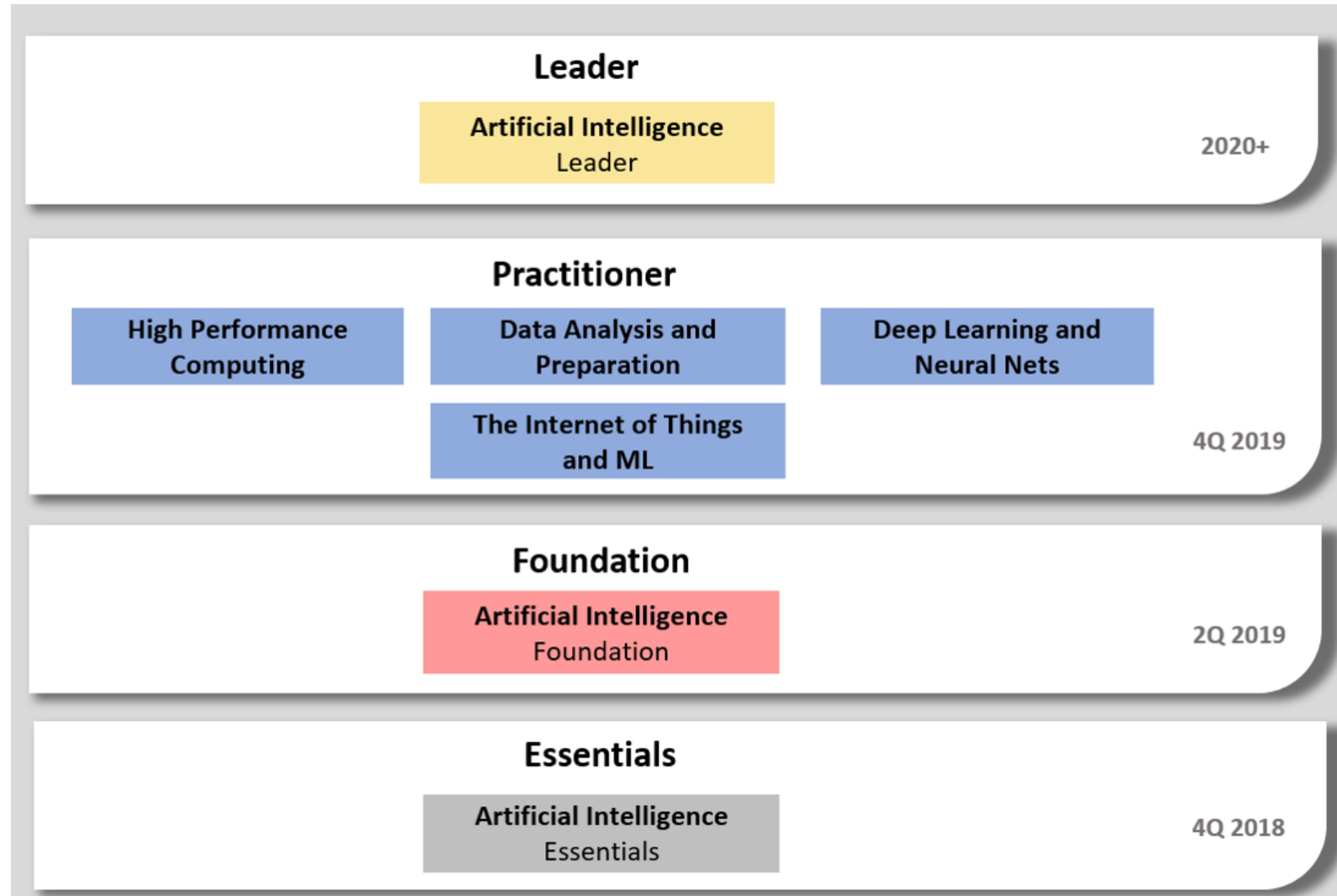
- Universities
  - University Graduates
  - Short AI courses
- Industry (propriety knowledge)
  - IBM
  - Amazon
  - Etc
- Self teach – Books, Blogs, Webinars etc

But its typically ML and Data Science...

