DE501894

Using Autodesk Fusion 360 and Generative Design to Make Lighter Rockets in Less Time

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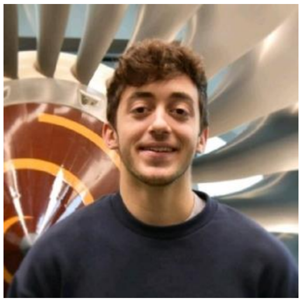
Learning Objectives

- Learn about the steps involved in the design of a high-powered rocket.
- Learn about the benefits of Autodesk Fusion 360 for student engineering teams.
- Learn about the benefits of Generative Design for design development.
- Learn about the challenges involved in successfully launching at a rocketry competition.

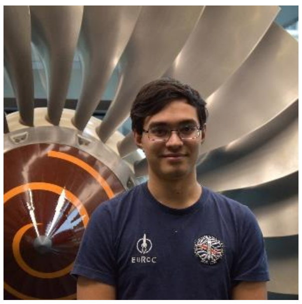
Description

Imperial College London Rocketry (ICLR) is a team of undergraduate engineers learning about aerospace through the design, build, and launch of rockets. With the desire to reach space one day, efficiency in both our process and our designs is critical. Follow us as we take you through our journey in preparation for the 2021 edition of the European Rocketry Challenge (EuRoC). EuRoC is an annual rocketry competition hosting university teams from all over Europe with the aim of building and launching rockets to reach a set altitude. Learn the basics of high-powered rocket design, and see how we integrate Autodesk Fusion 360 software into our process. We'll cover the many challenges we faced and the decisions we made throughout a grueling week-long competition. And you'll hear how the lessons we learned inform what we do now. Presented by current engineering students, you'll see the impact of the experience on our personal and professional development, as well as our plans for this year's edition of the competition.

Speakers



Currently studying Aeronautical Engineering at Imperial College London with an interest in structural design of spacecraft and launchers. Joined the student-led rocketry team, Imperial College London Rocketry (ICLR), in 2020. Currently leading the Airframe and Recovery sub-team as we aim to launch our new hybrid rocket at the European Rocketry Challenge 2022. Developed a range of skills in Fusion 360 such as CAD designing, structural simulations and generative design. Experienced with additive manufacturing and composite manufacturing for aerospace components.



Currently studying Aeronautical Engineering at Imperial College London with interests in spacecraft and electronics. Joined ICLR in 2019 and currently leads the Electronics and Payload sub-team. Currently leading the design of the avionics, engine control system and power distribution system of the team's hybrid rocket. The rocket's electronics play a key role in the controlling of our own custom engine as well as the recovery systems. Has led the development of a novel deployable payload which utilises flexible solar panels built into a parachute and HD cameras.

Recently graduated from Imperial College London with a degree in Aeronautical Engineering. Currently working at ARUP as a graduate engineer within airport planning. Joined ICLR in 2018 at its founding and was the former team lead for the Airframe and Recovery sub-team. Led the developments of several rockets including Constant Impulse: ICLR's first rocket to compete at the European Rocketry Challenge. A wide range of experience in student rocketry and managements as well as research skills in the areas of composite analysis and structural health monitoring.

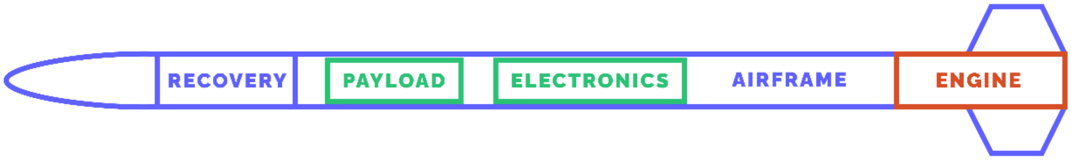
What is ICLR?

Imperial College London Rocketry (ICLR) is a student-led rocketry society based in the Aeronautics department at Imperial College London. Founded in 2018 with the aim of educating students with hands-on engineering projects. The team is split into four major sub-teams: Propulsion, Airframe and Recovery, Electronics and Payload, and Systems and Integration. Two early goals of the team were to compete at Spaceport America Cup (the largest international student rocketry competition in the world) and to reach the Karman line (an altitude of 100 kilometres signifying the edge of space). Since then, the team has built a broad range of experience in high-powered rocketry as we work towards our goals. Last year, the team competed at the 2021 edition of the European Rocketry Challenge (EuRoC) with our rocket Constant Impulse.

