

OCULII - EAGLE USER MANUAL



EDITION 0.5.41 Dec 2021

Oculii Corporation Copyright © 2021. All rights reserved 829 Space Drive, Beavercreek, Oh 45434, USA Phone: 937-829-0383 Email: info@oculii.com Website: <u>www.oculii.com</u>



Table of Contents

1. Overview	4
2. Radar Technical Specs	5
3. Product	6
3.1 Version	6
3.2 Field of View	6
3.3 Application Examples	6
3.4 What is in the Box?	6
3.5 Connection	7
3.6 Multiple Sensor Connection	8
4. I/O Configuration	9
4.1 IP Address and UDP Port	9
4.2 I/O Block Diagram	10
4.3 Static IP	11
5. Mechanical Dimension and Mounting	13
5.1 Mechanical Dimension	13
5.2 Sensor Coordinate System	14
5.3 Location Mounting Example	14
5.4 Secondary Surface Mounting	16
5.5 Sensor Radiation Cone	19
5.6 Sensor Operation Temperature	19
5.7 Multiple Sensor Mounting	19
5.8 Manual Alignment	20
5.9 Waterproof Ethernet Plug	20
6. Radar Interface and Decode	22
6.1 Radar Output Communication Flow	23
6.2 Output List	
6.3 Header Structure	
6.4 Detection Structure	
6.5 Tracker Structure	27
6.6 Radar Coordinate System	
7. Radar Configuration Modes and Commands	29



7.1 Synchronous Trigger	30
7.2 Radar Command - HostSetupCfg	31
8. Windows Visualizer	34
8.1 Getting Started	34
8.2 Settings	38
8.3 Saved Results	44
8.4 Binary to CSV file converter	44
9. Firmware and Visualizer Update	45
10. Safety and Risk	47
10.1 Note and Scope of Responsibility	47
10.2 Operating Risk	47
10.3 Service	47

1. OVERVIEW

Powered by Virtual Aperture Imaging, Oculii's EAGLE 77GHz Point Cloud Radars can deliver thousands of points per second, capturing all relevant environmental information. Oculii's radar point clouds perform in all weather conditions, and each point directly measures highly accurate doppler information, enabling immediate separation and efficient tracking of any moving targets. Virtual Aperture Imaging (VAI) is an array multiplier technique that can be used on any transceiver architecture. The Oculii EAGLE is a single chip, automotive grade sensor. Using VAI, Oculii's EAGLE can achieve <1⁰ angular resolution across an Azimuth Field of View of 110 degrees and <1⁰ angular resolution across an Elevation Field of View of 45 degrees.

2. RADAR TECHNICAL SPECIFICATIONS

Frequency	77.0 – 79.0GHz
Detection Range	0m – 400m
Range Resolution	0.86m
Range Accuracy	0.86m
Azimuth Angle Range	-56.5° to +56.5°
Azimuth Angle Resolution	< 10
Azimuth Angle Accuracy	0.44 ⁰
Elevation Angle Range	-22.5° to 22.5°
Elevation Angle Resolution	< 1 ⁰
Elevation Angle Accuracy	0.175 ⁰
Max Speed Range	-86.8m/s to +86.8m/s
Speed Resolution	0.27 m/s
Speed Accuracy	0.09 m/s
Points Per Second	21,000
Cycle Time	66ms (15Hz)
Data Output Format	UDP
Weight	644g
Dimensions (WxHxD)	130 x 115 x 31.6 mm
Power Consumption	7.5 W
Operation Temperature	-40 to +105 C

3. PRODUCT 3.1 Version

Product Version Number: EAGLE

3.2 Field of View







3.3 Application Examples

The EAGLE is equipped both with a point cloud capable of outputting thousands of points per second, as well as an embedded tracker capable of simultaneously tracking up to 100 objects. This allows the EAGLE to be used for several applications, some of which are listed below:

- Level 1-5 autonomous driving applications.
- Simultaneous Localization and Mapping (SLAM).
- Intelligent Transportation Systems (ITS).

3.4 What is in the Box?

Oculii will supply the following in the EAGLE box:

- Oculii EAGLE Sensor
- Power over Ethernet converter supplied from tp-link (part number: TL-POE150S)
- Cat 6 Ethernet cable, 2 foot (x1)

3.5 Connection



- Power

- Wall Adapter Input: 100 240V AC
- o Wall Adapter Output: 48V DC 0.5A
- Power Over Ethernet (POE) Injector Input: 48V, 0.5A
- o Power Over Ethernet (POE) Injector Output: 48V, 0.35A
- o Standard: IEEE802.3
- Length of Ethernet cable: 0 100m
- The wall adapter is powered through a 100-240V AC supply. The injector is powered through a 48V DC supply received from the wall adapter. The sensor is powered through a Cat 6 Ethernet cable connected from the 'Power + Data Out' port on the POE injector.



- I/O
 - Cat 6 Ethernet cable is used as a connection between the injector and the PC through the 'LAN IN' side. Data received from the sensor is transferred through the injector to the PC. (For settings on the PC to receive the data from the sensor please refer section 4).
- Circuit Protection
 - The POE injector used is an active POE which has an inbuilt circuit protection. If a short circuit is detected or the wrong ethernet connection is made, the injector does not supply power to the circuit. Before powering up, the active PoE switch will test and check to ensure the electrical power is compatible between the switch and the remote device. If it is not, the active PoE switch will not deliver power, preventing any potential damage to the non-PoE device. Despite the protection, take extra caution to connect the 'Power + Data' port to the sensor and the 'LAN' port to the PC.

3.6 Multiple Sensor Connection

When more than one sensor is used (n sensors) in the installation the connection can be made as shown in the figure below which shows the connection for n=5. Instead of connecting the 'LAN' port of the sensor to the PC, it can be connected to a switch, with one ethernet from the switch connected to the PC. Each ethernet is capable of supplying 100Mbits of data, so the switch should be capable of supporting up to n*100Mbits of data on each port (since the sum of data is sent to the PC through 1 port). The PC ethernet port should also be able to support n*100Mbits of data.





4. I/O CONFIGURATION

4.1 IP Address and UDP Port

The sensor IP address and UDP port number to **receive data** are linked to the serial number of the EAGLE sensor that you receive. To retrieve your IP address please look at the back of your case and make a note of the unit digit. We use 10 different IP addresses and UDP port numbers.

Unit Digit of Serial Number	IP Address	UDP Port Number
0	192.168.2.10	9910
1	192.168.2.11	9911
2	192.168.2.12	9912
3	192.168.2.13	9913
4	192.168.2.14	9914
5	192.168.2.15	9915
6	192.168.2.16	9916
7	192.168.2.17	9917
8	192.168.2.18	9918
9	192.168.2.19	9919



In the above example the sensor serial number is 1016. The **unit digit** is 6. Thus, the IP address will be 192.168.2.16 and the UDP port number will be 9916.

To send commands (refer to section 'Radar Commands') to the EAGLE Sensor you will need to send from **the IP address 192.168.2.65** and sent to the **UDP port 9909**.

4.2 I/O Block Diagram



The block shows the IP address and UDP port configurations for the Sensor with serial number ending with '1' and serial number ending with '4'. The Static IP of the PC and the UDP port to receive commands at the sensor are fixed at 192.168.2.65 and 9909, respectively. The IP address and UDP port over which data is sent is configurable based on the unit digit of the serial number as can be seen above.

4.3 Static IP



To receive data on your PC please set the Static IP address to 192.168.2.65

It is suggested to keep the PC off of any VPN connection which is known to interfere with the sensor communication.

