Honeywell

LASEREF I

Inertial Reference System

Product Description
April 2012

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1.0 Introduction

The Laseref IV IRS contains laser gyro inertial navigation technology in the industry's lightest 4 MCU rack mountable package. This new system has been designed to simplify crew workload while dramatically reducing installation time, weight, size, power, and cost. The Laseref IRS has been installed and certified on the following aircraft:

- Gulfstream GV
- Dassault Falcon 900, 2000
- Embraer 135/140/145 (Option)
- Embraer Legacy (Standard fit)
- Bombardier Global Express (Standard fit)
- Cessna Citation X

Laseref IV IRS features:

- Smallest, lightest, and lowest power IRS in the industry. One-half the size, one-third the weight, and one-third the power of competing systems.
- 20,000 hour MTBF Reliability
- Automatic Mode Control Logic and Automatic Initialization for reduced crew workload
- Powerful Processor with Partitioned Operating System

HG2001GD40 IRS features:

- Identical to the HG2001GD03 GPIRU with ASCB Version C interface
- Minor software change to the embedded Magnetic Variation map.
  - Magnetic map is based on 2010 Magnetic survey data projected to 2015 with a second Epoch projected to 2025.
    - Formerly, 1995 Magnetic survey data projected to 2000.
    - Enlarged Northern Magnetic Keyhole
- New software features
  - Operation without a MSU
  - Reception of initialization parameters via ASCB from a fault warning computer
  - Power supply switchover test change to eliminate nuisance alignment issues with certain power-up sequences.

HG2001GD20 IRS features:

- Identical to the HG2001GD40 GPIRU with ASCB Versions A and B (instead of ASCB version C) to support retrofits of Laseref II and Laseref III IRUs on early EFIS integrated cockpits such as SPZ-6000 and SPZ-8000
- Suitable for Gulfstream GIV-SP, Bombardier CL-601-3A, Dassault F-50 and F-900, Hawker 800 and 1000, some Cessna Citation Model 650
- Upgraded Magnetic Variation map.
  - Magnetic map is based on 2010 Magnetic survey data projected to 2015 with a second Epoch projected to 2025.

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- Enlarged Northern Magnetic Keyhole
- New software feature enables operation without a MSU

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System Components:

The Laseref IV Inertial Reference System may contain the following components:

- HG2001GD20 IRU – upgrade path for ASCB Versions A or B applications
- HG2001GD40 IRU – upgrade path for HG2001GD03 ASCB Version C IRU
- 4 MCU mounting tray – for new and retrofit applications
- CG1042AB, CG1227AB/AC, CG2015AC Mode Select Units
- CG1136AC Inertial System Display Unit
- CG1230AC/AG LaserTrak Navigation Display Unit
- WG2000AB01 – 4 MCU to 10 MCU adapter plate (retrofit applications)
- Installation and Maintenance Manual

HG2001GD IRU
The Laseref IV IRU is a self-contained Inertial Reference Unit that provides long range navigation using high accuracy inertial sensors. Industry standard ARINC-429 outputs are provided for Flight Management Systems, Primary Displays, Forward Looking IR Cameras, Head-Up Displays, Flight Control, antenna stabilization (Satcom, Weather Radar, Direct Broadcast Satellite), EGPWS, and other critical aircraft systems. Full inertial reference performance is provided for unaided RNP-10 and RNP-5 (time limited) without GPS inputs. When GPS inputs are applied, the IRU provides tightly coupled GPS/Inertial hybrid outputs.

4 MCU mounting tray
Several ARINC 600 4MCU mounting tray options are available. The options provide compatibility with available mounting space for the IRU fan. There are options for a rear mounted fan, side mounted fan and for a bottom mounted fan.

Mode Select Unit (MSU)
Compatible models include CG1042ABxx, CG1227ACxx, CG2015ACxx etc. New software feature enables operation without a MSU

Inertial System Display Unit (ISDU)
The Laseref IV is compatible with existing CG1136AB/AC ISDUs for retrofit applications

LaserTrak NDU
The Laseref IV is compatible with existing CG1230AC/AG LaserTrak Navigation Display Unit for retrofit applications

Installation and Maintenance Manual (IMM)
Honeywell Publication number M15-3343-043-00 Revision 1. The Laseref IV IMM is a FAA approved document defining the installation requirements, capabilities, accuracies and operating limitations. The IMM provides details on the many system configurations the Laseref IV provides.

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2.0 Technical Overview

The Laseref IV is an Inertial Reference System (IRS) which outputs ARINC 429 inertial reference information for flight control and aircraft navigation.

Key Features:

- Weight 17.1 lbs
- Size ARINC 600 - 4 MCU
- Dimensions (WxHxL) 4.88 x 7.64 x 15.12 (inches)
- Power Consumption <50 watts typical
- Cooling Forced air - Certified for 18 hrs without cooling
- MTBF 15,000 operational hours
- ARINC 429 Transmitters 6 (Can support up to 120 different LRUs)
- ARINC 429 Receivers 8
- ASCB Version A/B HG2001GD20
  Version C HG2001GD40
- Discrete Inputs 22
- Discrete Outputs 10
- Operation Mode Controlled or Automatic mode control
- Maintenance 95% Build-in Test Coverage
  NVM storage of performance and troubleshooting data
  Build-in automatic sensor calibration

Certification:

- Software Certification DO178B Level A
- Hardware Certification DO160C
- TSO C-4c, C-5e and C-6d
- FAR 121 Appendix G (Federal Aviation Regulations) – Operating Requirements: Domestic, Flag, and Supplemental Operations
- Advisory Circular 25-4 Inertial Navigation Systems (INS)
- AC 120-33 - Operational approval of airborne long range navigation systems for flight within the North Atlantic minimum navigation performance specifications airspace
- FAA Order 8400.12A, Required Navigation Performance 10 (RNP-10) Operational Approval, for 12 hours unaided

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- AC 90-96, Approval of u.s. operators and aircraft to operate under instrument flight rules (IFR) in European airspace designated for basic area navigation (BRNAV/RNP-5), for 2 ½ hours unaided

When connected with an ARINC 743A compatible GPS receiver, the IRS provides hybrid GPS/Inertial outputs.

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ARINC 429 Outputs:

The Inertial Reference (IR) component of the IRS contains three force rebalance accelerometers and three laser gyros, which it uses to measure inertial motion. The IR component requires system initialization (entry of latitude and longitude). Initialization may come from another system such as a Flight Management System (FMS), Inertial Systems Display Unit (ISDU) or from LaserTrak Navigation Display Unit. Once the IR component is properly aligned and initialized it transitions into its normal operating mode. It relies on inputs from an Air Data System (ADS) for wind, flight path and altitude. The inertial reference system outputs the parameters below.

