Intel® RealSense™ LiDAR Camera L515

Datasheet

Intel® RealSense™ LiDAR Camera L515

Revision 003

January 2021

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1 Description and Features

Description

The Intel® RealSense™ LiDAR Camera L515 is Intel's first release of a LiDAR camera enabling highly accurate depth sensing in a small form factor.

Small enough to fit in the palm of your hand, the L515 is 61mm in diameter and 26mm in height. At approximately 100g, it's designed to be easily situated on any system, or attached to a tablet or phone. It also runs at less than 3.5W, considerably lower than competing time-of-flight (TOF) solutions. All depth calculations run on the device resulting in true platform independence.

With a short exposure time of <100ns per depth point, even rapidly moving objects can be captured with minimal motion blur. Optimized for indoor lighting, the L515 processes over 23 million depth points per second via a custom made ASIC. The product has been designed for use case flexibility with the inclusion of an RGB camera and an inertial measurement unit.

Features

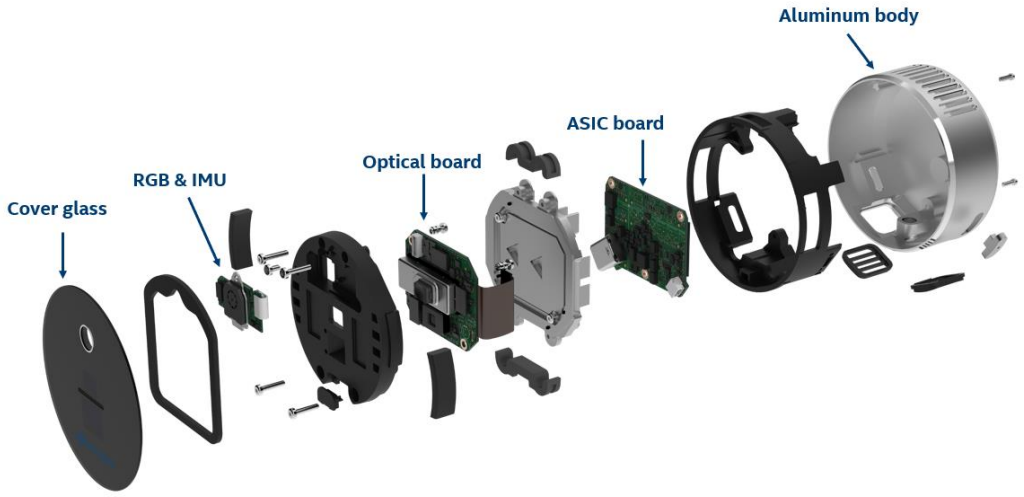
- Depth Capture from 0.25 to 9m(1)
- 2MP RGB Camera(2)
- Inertial Measurement Unit (IMU)
- Up to 30FPS Depth at 1024x768 (XGA)
- Up to 30FPS Color at 1920x1080 (FHD)
- Class 1 Laser Compliant
- Device Accuracy Health(2)

(1) Tested at 95% reflectivity.
(2) RGB camera always on.

Minimum System Requirements

USB 3.1 Gen1
Ubuntu*16.xx/18.04 LTS
Windows*10 (build 15063 or later)

Figure 1-1. Intel® RealSense™ LiDAR Camera L515 Exploded View



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2 Introduction

2.1 Purpose and Scope of this Document

This document captures the specifications for the Intel® RealSense™ LiDAR Camera L515.

2.2 Terminology

Table 2-1. Terminology Table

Term	Description
Depth	Depth video streams are like color video streams except each pixel has a value representing the distance away from the camera instead of color information
FOV	Field Of View (FOV) describes the angular extent of a given scene that is imaged by a camera. A camera's FOV can be measured horizontally, vertically, or diagonally
Host System	Computer or SOC connected to depth camera
IR Laser	This refers to the source of infrared (IR) light used for illuminating a scene, object, or person to collect depth data.
IMU	Inertial Measurement Unit is a system-in-package for the detection of acceleration in 3 dimensions and rotations in 3 dimensions.
LiDAR	Light Detection and Ranging is a remote sensing technology that measures the distance to objects and targets using a combination of laser light and receivers.
MEMS	Micro-Electro-Mechanical System
RH	Relative humidity
TBD	To Be Determined. In the context of this document, information will be available in a later revision.

2.3 LiDAR Technology Overview

The Intel® RealSense™ LiDAR Camera L515 uses an IR laser, a MEMS, an IR photodiode, an RGB imager, a MEMS controller, and a vison ASIC. The MEMS is used to scan the IR laser beam over the entire field-of-view (FOV). The L515 vision ASIC will process the data from the reflected beam captured by the photodiode and will output a depth point representing the accurate distance of a specific point in the scene from the camera. Aggregation of the depth points will generate a point cloud depth data representing the full scene.

