

CAREERS THROUGH MATHS: AEROSPACE ENGINEER



JOB DESCRIPTION

Aerospace Engineers in the UK design, develop, and test aircraft, spacecraft, satellites, and missile systems. On a typical day, you might be found at Airbus in Filton or Broughton running computational fluid dynamics (CFD) simulations on the next-generation wing design, or at Rolls-Royce in Derby analysing turbine blade fatigue under extreme thermal stress. Your work spans the full product lifecycle—from initial concept sketches and feasibility studies through to detailed design, prototyping, certification testing, and in-service support. For example, you could be calculating the thrust-to-weight ratio for a new short-haul jet destined for easyJet's fleet, or determining the orbital insertion parameters for a communications satellite being built by Surrey Satellite Technology Ltd (SSTL) in Guildford.

The work environment varies dramatically. You might spend part of your week in a design office using CAD software, another day in a wind tunnel at Farnborough testing scale models, and another at a test facility in Bristol analysing vibration data from a fuselage section. Collaboration is central to the role—you'll work alongside structural engineers, avionics specialists, and manufacturing teams, as well as liaising with regulators at the Civil Aviation Authority (CAA) or the European Union Aviation Safety Agency (EASA) to ensure your designs meet stringent safety certification standards. Many UK aerospace engineers are also involved in research and development, working on pioneering projects like the Tempest future combat air system or hydrogen-powered aircraft concepts through the Jet Zero Council initiative, which aims to decarbonise UK aviation by 2050.

Mathematics is the fundamental language of aerospace engineering. Every design decision, from the sweep angle of a wing to the diameter of a fuel line, is underpinned by mathematical analysis. When you calculate the lift coefficient for an aircraft at 35,000 feet, you're applying Bernoulli's equation and the Navier-Stokes equations. When you determine the structural integrity of a landing gear strut, you're performing finite element analysis that involves solving thousands of simultaneous linear equations. When you're working out the fuel required for a London-to-New York transatlantic flight, you're integrating fuel flow rates over time while accounting for changing atmospheric conditions. Without a deep understanding of calculus, linear algebra, differential equations, and statistics, none of this work would be possible.

Aerospace is one of the UK's most successful manufacturing sectors, contributing over £36 billion annually to the economy and supporting more than 200,000 jobs across the country. Major employers include BAE Systems (with sites in Lancashire, Yorkshire, and Hampshire), Leonardo Helicopters in Yeovil, and GKN Aerospace on the Isle of Wight, alongside thousands of smaller suppliers in the supply chain. As an aerospace engineer, you're not just designing exciting machines—you're contributing to UK national security, global connectivity, and the push toward net-zero aviation. The role demands precision, creativity, and rigorous mathematical thinking, and it offers one of the most intellectually rewarding career paths available to mathematically minded graduates.

HOW MATHEMATICS IS USED

- **Calculus (Differentiation and Integration):** Calculus is the backbone of aerospace engineering. When you're determining the rate of climb for an aircraft, you're differentiating altitude with respect to time. When you're calculating the total lift generated across a wing of varying chord length, you're integrating pressure distribution across the wing surface. At BAE Systems in Warton, engineers use differential calculus to model the rate of change of aerodynamic forces as a fighter jet manoeuvres at supersonic speeds—crucial for flight control system design. Integration is used to determine the total impulse (change in momentum) of a rocket engine by integrating thrust over its burn time, essential for trajectory calculations at UK launch companies like Orbex in Scotland.
- **Linear Algebra and Matrices:** Modern aerospace structures are analysed using the finite element method (FEM), which divides a complex structure into

thousands of smaller elements, each described by a set of simultaneous linear equations. These matrix equations are solved to determine stress, strain, and displacement throughout the structure. At Airbus Filton, engineers working on the A350 XWB wing use FEM to ensure the carbon-fibre composite structure can withstand the extreme bending moments experienced during turbulence. Similarly, flight dynamics and stability analysis rely heavily on matrix operations—the equations of motion for an aircraft are expressed as a state-space model using matrices, allowing control engineers to analyse stability and design autopilot systems for UK-built aircraft like the BAE Systems Hawk.