To set the Static IP follow the steps listed below:

- i) Make sure your sensor is powered and connected to the Ethernet port of your PC.
- ii) Visit the 'Network and Sharing Center'.
- iii) Double tap on 'Ethernet'

Network and Sharing Center				-		>
→ ··· ↑ 壁 → Control P	anel > Network and Internet > Network and Sharing Cent	5	~ Ö	Search Control Pa	inel	3
Control Panel Home	View your basic network information and	et up connections				
Change adapter settings	View your active networks					
hange advanced sharing ettings	Oculii-5G 3 Public network	Access type: Internet Connections: all Wi-Fi (Oculii-5G)				
fedia streaming options						
	Unidentified network	Access type: No network access				
	Public network	Connections				
	Change your networking settings					
	Set up a new connection or network					
	Set up a broadband, dial-up, or VPN connecti	on; or set up a router or access point.				
	Troubleshoot problems					
	Diagnose and repair network problems, or ge	troubleshooting information.				
iee also						
internet Options						
Windows Defender Firewall						

iv) Go to 'Properties'

General			
Connection		6.6	
IPv4 Connectiv	ity:	No network acc	ess
IPv6 Connectiv	ity:	No network acc	ess
Media State:		Enab	oled
Duration:		00:09	:36
Speed:		100.0 M	bps
Details	I		
Details	Sent —	🕅 — Receiv	red
Details Activity Bytes:	Sent —	Receiv	red
Details Activity Bytes:	Sent —		ved

v) Scroll to find 'Internet Protocol Version 4' and double tap.



	Properties			
Networking	Sharing			
Connect us	sing:			
🚽 Real	tek PCIe GBE I	Family Contr <mark>o</mark> ller		
			Configure	
This conne	ction uses the f	following items:		
	ient for Microso le and Printer S oS Packet Sch ternet Protocol	ft Networks haring for Microsofi eduler Version 4 (TCP/IP	t Networks v4)	^
	ICTOSOIL INCLIVOR	к жаартег маниреж	IN LICOCOL	
	icrosoft LLDP F ternet Protocol	Protocol Driver Version 6 (TCP/IP	v6) >	~
M M K Insta	icrosoft LLDP F ternet Protocol	Protocol Driver Version 6 (TCP/IP Uninstall	v6) Properties	~
Insta	icrosoft LLDP F ternet Protocol	Protocol Driver Version 6 (TCP/IP- Uninstall	v6) Properties	~

vi) Set the IP address to 192.168.2.65, the Subnet to 255.255.255.0 and Gateway to 192.168.2.1

General	
You can get IP settings assigned this capability. Otherwise, you ne for the appropriate IP settings.	automatically if your network supports ed to ask your network administrator
Obtain an IP address autom	atically
• Use the following IP address	
IP address:	192.168.2.65
Subnet mask:	255 . 255 . 255 . 0
Default gateway:	192.168.2.1
Obtain DNS server address a	automatically
• Use the following DNS serve	r addresses:
Preferred DNS server:	
Alternate DNS server:	
Validate settings upon exit	Advanced

5. MECHANICAL DIMENSIONS & MOUNTING

5.1 Mechanical Dimension

EAGLE – Dimensions



All dimensions are in mm unless specified

5.2 Sensor Coordinate System

The sensor coordinate system is defined in the image below. The sensor orientation is with a quarter inch screw hole in the bottom and the ethernet connector on the right-hand side of the sensor (seen from front). All the angular measurements input to the system should be between 0° and 360°



5.3 Location Mounting Example

The location mounting example includes a description for the horizontal and vertical position of the sensor location.

i) At 0-degree vertical angular rotation (no upward or downward tilt)

Horizontal Translation: Restriction is dependent on length of Ethernet POE. Under 100m. Note that the sensor data will be with respect to the sensor and not the vehicle center. Horizontal Rotation: Should be rotated less than 30 degrees in either direction from the intended location of maximum power.

Vertical Translation: 0.3m - 3.0m above ground level.

Vertical Rotation: 0 degrees.



Road Surface

In the diagram above the mounting tolerance of the sensor is provided. With no vertical rotation, the sensor can be placed from 0.3m to 3.0m above the ground and has full operation in the horizontal plane. The sensor can also be rotated on the horizontal plane but should be within 30 degrees of intended location of interest to ensure that maximum power is directed towards to region of interest.



ii) With angular rotation (with an upwards or downward tilt)

Horizontal Translation: Restriction is dependent on length of Ethernet POE. Under 100m. Note that the sensor data will be with respect to the sensor and not the vehicle center.

Horizontal Rotation: Should be rotated less than 30 degrees in either direction from the intended location of maximum power.

Vertical Translation: Maximum installation height can be up to 50m (recommended 0 to 15m).

Vertical Rotation: Rotation should depend on the intended location of maximum power and should be calculated with respect to the height the sensor is positioned at.



In the figure above the sensor is placed at a height and is tilted down in order to see a specified region (an over bridge traffic monitoring example). Similarly, by adjusting the height and the tilt angle, the EAGLE could be oriented for different applications requiring different intended regions of interest (examples include a small tilt upwards from the bumper to eliminate ground reflection, or a small tilt down when mounted on top of trucks to see objects close to the bus). Note that the data received is with respect to the center of the sensor. Any physical adjustments must be accounted on the user/customers end.

5.4 Secondary Surface Mounting (RADOME)

The sensor can be mounted with a surface between the radar and the outside environment (for example – vehicle bumper). This enclosure is called a Radar Dome (RADOME). Configuration of the RADOME for optimal performance depends on several factors listed below.

- i) Material type
- ii) Thickness
- iii) Distance
- iv) Tilt/Curvature of surface





v) Paint

Following are short descriptions on how these factors impact the performance of the sensor and how they can be configured for optimal performance.

Note: The radar is equipped with a front plate so a secondary surface mount for initial testing and validation is not recommended as performance degrades with addition of any secondary surface.

i) Material Type

Material properties should only be considered at the 77GHz frequency band and should have the following properties:

- Low di-electric constant (for low surface reflection)
- Low di-electric loss (for reduced transition damping of signal)
- Roughness less than lambda/10 (~400um)

Material	Di-electric constant (&r) at 77Ghz
Polypropylene	2.35
Polyamide	2.75
Polycarbonate	2.80
PC-PBT (Polycarbonate Type)	2.90
ABS (AcryInitril-Butadien-Styrol)	3.12
PMMA (Poly Methyl Methacrylate)	3.40
ASA (Acrylonitrile Styrene Acrylate)	3.80

Below is a table of commonly used secondary surface materials

Note: Di-electric constant (permittivity) of materials differ among manufacturers. Ensure that the material properties are quoted by all manufacturers at 77GHz bandwidth.

ii) Material Thickness

For optimal permittivity, the thickness of the material needs to be calculated. The material thickness can be any integer multiple of the optimal thickness (n*optimal thickness). A higher integer increases the attenuation, thus smaller thickness is recommended. Using the following 3 formulas we can calculate the thickness of the surface:

A.
$$\lambda_o = c_0 / f_c$$

B. $\lambda_m = \lambda_o / (\text{sqrt } \mathcal{E}_r)$

C. $T_m = \lambda_m / 2$



 λ_0 : Wavelength, c_0 : Speed of light (3 * 10⁸), f_c = 77GHz, \mathcal{E}_r : Relative permittivity in material, λ_m : Wavelength in material, T_m : Optimal Thickness of Material In the table below we calculate the thickness for the materials mentioned before:

Material	Di-electric	Optimal
	constant (\mathcal{E}_r) at	Thickness of
	77Ghz	Material (mm)
Polypropylene	2.35	1.27
Polyamide	2.75	1.18
Polycarbonate	2.80	1.17
PC-PBT (Polycarbonate Type)	2.90	1.15
ABS (AcryInitril-Butadien- Styrol)	3.12	1.10
PMMA (Poly Methyl Methacrylate)	3.40	1.06
ASA (Acrylonitrile Styrene Acrylate)	3.80	1.00

iii) Distance

- The distance between the radar sensor and the RADOME needs to be an integer multiple of lambda/2 which is ~1.95mm, thus n*1.95mm is acceptable.
- The distance should be large enough to avoid mechanical vibrations, mechanical interference, and mechanical stress.
- The distance should be enough to avoid thin films of water, snow, or mud from developing on the sensor front plate.

iv) Tilt/Curvature of the surface

The angle between the sensor and the secondary surface is the tilt angle. The tilt angle should always be between 0 to 30 degrees. Note that smaller tilt angles could introduce multipath, raise noise levels, or introduce false targets. Higher tilt angles increase the effective thickness and thus the damping effect of the material increases.

To prevent distortion of the signal, the secondary surface needs to be smooth with roughness less than lambda/10 (~400um). The curvature should be uniform and avoid sharp edges or abrupt thickness changes as shown in the image below.





v) Paint

For layers of paint, varnish, primer to be introduced on the secondary surface a study on the degradation of the signal would need to be performed. These layers would influence the performance of the sensor and need to be taken into consideration when choosing a secondary surface. Up to 4 layers of paint could be allowed if attenuation is kept within spec in the entire system.

Further, for metallic paint, more considerations will need to take place. The percentage of metal in the paint, the size of the metal particles in the paint and the thickness of the different layers of paint can all influence the attenuation of the radar and will need to be studied and kept within spec of the radar.

The max attenuation acceptable for the Oculii EAGLE to maintain its performance is described below:

- One-way attenuation shall not exceed 2dB
- Max reflectivity co-efficient shall not exceed -2.2dB.

5.5 Sensor Radiation Cone

The sensor radiation cone is shown in the following diagrams. The sensor radiation cone shall be kept free from metallic objects, or any objects that can interfere with the radar performance. The horizontal field of view for the sensor is 120 degrees and the vertical field of view is 40 degrees, both symmetric to the center of the sensor.



5.6 Sensor Operation Temperature

The sensor is designed to operate in the temperature range between - 40 to +105 Celsius. The metallic body of the sensor is the main medium of heat transfer. To ensure proper heat transfer the sensor should be exposed to cool free flowing air and should be in direct contact with thermal heat transferring materials.

5.7 Multiple sensors mounting

When mounting multiple sensors note that each sensor behaves like an individual unit with the data output with respect to the center of the sensor. Multiple orientations are possible if the above consideration is followed. Note the rotation and translation of the physical mounted sensors and adjust the radar data to the center of the vehicle as required. The figure below shows one installation scenario. In this case the sensors are installed at the four corners of the vehicle at 45 degrees with respect to the direction of motion of the vehicle. A fifth sensor is installed at the center facing the direction of motion. More information on how to measure the rotation and translation of the sensors can be found under section 8.2.



5.8 Manual Alignment

The EAGLE sensor needs to be manually adjusted along all 3 planes. Misalignment can be a result of many factors such as static deviations due to sensor and mechanical fixture tolerance, and dynamic deviations in loading and suspension. Variations in temperature and mechanical vibrations over time could also influence the calibration. The introduction of a secondary surface could also have an effect.

The user/customer shall determine misalignment via simulation or measurement. The user could validate the alignment with a simple test as described below.

After mounting the sensor place a corner reflector at 0 degrees in front of the sensor at 4.0m distance and same height from the ground. Measure the physical range between the center of the sensor and the center of the corner reflector. Look at the radar data and ensure that the z value equals 4m and the x and y values equal 0m.

5.9 Waterproof Ethernet Plug

The EAGLE sensor would include a waterproof ethernet plug (Keystone 988P) inside the box, please ensure to install this as this is a critical point in waterproofing the device. We recommend using a Cat 5e or Cat6 ethernet patch cable and installing the ethernet plug by cutting off the head of the patch cable and to crimp a RJ45 connector.



Please ensure the cable crimping pin order to match the T-568B (Straight through - Patch cable) and use a RJ45 Crimp tool to crimp the cable as shown in the installation diagram below.



6. RADAR INTERFACE AND DECODE

This section briefs the protocol used by Oculii for the transmission of detection and tracker data frames from the Oculii Radar Sensor.

The EAGLE radar sensor outputs the output list (Header + Detections + Tracks + Footer) at the configured frame rate. The output list is comprised of the Header, Detection information and Track information.

The Header is 48 Bytes and contains the Frame Number, Version Number, Number of Detection, Number of Tracks, Host Speed, Host Angle, and the accuracy values for Range, Doppler, Alpha and Beta. It also contains a few reserved fields for future use.

Each detection information is packaged into 8 Bytes and each track is packaged into 32 Bytes. The footer is 32 bytes. The number of detection field and the number of tracks field in the header provide the value for decoding detection and tracks, respectively.



6.1 Radar Output Communication Flow



Handshake Structure:

Magic	Frame Data Length (Dynamic)	Reserved
8	4	12

Magic Frame Data Length (Dynamic) Reserved : 8 bytes, [1 9 8 9 1 0 2 2] : 4 bytes, uint_32, frame size : 12 bytes

Frame Data Length is in the little-endian format and is the length of the packet structure. The data is dynamic and thus the length needs to be read in between frames. Since the data packet is truncated in chunks of 256 bytes, a calculation would need to be done to determine the number of 256 chunks as well as the length of the last chunk of data. For example, if the length is 1000, the data will come as 3 chunks of 256 bytes and 1 chunk of 232 bytes.



