Inertial Labs
Attitude is Everything

MADE IN USA

ADVANCED SENSOR FUSION PLATFORM

INS-NV

MULTIROTOR UAV

FIXED WING UAV

VTOL UAV

VISUAL ODOMETRY

RF AIDED NAVIGATION + ALTNAV NAVIGATION (IRIDIUM PNT)

INERTIAL NAVIGATION

NAVIGATION IN GPS-DENIED

VISUAL NAVIGATION USING MAPPING

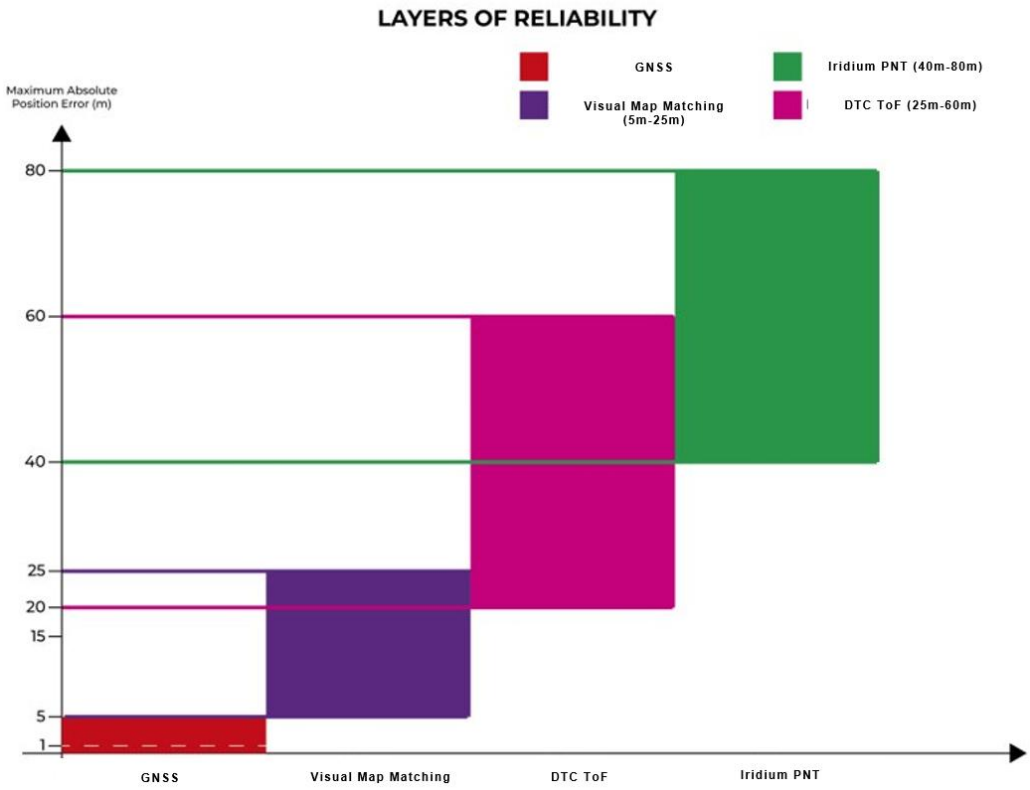
The **Inertial Labs NVIDIA Platform based Inertial Navigation System (INS-NV)** is the most advanced, modular and innovative inertial navigation system (INS) aided compute platform developed by Inertial Labs. **INS-NV** is the result of over 20 years of our experience in development of Inertial Navigation Systems solutions, signals of opportunities (SoOp) aided Alternative Navigation Algorithms (RF Ranging from Software Defined Radios (SDR) or STL signals from Iridium PNT) and Machine Vision Algorithms to be used in GPS-denied, Jamming and Spoofing Environments.

