

自动驾驶毫米波雷达 行业趋势与关键技术

MMW RADAR INDUSTRY TRENDS & TECHNOLOGIES

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RADAR Sys Mgr
APRIL 2023

HAWKEYE
隼眼科技



SECURE CONNECTIONS
FOR A SMARTER WORLD

PUBLIC

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RADAR: Taking safety to new levels - Saving Lives

DRIVER IN CHARGE

VEHICLE IN CHARGE

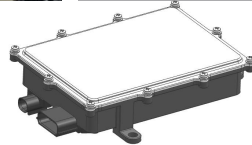
LEVEL 0 NO AUTOMATION	LEVEL 1 DRIVER ASSISTANCE	LEVEL 2 PARTIAL AUTOMATION	LEVEL 3 CONDITIONAL AUTOMATION	LEVEL 4 HIGH AUTOMATION	LEVEL 5 FULL AUTOMATION
Warnings and momentary assistance	Steering OR brake/acceleration	Steering AND brake/acceleration	Limited conditions YOU MUST DRIVE if requested	Limited conditions	All conditions
					



Conventional RADAR



4D RADAR



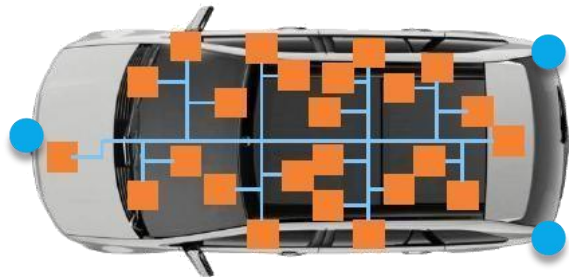
4D Imaging RADAR



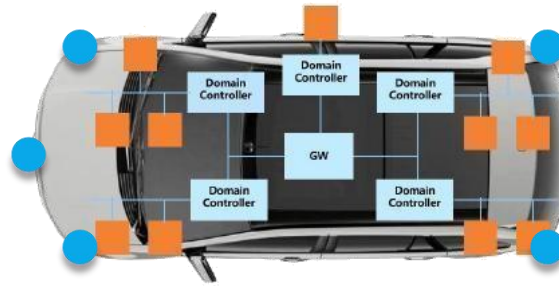
Remote RADAR



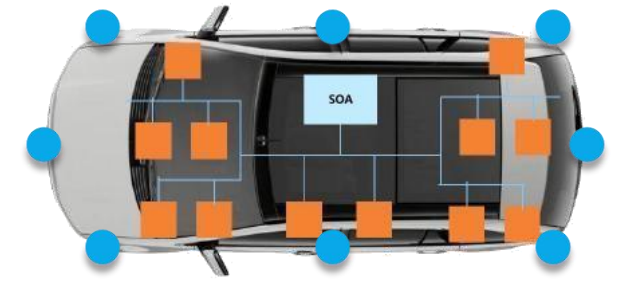
System Architecture



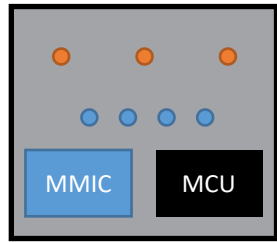
Distributed ECU



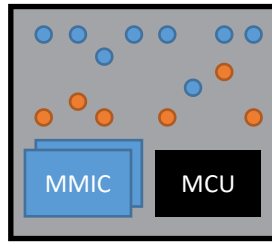
Domain Controller



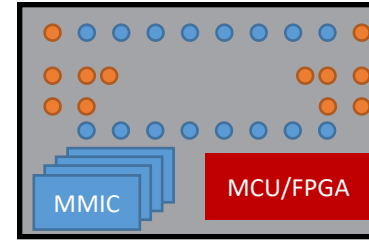
Centralized Computing



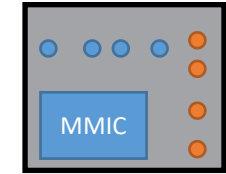
- 3D/3.5D RADAR
- Average resolution
- Func./Obj. output
- CAN based
- Func. in radar/ECU



- Obj./Det. output
- Focus on Obj. accuracy
- Good resolution
- CAN/ETH based
- Fusion/Func. in DCU



- Det. output
- Focus on Det. numbers
- Excellent resolution
- ETH based
- Fusion/Func. in DCU



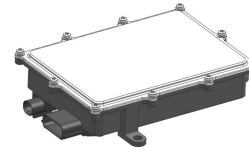
- Rawdata output
- GE based
- Algo. out of RADAR



Conventional RADAR



4D RADAR



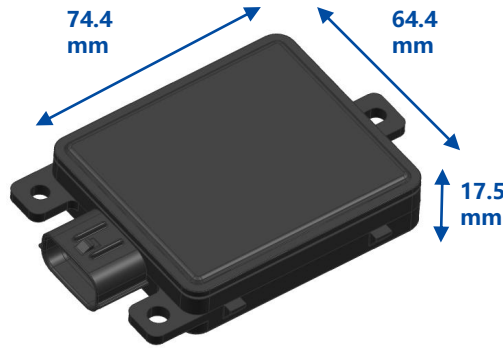
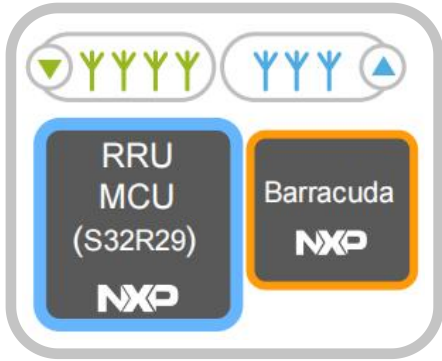
4D Imaging RADAR



