Technical Regulations

Airbus Sloshing Rocket Workshop

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EUROAVIA International

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1 Introduction

1.1 Background

Modelling the behaviour of sloshing liquids is of significant interest in various fields of the Aerospace industry.

In aircraft design, the study of fuel movement in tanks is of paramount importance for the design of the fuel management control system, the evaluation of the handling characteristics of the aircraft and ultimately the assessment of the structural integrity of the containment structure [1].

For modern satellites, the design is often driven towards lightweight structures, high pointing accuracy and long-life expectations. These can result in a large proportion of the overall weight being allocated to the liquid propellant. Therefore, the movement of the liquid fuel within its containers can significantly affect the dynamics of these systems, during in-orbit controlled manoeuvers and atmospheric gust encounters in the launch phase [1].

1.2 Competition Background

The Airbus Sloshing Rocket Workshop 2025 is a hybrid competition (online and physical) in which teams are required to design a low-cost reusable rocket which is destabilised by the movement of water stored in an unpressurised tank.

- The rocket design shall incorporate mechanisms to manage the dynamic forces introduced by the sloshing water to maximise its range, time of flight, and liquid payload capacity.
- The controlling mechanism can be designed based on passive and/or active means and its performance is a key aspect of the design.

This challenge aims to simulate the conditions experienced by real world aerospace vehicles containing liquid propellant such as satellites or next generation aircrafts.

Participants will first be provided with a series of lectures focused on the mathematics and physics behind the sloshing and design of rockets. This will include topics such as aerodynamics, propulsion, and more.

The overall objective of the competition is to design, build, and test the vector and stabilisation system of a rocket with your team. The description and justifications for the design are to be presented in the format of two design reports: a conceptual design report and a final design report.

All teams will submit a Conceptual Design Report detailing the conceptual design process undergone after completing the first round of the Speaker Series.

The deadline of the Conceptual Design Report is the 31st of March 2025 at 12:00 UTC.

The twenty (20) teams that scored the highest on the Conceptual Design Report will advance to the next phase of the competition to submit a Final Design Report after the second round of the Speaker Series.

The deadline of the Final Design Report is the 6th of June 2025 at 12:00 UTC.

A minimum of five (5) of the highest scoring teams from this round will advance to the final round from the 25th - 31st August, 2025. In this stage, the teams would meet with an Airbus panel to discuss their design proposals and defend their reports in a 45 minute design review (30 minutes presentation, 15 minutes Q&A). These teams will also be given the opportunity to manufacture and launch their rockets, to measure the flight performance of each design.

2 Technical Requirements

The vector design must conform to the requirements outlined in this document.

2.1 Physical

2.1.1 The vector's maximum length shall not exceed 1.5 m

2.1.2 The vector's maximum wingspan shall not exceed 2.25 m

2.1.3 The launch angle will be 85 degrees, an offset of 5 degrees from vertical, with a tolerance of +/- 3 degrees. Measurement devices will be used to check compliance with this rule, and a penalty will be applied if compliance is failed.

2.1.4 The primary structure of the vector shall be formed of readily available items forming two or more water tanks: **1 unpressurised tank** and **1 or more pressurised tank(s)**

2.1.5 **The unpressurised tank** shall contain a minimum of 500ml of water. The tank must contain 50% water and 50% air to generate sloshing loads. The fill level at 50% volume must be clearly marked to facilitate easy visualisation for the judges. The minimum cross sectional area should not be less than 50% of the maximum cross sectional area. The maximum cross sectional area is determined by the maximum area enclosed by the outer perimeter (i.e. a "normal" cylindrical tank with a diameter of *d* will have the same cross sectional area as a hollow cylindrical tank with an outer diameter of *d*). (*This rule applies individually to each XYZ axis. You must satisfy this requirement in all axes (i.e. min(Ax) > 0.5 max(Ax) AND min(Ay) > 0.5 max(Ay) AND min(Az) > 0.5 max(Az)*)

2.1.6 **The pressurised tank(s)** shall contain only water at ambient temperature for propulsion. **Only** these pressurised tanks will be allowed for propulsion. Any pressurised tanks used for the purpose of propulsion must launch with the rocket, and can only be discarded once airborne. The tanks will be checked to ensure they can be pressurised to the desired amount before launch.

2.1.7 The total mass of the propellant must be no greater than the mass of the sloshing liquid.

2.1.8 The total weight at take-off shall not exceed 5 kg when filled with liquid.

2.1.9 Teams will be given the opportunity to launch their rockets up to three (3) times during the finals. As a result, a rocket design that is recoverable and relaunchable is heavily recommended.

2.1.10 The judges would like to stress the importance of approaching the challenge with a flexible and fresh mind, meaning that arrangement of the tanks does not have to conform to a traditional rocket shape. Teams are not only warmly encouraged to consider aircraft concepts benefits and drawbacks, but are also expected to include an in-depth investigative analysis in the introduction to the technical report about ideas and researches in other disciplines that aviation should take inspiration from.

