SimINERTIAL

Integrated GNSS and Inertial Testing

Purpose of This Document

This document describes the functionality of SimINERTIAL for Keysight'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 Keysight representative before ordering to confirm compatibility.

Supported configurations are often complex. Please contact your Keysight representative for guidance and to confirm the appropriate configuration.

KEYSIGHT

SimINERTIAL Overview

Keysight PNT X is an all-in-one solution that generates all GNSS constellations, RF threats, and signals of opportunity available for comprehensive test coverage and high realism.

SimINERTIAL enables realistic performance testing of integrated global navigation satellite systems (GNSS) and inertial navigation systems (INS) in the lab with a Keysight PNT X positioning, navigation, and timing (PNT) simulator. The solution provides real-time emulation of inertial sensor outputs, with all inertial and GNSS signals coherently generated to match the simulated vehicle trajectory.

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 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, Keysight's **SimBARO** option offers a source of barometric pressure altitude as a 1553B remote terminal.

SimINERTIAL is also compatible with Keysight's earlier GSS9000 simulator.

An Export License may be required to export SimINERTIAL.

SimINERTIAL Host (C50 X or C50R V5.xx)

SimINERTIAL is a Microsoft Windows-based application that runs on a SimINERTIAL host controller. The SimINERTIAL host receives INS aiding data from SimGEN as UDP data packets 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 unit under test (UUT).

Depending on your system, the SimINERTIAL host 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 .

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.

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 Keysight for further information.

Many of these systems have differing variants and interface specifications. Please contact your Keysight representative to ensure support for your specific systems/variants and for Keysight 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]	EGI	
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	SilMU02	IMU	
Collins Aerospace	SiNAV	EGI	
Safran (Sensonor)	STIM300[4]	IMU	
NATO	StanAg 4572		

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, Keysight Federal customers can purchase ISRS2 from Keysight Federal.
4 Currently only accepted as Tailored Solution.

Important notes:

- Bundles of SimINERTIAL capability are offered.
- Keysight 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.
- Repackaged instances of the IMUs listed in Table 1 (for instance, NovAtel's SPAN products) are not necessarily supported. Compatibility for these products should be checked with Keysight.

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.

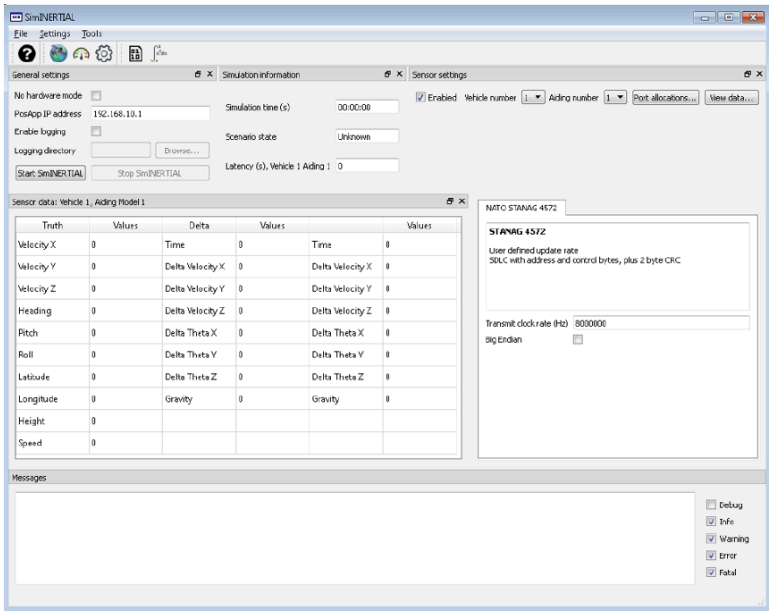

Figure 1. SimINERTIAL application

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.

Keysight’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.

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 Keysight. The physical and electrical configurations of the inertial interface are not standardized and are specific to 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 host 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.

