Drone IMU

Subsystem Specification

Example

Project:	DRONE-IMU
Document:	SSS
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This document is an example Subsystem Specification (SSS) for the inertial measurement unit (IMU) of a small unmanned aerial vehicle. It captures requirements across the software, electronics, and mechanical disciplines and is intended to demonstrate end-to-end requirements traceability from user needs to requirements, tests, and architecture.

Note: This is an example document, which is not complete.

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Revision History

Name	Date	Reason For Changes	Version
T. Stark	May 14, 2026	Initial export of Drone IMU Subsystem Specification from J.A.R.V.I.S. v4.2	1
O. Stane	June 30, 2026	Added electrical and PCB requirements	2
P. Potts	July 24, 2026	Update of mechanical and safety sections	3

1. Introduction

1.1 Purpose

The main purpose of this document is to specify the functional, software, electrical, and mechanical requirements for the inertial measurement unit (IMU) subsystem of a small multirotor unmanned aerial vehicle (UAV).

Note: This is an example document, which is not complete.

1.2 Scope

This document specifies requirements for the IMU subsystem that provides inertial sensing and attitude estimation to the flight control computer of the drone. It covers the subsystem across the software, electronics, and mechanical disciplines, including printed circuit board (PCB) design constraints.

The IMU subsystem is responsible for:

- Measuring three-axis linear acceleration, angular rate, and magnetic field
- Estimating the orientation of the drone body frame
- Compensating measurements for temperature and calibration errors
- Streaming time-stamped measurement data to the flight controller
- Reporting subsystem health and fault conditions

The IMU operates as an embedded subsystem and does not provide a direct user interface.

1.3 Subsystem overview

1.3.1 Context and interfaces

The IMU is mounted on the drone airframe and communicates with the flight control computer over a digital serial interface. It receives regulated power from the vehicle power distribution board. The subsystem consists of a sensor and processor PCB assembly housed in a machined enclosure.

1.3.2 Operating modes

The IMU subsystem supports the following operating modes: initialization, self-test, normal measurement, and fault (safe state).

1.4 Assumptions and dependencies

It is assumed that the IMU is rigidly mounted to the airframe and that the mounting location has been characterized for vibration during vehicle integration.

1.5 Definitions

Subsystem: The IMU hardware and software assembly delivering inertial sensing and attitude estimation to the flight control computer.

Body frame: The right-handed coordinate frame fixed to the drone airframe, with the X axis pointing forward, the Y axis to the right, and the Z axis downward.

Attitude: The orientation of the drone body frame relative to the local navigation frame, expressed as roll, pitch, and yaw or as a unit quaternion.

Bias: A constant or slowly varying offset in a sensor measurement in the absence of the measured quantity.

In-run bias stability: A measure of how much a sensor bias drifts over time while the sensor operates at a constant temperature.

1.6 Acronyms and abbreviations

DAL	Design Assurance Level
ESD	Electrostatic Discharge
IMU	Inertial Measurement Unit
I2C	Inter-Integrated Circuit
MTBF	Mean Time Between Failures
NVM	Non-Volatile Memory
PCB	Printed Circuit Board
RMS	Root Mean Square
SPI	Serial Peripheral Interface
SSS	Subsystem Specification
UART	Universal Asynchronous Receiver-Transmitter
UAV	Unmanned Aerial Vehicle

2. Requirements

2.1 Functional requirements

[IMU-FUN-3] The IMU shall measure three-axis linear acceleration along the X, Y, and Z body axes.

[IMU-FUN-6] The IMU shall measure three-axis angular rate about the X, Y, and Z body axes.

[IMU-FUN-9] The IMU shall measure the three-axis magnetic field strength for heading estimation.

[IMU-FUN-12] The IMU shall output the estimated orientation of the drone body frame as a normalized unit quaternion.

[IMU-FUN-15] The IMU shall report subsystem health and fault status to the host.

2.2 Software requirements

[IMU-SW-2] The IMU software shall estimate the drone attitude by fusing accelerometer, gyroscope, and magnetometer measurements.

[IMU-SW-5] The IMU software shall apply factory calibration for accelerometer and gyroscope bias, scale factor, and axis misalignment.

[IMU-SW-8] The IMU software shall apply temperature compensation to accelerometer and gyroscope measurements across the operating temperature range.

[IMU-SW-11] The IMU software shall allow the host to trigger a gyroscope bias re-calibration while the drone is stationary.

[IMU-SW-14] The IMU software shall allow the host to configure the measurement output data rate.

[IMU-SW-17] The IMU software shall perform a power-on self-test verifying the functionality of each sensor.

