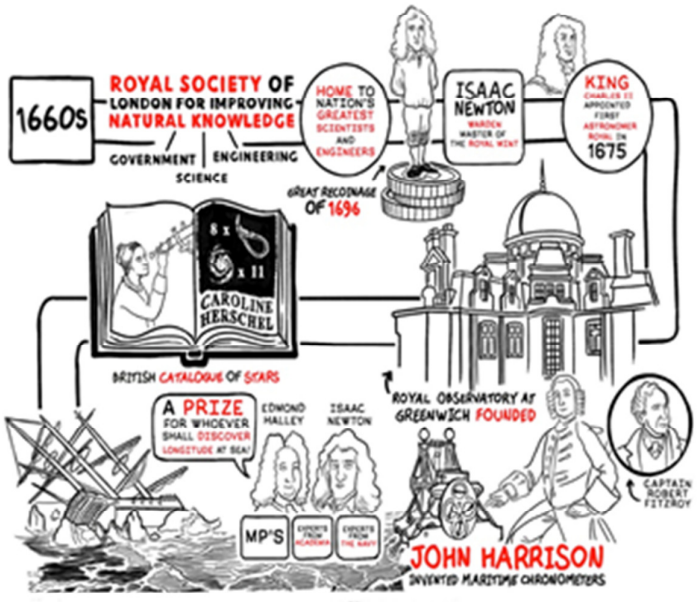
Slide 1: Who We Are

- The Government Science and Engineering (GSE) Profession boasts expertise, ranging from deep specialists and specialists, to those working in policy, analytical and non-science/engineering roles. It is this breadth and depth of expertise that is unique to the profession and that government relies on for continued credible and high quality advice.
- We are Civil and Crown Servants with a background in science and engineering - our skills, knowledge and expertise is grounded in scientific method, and engineering principles. This enables us to provide evidence based advice and apply systems thinking to support operational delivery, and to inform policy decisions made by Ministers and Senior Officials across Whitehall. We fulfill an important function as an intelligent customer in government.
- We were established in 2008, to build a network and a cohesive community that would support scientists and engineers within the Civil Service and to champion the profession across government. We will commit to this aspiration by publishing a GSE strategy in the next few months, which will set out clearly what we want the GSE profession to achieve in the next 5 years, giving us a stronger sense of purpose.
- And to build a stronger identity and raise the profile of the profession, we decided to tell a story: the GSE story, about the critical role that has been played and continues to be played by scientists and engineers in government.
- This story is not straightforward. Social, economic and political change, have all influenced our story down the centuries. It is not always a story about people acting beyond reproach, nor is it a story solely about eureka moments and great discoveries. But it is a story from

which we can learn, filled with rich examples of hard work, collaboration, innovation, diversity and inclusion.

- This story can only be a thin slice of a very complex history. We wanted to shine the spotlight on a few of the great things that scientists and engineers in government can achieve – a solid foundation upon which the GSE profession can build upon for the future. We want to share this story with you.



Slide 2: A Long History

- Perhaps the most important moment in the early history of the relationship between government, science and engineering in England and Wales came in the 1660s, with the formation of "The Royal Society of London for Improving Natural Knowledge", enthusiastically supported by King Charles II. Down the centuries, the society would be a home to many of the nation's greatest scientists and engineers.

- One of those leading lights was Sir Isaac Newton whose expertise was called upon by government to help stamp out a rash of counterfeiting which posed a serious threat to the pound. He took up the post of Warden, and later Master of the Royal Mint and spearheaded the Great Recoinage of 1696.

- King Charles meanwhile, was not satisfied merely to give his support to The Royal Society. He also appointed the first Astronomer Royal, John Flamsteed in 1675 and founded the Royal Observatory. Detailed knowledge of the heavens, combined with advances in mathematics, would become more vital than ever for maritime navigation. Brilliant astronomers would serve the court and the nation, including Edmond Halley, William Herschel and Nevil Maskelyne.

