Title of submission: **Career Readiness Challenge – Engineering Design in Robot Assisted Surgery**

Name: **Danyal (from TechnoGear)**

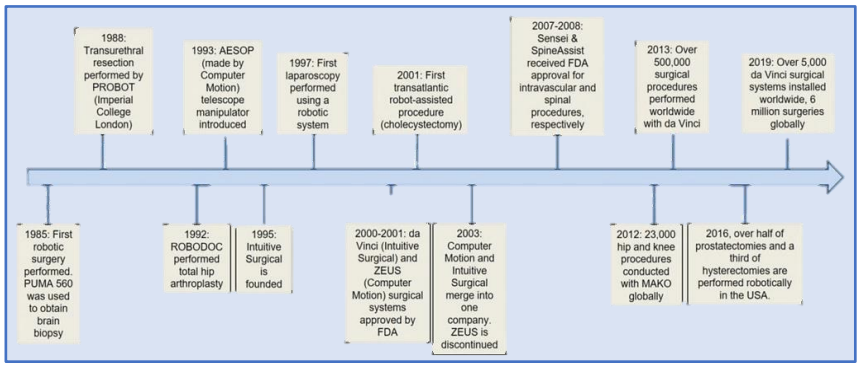
Team number: **21549E**

Location of team: **London, United Kingdom**

What is Robot Assisted Surgery (RAS)?

RAS is the shape of the future of surgery, spanning many opportunities for STEM careers. It is the forefront of saving lives, involving the use of tools given to surgeons. By surgeons providing input in design of their tools, enables engineers to design complex robots to aid surgery.

We have come a long way from concept of, 'robot,' (1900s), with Karel Capek's play "R.U.R," NASA experimentation of telesurgery for astronauts (1970s), first robotic surgery in brain surgery (1985), to FDA approval (2000s), resulting to practices of over 6 million surgeries globally (2019) [3][4]



Timeline of RAS post-1980s [4]

In 2012, 'Zeus': a robot allowed transatlantic surgery to be performed in a community hospital over 400 km away![1].

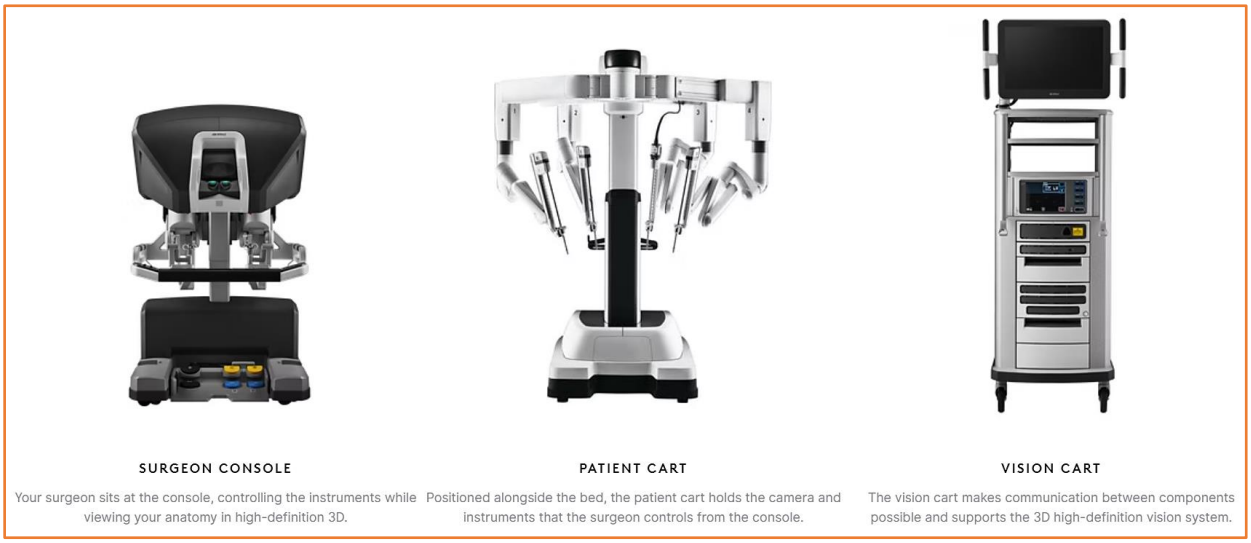
The projected outlook for growth in the RAS market is very positive [2]

This shows RAS provides possibilities for an inspiring, innovative future which fascinates me.

