AEROTHON 2022 – UNINHABITED AIRCRAFT SYSTEM (UAS) DESIGN, BUILD AND FLY CONTEST

Rule Book

Revision 0
March 15, 2022

REVISION HISTORY

Revision	Date	Description
0	Mar 15, 2022	First Issue
1	Mar 25, 2022	Payload capacity
2	Mar 30, 2022	Revised Registration Deadline

FOREWORD

Welcome to SAEINDIA AEROTHON – UNINHABITED AIRCRAFT SYSTEM (UAS) DESIGN, BUILD AND FLY CONTEST 2022. The system requirements are developed to align with real-world Uninhabited Aerial Vehicle (UAV) requirements and provide a healthy competition among teams. Let's look at these metrics a little closer.

The contest is planned in two phases a) Phase – 1: Design Report & Oral Presentation b) Phase – 2: Flying Competition.

The teams must submit a design report of their UAV in Phase - 1, adhere to the contest design rules and guidelines and also make a presentation to the jury. The top 20 teams from the phase - 1 will qualify for the phase - 2 of the contest which requires the teams to build an Uninhabited Aircraft System and successfully complete a payload drop mission during the flying competition. Top 3 teams will be selected as the winners of this contest.

Universities/Institutions can nominate any number of teams as long as they meet the team formation requirements listed in this document.

Lastly, contesting teams are requested to pay special attention to the bold and italicised fonts throughout this document. These are important updates and clarifications on a variety of aspects pertaining to the design. Please read these rules carefully. Watch out for official announcements and updates concerning this contest and rule interpretations in SAEINDIA website.

Best of luck to you all!!

SAEINDIA Aerospace Forum
SAEINDIA

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1. CONTEST DETAILS

1.1. OVERVIEW

The Indian government is on the mission to turn the country into an Uninhabited Aircraft System (UAS) / Drone hub by 2030 under the Atmanirbhar Bharat Abhiyan by accelerating the pace of development of India's Uninhabited Aircraft / Drone industry. India's UAS market could grow to INR 500 billion (US$6.8 billion) in the next five years.

Uninhabited Aircraft Systems (UAS) are used across many industries like defense, construction, infrastructure, mining, telecom, geospatial mapping, agriculture/farming, media & entertainment, law enforcement, oil and gas for surveillance, security, safety, disaster management, land survey, progress and condition monitoring through aerial photography and thermal imaging. The widespread consumer market applications will soon become reality, with the progress in technological innovations and the reduced costs. Some of these include drone-facilitated last-mile delivery for the retail, healthcare and logistics sectors.

SAEINDIA Aerospace Forum is organizing SAEINDIA AEROTHON - UNINHABITED AIRCRAFT SYSTEM (UAS) DESIGN, BUILD AND FLY CONTEST named as AeroTHON 2022 for students with a primary focus on developing skills to design and build an UAV to prepare them to be industry-ready in the emerging market.

This contest provides a real-life engineering exercise to undergraduate and graduate engineering students. The contest has been designed to expose the students to the real-life work environment of engineers in the industry.

In this contest, students will perform trade studies and make decisions to arrive at a design solution that will meet the mission requirements and conform to the defined configuration limitation and build a flightworthy UAV. In a nutshell, AeroTHON 2022 provides an opportunity for the students to experience the complete design and build cycle of a UAV that meets the specified mission requirements and a flight demonstration in the flying event.

The importance of practical and interpersonal communication skills is often overlooked by engineers. It is important to note that, apart from technical knowledge, written and oral communication skills are vital in the engineering workplace. To help the students develop these skills, the contest has been divided into two phases –

1. Phase – 1: Design Report & Oral Presentation
2. Phase – 2: Flying Competition.

1.2. OBJECTIVE

- To inculcate innovation mindset among the student community in emerging technologies like Uninhabited aerial vehicles (UAV)
- Incubate and nurture skills and capabilities of aero design in young minds and prepare them towards Atmanirbhar Bharat in critical aerospace technologies.

- To provide a platform for Aero-passionate students to demonstrate UAV design expertise
- To help develop the next generation of entrepreneurs

1.3. RULES AND ORGANIZER AUTHORITY

General Authority

SAEINDIA AEROTHON - UNINHABITED AIRCRAFT SYSTEM (UAS) DESIGN, BUILD AND FLY CONTEST committee reserves the right to revise the schedule of any contest and/or interpret or modify the contest rules at any time and in any manner that is, in their sole judgment, required for the efficient operation of the event.

Rules Authority

SAEINDIA Aerospace Forum Committee owns the responsibility and authority of the rules of SAEINDIA AEROTHON - UNINHABITED AIRCRAFT SYSTEM (UAS) DESIGN, BUILD AND FLY CONTEST and it has been issued under the authority of the SAEINDIA. Official announcements from the SAEINDIA AEROTHON - UNINHABITED AIRCRAFT SYSTEM (UAS) DESIGN, BUILD AND FLY CONTEST Committee shall be considered part of and have the same validity as these rules.

Ambiguities or questions concerning the meaning or intent of these rules will be resolved by the officials, SAEINDIA AEROTHON - UNINHABITED AIRCRAFT SYSTEM (UAS) DESIGN, BUILD AND FLY CONTEST Committee or SAEINDIA Staff.

Rules Validity

The SAEINDIA AEROTHON - UNINHABITED AIRCRAFT SYSTEM (UAS) DESIGN, BUILD AND FLY CONTEST Rules posted on the SAEINDIA Website and dated for the calendar year of the contest are the rules in effect for the contest. Rule sets dated for other years are invalid.