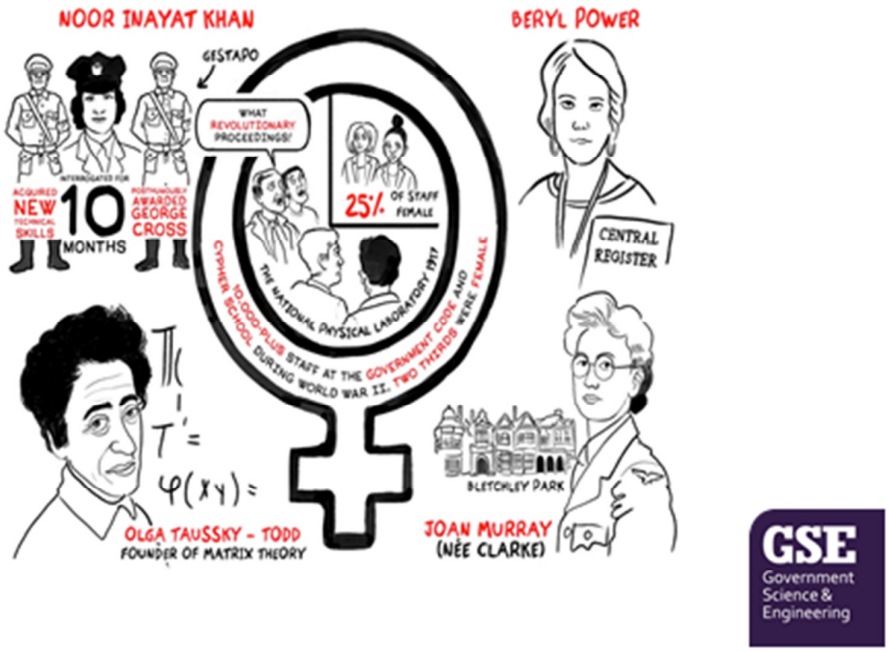
- With the world of court and politics dominated by wealthy men, many of these pioneers drew on sometimes hidden networks, including family and servants in their work. For example William Herschel's sister: Caroline Herschel though entirely self-taught, went on to discover or observe eight comets and eleven nebulae and published the British Catalogue of Stars, becoming one of the first women to gain international recognition as a scientist in her own right.

- Following a series of maritime disasters due to errors in reckoning position at sea, the expertise of both the Astronomer Royal and the Royal Society (in the form of Edmond Halley and Isaac Newton among others), working alongside MPs and experts drawn from academia and the Navy, was called on to find a means to establish longitude. In 1714 the Longitude Act was passed by the Longitude Board which recommended the establishment of a prize for "whoever shall discover longitude at sea".
- The quest to discover longitude revolutionised the relationship between science engineering and government.
    - Faced with a need beyond its immediate capacity, Government commissioned new technology
    - It called on industry – in the form of the East India Company and its fleet – to carry out testing on its behalf
    - That field testing went on for many years and relied on sailors being trained in the care and use of new equipment.
- Ultimately, the question of longitude was that of accurate time-keeping, and the person to answer it was John Harrison, a self-taught carpenter and clock maker, who invented a series of marine chronometers.
- As Britain navigated with this innovation, Sir Robert FitzRoy's newly established Met Office began issuing Gale Warnings to guide British ships away from stormy waters. The combination of these two innovations leading to the establishment of new trading routes, securing Britain's role at the centre of international trade and as a leading naval power.

Slide 3: A World at War

- In the 20th century, the relationship between scientists, engineers and government grew closer. Instead of offering prizes or passing legislation, government now sought to act more directly.
    - 1911 saw the beginnings of what would become the Health and Safety Laboratory (HSL), as government sought to focus on practical solutions to work place health and safety problems. At the time this focussed on investigating and improving the conditions of mine workers. Thousands of lives were lost as a result of coal-dust explosions and many more died as a result of the health consequences of working with coal.
- At the beginning of the twentieth century, tuberculosis was one of the UK's most urgent health problems, to address this a Royal Commission was appointed in 1901. The Commission recognised that there was a need to define and pursue its own TB research programme.
    - In 1913 the Medical Research Committee and Advisory Council was established: this was the first single research organisation for the whole of the UK. It covered the full remit of human health research, and was responsible for initiating its own research and providing funding to external bodies. It eventually gave rise to the establishment of the Medical Research Council (MRC) in 1919.
    - This model has since been replicated across a range of science and engineering disciplines, leading to the modern day system of Research Councils and the development of large scientific facilities.