6.2 Output List: Header + Detection + Tracker

Output List: Header + Detection + Tracker + Footer																	
Header Block (48 bytes)							Block (8	* N)			Tracker Blo	ck (32 * Nt)		Foot	er Block (3	2 Bytes)
Frame Num	Version Num	Num Det	Num Tracks	Decode/ Parse Info		Det 1	Det 2		Det N		Track 1	Track 2		Track Nt	CR	Reserv	red
4B	4B	2B	2B	28B		8B	8B		8B		32B	32B		32B	4B	28B	
	List: Heade ock (48 bytes) Frame Num 4B	List: Header + Detecti cock (48 bytes) Frame Num Version Num 48 4B	List: Header + Detection + Trans ock (48 bytes) Frame Num Version Num Num Det 48 48 2B	List: Header + Detection + Tracker + Food Jock (48 bytes) Frame Num Version Num Num Det Num Tracks 48 4B 2B 2B	List: Header + Detection + Tracker + Footer Detection + Tracker + Footer Frame Num Version Num Num Tracks Decode/ Parse Info 48 48 28 28 28	List: Header + Detection + Tracker + Footer Jock (48 bytes) State of the state of	List: Header + Detection + Tracker + Footer Dock (48 bytes) Detection Frame Num Version Num Num Det Num Tracks Decode/ Parse Info Det 1 4B 4B 2B 2B 28B 8B	List: Header + Detection + Tracker + Footer	List: Header + Detection + Tracker + Footer D	Detection + Tracker + Footer Detection	List: Header + Detection + Tracker + Footer Detection + Tracker + Footer <	List: Header + Detection + Tracker + Footer Frame Num Num Det Num Tracks Decode/Parse Info Det 1 Det 2 Det N Tracker Blo 48 48 28 28 288 88 88 88 328	List: Header + Detection + Tracker + Footer Section + Tracker + Footer Detection + D	List: Header + Detection + Tracker + Footer Detection + Tracker + Footer Sock (48 bytes) Frame Num Num Date Decode/ Parse Info Det 1 Det 2 Image: Sock (32 * Nt) Frame Num Version Num Num Date Num Tracks Decode/ Parse Info Det 1 Det 2 Det N Tracker 32 * Nt) 4B 4B 2B 2B 2B 2B Ba 8B 8B 8B 3B 32B 32B 32B	List: Header + Detection + Tracker + Footer Detection + Tracker + Footer Sock (48 bytes) Track I S * N Frame Num Num Det Num Tracks Detection + Colspan="6">Track I S * N Frame Num Num Det Num Tracks Decode/ Parse Info Det 1 Det 2 Det N Track I Track 2 Track Nt 48 28 28 288 88 88 88 88 328 328 328 328 328 328 328	List: Header + Detection + Tracker + Footer Detection + Tracker + Footer Sock (48 bytes) Frame Num Num Det Num Tracks Decode/ Parse Info Det 1 Det 2 Det N Track 1 Track 2 Track Nt CRC 48 48 28 28 288 88 88 88 328 328 328 328 328 48	List: Header + Detection + Tracker + Footer Detection + Tracker + Footer Sock (48 bytes) Frame Num Num Det Num Tracks Detection + Track (8 · N) Tracker (32 · N) Footer Block (8 · N) Frame Num Num Det Num Tracks Decode/ Parse Info Det 1 Det 2 Det N Track 1 Track 2 Track Nt CRC Reserved AB 4B 4B 2B 2B 2B 2B 8B 8B 8B 32B 32B 32B 4B 2B

Header: 384 bits (48 Bytes)

Detection	: 64 bits (8 Bytes) * N
Tracks	: 256 bits (32 Bytes) * Nt
Footer	: (32 Bytes)

6.3 Header and Footer Structure

			Ma	igic			
(8 bytes : 0				x21436587)			
Frame Number (4 bytes) (uint_32)				Version N	lumber		
			(4 bytes) (uint_32)				
Number o	f Detection	Number	of Tracks	Host Speed (2 bytes) (int_16)		Host Angle (2 bytes) (int_16)	
(2 bytes)	(uint_16)	(2 bytes)	(uint_16)				
				(Divide by value in me	100 to get ters/second)	(Divide by value in	100 to get degrees)
Reserved		Rese	rved	Reserved		Reserved	
(2 b	ytes)	(2 b	ytes)	(2 b)	ytes)	(2 bytes)	
Range Accuracy Idx 0 (2 bytes) (uint_16) (Divide by 10000 to get value in meters)		Doppler Accuracy ldx 0 (2 bytes) (uint_16) (Divide by 10000 to get value in meters/second)		Azimuth Accuracy ldx 0 (2 bytes) (uint_16) (Divide by 10000 to get value in degrees)		Elevation Accuracy Ids 0 (2 bytes) (uint_16) (Divide by 10000 to get value in degrees)	
DSP workload (%)	ARM workload (%)	Byte 43	Byte 44	Byte 45	Byte 46	Byte 47	Byte 48

Magic Header	: 8 Bytes, [2 1 4 3 6 5 8 7]
Frame Number	: 4 Bytes, uint32_t, frame number
Version number	: 4 Bytes, uint32_t, Version number, uint32_t format: MMddhhmm
NumDetections	: 2 Bytes, uint16_t, Number of Detection in the frame
NumTracks	: 2 Bytes, uint16_t, Number of Tracks in the frame
Host Speed	: 2 Bytes, int16_t, divide by 100 to get ego speed in m/s
	(e.g. 6453 = 64.53 m/s, e.g2456 = -24.56 m/s)
Host Angle	: 2 Bytes, int16_t, divide by 100 to get host angle in degree. Clockwise
	rotation corresponds to positive rotation.
	(e.g. 1400 = 14 deg)
Reserved*4	: 8 Bytes, currently reserved as 4 uint, data type could change.
Range Accuracy Idx0	: 2 Bytes, uint16_t, divide by 10000 to get value in m
Doppler Accuracy Idx(2 Bytes, uint16_t, divide by 10000 to get value in m/s
Azimuth Accuracy Idx	0 : 2 Bytes, uint16_t, divide by 10000 to get value in degree
Elevation Accuracy Id	x0 : 2 Bytes, uint16_t, divide by 10000 to get value in degree
DSP workload	: 1 Byte, double
ARM workload	: 1 Byte, double
Reserved	: 6 Bytes, variable data type.

Reserved (4 Bytes)				Reserved (4 bytes)			
Range Accuracy Idx 1 (2 bytes) (uint_16) (Divide by 10000 to get value in meters)		Doppler Ac (2 bytes (Divide by 10000 to get	curacy ldx 1) (uint_16) value in meters/second)	Azimuth Accuracy Idx 1 (2 bytes) (uint_16) (Divide by 10000 to get value in degrees)		Elevation Accuracy Idx 1 (2 bytes) (uint_16) (Divide by 10000 to get value in degrees)	
Byte 17	Byte 18	Byte 19	Byte 20	Byte 21	Byte 22	Byte 23	Byte 24
Byte 25	Byte 26	Byte 27	Byte 28	Byte 29	Byte 30	Byte 31	Byte 32

Range Accuracy Idx1: 2 Bytes, uint16_t, divide by 10000 to get value in mDoppler Accuracy Idx1: 2 Bytes, uint16_t, divide by 10000 to get value in m/sAzimuth Accuracy Idx1Elevation Accuracy Idx1: 2 Bytes, uint16_t, divide by 10000 to get value in degree: 2 Bytes, uint16_t, divide by 10000 to get value in degree: 2 Bytes, uint16_t, divide by 10000 to get value in degree

ÚCULii

6.4 Detection Structure:

Reserved (1 bit)	Flag (1 bit)	Reserved (6 bit)	Power Value (16 bits) (0 to 65535)	Beta Index (10 bits) (-511 to 512)
Beta cont		Azimuth Index	Doppler Index	Range Index
		(10 bits)	(10 bits)	(10 bits)
		(-511 to 512)	(-511 to 512)	(0 to 1023)

- Range Index: 10 bits, multiply with Range Accuracy value to get Range value in m.
- **Doppler Index:** 10 bits, multiply with Doppler Accuracy value to get Doppler value in m/s.
- Azimuth Index: 10 bits, multiply with Azimuth Accuracy value to get Azimuth (alpha) value in degree.
- Beta Index: 10 bits, multiply with Elevation Accuracy value to get Elevation (beta) value in degree.
- **Power:** 16 bits, 2 bytes, uint16_t, 0 to 65535, Power value is in dB scale and represents the signal to noise ratio of the detection. Divide by 100 to decode power. (e.g. 208 = 2.08dB)
- Flag: 1 bit, used for decoding. Source code provided in the SDK.

If bit is 0: Use Index 0 accuracy values from the header to obtain range, doppler, alpha and beta.

If bit is 1: Use Index 1 accuracy values from the footer to obtain range, doppler, alpha and beta.

- **Reserved***: 7 bits.
- XYZ: The XYZ coordinates can be retrieved using the following equation:
 - X = Range * Sin(Alpha) * Cos(Beta)
 - Y = Range * Sin(Beta)
 - Z = Range * Cos(Alpha) * Cos(Beta)

Below is a diagram showing the same.