[IMU-SW-21] The IMU software shall store calibration and configuration parameters in non-volatile memory.

[IMU-SW-24] The IMU software shall support firmware update over the UART interface with integrity verification of the received image.

2.3 Electrical requirements

2.3.1 Power

[IMU-EL-2] The IMU shall operate from a single regulated 3.3 V DC supply with a tolerance of ±5%.

[IMU-EL-4] The IMU shall consume no more than 250 mW during normal operation.

[IMU-EL-6] The IMU supply input shall be protected against reverse polarity.

2.3.2 Signal interfaces

[IMU-EL-9] The IMU shall provide an SPI interface operating at a clock rate of up to 10 MHz for measurement data output.

[IMU-EL-11] The IMU shall provide an I2C interface operating at up to 400 kHz as an alternative to the SPI interface.

[IMU-EL-13] The IMU shall provide a UART interface for configuration and diagnostics.

[IMU-EL-15] The IMU shall provide a dedicated data-ready interrupt output signal.

[IMU-EL-18] The external interface pins of the IMU shall withstand ±8 kV contact discharge in accordance with IEC 61000-4-2.

2.4 PCB requirements

[IMU-PCB-2] The IMU PCB shall be a 4-layer FR-4 board with a continuous internal ground plane beneath the inertial sensor.

[IMU-PCB-4] The IMU PCB outline shall not exceed 20 mm × 20 mm.

[IMU-PCB-6] The inertial sensor shall be placed within 1 mm of the PCB geometric center to minimize lever-arm effects.

[IMU-PCB-8] No component dissipating more than 100 mW shall be placed within 5 mm of the inertial sensor, in order to limit local thermal gradients.

[IMU-PCB-11] The IMU PCB assembly shall be manufactured and inspected to IPC-A-610 Class 3.

[IMU-PCB-13] The IMU PCB assembly shall be conformally coated after assembly and test.

[IMU-PCB-15] The IMU PCB shall provide test points for each supply rail and for the primary interface signals.

2.5 Mechanical requirements

[IMU-ME-3] The IMU enclosure shall not exceed 25 mm × 25 mm × 10 mm.

[IMU-ME-5] The IMU subsystem mass shall not exceed 15 g.

[IMU-ME-7] The IMU shall provide four M2 mounting holes arranged on an 18 mm × 18 mm rectangular pattern.

[IMU-ME-9] The IMU body coordinate frame shall be aligned to the mounting datum features within 0.5°.

[IMU-ME-12] The IMU enclosure shall provide IP54 ingress protection.

2.6 Performance requirements

[IMU-PERF-2] The IMU shall sample the accelerometer and gyroscope at a rate of at least 1 kHz.

[IMU-PERF-4] The IMU shall output a measurement sample within 2 ms of its acquisition.

[IMU-PERF-6] The gyroscope in-run bias stability shall be better than 10 °/h.

[IMU-PERF-8] The accelerometer noise density shall not exceed 150 µg/√Hz.

[IMU-PERF-11] The attitude estimate error shall not exceed 1° RMS in roll and pitch under steady-state hover conditions.

2.7 Environmental requirements

[IMU-ENV-2] The IMU shall operate over an ambient temperature range of -40 °C to +85 °C.

[IMU-ENV-4] The IMU shall withstand vibration up to 10 g RMS in the 20 Hz to 2000 Hz band in accordance with MIL-STD-810.

[IMU-ENV-6] The IMU shall survive a 40 g, 11 ms half-sine mechanical shock without damage.

2.8 Safety and reliability

[IMU-SAF-2] The IMU shall enter a defined safe state and assert a fault signal upon detection of an unrecoverable internal error.

[IMU-SAF-4] The IMU shall include an independent watchdog that resets the subsystem if the software fails to service it within the configured interval.

[IMU-SAF-6] The IMU shall have a predicted MTBF of at least 50,000 hours at 25 °C.

2.9 Standards compliance

[IMU-STD-2] The IMU software shall be developed in compliance with DO-178C at Design Assurance Level D.

[IMU-STD-4] The IMU PCB shall be designed in accordance with IPC-2221.

[IMU-STD-6] The IMU shall be environmentally qualified in accordance with MIL-STD-810G.

3. Verification

Verification activities are specified in the [DRONE-IMU-TESTS] document.

4. Supporting information

5. References

[DRONE-IMU-SRS]: Drone IMU Software Requirements Specification

[DRONE-IMU-ICD]: Drone IMU Interface Control Document

[DRONE-IMU-TESTS]: Drone IMU Verification Tests