Body Frame:

- Longitudinal, Lateral, and Normal Accelerations
- Pitch, Roll, and Yaw Rates

Local Level Frame:

- Pitch and Roll Angles
- Pitch and Roll Attitude Rates
- Flight Path Angle and Flight Path Acceleration
- Inertial Vertical Speed and Inertial Vertical Acceleration
- Platform Heading
- Turn Rate

Earth Frame:

- Latitude and Longitude
- N-S Velocity, E-W Velocity, and Ground speed
- Inertial Altitude
- True and Magnetic Heading
- Track Angle True and Track Angle Magnetic
- Track Angle Rate
- Wind Speed and Wind Direction True
- Drift Angle
- Along Track and Cross Track Accelerations
- Along Heading and Cross Heading Accelerations

Hybrid Function:

The GPS Hybrid function utilizes existing hardware components in the IRU to receive GPS data from one or two GPS Receiver systems. Data received is one Hz nominal RS-422 time mark signal unique for each GPS receiver input and ARINC 429 GPS high-speed satellite measurement and autonomous data. The GPS Hybrid function blends received GPS autonomous Pseudo Range with Inertial and Air Data altitude data in a tightly coupled Kalman filter to achieve optimal position, velocity, and attitude

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performance. The GPS Hybrid function provides the following output parameters:

- Hybrid Latitude and Longitude
- Hybrid N-S Velocity, E-W Velocity, and Ground Speed
- Hybrid Altitude and Vertical Velocity
- Hybrid True Heading, Track Angle, and Flight Path Angle
- Hybrid Horizontal and Vertical Figure Of Merit and Integrity Data
- Autonomous GNSS pass-through data

Input Power Requirements:

The Laseref IV IRS is capable of operating from 115VAC and/or primary input +28 VDC aircraft power source or a secondary input power source such as a +24 VDC battery. Priority is given to the primary power source if both primary and secondary sources are available and valid. The maximum DC power consumption of the unit is 55W (50W AC), however nominally the power consumption does not exceed 46W (41W AC) following a few seconds of operation.

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3.0 Experience

The Laseref IV IRU is the fourth generation RLG based inertial reference unit (IRU), providing Honeywell's proven laser inertial technology in the lightest 4 MCU rack mountable package. The Laseref IV IRU is a derivative product based on the highly successful 4 MCU inertial reference unit technologies used in a variety of high volume applications including the Boeing 737, Airbus A319/320/321/330/340. Reliability of the fleet of Digital RLG IRS systems has consistently exceeded 40,000 MTBF and 20,000 MTBUR since entry into service in 1997. This system has been instrumental in helping operators achieve low maintenance costs and high dispatch reliability.

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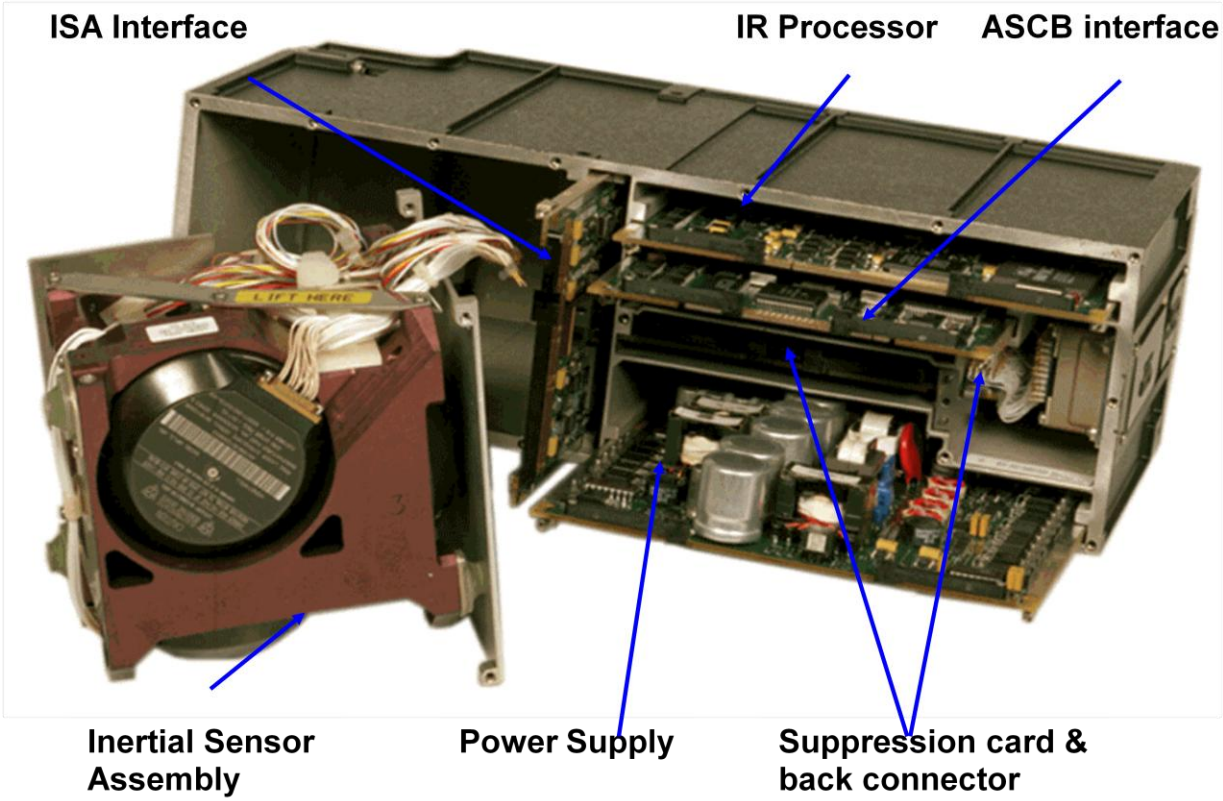
4.0 Hardware Description

HG2001GD Laseref IV IRU with ASCB version A and B or ASCB version C interfaces:



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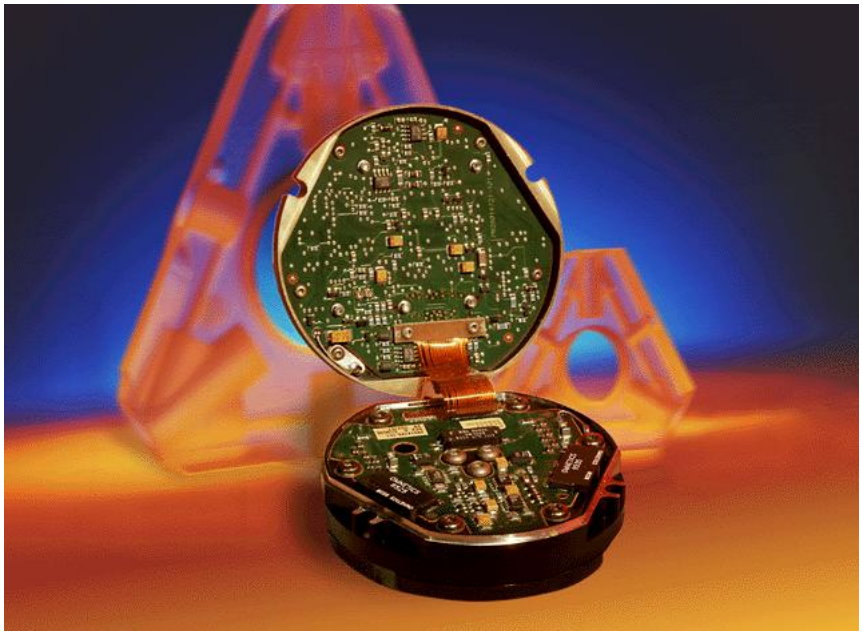
IRS Hardware Assemblies

Inertial Sensor Assembly:

GG1320 Digital Ring Laser Gyro



The Honeywell GG1320 Digital Gyro is established as a proven, high reliability, high performance, sensor that has been carefully engineered to meet the customers' needs.

