

I Am a Systems Engineer and I Do...

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Why did you choose to be a Systems Engineer?

I didn't really make a choice, it chose me. I grew into Systems Engineering (starting around software intensive systems of embedded controls) as it became apparent that I had the right attitude and mindset... what is today probably called Systems Thinking. I also think I had a lot of luck and some good mentors.

Like many small boys, I was always taking things apart to figure out how they work... but I usually could learn enough to put them back together. I was always fascinated by 'electronics' especially the transistor circuit diagrams, building many projects through my teenage years, analogue synthesizers, audio power amplifiers and even my first personal computer long before the advent of standardized component systems. My parents were horrified at the 'waste of money'.

After leaving school I pestered my way into a local company (using my hobby skills as evidence), writing in assembler on the new-fangled Intel 8080 and its family of peripheral chips to work in industrial automation.

A natural progression from 'taking things apart' made me fascinated in making the physical, real-world object obey my commands, whether electronic, electrical, electro-magnetic, hydraulic or pneumatic... and that meant dealing with all the non-linearity such systems exhibited. My inquisitiveness had me digging into the underlying physics of why sensors and actuators exhibited these strange responses (the real world is not linear!).

That inquisitiveness appears to have been a key. I have always had a thirst for learning and I still probably perform best with experiential learning.

My ability to abstract a problem (or solution) independent of the technology and details of an implementation, appeared to be an unusual trait when compared with my peers, and naturally led me to architecture of systems. It also led me to become a lifelong 'trainer', teaching groups of engineers about subjects I had learnt through my own experiences.

With some key job roles I was given responsibility for not just internal system behavior, but looking at system performance, future needs and technologies but more importantly spending much more effort on how the system would be used, or be abused, with focus on system interfaces and behavior. With bigger projects came bigger interaction with contract partners, their subsystem interfaces and capabilities, a huge quantity of system validation techniques and a much wider learning space than just my own company.

I had some excellent grounding in my embedded system development days that helped me realize the need for integrity (both of the system description and personally) in realizing highly-dependable solutions in which human lives were at stake.

Although I journeyed from engineer to manager, to senior manager, to chief technology officer, I have returned to systems and embedded Systems Engineering – because I enjoy solving the complexity such constrained systems bring.

What education/qualifications do you have for Systems Engineering?

I was talented at mathematics and applied physics, but didn't apply myself as I should in my teenage years (I was fascinated by more mechanical systems, motorbikes, cars etc because of the freedom they imparted, and the fun of competing (rallying in my case) and spent more time on them than I should.

I did an HTEC Electronic Engineering course, but as electronics went from analogue to digital, the allure waned for doing electronic hardware design.

I clearly had an aptitude (I left college as a prizewinner) and my senior college lecturer suggested I apply to Cranfield School of Electrical and Electronic Engineering to do an MSc. (Initially I was refused as I hadn't the requisite entry qualifications, yet somehow with his supporting recommendation, I was granted a place.) I opted for Computer Science as my specialization, even though I scored highly in analogue electronics exams, because I was more interested in control system software than digital electronic design.

After graduating I changed job to work in defence systems, as this was the place where, at that time, cutting-edge technology was being brokered. It was an era of complete immersion and huge technology change, most of which is still relevant today. I became a member of the IEEE as their publications were on topic and highly relevant and supported my need for wider learning.

I started out as an engineer, then designer, of a forerunner of mobile communications (with moving cells as well as people), with a volatile network topology. Later, as a key designer for a tri-service military communication system containing a 'packet data' system than ran over RF with guaranteed delivery as well as store-and-forward style message centres introduced me to data systems, layered protocols, error-correction techniques, switching and routing, cryptography and security systems, wireless systems, Over-the-Air updates, data relay and managing system power consumption and EMC emissions in software! We won a Queen's Award for Industry with the solution.

Planning and executing projects across a wide range of discipline domains, cultures and geographies was a journey I found hard to contemplate in my early engineering career, but there was a significant buzz gained from mastering this and then managing, coaching, mentoring and most of all leading a team to exceed their own expectations. Projects are like systems in their own right, morphing with every perturbation, resolving unknowns, and managing stakeholders with different objectives, views and expectations.

Although late in applying for CEng, I could clearly evidence sufficient knowledge and experience and as a result immediately applied to become a Fellow of the IET. I served on IET Council and became a professional development advisor, a job that requires mentoring and coaching skills.

