

## Introduction

Micro Air Vehicle (MAV) has attracted considerable attention during recent years due to their unique operational capabilities. Understanding of MAV aerodynamic characteristics is significant for the improvement of their performance. Obtaining reliable and accurate experimental data is challenging due to a number of factors such as the low Reynolds number flight regime, small size with low aspect ratio, large propellers slipstream, gust environment, light weight and flexible airframes etc.

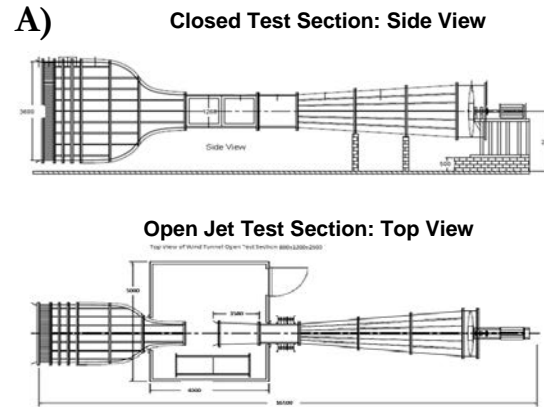
Wind tunnel testing has an important role to play in the development of mission-capable MAVs with high endurance. Micro air vehicle Aerodynamics Research Tunnel (MART) at CSIR-NAL is being established to meet all the special requirements for MAV studies. Some of the features of this low speed, suction type closed test section low turbulence wind tunnel include open jet test section with a large Betz chamber and active gust generation mechanism.

The open test section has the advantage of having no boundary layer effects and reflections due to wall during flapping/rotary wing studies. The Betz chamber helps in maintaining the static pressure in the open jet test section. It also helps in recording the flight trajectory of insects, butterflies, dragonflies etc. under varying gust conditions. The active gust generation mechanism consists of oscillatory vanes to generate sinusoidal variation in the tunnel flow velocity at different frequencies.

For studies involving measurements of unsteady low loads, 3-D deformation on flexible/flapping wings and propulsive models, highly specialized instrumentation is being developed; these include high precision low-load balances, LDV, time resolved stereo PIV, Digital Image Correlation (DIC) and NI-based wireless data acquisition systems.

The facility and the advanced instrumentation is funded by AR&DB under the National Program on Micro Air Vehicle (NP-MICAV). This wind tunnel is the first of its kind in India and is being made available to all the projects under NP-MICAV and other research organizations, academic institutions, industries to carry out research and development in MAVs.

## Facility Features



### B) Geometrical Specification

Type	Open Circuit, Suction
Contraction Ratio	9:1
Test Section	Closed: 0.8 m x 1.2 m x 2.5 m Open Jet: 0.8 m x 1.2 m x 1.0 m
Diffuser	6 m long, Circular Shape
Entry Section	Bell Shape, Fineness ratio 8
Honeycomb & Screen	Square cells with high aspect ratio, 3 Nos. (0.2 mm X 1 mm: 1, 0.2 mm X 0.8 mm: 2 )
Overall length	17 m
Fan & Motor	12 bladed (FRP) Belt driven, 45 kW, 1450 RPM

### C) Flow Characteristics

Velocity Range	Closed Test Section: 1 m/s to 45 m/s Open Test Section: 1 m/s to 25 m/s
Mean Flow Velocity Variation	$\pm 0.1\%$
Turbulence Intensity	Up to 10 m/s : $< 0.1\%$ 10 m/s to 45 m/s : $< 0.15\%$

## Performance Parameters

**Maximum Reynolds number:** Up to 600,000 based on airfoil chord of 200 mm

**Model Blockage:** Less than 6 % based on airfoil chord of 200 mm at incidence of  $20^\circ$

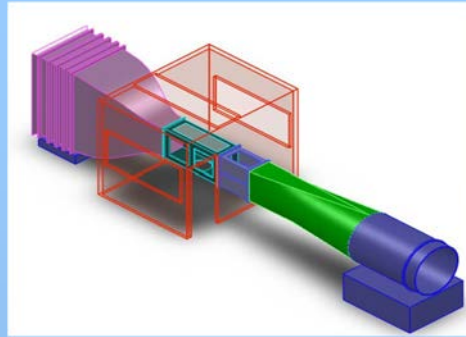
**Model orientation:** Pitch of  $-20$  to  $40^\circ$ , yaw of  $-15$  to  $15^\circ$ , roll of  $-180$  to  $180^\circ$

## Instrumentation

- Automated Controls and Data Acquisition:** Fully automated controls with latest National Instruments hardware and LabVIEW software.
- Model Mounting and Positioning System:** Automated 2D/3D model positioning for pitch, yaw and roll.
- Test Section Traverse System:** Motorized 2D traverse system for probe traversing.
- Force/Moment Measurements:** Six component sting balance, load cells, floor mounted balance, low load balance.
- Pressure Measurements:** ESP Scanners, Furness Control digital Micro-manometer, Setra differential pressure transducer.
- Turbulence Measurements:** Dantec CTA system.
- Advanced Flow Diagnostic Tools:** MSE Laser Doppler Velocimetry (LDV) system, Dantec 2D PIV system, Time Resolved Stereo Particle Image Velocimetry (PIV) and Digital Image Correlation (DIC) systems.
- Flow Visualization:** Smoke wire with laser sheet, illumination source and high speed camera, oil and tuft flow visualization.

## Areas of Research

- **Low Reynolds number flows:** Laminar Separation bubble, Insect aerodynamics
- **Unsteady Aerodynamics:** Flapping / Rotary wings, Vortex dynamics, Gust response
- **Aero-elasticity:** Flexible wings, Fluid structure interaction
- **Propulsion:** Propulsive induced flows
- **Control Surface Effectiveness**
- **Flow Topologies**
- **Flow Control:** Passive /Active control, Closed loop control



Conceptual 3D view of the Closed Test Section with Betz Chamber



Control room

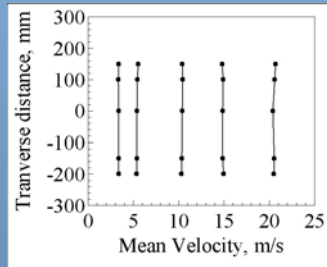


## MAV AERODYNAMICS RESEARCH TUNNEL (MART)

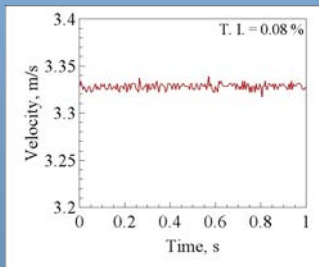
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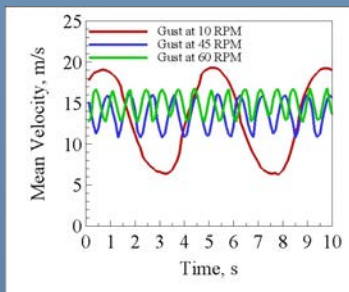
## Flow Quality Data



Flow velocity variation in the test section



Time series plot of velocity



Flow velocity variation with a sinusoidal gust generation

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