6.5 Tracker Structure:

Track ID		XPos	YPos	ZPos	XDot	YDot	ZDot
(4 bytes)		(2 bytes)					
Res 1	Res 2	Res 3	Flag	Class	Conf.	Res 4	Res 5
(2 bytes)							

- Track ID: 32 bits, 4 bytes, uint32_t, 0 to 4294967296 Track ID
- Track XPos: 16 bits, 2 bytes, int16_t, -32768 to 32767, divide by 100 to get x in m (e.g. 6453 = 64.53 m, e.g.: -2456 = -24.56 m)
- Track YPos: 16 bits, 2 bytes, int16_t, -32768 to 32767, divide by 100 to get y in m (e.g. 6453 = 64.53 m, e.g. -2456 = -24.56 m)
- Track ZPos; 16 bits, 2 bytes, uint16_t, 0 to 65535, divide by 100 to get z in m (e.g. 12654 = 126.54 m)
- Track XDot: 16 bits, 2 bytes, int16_t, -32768 to 32767, divide by 100 to get speed in the x direction in m/s (e.g. 6453 = 64.53 m/s, e.g. -2456 = -24.56 m/s)
- Track YDot: 16 bits, 2 bytes, int16_t, -32768 to 32767, divide by 100 to get speed in the y direction in m/s (e.g. 6453 = 64.53 m/s, e.g. -2456 = -24.56 m/s)



- Track ZDot: 16 bits, 2 bytes, int16_t, -32768 to 32767, divide by 100 to get speed in the z direction in m/s (e.g. 6453 = 64.53 m/s, e.g. -2456 = -24.56 m/s)
- **Reserved*5** : 2 Bytes, currently reserved as uint16_t, data type could change.
- Track Flag: 16 bits, 2 bytes, uint16_t, 0 to 65535. 16 1-bit flags, the flag definitions are internal to Oculii.

Bit 3 – Bit 15 : Reserved

Bit 0, Bit 1, Bit 2 : Track Quality. Currently only values 1 and 2 are used. Filter to use only value '2'.

- Track Class: 16 bits, 2 bytes, unit16_t, 0 to 5. Reserved for future.
 - o 0: Unknown Class
 - o 1: Pedestrian
 - o 2: Motorcycle/Bike
 - o 3: Vehicle and SUV
 - o 4: Bus and Truck
 - o 5: Background
- Track Class Confidence Score: 16 bits, 2 bytes, unit16_t, 80-99, assigns a confidence score for the classification made in Track Class higher score corresponds to higher confidence

6.6: Radar Coordinate System

Below is a diagram showing the radar coordinate system used in the EAGLE sensors.



7. RADAR CONFIGURATION MODES AND COMMANDS

7.1 Synchronous Trigger Command – PTP Time Synchronization

To send a trigger command that maintains synchronization the following command should be input.

Command	Read/ Write	Length	CRC	Payload
0X0A	0	0x1E	0	Byte 7 – Byte 30

Byte 7: Wait on PTP Sync (0 – No, 1- Yes)

Byte 8: If byte 7 is 0 Byte 8 value does not matter. If byte 7 is 1 Byte 8 determines PTP mode. (0 - unicast, 1 - multicast)

Byte 9-12: If byte 7 is 0 or byte 8 is 1. Otherwise, IP Address PTP Master (IPV4, delimiter ":"). Example IP 192.168.2.10 will be {0xC0, 0xA8, 0x02, 0x0A}

Byte 13-16: Hard Coded to match frame period of the configuration. Period in microseconds (uint32) {100000 = 0x000186A0 = 100ms = 10Hz}

Byte 17-20: Delay in microseconds (uint32) {10000 = 0x00002710 = 10ms}

Byte 21-30: Reserved, all 0x00.

Note: If you do not wait for PTP (byte 7) the sensor will internally trigger itself to match the timeperiod set in the front-end configuration.

Note: The cycle time of PTP synchronization needs to match the period configured in the Firmware by Oculii. For example if the Firmware runs at 10Hz, PTP synchronization (byte 13-16) of 100ms is required.

Note: If there is an intended use for PTP, please contact Oculii for additional documentation.

7.2 Radar Command HostSetupCfg

HostSetupCfg command is used to set the mounting angle of the sensor at the start of data collection. Once the Start Receive button on the visualizer (Section 8) is clicked to start the data collection process, the visualizer will prompt the user to input the sensor mounting angle. If the user is not using Oculii provided applications and SDK, this command is required at the boot-up sequence at every instance of initialization.

Following are the setup of the HostSetupCfg command:

- 1. Host Setup Config: 'HostSetupCfg <mounting_angle> 3 1 1\r'
 - For example, if the sensor is mounted at 45 degrees clockwise and the user in inputting the host information this command is: 'HostSetupCfg 45 3 1 1\r'.

Note: Uppercase and lowercase letters have different ascii bytes assigned to them **Note:** The space (ASCII: 0x20) needs to be input in the command if required. **Note:** The mounting angle should be between 0 and 360 degrees (clockwise).

To send Radar Commands the user must follow the following data transfer protocol.

The command includes a 6 byte header and the payload. Header:

- 1. Byte 0: Command
 - o 0x02: Radar Command Send
 - o 0x03: Acknowledgement
 - o 0xCD: Process Report Complete
- 2. Byte 1: Read/Write
 - o 0x00: Sending command from PC to Sensor
 - o 0x01: Receiving command from Sensor
- 3. Byte 2,3,4: Length of the payload in Little Endian format
- 4. Byte 5: Error.
 - o 0x00: No error
 - o 0x01: Error

Payload:

The command is sent as bytes following the ASCII string and ends with a null character '\r'. Example of header (6 bytes) + payload and length:

HostSetupCfg 0 3 1 1 = new byte[] {0x02, 0x00, 0x15, 0x00, 0x00, 0x00, 0x48, 0x6f, 0x73, 0x74, 0x53, 0x65, 0x74, 0x75, 0x70, 0x43, 0x66, 0x67, 0x20, 0x30, 0x20, 0x33, 0x20, 0x31, 0x20, 0x31, 0x0D };

Length of payload: 21



Example: Command for "HostSetupCfg 0 3 1 1\r" would be as follows:

Step 1: Send the command to the sensor. (Byte 0: 0x02, Byte 1: 0x00, Byte 2-4, Length of command, Byte 5: 0x00, Byte 6 onwards: Radar command ASCII ending with '\r').

Command	Read/ Write	Length	CRC	Payload(last byte: '\r')
2	0	21	0	HostSetupCfg 0 3 1 1'0x0D'

Step 2: Wait for the sensor to repeat the same command back to you (except byte 1 which would change from 0x00 to 0x01). Wait to read the same packet length that you sent and check byte by byte if the command returned matched the command you sent.