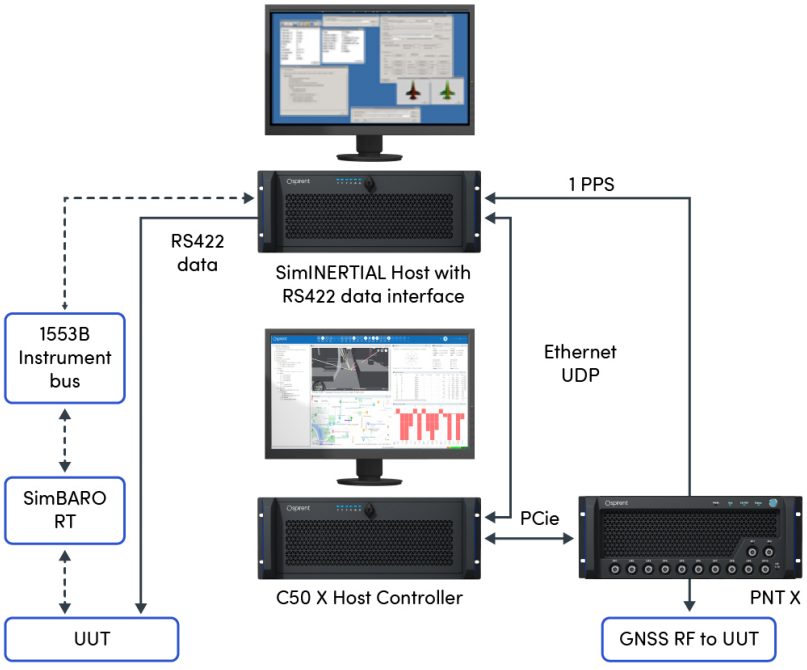

Figure 2. SimINERTIAL with optional SimBARO

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 Keysight SimINERTIAL. The ISRS2 is housed in the SimINERTIAL host 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.

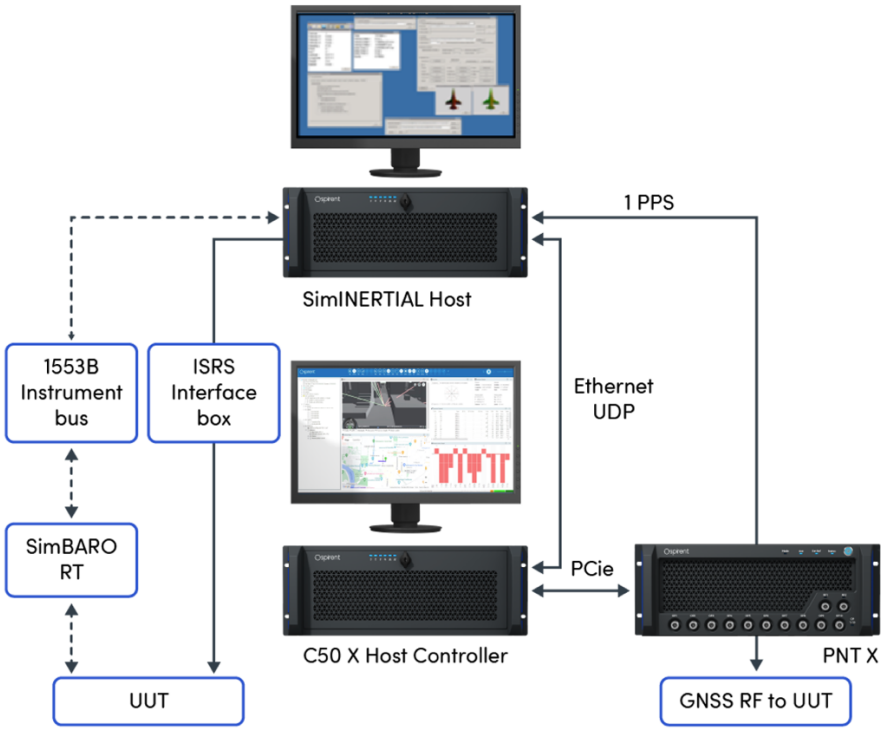

Figure 3. SimINERTIAL for H-764G with optional SimBARO

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.

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 hosts. (Additional timing distribution elements from Keysight 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 single or multiple vehicles.

Orders involving multiple SimINERTIAL variants are ONLY accepted as agreed Tailored Solutions to ensure compatibility and scope.Please contact your Keysight 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. For a test system to reproduce operationally representative sensor outputs, it is necessary to apply an error model to the nominal δv and $\delta\theta$ 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 Keysight, if appropriate) as a DLL and sharing the existing Keysight DLL interface.