The Dig-Gyro is a completely self-contained sensor whose small size, low cost, and low power requirements make it a particularly attractive component for inertial systems. A three-axis inertial sensor assembly (ISA) incorporates three Dig-Gyros and three accelerometers, weighs less than six pounds, occupies less than 90 cubic inches, and consumes less than 8 watts of power. The Dig-Gyro is also ideally suited for redundant inertial systems, because it is small and because the built-in electronics isolate each gyro from faults in other sensors.

Gyro Characteristics and Demonstrated Performance
Characteristics and demonstrated performance of the Dig-Gyro are as follows:

Characteristics

- <5.5 cubic inches
- <1 lb.
- <2 watts
- DC power in (+15 and +5 Vdc)
- Compensated serial digital data output

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- No external support electronics
- Built on proven RLG technology (>400,000 RLGs delivered)
- DO178B Level A Certification
- Built-in self test

Demonstrated performances:

- Low random walk
- Excellent scale factor stability
- Superb bias stability
- No turn-on bias transients
- Low magnetic sensitivity
- Environmentally insensitive
- Proven field reliability over 400,000 hours MTBF (Air Transport, Regional, Business Jet Fleets)
- Laser in full-scale production (over 20,000 digital gyros per year)

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Q-FLEX Accelerometer

Accelerometer

Honeywell accelerometers are the recognized industry standard for spacecraft, aircraft, missile and munitions inertial navigation, guidance, control and stabilization applications. The Laseref IV IRS uses the Honeywell Q-FLEX QA-950 accelerometer:

- Q-FLEX sets the standard for inertial navigation
- Excellent turn-on repeatability and stability performance
- Environmentally rugged
- Three fastener precision mounting flange
- Internal temperature sensor for thermal compensation
- Built-in self test
- Embedded compensation coefficients allow IRS repair with simple hand tools. No system calibration is required.

The Q-FLEX is the predominant sensor used in today's commercial and military aircraft strap-down inertial navigation systems. The long-term stability and superior reliability characteristics make it the best inertial-grade accelerometer available on the market today. As with the entire Q-FLEX family of accelerometers, the QA950 features a patented Q-FLEX etched-quartz-flexure seismic system. An amorphous quartz proof-mass structure provides excellent bias, scale factor, and axis alignment stability. The integral electronics develops an acceleration-proportional output current providing both static and dynamic acceleration measurements.

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Power Supply
The versatile power supply assembly of the Laseref IV allows interconnections of up to 3 separate power supply inputs. The power supply allows for operation on 115 VAC or 28VDC generated power aircraft with battery backed up emergency power. The power supply has AC to DC and dual input DC to DC converters. Switching of input power busses is fully automatic and seamlessly transitions from input to input with no interruption of normal operation.

EMI/Transient Protection
The EMI filtering and transient protection circuit card along with the connector assembly are housed in "dirty chambers" to isolate the aircraft EMI environment from the Laseref IV circuitry.

Processor and ARINC I/O
The processor and ARINC I/O assembly use technology from proven baselines with extensive FAA certification experience. The software is DO178B level A certified.

ASCB I/O

Version A and B (HG2001GD20 only)

The ASCB Version A and B interface card is the same as the Laseref III (HG2001AB02/03) IRU. The card has had a slight form factor change to fit in the Laseref IV chassis and has been requalified to the same levels as the Laseref IV device. This allows for simple upgrades from Laseref III and Laseref II equipped aircraft.

ASCB Version C I/O (HG2001GD40 only)

The ASCB Version C interface card is identical to the HG2001GD03 IRU. The latest operational software allows for reception of initialization parameters via the ASCB interface. This new software feature allows for compatibility with some PRIMUS 2000 equipped aircraft without a functioning FMS (for example DO-328Jet).

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5.0 Qualification Levels

Conditions	DO-160C Section	Description of Conducted Tests
Temperature and Altitude	**4.0**	**Category A2/F1.**
Low Ground Survival	**4.5.1**	-55°C
Low Short Term Operating	**4.5.1**	-40°C
Low Operating Temperature	**4.5.2**	-40°C
High Ground Survival	**4.5.3**	+85°C
High Operating	**4.5.4**	+70°C
In Flight Loss of Cooling	**4.5.5**	N/A – device is passively cooled.
Altitude	**4.6.1**	-2,000 to +55,000 feet
Decompression	**4.6.2**	8,000 to 55,000 ft in 15 seconds.
Overpressure	**4.6.3**	27.14 PSIA (-18,000 feet)
Temperature Variation	**5.0**	**Category A (10°C/Min)** 2 Cycles, -20C/+70C
Humidity	**6.0**	**Category A**
Shock	**7.0**	**Conforms to DO-160C, Chapter 7, unless noted otherwise.**
Vibration	**8.0**	**Category S**
Random	**8.5.2**	Figure 8-1, **Curve B**, modified to provide 2.2 gRMS Run 5 Hrs / axis
Sinusoidal	**8.5.1**	Figure 8-3, **Curve M**
Explosion Proofness	**9.0**	**Category X**
Waterproofness	**10.0**	**Category X**
Fluids Susceptibility	**11.0**	**Category X**
Sand and Dust	**12.0**	**Category X**
Fungus	**13.0**	**Category X**
Salt Spray	**14.0**	**Category X**
Magnetic Effect	**15.0**	**Category Z**
Power Input	**16.0**	**Category Z**
Voltage Spike	**17.0**	**Category A**
Audio Frequency Susceptibility	**18.0**	**Category Z**
Induced Signal Susceptibility	**19.0**	**Category Z**

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Conditions	DO-160C Section	Description of Conducted Tests
Radio Frequency Susceptibility	**20.0 (Change 3)**	**Category Y & R**
Radio Frequency Emission	**21.0**	**Category B** LISN method on power lines
Lightning Induced Transient Susceptibility	**22.0 (Change 2)**	**Category A3CZ** Single Stroke: Long Wave – 300V / 300A Short Wave – 300V / 600A 1 MHz Osc – 600V / 120A Pin Injection: Long Wave – 300V / 60A 1 MHz Osc – 600V / 24A Multiple Burst Bundle: 1 and 10 MHz Osc – 600V / 24A
Lightning Direct Effects	**23.0 (Change 1)**	**Category X**
Icing	**24.0**	**Category X**

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6.0 Input Parameter Characteristics

ARINC 429 IR Inputs

Required FMS Parameters	Label	Format	Range	LSB Weight	MSB Weight	Sig Bits	Units	Pos Sense	Xmit Interval
Set Latitude	041	BCD	-90 to +90	0.1 min	100	5	Deg:Min	North	Note 1
Set Longitude	042	BCD	-180 to +180	0.1 min	100	6	Deg:Min	East	Note 1
Set Heading	043	BCD	0 to 359.9	0.1 deg	300	4	Deg	CW Frm N	Note 1

Note 1 - Burst of 2 per second for 1 second, or a 500 ms burst with each label transmitted every 12 ms.