Rules Compliance

By entering the SAEINDIA AEROTHON - UNINHABITED AIRCRAFT SYSTEM (UAS) DESIGN, BUILD AND FLY CONTEST, the team members, faculty advisors and other personnel of the participating university/institute has agreed to comply with and be bound by the rules, interpretations or procedures issued or announced by SAEINDIA AEROTHON - UNINHABITED AIRCRAFT SYSTEM (UAS) DESIGN, BUILD AND FLY CONTEST Committee. All team members, faculty advisors and other university representatives are requested to cooperate and follow all instructions from the contest organizers, officials and the jury.

Understanding the Rules

The participating student teams are responsible for reading and understanding the rules in their entirety, their effect on the contest in which they are

participating. The section and paragraph headings of these rules are provided to facilitate the reading and will not affect the paragraph contents.

Consideration of "Participation" in the contest

Teams, team members as individuals, faculty advisors, and other representatives of a registered university who are listed as team members while registering their team are considered to be "participating" in the contest from the time they register for the event until the conclusion of the contest or earlier, in case of withdrawing.

Violations of Rule Intent

The violations of the intent of a rule will be considered a violation of the rule itself. Questions about the intent or meaning of a rule may be addressed to the SAEINDIA AEROTHON - UNINHABITED AIRCRAFT SYSTEM (UAS) DESIGN, BUILD AND FLY CONTEST Committee or SAEINDIA Staff.

Conditions and Penalties

Organizers have the right to modify the points and/or penalties listed in the various event descriptions to better reflect the design of their events, or any special conditions unique to the contest.

Force Majeure

The AEROTHON organising committee and SAEINDIA shall not be held responsible for non-fulfillment of their obligations under this agreement due to the exigency of one or more of the force majeure events such as but not limited to the acts of God, war, flood, earthquake, strikes, lockouts, pandemics, epidemics, riots, civil commotion, scarcity, of water, electricity or such other basic facilities, etc and shall inform the participating teams on the occurrence and cessation of the event within one week of such decision being made. If running the event is not feasible either due to unreasonable duration of force majeure conditions or any other reasons, the event may be cancelled for the year

(i) ("Force Majeure Events")

(a) Earthquake, flood, inundation and landslide, storm, tempest, hurricane, cyclone, lightning, thunder, pandemics, epidemics or other extreme atmospheric disturbances or any other act of God

(b) Strikes, labour disruptions or any other industrial disturbances not arising on account of the acts or omissions of the organisers, war, hostilities (whether declared or not), invasion, an act of a foreign enemy, terrorism, rebellion, riots, weapon conflict or military actions, civil war, ionising radiation, contamination by radioactivity from nuclear fuel, any nuclear waste, radioactive toxic explosion, volcanic eruptions or other such occurrences beyond the control of the organisers

(c) Acts of expropriation, compulsory acquisition or takeover by any government agency of the said venue where the event is to be held or any part thereof

(d) Any prohibitory order of any Court

1.4. ELIGIBILITY

1.4.1. TEAM MEMBER

Members of a Team must be undergraduate or postgraduate student and every member of the team must be a member of SAE India.

1.4.2. SOCIETY MEMBERSHIP

A university or institute can nominate as many teams as they wish by paying the requisite fee for each team. However, each team must work independently.

The registration fees indicated in the Section 8 must be paid within 15 days of registration.

1.5. OFFICIAL LANGUAGES

The official language of the SAEINDIA AEROTHON - UNINHABITED AIRCRAFT SYSTEM (UAS) DESIGN, BUILD AND FLY CONTEST is English. Document submissions, presentations and discussions in English are acceptable during all the phases of the contest.

1.6. CONTEST PHASES

1.6.1. Phase – 1: Design Report & Oral Presentation

- This phase invites innovative designs from the participant teams
- The innovative designs will be evaluated by industry and academic experts
- Top 20 teams shortlisted for phase - 2

1.6.2. Phase - 2: Flying Competition

- Students build physical prototype of their design
- Flight Test
- Prizes awarded to seven teams

1.7. IMPORTANT DATES

Here are the key dates for the contest.

Table 1 Contest Timeline

Key Event	Dates
Registration opened for AeroTHON 2022	28th Feb 2022
Rule Book Release	15th Mar 2022
Registration close	7th Apr 2022

Phase -1: Design report submission by students	30th April 2022
Students present design to Judges (industry and academic experts)	14th-15th May 2022
Judges (industry and academic experts) review reports & finalize scores	16th May 2022 – 27th May 2022
Announce winners of Phase -1 during AeroCON 2022	3rd Jun 2022
Phase 2: Physical prototype build	16th May 2022 – 17th Nov 2022
Phase 2: Physical prototype inspection	18th Nov 2022
Phase 2: Flying competition	18th &19th Nov 2022
Awards Ceremony	19th Nov 2022

1.8. REGISTRATION AND FEES

A team can comprise a maximum of ten students and one faculty advisor. Please note all student participants must be SAEINDIA members to participate in the events or contests by SAEINDIA. Faculty advisors are advised to become members of SAEINDIA, though it is not mandatory.

The **Registration fee** for AEROTHON is **Rs.15,000/- (Rupees Fifteen Thousand only) per team excluding 18% GST**. To register for AEROTHON visit: https://saeindia.glueup.com/event/aerothon-virtual-aero-design-contest-33371/

Steps to become a SAEINDIA Member

If you are not a SAEINDIA member, go to www.saeindia.comand select the "Membership" link. Students need to select the "Student Membership" link and provide the details as indicated.. Alternate link to sign up for SAEINDIA membership https://www.saeindia.org/become-a-member

Faculty members who wish to become SAEINDIA members should choose the "Professional Membership" link..

1.9. CANCELLATION OF CONTEST REGISTRATION

Teams registering for SAEINDIA AEROTHON – UNINHABITED AIRCRAFT SYSTEM (UAS) DESIGN, BUILD AND FLY CONTEST are required to submit a design report on the design of the UAV.

