EDU3651

Soaring Toward the Stars with the Autodesk Fusion Platform: The Elara Aerospace Journey

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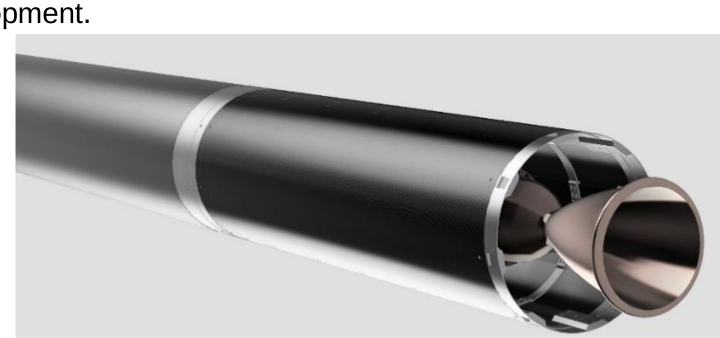
Learning Objectives

- Gain insight into the process and challenges of building a rocket within a one-year timeline
- Understand how to apply the morphological chart through a practical example
- Explore how Autodesk Fusion can solve construction challenges like sheet metal conversion and simulating different load cases
- Recognize the importance of strategic planning and foresight in engineering projects

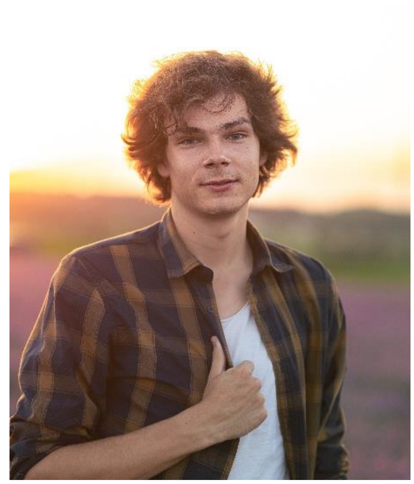
Description

This case study examines the journey of a group of ambitious students with a bold goal: building a rocket in just one year. Elara Aerospace, a student-led initiative founded in 2024, aims to break three world records in the process. The study delves into the team's motivation, the factors that make their project unique, and provides an overview of the rocket's design and development.
This case study offers a detailed exploration of the engineering process behind constructing a specific rocket component, a connector part. It walks through the steps of defining the problem, applying a structured approach, and arriving at a solution using Autodesk Fusion. This example highlights not only the technical skills involved but also the valuable lessons learned throughout the project's development.



Fusion rendering of the rocket

Speakers



Tobias Jäger is a 22-year-old graduate in Mechanical Engineering and a Medical Technology student at the Technical University of Munich. Driven by his ambition, he co-founded Elara Aerospace with like-minded friends he met through the TUM Boring initiative. Tobias has experience in various domains, with a primary focus on Quality Management, Strategy, and General Operations. Additionally, he can be found welding and working directly on the engine.

Theresa Schmitt is a 23-year-old mechanical engineering student from Munich, Germany, currently pursuing her Master's degree with focus on product development and propulsion systems. She completed her Bachelor of Science in Mechanical Engineering in 2024 and quickly transitioned to her Master's program. Theresa joined Elara Aerospace in June 2024, where she plays an integral role in designing and constructing components for the rocket airframe, applying her expertise in CAD software and finite element analysis. As a hands-on enthusiast from an early age, Theresa has always enjoyed building and designing mechanical systems and models. Outside the lab, she enjoys Karate, reading books and the Rubik's cube.

Elara Aerospace – Our Backstory

Elara Aerospace is a group of students with a shared passion for aerospace engineering and a determination to make the impossible possible.

In just a few decades, rocket science has evolved from a government-only initiative into something that students like us can pursue. What used to cost billions now requires nothing more than ambition, resourcefulness, and access to tools like Autodesk Fusion 360.

Our goal? To build a technologically advanced rocket powered by a bi-liquid methalox engine. Though most of our work so far was in simulation and CAD, we've learned that innovation happens in the details—whether it's designing complex aerospace parts or simply improving our workflow efficiency.

What makes us unique

At Elara Aerospace, we are not just another student-led rocket project. We are pushing the boundaries of what student teams can achieve, and here's why:

- **First Student Team to Send a Liquid-Propelled Rocket to Space**
  Our goal is to become the first student team to successfully launch a liquid-propelled rocket into space. While many have focused on solid propellant rockets, we are taking on the more complex challenge of designing and building a liquid-fueled rocket, with all the engineering intricacies that come with it.

