CAREERS THROUGH MATHS: SYSTEMS ENGINEER

JOB DESCRIPTION

A Systems Engineer is responsible for designing, integrating, and managing complex systems over their entire life cycle. They act as the crucial link between different engineering disciplines, ensuring that all parts of a project—from software and hardware to operational processes—work together seamlessly to meet the customer's needs. A typical day might involve liaising with mechanical engineers, software developers, and project managers to define system requirements, creating architectural diagrams, and running simulations to validate designs before physical implementation. For example, at a company like BAE Systems, a Systems Engineer might be tasked with defining the requirements for a new naval radar system, ensuring the software for target tracking integrates perfectly with the physical antenna mechanics and the electrical power supply.

The work environment is predominantly office-based, but can include time on-site with clients or in testing facilities. In the UK, major employers include defence and aerospace giants like Rolls-Royce and QinetiQ, automotive companies like Jaguar Land Rover, and large technology and transport organisations like Network Rail or BT. The role is highly collaborative, requiring constant communication to resolve conflicts and balance competing priorities such as performance, cost, safety, and schedule.

Mathematics is central to this role, providing the rigorous foundation for all decision-making. Systems Engineers use mathematical models to predict system behaviour, perform trade-off analyses to select the best solution from multiple options, and quantify risks. Whether calculating the reliability of a component using statistical failure rates or modelling the data flow through a new fintech payment platform to ensure security and speed, mathematics turns abstract requirements into quantifiable, testable specifications. This mathematical rigour is essential for developing complex, high-integrity systems that are critical to the UK's national infrastructure and economic competitiveness.

HOW MATHEMATICS IS USED

- **Calculus (Differential Equations):** Systems Engineers use calculus to model dynamic systems—those that change over time. This is fundamental for understanding control systems and feedback loops. For instance, when designing the active suspension system for a new McLaren sports car to improve handling, engineers use differential equations to model the relationship between road forces, spring damping, and the car's body motion. Similarly, in the energy sector, modelling the flow of electricity through the National Grid to maintain stability requires solving complex differential equations that describe voltage and current changes.

- **Linear Algebra:** This area of mathematics is crucial for managing multi-dimensional data and understanding transformations within a system. A key application is in signal and image processing. For a project like the SKA (Square Kilometre Array) telescope being developed with significant UK involvement, linear algebra is used to process massive datasets from thousands of antennas and reconstruct images of deep space. It is also fundamental to optimisation problems, such as calculating the most efficient routing for parcels in a national logistics network like Royal Mail's.

- **Probability and Statistics:** Systems Engineering relies heavily on probability to assess risk, reliability, and performance. A Systems Engineer at Babcock International, maintaining a fleet of Royal Navy vessels, would use statistical analysis of component failure data to predict maintenance schedules and ensure operational availability (a key metric known as 'Mean Time Between Failures'). In the development of autonomous vehicle systems in the UK, probabilistic models are used for sensor fusion, combining data from lidar, radar, and cameras to create a reliable understanding of the vehicle's surroundings despite uncertain measurements.

- **Boolean Algebra and Logic:** This is the mathematics of digital logic circuits and software decision-making. It is essential for designing and verifying complex digital systems. For example, when specifying the control logic for a railway signalling system for London Underground, Systems Engineers use Boolean algebra to ensure that safety-critical rules are never violated (e.g., "IF signal is red, THEN train MUST receive a brake command"). This formal logic is also used to create fault trees, which are diagrams that use logical operators (AND, OR) to trace the causes of potential system failures.

- **Statistical and Analytical Methods:** Beyond basic statistics, Systems Engineers employ advanced analytical methods for decision-making. Techniques like Design of Experiments (DoE) are used to systematically test different configurations of a system with minimal runs, which is vital in aerospace for optimising wing design without costly physical prototypes. Mathematical modelling and simulation, using tools like MATLAB and Simulink, allow engineers to create virtual prototypes of entire systems—from a new medical device for the NHS to a satellite for Airbus Defence and Space—enabling them to test performance, identify bottlenecks, and validate requirements long before physical manufacture, saving significant time and resource.