INS-NV is offered as an OEM or enclosed version. The NVIDIA-INS module consists of a fully integrated, Inertial Navigation System (INS) + Attitude & Heading Reference System (AHRS) + GNSS Receiver and NVIDIA Orin NX processor on a Hadron Carrier board. The platform is a high-performance strapdown system, that determines position, velocity and absolute orientation (Heading, Pitch and Roll) for Fixed-wing, VTOL and Multirotor Unmanned Aerial Vehicles. Horizontal and Vertical Position, Velocity and Orientation are determined with high accuracy for both motionless and dynamic applications, in GPS-enabled and GPS-denied environments. Moreover, optional add-ons from the Inertial Labs Aiding Data Ecosystem (IL-ADE) can be used as additional aiding data sources to increase a vehicle's reliability when navigating congested GNSS environments.

INS-NV is one of the most sophisticated Navigation Solutions and APNT sensor fusion modules on the market which allows Unmanned Aerial Vehicles to accomplish critical missions in congested GNSS environments.

Top Attributes of the INS-NV:

- Fully integrated navigation solution designed specifically for GNSS-denied and BLOS applications
- User defined output allows for interoperability with various sUAS/UAS platforms deployed.
- Modular architecture allows end user to choose the types of aiding data for any mission.
- Provides flight controller with continuous jamming and spoofing resilient orientation, position, velocity, and timing (OPVT) data.
- Readily available USB & Ethernet ports to support external sensors (e.g. cameras).
- Compatible with IL-VIU (Inertial Labs Visual Inertial Unit) – a fully calibrated miniAHRS and camera module in day/IR variants.
- User defined output allows easy inclusion in any Open System Architecture (xOSA).
- Custom development environment for user specific needs to meet mission critical objectives (i.e. ATR - Automatic Target Recognition, Reconnaissance & Surveillance, etc.)



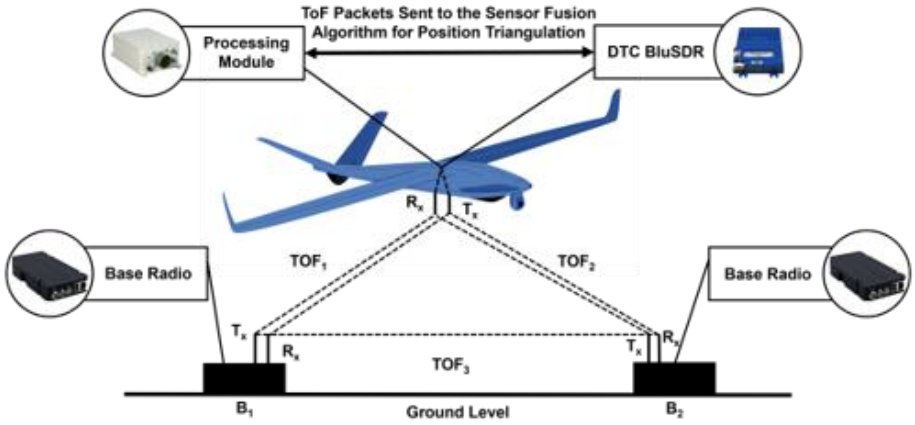
The INS-NV is embedded with a NVIDIA Orin NX processor which houses a development environment for pre-configured software for users to plan, control and log fusion data from all the different aiding data sources that are used with the INS's real time sensor fusion (Kalman filtering) algorithm. Users also have the ability to deploy their own custom developments and leverage the use of Inertial Labs' robust sensor fusion algorithm for custom software development that may be required for applications pertaining to Automatic Target Recognition (ATR), Assured PNT or other mission critical objectives. **INS-NV gives vehicles multiple layers of reliability with its versatile APNT algorithms and modular design that promise to integrate with any type of land, sea or aerial vehicle effortlessly.**

External Aiding Data Sources (Inertial Labs' Aiding Data Ecosystem – IL ADE):

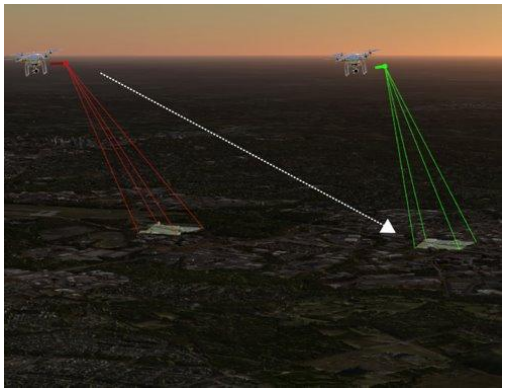
The Inertial Labs robust sensor fusion Kalman Filter algorithm is capable of seamlessly switching from aiding data streams depending on the environmental factors of a given mission to continuously provide a resilient GNSS-denied positioning solution. **Note: INS-NV is capable of operating with any component of the IL-ADE (Upon Request).**