- **World's Most Powerful Electric Turbopump-Fed Methalox Engine**
  Our team is developing what will be the world's most powerful electric turbopump-fed methalox engine. This advanced engine design is not only cutting-edge but also sets us apart from other student or even professional teams. The electric turbopump technology provides better control and efficiency, pushing the performance limits of modern rocket engines.

- **Proven Track Record of Ambitious Projects**
  This is not our first ambitious endeavor. Several of our team members previously participated in—and won—Elon Musk's Not-a-Boring Competition, a global challenge to build innovative tunneling solutions. That experience sharpened our skills in rapid problem-solving, collaboration, and innovative engineering—qualities that we now bring to the world of aerospace.

- **Combining German Engineering with a Lean Approach**: We blend the precision and reliability of German engineering with the fast-iteration, "fail fast" methodology used by innovators like SpaceX. This unique combination allows us to maintain high-quality standards while rapidly testing, learning, and improving our designs.

A closer look at a practical example: constructing an Aft-Tank-Connector

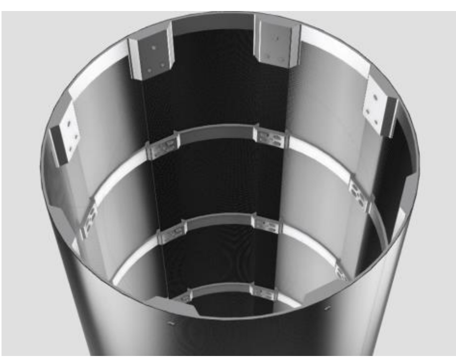
In this case study, the Aft-Tank Connector is used to illustrate the key steps in the construction process, including identifying challenges, applying a structured approach, and developing a solution. This connector serves as a critical link between the rocket's tanks and the aft section, which houses essential components such as the engine, turbo pumps, thrust vector control, and batteries.

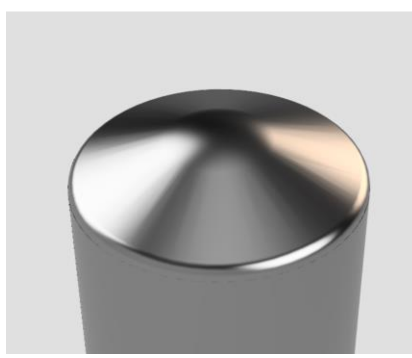
Understanding the challenges

The construction of an Aft-Tank Connector presents several complex challenges, including:

- Ensuring disassembly is possible
- Joining two different shapes
- Connecting two different materials
- Avoiding large protruding parts
- Distributing forces evenly
- Addressing other standard challenges

Given that the aft section houses critical components such as turbo pumps and batteries, it is essential to allow disassembly in this area for maintenance and repairs. Easy access to the internal components is crucial for ensuring the longevity and functionality of the rocket.
One of the key challenges is connecting the tank dome's round surface to the thin cylindrical edge of the aft section. These two geometrically distinct shapes must be joined in a way that maintains stability and structural integrity.


Aft Section


Tank Dome

If the tanks, aft section, or the connector itself are made from different materials, welding is not an option. Therefore, alternative attachment strategies must be employed to securely join these materials.
The rocket's aerodynamic profile must be preserved, meaning the connector cannot have large, protruding parts that might disrupt airflow. This constraint limits the design and attachment options for the connector.
The rocket experiences significant forces during launch, such as weight, thrust, and aerodynamic pressures. It is essential that the connector distributes these forces evenly to prevent deformation or failure during operation.

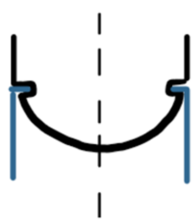
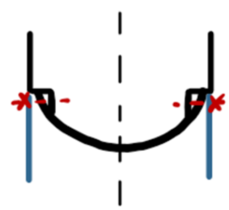
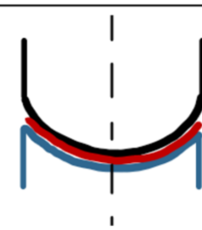
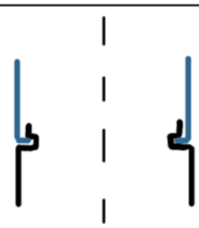
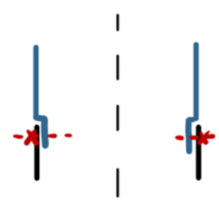
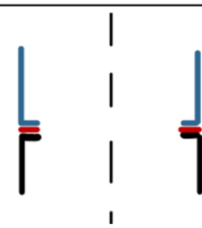
In addition to these primary challenges, other standard considerations must be addressed to ensure the connector is cost-effective and production-friendly. Factors such as weight, cost, complexity, manufacturability, and ease of assembly must also be taken into account.