- War has always catalysed innovation, sparked invention and inspired modern thinking.
    - World War I saw increased technological development in aerial reconnaissance, the tank, and, at Porton Down, the development of respirators to defend against mustard gas attacks.
    - The Haldane Principle, was derived from the key recommendation of Lord Haldane's 1918 report on the machinery of government. This was about separating departmental research from "intelligence and research for general use", through the establishment of "Advisory Councils" (today's Research Councils). This was written against the backdrop of the First World War, following years of funding, which was focused on the war effort. The principle is still in play today, where detailed decisions on how research money is spent is made through the Research Councils.
    - The Second World War saw government's involvement with science and engineering rise to a new height, seeking out, and bringing together brilliant individuals with the specialist skills and knowledge required to carry out work needed for the war effort. Their innovation, often behind the scenes, from computing, to radar, to atomic weapons, underwent a period of accelerated technological development, which would eventually go on to prevent new wars and change our everyday lives.
        - Code-breaking work at Bletchley Park not only gave the nation a crucial advantage by breaking the German Enigma code, it provided the foundation of the computer revolution.
        - The development of radar and the high-powered, reproducible cavity magnetron, (led to the development of airborne radar and microwave technology), had a profound effect on the outcome of the war and continue to affect the world today, from every time we take a flight to every microwaved meal we eat.
        - The development of the jet engine played a role in WW2 as jet powered aircraft shot down German V1 flying bombs and went on to underpin a revolution in air travel, enabling faster journeys over ever greater distances, bringing the whole world closer together.
- But war does more than bring military innovation. It also brought research such as Robert McCance and Elsie Widdowson's work on nutritional science, work that would inform rationing and the wartime austerity diet. The pair conducted experiments on themselves by following a rationed diet and fitness regime – including carrying out a 36 mile walk with 7000 feet of climbing in just 12 hours – to prove the ration provided enough energy for the nation's needs, putting their own health at the service of the public good.



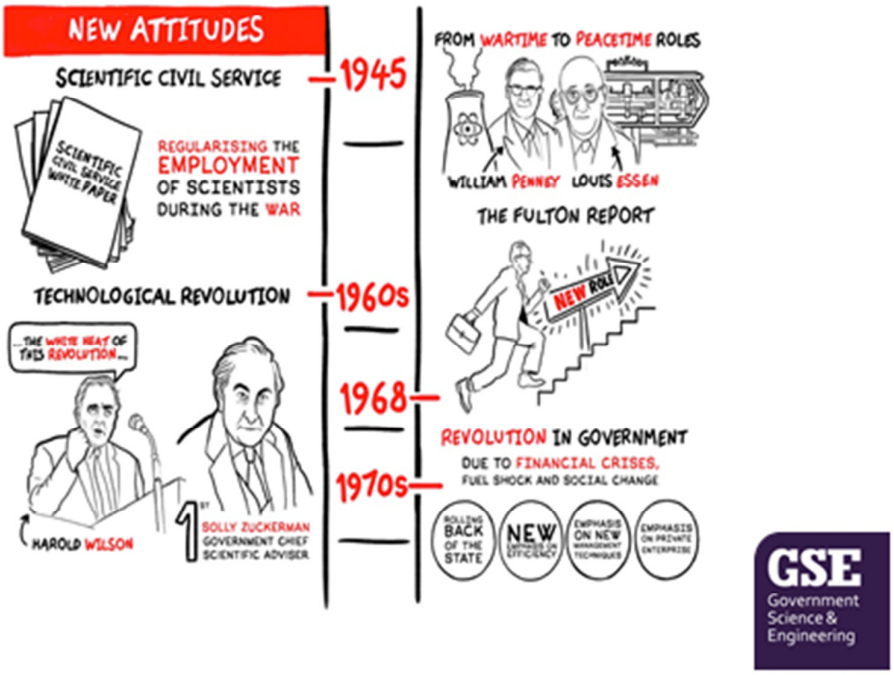
Slide 4: A Changing World

The events of the first half of the twentieth century also saw new opportunities for women as war and social change saw them win the vote, find new representation in government and take on new roles.

