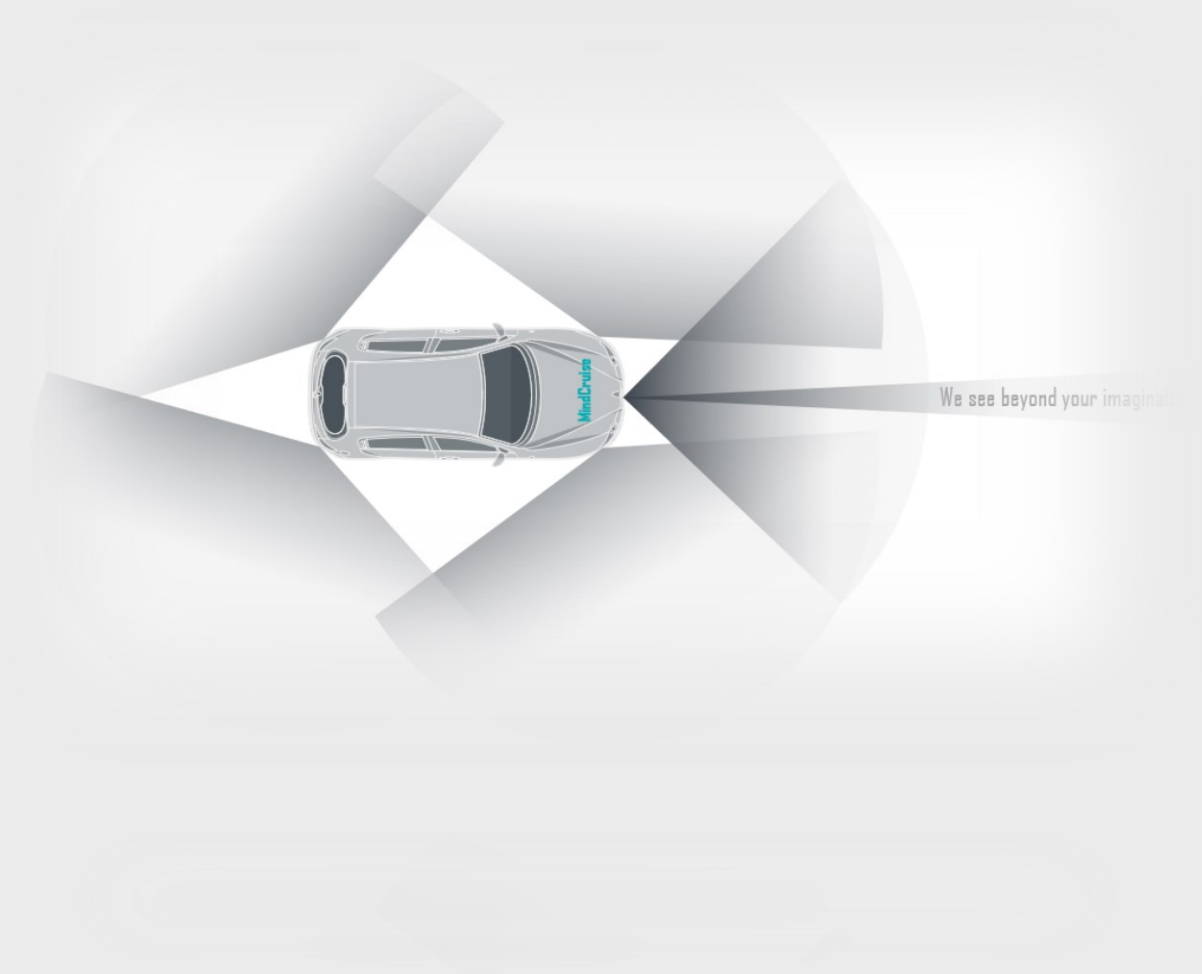


MindCruise

Ethernet Communication Protocol

Version 33



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Vehicle Static Data Packet <IN>

Vehicle Dynamic Data Packet <IN>

Detection List Packet <OUT>

Track List Packet <OUT>

DBF Matrix <OUT>

Freespace Packet <OUT>

Radar Overall Status Packet <OUT>

AUTOSAR Misc <IN/OUT>



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1 雷达数据输出协议

1.1 Output Message

Aries 雷达通过车载以太网输出点云、目标等信息，传输层使用 UDP 协议，应用层使用基于消息的自定义协议。

雷达的帧率为 **15fps**，每一帧内产生的点云以及目标等信息分成若干条 Message（每一条 Message 即是一条 UDP 报文）进行输出，Message 的定义如下：

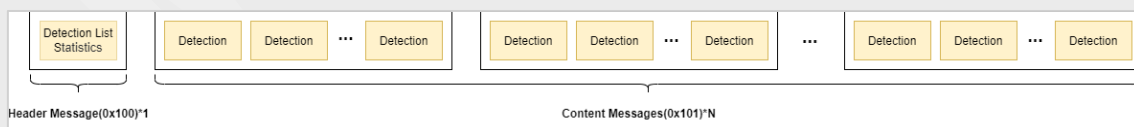
2 Bytes	2 Bytes	2 Bytes	1-248 Bytes	2 Bytes
Message ID	Data Length	Message Counter	Payload	CRC