All of these challenges combine to make the design and construction of the Aft-Tank Connector a highly complex engineering task.

Identifying the right attachment strategy using the morphological chart

The challenges outlined above highlight the importance of selecting the right strategy for attaching the connector to both the tank and aft section. To determine the best solution, the morphological chart method was employed.
The morphological chart breaks down a complex problem into smaller subfunctions, allowing each to be addressed individually. This approach provides a clear overview and simplifies the problem-solving process. For each subfunction, multiple solution ideas are generated by drawing on a variety of sources, including research, brainstorming, and input from experienced individuals.
Once potential solutions are identified, they are carefully evaluated by weighing the advantages and disadvantages of each. The goal is to identify which advantages are essential and which disadvantages must be avoided. In some cases, subfunctions are considered in relation to one another to ensure consistency across the design. The final solution is developed by combining the best solution for each subfunction. Throughout this process, the morphological chart ensures that everything is documented clearly and systematically.

The following example demonstrates how the morphological chart was applied to solve the problem of selecting the optimal attachment strategies for the Aft-Tank Connector.

	Form-Fitting (groove)	Screwing	Gluing
Subfunction 1: Attachment Tank			
Subfunction 2: Attachment Aft Sec.			

The attachment points for both the tank and the aft section were treated as separate subfunctions, allowing each side to be addressed independently. Three potential solutions were explored for both subfunctions: a form-fitting connection using grooves or holes, screwing, and gluing. To enhance understanding, sketches were included to visually represent each solution.

An example of how advantages and disadvantages are collected and analyzed is shown below:

	Form-Fitting (groove)	Screwing	Gluing
Advantages	• No additional material (=> lightweight, cost)	• Disassembly possible • Easy to use	• Lightweight • Few preprocessing • Evenly distributed stress • Different materials / shapes can be joined
Disadvantages	• Preprocessing • Wall thickness to low	• Screw nut can not always be reached • Preprocessing due to round surface	• Big contact surface • No attachement around edge

Developing a solution: Construction and Simulation in Fusion

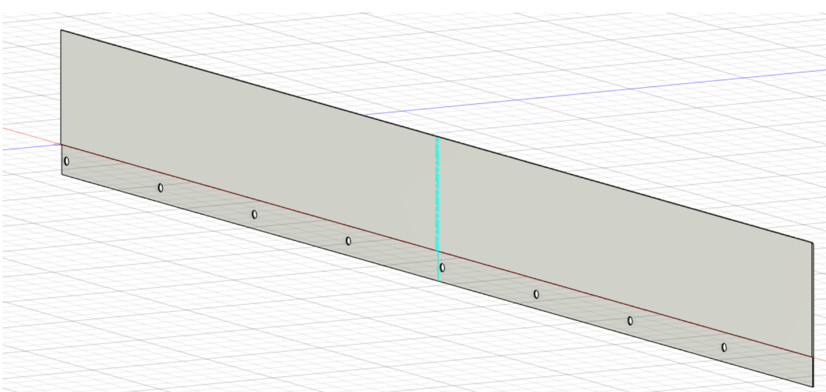
For reasons related to manufacturability and weight reduction, the connector will be designed as a sheet metal part. Although the original components were created as solid parts, Autodesk Fusion makes conversion to sheet metal simple with the following steps:

1. Select the **Sheet Metal** tab.
2. Click on **Create**.
3. Select **Convert to Sheet Metal**.
4. Choose the part to convert and confirm.

To further unfold the part, follow these steps:

1. Click on **Create Flat Pattern**.
2. Select the part to convert and confirm.

These steps are quick and efficient, even for parts with varying wall thicknesses or those originally modeled as solid.



Unfolded sheet metal cylinder from the Connector

Note: To successfully unfold a closed structure like for example a cylinder, a seam must be added first.

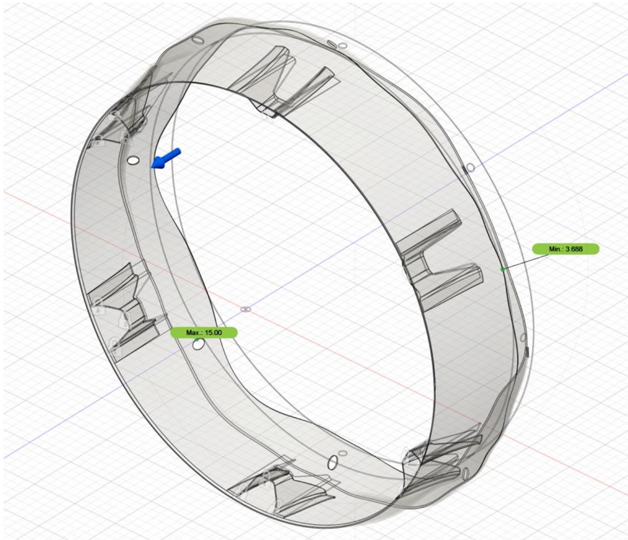
To ensure the connector can withstand the forces it will encounter, static simulations can be conducted using Autodesk Fusion's Simulation tool. In each simulation study, any material can be selected. If the desired material isn't available in the library, it can be added manually. Multiple load cases can also be analyzed within a single study. To add a new load case, simply right-click on the existing one and choose either "New Load Case" or "Clone Load Case." This feature makes it easy to simulate different scenarios using realistic material properties.