- **Differential Equations:** The behaviour of aircraft and spacecraft is governed by ordinary and partial differential equations. The Navier-Stokes equations, which describe fluid motion, are used to model airflow over wings and through jet engines. At Rolls-Royce Derby, engineers solve these equations numerically using computational fluid dynamics (CFD) software to optimise the shape of turbine blades for maximum efficiency. The equations of motion for a satellite in orbit are second-order differential equations that must be solved to predict its position and velocity over time. Engineers at SSTL in Guildford use these calculations to ensure that the NovaSAR-1 radar satellite maintains its correct sun-synchronous orbit, adjusting its trajectory using thrusters when atmospheric drag causes orbital decay.
- **Trigonometry and Geometry:** Trigonometry is essential for understanding forces, trajectories, and positioning. When calculating the components of thrust from a vectored-thrust engine like the one on the F-35B (assembled at BAE Systems in Samlesbury), you must resolve forces into their horizontal and vertical components using sine and cosine functions. For aircraft navigation, engineers use spherical trigonometry to calculate great-circle routes between London Heathrow and destinations worldwide, determining the shortest path across the Earth's curved surface. In structural design, geometry is crucial—engineers at GKN Aerospace on the Isle of Wight use geometric modelling to design the complex curves of wing leading edges, ensuring they meet aerodynamic specifications while remaining manufacturable.
- **Statistical and Analytical Methods:** Aerospace engineering generates vast amounts of test data, and statistics is vital for making sense of it. When conducting fatigue testing on aircraft structures, engineers at QinetiQ in Farnborough use statistical methods like Weibull analysis to predict the probability of failure over time. In flight testing, data from hundreds of sensors is analysed using regression analysis to validate that actual performance matches

theoretical predictions. Reliability engineering is another key application—engineers calculate the probability that a critical system will operate without failure for a given period, using techniques like Monte Carlo simulation to model the effects of component variability. For example, when designing the landing gear system for a commercial airliner, engineers must demonstrate through statistical analysis that the probability of catastrophic failure is less than one in a billion per flight hour, as required by CAA and EASA certification regulations.

KEY SKILLS & TOOLS

Skill/Tool	Application
CATIA V5/V6 (CAD Software)	Dassault Systèmes' CATIA is the industry standard for 3D computer-aided design in UK aerospace. Engineers use it to create parametric 3D models of aircraft components, applying geometric constraints and mathematical relationships between dimensions. At Airbus Broughton, engineers use CATIA's generative surface design module to model the complex double-curvature panels of the A380 fuselage, then use the software's analysis tools to calculate mass properties, centre of gravity, and moments of inertia.
MATLAB/Simulink	MathWorks' MATLAB is extensively used across UK aerospace for numerical computing, data analysis, and algorithm development. Engineers at Leonardo Helicopters in Yeovil use MATLAB to model helicopter flight dynamics, solving differential equations that describe rotor blade motion. Simulink is used for control system design—for example, developing the fly-by-wire control laws for the AW149 helicopter that translate pilot inputs into rotor commands, with mathematical verification of system stability using Bode plots and root locus analysis.
ANSYS (Finite Element Analysis)	ANSYS is used for structural and thermal analysis through finite element methods. Engineers at Marshall Aerospace in Cambridge use ANSYS to analyse the stress distribution in aircraft fuselage structures when they're modified for special missions, such as converting commercial airliners into aerial refuelling tankers for the RAF. The software solves matrix equations with thousands of degrees of freedom to determine whether a design meets safety factor requirements (typically 1.5 for ultimate load).

