DATASHEET

spirent
Federal Systems

Spirent SimINERTIAL

Integrated GNSS and Inertial Testing

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About This Document

This document describes the functionality of SimINERTIAL for Spirent's PNT X and GSS9000 simulators. The full issue of this document forms the basis of any equipment procurement contract for a SimINERTIAL system and should be read in conjunction with the relevant signal generator product specification in Referenced Documents. Northrop Grumman and Honeywell products typically have a number of variants. Compatibility with the SimINERTIAL package must be verified before contract acceptance. Some information on supported variants is contained in this document. However, in all cases, please contact your Spirent representative before ordering to confirm compatibility.

> **NOTE**:
> Supported configurations are often complex. Please contact your Spirent Federal representative for guidance and to confirm the appropriate configuration.

Overview

SimINERTIAL enables realistic performance testing of integrated global navigation satellite system (GNSS) and inertial navigation systems (INS) in the lab with a Spirent PNT X positioning, navigation, and timing (PNT) simulator. With SimINERTIAL, this solution provides real-time emulation of inertial sensor outputs, with all inertial and GNSS signals coherently generated to match the simulated vehicle trajectory. SimINERTIAL is also compatible with Spirent's GSS9000 simulator.

The unit under test (UUT) can be:

- An **embedded GPS/INS (EGI)**, also known as an integrated GNSS/INS (IGI): SimINERTIAL can stimulate the inertial test inputs of several types of supported EGI navigation sensors. It allows you to dynamically test EGIs in the laboratory in terms of generation of an inertial-only, GNSS-only, or blended GNSS/inertial solution.
- A **sensor fusion or positioning engine**: SimINERTIAL can emulate the presence of an inertial measurement unit (IMU) for GNSS receiver systems to be tested while being aided or assisted by data from an emulated IMU.

In all cases, the inertial sensors (accelerometers and gyroscopes) are NOT physically stimulated. SimINERTIAL provides a substitute for the inertial sensor outputs that is compatible with the particular test interfaces that are supported.

For applications requiring provision of an independent altitude reference, Spirent's **SimBARO** option offers a source of barometric pressure altitude as a 1553B remote terminal.

SimINERTIAL Controller

SimINERTIAL is a Microsoft® Windows®-based application that runs on a SimINERTIAL controller. The SimINERTIAL controller receives INS aiding data as UDP data packets from Spirent's SimGEN® simulator control software and converts these to delta-theta and delta-velocities at the specified sensor update rate. SimINERTIAL also applies gravitational effects and error models to the delta- data and then, at the correct time, transmits the data to the UUT.

Depending on your system, the SimINERTIAL controller can be either a C50 X (for a system using the PNT X signal generator) or a C50r (for a system using the GSS9000 signal generator).

SimINERTIAL can achieve a 1 kHz update rate when running in concert with a PNT X, SimGEN, and the attendant C50 X host controller.

> **NOTE**:
> SimINERTIAL for Honeywell ISRS2 (and variants thereof) requires an ISRS2 card, which must be hosted in a separate expansion box.

Supported EGIs and IMUs

The inertial data interface of an EGI or an IMU is not standardized and specific to the EGI or IMU model. Often, one model can have multiple variants, each with a different inertial interface. The inertial interface of an EGI or an IMU is usually described in an interface control document (ICD), published by the vendor. As such, SimINERTIAL is licensed and configured to work with a specific EGI or IMU. A wide range of devices is supported, as shown in Table 1 on the following page.

New SimINERTIAL variants can be added in many cases. The architecture of SimINERTIAL is designed to be flexible and support additional products as required. If the variant you are interested in is not listed, please contact Spirent Federal for more information.

All SimINERTIAL variants for Northrop Grumman are only available to customers in the USA. Customers outside the USA will require specific authorization for all variants with the exception of NATO STANAG 4572 Open Standard Architecture and Collins Aerospace (AIS) variants. As such, orders for Northrop Grumman EGI variants are ONLY accepted as agreed Tailored Solutions to ensure compatibility and scope.

Many of these systems have differing variants and interface specifications. Please contact your Spirent Federal representative to ensure support for your specific systems / variants and for the appropriate Spirent part number(s) to order.