# Why create the BCS AI training portfolio

- To separate fact from fiction (professional footing)
- To create a wider interest in AI
- To drive innovation
- To help delegates identify opportunities
- To fill the knowledge gaps
- To help underpin the experts
  - Create Intelligent Customers
- Accredited recognition of AI knowledge (AI professional)
- To educate the masses

# The BCS AI portfolio



# How organisations can get started and use AI

# Getting started

- Key driver of the 4<sup>th</sup> Industrial revolution
- AI currently has peoples attention (good/bad)
- There is a lot of Open Source, so no need to reinvent the wheel
- Do you need an 'Ethical Proposition'
  - E.g. improve humanity, solve climate change...
- To gain adoption AI implementations need to be 'Trustworthy' and 'Sustainable'
- Can we define a MVP (Minimum Viable Product)
- Should you Buy or Build

# Organisations can reimaging everything

- Automation
- AI supporting humans
  - Transactions – monotonous tasks
  - Prediction
  - Iterate
  - Adaption
- Humans supporting AI
  - Provide Leadership - Set the Goals
  - We are creative
  - We can empathize ( humans, groups, animals, nature, ideas, ethics )
  - We can judge ( law, ambiguity, 50/50 )



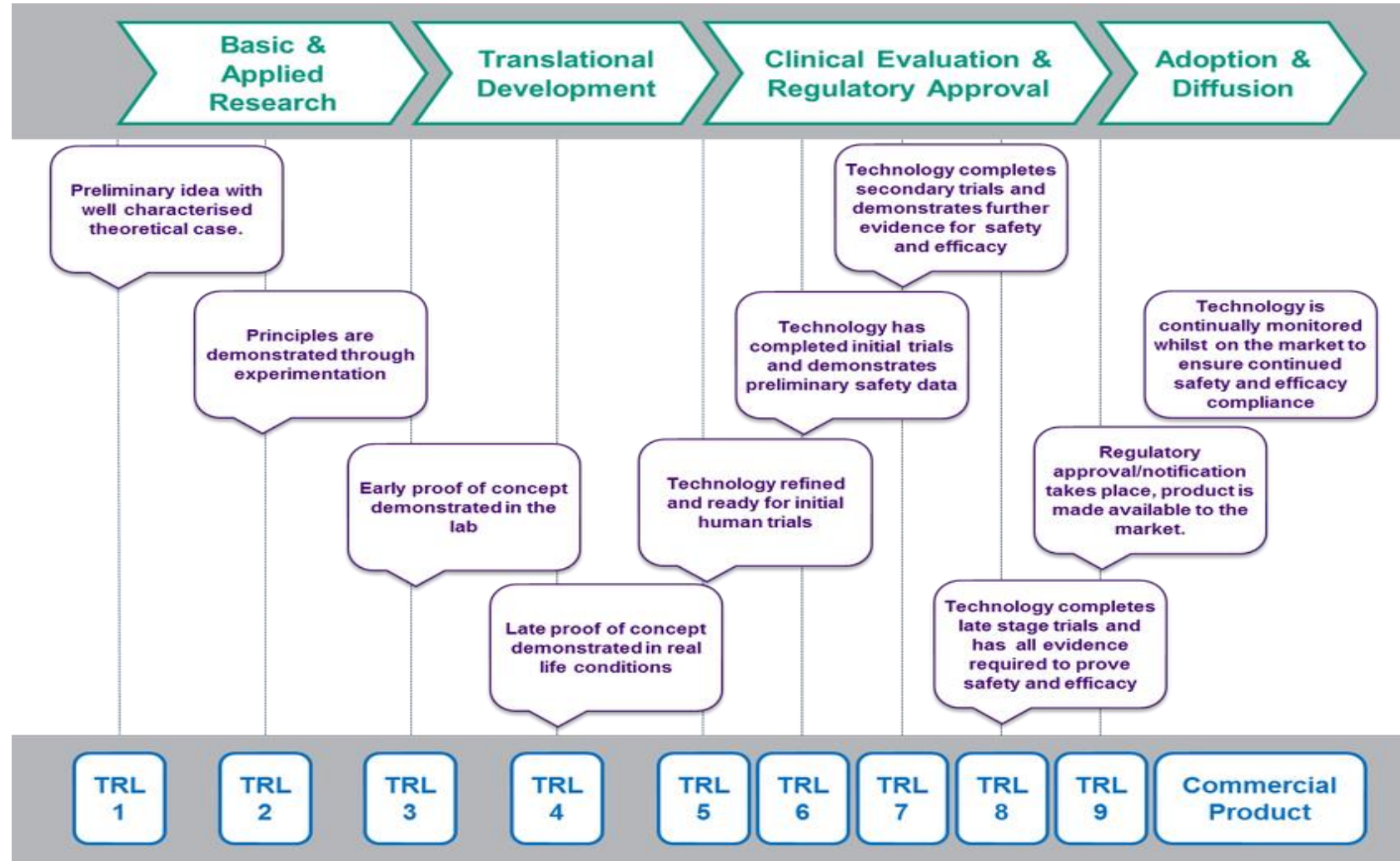
# Considerations for an AI project

- Is the business case different for AI
- Are we already using AI in the organisation
- Ethical purpose
- Sustainability
  - Social
  - Economic
  - Environmental
- Explainable AI
- Lack of quality or biased data
- Contextual data
- Speed to market