KEY SKILLS & TOOLS

Skill/Tool	Application
MATLAB & Simulink	Used extensively for mathematical modelling, simulation, and data analysis. A Systems Engineer might use Simulink to model the entire electrical system of a hybrid bus for Wrightbus in Northern Ireland, running simulations to analyse energy consumption and battery life under different London driving cycles.
SysML (Systems Modeling Language)	A specialised language for representing system requirements, structure, behaviour, and parametrics. Engineers use it to create precise, unambiguous models. For example, it would be used to formally specify the interactions between software, hardware,

	and human operators in a new air traffic control system for NATS.
Python (with NumPy, SciPy, Pandas)	The leading programming language for data analysis, automation, and scripting custom calculations. An engineer might write a Python script to statistically analyse performance test data from a new broadband network for Sky UK, or to automate the generation of system requirements documents.
DOORS (Dynamic Object-Oriented Requirements System)	A requirements management tool used to capture, trace, and analyse thousands of system requirements. It ensures mathematical rigour by helping manage links between high-level customer needs and low-level component specifications, which is critical in safety-conscious industries like nuclear power with EDF Energy.
Statistical Analysis Tools (e.g., Minitab)	Used for rigorous statistical analysis, particularly in quality control and process improvement. A Systems Engineer might use Minitab to perform a regression analysis on manufacturing data from a JCB factory to reduce variability in a component's dimensions, improving overall product reliability.
Verbal and Written Communication	Essential for translating complex mathematical models and technical trade-offs into clear recommendations for non-technical stakeholders. This could involve presenting the cost-benefit analysis of two different architectural designs to senior management at a company like Dyson.
Failure Mode and Effects Analysis (FMEA)	A systematic, quantitative method for identifying potential failures in a design. Engineers assign numerical scores for severity, occurrence, and detection, then calculate a Risk Priority Number (RPN) to prioritise which issues to address first, a process mandated in UK automotive and aerospace standards.

Typical Pathway: To become a Systems Engineer in the UK, a strong foundation in mathematics and physics at GCSE and A-Level (or Scottish Highers) is essential. The most common route is a bachelor's degree in a relevant field such as Systems Engineering, General Engineering, Aerospace Engineering, or Electronic Engineering from an institution accredited by the Institution of Engineering and Technology (IET) or the Royal Aeronautical Society (RAeS). Many graduates enter the profession through graduate schemes offered by major employers like BAE Systems, Thales UK, or the Civil Service Fast Stream. Career progression typically moves from

Junior Systems Engineer to Senior, then to Lead or Principal Engineer, and potentially into technical management. A key step for career advancement is achieving Chartered Engineer (CEng) status through a professional body like the IET, which demonstrates a commitment to the highest professional standards. Continuous professional development (CPD) is supported by these institutions through courses, seminars, and industry publications.

Industry Demand: The demand for Systems Engineers in the UK is strong and growing, particularly in the defence, aerospace, automotive (especially with the shift towards electric and autonomous vehicles), and technology sectors. According to the UK Government's official data, roles like "Engineering Professionals" are identified as having a positive outlook. This demand is driven by the increasing complexity of technology and the critical need for professionals who can manage interdisciplinary projects, ensure cybersecurity, and deliver solutions that are robust, efficient, and fit for purpose within the UK's stringent regulatory environment.

Real-World Impact: Systems Engineers in the UK play a vital role in delivering nationally significant projects. They were integral to the development of the Elizabeth-class aircraft carriers, the largest warships ever built for the Royal Navy, ensuring the integration of millions of components. They contribute to sustainable energy projects, such as the Hornsea Wind Farm, by designing the complex control systems that integrate renewable power into the national grid. Their mathematical work ensures the safety, reliability, and efficiency of the technologies that underpin modern British society, from transport networks and communication systems to healthcare technologies and national security.