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3 Functional Specification

3.1 Depth Camera Specification

Table 3-1. Depth Specification

Depth Resolution	Number of depth points per second	FOV[1]	Range @ 15% reflectivity[2]	Range @ 95% reflectivity[2]
QVGA (320x240)	2.3M	70° x 55°	0.25 - 3.9m	0.25 - 9m
VGA (640x480)	9.2M	70° x 55°	0.25 - 3.9m	0.25 - 9m
XGA (1024x768)	23.6M	70° x 55°	0.25 - 2.6m	0.25 - 6.5m

[1] Due to mechanical tolerances, FOV can vary +/- 2 degrees.

[2] Max range is specified for the center 10% ROI of the image, as long as the operating conditions are met.

3.1.1 Camera Accuracy Health

In order to ensure the long-term optimal accuracy of the L515's cutting edge depth technology, Intel® has implemented an additional accuracy assurance method utilizing the RGB camera. The feature runs on the host as part of the Intel® RealSense™ SDK 2.0 and will require a few RGB frames to be sent to the host. These RGB frames are used to analyze the scene and compared with the depth camera to verify alignment between both cameras.

The accuracy health-test and maintenance feature is automatically enabled and all customers gain this feature without any user interaction.

To ensure complete transparency, this functionality is in the Intel® RealSense™ SDK 2.0 open source SDK (LibRealSense).

3.2 Depth Camera Controls and Data Format

In order to achieve optimal performance of the camera, three presets are offered based on the desired range of the application.

Table 3-2. Depth Camera Controls

Preset	Description
Max Range	This preset is useful when there is no ambient light in the scene (fully indoors use case, with no light coming through windows). With this preset the laser power is set to maximum as well as the receiver gain which optimize the depth quality in indoor conditions.

Preset	Description
Short Range	This preset lowers the laser power and gain so that close objects do not oversaturate the receiver. This allows operation at a close distance to objects. This setting may not be good if objects further away in the scene also need to perform well.
No Ambient Light	Same as Max Range preset, this preset is useful when there is no ambient sunlight in the scene. The main difference between the presets is the laser power which is lower on this preset to avoid false depth on objects that are on longer distances than the ambiguity range (10m-VGA, 6.5m-XGA).
Low Ambient Light	This preset is recommended for environments where there may be a low amount of ambient sunlight present. Similar to Max Range preset the laser power is set to maximum but the receiver gain is reduced to avoid saturation of the camera due to ambient sunlight. The preset is also recommended for cases that the user wants to detect close objects (<50cm).

Table 3-3: Depth and Infrared Data Formats

FORMAT	KEY	TYPE	DESCRIPTION
Depth	Z	16b UINT	Depth format equating to distance from the device subassembly planar surface to the object.
Infrared	Y8	8b UINT	IR image representing the intensity of the reflected IR laser reflected off the objects in the scene.
Confidence	C	4b UINT	Provides a per pixel confidence value, 0xF equals high confidence and 0x0 represents low confidence.

3.3 Depth Quality Metrics

Table 3-4: Depth Quality Metrics

METRIC	DEFINITION
Depth Accuracy	Represents the average difference of valid pixels relative to ground truth.
Depth Standard Deviation	Represents the total spread (noise) of the depth values relative to ground truth.