- 每一条 Message 的最大长度定为 256 Bytes；
- Message 由 Message ID 开头，不同类型的 Message 由 Message ID 进行区分；
- Message 的末尾为 CRC，用于校验 Message 的完整性，CRC 计算从 Message ID 开始到 Payload 末尾结束；
- Data Length 为 Payload 的长度，不包含头和 CRC；
- Message Counter 用于 Message 的计数，自增到 0xFFFF 自动反转，用于包序处理和丢包检测。

雷达的每一种数据被分配了一个或多个 Message ID：

- 对于数据量较小(<256 Bytes)的数据，分配一个 Message ID，用一条 Message 输出，例如雷达的状态等；
- 对于列表型数据，例如 Detection List 或 Object List，分配两个 Message ID，采用 **Header*1 + Content*N** 的形式输出，Header 占用一个 ID，Content 占用一个 ID；
- 对于其他数据量较大且没有重复性的数据，按需分配连续的 Message ID，由多个独立的 Message 分包输出(目前没有这种数据)。

Detection List 输出示例（同 Object List）：



1.2 Message ID

目前雷达的 Message ID 和对应的数据定义如下：



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Message ID	数据类型
0x0001	Radar status message
0x00FF	Radar sensor meta infomation (i.e. HW version, SW version, serial number, etc.)
0x0100	Detection List Header
0x0101	Detections
0x01FF	Detection List Tail
0x0200	Object List Header
0x0201	Objects
0x0300	DBFMatrix Header
0x0301	DBFMatrixs
...	...

1.3 RS Status Message

ID: **0x0001**

Length: 16 Bytes

Content:

8 Bytes/UINT64	8 Bytes/UINT64
timestamp (us)	Reserved

1.4 Radar

ID: **0x00FF**

Length: This is a null-terminated string, in JSON format.

JSON Keys:

Key	Description	Example value
meta-version	Version of this meta information string, new keys might be included in new versions.	1.0
hwver	Sensor hardware version string	Aries C2 HW
swver	Sensor application software version string	MC.A1.123
fpgaver	Sensor fpga firmware version string	20240612



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Key	Description	Example value
sn	Sensor serial number string	TEMPSN123456

JSON Example: {"meta-version":"1.0", "hwver":"Aries C2 HW", "swver":"MC.A1.123", "fpgaver":"20240612", "sn":"TEMPSN123456" }

Note that only the message payload is encoded as JSON, the message header (id, length) and tail (crc) are still encoded in binary format.

1.5 Detection List

Detection List Header Message:

ID: 0x0100

Length: 8 Bytes

Content:

2 Bytes/UINT16	2 Bytes/UINT16	2 Bytes/UINT16	2 Bytes
version	frame count	number of detections	reserved

Detections Message:

ID: 0x0101

Length: 240 Bytes

Content:

	2 Bytes	2 Bytes	4 Bytes	2 Bytes	2 Bytes	2 Bytes	2 Bytes	2 Bytes	1 Byte	1 Byte	2 Bytes	1 Byte	1 Byte
Detection 0	ID	flags	range	doppler	azimuth	elevation	rsc	snr	doppler anti-ambiguity confidence	existence confidence	frame	beam	extrapolation counter
Detection 1	ID	flags	range	doppler	azimuth	elevation	rsc	snr	doppler anti-ambiguity confidence	existence confidence	frame	beam	extrapolation counter
...	...	...	...	...	...	...	...	...	...	...	...	...	...
Detection 9	ID	flags	range	doppler	azimuth	elevation	rsc	snr	doppler anti-ambiguity	existence confidence	frame	beam	extrapolation counter



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	2 Bytes	2 Bytes	4 Bytes	2 Bytes	2 Bytes	2 Bytes	2 Bytes	2 Bytes	1 Byte	1 Byte	2 Bytes	1 Byte	1 Byte
									confidence				

Detection Details:

Name	Type	Factor	Accuracy	Unit
ID	UINT16	N/A	N/A	N/A
flags	UINT16	N/A	N/A	N/A
range	INT32	100	0.01	m
doppler	INT16	100	0.01	m/s
azimuth	INT16	100	0.01	degree
elevation	INT16	100	0.01	degree
rsc	INT16	256	0.0039	dBsm
snr	INT16	100	0.01	dB
doppler anti-ambiguity confidence	UINT8	N/A	N/A	N/A
existence confidence	UINT8	N/A	N/A	N/A
frame	UINT16	N/A	N/A	N/A
beam	UINT8	N/A	N/A	N/A
extrapolation counter	UINT8	N/A	N/A	N/A

Detection List 满载流量估算: 15fps*8000 点*24 bytes + overhead $\approx$ 3.0MBps, 约占百兆以太网的 24%(3.0MBps/12.5MBps)

Detection List Tail Message:

This message is transmitted immediately when all detection messages are transmitted, and thus is suitable for 'end-of-frame' checking in 3rd-party message receivers.