2	1	21	0	HostSetupCfg 0 3 1 1'0x0D'
Command	Read/ Write	Length	CRC	Payload

Step 3: Send the sensor a confirmation if the commands match. (Byte 0: 0x03, Byte 1-5: 0x00)

Command	Read/ Write	Length	CRC	Payload
3	0	0	0	None

Step 4 (optional): Wait to receive the status packet from the sensor

Command	Read/ Write	Length	CRC	Payload
CD	1	6	0	None

Wireshark data packet:

	1518 7.971463	192.168.2.65	192.168.2.10	UDP	69 9910 → 9909 Len=27 Step1: Send command to sensor
	1519 7.971811	192.168.2.10	192.168.2.65	UDP	69 9909 → 9910 Len=27 Step2: Sensor sends the same command back
	1520 7.972573	192.168.2.65	192.168.2.10	UDP	48 9910 → 9909 Len=6 Step3: Send a confirmation to sensor
	1521 7.975145	192.168.2.10	192.168.2.65	UDP	60 9909 → 9910 Len=6 Step4: Sensor sends process report
	1522 7.997502	192.168.2.10	192.168.2.65	UDP	66 9909 → 9910 Len=24 Sensor sends frame header
	1523 7.997684	192.168.2.10	192.168.2.65	UDP 2	298 9909 → 9910 Len=256
	1524 7.997872	192.168.2.10	192.168.2.65	UDP 2	298 9909 → 9910 Len=256 Frame data
	1575 7 002076	102 168 2 10	102 168 2 65	HIND 1	008 0000 - 0010 Lan-256 -
<					
0000	70 b3 d5 b9 60	00 2c f0 5d b4 ff	cf 08 00 45 00 p	···`·j·]····E·	
0010	00 37 04 52 00	00 80 11 00 00 c0	a8 02 41 c0 a8 ·7	7 · R · · · · · · · · · · A · ·	
0020	02 0a 26 b6 26	b5 00 23 85 d0 02	00 15 00 00 00	&-&-+	
0030	48 6f 73 74 53	65 74 75 70 43 66	67 20 30 20 33 Ho	ostSetu pCfg 0 3	
0040	20 31 20 31 0d		1	1.	

The chart below explains the communication between the PC and the Radar for the steps listed above.





Note: All data is transmitted in Little Endian format.



8. WINDOWS VISUALIZER

8.1 Getting Started

To run the Windows Visualizer, follow the steps below:

Step 1: Plug the Flash Drive into your computer and copy the Oculii folder to your PC's C drive.

Step 2: Follow the path C:\Oculii\Visualizer under which you will find the OculiiWinView application file. Run the application file.

🗟 Emgu.CV.World.dll	4/17/2020 10:36 AM	Application extension
🗟 Emgu.Util.dll	4/17/2020 10:36 AM	Application extension
OculiiWinView	5/12/2020 4:07 PM	Application
🖓 OculiiWinView.exe	4/17/2020 10:36 AM	XML Configuration File
🗿 OculiiWinView	5/12/2020 4:07 PM	Program Debug Database
📧 OculiiWinView.vshost	5/12/2020 4:05 PM	Application

Step 3: Dependency required for installation - Visual C++ Redistributable for Visual Studio 2012 which should be pre-installed in Windows, but if it is not it can be downloaded from the following link: <u>https://www.microsoft.com/en-us/download/confirmation.aspx?id=30679</u>

Step 4: Provide Firewall access to the application when prompted. If your PC does not prompt you to do the same, and if you cannot receive data on the visualizer follow the following steps to allow Firewall access.



Step 4i): Open Control Panel => System and Security => Windows Firewall => Allowed Programs.



ÚCULii

Step 4ii) Click the Change Settings button.

🍤 System and Security		- 0	×
← → × ↑ <mark>S</mark> > Control	nel → System and Security v ඊ	Search Control Panel	P
Control Panel Home • System and Security Network and Internet	Security and Maintenance Review your computer's status and resolve issues Security Change User Account Control settings Troubleshoot common computer problems		
Hardware and Sound Programs User Accounts Appearance and	Windows Defender Firewall Check firewall status Allow an app through Windows Firewall System System System System Saste har and this consumer		
Personalization Clock and Region Ease of Access	Power Options Change battery settings Change what the power buttons do Change when the computer sleeps File History File History		
	Save backup copies of your files with File History Save backup copies of your files with File History Backup and Restore (Windows 7) Backup and Restore (Windows 7) Restore files from backup		
	Storage Spaces Manage Storage Spaces Work Folders		
	Manage work roless Administrative Tools Free up disk space Defragment and optimize your drives Create and format hard disk partitions View event logs Schedule tasks		
	Flash Player (32-bit)		

Step 4iii) Check all the Application programs OculiiWinView.exe in the list showing in the figure below.

Allow apps to communicate through Windows I To add, change, or remove allowed apps and ports, click Chan What are the risks of allowing an app to communicate?	Defender Firewall ge settings.	ange settings
Allowed apps and features:		
Name	Private	Public 👌
☑ OculiiWinView		
✓ OculiiWinView		
✓ OculiiWinView		
✓ oculiiwinview.exe		
🗹 oculiiwinview.exe		
✓ oculiiwinview.exe		
🗹 oculiiwinview.exe		✓ /

Step 5: Enter the IP address and UDP port of the sensor provided.

- 1. IP address is 192.168.2.1x,
- 2. UDP port is 991x
- 3. \mathbf{x} is the unit place digit of the sensor serial number and the port.

OculiiWinView	(v.8.2.177)				
Application Co	onfig				
Data Receive					
Sensor Rece	eive Settings				
Number of S	ensors : 💿 1 🔾 2	○3 ○4 (5 0 6 0	7 0 8	Start Receive
0.10	100.100.0.10	Data i 0010			
Sensor TIP	: 192.168.2.10	Data : 9910	Track : 99	41	
Sensor 2 IP	192.168.2.11	Data : 9911	Track: 99	42	
Sensor 3 IP	192.168.2.12	Data : 9912	Track: 99	43	
Sensor 4 IP	192.168.2.13	Data : 9913	Track: 99	44	
Sensor 5 IP	192.168.2.14	Data : 9914	Track: 99	45	
Sensor 6 IP	192.168.2.15	Data : 9915	Track: 99	46	
Sensor 7 IP	192.168.2.16	Data : 9916	Track: 99	47	
Sensor 8 IP	192.16.2.17	Data : 9917	Track: 99	48	
Data Receiv	re Status				
Sensor 1 Da	ta :	Track :			
Sensor 2 Da	ta :	Track :			
Sensor 3 Da	ta :	Track :			
Sensor 4 Da	ta :	Track :			
Sensor 5 Da	ta :	Track :			
Sensor 6 Da	ta :	Track :			
Sensor 7 Da	ta :	Track :			
Sensor 8 Da	ta :	Track :			

Step 6: Press the 'Start Receive' button after which you will be directed to sensor Mounting information pop-up window. Input the correct mounting information, followed by 'Ok' button. Please note if you press "Cancel" the default value will be set to 0 degrees.