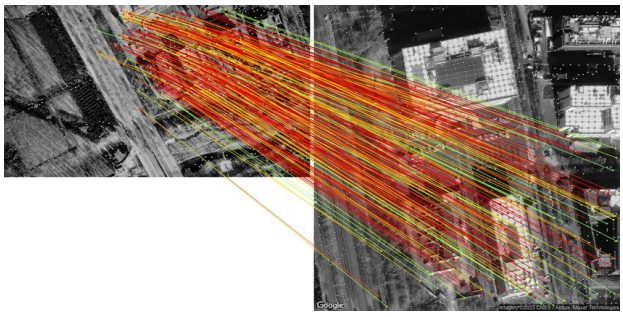
- **Iridium PNT (ALTNAV Receiver):** The Iridium PNT receiver (STL-2600) provides SVI (Space Vehicle Information) data in a "PJLTSVI" message format, which provides the INS' tightly coupled filter with doppler, signal time of arrival (TOA), pseudo ranges, carrier-to-noise ratio, and satellites' orbital position and velocity vectors.
  When these raw observables are injected into a mathematical model that correctly propagates the receiver and system state with each valid time increment, the Inertial Labs tightly coupled navigation filter can then estimate precise vehicle position within static and dynamic applications.

- **DTC BluSDR RF Ranging:** Inertial Labs INS-based RF Ranging with DTC SDR uses SoOP (Signals of Opportunities) to triangulate an aerial vehicle's position in complete GNSS-denied environments. DTC's LPI/LPD (Low Probability of Intercept/Detection)- based RF technologies significantly reduce the chances of jamming/spoofing RF signals.
  Live RF-based ranges can be easily viewed and tracked on a real-time map by accessing the mission computer's web panel during any stage of an operational mission. This feature provides end users with complete visibility over the system's operating state to achieve mission objectives.



- **Visual Navigation:**
  - **VIO – Visual Inertial Odometry** is a visual aiding algorithm that estimates accurate ground speed by observing gradual changes in captured terrain imagery at low or high altitudes.
  - **VPS – Visual Positioning System** is real-time map matching of features. VPS produces 3D position estimates (<25m RMSE) that are provided as aiding data to the onboard INS's Kalman filter.





NVIDIA Orin-Nx Specifications:

Model	Jetson Orin Nx, 1024 CUDA cores and 32 Tensor cores, a 6-core Arm Cortex-A78AE CPU, 8GB RAM (128-bit LPDDR5), up to 70 TOPS (AI Performance)
Orin NX – BSP (Board Support Package)	Orin NX L4T r35.2.1 BSP
Storage	M.2 NVMe 1TB SSD (For Offline Maps, real-time logging, etc.)
Interfaces	Serial (UART, SPI, I2C), 1 Gb/s Ethernet, GPIO, USB 2.0/3.0
OS	JetPack 5.1.0 (Orin NX Only)

INS-NV Performance Specifications (Based on Inertial Labs Aiding Data Ecosystem)

Parameter	GNSS-Enabled	GNSS-Denied
Horizontal Position (VIO)	1 meter	<1% DT
Horizontal Position (VPS)	1 meter	<25 meters
Horizontal Position with RF Ranging aiding data	1 meter	<60 meters
Horizontal Position with Iridium PNT aiding data	1 meter	<80 meters
Vertical Position	2 meters	<5 meters
Velocity	0.03 m/sec	<1 m/sec
Heading	0.1 deg	<1 deg
Pitch & Roll	0.03 deg	<0.1 deg

INS-NV mechanical specifications**:**

- Size: 111 x 75 x 92 mm (L x W x H)
- Size (OEM): 107 x 68 x 92 mm (L x W x H):
- Weight: 480g

INS-NV electrical specifications:

- Input power: 9 to 36 V DC
- Power consumption: 15 W
- Interface: RS-232, RS-422, Ethernet, GPIO, USB 2.0, PPS output, Camera Strobe I/O.

