NODAR

HDK Datasheet

Hammerhead Development Kit

Ultra-Wide Baseline Stereo Vision for Ultra-Long-Range Detection

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Technical Specifications v2.0.1

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OVERVIEW

Welcome to the NODAR HDK

The NODAR Hammerhead Development Kit (HDK) is a complete stereo vision platform for evaluating and integrating ultra-wide baseline depth perception into autonomous vehicles, robotics, and industrial automation systems. The HDK ships with automotive-grade 5.4 MP HDR stereo cameras and a ruggedized NVIDIA Orin processing unit pre-loaded with NODAR Hammerhead software, delivering color point clouds and occupancy maps out of the box.

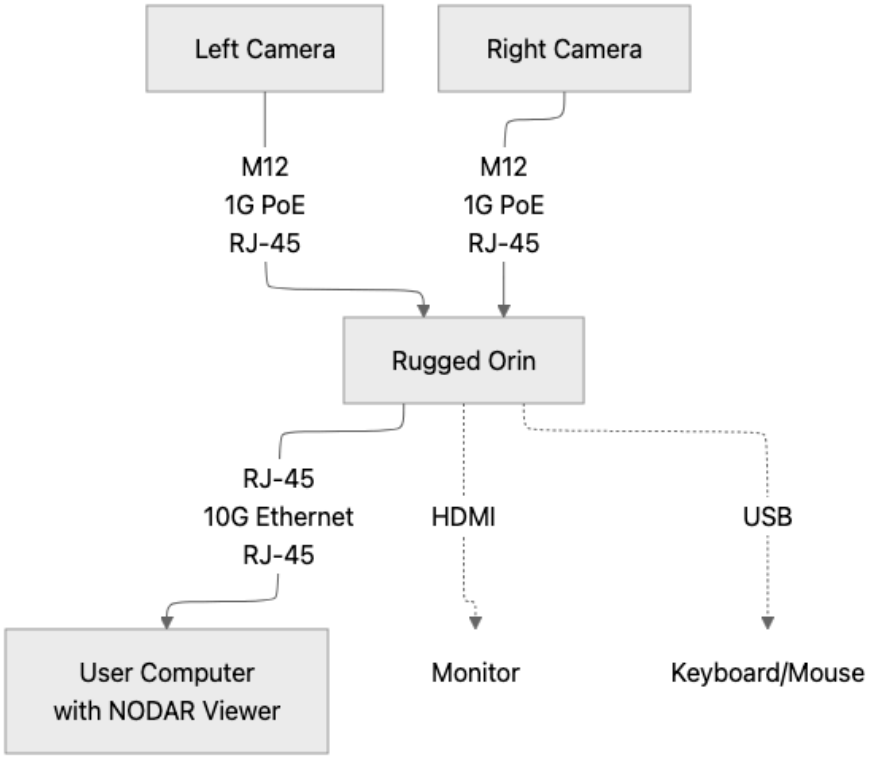
Ultra-wide baseline stereo vision revolutionizes depth perception by expanding baseline distances from 100 mm to 1000 mm — 10 times wider than conventional setups. This extended baseline increases depth accuracy and range by a factor of 10, enabling precise 3D vision over greater distances for applications in autonomous vehicles, robotics, and industrial automation.

Experience the power of HDR Stereo Vision!

System Architecture

The left camera and right camera are each connected to the ruggedized Orin processing unit via 1G PoE (Power over Ethernet), enabling power and data transmission through the same cable. The Orin is connected to the user system via 10G Ethernet, providing high-speed data transfer to the user's computing environment. The Orin also connects to a monitor using HDMI, providing a visual interface for output. Additionally, the Orin is connected to a keyboard and mouse through USB, enabling user interaction for system control.

The NODAR Viewer can be installed on the Orin or the user computer. Note that the Viewer takes up some GPU resources, so it does reduce the frame rate when running on the Orin.