Required Air Data Parameters	Label	Format	Range	LSB Weight	MSB Weight	Sig Bits	Units	Pos Sense	Xmit Interval
Pressure Altitude[2]	203	BNR	±131072	1.0 ft	65536	17	Feet	Up	62.5 ms
Altitude (Baro)[2]	204	BNR	±131072	1.0 ft	65536	17	Feet	Up	62.5 ms
True Airspeed	210	BNR	0 to 2047	0.0625 kts	1024	15	Knots	Alwys Pos	31.25 ms
Altitude Rate	212	BNR	±32768	1.0 ft	16384	15	Ft/Min	Up	62.5 ms

Note 2 – Either label 203 or label 204 must be received. If both inputs are received the IRU will use label 203

Optional FMS Parameters	Label	Format	Range	LSB Weight	MSB Weight	Sig Bits	Units	Pos Sense	Xmit Interval
Greenwich Mean Time	125	BCD	0-99:99	1.0 min	90	4	Hr:Min	N/A	Note 3
Date	260	BCD	0-39/19/99	1 day	90	6	D:M:Y	N/A	Note 3

Note 3 - Not provided by an ISDU or NDU. UTC and date information is used as a maintenance aid and may be used by the IRU in a GPS hybrid configuration to retransmit back to the GNSSU to reduce its satellite acquisition time.

ARINC 429 Digital Inputs Notes:

Input requirements are in compliance with standard ARINC 704A IRS

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ARINC 429 GPS Receiver Inputs (Optional)

Parameter	Label (Octal)	Signal Format	Minimum Update Rate (Hz)	Significant Bits/ Figures	Units	Range	Positive Sense
User Range Accuracy	057	BNR	1	17	Meters	+8192	Always +
Measurement Status	060	DIS	1	N/A	N/A	N/A	N/A
Pseudo Range	061	BNR	1	20	Meters	+268435456	+
Pseudo Range Fine	062	BNR	1	11	Meters	256	(4)
Range Rate	063	BNR	1	20	M/Sec	+4096	+
Delta Range	064	BNR	1	20	M/Sec	+4096	+
SV Position X	065	BNR	1	20	Meters	+67108864	ECEF
X Fine Position	066	BNR	1	14	Meters	64	(4)
SV Position Y	070	BNR	1	20	Meters	+67108864	ECEF
Y Fine Position	071	BNR	1	14	Meters	64	(4)
SV Position Z	072	BNR	1	20	Meters	+67108864	ECEF
Z Fine Position	073	BNR	1	14	Meters	64	(4)
UTC Measurement Time	074	BNR	1	20	Seconds	10.0	(3)
Aut GPS Altitude	076	BNR	1	20	Feet	+131072	Up
Aut GPS HDOP	101	BNR	1	15	N/A	1024	(3)
Aut GPS VDOP	102	BNR	1	15	N/A	1024	(3)
Aut GPS Track Angle	103	BNR	1	15	Degrees	+180	CW-North
Aut GPS Latitude	110	BNR	1	20	Degrees	+180	North
Aut GPS Longitude	111	BNR	1	20	Degrees	+180	East
Aut GPS Gnd Speed	112	BNR	1	15	Knots	4096	(3)
Aut GPS Lat. Fine	120	BNR	1	11	Degrees	$180 * 2^{-20}$	North
Aut GPS Long. Fine	121	BNR	1	11	Degrees	$180 * 2^{-20}$	East
UTC (BCD)	125	BCD	1	5	Hr:Min	0.1 minute	(3)
Horiz Aut. Integrity Limit	130	BNR	1	17	NM	16	(3)
Vertical Aut. Integrity Limit	133	BNR	1	17	Feet	32768	(3)
GPS Vertical FOM	136	BNR	1	18	Feet	32768	(3)
UTC Fine	140	BNR	1	20	Seconds	1.0	(4)
UTC Fine Fracs	141	BNR	1	10	Seconds	$1.0 * 2^{-20}$	(4)
Terminal Area HIL	143	BNR	1	17	NM	16	(3)
Terminal Area VIL	144	BNR	1	17	Feet	32768	(3)
UTC (Binary)	150	BNR	1	17	Hr:Min:s	23:59:59	(3)
Destination ETA	162	BNR	2	11	Hr:Min	23:59	(3)
Alt. Waypoint ETA	163	BNR	2	11	Hr:Min	23:59	(3)
Aut GPS Vert Velocity	165	BNR	1	15	Feet/Min	+32768	Up
Aut GPS N-S Velocity	166	BNR	1	15	Knots	+4096	North
Aut GPS E-W Velocity	174	BNR	1	15	Knots	+4096	East
GPS Horizontal FOM	247	BNR	1	18	NM	16	(3)
Date	260	BCD	1	6	D:M:Yr	1 day	(3)
GPS Sensor Status	273	DIS	1	N/A	N/A	N/A	N/A
Destination HIL	343	BNR	2	13	NM	16	(3)
Alt. Waypoint HIL	347	BNR	2	13	NM	16	(3)
GPS Rec. Maint.	352	DIS	1	N/A	N/A	N/A	N/A
GPS Nav Maint.	355	DIS	1	N/A	N/A	N/A	N/A

ARINC 429 Digital Inputs Notes:

ARINC 743A or ARINC755 standard GPS inputs listed above will enable GPS/IRS hybrid outputs.

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7.0 Output Parameter Characteristics