- During World War I, women were recruited to the National Physical Laboratory (NPL) for the first time (in the face of some concerns from male staff over such "revolutionary proceedings"). By 1917 almost a quarter of the NPL's staff were women. Though that number fell back at the end of the war, the NPL was never again an all-male institution.
- During World War II, Beryl Power played a vital role in leading the "*Central Register for Persons with Scientific, Technical, Professional and Higher Administrative Qualifications*", the theory was that the UK wasn't going to make the same mistake as in the First World War "when some of our most brilliant scientists went in and were shot almost immediately". Her team identified the best people available – among them many of the Bletchley Park team - and moved swiftly to appoint them where they were most needed.
- Women made vital contributions at all levels of the war effort.
    - Joan Murray's work at Bletchley Park in the 1940s, with her colleague and friend Alan Turing, made a vital contribution to the breaking of the German Enigma code, despite her being initially assigned to clerical duties and paid just £2 per week.
    - SOE agent Noor Inayat Khan, a volunteer, trained as a radio technician despite having no previous technical experience, using her newly-acquired skills to support operations in France until her eventual capture by the Gestapo. Despite 10 months of interrogation before her eventual execution, she

revealed nothing to her captors. She was posthumously awarded the George Cross.

- At NPL, Olga Taussky-Todd's work during World War II would form the foundation of Matrix Theory, work that underpins the development of modern computer coding and algorithms.



Slide 5: A New Attitude

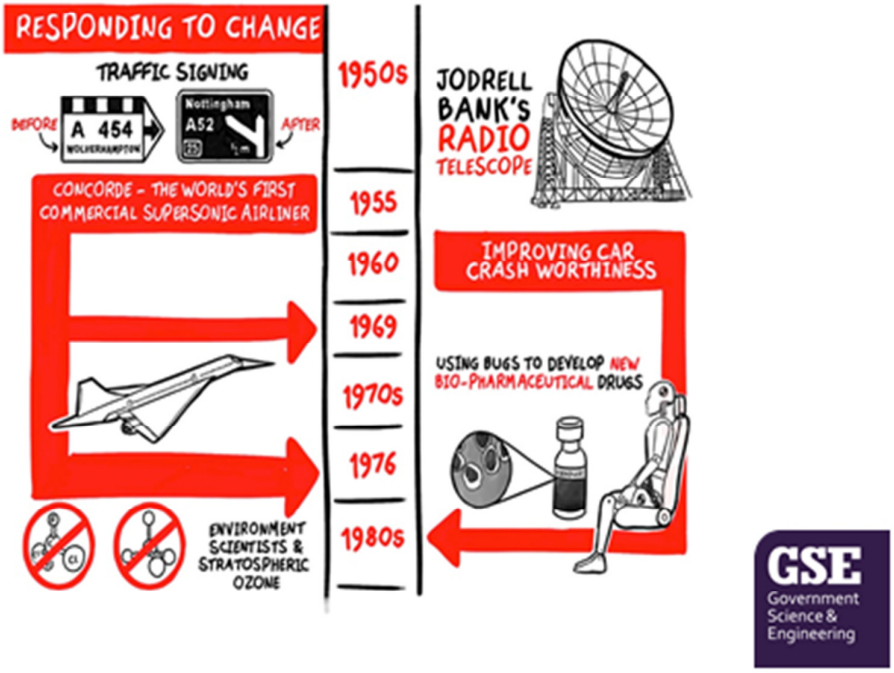
- Following the high-speed innovation brought about by government and engineering working hand-in-hand during World War II, post-war governments decided to bring this expertise ever more into Whitehall itself.

- The first steps were taken in 1945, when The Scientific Civil Service white paper recommended regularising the *ad hoc* arrangements made for employing scientists during the war, such as Beryl Power's Central Register. Both were put to good use for civilian purposes in the post-war climate of suspicion that followed during the Cold War.

    - One of the scientists who moved from a war-time to peacetime role was William Penney. He and his team had worked on the "Tube Alloys" project with the Canadians in an effort to develop an atomic bomb. He later went on to work on the Manhattan Project itself. After the war Penney would go on to lead UK atomic research efforts, helping to develop the British "H" Bomb , which was later recognised for its contribution to the development of Civil Nuclear Power.

    - The work of Louis Essen and Jack Parry on time signals and the atomic clock, led to the introduction of a worldwide synchronised time service and a new definition of the second. Essen's collaboration with Jack Pierce at Harvard contributed to the development of the first radio aid to navigation for civilian as well as military navigators. Two decades later, atomic clocks would form an essential part of the Global Positioning System (GPS) that so many of us rely on each day - Essen's work becoming the basis for a new "Longitude" for the 20th and 21st centuries.