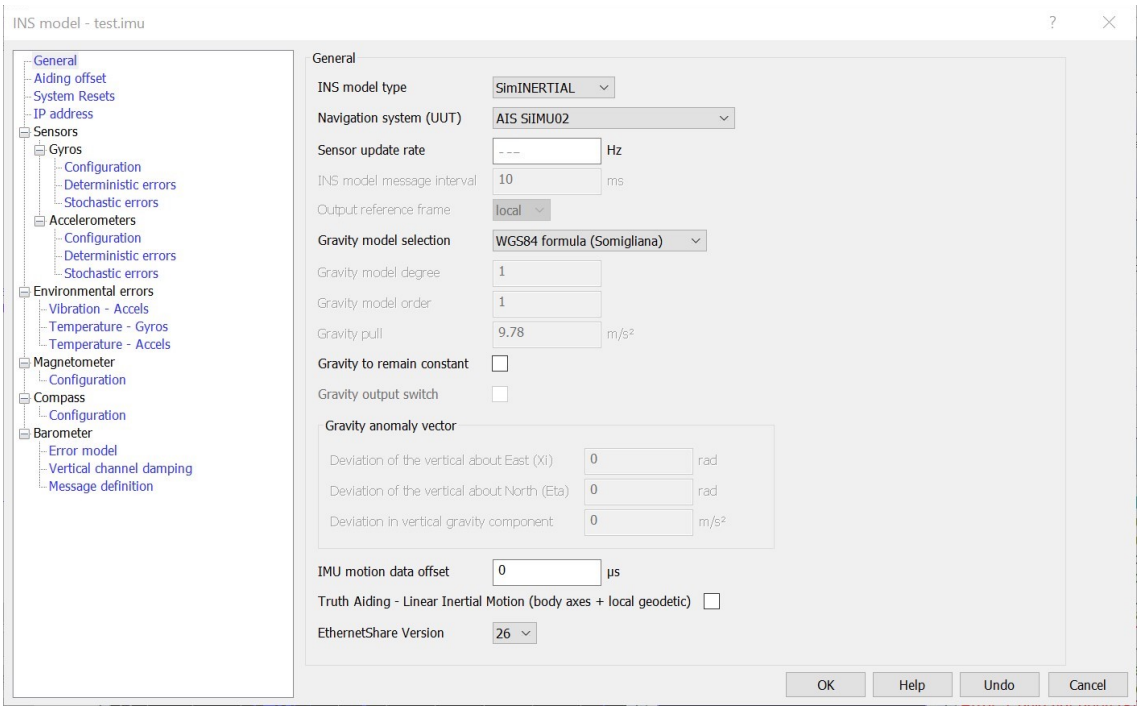

Figure 4. SimINERTIAL error model

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 (e.g. 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.

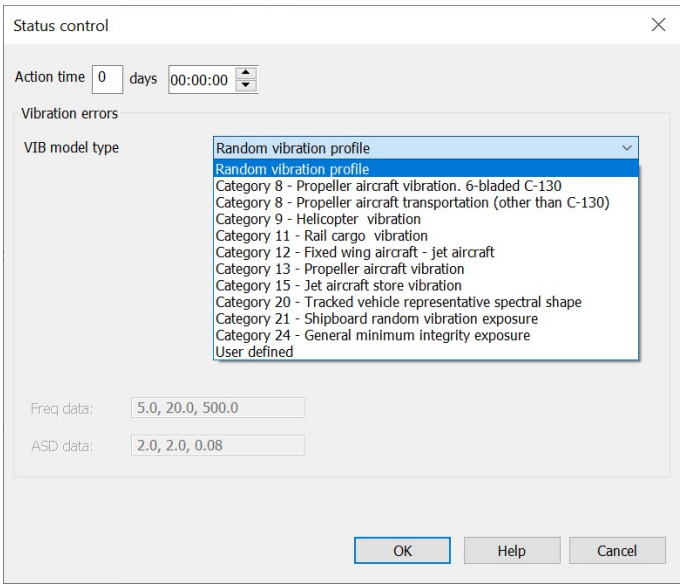

Figure 5. Vibration error model

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.