Figure 3-1. Depth Quality Metric Illustration

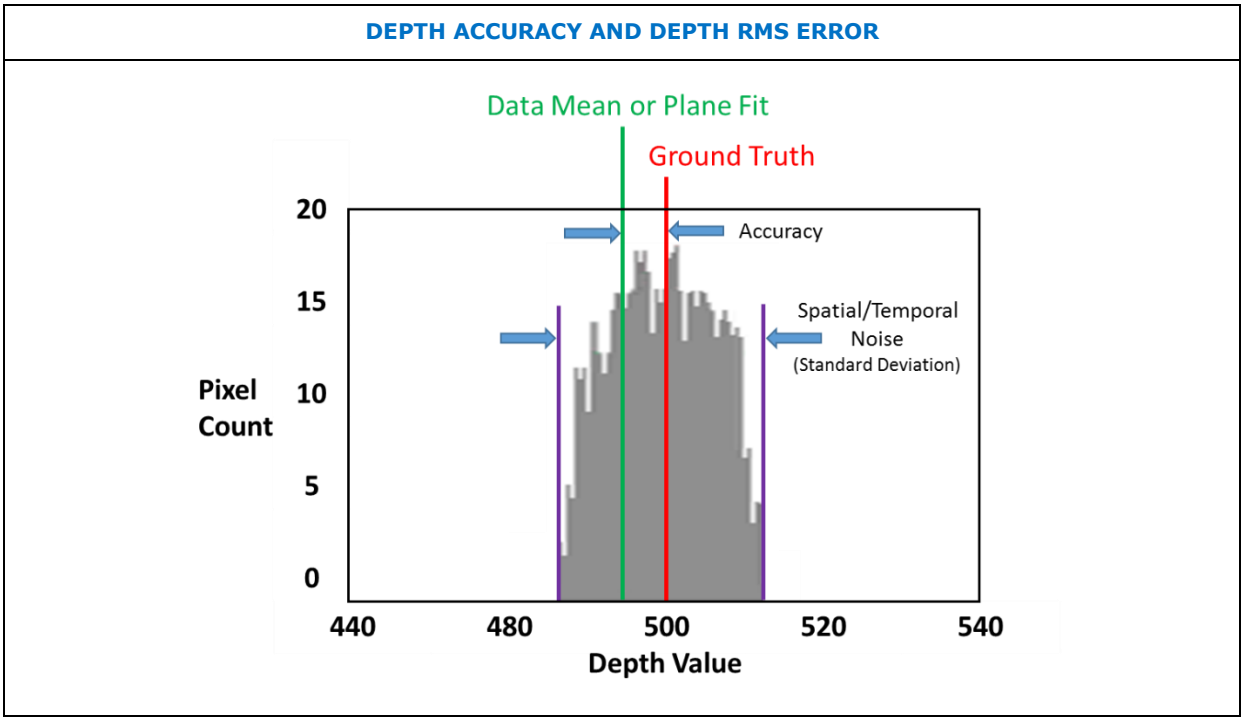


Table 3-5. Depth Quality Specification

Metric	Value	Notes
Depth Accuracy – Avg	< 5mm @ 1m < 14mm @ 9m	VGA resolution, 95% reflectivity
Depth – Std Dev	2.5mm @ 1m 15.5mm @ 9m	VGA resolution, 95% reflectivity
Exposure Time	< 100ns per depth point	Robust against motion blur
Lighting Condition	< 500 lux sunlight (0.4uW/cm2/nm)	

3.4 Depth Start Point (Ground Zero Reference)

The depth start point or the ground zero reference can be described as the starting point or plane where depth = 0. For LiDAR camera (L515), this point is referenced from front of camera cover glass