- As time went on, government realised there was a need for greater flexibility. In 1968, the Fulton Report made it easier for all Civil Servants – particularly scientists and engineers – to move beyond their initially assigned roles, using their expertise and skills where most needed whilst gaining new breadth of experience.
- With the country immersed in the “white heat” of the sixties technological revolution, steps were taken to bring scientific advice right into the heart of government, with the appointment of Sir Solly Zuckerman in 1964 as the first Government Chief Scientific Adviser (GCSA) to advise the Cabinet and Prime Minister.
- The financial crises, fuel shock and social change of the 1970s ushered in a revolution in government, a rolling back of the state and a new emphasis on efficiency, new management techniques and private enterprise. This though, was nothing new for us: the whole history of science and engineering in the United Kingdom has been one of partnerships between government and industry, universities, research centres, agencies and individuals, going back for centuries.



Slide 6: Responding to Change

- The work of government scientists and engineers continued to evolve, moving deeper into everyday life, whilst also reaching further across this world and even beyond.
    - Work at the Department for Transport (DfT) and Transport Research Laboratory (TRL):
        - revolutionised traffic signing, devising the fonts and images used on traffic signs across much of the globe,
        - took new steps to study car crashworthiness, helping to make cars safer than ever before.
    - At the labs at Porton Down, British government scientists pioneered in the field of biotechnology, exploiting the potential of bacteria to produce a whole range of therapeutic products and mastering the processes to purify specialist enzymes such as Erwinase, used to treat a form of leukaemia.
    - At the cutting edge of technological development and design, the hard work and collaboration of The Royal Aircraft Establishment (RAE) and the NPL and French agencies achieved a feat of engineering in building Concorde, the world's first commercial supersonic passenger airliner. It flew at twice the speed of sound (Mach 2), and reduced travel times from London to New York to less than 3 hours.
    - The RAE worked at Jodrell Bank, using Sir Bernard Lovell's famous radio telescope to detect nuclear missile tests and track Soviet satellites and rockets. This work at the same time helped to support the pure scientific research of the observatory, which

would detect the first millisecond quasars, the first gravitational lens to confirm the theory behind the first Einstein ring.

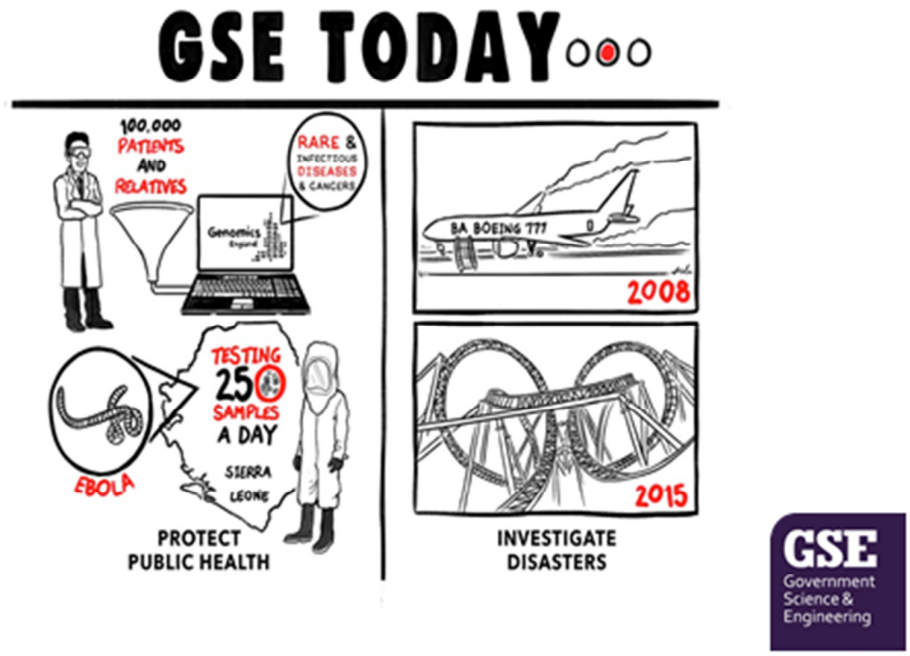
- Scientists at the Department of Environment commissioned research on ozone depletion and helped set up the EU Ozone Research Coordination Unit at Cambridge. Their work as an intelligent customer for government - played a vital part in banning CFCs and halons, a step which has seen ozone depletion start to reverse.

