CONTACT-BASED AIRSPEED SENSOR

INTRODUCTION

Welcome to Stage 1 of the sensing & signal-conditioning project. You will design and build an embedded, contact-based airspeed sensor that measures 2–10 m s^{-1} and streams results at 200 Hz over 115200 baud to a virtual COM port. Your device must fit inside a 30 × 30 × 30 cm test envelope and mount to the provided mounting plate. Ground truth will be provided by a Dwyer 616KD-LR-B42-BD1 differential-pressure sensor + pitot. This brief follows the same structure you used previously (Intro → Objectives → Environment → Tasks → Deliverables → Assessment).

OVERVIEW AND OBJECTIVES

- **Team Size:** three students per team
- **Core Task:** Estimate instantaneous airspeed (no direction required), including dynamic changes (steps/ramps) between 2–10 m s^{-1}.
- **Primary Hardware:**
    - Nucleo-F411RE (mandatory target)
    - X-NUCLEO-IKS4A1 (IMU + environmental: accel/gyro/mag + baro)
    - SparkFun Qwiic Scale (NAU7802) + 5 kg strain-gauge load-cell
    - TMP36 (analog temperature) and MCP9808 (I^2C temperature) for density compensation
    - Bourns EM14 optical incremental encoder (panel-mount, shafted)
    - Eclipse neodymium magnets (3 mm discs)
    - Allegro through-hole Hall-effect sensor
    - Any Innovation Lab passive/consumable parts (bearings, springs, shields, encoders, resistors, etc.)

Contact-based requirement: The transducer must interact with the air (e.g., cups/vanes moved by flow; plate drag force; pitot tapping pressure; hot-wire; flexible cantilever deflection). Camera/remote methods are reserved for Stage 2.

ENVIRONMENT SETUP

- **Flow source:** High-pressure duct fan providing **2–10 m s^{-1}** at the fixture.
- **Test envelope: 30 × 30 × 30 cm** clear volume; device must attach to the **30 cm square mounting plate**.
- **Ground truth: Dwyer 616KD-LR-B42-BD1 + pitot** sampled at 200 Hz
- **Safety:** Guards around rotating parts; secure magnets with epoxy/heat-shrink; no sharp edges.

- **Dynamic Wind Profiles (ISO 17713-1):**
    - **Step up/down:** 3 → 8 $m \cdot s^{-1}$ (hold), then 8 → 4 $m \cdot s^{-1}$. Use for ISO distance-constant measurement and step metrics.
    - **Linear ramp:** 2 → 10 $m \cdot s^{-1}$ (up to 1 $m \cdot s^{-2}$ gradient), then back down. Use for ramp tracking error/lag.
    - **Gusty block:** Piecewise plateaus with embedded 1–2 s pulses.

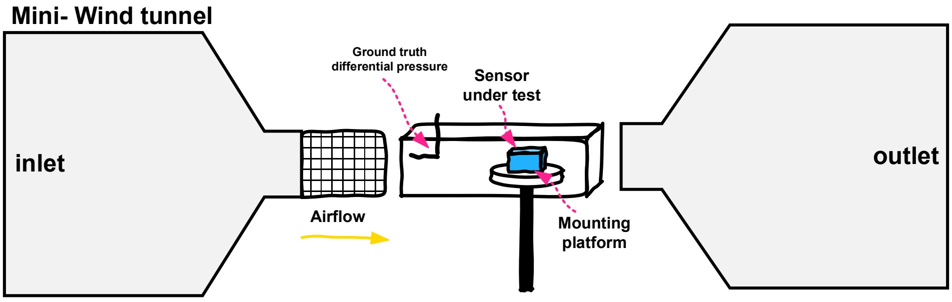

Fig.1: Wind tunnel with sensor test area.

PROJECT TASKS

- Pick a sensing design – You can prototype multiple ideas if you like.
- Using your selected design estimate the velocity using physics, signal processing, sensor fusion or machine learning. The only constraint is that **it needs to run entirely on the Nucleo**. You should calibrate your sensor as needed.
- Output your velocity estimate at 200 Hz, by sending a floating-point value via a virtual serial port (baud 115200) over USB. This will be read by the Python script to compare your sensor values to the ground truth.

DELIVERABLES

- **Live demo (30 Oct):** Device mounted on plate; real-time 200 Hz stream; calibration file on demand.
- **Code submission:** Buildable CubeIDE/PlatformIO project → no PC-side processing.
- **6-page IEEE-style report (due 4 Nov at 17:00):** design rationale, modelling, calibration method, error budget, dynamic results (MSE, bias, σ), limitations, and originality (creative mechanics/filtering rewarded). Template/guidance to follow.

ASSESSMENT

- **Practical Performance (70%)**
    - Accuracy rank (MSE)
    - Meets 200 Hz/115200 streaming without drops
- **Report (30%)**
    - Clarity & depth; correct modeling/calibration; quality of experiments/plots
    - Originality/creativity of mechanical transducer and/or embedded processing

Good luck! 😊