Failure to submit the Design report on or within the specified date will constitute an automatic withdrawal of your team from the contest. Your team will be notified the next day of the due date about non-submission, your team's registration will be cancelled after two days of this notification and no refund will be given.

1.10. EXPECTATIONS

1.10.1. DESIGN WITH NO PROFESSIONAL'S INVOLVEMENT

The UAV must be designed by the SAEINDIA student members without direct involvement from professional engineers, faculty members, or related professionals. The students may use any literature or knowledge related to UAV or aircraft design and construction and information from professionals' / industry mentors or professors, as long as the information is given as discussion of alternatives with their pros and cons and is acknowledged in the references in the design report. Professionals may not make design decisions, nor contribute to the drawings, the report, or the construction of the UAV. The Faculty Advisor must sign the Statement of Compliance given in Appendix A.

1.10.2. ORIGINAL DESIGN

Any UAV presented in the contest must be an original design whose configuration is conceived by the student team members. Photographic scaling of an existing model UAV design is not allowed.

1.10.3. UNIQUE DESIGNS

Universities or institutions may register more than one team in SAEINDIA AEROTHON - UNMANNED AIRCRAFT SYSTEM (UAS) DESIGN, BUILD AND FLY CONTEST, but each entry must be with a unique design, significantly different from each other. If the UAV designs were not significantly different based on the assessment by the organising committee, then the university/institution will be considered to have a single entry and one of the team will be allowed to participate in the contest. For example, two designs with the same motor configurations and dimensions would not be considered significantly different.

1.10.4. FACULTY ADVISOR

Each team is expected to have a Faculty Advisor from the registered university or institution. Non-faculty members are not allowed to be advisors. The Faculty Advisor will be considered as the official university representative for that team by contest organisers. Faculty Advisors may advise their teams on general engineering and engineering project management theory but should not be directly involved in the design of any part of the vehicle nor directly participate in the development of any documentation or presentation. They may review the design reports and provide suggestions and guide the team prior to the report submission and flying competition.

2. UAV DESIGN AND FLIGHT REQUIREMENTS

The objective for this year's contest is to design, build and fly a multirotor UAV that can deliver cargo to a specified location. The teams shall design a UAV that can carry a specified payload and deliver it to a target area by manual as well as autonomous operations.

2.1. DESIGN REQUIREMENTS

The design requirements of the UAV are listed in Table 2 and The payload dimensions are 10 cm x 5 cm x 5 cm as shown in Figure 1.

Table 2 UAV Design Requirements

S.No.	Parameter	Requirement/Limitation
1.	UAV Type	Multirotor
2.	UAV Category	Micro UAS (i.e., Take-off weight < 2kg)
3.	Payload Capacity	200 grams
4.	Propulsion Type	Electric
5.	Communication System Frequency	Data Telemetry - 2.4 GHz Video Telemetry – 2.4 GHz or 5.8 GHz
6.	Communication System Range	At least 1 km

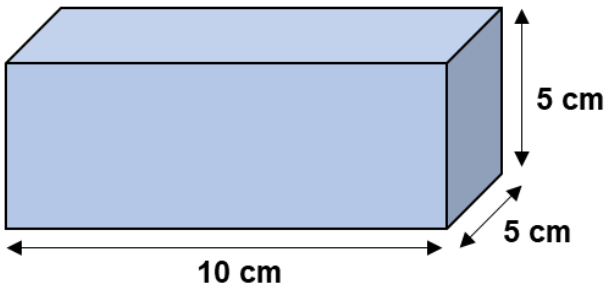

Figure 1 Payload Dimensions

Note: This year's contest is only for multirotor UAVs. Fixed wings and VTOL Fixed-wings are not allowed. Students are expected to bring innovation in the payload dropping method and mechanism to ensure a safe delivery of payload to the target point. Provide design and analysis details of various systems and sub-systems, selection of Commercially Off The Shelf (COTS) items like batteries, motors etc. Students should consider safety of the platform and the environment in the design and highlight the risks and how they have been mitigated in the design

3. PHASE – 1: DESIGN REPORT & ORAL PRESENTATION

In phase – 1, the participant teams are required to submit a technical design report of their UAV asper the design requirements & constraint given in Section 2. The teams are also required to give a presentation to a jury comprising of industry and academic experts who will evaluate the designs.

3.1. DESIGN REPORT& PRESENTATION

Design Report is the primary means by which a team is to convey to the judges how they arrived at their design decisions, such that their Uninhabited aircraft system is most suited to perform the intended mission. The Design Report should explain the team's thought processes and engineering philosophy that drove them to their conclusions. Further, it should detail the methods, procedures, and where applicable, the calculations used to arrive at the presented solution.

Teams are required to submit a Design Report and also prepare a detailed presentation (Microsoft Power Point Format) and present it to the jury. The design report and presentation must have the following contents:

a) Conceptual Design

   I. High-level physical view: Physical elements and their arrangements

b) Detailed Design

   I. Estimation of Preliminary Weight.

   II. Estimation of Thrust required.

   III. Selection of Propulsion System.

   IV. UAV Sizing (Wheelbase, Rotor Arm, Hub, Propeller Clearance, Landing gear)

   V. UAV Performance (Power required estimation, Power System (battery) Selection, Endurance Estimation)

   VI. Material selection

   VII. Subsystem Selection (Communication system, Control & Navigation System & Other Avionics/Sensors)

   VIII. C.G. Estimation & Stability Analysis

   IX. Preliminary CAD model (2D Drafting Front view, Top view and Side View, 3D Model)

   X. Computational Analysis

   XI. Optimized Final Design (Summary of Design Changes/Optimizations including the Final CAD model and 2D Drafting & C.G.)