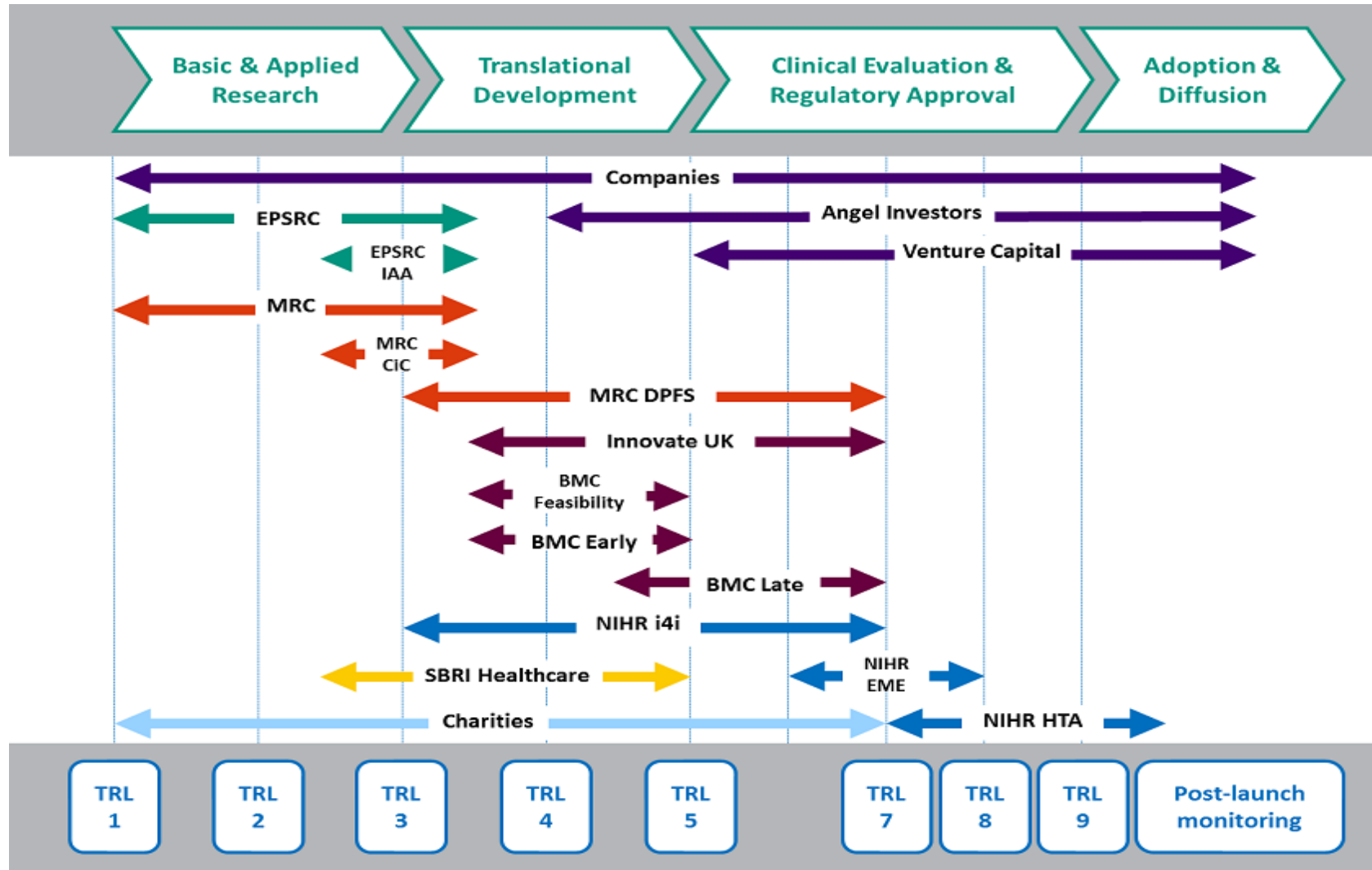
# Funding

- Self fund
- External funding
  - UK Research & Innovation (UKRI) (<https://www.ukri.org> )
  - Innovate UK (<https://www.gov.uk/government/organisations/innovate-uk> )
  - Engineering & Physical Science Research Council (EPSRC)
- TRL – Technology Readiness Levels developed by NASA and adopted by the EU and UK.
  - [http://www.earto.eu/fileadmin/content/03\\_Publications/The\\_TRL\\_Scale\\_as\\_a\\_R\\_I\\_Policy\\_Tool - EARTO Recommendations - Final.pdf](http://www.earto.eu/fileadmin/content/03_Publications/The_TRL_Scale_as_a_R_I_Policy_Tool_-_EARTO_Recommendations_-_Final.pdf)

# Technology Readiness Levels



# Likely Funders



Why AI Ethics and  
sustainability is so  
important

# Artificial Intelligence Ethics

## Guidelines and Legislation (both in development)

- Future of Life Institute (US founded)
  - Asilomar Principals
  - <https://futureoflife.org/ai-principles/>
- Ethics Guidelines for Trustworthy AI (EU founded)
