# NEA Scout IMU Test

# IMU Test Setup

The IMU tests were conducted in the Guidance, Navigation, and Control Laboratory facility at the NASA-Marshall Space Flight Center, Huntsville, AL. The test utilized the facility’s Contraves Goerz Corp. high precision three-axis rotational rate table. The three-axis rotational rate table is vibrationally isolated from the building by resting on an independent concrete foundation that is separate from the building’s foundation. The rate table allows the user to program angular rates of up to ±200°/sec for each axis, with an angular rate precision of ±0.00001°/sec.

To test the Sensonor STIM 300 IMU, a custom mounting plate was fabricated by 3D printing to allow the device to be mounted to the center of the rate table. After mounting the device, the appropriate electrical connections were made. In order to communicate with the IMU, a special RS-422 to USB cable was purchased from Sensonor. The USB-RS422 converter cable is a USB to RS-422 levels serial UART converter cable, incorporating FTDI’s (Future Technology Devices International) FT232RQ USB to serial UART interface IC device that handles all the USB signaling and protocols [3]. The cable provides a fast, simple way to connect the IMU module with a RS422 interface to USB. The cable provides both communication and power from a connected laptop that is secured to the top of the rate table. Data were captured and stored using the Sensonor STIM 300 EVK software which allows the user to configure the IMU as well as graphically display gyroscope, accelerometer, and inclinometer data and export the raw data as a text file.

To measure the performance characteristics of the IMU under rotational rates similar to those that will be encountered during the NEA Scout mission, several tests were designed. For each test, carried out in ambient conditions, the IMU was configured to collect gyroscope, accelerometer, and inclinometer data for each axis. To measure the IMU bias, two tests were performed. First, the device was placed on a non-rotating rate table and data were collected from the IMU for 10 seconds, after which the IMU’s power was cycled off and then on. Another bias test was performed for a one hour duration. Subsequent testing measured the run-to-run bias repeatability.

The testing matrix, shown in Table 1, describes the battery of tests that was designed, and each test’s current status. It includes tests for bias, run-to-run bias repeatability, and IMU sensitivity at slew rates that will be experienced on the NEA Scout spacecraft. Additional tests were also designed to measure the IMU’s performance characteristics during multi-axis rotations.

Table 1. **Sensonor STIM 300 IMU Test Matrix**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Test Name** | **Roll (°/sec)** | **Pitch (°/sec)** | **Yaw (°/sec)** | **Description** | **Status** |
| Bias Offset | 0 | 0 | 0 | Measure initial bias offset. Two test were run one for 10 seconds and the other for an hour. | Completed |
| Run-to-Run Bias: Power cycle IMU | 0 | 0 | 0 | Measure run-to-run bias offset | Completed |
| Detumble – Roll | ±10 | 0 | 0 | Measure IMU performance at tumbling rate. | Completed |
| Detumble – Pitch | 0 | ±10 | 0 | Completed |
| Detumble – Yaw | 0 | 0 | ±10 | Completed |
| Min slew rate – Roll | 0.01 | 0 | 0 | Measure IMU performance at the minimum slew rate. | Completed |
| Min slew rate – Pitch | 0 | 0.01 | 0 | Completed |
| Min slew rate – Yaw | 0 | 0 | 0.01 | Completed |
| Max slew rate before sail deployment – Roll | 1 | 0 | 0 | Measure IMU performance at the maximum slew rate prior to solar sail deployment. | Completed |
| Max slew rate before sail deployment –Pitch | 0 | 1 | 0 | Completed |
| Max slew rate before sail deployment–Yaw | 0 | 0 | 1 | Completed |
| Max slew rate with sail deployed – Roll | 0.04 | 0 | 0 | Measure IMU performance at the maximum slew rate with the solar sail deployed. | Completed |
| Max slew rate with sail deployed – Pitch | 0 | 0.04 | 0 | Completed |
| Max slew rate with sail deployed – Yaw | 0 | 0 | 0.04 | Completed |
| Min rate for navigational stability – Roll | 0.0001 | 0 | 0 | Measure IMU performance at the minimum slew rate for navigational stability. | Pending |
| Min rate for navigational stability – Pitch | 0 | 0.0001 | 0 | Pending |
| Min rate for navigational stability – Yaw | 0 | 0 | 0.0001 | Pending |
| Multi-axis rotation performance–Roll+Pitch | 10 | 10 | 0 | Measure IMU performance during multi-axis rotation at detumble rotational rates. | Pending |
| Multi-axis rotation performance–Roll+Yaw | 10 | 0 | 10 | Pending |
| Multi-axis rotation performance Pitch+Yaw | 0 | 10 | 10 | Pending |
| Multi-axis rotation perf. – Roll+Pitch+Yaw | ±10 | ±10 | ±10 | Pending |

To perform this test, the IMU was power cycled and data was taken on the stationary rate table for 10 seconds after the system was rebooted (note the STIM 300 reboot time specification is 0.3 seconds). This test was repeated twenty times in order to obtain an adequate sample size to measure run-to-run bias repeatability. Additional tests were designed to measure the IMU’s sensitivity at the minimum and maximum slew rates for the spacecraft in different configurations: solar sail stowed versus deployed. Further tests were also designed to test the IMU’s performance during multi-axis rotation.

As designated in the right-hand column of Table 1, many of the planned tests were completed. However, due to a critical malfunction of the rate table, not all of the proposed tests were completed. The authors plan to complete the remainder of the testing once the rate table is functional again. According to the point-of-contact for the lab, the timeline for repair may be several months.