# The Aeronautical Society of India

## Design Division & Mumbai Branch

## present

# 7th National Aerospace Conceptual Design Competition (NACDeC-VII)

Background:

The Design Division of The Aeronautical Society of India was set up in 2017. It is expected to act as a torch bearer for aerospace design professionals, and to help them scale the professional heights by offering a platform for inter-organizational exchange of ideas, to report professional contributions, to meet, interact and learn from professionals from across the world, and to update and augment professional knowledge.

One of the mandates of the Design Division is to encourage and nurture Aerospace design related activities in the country, especially among the engineering college students, and encourage them to apply their mind to address challenging aerospace design problems that are relevant to the needs of our country. With this in mind, the Design Division, in association with the Mumbai Branch, conducts an annual National Aerospace Conceptual Design Competition (NACDeC) for the students. Six NACDeC

versions have been successfully conducted so far, as per the following details:

| NACDeC | Year | Problem Statement |
|---|---|---|
| I | 2017-18 | Multi-role amphibian aircraft |
| II | 2018-19 | High Altitude UAV for Coastal Aerial Mapping |
| III | 2019-20 | High Altitude Long Endurance Aerial Platform |
| IV | 2020-21 | Inter City Electrical Vertical Take-Off and Landing Aircraft |
| V | 2021-22 | Water Scooping Amphibian Aircraft for Fire Fighting |
| VI | 2022-23 | Vertical Take-off and Landing Autonomous Air Ambulance |

## NACDeC-VII:

We are happy to announce the 7th edition of NACDeC for the academic year 2023-2024, which will involve conceptual design and sizing of a UAV for exploration over Mars. This competition will be open to teams of Undergraduate and/or Postgraduate students from CFTIs, or AICTE approved institutions in India. Each institute can nominate only **one** team consisting of up to 05 (Five) students, **at least two** of which should be from Aeronautical/Aerospace Engineering Department, and one Faculty mentor. The role of the faculty mentor is to liaise with the competition organizers on all policy matters. The faculty mentor is not supposed to carry out any specific tasks related to the project.

## Schedule of activities:

NACDeC-VII will consist of four distinct stages: the synopsis video report, mid-term report, final design report, and the technical presentation in front of a panel of judges. Each stage will require specific tasks to be completed by the participating teams. NACDeC-VII will be conducted as per the following schedule:

| **Stage-I** | | **Stages -II & III** | |
|---|---|---|---|
| **Deadline (2023)** | **Task** | **Deadline (2024)** | **Task** |
| 15th Aug | First announcement of Competition | 15th Feb | Mid-Term Report Submission |
| 07th Sep | Release of Problem Statement | 15th Mar | Shortlisting of teams for Stage-III |
| 05th Oct | Deadline for Team Registration | 15th Jun | Final Report Submission |
| 15th Nov | Submission of Initial Video Report | 15th Jul | Shortlisting of teams for Stage-IV |
| 15th Dec | Shortlisting of teams for Stage-II | 17th Aug | Final Round (Stage-IV) |

## Prizes and Certificates:

The total Prize money of NACDeC-VII is to be decided. The details will be shared on the website.

The members and Faculty mentors of teams who successfully complete Stage-III of the competition will be given participation certificates. Further, the round about travel expenses (limited up to 2 AC Rail fare for the shortest distance) for the outstation teams will be reimbursed from their institutions to the venue of Stage-IV presentation, and suitable accommodation will be provided. No reimbursements will be made for local travel, as well as for Teams who are based locally.

The e-mail address <nacdec.aesi@gmail.com> should be used for all communications and queries related to NACDeC-VII. Emails sent to any other address will be ignored. Members of registered teams will also be added to a dedicated NACDeC WhatsApp group, to enable quick communication. Latest information and updates about NACDeC-VII will be posted on <https://www.nacdec.in/>.

Link for our Social Media handles:

| | | | |
|---|---|---|---|
|  | https://bit.ly/2SUClmk |  | https://bit.ly/310IG4e |
|  | https://bit.ly/2SOdcKj |  | https://bit.ly/3dmiSER |
|  | https://bit.ly/3iP5w52 |  | https://www.nacdec.in/ |

## Problem Statement:

The problem statement for NACDeC-VII is listed vide Appendix-I.

## Webinars:

Regular online webinars will be conducted via ZOOM platform on various aspects related to the topic of NACDeC-VII. The aim of these webinars is to clarify any doubts that the teams may have related to the rules and regulations of NACDeC-VII, mission requirements, or to seek information and guidance on carrying out the various tasks by experts who will conduct them. A team of volunteers and experts lead by the Convener of NACDeC-VII will conduct the

Webinars, and carry out an evaluation of the initial concepts, shortlisting of the teams for the final presentation, and declaration of the winners. The decisions of the NACDeC-VII organizing committee will be final and binding on all the competitor teams, and no objections will be entertained.