IR ARINC 429 Digital Outputs

Signal	Oct Lbl	Cod(1)	Sig (2) Bit	Range(3)	LSB(9) Weight	MSB Weight	Units	Positive Sense	Filter(5) Type	Flt(6) BW (Hz)	Transport(7) Delay (msec)	Xfer(8) Rate Hz
IR Time to Nav	007	BCD	2	0-9.9	0.1	-	Minutes	Always +	N/A	N/A	N/A	3
Position Latitude	010	BCD	5	90S-90N	0.1	-	Deg:Min	North	-	-	N/A	3
Pos Longitude	011	BCD	6	180E-180W	0.1	-	Deg:Min	East	-	-	N/A	3
Ground Speed	012	BCD	4	0-4095	1	-	Knots	Always +	1-BW	2	N/A	3
Track Angle True	013	BCD	4	0-359.9	0.1	-	Degrees	CW from N	1-BW	2	N/A	3
Magnetic Heading	014	BCD	4	0-359.9	0.1	-	Degrees	CW from N	1-BW	2	N/A	3
Wind Speed	015	BCD	3	0-255	1	-	Knots	Always +	1-BW	2	N/A	3
Wind Direction True	016	BCD	3	0-359	1	-	Degrees	CW from N	1-BW	2	N/A	3
True Heading	044	BCD	4	0-359.9	0.1	-	Degrees	CW from N	1-BW	2	N/A	3
IR Time In Nav	126	BNR	15	0-32768	1	16384	Minutes	Always +	N/A	N/A	N/A	2
Data Loader SAL(11)	226	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
IRS Discrete	270	DIS	19	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3
Test Word	277	DIS	18	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12
Position Latitude	310	BNR	20	90(10)	1.72E-4	90	Degrees	North	1-BW	2	160	12
Position Longitude	311	BNR	20	180	1.72E-4	90	Degrees	East	1-BW	2	160	12
Ground Speed	312	BNR	18	0-4096	0.01563	2048	Knots	Always +	1-BW	2	110	25
Track Angle True	313	BNR	18	180	6.87E-4	90	Degrees	CW from N	1-BW	2	110	25
True Heading	314	BNR	18	180	6.87E-4	90	Degrees	CW from N	1-BW	2	110	25
Wind Speed	315	BNR	18	0-256	9.77E-4	128	Knots	Always +	1-BW	2	110	12
Wind Direction True	316	BNR	18	180	6.87E-4	90	Degrees	CW from N	1-BW	2	110	12
Track Angle Magnetic	317	BNR	18	180	6.87E-4	90	Degrees	CW from N	1-BW	2	110	25
Magnetic Heading	320	BNR	18	180	6.87E-4	90	Degrees	CW from N	1-BW	2	110	25
Drift Angle	321	BNR	18	90(10)	6.87E-4	90	Degrees	Nose Right	1-BW	2	110	25
Flight Path Angle	322	BNR	18	90(10)	6.87E-4	90	Degrees	Up	1-BW	2	110	25
Flight Path Accel	323	BNR	18	4	1.53E-5	2	G's	Forward	2-BW	6.4	70	50
Pitch Angle	324	BNR	18	90(10)	6.87E-4	90	Degrees	Up	1-BW	8	70	50
Roll Angle	325	BNR	18	180	6.87E-4	90	Degrees	Right Wing Down	1-BW	8	70	50
Body Pitch Rate	326	BNR	18	128	4.88E-4	64	Deg/Sec	Up	2-BW	6.4	70	50
Body Roll Rate	327	BNR	18	128	4.88E-4	64	Deg/Sec	Right Wing Down	2-BW	6.4	70	50
Body Yaw Rate	330	BNR	18	128	4.88E-4	64	Deg/Sec	Nose Right	2-BW	6.4	70	50
Body Long Accel	331	BNR	18	4	1.53E-5	2	G's	Forward	2-BW	6.4	70	50
Body Lat Accel	332	BNR	18	4	1.53E-5	2	G's	Right	2-BW	6.4	70	50
Body Norm Accel	333	BNR	18	4	1.53E-5	2	G's	Up	2-BW	6.4	70	50
Platform Heading	334	BNR	18	180	6.87E-4	90	Degrees	CW	1-BW	2	110	25
Track Angle Rate	335	BNR	18	32	1.22E-4	16	Deg/Sec	CW from N	1-BW	8	45	50
Pitch Att Rate	336	BNR	18	128	4.88E-4	64	Deg/Sec	Up	2-BW	8.0	70	50
Roll Att Rate	337	BNR	18	128	4.88E-4	64	Deg/Sec	Right Wing Down	2-BW	8.0	70	50
IRU Maintenance	350	DIS	19	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3
Time to NAVRDY	351	BCD	2	0-9.9	0.1	N/A	Minutes	Always +	N/A	N/A	N/A	3
Cycle Counter	354	BNR	19	0-524288	1	262,144	Count	Always +	N/A	N/A	N/A	50
Potential Vertical Speed	360	BNR	18	32768	0.125	16384	Ft/Min	Up	1-BW	8	65	50
Inertial Altitude	361	BNR	20	-2K to 60K(4)	0.125	65536	Feet	Up	1-BW	8	65	25
Along Track Accel	362	BNR	18	4	1.53E-5	2	G's	Forward	2-BW	6.4	70	50
Cross Track Accel	363	BNR	18	4	1.53E-5	2	G's	Right	2-BW	6.4	70	50
Vertical Accel	364	BNR	18	4	1.53E-5	2	G's	Up	2-BW	6.4	70	50
Inertial Vertical Spd	365	BNR	18	32768	0.125	16384	Ft/Min	Up	1-BW	8	65	50
N-S Velocity	366	BNR	18	4096	0.01563	2048	Knots	North	1-BW	2	110	12

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Signal	Oct Lbl	Cod(1)	Sig (2) Bit	Range(3)	LSB(9) Weight	MSB Weight	Units	Positive Sense	Filter(5) Type	Flt BW (Hz) (6)	Transport (7) Delay (msec)	Xfer(8) Rate Hz
E-W Velocity	367	BNR	18	4096	0.01563	2048	Knots	East	1-BW	2	110	12
Unbiased Normal Accel	370	BNR	18	8	3.05E-5	4	G's	Up	2-BW	6.4	70	12
Equipment ID	371	DIS	19	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3
Along Heading Accel	375	BNR	18	4	1.53E-5	2	G's	Forward	2-BW	6.4	70	50
Cross Heading Accel	376	BNR	18	4	1.53E-5	2	G's	Right	2-BW	6.4	70	50

IR ARINC 429 Digital Output Notes

Note 1: Per ARINC 429, the Sign Status Matrix for the label formats Binary, Binary Coded Decimal, and Discrete are as follows.

BNR Bits

31	30	Condition
0	0	Failure Warning
0	1	No Computed Data
1	0	Functional Test
1	1	Normal Operation

BCD Bits

31	30	Condition
0	0	Normal Operation (positive)
0	1	No Computed Data
1	0	Functional Test
1	1	Normal Operation (negative)

Under Failure Warning Conditions, BCD coded ARINC words are not transmitted.

Disc Bits

31	30	Condition
0	0	Normal Operation
0	1	(Not Used Under Any Conditions)
1	0	Functional Test (Not Used Under Any Conditions)
1	1	Normal Operation (used in wraparound word 277)

Under Failure Warning and No Computed Data conditions, Discrete coded ARINC words are transmitted as Normal Operation.

In the case where two or more status/validity conditions are present, the priority of the status/validity condition is

Condition	Priority
Functional Test	1 (highest)
Failure Warning	2
No Computed Data	3
Normal Operation	4

Bits 30 and 31 are used for purposes other than SSM for labels 226 and 277.

Bit 32 is the parity bit for all labels. The 32 bit parity is odd for all output labels.

Note 2: Significant bits for BNR data is defined as the number of ARINC 429 data bits excluding the sign bit. The accuracy for each associated output is defined in Table 5.3.6-1.

Note 3: For BCD labels, the actual digital range is as specified. For BNR labels, the

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range is as specified for a negative value and is full scale minus 1 LSB for a positive value if not range limited. Output range may be limited by software.

Note 4: Air Data altitude reference to the IR is input limited between -2,000 and 60,000 feet. The inertial altitude may overshoot these limits before converging to the Air Data altitude. Bit weighting range of the output is 131072 feet.

Note 5: Low Pass Digital Butterworth filters are used to filter the digital signals before being transmitted on the ARINC 429 bus.

1-BW = 1st order Butterworth
2-BW = 2nd order Butterworth

Note 6: The filter bandwidth is defined as the –3 db cut-off point.

Note 7: The transport delays listed are the maximum required delays. The actual transport delay for each label may be considerably less than the listed value. The maximum transport delay for a 2nd order Digital Butterworth filter occurs at the -3 db break frequency. The maximum transport delay for a 1st order Digital Butterworth filter occurs when the frequency approaches 0 Hz. Delays specified are comprised of sensor input, filter, software, and output delays. The delays given may not be in agreement with the ARINC 704/738 specification, since the delays specified in this specification assume different filter breakpoints.

Note 8: Rounded (Actual) transmission rates are: 50(50), 25(25), 12(12.5), 6(6.25), 3(3.125).

Note 9: Least significant bit weighting of the output does not necessarily equate to the resolution of that output. Resolution is defined as the minimum monotonic step amplitude in the output for a given change in the input.

Note 10: Angular outputs are limited by software to $\pm$ 90 degrees. Bit weighting range of these outputs is 180 degrees.