Accreditation and Compliance

Table 2. Safety and EMC Compliance

Compliance	Applicable Standard
Safety	Low Voltage Directive (LVD) 2014/35/EC IEC 62368-1:2014 (Second Edition) Audio/video, information and communication technology equipment. Safety requirements
EMC	EMC Directive 2014/30/EC EN 61326-1:2021 Electrical equipment for measurement, control and laboratory use. EMC requirements. General requirements
MET	MET Certification. Listing number E113897; MET Project Number 109752 UL 62368-1/CAN C22.2 CSA 62368-1, Second Edition: Audio/video, information, and communication technology equipment. Safety requirements

Ordering Information

Table 3. Ordering Information

Type	Part Number	Description	UK Export License Status
General	2003-4100	SIMINERTIAL APPLICATION SOFTWARE (MS3030)	UK export license not required
	2003-5350	SIMINERTIAL (C50R) CONTROLLER (MS3030)	
	2003-5101X	SIMINERTIAL (C50X) CONTROLLER (MS3030)	
IMU interfaces	2003-3010	SIMINERTIAL HONEYWELL HG1700SDLC INTERFACE (MS3030)	UK export license not required
	2003-3011	SIMINERTIAL NG LN200 SDLC INTERFACE (MS3030)	
	2003-3014	SIMINERTIAL HONEYWELL ISRS2 HG9900 INTERFACE (MS3030)	
	2003-3018	SIMINERTIAL AIS SILMU02 INTERFACE (MS3030)	
	2003-3020	SIMINERTIAL HONEYWELL HG1700 AMRAAM INTERFACE (MS3030)	
	2003-3022	SIMINERTIAL NATO STANAG 4572 INTERFACE(MS3030)	
	2003-4004	ADD NATO STANAG 4572 TO EXISTING SIMINERTIAL-IMU (MS3030)	
	2003-4010	UPGRADE SIMINERTIAL TO ADD HONEYWELL HG1700 SDLC (MS3030)	
	2003-4011	UPGRADE SIMINERTIAL ADD NORTHROP GRUMMAN LN200 SDLC (MS3030)	
	2003-4014	UPGRADE SIMINERTIAL TO ADD HONEYWELL ISRS 2 HG9900 (MS3030)	
	2003-4018	UPGRADE SIMINERTIAL TO ADD AIS SILMU02 (MS3030)	
	2003-4020	UPGRADE SIMINERTIAL TO ADD HG1700 AMRAAM (MS3030)	
	2003-4022	UPGRADE SIMINERTIAL TO ADD NATO STANAG 4572 (MS3030)	
EGI interfaces	2003-3012R	SIMINERTIAL HONEYWELL ISRS2 H764G & SIGI INTERFACE (MS3030)	UK export license required
	2003-3013R	SIMINERTIAL HONEYWELL ISRS2 NAV100 INTERFACE (MS3030)	
	2003-3015R	SIMINERTIAL LN100G INTERFACE (MS3030)	
	2003-3016R	SIMINERTIAL LN25X INTERFACE (MS3030)	
	2003-3017R	SIMINERTIAL LN260 INTERFACE (MS3030)	
	2003-3019R	SIMINERTIAL AIS SINAV02 INTERFACE (MS3030)	
	2003-4012R	UPGRADE SIMINERTIAL ADD HONEYWELL ISRS 2 H764G & SIGI MS3030	
	2003-4013R	UPGRADE SIMINERTIAL TO ADD HONEYWELL ISRS 2 NAV100 (MS3030)	
	2003-4015R	UPGRADE SIMINERTIAL TO ADD LN100G (MS3030)	
	2003-4016R	UPGRADE SIMINERTIAL TO ADD LN25X (MS3030)	
	2003-4017R	UPGRADE SIMINERTIAL TO ADD LN260 (MS3030)	
	2003-4019R	UPGRADE SIMINERTIAL TO ADD AIS SINAV02 (MS3030)	
SimBARO	2003-6050	BAROMETRIC DATA EMULATION H/W OPTION FOR C50R (MS3056)	UK export license not required
	2003-6051	SNU-84 (C01) BAROMETR MESSAGE INTERFACE (MS3056)	
	2003-6052	SNU-84 (C03) BAROMETR MESSAGE INTERFACE (MS3056)	
	2003-6053	H-764G IGI(EI-30) BAROMETR MESSAGE INTERFACE (MS3056)	
	2003-6054	LN100 IGI (AE6B-R27) BAROMETR MESSAGE INTERFACE (MS3056)	