Slide 7: What GSE Does Today – Part I. Building Resilience, Supporting Law Enforcement

- Today, the work of the GSE Profession continues to touch every part of every citizen's life.
- We protect citizens at home and abroad, ensuring their security, responding in times of emergency, supporting criminal investigation and policing
- We are there in emergencies:
    - In 2010 the Scientific Advisory Group for Emergencies (SAGE) chaired by the GCSA, was called on to advise on the hazards to air travel caused by the eruption of Icelandic volcano Eyjafjallajökull [*AY-yah-fyad-layer-kuh-tel]*, while scientists and engineers from the Met Office and Department for Transport worked with academia, industry and regulatory bodies to develop new protocols for air space closures and new detection and monitoring equipment.
- In crime and policing:
    - The Centre for Applied Science and Technology's (CAST) Forensic Early Warning System project has worked to identify new psychoactive substances, combating new so-called "legal highs" by developing reference standards and an information-sharing platform to enable them to be identified and dealt with quickly.
    - Following the poisoning of former Russian Spy Alexander Litvinenko by Polonium-210, the Atomic Weapons Establishment (AWE) and Public Health England (PHE) played a vital role in tracing the source and date of the poisoning and ensuring the

proper clean-up of sites around the capital. This evidence was presented to the Litvinenko Inquiry in January 2016 and played a vital role in its conclusions.

- We provide practical engineering solutions to problems of security and safety:
    - The Centre for the Protection of National Infrastructure (CPNI) has worked with industry to pioneer new materials and shallower installation techniques for counter-terrorist vehicle security barriers. These barriers keep Vehicle-Borne Improvised Explosive Devices (VBIEDs) at safer blast stand-off distances from vulnerable critical assets, such as locations across Whitehall.
    - The Health and Safety Executive (HSE) has created new GRIP ratings for footwear, rigorously testing outsoles so users and employers can know their boots and shoes are fit for purpose.



Slide 8: What GSE Does Today – Part II. Protecting, Preventing Harm

•The GSE Profession protects health and ensures safety, at home and abroad.
•In health:

- Genomics England, owned by the Department of Health, is creating a new genomic medicine service within the NHS, collecting the genomic data related to rare or highly infectious diseases and cancers from 100,000 patients and their relatives. This data will make a vital contribution to the fight against such diseases in the future.
- During the recent Ebola outbreak in Western Africa, UK Government scientists were at the forefront of the international cross-government response. With HSE coordinating the establishment of Ebola Treatment Centres and HSE & PHE staff travelling to affected areas of Sierra Leone to deliver on the ground assistance. Together they speeded up diagnoses and tested up to 250 samples per day. More widely, the UK government has funded vaccine trials and research into Ebola to ensure lessons are carried forward to events such as the recent Zika outbreak.

•We investigate when things go wrong:

- Following the accident to a BA Boeing 777, which landed short at Heathrow in 2008, engineering and operations investigators from the Air Accidents Investigation Branch investigated, forming the nucleus of a team involving many government and industry engineers and scientists that crossed disciplines, jurisdictions and

national boundaries. They discovered the potential for ice build-up in aircraft fuel systems that can lead to blockage of engine fuel supplies in flight. Recommendations led to changes in system design, testing and certification for all aircraft.

- At HSE, staff with knowledge and expertise which spans multiple technological disciplines, undertake complicated investigative work into industrial accidents, such as the tragic explosion at Bosley Wood Flour mill in 2015 or the horrific crash on the Alton Towers "Smiler" ride in the same year.