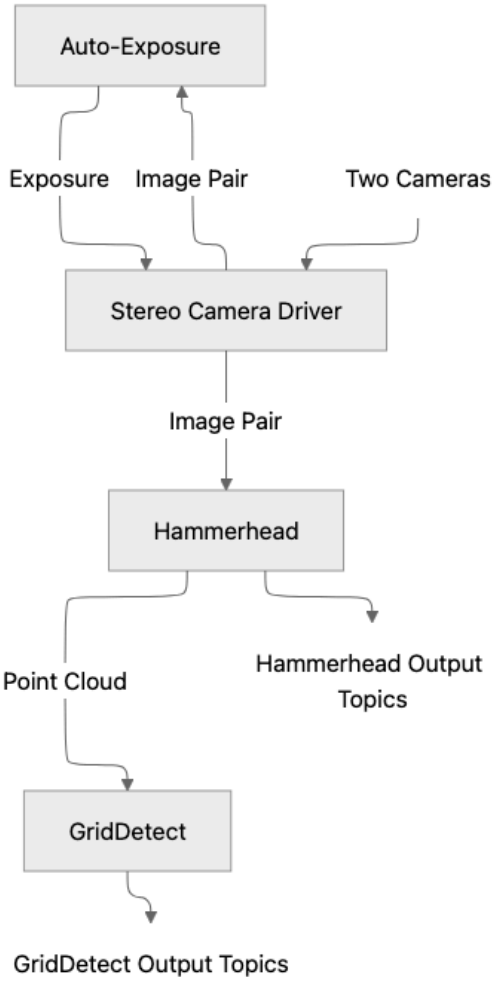


HDK Software Stack

NODAR HDK software runs on the ruggedized Orin and consists of three blocks:

- Stereo Camera Driver - captures images from two cameras.
- Auto-Exposure - automatically sets the camera exposure for both left and right cameras. The feedback loop is limited to approximately 1 second.
- HDK API - converts raw images into high-quality color point clouds and occupancy maps. Supports ROS2, ZeroMQ, and a ZeroMQ/ROS2 bridge.

The input and output topics are discussed in the linked API documentation. Data fields that can currently be recorded through the NODAR Viewer are found on the NODAR Documentation site.



SPECIFICATIONS

Camera Specifications

Parameter	Value
Class	Automotive
Format	5.4 MP HDR
Resolution	2880 × 1860 pixels
Pixel Size	3 µm
Shutter	Rolling Shutter
HDR Type	Two photodiodes and four TIAs
Dynamic Range	120 dB
Companded Bit Depth	16-bit
Exposure	86 µs to 47 ms
Gain	0 to 30 dB
Ingress Protection	IP67
Focus	Infinity
Lens Mount	S-mount
IR Filter	650 nm cutoff
Synchronization	PTP (IEEE 1588)
Camera-to-Camera Timing Jitter	10 µs average, <20 µs maximum
Data Rate per Camera	<1 Gbit/s (800 Mbit/s typical)

Lens Options

Option	Focal Length	Ingress Protection
30° FOV	16 mm	IP67
65° FOV	6.8 mm	IP69
135° FOV	4.0 mm	IP69

3D Specifications

Parameter	30° FOV	65° FOV	135° FOV
Horizontal Field of View	30°	65°	135°
Vertical Field of View	19.4°	42°	87°
Baseline B	1 m	1 m	0.5 m
Disparity Search Range	1024 pixels (0–1023)	1024 pixels (0–1023)	1024 pixels (0–1023)
Minimum Depth (Z_{min})	5.23 m	2.20 m	0.65 m
Maximum Depth (±2% range error)	1067 m	450 m	—
IFOV (Instantaneous Field of View)	0.01°	0.026°	0.043°
Focal Length (f = 1/IFOV)	5333 pixels	2250 pixels	1333 pixels

Disparity is related to depth by the equation $D = \frac{fB}{z}$, where D is the disparity in pixels, f is the focal length in pixels, B is the baseline length, and z is the depth to the object.
Instantaneous Field of View (IFOV) is the angle subtended by one pixel.

Disparity Discretization

Disparity Range	30° FOV	65° FOV	135° FOV
0–127 pixels	1/16 pixel	1/16 pixel	1/16 pixel
127–511 pixels	1/8 pixel	1/8 pixel	1/8 pixel
511–1023 pixels	1/4 pixel	1/4 pixel	1/4 pixel

Disparity Error

Condition	30° FOV	65° FOV	135° FOV
Good weather	±0.1 pixel	±0.1 pixel	±0.1 pixel
Bad weather (32 mm/hr rain)	±0.3 pixel	±0.3 pixel	±0.3 pixel

Disparity error is median disparity when measuring a flat target.