Note 11: Data Loader SAL label 226 is only transmitted when data loading is enabled

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GPS ARINC 429 Digital Outputs

Signal	Oct Lbl	Cod[1]	Sig Bit[2]	Range[3]	LSB Wght[8]	MSB Wght	Units	Pos. Sense	Max Delay[5] (msec)	Act Delay[6] (msec)	Xfer Rate[7]
Autonomous Altitude	076	BNR	20	131072	0.125	65536	Feet	Up	200	2.9	1
Autonomous HDOP	101	BNR	15	0-1024	0.031	512	N/A	Always +	N/A	N/A	1
Autonomous VDOP	102	BNR	15	0-1024	0.031	512	N/A	Always +	N/A	N/A	1
Autonomous Track Angle	103	BNR	15	180	0.0055	90	Degrees	CW from N	N/A	N/A	1
Autonomous Latitude	110	BNR	20	90	0.000172	90	Degrees	North	200	3.6	1
Autonomous Longitude	111	BNR	20	180	0.000172	90	Degrees	East	200	3.9	1
Aut. Ground Speed	112	BNR	15	0-4096	0.125	2048	Knots	Always +	N/A	N/A	1
Aut. Latitude Fine	120	BNR	11	0.000172	8.38E-8	8.6E-5[4]	Degrees	North	200	5.4	1
Aut. Longitude Fine	121	BNR	11	0.000172	8.38E-8	8.6E-5[4]	Degrees	East	200	5.7	1
UTC	125	BCD	5	23:59.9	0.1	-	Hr:Min	Always +	N/A	N/A	1
Aut Hor Integrity Limit	130	BNR	18	0-16	6.1E-5	8	NM	Always +	N/A	N/A	1
Hyb Hor Integrity Limit	131	BNR	18	0-16	6.1E-5	8	NM	Always +	N/A	N/A	1
Hyb True Heading	132	BNR	15	180	0.0055	90	Degrees	CW from N	110	109	25
Aut Vert Integrity Limit	133	BNR	17	0-32768	0.25	16384	Feet	Always +	N/A	N/A	1
Hyb Vertical FOM	135	BNR	18	0-32768	0.125	16384	Feet	Always +	N/A	N/A	1
Aut Vertical FOM	136	BNR	18	0-32768	0.125	16384	Feet	Always +	N/A	N/A	1
Hyb Track Angle	137	BNR	15	180	0.0055	90	Degrees	CW from N	110	106.5	25
Terminal Area HIL	143	BNR	17	0-16	6.1E-5	8	NM	Always +	N/A	N/A	1
Terminal Area VIL	144	BNR	17	0-32768	0.25	16384	Feet	Always +	N/A	N/A	1
UTC (Binary)	150	BNR	17	23:59:59	1.0	16 Hr	H:M:S	Always +	N/A	N/A	1
Destination ETA	162	BNR	11	23:59	1 Min	16 Hr	H:M	Always +	N/A	N/A	3
Alt. Waypoint ETA	163	BNR	11	23:59	1 Min	16 Hr	H:M	Always +	N/A	N/A	3
Aut GPS Vert Velocity	165	BNR	15	+32768	1.0	16384	Ft/Min	Up	N/A	N/A	1
Aut GPS N-S Velocity	166	BNR	15	+4096	0.125	2048	Knots	North	N/A	N/A	1
Aut GPS E-W Velocity	174	BNR	15	+4096	0.125	2048	Knots	East	N/A	N/A	1
Hyb Ground Speed	175	BNR	15	0-4096	0.125	2048	Knots	Always +	110	106.9	25
Aut Horiz FOM	247	BNR	18	0-16	6.1E-5	8	NM	Always +	N/A	N/A	1
Hyb Latitude	254	BNR	20	90	0.000172	90	Degrees	North	160	106.7	12
Hyb Longitude	255	BNR	20	180	0.000172	90	Degrees	East	160	107.1	12
Hyb Latitude Fine	256	BNR	11	0.000172	8.38E-8	8.6E-5[4]	Degrees	North	160	108.2	12
Hyb Longitude Fine	257	BNR	11	0.000172	8.38E-8	8.6E-5[4]	Degrees	East	160	108.5	12
Date	260	BCD	6	31:12:99	1 Day	-	D:M:Yr	Always +	N/A	N/A	1
Hyb Altitude	261	BNR	20	131072	0.125	65536	Feet	Up	65	44	25
Hyb Flight Path Angle	263	BNR	12	90	0.044	90	Degrees	Up	110	107.2	25
Hyb Horiz FOM	264	BNR	18	0-16	6.1E-5	8	NM	Always +	N/A	N/A	1
Hyb N-S Velocity	266	BNR	15	4096	0.125	2048	Knots	North	110	106.0	12
Hyb E-W Velocity	267	BNR	15	4096	0.125	2048	Knots	East	110	106.4	12
GPS Sensor Status	273	DIS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1
Hyb Sensor Status	274	DIS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1
Destination HIL	343	BNR	13	0-16	1.95E-3	8	NM	Always +	N/A	N/A	3
Hyb Vertical Velocity	345	BNR	15	32768	1.0	16384	Ft/Min	Up	65	48	25
Alt. Waypoint HIL	347	BNR	13	0-16	1.95E-3	8	NM	Always +	N/A	N/A	3
GPS Rec. Maint.	352	DIS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1
Hyb Maintenance Word	353	DIS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1
GPS Nav Maint.	355	DIS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1

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GPS ARINC 429 Digital Outputs Notes:

Note 1: Per ARINC 429, the Sign Status Matrix for each of the two label formats (Binary and Discrete) are as follows.

BNR	Bits	
	31 30	Condition
	0 0	Failure Warning
	0 1	No Computed Data
	1 0	Functional Test
	1 1	Normal Operation

Disc	Bits	
	31 30	Condition
	0 0	Normal Operation
	1 0	Functional Test

Under Failure Warning and No Computed Data conditions, Discrete coded ARINC words are transmitted as Normal Operation.

In the case where two or more status/validity conditions are present, the priority of the status/validity condition is

Condition	Priority
Functional Test	1 (highest)
Failure Warning	2
No Computed Data	3
Normal Operation	4

Note 2: Significant bits for BNR data are defined as the number of ARINC 429 data bits excluding the sign bit.

Note 3: For BNR labels, the digital range is as specified for a negative value and is full scale minus 1 LSB for a positive value. Output range may be limited by software.

Note 4: Fine data words contain the truncated portion of the original data word. This information is unsigned although the sign bit is reserved. The two labels are concatenated (or combined) to form the complete data word. The MSB weight of these labels refers to the next most significant bit of the latitude or longitude signal after the LSB of the course signals. Note that these MSB weights are not exact.

Note 5: Transport delay requirements are per ARINC 704A.

Note 6: The actual transport delays are determined differently depending upon the label type.

The actual transport delays given for the hybrid labels 132, 137, 175, 254, 255, 256, 257, 261, 263, 266, 267, and 345 are based upon sensor, GPS processing, filter, and output delays.

Actual transport delays are not applicable for hybrid FOMs (135 and 264) and the Hybrid status and maintenance labels (274 and 353).

Note 7: Rounded (Actual) transmission rates are: 25(25), 12(12.5), 3(3.125), 1(1.5625).

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Note 8: Least significant bit weighting of the output does not necessarily equate to the resolution of that output. Resolution is defined as the minimum monotonic step amplitude in the output for a given change in the input.