Optional IL-VIU Components:

(Day Camera Option)

- Fusion of a high precision optical camera and miniature Attitude & Heading Reference System (miniAHRS).
- ±2000 deg/sec MEMS Gyroscope.
- ±15 g MEMS Accelerometer.
- Fluxgate Magnetometer.
- Heading, Pitch & Roll.
- Up to 2048x1576 grayscale camera images per GEN<i>CAM interface over USB2.0.
- Camera strobe pulses (3VTTL, configurable polarity)
- Camera intrinsic calibration and alignment to the miniAHRS, accessible in camera's NVMe.

(IR Camera Option)

- Fusion of a high precision optical camera and miniature Attitude & Heading Reference System (miniAHRS).
- ±2000 deg/sec MEMS Gyroscope.
- ±15 g MEMS Accelerometer.
- Fluxgate Magnetometer.
- Heading, Pitch & Roll.
- Up to 640 x 512 IR camera images, Boson+ Driver, interface over USB2.0.
- Camera strobe pulses (3VTTL, configurable polarity).
- Camera intrinsic calibration and alignment to the miniAHRS, accessible in camera's NVMe.

IL-VIU General Specifications:

Main Component	Weight	Size
VIU (FLIR BFS -> Day Camera)	430 grams	80 x 100 x 78 mm
VIU (Boson+ -> IR Camera)	330 grams	83 x 100 x 80 mm
OEM VIU (FLIR BFS -> Day Camera)	170 grams	68 x 62 x 49 mm
OEM VIU (Boson+ -> IR Camera)	80 grams	62 x 56 x 49 mm

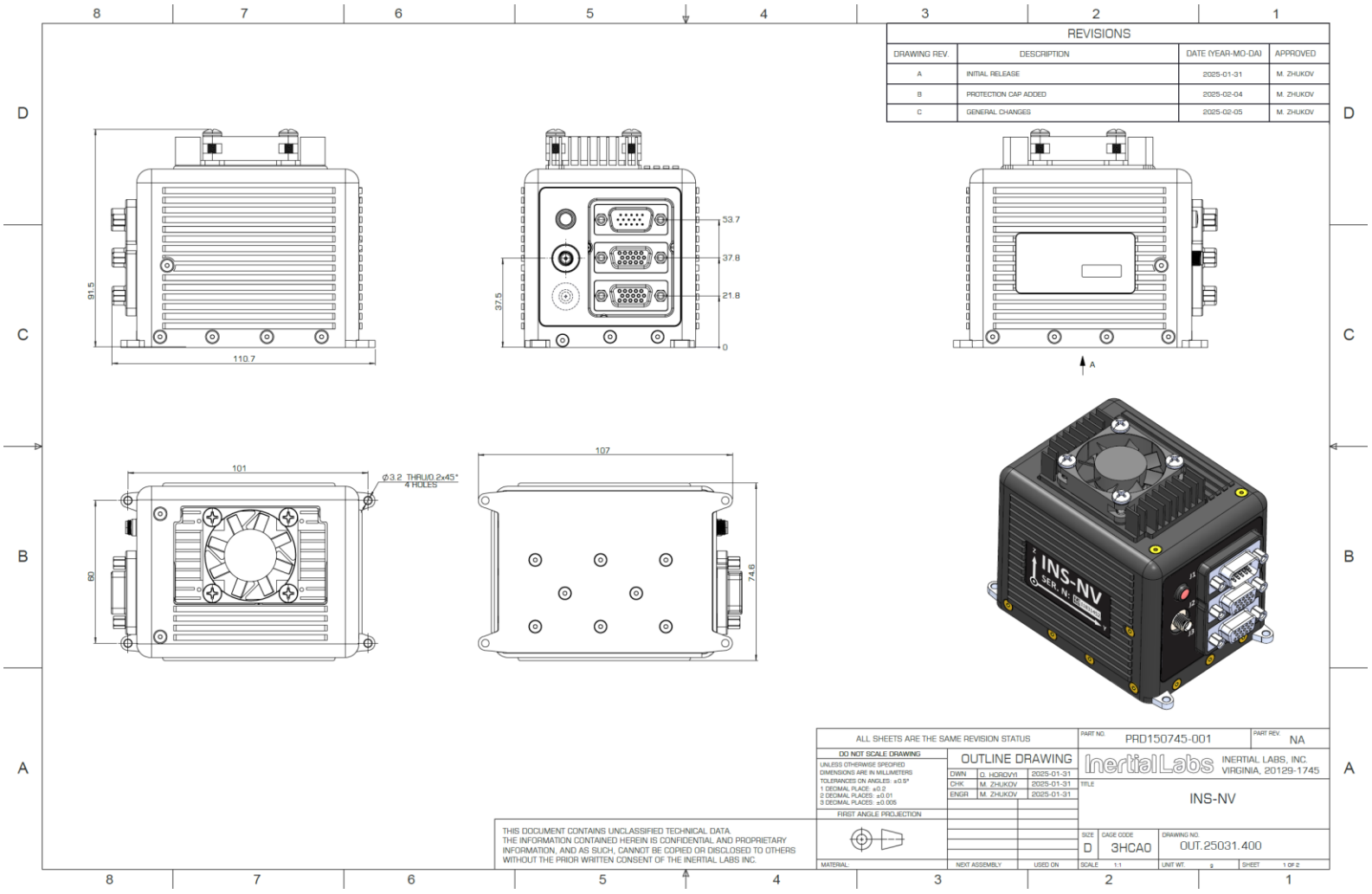
IL-VIU Camera Calibration Specifications:

Camera Calibration Parameters:	Definition:
Intrinsics	
Cx	Normalized coordinates of the optical axis projection onto the image sensor (The principal point in pixel coordinates).
Cy	
Fx	Focal length component scale factors defining the image sensor size and pixel flatness.
Fy	
Extrinsics	
Yaw	Small camera misalignment angles relative to the IMU center in Euler Angle format.
Pitch	
Roll	
Lens Distortion Coefficients (Rational Polynomial Model)	
K1	Lens distortion coefficients that are used within the following manner: d= (1+k1*r^2) / (1+ k4*r^2)
K4	

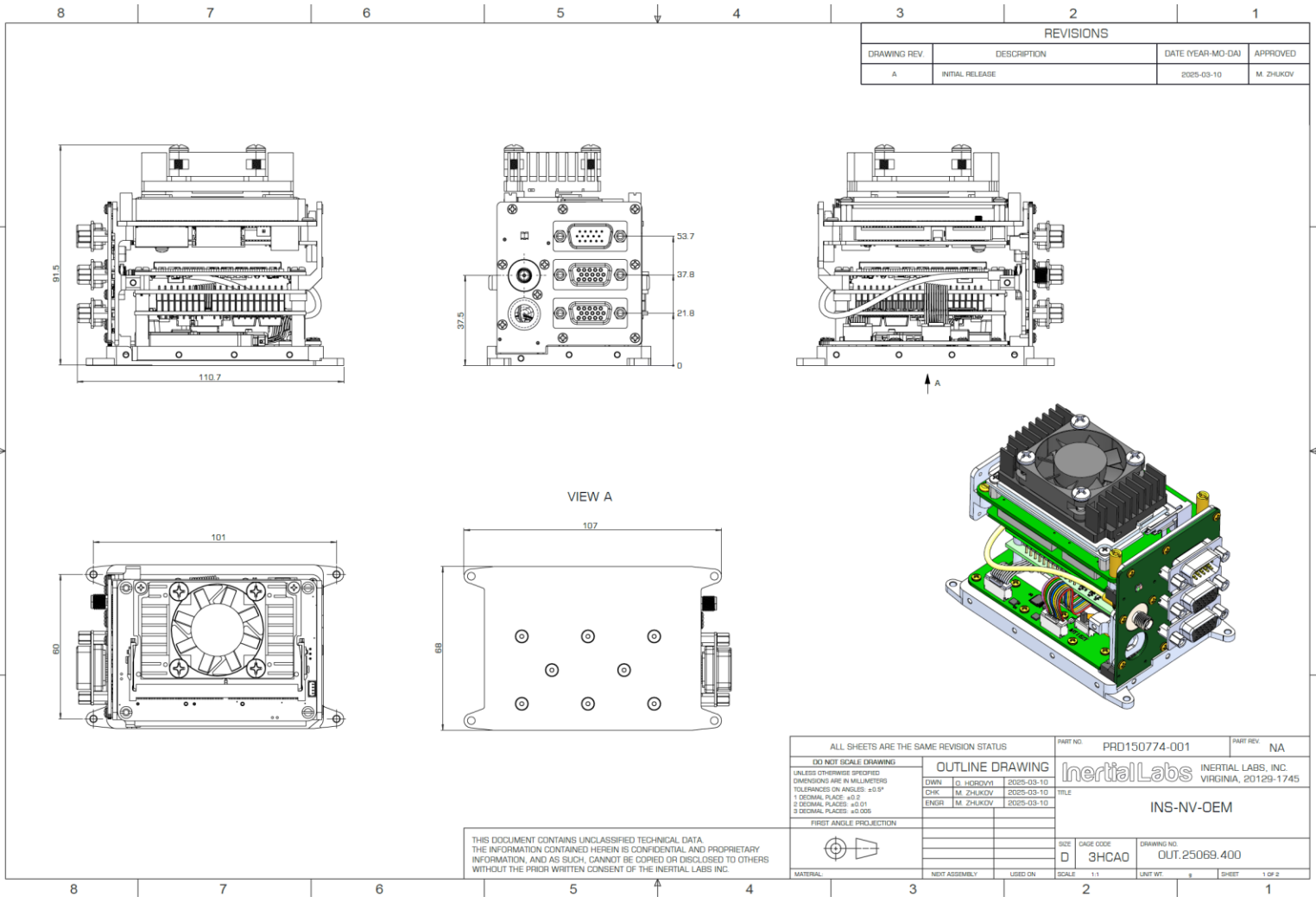
- Formulas related to formation and utilization of the camera calibration matrix for undistorting camera imagery can be found within the following knowledge base link: https://docs.opencv.org/4.x/d9/d0c/group__calib3d.html

- Each sensor module is embedded with highly precise factory camera calibration parameters that do not require additional dynamic alignment maneuvers for end user application use.

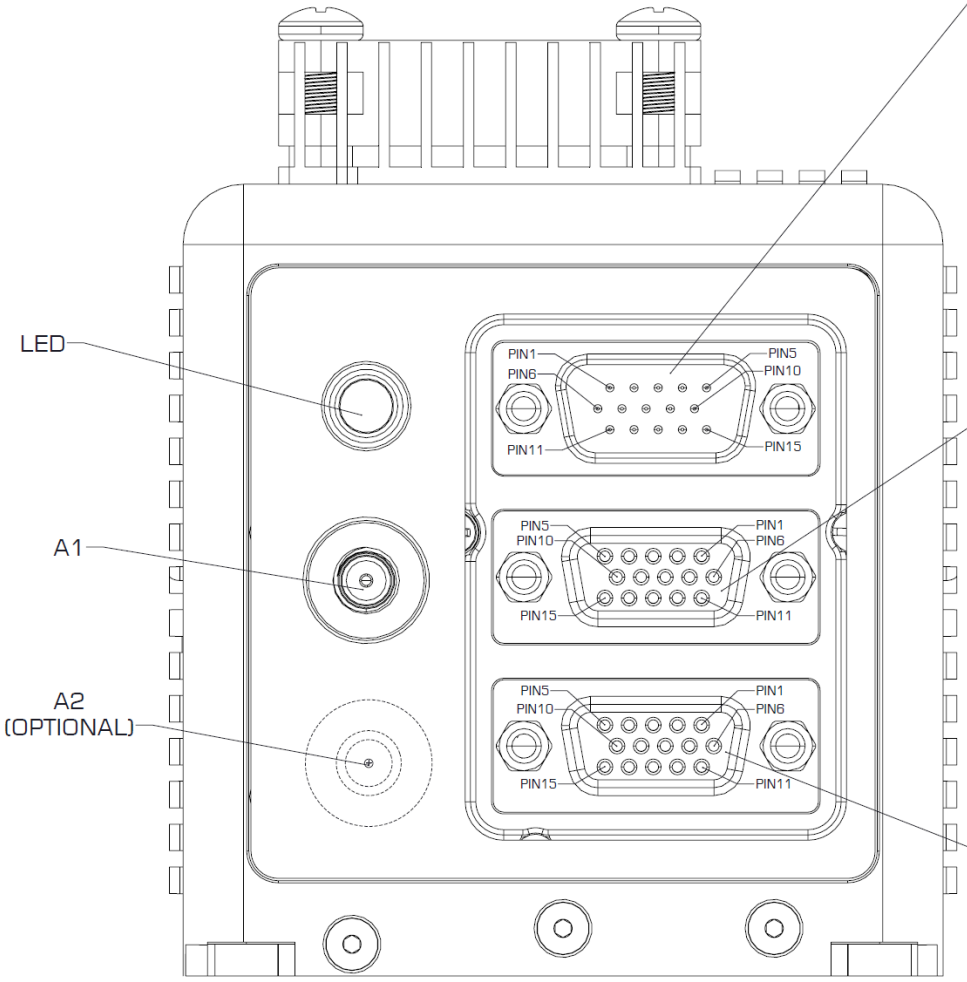
INS-NV Engineering Drawing:



INS-NV-OEM Engineering Drawing:



INS-NV Interface Panel Pinout Diagram:



X1
K86X-ED-15P-BR (MALE)

1	VIN	SUPPLY INPUT
2	GND	SUPPLY RETURN
3	NC	NOT CONNECTED
4	1Gb_ETH2-	NVIDIA ETHERNET
5	1Gb_ETH2+	NVIDIA ETHERNET
6	VIN	SUPPLY INPUT
7	GND	SUPPLY RETURN
8	1Gb_ETH3-	NVIDIA ETHERNET
9	1Gb_ETH3+	NVIDIA ETHERNET
10	1Gb_ETH1-	NVIDIA ETHERNET
11	VIN	SUPPLY INPUT
12	GND	SUPPLY RETURN
13	1Gb_ETH0+	NVIDIA ETHERNET
14	1Gb_ETH0-	NVIDIA ETHERNET
15	1Gb_ETH1+	NVIDIA ETHERNET

X2
K86X-ED-15S-BRJ (FEMALE)

1	USB1_D_N	NVIDIA USB1
2	USB1_D_P	NVIDIA USB1
3	USB1 VSUP	NVIDIA USB1
4	USB0_D_N	NVIDIA USB0
5	USB0_D_P	NVIDIA USB0
6	USB0 VSUP	NVIDIA USB0
7	GND	SUPPLY RETURN
8	GPIO10	NVIDIA GPIO 10
9	GPIO13	NVIDIA GPIO 13
10	IMU_TOV	IMU TOV INPUT
11	IMU-RS422-TX+	IMU DATA
12	IMU-RS422-TX-	IMU DATA
13	IMU-RS422-RX+	IMU DATA
14	IMU-RS422-RX-	IMU DATA
15	SUPPLY OUT	SUPPLY OUTPUT

X3
K86X-ED-15S-BRJ (FEMALE)

1	GND	SIGNAL GROUND
2	RS232_RX1	INS COM1 RS232
3	RS232_TX1	INS COM1 RS232
4	RS232_RX0	NVIDIA DEBUG PORT
5	RS232_TX0	NVIDIA DEBUG PORT
6	RS232_RX3	INS COM3 RS232
7	RS232_TX3	INS COM3 RS232
8	GNSS_PPS	GNSS 1PPS IN/OUT
9	RS232_RX4	INS COM4 RS232
10	RS232_TX4	INS COM4 RS232
11	GNSS_EV2	GNSS EVENT/MARK
12	100Mb_ERHX+	INS ETHERNET
13	100Mb_ERHX-	INS ETHERNET
14	100Mb_ETHX+	INS ETHERNET
15	100Mb_ETHX-	INS ETHERNET