Figure 3-2. LiDAR Camera Depth Start Point Reference

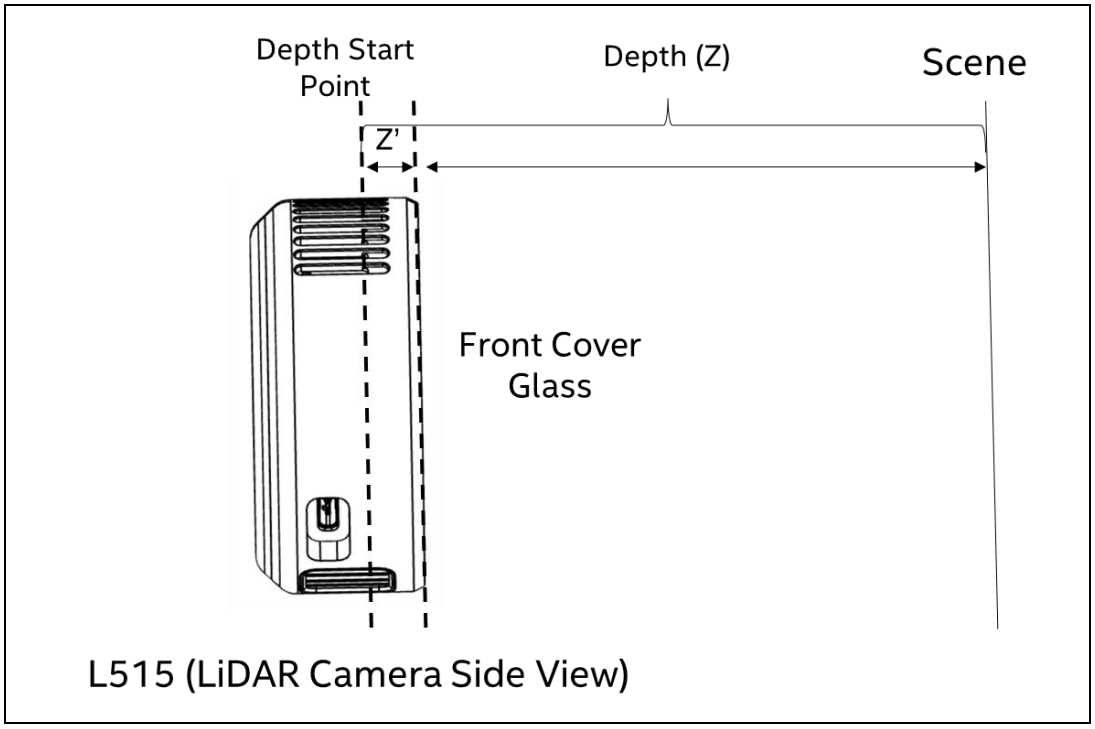


Table 3-6. LiDAR Depth Start Point

LiDAR Camera	Camera Front Glass (Z')
L515	-4.5mm

NOTES:

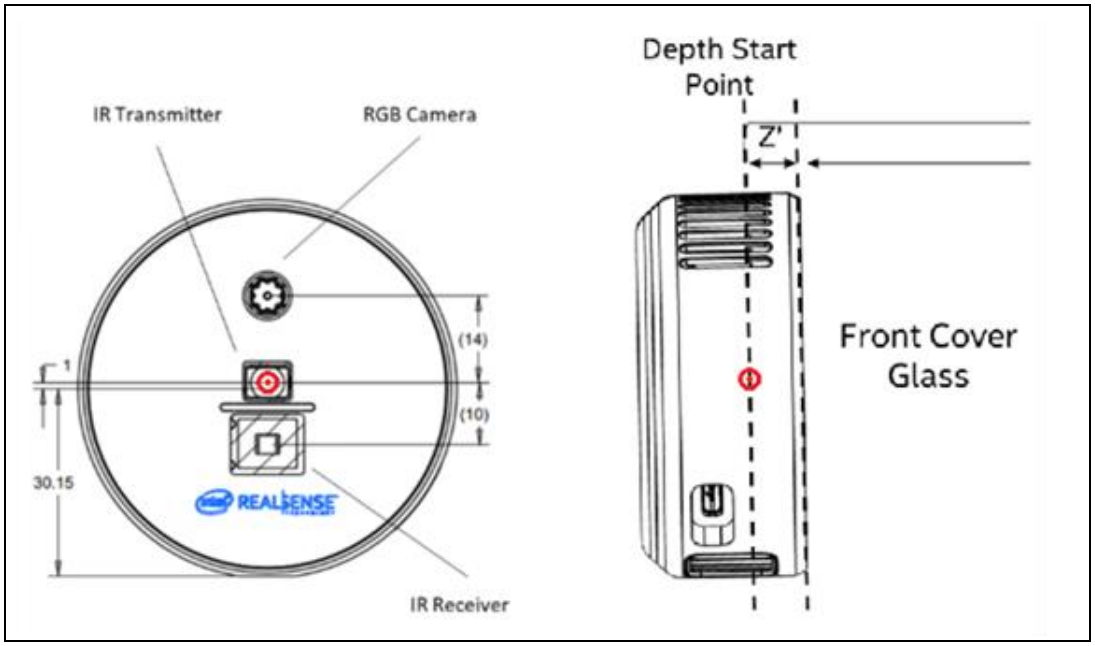
If depth measurement reference is front cover glass, then |Z'| should be added to measured value to determine Ground Truth.

This value can be read via Intel® RealSense™ SDK 2.0 APIs. Please see the latest SDK for reference.

3.4.1 Depth Origin X-Y Coordinates

The depth origin X-Y coordinates is the X-Y center of the IR Transmitter.

Figure 3-3. LiDAR Camera X-Y Depth Origin Reference



3.5 Image Formats and Color Camera Functions

Table 3-7. Image Formats

Format	Resolution	Frame Rate (FPS)	Comment
YUY2	1920x1080	6,15,30	Color Stream from RGB camera
	1280x720	6,15,30,60	
	960x540	6,15,30,60	

NOTE:

Color camera frame rates are expressed as nominal. Effective frame rates can vary depending on the exposure settings of the camera. Camera settings that increase the exposure time can decrease the effective frame rate.