   XII. Detailed weight breakdown & C.G. of Final UAV Design

   XIII. UAV Performance Recalculation (Thrust/Weight, Power Required for the mission & Endurance calculation)

c) Final UAV Specifications and Bill of Materials.

d) Methodology for Autonomous Operations – how autonomous flight will be implemented, Method for autonomous identification of the target and how the UAV will be used to autonomously drop/deliver the payload to the precise position.

e) Summary of innovations in the overall design

Refer to the Sections 5*,* 6*, &* 7 *the evaluation criteria, Design Report and presentation guidelines*

4. PHASE – 2: FLYING COMPETITION

The phase - 2 of the SAEINDIA AEROTHON - UNINHABITED AIRCRAFT SYSTEM (UAS) DESIGN, BUILD AND FLY CONTEST 2022 will have three stages,

1) **Technical Presentation**
2) **Technical Inspection**
3) **Flying Competition**

4.1. TECHNICAL PRESENTATION

Prior to the flight inspections and the flying competition, the teams must give a 15-minute presentation on the design performance of their UAV. This presentation shall include a brief overview of the design parameters (same as submitted during the phase-1). If there are any changes to the UAV design with respect to the submitted design report, then the team shall appropriately highlight them in their presentation and also provide a justification for the change.

Before the flying competition, the teams must have successfully flown their UAV at least a few times. The teams must include these flight performance logs, test pictures and videos in this presentation.

Scoring for this stage will be provided based on the UAV design conformance to the original design submitted in Phase -1, the flight performance achieved during these test flights compared to performance parameters submitted during the Phase – 1 design report and the successful testing of the autonomous operations. The Detailed evaluation criteria for the Phase – 2 of the contest is provided in Section 5.2.

4.2. TECHNICAL INSPECTION

All UAVs will undergo a technical inspection by designated UAV inspector(s) prior to being allowed to make any flight demonstration. Technical and Safety inspection of all UAVs will be conducted as per the general safety guidelines followed in the industry and all decisions of the UAV inspector are final.

Technical and Safety Inspection is the process of checking all UAV for:

1. Compliance with all specified UAV design requirements.
2. Overall safety and airworthiness.

All UAVs must pass the Technical and Safety Inspection in order to compete. It is strongly recommended to have a self-inspection checklist before arriving at the contest.

During the Technical Inspection the following will be checked,

a) UAV Dimensions Conformance to 2D Drawings Submitted during Phase - 1

b) Use of the same components selected in Phase - 1

- Propulsion - Motor, Electronic Speed Controller & Propeller, Power System – Battery, Control & Communication System - Flight Controller, Radio Transmitter & Receiver)

c) Take-off Weight Same as submitted in the design report

d) Structural Integrity

- All the components are secured well, proper wiring (i.e., no wires hanging, use of appropriate gauge wires and connectors), secure fasteners - use of locknuts or thread locker for fasteners no structural components are loose or shaking, propeller attachment, payload attachment.

e) Other Checks

- Proper control response (motor rpm) to Radio controller inputs, Motor/Propeller Rotating direction, Radio Range Check, Motor Arming and Disarming check, FPV video transmission check

4.2.1. UAV Conformance to 2D Drawing

During Technical Inspection, the UAV will be inspected and measured for conformance to the 2D drawing presented in the Design Report.

a) At a minimum, UAV arm length, landing gear height and UAV height dimensions will be measured and compared to the 2D drawing.

b) All teams must have a hard copy of their design report with them during technical inspection.

c) UAV actual empty CG will be compared to the empty CG presented in the design report's 2D drawing.

4.2.2. Deviations from 2D Drawing

Any deviation in construction of the UAV from the submitted 2D drawing since submission of the Design Report must be reported in writing.

a) Each design change must be documented separately using the Modification Change Request (CR).

b) Only one design change may be submitted per CR form.

c) Jury will assess penalty points for design changes.

4.2.3. Inspection of Spare UAV Components

- All spare UAV components (structural parts, motors, propeller, batteries etc.) must be presented for inspection at the same time of the UAV inspection.

4.2.4. Inspection Requirements throughout the Contest

- All UAV must meet all Technical and Safety Inspection requirements throughout the contest.
- Any official may request that an UAV be re-inspected if a general or safety requirement problem is seen on an UAV at any time during the event.
- This includes any unintended errors or omissions made by officials during inspection.

4.2.5. Technical and Safety Inspection Penalties

- Points are allotted for the Technical and Safety Inspection.
- Teams may only lose points as a result of errors and problems encountered during the inspection process. Any penalties assessed during Technical Inspection will be applied to the overall contest score.

4.3. FLYING COMPETITION

The flying competition is tentatively scheduled for 18th and 19th November 2022 and it is anticipated to run from 8:00 AM to 5:00PM on 18th and 19th of November 2022. Technical inspections will begin on 18th November 2022 and will continue if required on the 19th November 2022.

4.3.1. General Mission Requirements

- The objective of AeroThon 2022 is to design, build and fly an UAV to deliver a small payload to a specified target point. There will be a total of two flight missions. In the first mission the UAV must be operated manually and drop the payload on the given target and in the second mission the same task must be performed using autonomous operation.
- The UAV must remain substantially the same as documented in the design report and it must be flown in the same configuration, including all structure, delivery mechanisms, propulsion and other systems.
- **A total of three attempts will be provided. After successful completion of Flight mission 1 team will be eligible for Flight mission 2.**
- If an UAV is damaged after an unsuccessful flight attempt, the teams shall carryout necessary repairs, if possible, without making any modifications that deviates from the submitted design before the flight call for their next attempt. However, the UAV must go through the inspection once again and cleared as airworthy before their next attempt or else the team shall be forfeited by default.
- If the UAV is damaged beyond repair or if it is deemed not airworthy by the UAV inspectors, then the team shall forfeit their next attempts.