Slide 9: What GSE Does Today – Part III. Supporting, Innovating, Exploring

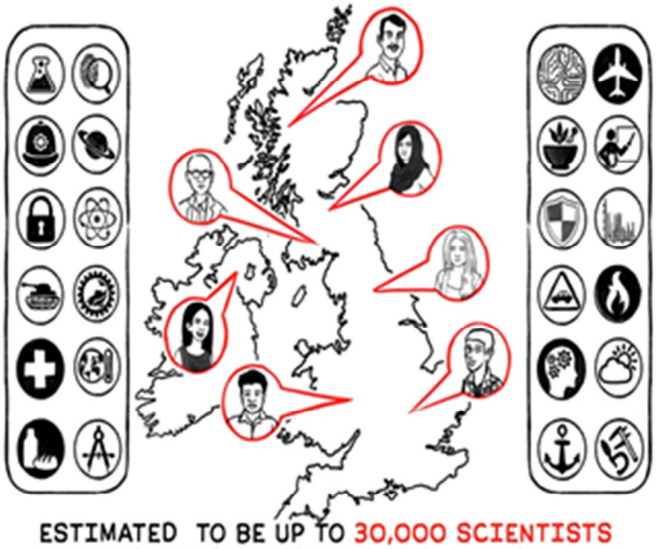
- The GSE profession constantly strives for excellence, through continuous peer-review, challenge and innovation. We also support innovation, investigation and exploration by others.
- In the sphere of Climate Change:
    - Scientists in DEFRA, DECC, and the Met Office Hadley Centre, together with engineers and officials, continue to lead on the Intergovernmental Panel on Climate Change (IPCC) and to ensure that the UK's policy on climate change – both on a domestic and international level – is based on the best possible scientific advice.
- We work to protect our food supply and preserve and enhance fish stocks:
    - Work by Marine Scotland, alongside the Department for Environment, Food and Rural Affairs (DEFRA) and the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) – in carrying out scientific assessments, advising fisheries managers and collaborating with the fishing industry - has seen great improvements in many North Sea fish stocks. This work has served to secure increases in fishing quotas, safeguarding Scottish fishing fleets.
    - DEFRA's Genetic Improvement Networks - ground-breaking networks linking government, academia and industry - have carried out most of the pre-breeding work for the main UK crops for over 10 years. Their work has, for instance, helped optimise nitrogen-fixation in pulse crops, lessening demand for nitrogen fertiliser and thus reducing cost, energy demand and environmental pollution.

- We support innovation:
    - Every day the Intellectual Property Office (IPO) works to protect UK innovators and entrepreneurs, helping new inventions make their way to market, new inventions such as Sugru, the mouldable glue that can be used to fix and modify anything from shoes to dishwashers, created by Jane Ni Dhulchaointigh [pron: nee-gull-queen-tigg] whilst a student at The Royal College of Art.
    - DfT has been working to develop battery-powered rail vehicles under its Independently Powered Electric Multiple Unit programme as part of a £7m collaboration with Network Rail, RSSB, Abellio and Bombardier, with the aim of changing the shape and price of future electrification projects across the country's rail network.
- We explore not just across the globe but beyond it:
    - The recent launch of British astronaut Tim Peake on his Principia mission to the International Space Station (ISS), uses the unique environment of space to run experiments that cannot be done anywhere on Earth, as well as trying out new technologies for future human exploration missions. The UK Space Agency have been working on an educational and outreach programme for young people across the country to increase interest in STEM subjects, hoping to inspire the next generation of scientists and engineers.

Slide 10: The GSE Profession Today – Innovating for a New World

- Government and the GSE Profession continue to innovate each and every day.
- We provide opportunity and nurture skills:
    - Encouraging girls and women to study STEM subjects and pursue careers in science and engineering, as in the Welsh Government's Talented Women for a Successful Wales initiative.
    - Through the Foreign and Commonwealth Office (FCO) and the Department for International Development we assist scientists and engineers across the Commonwealth, supporting people like:
        - Professor Kolawole Adebayo, who built a joint research collaboration between his university in Nigeria and the University of Greenwich into a multimillion pound sustainable agriculture project;
        - Dr Boghuma Titanji's cutting-edge research into HIV drug resistant viruses, aims for a better understanding of the mechanisms of drug resistance and identifying new ways of targeting resistant viruses. She has been a vocal advocate for ethical medical research, calling for researchers to find less exploitative ways to study diseases in developing nations.
- We open up new research areas, such as operational analysis, begun during World War II at the RAE but today, led by the Government Operational Research Service (GORS), providing the "science of better" across all of government.