Table 3-8. Color Camera Controls

Control	Description	Min	Max
Auto-Exposure Mode	Automatically sets the exposure time and gain for the frame.	0x1	0x8
Manual Exposure Time	Sets the absolute exposure time when auto-	1	10000

Control	Description	Min	Max
	exposure is disabled.		
Brightness	Sets the amount of brightness applied when auto-exposure is enabled.	-64	64
Contrast	Sets the amount of contrast based on the brightness of the scene.	0	100
Gain	Sets the amount of gain applied to the frame if auto-exposure is disabled.	0	4096
Hue	Sets the amount of hue adjustment applied to the frame.	-180	180
Saturation	Sets the amount of saturation adjustment applied to the frame.	0	100
Sharpness	Sets the amount of sharpening adjustment applied to the frame.	0	100
White Balance Temperature Control	Sets the white balance when AWB is disabled.	2800	6500
White Balance Temperature Auto (AWB)	Enables or disables the AWB algorithm.	0	1
Power Line Frequency	Specified based on the local power line frequency for flicker avoidance.	Disabled 50Hz 60Hz Auto	
Backlight Compensation	Sets a weighting amount based on brightness to the frame.	0	255

3.6 IMU Specification and Operating Modes

Table 3-9. Inertial Measurement Specifications

Parameter	Properties
Model	Bosch BMI085
Degrees of Freedom	6
Acceleration Range	±4g
Accelerometer Output Data Rate	100Hz/200Hz/400Hz

Gyroscope Range	±1000 Deg/s
Gyroscope Output Data Rate	100Hz/200Hz/400Hz
Data Format	32b Float

Accelerometer and gyroscope data streams from the onboard IMU are available via Intel® RealSense™ SDK 2.0.

3.7 L515 Device Firmware Update (DFU)

The firmware contains the operation instructions. Upon runtime, Vision ASIC loads the firmware and programs the component registers. If the Vision ASIC is configured for update or recovery, the unlocked R/W region of the firmware can be changed.

3.7.1 Update

During a firmware update, the firmware utility will issue a device firmware update command to the Vision ASIC. The Vision ASIC will then reset into firmware update mode. The firmware utility uses a single binary file to maintain the firmware image.

3.7.1.1 Update Limits

The firmware update engine does not allow infinite update cycles between older and current versions of firmware. The engine will establish a baseline version of firmware based on the latest firmware version installed. The engine will allow a return to a previous version or baseline version of firmware up to 20 times. After the 20th update, the engine will only allow an update to a firmware revision higher than the baseline version.

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4 Intel® RealSense™ LiDAR Camera L515 Hardware Specification

4.1 L515 Device Components

Table 4-1. Main components

Component	Description
BMI085	Accelerometer and Gyroscope in a single package
OV2740	RGB image sensor
IR emitter	860nm IR laser

4.2 Color Camera Properties

Table 4-2. Color Camera Properties

Parameter	Camera Sensor Properties
Color Image Signal Processor	Embedded*
Active Pixels	1920 X 1080
Sensor Aspect Ratio	16:9
Format	1/6”
F Number	2.0
Focal Length	1.88mm
Focus	Fixed
Shutter Type	Rolling Shutter
Signal Interface	MIPI CSI-2, 2X Lanes
Horizontal Field of View	69° +/-1°
Vertical Field of View	42° +/-1°

* arm This product uses Arm® Assertive Camera™ technology by Arm Limited.

4.3 Camera L515 Power Consumption

The Intel® RealSense™ LiDAR Camera L515 is powered through USB VBUS power connected to host platform via USB type-C connection. The same cable is used for data transfer.

Table 4-3. Power Requirements

Parameter		Min	Nom	Max	Unit
VCC	Supply Voltage	4.5	5	5.5	V

Table 4-4. Power Consumption

Model	Idle Power (W)	Normal Power (W) *Typical Usage Configuration (@ 25ºC)*	Notes
L515	0.8	3.0	Depth (VGA)
		3.2	Depth (VGA) + RGB (1080p, 30FPS)
		3.1	Depth (XGA)
		3.3	Depth (XGA) + RGB (1080p, 30FPS)

4.4 Camera Interface

The interface to L515 is USB 3.0 Type-C. Standard USB3 cables with max over-mold size of 6.5mmx12mm are supported.

4.5 Camera L515 Storage and Operating Conditions

Table 4-5. Storage and Operating Conditions

Parameter	Condition	Min	Max	Unit
Storage (Still Air), Not Operating	Sustained, Controlled (1)	0	50	ºC
	Short Exposure (2)	-20	70	ºC
	Humidity, Non-Condensing	Temperature/ RH: 40ºC / 90%		
Operating(3)(4)	Ambient temperature range when the device is streaming	0	30	ºC
Skin Temperature @ 25C Ambient(3)(4)	Camera housing temperature	N/A	50	ºC

NOTE:

(1) Controlled conditions should be used for long term storage of product.