Python	Python has become essential for data analysis, automation, and scientific computing in UK aerospace. Engineers use libraries like NumPy and SciPy for numerical calculations—for instance, writing scripts to process and visualise telemetry data from test flights at Boscombe Down. Python is also used for machine learning applications, such as developing predictive maintenance algorithms that analyse engine sensor data to forecast component failures before they occur, saving millions in unscheduled downtime.
Computational Fluid Dynamics (CFD) Software	Tools like Fluent and STAR-CCM+ are used to simulate airflow over aircraft surfaces. At Reaction Engines in Oxfordshire, engineers use CFD to model the hypersonic airflow through the SABRE engine's precooler, solving the Navier-Stokes equations at Mach 5 speeds. These simulations require solving millions of equations simultaneously, and results are validated against wind tunnel test data from facilities at the University of Southampton.
Project Management & Communication Tools	Aerospace engineers must present complex mathematical results to diverse audiences. Engineers use tools like Microsoft PowerPoint to present certification evidence to CAA/EASA auditors, explaining how safety margins have been calculated and verified. Technical reports written in LaTeX are common for documenting mathematical derivations. Engineers also use project management software to track design milestones, budget allocation, and resource planning across multi-year development programmes.
Statistical Process Control (SPC)	SPC is used in aerospace manufacturing to ensure quality and consistency. At Rolls-Royce's Advanced Manufacturing Facility in Rotherham, engineers use control charts to monitor the dimensions of turbine disc forgings, calculating process capability indices (C_p and C_{pk}) to ensure manufacturing tolerances are maintained within specification. When measurements fall outside control limits, mathematical analysis identifies the cause and informs corrective action, ensuring that the safety-critical components meet their rigorous specifications.

Typical Pathway: The route to becoming an aerospace engineer in the UK typically begins with strong GCSEs in mathematics (grade 6 or above) and sciences, followed by A-levels in mathematics and physics (grade B or above is typically expected for competitive university courses). The most common route is a BEng (3 years) or MEng (4 years) degree in Aerospace Engineering from universities such as the University of

Southampton, Imperial College London, the University of Bristol, or Cranfield University, all of which have strong links with UK industry. Alternatively, apprenticeships offer a vocational route—for example, Airbus in Broughton offers a degree apprenticeship where you work on real aircraft programmes while studying for a BEng at the University of South Wales. After graduation, you'll typically join a graduate scheme at a company like BAE Systems or Rolls-Royce, rotating through different departments. Full chartered status as a Chartered Engineer (CEng) through the Royal Aeronautical Society (RAeS) is the gold standard for professional recognition, typically achieved four to six years after graduation. Many engineers also pursue a master's degree or PhD while working, often sponsored by their employer, to specialise in areas like aerodynamics, propulsion, or flight control systems.

Industry Demand: The UK aerospace sector is growing strongly, with industry body ADS Group reporting that the sector's order book stands at over £200 billion. The Aerospace Technology Institute (ATI) forecasts that the UK will need to recruit approximately 4,000 engineers per year to meet demand, particularly in areas related to sustainable aviation—the development of hydrogen-powered aircraft, electric propulsion systems, and more efficient aerodynamics. The UK government's Jet Zero Strategy, published in 2022, commits £685 million to support the development of zero-emission aircraft, creating significant demand for engineers with strong mathematical skills. Additionally, the UK's growing space sector, which includes launch companies like Orbex and satellite manufacturers like SSTL, is projected to grow from £17.5 billion to £30 billion by 2030, according to the UK Space Agency, requiring a steady pipeline of mathematically skilled aerospace engineers.

Real-World Impact: Aerospace engineers in the UK make profound contributions to society, national security, and the economy. They design and build the aircraft that connect the UK to the world—Airbus wings made in Broughton are fitted to every Airbus commercial aircraft, meaning that every Airbus flight worldwide relies on UK engineering expertise. They develop the fighter jets that protect UK airspace and support NATO operations through BAE Systems' Tempest programme, which aims to deliver a sixth-generation combat aircraft by 2035. In the civil sector, engineers at Reaction Engines are developing the SABRE engine, which could revolutionise space access by enabling aircraft to reach orbit from conventional runways. The mathematical work of aerospace engineers also contributes to the UK's net-zero targets—developing hydrogen propulsion systems and optimising flight paths to reduce fuel burn is directly helping to decarbonise one of the hardest-to-abate sectors of the economy. For mathematically talented students, aerospace engineering offers the opportunity to apply their skills to challenges that genuinely shape the future of UK technology, security, and sustainable development.