4.3.2. Flying Competition Chronology

- Flying chronology will be shared with all the teams at least two days prior to the flying demonstration event scheduled as per the announced dates via email. Teams shall follow the chronology during the flight demonstration. The same order will be repeated for the second flight attempt.
- The position of each team in the chronology will be determined based on the phase 1 score. The team with the highest score will be placed at the top of the order and the lowest will be at the bottom.

  If a team is not ready to fly during their turn, they will miss (forfeit) their opportunity for that attempt.

4.3.3. Flight Mission 1 – Manual Operation

- In this mission, the UAV must be flown with a payload of 200 grams from the take-off point to the target point manually by means of tele-operation i.e., using a Radio Controller and dropping the payload at the specified target point. The flight course is shown in Figure 2
- The Flight mission is as follows,
  - ❖ Take-off and reach an altitude of 30 m
  - ❖ The UAV must be flown at 30 m altitude to reach the search area and identify the target
  - ❖ After identifying the target, the UAV must descend down to 20 m and drop the payload
  - ❖ After the payload is dropped, the UAV must again climb to an altitude of 30 m and fly back to the take-off point.
  - ❖ After reaching the take-off point the UAV must be landed.
- The coordinates for the search area for the target as shown in Figure 2 will be provided at the time of the flying competition.
- The target maybe identified visually by means of a First-Person View (FPV) camera.
- Each team will be provided a flight time of 10 minutes to complete the mission.
- The time starts when the throttle input is increased for the take-off.
- Scoring will be provided for a successful flight mission. A flight is considered successful only if the UAV takes off, identify target, and return to the take-off point and land safely on the ground.
- Points will also be provided for the payload drop. Scoring for the payload drop will be based on the distance at which the payload is dropped from the centre on the target area i.e., closer the payload is to the target centre, higher the score. Payload Drop Target Area – Scoring is shown in Figure 3.

- Data recorded from telemetry will be analysed for precise estimation of timing and performance.
- UAV profiles maintaining minimum error in timing, altitude requirements will be scored higher.

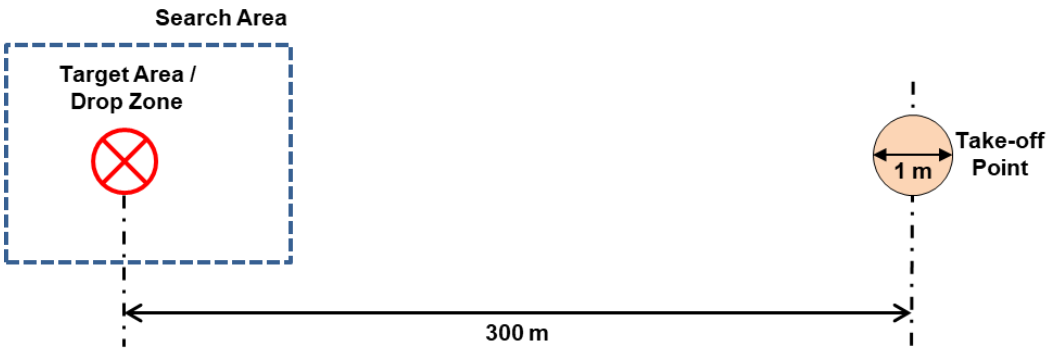

Figure 2 Flight Course

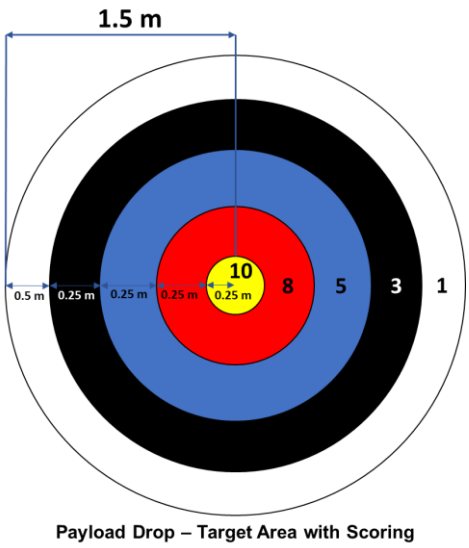

Figure 3 Payload Drop Target Area with Scoring

4.3.4. Flight Mission 2– Autonomous Operation

- In this mission, the UAV must be flown with a payload of 200 grams from the take-off point to the target point and drop the payload on the target autonomously.
- The task for this mission is same as flight mission - 1,
  - ❖ Take-off and reach an altitude of 30 m
  - ❖ The UAV must fly at 30 m altitude to reach the search area and identify the target
  - ❖ After identifying the target, the UAV must descend down to 20 m and drop the payload

- ❖ After the payload is dropped, the UAV must again climb to an altitude of 30 m and fly back to the take-off point.
- ❖ After reaching the take-off point the UAV must be landed.

- The teams may search and identify the target by means of computer vision & object detection techniques. After the target has been identified, the payload must be dropped autonomously. **(The image of the target will be given to the teams selected for the phase 2 of the contest)**
- The coordinates for the search area for the target as shown in Figure 2. will be provided at the time of the competition. Using this, the teams may pre-program the mission (flight path) in the ground station software and carryout the mission (Note: the target may not be necessarily in the centre of the given search area, it can be anywhere within it). UAV has to identify the target and drop the payload.
- The UAV must have geo-fencing capability. At the time of the flying competition the coordinates for the geo-fence will be given to the teams. These coordinates must be programmed in ground station software so that the UAV does not fly beyond this boundary.
- Each team will be provided a flight time of 10 minutes to complete the mission.
- The time starts when the throttle input is increased for the take-off.
- Scoring will be provided for a successful flight mission and the time taken to complete the mission. A flight is considered successful only if the UAV lands safely on the ground.
- A score will also be provided for the payload drop. Scoring for the payload drop will be based on the distance at which the payload is dropped from the centre on the target area i.e., closer the payload is to the target centre, higher the score. Payload Drop Target Area – Scoring is shown in Figure 3.