## Evaluation Criteria:

The detailed evaluation Criteria for each stage of NACDeC-VII is listed vide Appendix-II.

## Organizing Committee:

Patron: Dr. Kota Harinarayana, Chairman, Design Division, Aeronautical Society of India

Convener: Dr. Rajkumar S. Pant, Professor, Aerospace Engineering Department, IIT Bombay

Members:

- Dr. Pankaj Priyadarshi, Group Director, ADSG, Aeronautics Entity, VSSC Thiruvananthapuram
- Dr. Abhishek, Professor, Department of Aerospace Engineering, IIT Kanpur
- Ms. Prachi Magar, Assistant Professor, Thakur Shyamnarayan Degree College, Mumbai
- Mr. Pranav Gupta, Project Research Associate, IIT Bombay

Volunteers:

- Mr. Nouman Uddin, IIST, Thiruvananthapuram
- Mr. Ajit Chetry, ADA, Bengaluru
- Ms. Tanishka Mourya, Parul University, Vadodara
- Mr. Vivek S. Maleppanavar, IIT Kanpur

Appendix-I

## Request for Proposal (RFP) for

# Unmanned Aerial Vehicle for Martian Exploration

### Background

Exploration fulfils human curiosity to find answers to the mysteries of science present in the Universe. Exploration isn't just about satisfying curiosity; it is an essential step to broaden the horizons of understanding for mankind. Exploring Space challenges Engineers and Scientists to develop innovative technology and new methods for conquering these problems efficiently and cost effectively.

Mars, the red planet, has been a high priority for space exploration for several decades and many space agencies worldwide have launched various Orbiters, Landers, Rovers, and Probes to Mars in order to understand its atmosphere, geology, and composition. The unmanned robotic missions having proved their worth at exploring Mars while enduring the harsh atmosphere and radiation doses. The robotic exploration is providing significant insight through research and technology development to eventually support human settlement on Mars. The *Opportunity* and *Spirit* Rovers have paved the way for developing technology to send complex systems to conduct various experiments on Mars. On the other hand, Orbiters have mapped the local terrain with great precision that helps scientists to plan future missions with advanced mission objectives. Even after using ground-based exploration methods on Mars, there have been several limitations such as limited range, obstacles, and rough terrain and limitations in characterizing the thin Mars atmosphere. Thus, there exists a technological gap for such systems inhibiting the exploration of Mars in a major way.

This technological gap may be addressed with the use of Unmanned Aerial Vehicles (UAVs) near the surface of Mars which are capable of traversing long distances and fly near the surface to obtain very precise measurements at the same time complementing the use of Landers, Orbiters, and Rovers. Unmanned Aerial Vehicle observations can provide insights to a new perspective for scientific discovery which would have the ability to survey scientifically inaccessible or hazardous to Rovers and Landers.

## Scope and Outcome:

NACDeC-VII competition is focused on conceptual design and sizing of a Martian Unmanned Aerial Vehicle (UAV) intended for conducting atmospheric exploration missions in close proximity to the planet's surface. This project aims to identify feasible UAV design by considering various configurations and leveraging available technologies.

## Mission Objectives

The primary mission goal of the Martian Unmanned Aerial Vehicle (UAV) entails achieving repeated ascents to an altitude of 100 meters, facilitating the comprehensive exploration of the lower stratum of the Martian boundary layer. Participating teams are tasked with formulating a mission profile tailored to their UAV design, with a key emphasis on optimizing both flight endurance and operational frequency while operating within the specified constraints.

The exploration of the Martian boundary layer in the close vicinity top the planet's surface holds immense importance due to its role in the planet's atmospheric dynamics. Similar to Earth, this layer affects climate patterns and particle distribution on Mars. The UAV's capabilities enable the collection of essential data on temperature, pressure, and wind dynamics, shedding light on intricate atmospheric processes. The chosen altitude of 100 m for the UAV is influenced by factors like terrain and daily variations, enhancing the mission's significance.

The UAV should be capable of performing multiple flights in a Martian day (i.e., sol); the only requirement being that it should traverse from ground level to 100 m AGL and back in each flight. The Martian UAV's flight operations should commence sometime after sunrise and conclude before sunset, and aim for maximum number of daily traverses, using solar energy to recharge its batteries. The ascent and descent segments need not be in perfectly vertical mode. The design proposal should emphasize the total duration of flight time available during the day for exploration of the boundary layer in 100 m AGL of Mars.