I have been budget holder and technical mentor for many research projects in well-respected universities from UK to Singapore, enjoyed being a member (and chair) of Research initiatives and on Doctoral training school industrial advisory boards, whilst accessing lots of novel ideas, cutting edge technologies and growing an enviable professional network.

What is it about Systems Engineering that you find so compelling?

Every industry thinks they are different and the language they use may differentiate them, but ultimately the set of problems they face are often resolvable by a Systems Engineering process.

Helping your colleagues get clear recognition of the problem, helping them identify what they really need (or want) and the potential candidate solutions (with their trade-offs) in clear analytical, objective comparison, using enumerated evidence (rather than hand-waving beliefs and assumptions) is a real thrill.

Puzzles - you need to love puzzles. A System Engineering project is like solving a unique n-dimensional puzzle. Experiences and anecdotes, collected from many different industries, with different business needs, under myriad constraints of environmental, physical, performance, safety, security and other attributes, helps hone your intuition (personal knowledge base) to identify effective solutions and provide early recognition of dead-ends.

Re-application of Knowledge - My defence systems career taught me much of communication systems, whose technologies have changed, but some mechanisms have only recently appeared in commercial applications – a true indicator that patterns repeat themselves. But more importantly, the importance of system use, system interfaces and controlling behavior in undefined use or abuse (whether unintended or malicious) has enabled my clarity of thought when describing and assuring high-integrity systems, and a useful guide for both designing and managing Safety and Security specialisations

Socio-Technical - I led large teams on 4 different continents, with different cultures, working on the design of a single product (no conference calls!). I turned that product into a successful product line architecture recognizing the platform independence and feature abstractions were the key to its variants in a cost-sensitive market.

Persuasion - I helped change the process of engineering within an automotive controls business organization from mechanically-led to electronic/software-led, by helping them recognise the business sensitivity to product failures were largely 'controls' issues, as the control system was tasked to protect the mechanical system from abuse (which itself enabled significant mechanical optimization).

Patterns and Re-use - I repeated some of this journey in new jobs in Aerospace, Nuclear, Medical, often teaching Systems Engineering approaches as well as product safety and product line engineering, showing that these techniques were portable in abstract.

I have returned to engineering as a consultant with more emphasis in systems modeling, design, software architecture, safety and security engineering across a number of industries, as it is the re-application of ideas from 'outside' the client's home industry that delivers value.

I have co-authored papers on the future challenges of complexity and resilience in complex engineering systems, as in my opinion, future Systems Engineering will be less about 'clean-sheet' design, but more about integration of diverse legacy systems that are themselves evolving.

Managing such evolutionary complexity with potentially competing component system goals, often poorly documented behavior or performance, with ill-defined future stakeholder interaction is deliciously challenging – as long as we can manage expectations! Engineers are not magicians – and 'ye cannae change the laws of physics'!

What advice would you give a systems engineer just starting out in their career?

Be inquisitive, always ask questions, but look for evidence to support what you are being told. Don't be afraid to be wrong, but be willing to learn. Get involved, don't pass up an opportunity because it's outside your comfort zone. Consume everything you can in your chosen field, technology trends, especially flaws and failures of systems, as lots of lessons to be found here.

Manage your career, and don't be afraid to cross industry boundaries or domains by taking on new roles or new jobs. What you have already learnt may be useful, what you will learn will add to your value as a system engineer, especially with diverse experiences.

Your focus may change as you acquire knowledge, experience and expertise, and you gain competence but keep enjoying what you do. Embrace professional development and use it to plot the acquisition of the experiences you need, it's a good framework and there are some industries and roles that require the recognition.

Accept that abstraction is not a skill that everyone can grasp, so be prepared to use analogs (solution or domain specific) as examples to elucidate an abstract principle to others.

Don't expect to know it all, but engage with the experts, build and validate your own (simplified) mental model with each encounter. Your perception is enriched by relationships and dependencies between these domains, your intuition is governed by your perception.

Dealing with the required functionality of a system is often the obvious, but simple, part of the task, dealing with the consequences of a system that is operated in all other circumstances can drive significant complexity: your task is to tame that complexity. Focus your engineering efforts on the 'tricky bits', to reduce risk, but don't expect to have a uniform level of detail as a result, but sufficient to allow domain experts to apply their skills in implementing a solution.

If you want to know where your competitors are, join collaborative groups or standards bodies and contribute, they're good for networking and job prospecting.

Remember, academia gave you the tools to take your first step, but your lifetime learning journey has just begun!