ID: 0x01FF

Length: 8 Bytes

Content:

2 Bytes/UINT16	2 Bytes/UINT16	2 Bytes/UINT16	2 Bytes
version	frame count	number of detections	reserved



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1.6 Object List

Object List Header Message:

ID: 0x0200

Length: 8 Bytes

Content:

2 Bytes/UINT16	2 Bytes/UINT16	2 Bytes/UINT16	2 Bytes/UINT16
version	frame count	number of objects	reserved

Objects Message:

ID: 0x0201

Length: 224 Bytes

Content:

	2 Bytes	2 Bytes	2 Bytes	2 Bytes	2 Bytes	2 Bytes	2 Bytes	2 Bytes	2 Bytes	2 Bytes	2 Bytes	2 Bytes	1 Byte	1 Byte	6 Bytes
Object 0	ID	x	y	z	vx	vy	ax	ay	heading	width	length	height	classification	confidence	reserved
Object 1	ID	x	y	z	vx	vy	ax	ay	heading	width	length	height	classification	confidence	reserved
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Object 6	ID	x	y	z	vx	vy	ax	ay	heading	width	length	height	classification	confidence	reserved

Object Details:

Name	Type	Factor	Accuracy	Unit
ID	UINT16	N/A	N/A	N/A
x	INT16	100	0.01	m
y	INT16	100	0.01	m
z	INT16	100	0.01	m
vx	INT16	100	0.01	m/s
vy	INT16	100	0.01	m/s
ax	INT16	100	0.01	m ² /s
ay	INT16	100	0.01	m ² /s
heading	INT16	100	0.01	degree



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Name	Type	Factor	Accuracy	Unit
width	UINT16	100	0.01	m
length	UINT16	100	0.01	m
height	UINT16	100	0.01	m
classification	UINT8	N/A	N/A	N/A
confidence	UINT8	N/A	N/A	N/A

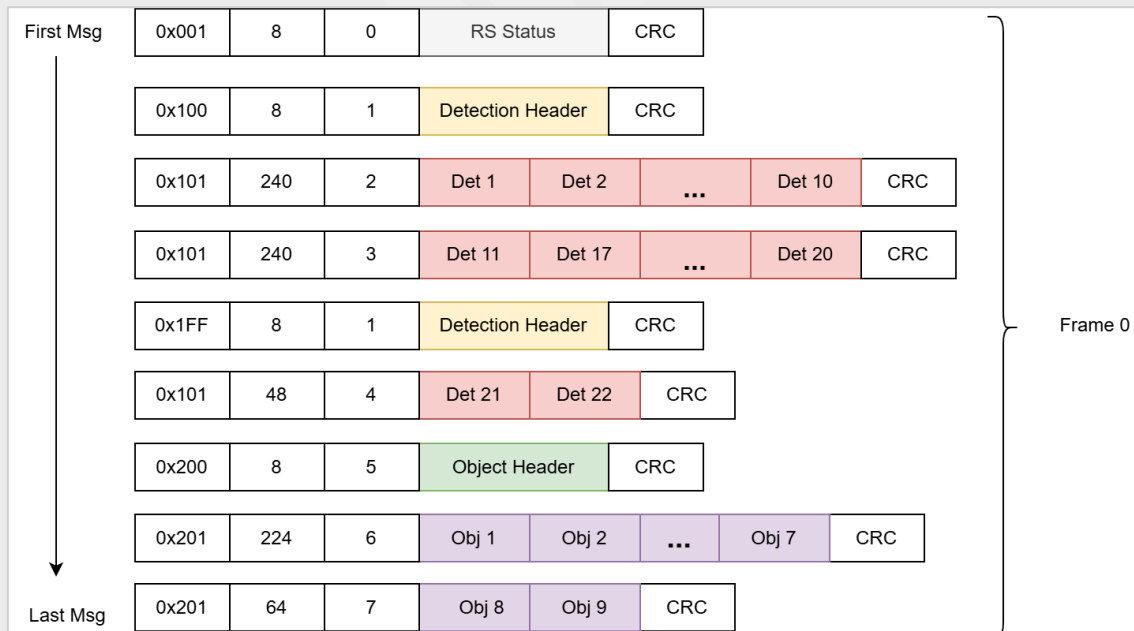
Object List 满载流量估算: $15\text{fps} \times 250\text{obj} \times 32\text{ bytes} + \text{overhead} \approx 130\text{KBps}$, 约占百兆以太网的 1.04%(130KBps/12.5MBps)

1.7 DBF Matrix

TBD

1.8 雷达消息输出示例

假设雷达在 Frame 0 里输出了 22 个 Detection 和 9 个 Object, 那么本帧所有的输出消息如下图:





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