## Mission Requirements

| Parameter | Value |
|---|---|
| All up Mass of UAV | ≤ 70 kg |
| Payload Mass | ≥ 5 kg |
| Modularity | Stowed inside an aeroshell diameter of 2.5 m |
| Waiting period between two flights (after recharging the battery) | 100 s |

## Constant Parameters

| Parameter | Value |
|---|---|
| Battery Energy Density | 650 kJ/kg |
| Peak Irradiance (at an altitude of 100 m) on Mars | 586.2 $W/m^2$ |
| Irradiance attenuation factor at 100 m altitude | 0.70 |
| Length of Solar day on Mars | 12 hours 40 minutes |
| Acceleration due to gravity on Mars | 3.72 $m/s^2$ |
| Solar Panel Efficiency | 17 % |
| Reserve Battery power fraction in each flight | 25 % |
| Battery health management system mass fraction | 10 % |
| Stowage system Mass Fraction | 10 % |
| Avionics system mass fraction | 05 % |

## List of tasks to be carried out in each Stage

### Stage-I: Initial Video Report

S-1: Survey of Literature of existing UAVs for Mars exploration

S-2: Study of properties of Martian Reference Atmosphere

S-3: Creation of Irradiance model on Mars

S-4: Identification of promising UAV configurations

S-5: Identification of key design challenges

S-6: Proposed plan of action for remaining Stages

Stage-II: Mid Term Report

M-1: Finalizing the Mission Profile

M-2: Development of the sizing methodology for each configuration

M-3: Determination of Aerodynamic parameters

M-4: Propulsion system sizing & Energy balance

M-5: Vehicle sizing and Mass breakdown

M-6: Identification of stowage concepts for UAV

Stage-III: Final Design Report

F-1: Shortlisting of final design configuration

F-2: Creation of 3D CAD model of UAV in an opensource program (e.g., *OpenVSP*)

F-3: Structural design of various UAV subsystems

F-4: Determination of number of sorties possible in one sol

F-5: Study of Entry, Descent & Landing (EDL) approaches

F-6: Sensitivity studies of key design parameters

Appendix-II

# Evaluation Criteria for NACDeC-VII

This competition will be conducted in three stages as outlined below. At each stage, the Teams will be evaluated, and shortlisted for the next stage.

## Stage-I

The evaluation of this Stage is to check if the teams have carried out sufficient literature survey and background study about the type of vehicle being designed, identified the critical requirements and desirable features, and have a clear-cut roadmap for the tasks to be done in the next stage. During this stage, each team is required to prepare and submit a concise and informative Initial Video Report (IVR) that presents an overview of their project. The video should highlight the project's objectives, proposed approach, and anticipated outcomes. It should be professionally crafted and effectively communicate the team's vision to execute the goals of the problem statement.

## Stage-II

Teams must submit a comprehensive mid-term report (MTR) that demonstrates their progress and achievements up to the midway point of the competition. The report should include a detailed analysis of the project's development and the solutions implemented. Technical specifications, design considerations, and initial results should also be presented in the mid-term report.

## Stage-III

In this phase, shortlisted teams are required to provide a detailed and exhaustive final design report (FDR) that encompasses all aspects of their project. The report should cover the final design of the solution, including technical schematics, system architecture, algorithms, and software implementation details. It should contain a Design & Performance Data Sheet, mentioning values of all the important design and performance parameters in a single table. Additionally, a thorough analysis of the project's performance, testing methodologies, and validation results should be included in the final design report.

The evaluation criteria for Stage-II and Stage-III is as follows:

A. Technical Content (40 points)

- Does the submitted design meet RFP requirements?
- Are the assumptions clearly stated and logical?
- Does the team have a thorough understanding of the analysis tools used?
- Are all major technical issues and points considered in the analyses?
- Have proper trade studies been performed during the design process?
- Are all important systems and sub-systems properly elaborated?
- Are all technical drawings clear, descriptive, and represent a feasible design?

B. Application & Feasibility (25 points)

- Is there a proper justification and substantiation of all technologies proposed?
- Are critical technological issues appropriately emphasized?
- Have affordability considerations influenced the design process?
- Have safety, reliability and maintainability features been incorporated in the design?
- Have the materials and manufacturability constraints been considered in the design process?
- Have the operational issues adequately addressed in the final design?

C. Originality (20 points)

- Does the concept demonstrate originality and aesthetics?
- Does the proposed concept contain innovative solutions to address the problems?

D. Organization & Presentation (15 points)

- Does the report meet all format and content requirements?
- Is the Executive Summary self-contained, and does it contain all the pertinent information?
- Is the report well organized and information readily accessible and in a logical sequence?
- Does the report contain clear and uncluttered graphs and drawings?

## Report Format and Lengths

The reports must be submitted in PDF readable with Adobe Acrobat, and follow these guidelines:

- Mid Term Report shall be no more than 50 pages
- Final Design Report shall be no more than 100 pages
- All pages are to be numbered
- Page count includes all Figures, Diagrams, Drawings, and Appendices
- Pages shall be standard A4
- Use of 12-point font with 1.5 line spacing
- If a submission exceeds the page limit for its category, the judges will apply a penalty of one mark per page over the limit.