2.2 Launch Mechanism

2.2.1 The vector must be launched vertically at a pressure less than 10 atmospheres [or 147 psi].

2.2.2 The rocket design shall incorporate a means of pressurising the propulsion tanks with air. The design should present how the tanks would be pressurised and depressurised from a safe distance. Teams may be asked to display this during finals.

2.2.3 Only air is permitted as an inflation gas and no propellant other than water at ambient temperature is permitted. This forbids the use of propellers, propulsive gas, engines and lighter than air gases such as helium.

2.2.4 The ratio of air-to-water inside the propulsion tank or tanks (not the payload tank) is customisable and should be exploited to optimise the performance of the vehicle.

2.2.5 The vector must be capable of being launched from a **minimum** of 5m away. Note that finalist teams may be asked to launch from further away depending on safety regulations of the site.

2.3 Control Mechanism

The design shall incorporate a means of controlling the descent of the vector to counteract the destabilising motion of the sloshing liquid. Details of how the sloshing liquid behaviour has been predicted and justification for the embodied solution shall be provided as part of the design submission. This could be achieved by using passive or active means or a combination of both:

2.3.1 **Passive Control**: e.g., baffles. Any singular baffle inside the tank cannot cover more than 50% of the cross-sectional area of the tank. (*The area should not cover more than 50% of the cross sectional area at any point along the axis. This rule is applied individually on each XYZ axis, and you must satisfy this requirement in all axes (i.e. max(Ax)<0.5 min(Ax) AND max(Ay)<0.5 min(Ay) AND max(Az)<0.5min(Az).*)

2.3.2 **Active Control:** e.g. control surfaces.

2.3.3 Please note that while there are no restrictions on the transparency of the sloshing tank material, teams may be required to demonstrate compliance of the sloshing tank with the regulations at judges' discretion. This may include, but is not limited to cutting open the sloshing tank after the launches at the final event.

2.4 Electronics and Additional Technology

2.4.1 An altimeter will be provided to the teams during the finals in order to measure the maximum altitude achieved during flight. The specifications for the model of altimeter used for the competition can be found in Appendix B.

2.4.2 Teams will not be given the altimeter in advance but will instead design a mounting location for it. The altimeter will then be given to teams prior to launch. The mounting and zeroing of the device will be monitored by judges to ensure accurate use.

2.4.3 The specific location of mounting is up to the discretion of the team. Note that the altimeter operates using air pressure sensors and therefore if placed inside the rocket (eg. in the section of the vector opposite to the nozzle), at least three evenly spaced 3mm square or round vent holes must be drilled to allow for a reading of the atmospheric pressure. It is recommended that the placement of these holes avoid high or low pressure areas. Note that if the altimeter does not have adequate airflow, a lower altitude reading will be shown.

2.4.4 The design of the vector should include solutions to maintain the altimeter fixed to its position and reduce the risk of the damaging or loss of the equipment. Penalties will be applied for the damage or loss of the altimeter.

2.5 Materials and Costs

2.5.1 The total cost of the vector must not exceed €500, including estimates for materials, delivery of the materials to the manufacturing place, and consumables used during the design and manufacturing.

2.5.2 The vector design shall not rely on COTS (Commercial off-the-shelf) items costing in excess of €300. A bill of materials and cost breakdown is required as part of the design submission. Cost efficient solutions will be awarded more points.

2.5.3 Teams will not be allowed to bring pre-made pieces or any parts from outside the stated items in the Bill of Materials into the final stage of the competition. All items listed will be provided by the organising party, and any items used not mentioned will not be allowed. Furthermore, sharing of materials between teams and/or taking materials from another source during the competition is also strictly prohibited. A penalty will be applied if this is found to be violated.

2.6 Flight Performance

2.6.1 Flight performance marking will be based on the following parameters:

- Distance covered horizontally.
- Altitude reached.
- Total flight time.
- Payload mass/TOW.

2.6.2 The scoring formula is as follows:

$$\text{Flight Score} = \left(\sqrt{\text{Horizontal Distance (m)}^2 + \text{Altitude (m)}^2} + \text{Time (s)}\right) \times \frac{\text{Payload (kg)}}{\text{Takeoff Weight (kg)}}$$

3 Competition Marking

The 2025 Airbus Sloshing Rocket Workshop will include two submissions: a Conceptual Design Report and a Final Design Report. All teams who wish to take part in the competition will submit a Conceptual Design Report after the completion of the first round of the Speaker Sessions.

The reports will then be scored with feedback and teams will be selected to move onto the next stage of the competition. Selected teams will participate in the second round of the Speaker Sessions and will write a Final Design Report, similar in style to the previous year's primary report.

Qualification for the finals is based on the scoring of the Final Design Report. The overall competition winner will be decided based on the two report scores, the flight performance during the competition, and the panel feedback on the design review at finals.

3.1 Conceptual Design Report

The Conceptual Design Report will be a document of maximum 2000 words (without appendix), showcasing the conceptualisation of multiple ideas in the preliminary stages of the team's design process.