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8.0 ASCB Interfaces

8.1 ASCB Version A/B

8.1.1 ASCB A/B Version selection

The HG2001GD20 IRU can receive and transmit ASCB data on two-wire (version B) or four-wire (version A) buses. Two-wire buses provide unclocked data transmissions, and four-wire buses provide data and clock signals on separate wire pairs. When the IRU powers on, it reads the ASCB 2W/4W Sel Discrete (A-E14) and the ASCB Data Sel Discrete (A-E13) Inputs:

- If the two discrete inputs are open, the HG2001GD20 IRU selects Version A.
- If the two discretes inputs are grounded, the HG2001GD20 IRU selects Version B.
- All other combinations of the two discrete inputs cause externally detectable invalid output data.

8.1.2 Ports

The HG2001GD20 IRU has two bi-directional ASCB version A output buses and two bi-directional ASCB version B buses on which ASCB data is transmitted.

8.2 ASCB Version C

8.2.1 ASCB version C Input Data

The HG2001GD03/GD40 IRU receives FMS and DADC inputs on its bi-directional ASCB buses.

- The HG2001GD03/GD40 IRU can receive required initialization and time data from an FMS when the FMS sends miscellaneous data (WSP 2 header code = 0001H) as a part of the FMS background set.
- The HG2001GD03/GD40 IRU can receive required air data inputs in ASCB format from one of four DADCs. Each DADC has a unique address, which is in bits 7 through 0 of WSP 1. Each also responds to a request address from the bus controller and transmits data during specific transmit frames.

8.2.2 ASCB version C Transmit Data

The HG2001GD03/GD40 IRU transmits IRS sensor data in normal or SPZ-8500/PRIMUS 2000XP formats based on the ASCB-C Select discrete input.

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- When ASCB-C version select discrete (B-C9) is open the IRU transmits the normal format.

- When the ASCB-C version select discrete (B-C9) is grounded the IRU transmits the format required for proper SPZ-8500/PRIMUS 2000XP interfacing.

8.2.3 ASCB version C Ports

The HG2001GD03/GD40 IRU has two bi-directional ASCB version C busses and an On-Side Backup bus (receive only) which ASCB data is transmitted and received.

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9.0 Output Parameter Accuracy

IR Digital Output Performance (ARINC-704 Specification)

Parameter	Limitations	Navigation Mode (1)	Reversionary Attitude Mode
Present Position	See note 2.	For times less than 10 hrs Accuracy = 2nmph R95 For times between 10 and 18 hrs Accuracy = 20 nm R95 Resolution = 1.72e-4 degrees	N/A
Pitch Angle	Pitch angle limited to |90| degrees.	Accuracy = 0.10 degrees 2σ Resolution = 4.12e-3 degrees	Accuracy = 2.5 degrees 2σ Resolution = 4.12e-3 degrees
Roll Angle	Held constant for pitch angles exceeding |85| degrees.	Accuracy = 0.10 degrees 2σ Resolution = 4.12e-3 degrees	Accuracy = 2.5 degrees 2σ Resolution = 4.12e-3 degrees
True Heading	Held constant for pitch angles exceeding |85| degrees.	Accuracy = 0.40 degrees 2σ Resolution = 6.87e-4 degrees	N/A in Reversionary Attitude
Magnetic Heading	Held constant for pitch angles exceeding |85| degrees. Accuracies valid for years 2010 through ~2030 based upon selecting appropriate magnetic variation map	Between N50 and S50 degrees Accuracy = 2 deg between 50N and 68N Accuracy = 3 deg between 50S and 60S Accuracy = 3 deg All other regions where magnetic heading is valid Accuracy = 4 deg Accuracies are 95% Absolute Accuracy = 10 degrees Resolution = 6.87e-4 degrees	Accuracy dependent upon entered heading Operational accuracy is 15 deg/hr maximum drift Resolution = 6.87e-4 degrees
Ground Speed	See note 2 and note 3	Accuracy = 10 knots R95 Resolution = 0.0156 knots	N/A
Vertical Velocity	Pressure altitude input required. Accuracy valid 120 seconds after vertical loop closure. Assumes no ADS errors. Accuracy valid over ADS altitude range of -2,000 to 60,000 feet.	Accuracy = 30 ft/min 2σ Resolution = 0.125 ft/min	Accuracy = 30 ft/min 2σ Resolution = 0.125 ft/min
Body Pitch Rate	Minimum range of 70 deg/sec.	Accuracy = 0.02 deg/sec or 0.5% of output whichever is greater Accuracy's are 2σ Resolution = 4.88e-4 deg/sec	Accuracy = 0.1 deg/sec or 1% of output whichever is greater Accuracy's are 2σ Resolution = 4.88e-4 deg/sec

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Parameter	Limitations	Navigation Mode (1)	Reversionary Attitude Mode
Body Roll Rate	Minimum range of 70 deg/sec.	Accuracy = 0.02 deg/sec or 0.5% of output whichever is greater Accuracy's are 2σ Resolution = 4.88e-4 deg/sec	Accuracy = 0.1 deg/sec or 1% of output whichever is greater Accuracy's are 2σ Resolution = 4.88e-4 deg/sec
Body Yaw Rate	Minimum range of 40 deg/sec.	Accuracy = 0.02 deg/sec or 0.5% of output whichever is greater Accuracy's are 2σ Resoluton = 4.88e-4 deg/sec	Accuracy = 0.1 deg/sec or 1% of output whichever is greater Accuracy's are 2σ Resolution = 4.88e-4 deg/sec
Pitch Attitude Rate	Minimum range of 30 deg/sec. Roll angle component held constant for pitch angles exceeding |85| degrees.	Accuracy = 0.1 deg/sec or 1% of output whichever is greater Accuracy's are 2σ Resolution = 4.88e-4 deg/sec	Accuracy = 0.1 deg/sec or 1% of output whichever is greater Accuracy's are 2σ Resolution = 4.88e-4 deg/sec
Roll Attitude Rate	Minimum range of 30 deg/sec. Set to zero for pitch angles exceeding |85| degrees.	Accuracy = 0.1 deg/sec or 1% of output whichever is greater Accuracy's are 2σ Resolution = 4.88e-4 deg/sec	Accuracy = 0.1 deg/sec or 1% of output whichever is greater Accuracy's are 2σ Resolution = 4.88e-4 deg/sec
Inertial Altitude	Pressure altitude input required. Accuracy specified with constant altitude input, and assumes no ADS error. Accuracy and resolution valid over ADS altitude range of -2,000 to 60,000 feet. Resolution assumes a maximum ADS granularity of 6 feet at an altitude rate of 8,000 ft/min.	Accuracy = 5 feet 2σ Resolution = 0.125 feet	Accuracy = 5 feet 2σ Resolution = 0.125 feet
Longitudinal Acceleration	Minimum sensing range of 4 Gs.	Accuracy = 0.005 Gs or 0.5% of output , whichever is greater Accuracy's are 2σ Resolution = 1.53e-5 Gs	Accuracy = 0.01 Gs or 1% of output , whichever is greater Accuracy's are 2σ Resolution = 1.53e-5 Gs
Lateral Acceleration	Minimum sensing range of 4 Gs.	Accuracy = 0.005 Gs or 0.5% of output , whichever is greater Accuracy's are 2σ Resolution = 1.53e-5 Gs	Accuracy = 0.01 Gs or 1% of output , whichever is greater Accuracy's are 2σ Resolution = 1.53e-5 Gs
Normal Acceleration	Minimum sensing range of 4 Gs.	Accuracy = 0.005 Gs or 0.5% of output , whichever is greater Accuracy's are 2σ Resolution = 1.53e-5 Gs	Accuracy = 0.01 Gs or 1% of output , whichever is greater Accuracy's are 2σ Resolution = 1.53e-5 Gs