Depth Precision — Good Weather

Range	30° FOV (1 m baseline)	65° FOV (1 m baseline)	135° FOV (0.5 m baseline)
10 m	±0.8 cm	±0.8 cm	—
20 m	±1.6 cm	±1.8 cm	—
30 m	±3.4 cm	±4.0 cm	—
50 m	±4.7 cm	±11.1 cm	—
100 m	±18.8 cm	±44.4 cm	—
200 m	±75 cm	±178 cm	—
300 m	±169 cm	±400 cm	—

Depth precision is range-dependent and derived from the disparity error according to $dz = \frac{z^2}{fB}\times\text{pixel error}$, where f is the focal length in pixels, B is the baseline length, and z is the depth to the object.

Lateral Resolution

Range	30° FOV	65° FOV
10 m	0.2 cm	0.4 cm
20 m	0.4 cm	0.9 cm
30 m	0.7 cm	1.5 cm
50 m	0.9 cm	2.2 cm
100 m	1.9 cm	4.4 cm
200 m	3.8 cm	8.9 cm
300 m	5.6 cm	13.3 cm
500 m	9.4 cm	22.2 cm
1000 m	18.8 cm	44.4 cm

Minimum Detectable Object Size (Tire on Road)

	30° FOV TP 50%	30° FOV TP 80%	30° FOV TP 90%	65° FOV TP 50%	65° FOV TP 80%	65° FOV TP 90%
10 m	1 cm	1 cm	2 cm	2 cm	3 cm	4 cm
20 m	2 cm	3 cm	4 cm	4 cm	6 cm	9 cm
30 m	3 cm	4 cm	6 cm	7 cm	9 cm	13 cm
50 m	5 cm	7 cm	9 cm	11 cm	16 cm	22 cm
100 m	9 cm	13 cm	19 cm	22 cm	31 cm	44 cm
150 m	14 cm	20 cm	28 cm	33 cm	47 cm	67 cm
200 m	19 cm	26 cm	38 cm	44 cm	62 cm	89 cm
300 m	28 cm	39 cm	56 cm	67 cm	93 cm	133 cm

Minimum detectable object size of a tire on a road using 1-m baseline and GridDetect. GridDetect uses a particle filter approach and is a recursive filter like a Kalman filter so that the tracker state at frame "t" has all the accumulated information up to that frame. For practical purposes, it can be thought to integrate over approximately three frames. The ranges corresponding to true positive (TP) detection probabilities of 50, 80, and 90% are reported for a tire on a road. The TP detection range increases with higher contrast objects and depends on the number of pixels on the target, with 50% corresponding to 5 x 5 pixels, 80% corresponding to 7 x 7 pixels, and 90% corresponding to 10 x 10 pixels.

The minimum detectable object size with high confidence is 7 pixels wide. According to the table, the thinnest object at 100-m range is 13-cm wide using the 30° FOV lenses.

The smallest height object at 150 meters is 7 pixels high, or 26 cm, using 30° FOV lenses (see table for the minimum detectable object size).

Calibration

Hammerhead applies continuous per-frame online calibration to maintain stereo alignment under vibration, temperature change, and mechanical drift. Hammerhead also offers a factory calibration routine that can be run at the factory or whenever there is a large uncertainty of the camera extrinsic parameters. Extrinsic parameters are automatically calibrated; intrinsic parameters are currently not calibrated.

Factory Calibration

Parameter	Value
Run Time	30 seconds
Maximum Relative Angular Search Range	3°
Absolute Range Calibration	Included

Online Calibration

Parameter	30° FOV	65° FOV
Update Rate	Every frame	Every frame
Max Angular Search Range per Frame	0.05°	0.125°
Vibration Bandwidth	∞ Hz	∞ Hz

For cars, the vibration bandwidth exceeds the Nyquist rate of the camera. For example, engine vibrations may be between 100-300 Hz, which far exceed the standard video frame rates of 10, 15, 20, 30, and 60 Hz. Therefore, calibration every frame is required for calibration because it is not possible to interpolate the extrinsic camera parameters between multiple frames.

Although our calibration can handle any perturbation speed, the captured images become blurred with excessive vibration amplitude, and blurring gradually degrades stereo matching performance. In practice, with short camera exposure time with respect to the angular perturbation rate, the blurring effect is small, and the vibration is negligible and can largely be disregarded.