Table 1: SimINERTIAL Currently Supported Inertial Types

Inertial Supplier	Product Supported	Type	Variants Supported (if applicable)
Northrop Grumman	LN-100G[1]	EGI	
Northrop Grumman	LN-250/LN-251[1,2]	EGI	LN-351
Northrop Grumman	LN-260[1]	EGI	
Northrop Grumman	LN-200 SDLC	IMU	
Honeywell	H-764G & SIGI[1,3]	EGI	
Honeywell	Nav100™[3]	IMU	
Honeywell	HG-9900[3]	IMU	
Honeywell	HG-1700 SDLC	IMU	AG58, AG59, AG60 HG-1900, HG-1930, HG-9848
Honeywell	HG-1700 AMRAAM	IMU	AG43, AG70, AG71, AG72, AG73, AG74
Collins Aerospace	SiIMU02	IMU	
Collins Aerospace	SiNAV	IMU	
Safran (Sensonor)	STIM300[4]	IMU	
NATO	StanAg 4572		

Important Notes:

- For customers in the USA, bundles of SimINERTIAL capability are offered.
- Spirent is not at liberty to supply any underlying ICDs. It is the customer's responsibility to make sure they obtain the required information from the specific vendor or organization.

[1] Normally requires SimBARO option for INS-only operation.

[2] LN250/1 normally requires an RS422 interface to control test mode and to capture data.

[3] Requires ISRS2. ISRS2 can be sourced from Honeywell or, if required, supplied by Spirent.

[4] Currently only accepted as Tailored Solution.

SimINERTIAL System

SimINERTIAL delivers simulated inertial sensor data for the system under test. A range of data interface types and protocols are supported, relevant to the application. The following figure shows the SimINERTIAL window.