(2) Short exposure represents temporary max limits acceptable for transportation conditions.

(3) Under typical indoor air flow.

(4) Depth and RGB enabled simultaneously.

4.6 Material, Vendor and Device ID

4.6.1 Camera L515 Product Identifier and Material Code

Table 4-6. Product Identifier and Material Code

Production	Product Material Code
Camera L515	999NGF

4.6.2 Vendor Identification (VID) and Device Identification (DID)

Table 4-7. Vendor ID and Device ID Table

Depth Module/Depth Camera	Vendor ID	Device ID
Intel® RealSense™ LiDAR Camera L515	8086	0x0B64

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5 Software (SDK)

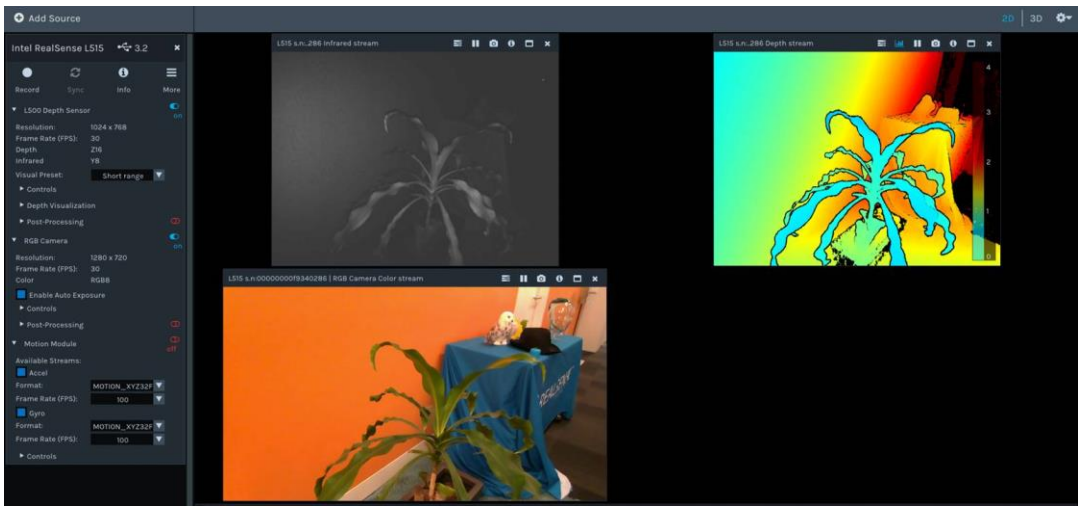
5.1 Intel® RealSense™ Software Development Kit 2.0

Intel® RealSense™ SDK 2.0 is a cross-platform library for working with Intel® RealSense™ LiDAR Camera L515. It is open source and available on https://www.intelrealsense.com/sdk-2/

The SDK at a minimum includes:

- **Intel® RealSense™ Viewer** - This application can be used view, record and playback depth streams, set camera configurations and other controls.
- **Depth Quality Tool** - This application can be used to test depth quality, including: distance to plane accuracy, Z accuracy, standard deviation of the Z accuracy and fill rate.
- **Debug Tools** - These command line tools gather data and generate logs to assist in debug of camera.
- **Code Examples** - Examples to demonstrate the use of SDK to include D400 Series camera code snippets into applications.
- **Wrappers** -Software wrappers supporting common programming languages and environments such as ROS, Python, Matlab, node.js, LabVIEW, OpenCV, PCL, .NET and more