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Parameter	Limitations	Navigation Mode (1)	Reversionary Attitude Mode
Unbiased Normal Acceleration	Minimum sensing range of 8 Gs.	Accuracy = 0.01 Gs or 1% of output , whichever is greater Accuracy's are 2σ Resolution = 3.05e-5 Gs	Accuracy = 0.01 Gs or 1% of output , whichever is greater Accuracy's are 2σ Resolution = 3.05e-5 Gs
Vertical Acceleration	Minimum sensing range of 4 Gs.	Accuracy = 0.01 Gs or 1% of output , whichever is greater Accuracy's are 2σ Resolution = 1.53e-5 Gs	Accuracy = 0.01 Gs or 1% of output , whichever is greater Accuracy's are 2σ Resolution = 1.53e-5 Gs
Flight Path Acceleration	Valid for Vg > 20 kts.	Accuracy = 0.01 Gs or 10% of output whichever is greater Accuracy's are 2σ Resolution = 1.53e-5 G's	N/A
Along Track Acceleration	Valid for Vg > 20 kts.	Accuracy = 0.01 Gs or 10% of output whichever is greater Accuracy's are 2σ Resolution = 1.53e-5 Gs	N/A
Cross Track Acceleration	Valid for Vg > 20 kts.	Accuracy = 0.01 Gs 2σ at 120 kts or greater Resolution = 1.53e-5 Gs	N/A
Platform Heading	Held constant for pitch angles exceeding |85| degrees.	Accuracy = 0.40 degrees 2σ Resolution = 6.87e-4 degrees	Accuracy dependent upon entered heading Operational accuracy is 15 deg/hr maximum drift
Track Angle True	Not computed when ground speed is below 20 knots. Accuracy requirement varies as a function of ground speed.	Accuracy = 4 deg 2σ at 120 kts or greater Accuracy = 2 deg 2σ at 230 kts or greater Resolution = 2.06e-3 degrees	N/A
Track Angle Magnetic	Not computed when ground speed is below 20 knots. Accuracy equals the RSS of Track Angle True error plus the Magnetic Variation error. Track Angle Magnetic error varies as a function of ground speed and present position.	For latitudes between 82 degrees South and 82 degrees North Accuracy= 5 deg 2σ at 120 kts or greater Resolution = 2.06e-3 degrees	N/A
Flight Path Angle	Not computed when ground speed is below 20 knots.	Accuracy = 0.4 degrees 2σ Resolution = 2.06e-3 degrees	N/A
Drift Angle	Not computed when ground speed is below 20 knots. Accuracy requirement varies as a function of ground speed. Heading component held constant for pitch angles exceeding |85| degrees.	Accuracy = 4 deg 2σ at 120 kts or greater Resolution = 2.06e-3 degrees	N/A

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Parameter	Limitations	Navigation Mode (1)	Reversionary Attitude Mode
Track Angle Rate	Not computed when ground speed is below 20 knots.	Accuracy = 0.25 deg/sec 2σ at 60 kts or greater Resolution = 1.22e-4 deg/sec	N/A
Wind Speed	No error assumed in ADS TAS input. See note 2.	Accuracy = 12 knots R95 Resolution = 9.77e-4 knots	N/A
Wind Direction	No error assumed in ADS TAS input. For Wind Speeds ≥50kts	Accuracy = 10 degrees 2σ Resolution = 4.4e-3 degree	N/A
N-S Velocity	See note 3.	Accuracy = 8 knots 2σ Resolution = 0.0156 knots	N/A
E-W Velocity	See note 3.	Accuracy = 8 knots 2σ Resolution = 0.0156 knots	N/A
Along Heading Accel	Minimum sensing range of 4 Gs. Roll angle component held constant for pitch angles exceeding |85| degrees.	Accuracy = 0.01 Gs or 1% of output , whichever is greater Accuracy's are 2σ Resolution = 1.53e-5 Gs	N/A
Cross Heading Accel	Minimum sensing range of 4 Gs. Roll angle component held constant for pitch angles exceeding |85| degrees.	Accuracy = 0.01 Gs or 1% of output , whichever is greater Accuracy's are 2σ Resolution = 1.53e-5 Gs	N/A

IR Digital Output Performance Notes:

Note 1: The term R95 represents the radial length of a circle which encompasses a 95% probable accuracy. The well known term 2σ represents two times the standard deviation of a Gaussian distribution. The term 95% represents percent probable accuracy. The resolution specified applies only to the BNR ARINC 429 data.

Note 2: Present position, ground speed, and wind speed are 2-dimensional parameters. The error in these parameters is computed as a vector difference between the observed and true values.

Note 3: N-S velocity and E-W velocity are single axis errors that are the components to the ground speed error vector.

General Note:

Some system performance values listed are from ARINC-704a as a minimum requirement. Actual performance may be better.

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Hybrid GPS System Performance

Parameter	SA[1]	Conditions	Navigation Mode[2]
Hyb Horizontal Position	Off	HDOP = 1.5	25 meters (2DRMS)
	ON	HDOP = 1.5	100 meters (2DRMS)
Hyb Ground Speed	Off	HDOP = 1.5	0.25 knots R95[3]
	On	HDOP = 1.5	1.8 knots R95[3]
Hyb Vertical Velocity	Off	VDOP = 2.0	30 feet/minute 2σ
	On	VDOP = 2.0	150 feet/minute 2σ
Hyb Track Angle True	Off	HDOP = 1.5[4]	0.10 degrees 2σ
	On	HDOP = 1.5[4]	0.70 degrees 2σ
Hyb North-South Velocity	Off	HDOP = 1.5	0.2 knots 2σ
	On	HDOP = 1.5	1.3 knots 2σ
Hyb East-West Velocity	Off	HDOP = 1.5	0.2 knots 2σ
	On	HDOP = 1.5	1.3 knots 2σ
Hyb Altitude	Off	VDOP = 2.0	150 feet 2σ
	On	VDOP = 2.0	500 feet 2σ
Hyb Flight Path Angle	Off	VDOP = 2.0[5]	0.15 degrees 2σ
	On	VDOP = 2.0[5]	0.80 degrees 2σ
Hyb True Heading	Off	None	0.4 degrees 2σ
	On	None	0.4 degrees 2σ

Hybrid GPS System Performance Notes:

Note 1:. Accuracies with SA on are based on an SA model which assumes a worst case dithering (i.e. no biases) with the following characteristics:

Natural Frequency	0.0174 radians/ second
Damping Ratio	0.4
Pseudorange Sigma	33.4 meters
Pseudorange Rate Sigma	0.39 meters/second

Note 2: The term R95 represents the 95% probable accuracy for a Rayleigh distribution. The term 2 σ represents two times the standard deviation of a Gaussian distribution. The term 2DRMS represents the root-mean-square value of the x-y distances (two-dimensional distance root-mean-square) from the true location point. The confidence value for a 2DRMS depends on the elongation of the error ellipse. As the error ellipse collapses to a line segment, the confidence value approaches 95 percent; as the error ellipse becomes circular, the confidence value approaches 98%.

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Note 3: The resolution of the ARINC output is 0.125 knots.

Note 4: Based upon a ground speed of 120 knots with circular error distribution.

Note 5: Based upon a ground speed of 120 knots.

General Note:

Some system performance values listed are from ARINC-704a as a minimum requirement. Actual performance may be better.

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