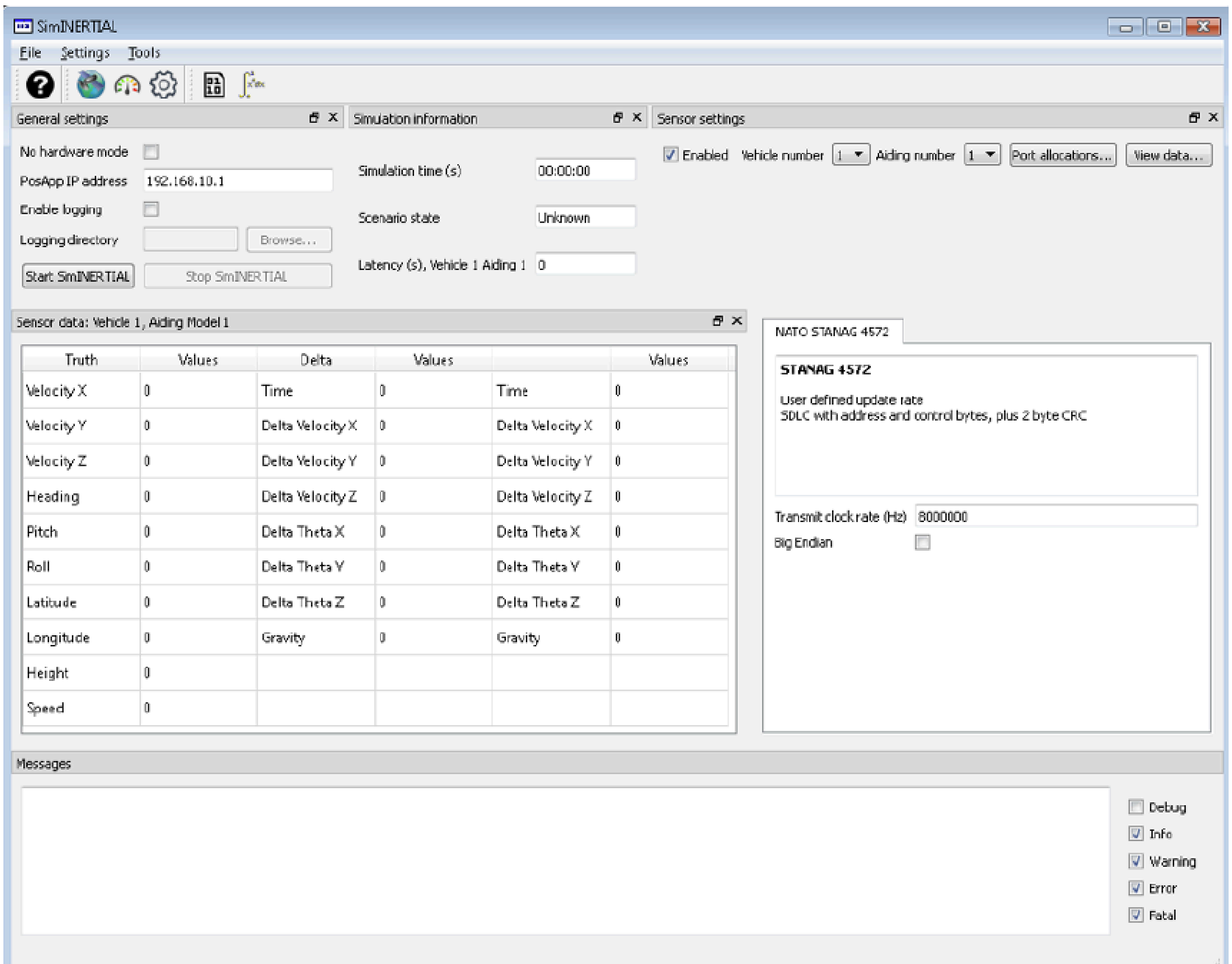

Figure 1: SimINERTIAL application

Inertial Sensor Data Sources

SimINERTIAL runs on its own controller and accesses truth data relating to the simulated motion and orientation of the vehicle from the GNSS simulator via SimGEN's data streaming function. This data could represent the output of one of SimGEN's vehicle models or externally supplied data.

SimINERTIAL is able to derive from the truth data the appropriate accumulated values for the simulated inertial sensor output data. The inertial sensors are typically accelerometers and gyros.

All data generated are fully synchronous and coherent with the GNSS signal provided by the GNSS simulator.

Delta-V

Accelerometers detect changes in vehicle velocity in three orthogonal physical axes. These axes can be aligned with the natural body frame of the host vehicle. Where they are not aligned, their contributions can be translated into the body frame.

In the test environment, simulated vehicle motion is usually referred to the body frame, and SimINERTIAL makes the translation to the sensor frame. This is normally referred to as the 'delta-v' or δv data.

Delta-Theta

Gyroscopes or gyros detect changes in the orientation or attitude of a moving vehicle. As with acceleration sensors, gyros are usually organized around three orthogonal axes, and translation to body axes may again be performed through SimINERTIAL. This is normally referred to as the 'delta-theta' or $\delta\theta$ data.

Barometric Pressure Input

Many EGIs require an altitude reference data input when operating in INS-only mode as a way to damp down the vertical plane errors inherent within inertial systems. The independent altitude reference is usually derived from barometric correction data provided by a barometric pressure altimeter (Baro) via a MIL-STD-1553B serial data bus. The aircraft system control and display unit (CDU) would normally provide occasional altitude updates to the EGI via a 1553B remote terminal (RT) or bus controller (BC) transfers.

Spirent's **SimBARO** option can be used to transfer the barometric altitude to the UUT over 1553 via standard messages. SimBARO maintains a user-specified RT address on the supplied MIL-STD-1553B card that contains an appropriate barometric pressure altitude value.

Outside the USA, the Spirent SimBARO package is available to authorized customers only. However, there is a generic barometric pressure data port available as standard within SimGEN.

SimINERTIAL Configurations

Although the operational concept for SimINERTIAL is common, the test configurations required differ depending on the UUT. Please note the following:

- Cabling between the serial card and the UUT is not supplied by Spirent. The physical and electrical configurations of the inertial interface are not standardized and specific for each UUT interface. The customer is responsible for furnishing suitable cabling.
- A DC power source for the UUT is not supplied.
- The SimBARO option is available for EGI and IMUs. SimBARO is supplied with a 1553B PCIe interface card. No cables or bus couplers are supplied for the 1553B connections.

Configuration for all UUT Except Honeywell ISRS2

This configuration applies to all supported inertial devices, with the exception of the Honeywell ISRS2 devices. In this configuration, SimINERTIAL uses an RS422 connection via a commercial interface card housed in the SimINERTIAL controller for transmission of the inertial sensor data to the UUT.

Figure 2 shows a typical system schematic for this configuration. The figure also shows the SimBARO option, which is usually required to support EGIs INS-only operating modes.