Goode - Contraction				a sure a Manda Dat	
Application Config Sp	lit ViewL Update QS	14		Spit View-R Mounting Her	
Mouting Angle (deg) N	Nouting Distance (m)			
Yaw	Pitch Roll	x <u>y</u> z			
Sensor 1 0	0 0	0 0	Note: Kindly input mounting angle between 0 and 360 in degr rotation from the host sensor.	yrees. Clockwise	
Sensor 2 33.5	0 0	0 0	Note: Mounting distance should be input in meters. Positive 2	X for right)
Sensor 3 151.6	0 0.	.7 0 -1.5	Positive Z for back.	Mouting	Distance (m)
Sensor 4 204.6	0 -0	0.7 0 -1.5		Sensor 1	x Y Z 0 0 -0.85
Sensor 5 329.8	0 -0	0.7 0	Pi	Pause Data Read Sensor 2	0.6 0 -0.8
Sensor 6 0	0 0	0 0		Land Calibration Series 4	0.6 0 0.8
Sensor 7 0	0	Sensor 1 Mounting Angle :	×	Sensor 5	0.6 0 0.8
Sensor 8 0	0	Mauritino Ancie Insuit	Ca	alibration Settings 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5	
		Planting region (co.	OK	Sensor 8	0 0 0
			Cance	Reset Auto Calib x	
				Auto Calibration	Vigle (deg)
	, i			z Sensor 1	Yaw Pitch Roll
Feature (On/Off)				0.6 m Sensor 2	45 0 0
Show Detection	🗹 Data/Result Sav	re 📄 Filter Ground	Power Intensity FrCmp DeNoise	1 Sensor 3	135 0 0
3D View	Height Color	Show Tracks	🗹 Moving Mode 🛛 3D Show Tracks	E Sensor 5	315 0 0
Filter Height	Enhanced Pcl	Depth Color	Cluster Correction Print Info	0.6 m Sonsor 6	0 0
CF 0.9	Detection Only	CFAR Only		S CC Sensor 7	
GPS Stat Filter	🗌 Pause Lidar Disp	p GPS Offine	DetFag DeNoise		1 10 10
ROI Filter	🗌 Multipath Mitigati	ion	3 Level Speed	0.05 m	,
Radar Sensors Sele	ect		Save Video Bit Rate (kbps)		
Ø1 □2 □:	3 🗌 4		3000 ~		
5 6	7 🗌 8				
Height Info	Dis	play Config	SplitViewL Scale		
Height Limit (m) 10	Peal	k Power Value 30	Radius Scale 400 m Loa	ad Scale	
Radar Height (m) 2	Pow	or Filtor	Show Tracks		
	Num	Accumiation 48	Salit/JourD Scolo		
			Badius Scale 400 m		
		Ch	ange Loa	ad Scale	
			Show Tracks		



Step 7: You should receive data which can be seen on the right-hand side of the visualizer. Please note you may need to wait 20 sec before you receive data.





8.2 Settings

In the Config, Visualizer and Application tab, there are 7 fields as described below:

- i) Mounting Angle (deg) and Mounting Distance (m)
- ii) Feature (On/Off)
- iii) 3D View
- iv) Enhanced Point Cloud
- v) Heatmap View Scale
- vi) Display Config
- vii) Radar Sensors Select

i) Mounting Angle and Mounting Distance (deg):



For multiple sensors connected please note the physical length (z), width (x) and height (y) from the user defined center. In the above diagram the center is defined to be at the same level of installation as the five sensors and at the center of the car. The coordinate axis to be used is defined in the figure as well. The translation values for the five sensors for the figure would be:



3	×	Y	Z
Sensor 1	0	0	-0.85
Sensor 2	0.6	0	-0.8
Sensor 3	0.6	0	-0.8
Sensor 4	-0.6	0	0.8
Sensor 5	-0.6	0	0.8
Sensor 6	0	0	0
Sensor 7	0	0	0
Sensor 8	0	0	0

Mouting Distance (m)

For multiple sensors connected please note the physical yaw (if the sensor is mounted flat at ground level and perpendicular to the ground) or the yaw, pitch, and roll. In the visualizer, clockwise rotation is positive from 0 to 360 degrees. Note that these measurements should be with respect to the center that the user has fixed. The sensors individually always report data to the center of the sensor. In the figure above the sensors are installed at ground level and are perpendicular to the ground. The first sensor is at the center and the rest are at 45 degrees from the plane of the vehicle front and back. Thus, the pitch and roll would be 0. The rotation values for the five sensors for the figure would be:

3	Yaw	Pitch	Roll
Sensor 1	0	0	0
Sensor 2	45	0	0
Sensor 3	135	0	0
Sensor 4	225	0	0
Sensor 5	315	0	0
Sensor 6	0	0	0
Sensor 7	0	0	0
Sensor 8	0	0	0

Mouting Angle (deg)



ii) Feature (On/Off):

There are 3 features which can be enabled and disabled in Realtime. If you check the respective checkbox, the feature is enabled. If the checkbox is unchecked, the feature is disabled.

Feature (On/Off)	
Show Detection	✓ Data/Result Save
☑ 3D View	Height Color
Filter Height	Enhanced Pcl

a) Show Detection:

Checked: Point Cloud data is visualized. Not Checked: Point Cloud data is hidden.

b) Data Save:

Checked: Data is saved while visualizer is running. Unchecked: Data is not saved while visualizer is running to preserve disc space.

c) Filter Height:

Checked: The visualizer filters the objects above a set height (height set in the Display Config section) Unchecked: No height filter on the visualizer.

d) Height Color:

Checked: Height color scale applied to the 3D visualization to distinguish objects at different heights.

Unchecked: No height color scale applied to the 3D visualization. Default color scheme is power based.

iii) 3D View:

Under the Feature section there is an option to view the data as a 3D point cloud. Check the box "3D" to proceed. The view on the right-hand side of the visualizer will change to 3D. Here is a list of commands that control the viewing of the 3D viewer.

• Right Click and Drag: Pitch



ÚCULii

- Left Click and Drag: Yaw
- W: Zoom in
- o S: Zoom out
- A: Translation. Move view left (+x direction in radar coordinate)
- o D: Translation. Move view right (-x direction in radar coordinate)
- Q: Translation. Move plane down (-y direction in radar coordinate)
- E: Translation. Move plane up (+y direction in radar coordinate)

Under the 3D view there are a few different features that the user can enable/disable certain features as well.

- Height Filter: It removes all the points above the set maximum (maximum height can be set in the Display Config) as well as all points below the ground (0m).
- Height Color: In the 3D view the color is based on height with the red spectrum on VIBGYOR representing targets with a lower height value and the violet spectrum representing targets with a higher height value.
- Show 3D Tracks: Plots the tracks in the 3D Bitmap.

Note: Height filter and Height color will only work together

Note: Height filter and Height color are accurate only when the radar mounting angle has no depression/elevation angle.

The user can also simultaneously view the 2D and 3D point cloud by checking the 3D box and then the 2D Viewer tab found on the top left section of the visualizer. The left-hand side display is the 2D display and the right-hand side display is the 3D display.



iv) Enhanced Point Cloud

This SDK feature uses the host kinematics and neighborhood information to increase the density of the point cloud information and provide more accurate results with higher confidence. Checking the enhanced point cloud is recommended on the visualizer.

v) Heatmap Scale View:





This field is for controlling the scale in the Data View. We have three parameters to control it.

SplitViewL Scale				
Radius Scale	50 m	Load Scale		
SplitViewR So	ale			
Radius Scale	150 m	Load Scale		
C character				

(a) **SplitViewL Scale:** This scale controls the left bitmap display.

(b) SplitViewR Scale: This scale controls the right bitmap display.

(c) **Show Tracks:** This button click allows for tracks to be displayed in their respective bitmaps.

vi) Display Config:

There are two parameters which can be controlled for the display config

Height Info)	Display Config	
Height Limit	16.1	Peak Power Value	40
Radar Height	0.5	Power Filter	-1

Change

(i) **Peak Power:** The Peak power varies from 0 to 100. It can be controlled to show the higher peak points on the display in Data View. There is a color pattern for each peak power range where colors on the red spectrum represent higher power, and on the violet spectrum represent lower power. This field depends on the power threshold filter entered below.

(ii) **Power Threshold Filter:** The Power Threshold filter varies from 0 to 10. This filters below the specific threshold in dB entered in the textbox. Example: If the power threshold filter is entered as 5, the targets below 5dB are filtered. Default recommended is 0-1dB.



(iii) Height Limit: Used to filter out height information beyond a certain height, the limit of which is set here.

(iv) Radar Height: For correct visualization of the 3D point cloud information, the correct height of the radar from the ground would be required. The grid in the 3D display is the actual ground, and the point cloud information is displayed from that reference.

vii) Radar Sensors Select:

There are two checkboxes in the field which is chosen for the Front Sensor (Single Sensor) and 360-degree (Multi Sensor) views.