The RAS System (Da Vinci by Intuitive Surgical)

An example of a RAS system is, 'Da Vinci,' produced by the company Intuitive Surgical which currently dominates the RAS market.

Components of the Da Vinci RAS System [5]



Surgeons use advanced instruments (Patient Cart) to perform from the Surgeon Console. It has an accessible design with robotic limbs and 3D video analysis (Vision Cart) allowing surgeons to have the best precision. The surgeons hand movements are translated in real time to perform the surgery.

RAS Surgery Use - Pros and Cons

PROS

- Accuracy/precision
- Better visualisation
- Telesurgery
- Internal body surgery easier
- Less pain during recovery
- Lower infection risk
- Reduced blood loss
- Shorter hospital stays
- Smaller scars/incision

CONS

- Expensive (not available everywhere)
- Surgeons have to be specially trained
- Complications (Convert back to open procedure)
- Risk of nerve damage/compression
- Robotic malfunction
- Regulatory Approvals
- Gaining trust/confidence

Types of Robotic Surgery Possible [5] [6]

- Cardiac
- Colorectal
- General
- Gynaecology
- Head and neck
- Thoracic
- Urology

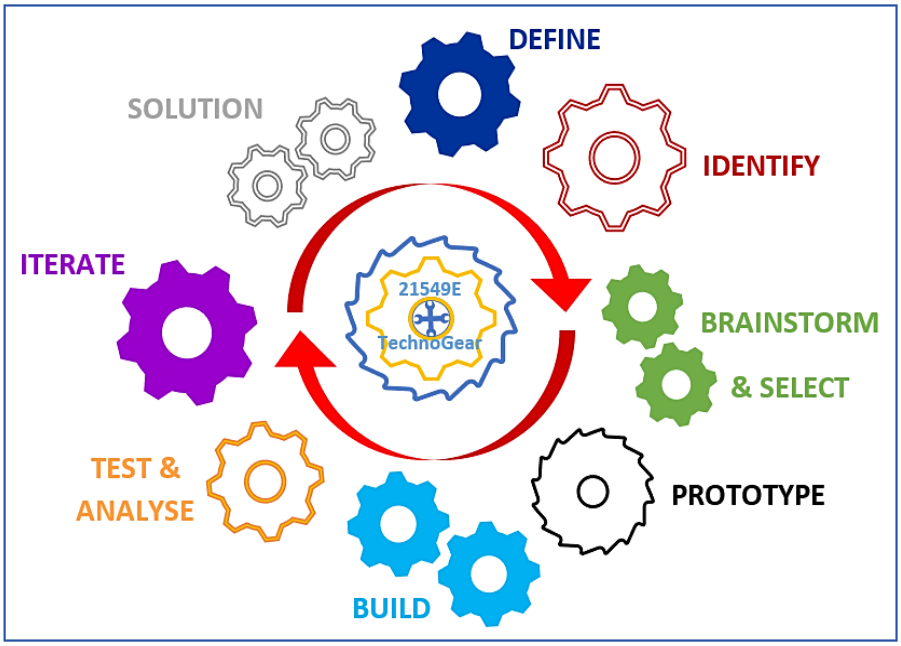
VEX IQ Competition - Engineering Design Process

In VEX, my team have adopted the Engineering Design Process to achieve success.

As engineers, we are our own customer following various stages with continuous iteration.

This process is vital with regular team meetings, discussions, polls, use of CAD, Solidworks, and documenting designs in the Engineering Notebook.

Engineering Design Process used by my team in VEX



DEFINE:	As a team we look and understand the brief of the VEX IQ Competition game (Slapshot rules).
IDENTIFY:	We have an initial understanding of potential problems we will face by conducting research and try to find early solutions or accept limitations like lack of parts, time, space.
BRAINSTORM & SELECT:	We ideate, going through a number of ideas and each collaborate to produce a shortlist to then detail further, documenting along the way. We then select a design, prioritising an option.
PROTOTYPE:	We bring the selected design to life, building the initial functioning version.
BUILD:	This is one of the longest stages with our involvement in constant build work, ensuring tweaks to deliver the final build solution.
TEST & ANALYSE:	This is where the drivers test the robot for each dispenser and decide with the team whether it suits the final solution or needs adjustment.
ITERATE:	Usually is needed (even if the bot works seamlessly to improve it) the process to rebuild, retest and reanalysis is conducted repeating previous steps where relevant.
SOLUTION:	The final product is communicated, tested and practiced with before competition so that we can learn from the whole process.