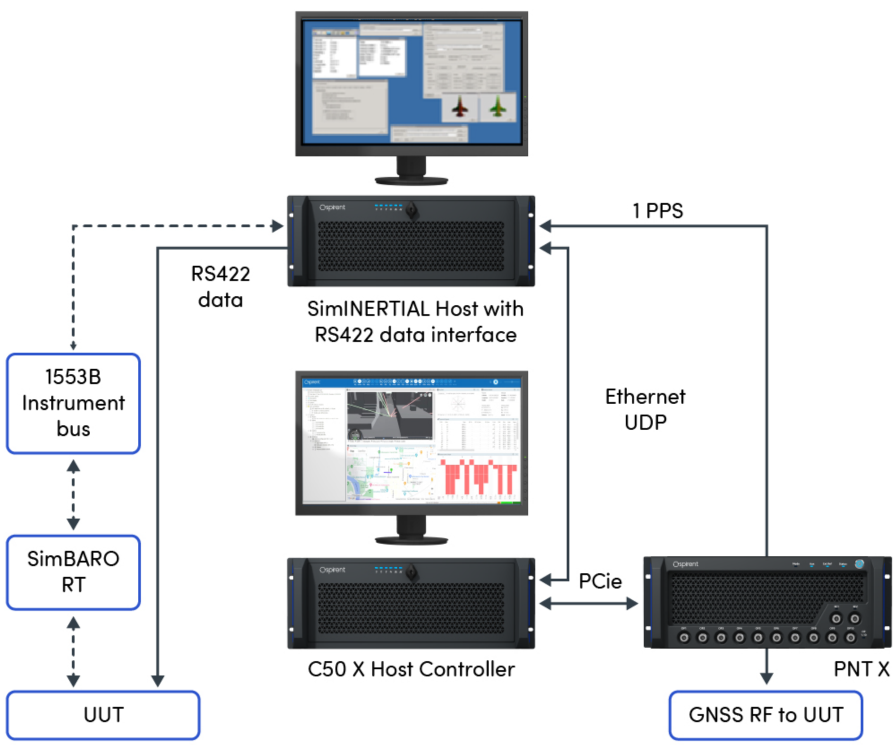

Figure 2: SimINERTIAL with optional SimBARO

SimINERTIAL for the STANAG 4572 interface supports data from two inertial sensor blocks, providing a total of 6 accelerometer and 6 gyro data fields in one stream.

Configuration for Honeywell ISRS2

This configuration applies to SimINERTIAL for H-746G, SIGI, NAV100, and HG9900 devices. In this configuration, the test interface is provided through Honeywell's proprietary ISRS2 interface card solution. The Honeywell ISRS2 card is an interface card that allows Honeywell EGIs to be put into test configuration for use with Spirent SimINERTIAL. The ISRS2 is housed in the SimINERTIAL controller to provide the transport interface to the UUT.

Figure 3 shows a system schematic for the Honeywell ISRS2 configuration. The figure also shows the SimBARO option, which is usually required to support EGIs INS-only operating modes.