  - European Commission Directorate-General for Communication
  - Latest revision March 2019:  
[https://ec.europa.eu/futurium/en/system/files/ged/ai\\_hleg\\_draft\\_ethics\\_guidelines\\_18\\_december.pdf](https://ec.europa.eu/futurium/en/system/files/ged/ai_hleg_draft_ethics_guidelines_18_december.pdf)

# Future of Life - Asilomar AI Principals

***‘Our Call to Action -> Reimagining Every Aspect of our lives with AI’***

Beneficial AI conference 2017 developed the Asilomar Principals for AI

There are 23 principals relating to:

## **Research**

Goals, Funding, Policy, Cultures, Race Avoidance { speed of progress }

## **Ethics and Values**

Safety, Failure Transparency, Judicial Transparency, Responsibility, Value Alignment,  
Human Values, Personal Privacy, Liberty and Privacy, Shared Benefit, Shared  
Prosperity, Human Control, Non-subversion, AI Arms Race

## **Longer term Issues**

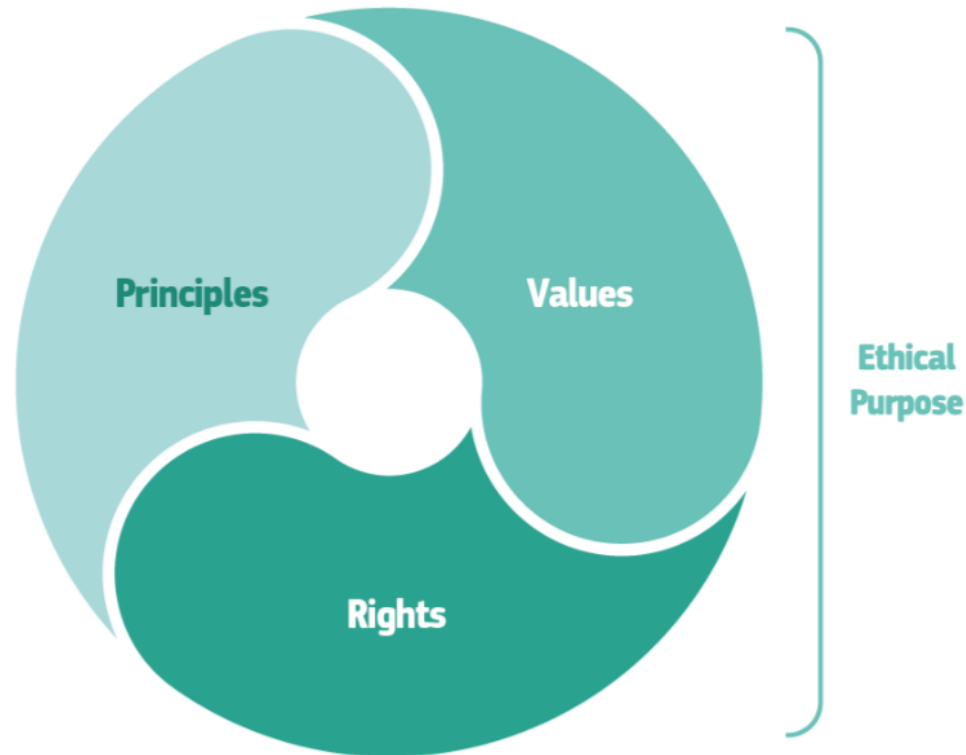
Capability Caution, Importance, Risks, Recursive Self-improvement, Common Good