Deliverables

Table 4. Main Deliverables

Part Numbers		Main Deliverables
2003-3010, 2003-3011, 2003-3018, 2003-3020, 2003-3022	2003-3015R, 2003-3016R, 2003-3017R, 2003-3019R	Soft license, RS422 Card
2003-3012R, 2003-3013R, 2003-3014		Soft license, Additional PCI Box
2003-4004, 2003-4010, 2003-4011, 2003-4014, 2003-4018, 2003-4020, 2003-4022, 2003-6051, 2003-6052, 2003-6053, 2003-6054	2003-4012R, 2003-4013R, 2003-4015R, 2003-4016R, 2003-4017R, 2003-4019R	Soft license
2003-6050		1553 Card

Environmental, Social, and Governance (ESG)

At Keysight, 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 Keysight'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

Our approach is to follow a Continual Improvement process in respect of ESG:

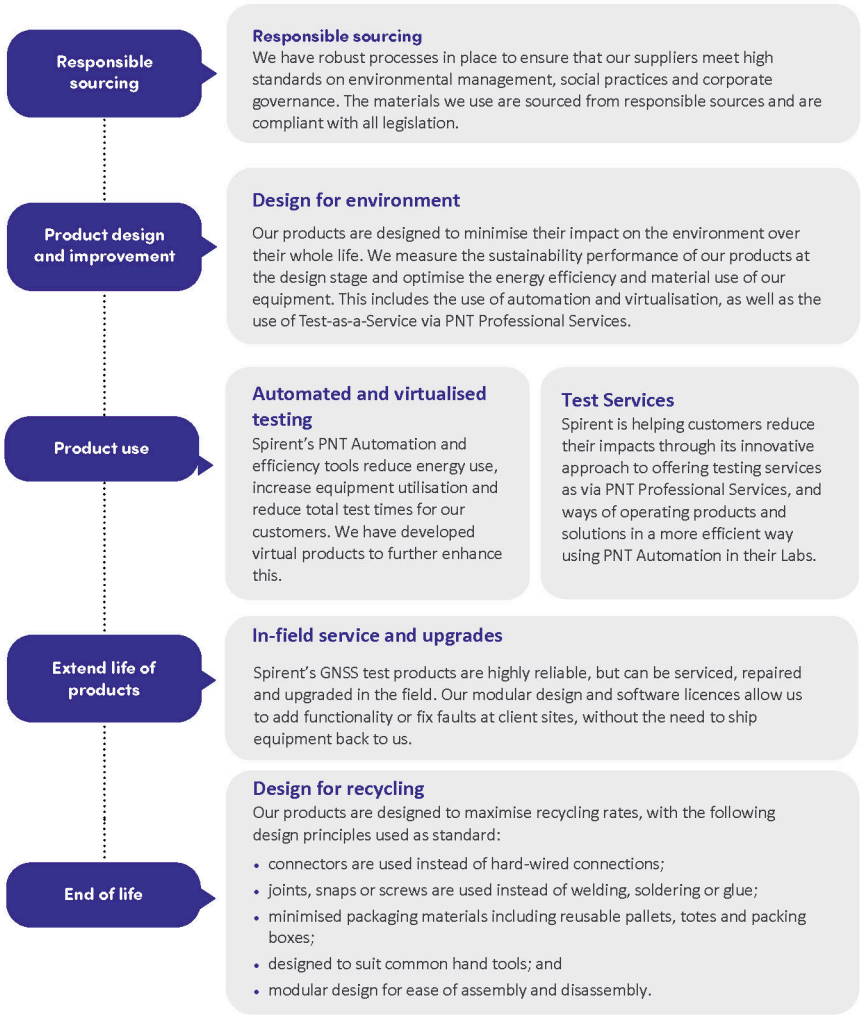

Figure 6. Keysight's ESG Continual Improvement process

We use formal sustainability metrics in the product development process.

For more specific information on how EGS applies to our PNT Test Solutions, please contact your Keysight representative.