Note:

In case if there is a tie between teams, the time taken to complete the missions will be considered. The teams will be ranked in the ascending order of their flight time. Telemetry data and on board data will be analysed for the selection of winners.

The direction of the flight take-off, landing or even the entire course will be adjusted based on the prevailing winds as determined by the Air safety engineer of the competition. The flight course will be positioned to maintain the greatest possible safety to personnel and facilities

4.3.5. Fail Safe Mode

- All UAVs must enter Fail Safe Mode when radio communication from the UAV's Controller is lost.

- Fail Safe Mode ensures that the UAV will behave in a predictable and safe manner if radio communication is lost.
- Fail Safe Mode can also be deliberately entered by turning off the remote control as a last resort if the UAV is out of control.
- When in Fail Safe Mode, the UAV must either descend vertically to the ground and land or automatically fly to its take-off location.

5. EVALUATION CRITERIA

5.1. PHASE 1 EVALUATION

The evaluation of Phase 1 is on the design report submitted for the preliminary round and the presentation by the team and the scoring will be based on the parameters listed in Table 3.

Table 3 Evaluation Criteria for Phase 1

S.No.	Parameter	Score
1	**Technical Content**	
	1.1. Conceptual design	2
	1.2. Preliminary Weight Estimation	4
	1.3. Thrust Required Estimation (2) & Propulsion System Selection (3)	5
	1.4. UAV Sizing (Rotor Arm (2), Hub, Wheelbase (2), Propeller Clearance (2), Landing gear (2))	10
	1.5. UAV Performance (Power required estimation (3), Power System (battery) Selection (3), Endurance Estimation (4))	10
	1.6. Material Selection	4
	1.7. Subsystem Selection - Communication system (2), Control & Navigation System (3)	5
	1.8. C.G. Calculation (2) & Stability Analysis (3)	5
	1.9. Preliminary Computer Aided Design Model (2D Drafting Front view, Top view and Side View, 3D Model)	5
	1.10. Computational Analysis	5
	1.11. Optimized Final Design (Summary of Design Changes/Optimizations including the Final CAD model and 2D Drafting & C.G.)	5
	1.12. Detailed Weight Breakdown (3), UAV Performance Recalculation (3) (T/W, Power Required for the mission & Endurance calculation), Final UAV Specifications (1) and Bill of Materials (3)	10
2.	**Methodology for Autonomous Operation**	
	2.1 Autonomous Flight	3
	2.2 Autonomous Identification of Target	4
	2.3 Autonomous Payload Drop	3

3.	**Innovation**	10
4.	**Presentation**	10
Total		**100**

5.2. PHASE 2 EVALUATION CRITERIA

The evaluation of Phase 2 is on the technical presentation, prototype build, and the flying competition, and the scoring is based on the parameters listed in Table 4.

Table 4 Evaluation Criteria for Phase 2

S.No.	Parameter	Score
1.	**Technical Presentation**	
	1.1. UAV Design Overview - Prototype UAV must be the same design as design submitted in Phase – 1 Design of Rotor Arm (2), Motor Mount (2), Hub (2), Landing gear (2), Overall Design (2)	10
	1.2. UAV Performance Overview - (Conformance to submitted design in Phase 1) T/W (1), Power Consumption (1) & Endurance (1), Flight Test Pictures (2), Flight Test Video (3) & Flight Log (2)	10
	1.1. Video of Autonomous Flight (3) & Proof of Implementation of Target Identification using computer vision (2)	5
2.	**Technical Inspection**	
	2.1 UAV Dimensions Conformance to 2D Drawings Submitted during Phase - 1	2
	2.2 Use of the Same Components Selected in Phase - 1 ❖ Propulsion - Motor, ESC & Propeller (1) ❖ Power System - Battery (1) ❖ Control & Communication System - Flight Controller, Radio Transmitter & Receiver (1)	3
	2.3 Take-off Weight Same as submitted in the design report ❖ Weight difference < 50g - 3 points ❖ Weight difference > 50g & < 100g - 2 points ❖ Weight difference > 100g & < 200g - 1 points ❖ Weight difference > 200g - No points	3
	2.4 Structural Integrity - All the components are secured well (1), proper wiring (i.e., no wires hanging, use of appropriate gauge wires and connectors) (1), Secure fasteners - use of locknuts or thread locker for fasteners (1), no structural components are loose or shaking (1), propeller attachment (1), Payload attachment (1)	6
	2.5 Other Checks - Proper control response (motor rpm) to Radio controller inputs (1), Motor/Propeller Rotating direction (1), Radio Range Check (1), Motor Arming and Disarming check (1), First Person View video transmission check (1), Fail Safe Check (1)	6

3.	**Flight Mission 1**	
	3.1 Successful Flight - Take-off (2), Identify target (5), Return to Take-off point and Land (3)	10
	3.2 Maintain Mission Altitude	5
	3.3 Payload Drop Distance	10
4.	**Flight Mission 2**	
	4.1 Autonomous Take-off	3
	4.2 Autonomous Flight - Maintain Flight Path (± 2 m)	3
	4.3 Maintain Mission Altitude (± 2 m)	3
	4.4 Autonomous Identification of Target	5
	4.5 Autonomous Payload Drop	3
	4.6 Payload Drop Distance	10
	4.7 Autonomous Landing	3
Total		**100**

6. DESIGN REPORT GUIDELINES FOR PHASE - 1

6.1. INTRODUCTION

Technical report writing is a skill that is different from informal writing – letters, notes, email – and, like all skills, needs the practice to master them. The SAEINDIA AEROTHON - UNINHABITED AIRCRAFT SYSTEM (UAS) DESIGN, BUILD AND FLY CONTEST 2022 provides an excellent opportunity for students to exercise this skill. This document provides guidelines to help design teams write clear, succinct, and data-rich reports. The guidelines are grouped in three areas: organization, writing process, and writing clearly and succinctly.