One aspect that does not come across in this, is the level of interaction with team building, morale, and friendships forged, not forgetting how much I enjoy it. All this builds on growth of my confidence of technical skills as well as my interpersonal skills; it is a rollercoaster ride!

RAS Engineering Design Careers (Intuitive Surgical)

There are a whole host of STEM careers that are teeming in RAS, for instance there are over 50 roles currently within the Product Engineering & Design areas in Intuitive Surgical.

I have homed in on a specific role of, **'Staff Mechanical Engineer, Surgical Medical System Design'**, within Intuitive Surgical which appeals to me.

Highlighted are relevant skills within the job description that captures parallels with skills and attributes that I have actually experienced with VEX.

These include creativity, design, analysis, testing, problem solving, implementation, debugging, CAD/SolidWorks use, decision making, collaboration and team working. All steps within the Engineering Design Process.

Staff Mechanical Engineer, Surgical Medical System Design

Job Description
Primary Function of the Position

As a Staff System ME, you must utilize creativity and sound technical judgment as the architect of new medical capital equipment products, achieving an advanced level of technology, design, and integration for robotic-surgical components. You will ideate and develop architectural interfaces for various subsystems, including but not limited to structures and body parts, electro-mechanical packaging, sensors and actuators, manipulators, and physical user interfaces. You will spearhead high-complexity design activities, to introduce novel features and drastic performance improvements in Surgical Systems. You will understand and address multi-domain physics challenges involved in design optimization, and use analytical, simulation and experimental tools to drive development. You will be responsible for high-maturity design reviews, including multiple levels of product owners, stakeholders, and cross-functional teams. As a lead design engineer, you will interface with suppliers and manufacturing to build high-quality hardware prototypes and productize new designs. You will be trusted to allocate your time and efforts to make sound decisions, when faced with time constraints and ambiguous or incomplete information.

Key Roles & Responsibilities

Developing system mechanical assemblies, with careful consideration for key functions and safety.
Working within multi-disciplinary teams to define requirements for new robotic surgical products.
Producing and iterating full-scale functional prototypes in a fast-paced New Product Design environment.
Creating and managing design failure-modes analysis and associated verification testing.
Collaborating with Product Owners for product validation activities and mission-critical risk-assessment.
Defining product's performances and specifications, with an eye to final product delivery.
Generating and owning models for assemblies, components, and drawings, in a government regulated environment.
Collaborating with vendors, suppliers, quality and manufacturing through the design-transfer and launch.
Mentoring and coaching other engineers in problem solving and technical expertise.

Qualifications
Key Skills, Experience, Education, & Training
Required

Minimum BSME or similar, with minimum 12 years of relevant experience. Primary Function of the Position
As a Staff System ME, you must utilize creativity and sound technical judgment as the architect of new medical capital equipment products, achieving an advanced level of technology, design, and integration for robotic-surgical components. You will ideate and develop architectural interfaces for various subsystems, including but not limited to structures and body parts, electro-mechanical packaging, sensors and actuators, manipulators, and physical user interfaces. You will spearhead high-complexity design activities, to introduce novel features and drastic performance improvements in Surgical Systems. You will understand and address multi-domain physics challenges involved in design optimization, and use analytical, simulation and experimental tools to drive development. You will be responsible for high-maturity design reviews, including multiple levels of product owners, stakeholders, and cross-functional teams. As a lead design engineer, you will interface with suppliers and manufacturing to build high-quality hardware prototypes and productize new designs. You will be trusted to allocate your time and efforts to make sound decisions, when faced with time constraints and ambiguous or incomplete information.
Key Roles & Responsibilities
Developing system mechanical assemblies, with careful consideration for key functions and safety.
Working within multi-disciplinary teams to define requirements for new robotic surgical products.
Producing and iterating full-scale functional prototypes in a fast-paced New Product Design environment.
Creating and managing design failure-modes analysis and associated verification testing.
Collaborating with Product Owners for product validation activities and mission-critical risk-assessment.
Defining product's performances and specifications, with an eye to final product delivery.
Generating and owning models for assemblies, components, and drawings, in a government regulated environment.
Collaborating with vendors, suppliers, quality and manufacturing through the design-transfer and launch.
Mentoring and coaching other engineers in problem solving and technical expertise.
Previous experience in Medical Capital Device industry (Class II or III).
Proficiency using CAD, computational modeling and analysis (e.g. Matlab), and FEA tools.
Detail-oriented in creating reliable systems that harmonize multiple requirements, e.g. structural, thermal, packaging, acoustic, sterilization, cleanability, ergonomics, user-interface.
Demonstrated ability in system design ownership at component, system, and process levels.
Experience with metallic and non-metallic materials selection, finishes and treatments, and manufacturing processes.
Experience in bringing systems through all phases of product development lifecycle phases: design, implementation, debug, verification, qualification, and transfer.
Self-driven with the ability to excel in a high-energy, focused team environment, to maintain a strong sense of shared responsibility and reward, and to make work interesting and intellectually vibrant.