Teams will need to put together a requirements scheme, a selection of designs they believe could be feasible for their final product, and utilise their reasoning skills to decide on a preliminary design concept they believe should move forward.
This concept does not actually need to end up being the final design used later on, but any changes will require a justification in the Final Design Report.

Contents of the Conceptual Design Report can and should be reused in the Final Design Report as teams see fit. Teams are highly encouraged to use feedback from the Conceptual Design Report to improve their scoring on the final submission.

More information regarding the requirements of the Conceptual Design Report will be released prior to the first set of webinars.

Please note that teams that are selected to the second phase may be required to implement design changes at the judges' discretion, should there be any design features non-compliant with the technical regulations.

3.2 Final Design Report

The Final Design Report will be a document of maximum 9000 words (without appendix), detailing the process the team underwent to achieve their final design. This will include the contents of the Conceptual Design Report, a detailed design investigation, and V&V of the selected design. Teams are also required to provide evidence of any analysis or physical testing performed to assess the safety of the rocket.
This assessment of safety using analysis or physical testing is required to move forward to the final phase of the competition. A template will be provided to aid in the team's general risk assessment. Please note that teams may be required to implement design changes at the judges' discretion, should there be any design features posing a significant safety risk to the participants.

More information regarding the requirements of the Final Design Report will be released prior to the second set of webinars.

3.3 Bill of Materials

The Bill of Materials document will be submitted alongside the Final Design Report. This submission consists of a list of materials and tools needed for the manufacturing and testing of the vector. This document should include the materials, consumables, and costs of each component.

As mentioned above in section 2.5 Materials and Costs, the Bill of Materials and the contents listed will be the sole materials allowed to build the vector. No other materials will be allowed during the competition.

More information regarding the Bill of Materials will be released with the Final Design Report guidelines.

3.4 Finals

A minimum of five (5) teams will be selected to participate in an in-person competition consisting of a 45 minute design review presentation to a panel of judges and a launch where the flight performance of the rockets will be assessed. More information about the finals as well as the scoring used will be released closer to the date of the finals.

This year's competition will be hosted in **Forli, Italy**.

4 Organisation and schedule

Participating teams will consist of between two (2) and six (6) members, and is reserved for undergraduate students enrolled in a university at the moment of the application. The event is open to bachelor's and master's degree students pursuing a BSc, MSc, BEng, MEng, or equivalent degree qualifications.

The overall event will consist of three phases: two online and one in person.

4.1 First Phase [Online]

For the first online phase, teams will attend a series of webinars and submit a Conceptual Design Report. This first phase will take place between **February and April 2025**.

- Webinars will take place after registration in mid February and the beginning of April. The specific dates will be communicated to the teams.
- The Conceptual Design Report submission is to be completed by all teams taking part in the competition and should incorporate lessons learned not only from literature but also from the webinars.
- Reports and additional documents will be submitted before **31st March 2025**.
- The selected teams will be announced before **22nd April 2025**.

4.2 Second Phase [Online]

The twenty (20) teams selected from the first phase will refine their design process from the first phase and attend a series of additional webinars. A Final Design Report deliverable will be submitted to evaluate the work done for selection to the final stage. This phase will take place between **April and June 2025**.

- The second set of webinars will take place between early April and May. The specific dates will be communicated to the teams.
- Reports and additional documents will be submitted before **6th June 2025**.
- The selected teams for the finals will be announced before **20th June 2025.**

4.3 Third Phase [In Person]

The final phase will consist of an **in person** 7-day event (accounting for arrivals and departures). A minimum of five (5) of the highest scoring teams, selected from their performance in the first two phases, will work in person on their proposals and defend their reports to a panel of judges.

The event this year will take place in Forli, Italy from the 25th to the 31st of August 2025.

Appendix

A. Bibliography

[1] F. Gambioli und A. G. Malan, "Fuel Load in Large Civil Airplanes" in International Forum on Aeroelasticity and Structural Dynamics, Como - Italy, 2017.

[2] Estes Rockets. (2023). Estes® Altimeter - Estes Rockets. [online] Available at: https://estesrockets.com/products/altimeter?srsltid=AfmBOooWOiqgV5FbONhGZjbPsbwA0EvoXaFSVa-iucz4wb-rkq0K-CwR.

B. Altimeter Specifications

The altimeter provided for the competition will be the Estes® Altimeter (Figure 1). The specifications are shown in Table 1. It is capable of reading altitudes up to 9999ft (3000m), with a sampling accuracy of 1 foot below 3300 feet.

More information can be found in the official instructions, including specifics on vent holes and an example of an installation method. Note that the way that the altimeter has been installed in the instructions is the recommended method for High Powered Rocketry (HPR). For the purposes of this competition teams can choose whether or not to follow the method presented by Estes.

Figure 1: Estes® Altimeter [2]

Table 1. Estes Altimeter Dimensions and Weight

Metric	**Value**
Length	5.5 cm (2.2 in.)
Width	1.9 cm (0.75 in.)
Height	1.3 cm (0.5 in.)
Weight	12 g (0.415 oz.)