- We fund innovation:
    - In 2006, responding to the government's Innovative Research Call (IRC) following plots to blow up transatlantic airliners using liquid explosives, researchers at Cobalt Light Systems developed a liquid screening system to discover the contents of sealed containers.
    - DEFRA and BIS have provided a £2 million grant to CEFAS and the University of Exeter to develop new molecular biology techniques to reduce the impact of major aquaculture diseases across India, Bangladesh and Malawi.
- We work with external partners in industry and academia, for instance on the exploitation of graphene. Teams at the NPL and the University of Cambridge combined to produce the first graphene single electron pump, a development with the potential to redefine the ampere based on electron charge, enabling more accurate measurements of current than ever before.
- We collaborate across government:
    - Working with others during the design, building and assurance stages of the Olympic and Paralympic 2012 venues to ensure their safety, bringing in high-level screening technologies to the Olympic Park itself and working with security suppliers to ensure their solutions were fit for purpose.
    - When, just a day after the announcement that London would host the games, the capital was hit by the 7/7 bombings, government scientists and engineers supported front-line response and law enforcement, working on everything from collecting forensic evidence to triage of victims to assessing transport infrastructure damage, pooling resources, skills and knowledge for public security and safety.
    - We make sure government is prepared for future challenges:
    - In 2013, following the Jon Day review, a central horizon scanning co-ordination team was established, hosted jointly by GO-Science and the Cabinet Office. The team coordinates strategic horizon scanning work across departments, encouraging the use of evidence on future trends to help government to manage risk and to assess whether their policies are resilient enough to withstand the medium-to-long term challenges facing the UK. This has included advice on Internet of Things (IoT), Big Data, and Demographic Change.



GSE
Government Science & Engineering

Slide 11: The GSE Profession Today – Who We Are

- It is estimated that there are up to 30,000 scientists and engineers working for government (in the Civil Service and wider public sector), in everything from biopharma to road safety, from space exploration to fisheries technology, from defence to nuclear fusion.
- Until recently, we were Civil and Crown Servants working in separate silos. But in 2008, the then Government Chief Scientific Adviser(GCSA) Professor Sir John Beddington decided to create the GSE Profession, an innovation that brings together all those Civil Servants working in government with a scientific or engineering background.
- Today, under the current GCSA, Sir Mark Walport, we want to build on those reforms, no longer a network of experts but instead a body of highly-valued scientists and engineers, working together, with the skills, expertise and knowledge we all need and the continuing professional development opportunities we all desire.
- Most of all, we want to ensure that the GSE Profession continues to be a body in which we can all have pride, in ourselves and in our fellow members, as we work in collaboration for the good of the nation.

Slide 12: The GSE Profession Today … and Tomorrow

- In our rapidly changing world, the GSE Profession is at the forefront of what government does today and will do tomorrow.
- Through the work of the GCSA and the Departmental Chief Scientific Advisers, we have created an internationally-recognised method of ensuring the very best scientific evidence is available to ministers and that policy is devised with all the relevant data to hand.
- Heads of Science and Engineering Profession (HoSEP) have seen their roles strengthened, empowering them to act as ambassadors for the Profession, committed to ensuring continuing professional development and flexible careers are accessible to their staff.
- And we must continue to adapt, ensuring we have the skills to face the future and the new and emerging technologies that it will bring.
- As the Civil Service develops its five year vision for the future, we will use it to create the GSE Strategy – our blueprint for the future of the profession. The GSE Profession will be a leader in the changes to come. By working together as a Profession, we will:
- ensure our members have access to the skills and training they need to do their jobs effectively;

- provide access to a greater choice of careers, able to move across departments and even sectors;
- ensure there is opportunity for all in a diverse and inclusive profession
- be a voice for all in the profession, ensuring policy makers know who we are, what we do and the vital role that our evidence and advice must play,
- secure the GSE Profession's place at the heart of government policy-making.
- We will encourage new recruits, making work in government one of the best career choices for any scientist or engineer through initiatives such as the Science and Engineering Fast Stream (SEFS) and new science and engineering apprenticeships.
- We recognise that the future success of the GSE profession lies in its people - ensuring that they have the right skills, knowledge and expertise to provide support in the new challenges of technology and to strengthen their role at the centre of government advice and decision making.
- We have achieved a lot to date, continually evolving and adapting to change to tackle real-world problems ranging from disease and terrorism to pollution. We remain committed to working for the public good, ready to respond to the future challenges in technology and government.
- **We are GSE. Join us. Collaborate with us. Champion us!**