Mechanical, Electrical, and Environmental Specifications

Stereo Camera

Parameter	Value
Camera-to-Camera Spacing	1 meter
Dimensions	97 × 173 × 1100 mm
Power Consumption per Camera	3.1 W
Compliance	CE, FCC, RoHS, REACH, WEEE
Storage Temperature	-30 to 60°C
Operating Temperature	-20 to 55°C ambient
Humidity	20% ~ 80%, relative, non-condensing
Shock and Vibration	DIN EN 60068-2-27, 60068-2-64, 60068-2-6
Industrial EMC Immunity	DIN EN 61000-6-2
Ingress Protection	IP67
Hermetically Sealed	No
M12-to-RJ45 Cable Length	15 m (two cables from stereo camera to the Orin)

Computer

Parameter	Value
Processor	NVIDIA AGX Orin
Operating Temperature	-25°C to 55°C
Regulatory Certifications	CE, FCC, RoHS, UKCA
Shock / Vibration	IEC 60068-2-64, IEC 60068-2-27
DC Power Input Range	9 VDC to 36 VDC (≤130 W)
Power Connector	DC Power input via 4-Pin DIN Molding Style Connector

Weight

Item	Weight
Stereo camera (1-m baseline)	7.4 lbs
Ruggedized Orin computer	4.0 to 9.4 lbs (model-dependent)
Computer power supply	2.6 lbs
Two M12-to-RJ45 ethernet cables (15 m)	3.4 lbs
Shipping box (complete kit)	33 lbs

Shipping box dimensions: 48 × 16.5 × 11.5 inches.

INSTALLATION

Mounting Configurations

The HDK sensor bar supports three mounting configurations. The bottom center has a 1/4"-20 threaded hole for tripod use. Four additional 1/4"-20 threaded holes at the bar ends are used for vehicle or infrastructure mounts.

Tripod Mount

Mount the center threaded hole to a standard camera tripod. A solid, smooth-motion tripod is recommended. The tripod shown in the image above is the SIRUI AM-25S professional heavy-duty tripod.

Item	Make	Model	Quantity
Heavy duty tripod	SIRUI	AM-25S	1

Vehicle Roof Mount

The bottom of the HDK bar has four 1/4-20" threaded holes on the left and right ends. Two of the threaded holes are used for eyebolts for safety straps, and two are used for magnetic or suction cup mounts with ball heads.

Item	Make	Model	Quantity
Magnetic Camera Mounting Base with Mini Ball Head	ULIBERMAGNET	ULIMAG-D6608YT-INCH	2
Suction Cup Mounts (using ball head above)	SeaSucker	VM1002W	2
Eye bolt, 1/4"-20 threaded (use hex nut to set orientation)	Multiple	Multiple	2
Safety lashing straps	SeaSucker	0.75" x 48''	2

Infrastructure Mount

Two threaded holes on the back of the enclosure allow attachment to walls or fixed structures. To securely attach the sensor head, we recommend RAM mounts or similar mounts.

Item	Make	Model	Quantity
Round plate	RAM Mounts	RAM-202U	2
Socket arm	RAM Mounts	RAM-201U-B	2
Threaded stud	RAM Mounts	RAP-379U-252050	2