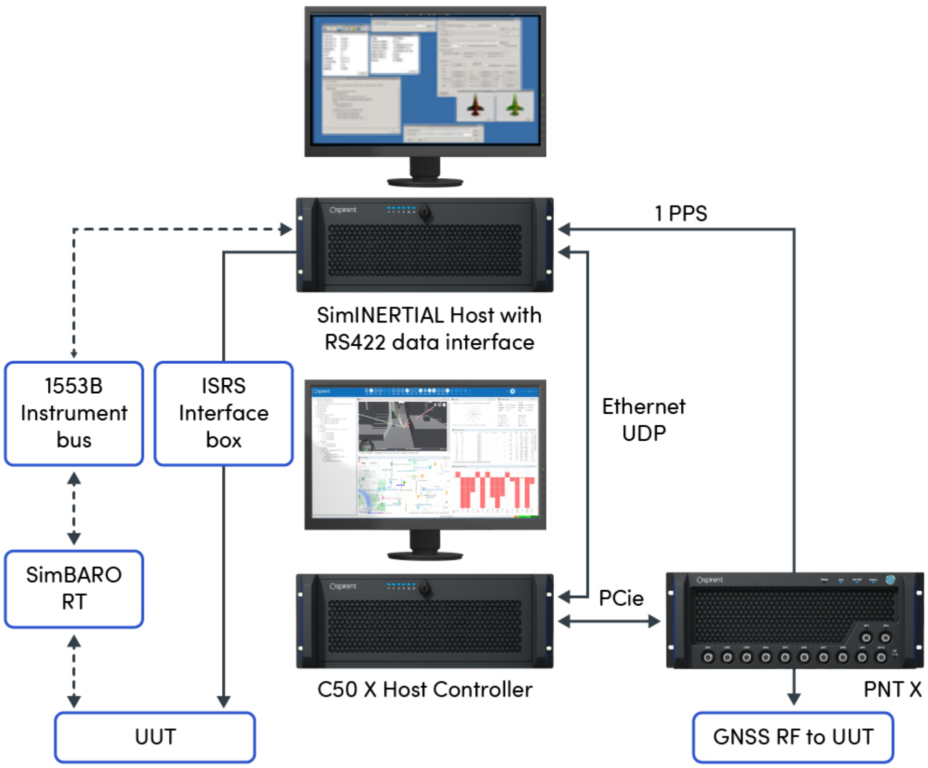

Figure 3: SimINERTIAL for H-764G with optional SimBARO

Software Licensing

SimINERTIAL uses licenses embedded in a license key to provide the type-specific capabilities for the test interface standards supported. Each interface listed in Table 1 is sold separately with its own part number. Licenses and the associated interface hardware are priced separately to provide system capability against a specific IMU type or standard.

Approvals may be required for the provision of licenses outside the USA, except in the case of the STANAG 4572 and AIS (Collins Aerospace) variants.

Multiple Inertial Interface Configurations

For customers wanting to exercise more than one device-under-test simultaneously, for example in dual-redundant applications or supporting multi-vehicle simulations, it is possible to operate SimGEN with several instances of SimINERTIAL installed on separate SimINERTIAL controllers. (Additional timing distribution elements from Spirent are usually required.) This includes using a single RF generator representing one antenna that is shared or multiple RF generators/outputs to represent multiple antennas or vehicles.

SimBARO can also support multiple independent barometric sources on a single or multiple vehicles.

> **NOTE**:
> Orders involving multiple SimINERTIAL variants are ONLY accepted as agreed Tailored Solutions to ensure compatibility and scope. Please contact your Spirent Federal sales representative for further advice on supported configurations.

Inertial Error Modeling

Physical sensors such as accelerometers and gyroscopes suffer from a complex range of imperfections that yield errors in the measurements made. In order for a test system to reproduce operationally representative sensor outputs, it is necessary to apply an error model to the nominal δv and δθ data produced by the base simulation.

SimINERTIAL uses a generic error model specified in Appendix 2 to STANAG 4572. This model has been derived from mature Accelerometer and Ring Laser Gyroscope designs plus recognized IEEE standards. The strapdown model includes a quaternion co-ordinate transformation from the body frame to the sensor frame, and the user may specify the coefficients of this model that cover scaling factors, biases, misalignments, lags, and stochastic error terms.

For NG and Honeywell SimINERTIAL variants, representative error model coefficients for the particular navigator under test must be obtained from NG or Honeywell.

The error model is supplied as a separate DLL, but it also supports the possibility of integrating user-defined models. User-defined models are models compiled by the customer (or Spirent, if appropriate) as a DLL and sharing the existing Spirent DLL interface.