ICLR team photo at Imperial College London

What is a High-Powered Rocket?

In student rocketry competitions, rockets are designed to carry payloads of a certain mass to specific altitudes. All rockets are powered by an engine which uses a propellant to produce thrust. Engines come in three varieties: solid, hybrid or liquid. The engine is controlled by the electronics. Flight tracking and the recovery system are also controlled by the rocket's avionics system. The recovery system ensures that the rocket and its payload return safely to allow for data and footage to be collected, to ensure the safety of people nearby and for reusability. The airframe of the rocket holds all these components together inside of an aerodynamic shape. It also protects them from the harsh loads of flight.



Systems of a high-powered rocket

What is EuRoC?

The European Rocketry Challenge (EuRoC) brings together over 400 engineering students from universities across Europe to build and fly their rockets in Ponte de Sor in Portugal. The competition runs over a week as students compete for prizes in various categories. Each rocket must carry a payload weighing at least 3kg (6.6lbs) to an altitude of either 3km (10,000 feet) or 9km (30,000 feet). There are categories for solid, hybrid and liquid powered rockets. In 2021, ICLR competed in the 3km solid class with our rocket Constant Impulse. Every team must prove the airworthiness of their rocket to a panel of expert judges who inspect every aspect of the design. This year ICLR will be competing in EuRoC once again with our new rocket Sporadic Impulse.

Using Fusion 360 to Design Rockets

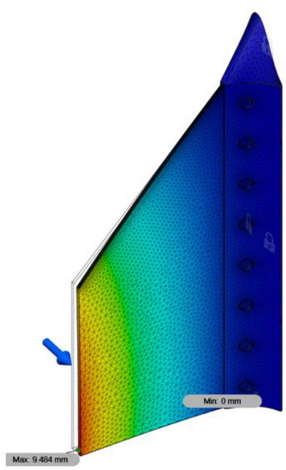
A rocket is made up of various systems such as the electronics, airframe, propulsion and recovery systems. Within each system is a set of components such as bulkheads, PCBs and parachutes. Each component must be designed individually to cohesively work with the other components in the rocket. By designing on the cloud, Fusion 360 has allowed us to share designs and streamline our workflow.

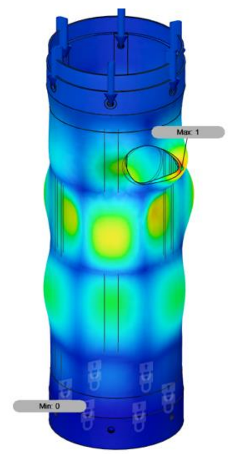
Manual Workflow

In order to design a component, a list of requirements must be produced. These can include the loads it must sustain, interfaces with neighbouring components and functionality. Often within the requirements an objective is defined, such as minimizing mass or volume or maximising stiffness.

Once the requirements are defined, initial conceptual designs can be made in CAD. Each design can be checked against its requirements. This can include running structural simulations for the loads on the component. Most components experience three major load cases:

- Thrust Loads: compressive forces from the engine's thrust during ascent.
- Shock Loads: tensile forces from the drag of the parachute as it deploys during descent.
- Bending Loads: bending moments from the aerodynamic forces on the fins.





Examples of structural simulations of parts

Fusion 360 allows structural simulations to be run on the cloud. This ensures that the features are accessible to all students, no matter what computer they are using to run it. Structural simulations can be used to identify stress concentrations within the part. It can also highlight buckling issues for slender parts under compressive loads. Stress concentrations can lead to the yielding of the material and the failure of the component. By identifying vulnerable areas, the

CAD design can be refined to move material to the areas that require it most. An iterative process of design refinement and simulations is carried out until an optimal design is reached.

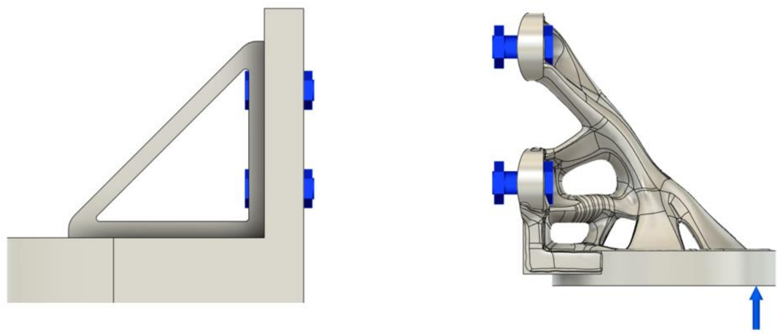
Design workflow of a component

Incorporating Generative Design

Fusion 360's generative design feature has allowed us to accelerate the design of components whilst also producing mass savings. The feature allows a set of requirements to be defined from which an algorithm designs a part to meet these requirements whilst minimising mass. The following requirements must be defined:

- Material
- Loads
- Constraints
- Preserved Geometries
- Obstacle geometries

For each part, during the conceptual design stage, a generative design alternative can be made. This generatively designed part often informs us of the load paths on a part and can guide the manual design of a part. At the end of the design workflow mentioned in the previous section, the manual part can be compared to the generatively designed part to decide whether the cost of exotic manufacturing techniques is worth the potential savings in mass.



Comparison of manually designed and generative designed components

EuRoC 2021

EuRoC 2021 was our first experience of an international student rocketry competition. From arrival in Ponte de Sor in Portugal, the difficult week was packed with activities as we proved the safety of our rocket. This culminated in the launching of Constant Impulse:

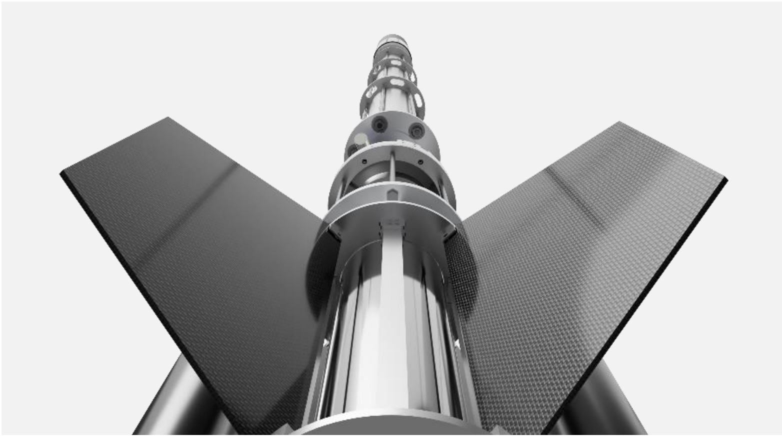
- Unpack rocket from transport
- Ground test recovery system
- Present to judges during the flight readiness review (FRR)
- Prepare the rocket on launch day
- Launch

Constant Impulse preparing for launch

The Future

Sporadic Impulse

ICLR continues to set its goals high and has learnt from EuRoC last year. This year we will return with our new rocket Sporadic Impulse. This rocket features our own custom hybrid engine, designed completely by students. 3 years in the making, it utilises a paraffin wax fuel paired with a nitrous oxide oxidiser. Several hot fires over the last few months have proved its capabilities ahead of its flight in October. Sporadic Impulse features an advanced new modular airframe design with a carbon fibre and fibreglass external skin and a machined aluminium internal structure. The rocket also contains several generatively designed parts manufactured using SLS metal 3D printing. A custom mechanical separation system should ensure the successful recovery of the rocket. Sporadic Impulse features our most advanced electronics package to date. It will control the engine, track the trajectory of the rocket and actuate the recovery system. The design also includes a deployable payload featuring solar panels built into its parachutes.



Render generated in Fusion 360 of Sporadic Impulse

CanSat and ART

Alongside the main projects, two advanced research projects push the future of ICLR's capabilities. The CanSat team design novel, compact payloads with the aim of using the technologies developed on future rockets. They have competed in several CanSat competitions and even won the annual CanSat competition hosted at Machrihanish air base in Scotland.

The Altitude Record Team (ART) develops lightweight rockets to break UK altitude records for various engine sizes. Recently they were able to break the UK L1 altitude record. Their rockets have helped build experience in supersonic flight and lightweight airframe design.

Long Term Goals

ICLR's main goal of reaching the edge of space at the Karman Line still remains. However, along the path to this lofty goal, the team will continue to compete at competitions such as EuRoC and SA Cup to build the experience it takes to reach space. Since its inception, ICLR has already come a long way but there are plenty of exciting challenges ahead.

Useful Links

ICLR Website: https://imperialrocketry.com/
ICLR LinkedIn: https://www.linkedin.com/company/iclrocketry/mycompany/
ICLR Instagram: https://www.instagram.com/icl.rocketry/?hl=en