Figure 5-1. RealSense Viewer – L515



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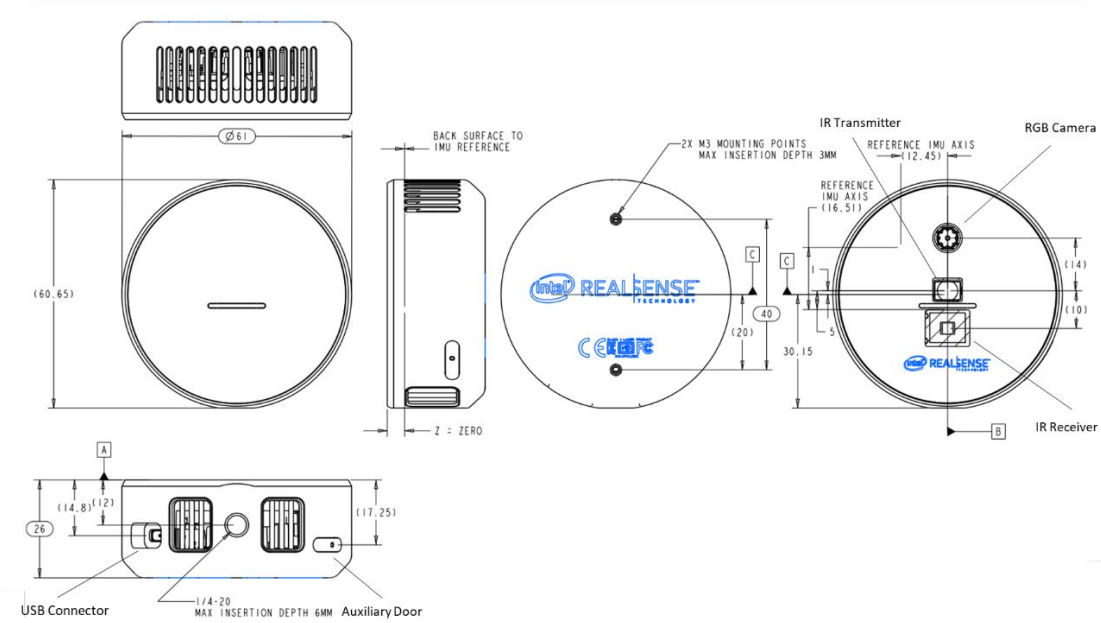
6 Mechanical Specifications

6.1.1 Mechanical Dimensions

Table 6-1. Intel® RealSense™ LiDAR Camera L515 Mechanical Dimensions

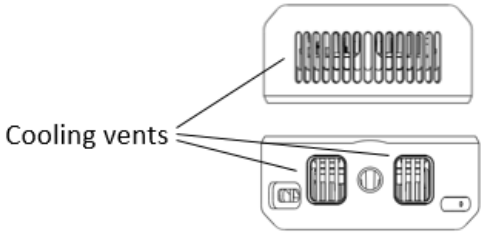
Dimension	Nominal	Unit
Diameter	61	mm
Height	26	mm
Weight	95	g

Figure 6-1. Intel® RealSense™ LiDAR Camera L515



When integrated into system, it is recommended that the L515 be secured via the two M3 mounting screw holes on the back of the product. The cooling vents need to remain unobstructed at all times.

Figure 6-2. Intel® RealSense™ LiDAR Camera L515 Cooling Vents



The cooling vents need to remain unobstructed at all times. Clearance of 12mm needed around the vents for airflow.

6.2 L515 Cover Material Cleaning Procedure

1. Do not use any chemical or water on the camera cover material
2. Remove dust and dirt as much as possible from the cover material with a lens blower brush.
3. Wipe with a dry, clean micro-fiber cloth.

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7 Regulatory Ecology Compliance

7.1 System Laser Compliance

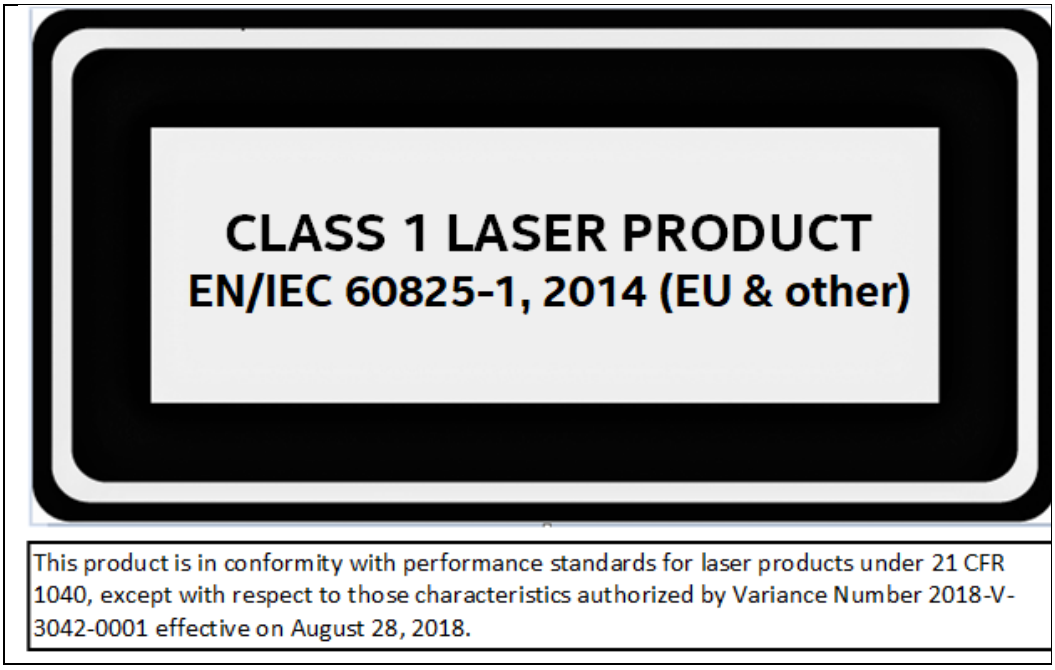
The Intel® RealSense™ LiDAR Camera L515 certification is transferable to the system and no system recertification is required. However, the following statements and labels must be included in the user manual of the end product.