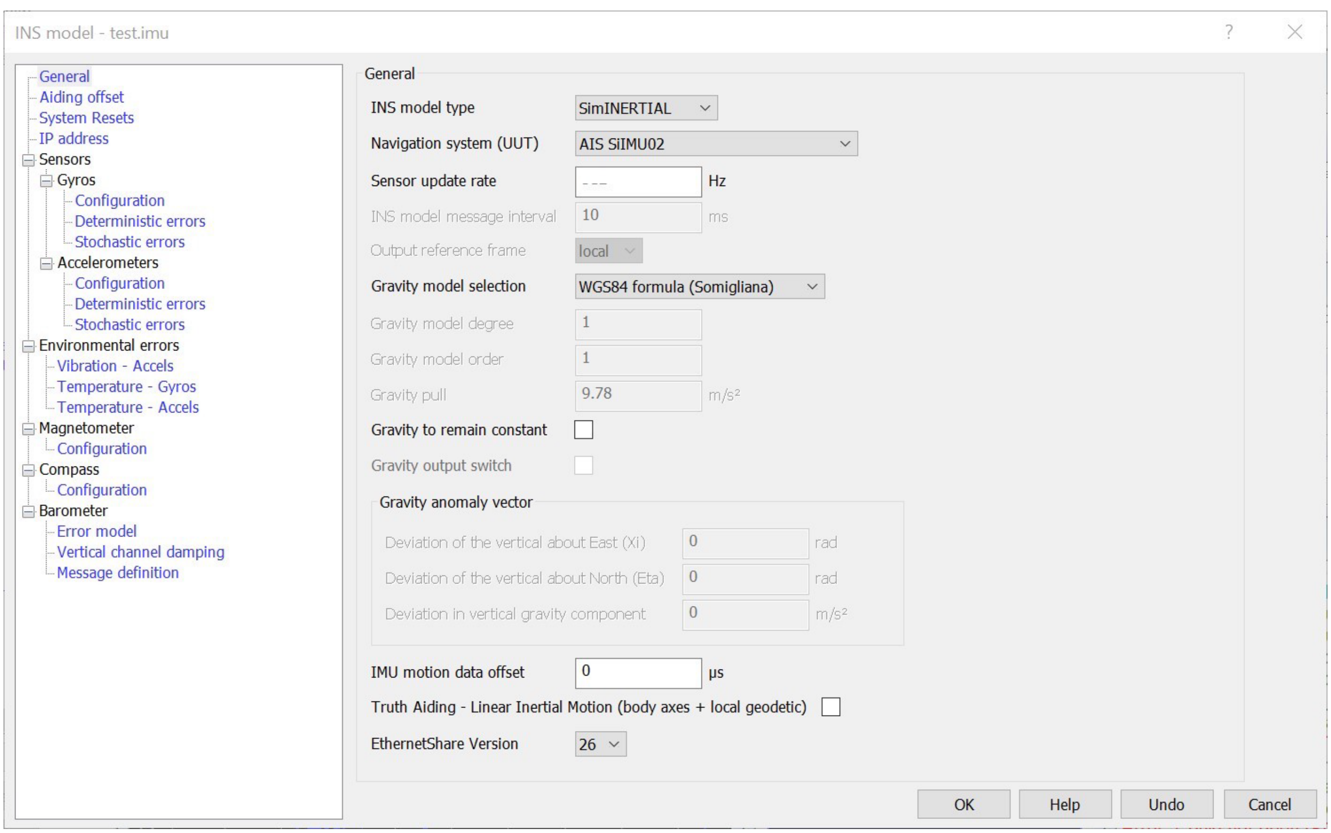

Figure 4: SimINERTIAL error model

Temperature and Vibration Models

The effects of environmental errors such as temperature and vibration on inertial sensors are applied via **embedded temperature and vibration error models**.

Vibration-induced errors affecting accelerometers are simulated via a vibration model based on MIL-STD-810-H. The model includes the pre-defined vibration profiles defined in the standard (for example, aircraft, helicopter, and shipboard) as well as user-defined ASD vs. frequency vibration profiles. Multiple vibration profiles can be applied at different times in a given scenario.

The temperature model is based on two industry-recognized research papers and simulates the effects of temperature on microelectromechanical systems (MEMS)-based accelerometers and gyroscopes. The user can define the scenario temperature profile and set the values of critical temperature parameters.