Preferred

Post-graduate study or equivalent work experience preferred.
Experience in medical systems for patient gas delivery (respirators, insufflators, artificial ventilation).
Experience in growing design maturity for product launches, scalable manufacturing processes, design for reliability, yield, and cost.
Mechatronic design experience. Surgical and/or robotic product experience is a plus.
Effective collaboration with cross-functional teams like system analysts, field/clinical engineers, human factors, industrial design, UI design, etc.
SolidWorks, Matlab, Ansys and Windchill experience.
We provide market-competitive compensation packages, inclusive of base pay, incentives, benefits and equity, and the anticipated pay rate for this position is $162,500 to $233,900. It would not be typical for someone to be hired at the top end of range for the role, as actual pay will be determined based on several factors, including location, skills, and experience level.

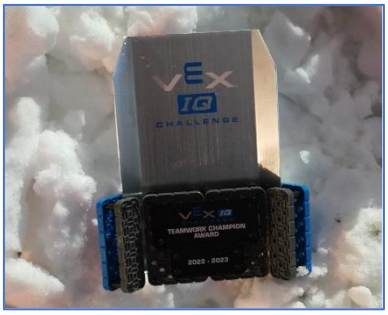
Job Specification of STEM career in RAS Design - Intuitive [7]

As can be seen, a vast amount of the job specification is highlighted marrying up with skills that I have been practicing.

Engineers carry out surgeons' brief to design the perfect product. The robot itself is the final product. In VEX this is similar where we figure out the problem for the robot and choose multiple options of the best way to reconfigure your robot to compete in the VEX. However, we do not have to understand the stakes of life or death. This is something that VEX can never fully prepare us for, despite its competitive environment. The whole iterative Engineering Design Process steps would be crucial, rigorous, heavily applied and documented throughout to create the RAS system before use on actual people.

Career Readiness

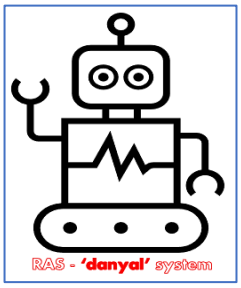
I am greatly passionate about Science, Technical Design and Engineering, therefore a career in Mechanical Engineering Design with RAS would be a perfect fit and is an exciting prospect to venture into. The majority of skills within this role, as well as Mechanical Engineer careers overall, embodies the commonality of good practices of the 'Engineering Design Process,' used within the industry.



I believe participation in VEX and practicing the Engineering Design Process has set up a solid foundation for aiding career readiness for a future career within STEM and RAS Engineering Design. By securing a spot in Nationals, the VEX experience so far makes me believe that it is possible to achieve anything, for my dreams to take reality. It makes me imagine Engineering Design in RAS is not out of my reach but can be attainable. How wonderful it would be, to be able to be part of something that can help make people's lives better, even save lives!

Look out RAS Engineering Design… here I come!

Thank you VEX!



Sources

Source Number	Source Link
[1]	https://www.bbc.com/future/article/20140516-i-operate-on-people-400km-away
[2]	https://www.meddeviceonline.com/doc/the-market-outlook-for-robotic-assisted-surgery-in-0001
[3]	https://thesurgicalclinics.com/history-of-robot-assisted-surgery/
[4]	https://www.cbinsights.com/research/robotic-surgery-outlook-startups-funding-tech/
[5]	https://www.intuitive.com/en-us/products-and-services/da-vinci
[6]	https://www.delveinsight.com/blog/robotic-surgery-market
[7]	https://careers.intuitive.com/us/en/job/JOB2868/Staff-Mechanical-Engineer-Surgical-Medical-System-Design
[8]	https://www.roboticoncology.com/history-of-robotic-surgery/
[9]	https://knowyourmeme.com/memes/they-did-surgery-on-a-grape
[10]	https://my.clevelandclinic.org/health/treatments/22178-robotic-surgery