6.2. ORIGINAL WORK

The Technical Design Report shall be the team's original work for the current contest year. Resubmissions of previous and current year's design reports will not be accepted. Recitation of previous year's work is acceptable if and only if appropriately cited and credited to the original author(s). Plagiarism is a forbidden industry and academic practice. All references, quoted text and reused images from any source shall have an appropriate citation within the text and within the Technical Design Report's Table of References, providing credit to the original author and editor.

Reports may be checked against previous and current years' submissions to determine if re-use, copying, or other elements of plagiarism are indicated.

For the SAEINDIA AEROTHON – UNINHABITED AIRCRAFT SYSTEM (UAS) DESIGN, BUILD AND FLY CONTEST, plagiarism is defined as any of the following:

a) Use of information from textbooks, reports, or other published material without proper citation

b) Use of sections or work from previous SAE Aero Design contests without proper citation

If plagiarism is detected in the design report, the team will be disqualified, or points will be deducted as deemed by the rules committee/jury depending on the amount of plagiarised content present in the design report.

The SAEINDIA AEROTHON – UNINHABITED AIRCRAFT SYSTEM (UAS) DESIGN, BUILD AND FLY CONTEST Rules Committee & SAEINDIA has the sole discretion to determine whether plagiarism is indicated, and the above rules are enacted. The above rules may be implemented at any time before, during, or for up to six (6) months after the contest.

6.3. ORGANIZATION OF CONTENTS

Reports are written for a person or group to read, and these readers have a purpose for reading the report. In the SAE contest, the readers are the jury, and their purpose in reading is to grade the paper. Therefore, the design team authors should write the design report using techniques that make it easy for the jury to grade them. Organizing the report for the reader's purpose is the first technique for effective technical writing.

Outline - The judge's grading criteria predominantly depend on the technical aspects. So, the teams are expected to,

- Explain the team's thought processes and engineering philosophy that drove them to their conclusions
- Detail the methods, procedures, and where applicable, the calculations used to arrive at the presented solution
- Cover these topics
    - UAV configuration selection
    - UAV design including rotor arm, hub, landing gear, etc.
    - Subsystem Selection
    - UAV Performance
    - UAV C.G., stability and control
    - Computational Analysis
    - Other as appropriate

It also covers the administrative aspects of the report – page limits, formats, and specific graphs and drawings. Although it may be harder to write the report to this outline, it will be easier for the jury to grade it. This outline also forces the team to address topics the jury must grade and develop necessary data.

6.4. WRITING PROCESS

Writing a multi-page design report can be made less daunting by using a multi-step process. The first step is described above, generating an outline that addresses the reader's purpose. The next steps, described below, help in generating a data-rich, well-edited design report.

Allocate Pages – Allocate 40 pages to the sections of the outline. The allocations should reflect the emphasis areas of the team's design. Do this before writing begins and adjust after reviewing the first draft. For each page of the design report, define the topic to be discussed and the message to be delivered. Make writing assignments for each page. Giving authors page-by-page assignments makes it easier to attack the writing – they are writing only one page at a time.

Create the Figures – Most juries will be engineers, and engineers are graphically inclined - they can understand a concept more easily when looking at a picture. Therefore, build each page around at least one figure. Create the figures first and review them before starting to write. Each figure needs a message which should be summarized in the figure title. Make the figures data-rich, but legible (9-point font is a minimum size - another advantage of using figures is that the rules do not constrain type font or spacing on figures). Equations can be incorporated in figures to save space.

Draft the Text - Use text to highlight, explain, or further develop the major points of the figure. Writing guidelines for clarity and succinctness are presented in a subsequent section.

Edit the Text and Figures – Take the time to edit the document at least twice. A good approach is to perform one edit cycle based on a group review of the draft document (called a Red Team). Have the Red Team members read the document as juries, supplying them with a scoring sheet and a copy of the rules?

Create the Final Document – Although several persons may contribute to the writing process, one team member should make the final version. This person works to achieve a consistent style to the text and to make the messages consistent.

Schedule the Effort – Although this is the first step, I describe it last so that the reader can see what the team needs to schedule! A good report takes more than a week to create. One month is a guideline for the duration of the writing effort. Create a schedule of the above tasks and status it regularly. An efficient method is to establish the outline, page allocations, and figures early in the project, so the team can generate the necessary data as the design progresses. This reduces both the last-minute cram and the amount of unused documentation.

6.5. DESIGN REPORT SPECIFICATIONS

6.5.1. Page Limit

The design report must not exceed forty (40) single-spaced, typewritten pages; cover page, table of contents and appendix. The maximum limit of the document is given below:

Document	Max. Number of Pages
Main content	30
Appendix- additional supporting material	10

Note: Statement of Compliance will not be counted toward the 40-page limit.

6.5.2. Electronic Report Format

All reports must be submitted in (.PDF) format only. The document should be submitted electronically, and no handwritten documents will be accepted.

6.5.3. Font

The minimum size type is Arial 12 point proportional.

6.5.4. Margin

The report margins shall be: 1” Left, 0.5” right, 0.5” top, and 0.5” bottom. Each page, except the cover page, Certificate of Compliance, 2D Drawing and technical data sheet shall include a page number.

6.5.5. Page size

All report pages shall be A4 portrait format.

6.5.6. Cover page

All Design Reports must feature a cover page that states the team’s name, college or university, and team number. The cover page will count against the 30-page limit.

6.5.7. Submission of Reports

Teams are required to upload technical report in PDF file by the deadline date at the web link.