# EU Ethics Guidelines for Trustworthy AI (EU)

- AI Ethics Guidelines produced by the European Commission's High-Level Expert Group on Artificial Intelligence (AI HLEG)
- Trustworthy AI has **two components**:
  - (1) it should respect fundamental rights, applicable regulation and core principles and values, ensuring an “**ethical purpose**”  
and
  - (2) it should be **technically robust** and reliable since, even with good intentions, a lack of technological mastery can cause unintentional harm.



# From Fundamental rights to Principles and Values



# Definitions

**Principles** – A fundamental well settled rule of law or standard for good behaviour, or collectively they are our moral or ethical standards.

**Values** – Ethical ideals or beliefs for which a person has enduring preference and determine our state of mind and act as a motivator.

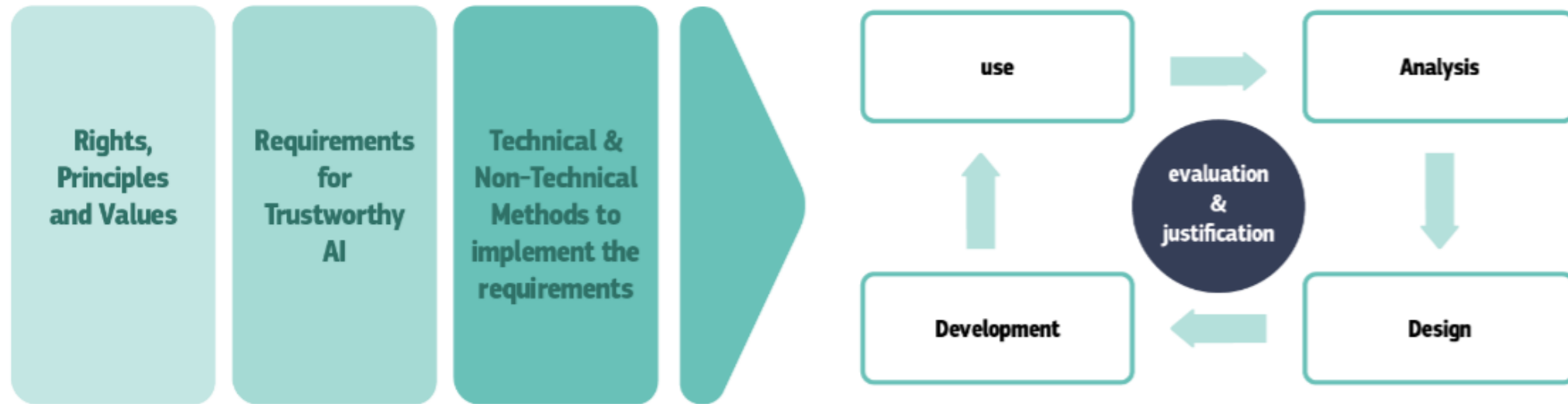
**Rights** – A collection of entitlements for which a person may have, and are protected by government and the courts.

# Ethical Principles in the Context of AI and Corresponding Values

**Five principles and corresponding values that must be observed** to ensure that AI is developed in a human-centric manner.

- The Principle of Beneficence: “Do Good”
- The Principle of Non maleficence: “Do no Harm”
- The Principle of Autonomy: “Preserve Human Agency”
- The Principle of Justice: “Be Fair”
- The Principle of Explicability: “Operate transparently”

# Technical and Non-Technical Methods to achieve Trustworthy AI



# Technical and Non-Technical Methods to achieve Trustworthy AI

EMBEDDED IN ETHICS IS:

1. United Nations 17 sustainability goals!\
2. Universal Design – Design for ALL



What the future holds  
for humans and AI

# Utopia or Dystopia or somewhere in between

- **Utopia** – What happens if we get it right
  - The ability to become more human
  - Beneficial use of technologies
  - Universally sustainable lifestyle worldwide
  - Long term personal and societal health and wealth gains
- **Dystopia** – What happens if we get it wrong
  - Abuse and unethical use of AI for personal, organisational or group gain
  - An increasingly unequal society
  - Basically more problems than answers



Q&A