7.1.1 Certification Statement

This product is classified as a Class 1 Laser Product under the EN/IEC 60825-1, Edition 3 (2014) internationally.

In the US, this product is in conformity with performance standards for laser products under 21 CFR 1040, except with respect to those characteristics authorized by Variance Number 2018-V-3042-0001 effective on August 28, 2018.

7.1.2 Explanatory Label



7.1.3 Cautionary Statements

System integrators should refer to their respective regulatory and compliance owner to finalize regulatory requirements for a specific geography.

Caution - Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

- Do not power on the product if any external damage was observed.
- Do not attempt to open any portion of this laser product. There are no user serviceable parts.
- Invisible laser radiation when opened. Avoid direct exposure to beam.
- There are no service/maintenance, modification, or disassembly procedures for the stereo module and infrared projector. The system integrator must either notify Intel or return modules before any failure analysis is performed.
- Modification or service of the stereo module, specifically the infrared projector, may cause the emissions to exceed Class 1.
- Do not try to update camera firmware that is not officially released for specific camera module SKU and revision.

7.1.4 Embedded Laser Information

- Wavelength (0-50°C): 844-875nm
- Beam divergence (without collimation): (6x10) deg to (15-21) deg; parallel x perpendicular
- Pulse duration and repetition rate:
  - 1ns pulse duration
  - 500 MHz repetition
  - Rise/Fall time: 300ps
- Maximum power or energy output: 240mW

7.1.5 US FDA Accession Number

Table 7-1. U.S. FDA Accession Number

Component	U.S. FDA accession numbers
Intel® RealSense™ LiDAR Camera L515	1820840

This accession number should be entered into Box B.1 of the Food and Drug Administration (FDA) 2877 Declaration for Imported Electronic Products Subject to Radiation Control Standards.

7.2 Regulatory Compliance

7.2.1 Manufacturer's Information

Intel Corporation:
Attn: Corp. Quality
2200 Mission College Blvd,
Santa Clara, CA 95054-1549, USA

7.2.2 EU Single Place of Contact

Att. Corp Quality
Intel Deutschland GmbH
Am Campeon 10-12
Neubiberg, 85579 – Germany

7.3 Ecology Compliance

7.3.1 China RoHS Declaration

China RoHS Declaration

产品中有毒有害物质的名称及含量

Hazardous Substances Table

部件名称 Component Name	有毒有害物质或元素 Hazardous Substance					
	铅 Pb	汞 Hg	镉 Cd	六价铬 Cr (VI)	多溴联苯 PBB	多溴二苯醚 PBDE
相机 Camera	○	○	○	○	○	○
印刷电路板组件 Printed Board Assemblies	X	○	○	○	○	○
三角架 Tripod	○	○	○	○	○	○
电缆 Cable	○	○	○	○	○	○

○：表示该有毒有害物质在该部件所有均质材料中的含量均在GB/T 26572标准规定的限量要求以下。

○：Indicates that this hazardous substance contained in all homogeneous materials of such component is within the limits specified in GB/T 26572.

×：表示该有毒有害物质至少在该部件的某一均质材料中的含量超出GB/T 26572标准规定的限量要求。

×： Indicates that the content of such hazardous substance in at least a homogeneous material of such component exceeds the limits specified in GB/T 26572.

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除非另外特别的标注,此标志为针对所涉及产品的环保使用期限标志. 某些可更换的零部件可能会有一个不同的环保使用期限(例如,电池单元模块).

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7.3.2 Waste Electrical and Electronic Equipment (WEEE)

"In the EU, this symbol means that this product must not be disposed of with household waste. It is your responsibility to bring it to a designated collection point for the recycling of waste electrical and electronic equipment. For more information, contact the local waste collection center or your point of purchase of this product."

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8 Appendix A – L515 Product Box

Inside Intel® RealSense™ LiDAR Camera L515 product box you will find the L515 camera, a tripod and a USB3 cable.

Figure 8-1. L515 Product Box