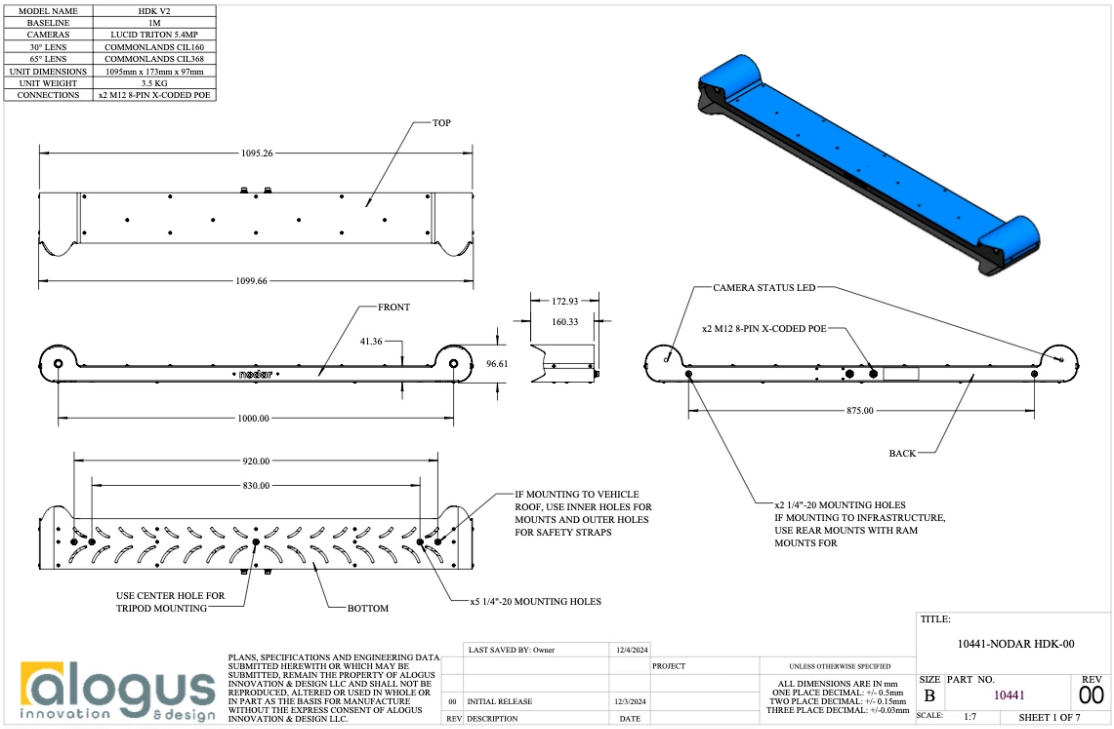
OPTIONS

Hardware Reference Design and SDK

The HDK hardware design is available for licensing and seamless integration into your product ecosystem. Each reference design includes a comprehensive technical package:

- **CAD Models:** Native SolidWorks files for easy modification.
- **Manufacturing Instructions:** Detailed assembly drawings and instructional videos for manufacturing.
- **Full BOM:** A complete Bill of Materials covering hardware, optics, cables, and computing components.

Licensing grants a non-exclusive, worldwide, perpetual right to modify and deploy these designs within your own hardware products. Refer to the Reference Design License Term Sheet for details.



NODAR SDK

The NODAR SDK includes example code for interfacing with the HDK using ROS2 and ZMQ. Full documentation is available from the HDK Communication documentation and the SDK documentation in our GitHub repository: https://github.com/nodarhub.

ORDERING

Ordering Information

Part Number Structure

NDR-HDK-2.0-xxx-yy[-A]

- xxx = 50 for 50-cm baseline | xxx = 100 for 100-cm baseline | xxx = U for an untethered system
- yy = 30 for 30° FOV | yy = 65 for 65° FOV | yy = 135 for 135° FOV
- Append -A to include the ruggedized Orin computer (e.g., NDR-HDK-2.0-100-65-A)

Example Part Numbers

Part Number	Description
NDR-HDK-2.0-100-30	Hammerhead Development Kit v2.0, 1 m baseline, 30° FOV. Sensor head only.
NDR-HDK-2.0-100-65	Hammerhead Development Kit v2.0, 1 m baseline, 65° FOV. Sensor head only.
NDR-HDK-2.0-100-65-A	Hammerhead Development Kit v2.0, 1 m baseline, 65° FOV, with ruggedized Orin computer.
NDR-HDK-2.0-U-65-A	The Hammerhead Development Kit v2.0 with untethered cameras, 65° FOV lenses and ruggedized Orin computer.
NDR-HDK-2.0-A	Orin AGX computer with Hammerhead software. No stereo camera.
NDR-HW-REF-2.0	Hardware reference design with perpetual, worldwide license

Bill of Materials

NDR-HDK-2.0-xxx-yy

#	Description	Qty
1	Stereo camera, IP67, 5.4 MP	1
2	M12-to-RJ45 CAT-6a ethernet cable, 5-m length	2

3	Quick start card	1

NDR-HDK-2.0-xxx-yy-A

#	Description	Qty
1	Stereo camera, IP67, 5.4 MP	1
2	M12-to-RJ45 CAT-6a ethernet cable, 5-m length	2
3	Quick start card	1
4	Ruggedized AGX Orin computer	1
5	AGX Orin power supply	1
6	OWC 10gb ethernet to usb adapter	1

About NODAR

NODAR develops ultra-wide baseline stereo vision software for autonomous vehicles, robotics, and industrial automation. The Hammerhead platform is proven across automotive and industrial deployments and is the foundation of the HDK development system.

Website	nodarsensor.com
Technical documentation	docs.nodarsensor.net
Integration enquiries	support@nodarsensor.com