Front Sensor View Checked: Radar 1 is automatically checked and only the first radar will display data on the Data View tab.

360 Degree View Checked: All the radars are automatically checked, and they all display data on the Data View tab.

☑ 1	2	3	4	360 degree View
5	6	7	8	Front Sensor View

8.3 Saved Results

Oculii saves the following results for the user.

- a. Binary Point Cloud Data when the visualizer was running.
- b. Point Cloud Data under a .csv format to view on a spreadsheet.
- c. Tracker Data under a .csv format to view on a spreadsheet.
- d. Saved Point Cloud Video from the visualizer.

The data will be saved under C:\Oculii\Saved Results. A folder will be created with the date the visualizer was run under the [YYYY-MM-DD] format followed by another folder under the [YYY-MM-DD] format followed by another followed by another folder under the [YYY-MM-DD] format followed by anothe

8.4 Binary to CSV file Converter

The binary file saved by the visualizer can be converted to CSV to read the data. To run the Binary to CSV parser:

a. Copy the 'OculiiParser_BinToCSV' executable to the Sensor - Data folder where you will find a file ending with _Pcl.bin.

b. Run the executable





Name	Date modified	Туре	Size
11232020_184936_Pcl	11/23/2020 7:33 PM	Binary File	63,888 KB
OculiiParser_BinToCSV	11/23/2020 4:35 PM	Application	29 KB
🕺 Pcl	11/23/2020 7:43 PM	Microsoft Excel C	822,254 KB
🖬 Track	11/23/2020 7:43 PM	Microsoft Excel C	26,270 KB

Both the Point Cloud and Tracker CSV file will be generated from the saved binary.

9. FIRMWARE UPDATE ON VISUALIZER

The firmware and configuration files can be updated by following the below procedure.

- 1. The provided Update_Eagle.bin file should be copied to the visualizer folder.
- 2. Run the Windows Visualizer.
- 3. Enter the sensor IP and data as shown with the last digit replaced by the last digit of the sensor.
- 4. Click on the Start Receive button.
- 5. Once you receive data and the UDP connection is live, click on the Install Update button.

plication C	Config S	Split ViewL							
lata Receive	8								
Sensor Red	ceive Se	ttings							
Number of \$	Sensors	€10	2 0 3 0	4 0 5	06 07	08	Start F	Receive	
Sensor 1 IP	: [192.168.2.11	Data :	9911	Version :			OTA Update	Install Update
Sensor 2 IP	1	192.168.2.12	Data :	9912	Version:				
Sensor 3 IP	: 1	192.168.2.13	Data :	9913	Version:				
Sensor 4 IP	: 1	192.168.2.14	Data :	9914	Version :				
Sensor 5 IP	: 1	192.168.2.15	Data :	9915	Version:				
Sensor 6 IP	÷ [Data :	0	Version:				
Sensor 7 IP	:		Data :	0	Version :				
Sensor 8 IP	:		Data :	0	Version :				
Data Recei	ive Statu	s							
Sensor 1	Dat	a:							
Sensor 2	Dat	a:							
Sensor 3	Dat	a: 📃 🗌							
Sensor 4	Dat	a:							
Sensor 5	Dat	a:							
Sensor 6	Dat	a:							
Sensor 7	Dat	a:							
Sensor 8	Dat	a:							
SwitchMode	(LS : L	ow Speed, HS :	High Speed,	TS: Static	onary)				
Sensor 1	⊖ LS	O HS	⊖ ms		S	witch Mode			
Sensor 2	O LS		ं गाड		S	witch Mode			
Sensor 3	O LS		ା ୮୮୫		S	witch Mode			
Sensor 4	O LS		ं गड		S	witch Mode			
Sensor 5	O LS	O HS	ं गड		S	witch Mode			
	018	O HS	ं गड		S	witch Mode			
Sensor 6									
Sensor 6 Sensor 7	OLS	O HS	ं गाइ		S	witch Mode			





6. The following pop-up will appear. Select sensor type (Example: EAGLE) and then click the Update button.

Please enter the	number of sensors an	dater Id sensor info before u	sing the updater)		
Sensor Type					
Eagle	~				
File Source					
C Local D	rectory 🗌 Onlin	e			
	nber of sensors to	be updated			
Select the nur	All Ga	C PROVIDE CONTRACTOR			
Select the nur	lensor 🗋 All Be				
Select the nur Single 1 Enter Sensor N	lensor 🗌 All Be lumber : 1				
Select the nur	vensor 🗋 All Se Number: 1		U	pdate	

Note: Please do not close the window before the update completes. Please close the window "Firmware_Update" after update finishes and it is recommended to close the window and click the update button for every update.

If the update is not successful after approx. 3 minutes, please close the entire application and power cycle the sensor before attempting a new update.

🖳 Firmware_Update	-		\times
Firmware-QSPI Updater (Please enter the number of sensors and sensor info before using t	he updater)		
Sensor Type Eagle			
File Source			
Select the number of sensors to be updated Single Sensor All Sensors Enter Sensor Number : 1			
	U	lpdate	
Status Log : MCU report : Receiving. Please wait MCU report : QSPI_B Updated. EAGLE : Update Successful.			^ ~
Update function Complete. SUCCE	SSFUL		

 Once the update is complete, the pop-up displays that the update succeeded as below and the data will be visible on the client. The data and new version appears after appox. 10 seconds.

10. SAFETY AND RISK



10.1 Note and Scope of Responsibility

This section specifies practices the user should adhere to and the risks operators should recognize when operating the Oculii EAGLE sensor. This device should only be handled by technical operators with basic technical knowledge. The owner of the sensor module is responsible for the device and understands and observes the safety notes. If the EAGLE sensor is a part of a larger system, the system manufacturer is responsible for ensuring that all safety features are practiced. The owner of the device is responsible for ensuring that the device is used for its intended purpose and for the actions of their employees while operating the sensor. The owner is also responsible to notify Oculii as soon as the sensor displays any safety defects.

10.2 Operating Risk

- i) The system is not defined for free use in safety critical systems. However, it can be integrated into a system by the user, to adhere to safety regulation systems, features, or applications.
- ii) The user should be aware of falsified information that could occur over time due to external factors such as mechanical stress, accident, accidental drop, or natural disasters. The user should thus adopt practices that to measure the data output periodically and ensure that it meets expected results. The user should also ensure that any surfaces in the field of view of the sensor are kept clean and metal free. If the sensor starts displaying false information the user should report the same to Oculii.
- iii) Lack of knowledge or incomplete training of employees operating the sensor could result in accidents, injury or damage to property, assets, or the environment. Users should ensure all personnel operating the sensor are equipped with the technical knowledge and training to do so.
- iv) When deploying multiple sensors ensure that there is no falsified information that is present, either from the interruption of the radar beams or from interference from other sensors or electromagnetic radiations from other devices.
- v) When installing the sensor ensure that the front plate or any secondary surface in the field of view is free from the potential accumulation of ice, water or mud films.
- vi) Ensure that the power supplied is enough to operate the sensor and that the POE injector ports are matched to their intended destination.
- vii) Ensure that the housing of the sensor develops no scratches or cracks as that can impact signal integrity and heat transfer properties.

10.3 Service

Oculii must be contacted before the manipulation of the sensor for certain applications. Oculii must be contacted if the sensor starts displaying falsified information over time. For any other service needs and feature requests you could contact Oculii at <u>techsupport@oculii.com</u>.