Before starting a simulation, double-check for any unintended degrees of freedom using the DOF View tool under the Display section. If all parts are highlighted in green, the structure is fully fixed. For parts marked in red or yellow, automatic contacts (available under the Contacts section) or fixed constraints can be applied to properly secure them.

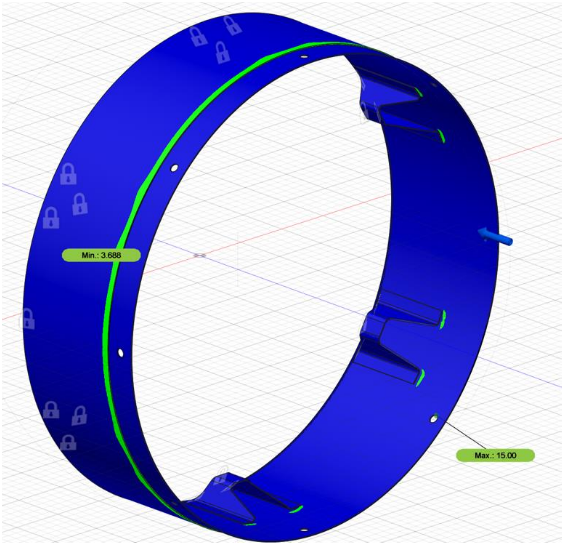
The connector is designed to withstand a total compression force of 62.5 kN, based on the following:

- Engine launch force: 32 kN (in a vacuum)
- Weight force: 10 kN (approximately 1 ton)
- Aerodynamic forces: 8 kN
- Safety factor: 1.25

By applying fixed constraints where the connector will be welded (such as the stringer edges and cylinder edge) and simulating forces from the lower side (flange surface), the simulation results show a minimum safety factor of 3.668. This confirms that the connector can easily withstand the applied forces.



Adapted deformation



Actual deformation (none)

The importance of foresight: assembly example

When designing a functional part, it is crucial for the designer to consider manufacturing, assembly, and operational factors. Applying this principle to the Connector, it becomes apparent that the part may shift during assembly due to the rounded dome shape of the tanks. Manufacturing inaccuracies can exacerbate this issue, potentially causing misalignment. Since the Connector is the sole element connecting the tanks to the aft section, this misalignment could result in a skewed structure, leading to kinks that may affect the rocket's flight path and aerodynamics.


Assembly Aid

To address this issue, an additional assembly aid was designed. The outer ring fits inside the Connector, preventing twisting and ensuring it remains properly aligned. The inner cylinder centers the Connector by fitting into the tank dome’s filling hole. Once the Connector is securely positioned, it can be welded on the outside. Afterward, the assembly aid is removed, allowing for the final weld on the inside.

Funding: Fueling Our Ambitious Vision

At Elara Aerospace, our passion for space exploration drives us forward, but passion alone doesn’t launch rockets—funding is essential. Unlike large aerospace corporations backed by government contracts or deep-pocketed investors, we operate on a lean budget. We rely on a combination of sponsorships, grants, donations, and strategic partnerships to bring our ambitious vision to life.

This doesn’t always mean we receive money to spend. Sometimes we are provided with the resources we need directly from the companies and experts who produce them.

One of our core philosophies is resourcefulness. We make every dollar count, starting with simulations and prototyping to avoid the expensive overhead of physical testing until we are ready. However, as we transition from simulation to building real components—particularly for our bi-liquid methalox engine—our need for funding, especially for real-world tests, increases.

Our mission is ambitious, but it is achievable with the right support. We are always on the lookout for additional sponsors and partners who believe in what we are trying to accomplish: to be the first student team to launch a liquid-propelled rocket into space. The success of this project will demonstrate that innovation and determination can overcome the constraints of funding, and we invite like-minded individuals and organizations to join us on this journey.

Convinced? Feel free to reach out to us anytime at team@elara-aerospace.com!