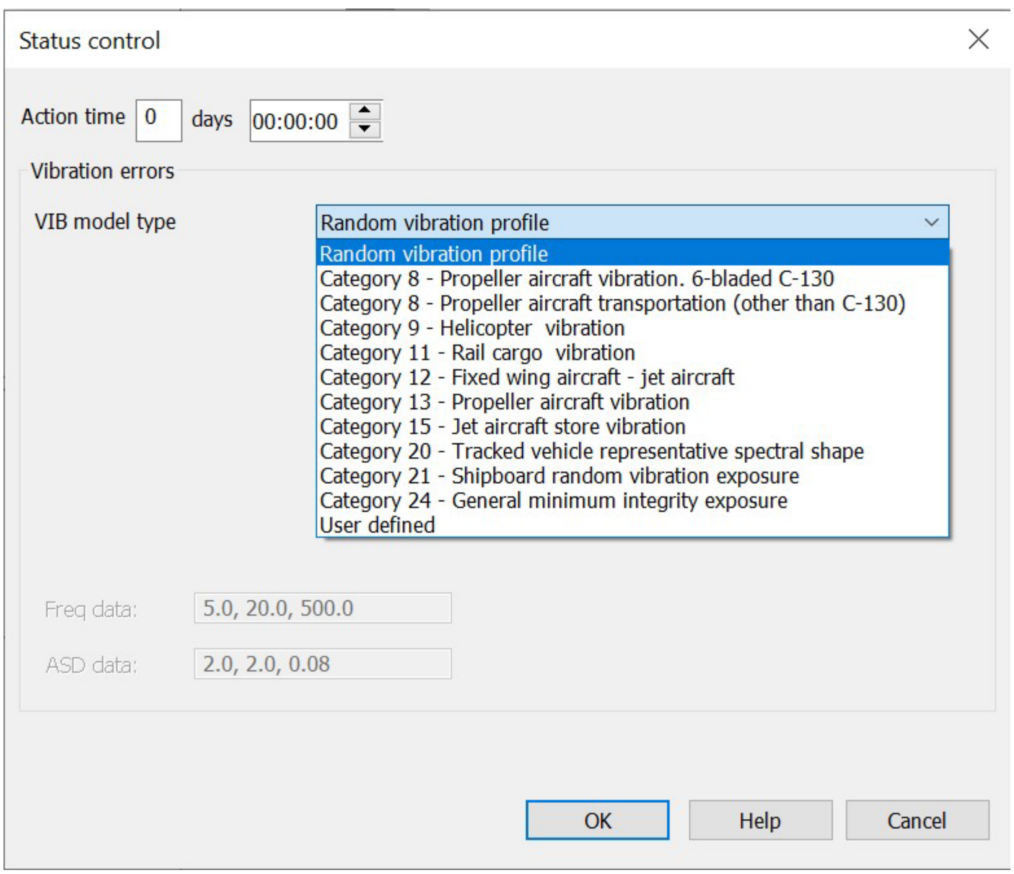

Figure 5: Vibration error model

GNSS-to-Inertial BIAS

SimINERTIAL is able to adjust the relative timing between the generation of the GNSS signals and the simulated inertial sensor data to ensure that these are coherently presented to the embedded navigation algorithms and hardware being tested.

Environmental Social & Governance (ESG)

Spirent's Positioning Technology Business Unit has been committed to ESG good practice and improvement since achieving ISO14001:2015 Environmental Managemental System certification in 2004.

We take ESG seriously across all aspects of our business from sustainable buildings, sustainable product design to sustainable supply chain, manufacturing, and shipping/exports.

Many of Spirent's Test Solutions rely on physical test equipment used in situ by our customers. We are working to reduce the lifecycle impacts of our products and the environments they are used in through a range of ways:

- Designing for environment and end of life, including compliance with all legal requirements;
- Reducing the size, weight, noise, and power use of our products;
- Virtualization and the development of Test-as-a-Service via PNT Professional Services;
- Improving utilization and automation; and
- In-field servicing and upgrades.

We use formal sustainability metrics in the product development process.

For more specific information on how ESG applies to our PNT Test Solutions, please contact your Spirent Federal representative.

For more information visit, https://corporate.spirent.com/sustainability.

For More Information

For more information on any aspect of SimINERTIAL, please contact Spirent Federal.

US Government & Defense, Spirent Federal Systems Inc.

Address: 1402 W. State Road, Pleasant Grove, UT 84062

Telephone: +1 801 785 1448

E-mail: **info@spirentfederal.com**

Website: **www.spirentfederal.com**

Why Spirent?

Across five decades Spirent has brought unrivaled power, control, and precision to positioning, navigation and timing (PNT) simulation. Spirent partners with the leading developers and integrators to consult and deliver on innovative solutions, using the highest quality hardware and the most flexible and intuitive software on the market.

Spirent delivers

- Simplified testing to accelerate the innovation cycle and deployment of robust PNT systems
- A proven track record of being first-to-market with new signals and ICDs
- Unrivaled investment in customer-focused R&D
- World-leading expertise, redefining industry expectations
- Powerful, flexible, and customizable SDR technology for future-proofed test capabilities
- Signals built from first principles — giving reliable and precise truth data

About Spirent Positioning Technology

Spirent enables innovation and development in the GNSS and additional PNT technologies that are increasingly influencing our lives. Our clients promise superior performance to their customers. By providing comprehensive and tailored test and assurance solutions, Spirent assures that our clients fulfill that promise.

About Spirent Federal Systems

Spirent Federal Systems provides the world's leading PNT test solutions to the US Government and contractors to enable resilient PNT under any conditions and outpace evolving navigation warfare threats. As a US proxy company, Spirent Federal enhances Spirent's commercial offerings with classified and other sensitive military signal emulation capabilities.