6.6. ELECTRONIC DOCUMENT SPECIFICATIONS

6.6.1. Format Size

Plan sheet must be in A3 page (PDF) format (11 x 17 inches). Plans must only consist of one (1) page and must have the US-standard third-order projection.

6.6.2. Required Views

The plans shall consist of a standard aeronautical three-view, using a US-standard third-order projection; i.e., right side view in the lower left with the nose pointing right, top view above the right-side view also with the nose pointing right, and front view in the lower right.

6.6.3. Dimensions

At a minimum, the UAV must have the length, width, height, and CG location marked clearly and dimensioned in the submitted engineering drawings. All dimensions must be in Metric units to an appropriate level of precision. (Hint: four decimal places are too many!)

6.6.4. Summary Data

The plans must also contain a table with a summary of pertinent UAV data such as dimensions, empty weight, motor/engine make and model.

6.6.5. Weight and Balance Data

The plans must also contain a weight and balance table with a summary of pertinent UAV equipment (motor, battery, payload, etc.), location from datum in metric units, moment arms and resultant moment of CG.

- All UAV must have a designated UAV datum indicated on the 2D drawings.
- All UAV drawings must indicate the following static CG margins: forward CG limit, aft CG limit and empty weight CG. Hint: Weight and Balance worksheet should correspond with static margins on 2D drawings.

6.6.6. Other Required Markings

The plans must be marked with the team's name and university or institute name.

6.7. SUBMISSION DEADLINES

The Design Report and 2D drawing plans must be electronically submitted to SAEINDIA no later than the date indicated on the Action. Neither the Organizer nor the SAEINDIA is responsible for any lost or misdirected reports, plans, or Server routing delays. SAEINDIA will not receive any paper copies of the reports through regular mail or email.

7. PRESENTATION GUIDELINES FOR PHASE - 1

7.1. INTRODUCTION

Creating slides for presentation is a skill that is different from design report. PowerPoint Presentations skill is one of the effective visual communication tools that create the best first impression among the targeted audience. The SAEINDIA AEROTHON - UNINHABITED AIRCRAFT SYSTEM (UAS) DESIGN, BUILD AND FLY CONTEST 2022 provides an excellent opportunity for students to master their presentation skills and showcase their project to Jury.

7.2. GENERAL

Presentation slides should effectively capture the work of the team. Follow a logically sound structure to organize the presentation. Here are some tips for making an effective presentation

- Plan and prepare your presentation professionally to deliver an effective message.
- Use visual points effectively, do not overwhelming your audience. A good PowerPoint presentation visual shouldn't complicate your message.
- Practice to perfection; rehearse your timing and delivery so that your points land as practiced with THE Jury.
- Present with a relaxed calm and confident outward projection. Give your audience warmth, excitement, and energy.
- Avoid typos, cheesy clip art, and miscues like reading directly from your slides.

The team can identify preferably one or two team members to present their work in a compelling and influential manner to the Jury.

7.3. ORGANIZATION OF CONTENTS

Similar to the design report the presentation must all contain the following,

- Explain the team's thought processes and engineering philosophy that drove them to their conclusions
- Detail the methods, procedures, and where applicable, the calculations used to arrive at the presented solution
- Cover these topics
    - ❖ UAV configuration selection
    - ❖ UAV design including rotor arm, hub, landing gear, etc.
    - ❖ Subsystem Selection
    - ❖ UAV Performance
    - ❖ UAV C.G., stability and control
    - ❖ Computational Analysis
    - ❖ Other as appropriate

Note: The teams/students shall have all the CAD and CAE files in the PC or Laptop they will be using during the presentation. During the presentation, the teams can open the CAD model files and Computational analysis files in the appropriate software and present them to the jury for validation. The teams are expected to have the following documents ready during their presentation – a) CAD files of the UAV b) FEA input file along with format details; & c) CFD input file along with format details.

7.4. TIME LIMIT

While there is no limit on the number of PowerPoint slides, Teams needs to complete their presentation within the allotted 15 minutes. In case teams are unable to complete their whole presentation, they would be stopped at whatever point they are at after end of 15 minutes. Post completion of the presentation, there would be 10 minutes Q&A with Jury.

8. REFERENCE BOOKS

- Introduction to UAV Systems - Paul Fahlstrom and Thomas Gleason
- Unmanned Aircraft Systems: UAVS Design, Development and Deployment - Reg Austin
- Advanced Aircraft Design: Conceptual Design, Analysis and Optimization of Subsonic Civil Airplanes - Egbert Torenbeek
- Aircraft design: A conceptual approach - Daniel P. Raymer
- Introduction to Flight- John D. Anderson
- Fundamentals of Aerodynamics - John D. Anderson
- Airplane Performance and Design - John D. Anderson
- Flight stability and automatic control, Robert C. Nelson
- Airframe stress analysis and sizing – Michael Chun-Yung Niu
- Aircraft Structures, T.H.G. MEGSON (4th Edition)
- https://docs.px4.io/master/en/concept/ (Ty Audronis , Designing Purpose-Built Drones for Ardupilot Pixhawk 2.1: Build drones with Ardupilot)

APPENDIX A

STATEMENT OF COMPLIANCE

Certification of Qualification

Team Name: _____ Team Number: _____

University/Institute: _____

Faculty Advisor: _____

Faculty Advisor's Email: _____

Statement of Compliance

As Faculty Advisor, I certify that the registered team members are enrolled in collegiate courses. This team has designed the UAV for the SAE AEROTHON 2022 contest, without direct assistance from professional engineers, R/C model experts or pilots, or related professionals.

_____ _____

Signature of Faculty Advisor Date

Team Captain Information:

Team Captain's Name: _____

Team Captain's E-mail: _____

Team Captain's Phone: _____

<u>Note:</u>

A copy of this statement needs to be included in your Design Report as page 2