Remote RADAR

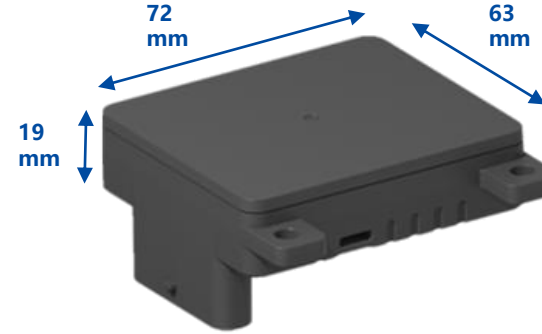


Single-chip RADAR






CORNER RADAR

-  **150 / 20 deg**
FoV(AZ/EL)
-  **4 deg**
AZ Resolution
-  **0.5 / 0.5 deg**
AZ/EL Precision
-  **100 m**
MAX Range



FRONT RADAR

-  **100 / 20 deg**
FoV(AZ/EL)
-  **3.5 deg**
AZ Resolution
-  **0.3 / 0.5 deg**
AZ/EL Precision
-  **210 m**
MAX Range

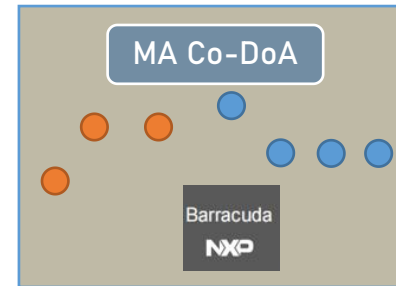
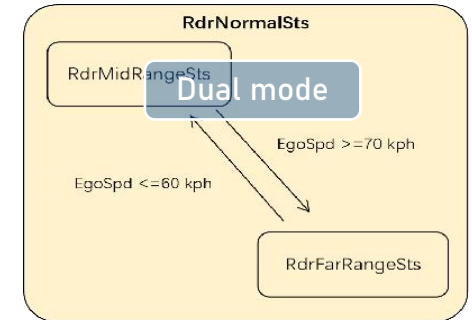
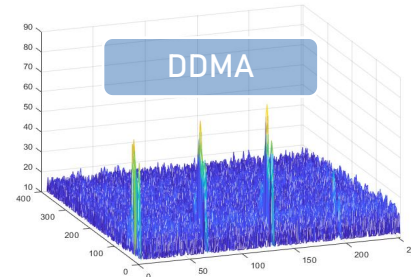
LEVEL 0/1/2
SAE DAS

Key Features

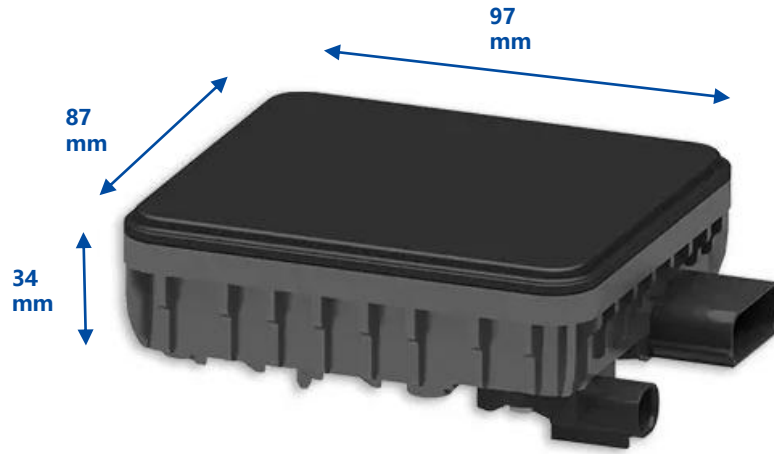
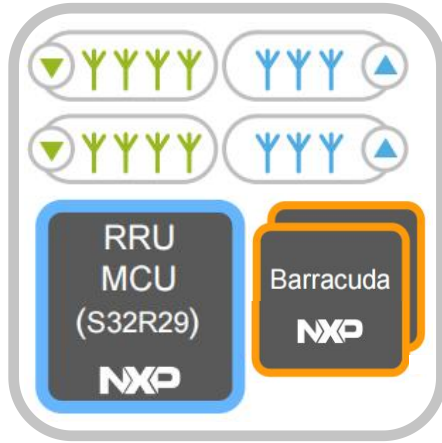
- ◆ Corner: BSD/LCW/RCTA/DOW/RCW/
FCTA/Parking
- ◆ Front: ACC/AEB/AEB-P
- ◆ Object/Point cloud (CAN-FD/ETH)
- ◆ Environment detecting
(Guardrail/boundary/tunnel)
- ◆ Classification
- ◆ 2D auto alignment

New Techs

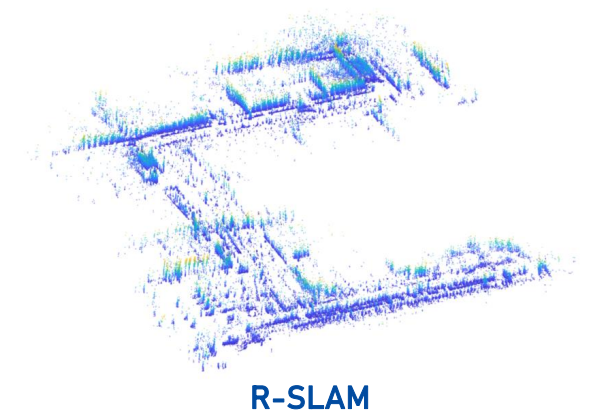
- ◆ DDMA
- ◆ Multi-Array Co-DoA
- ◆ Dual operation mode
- ◆ SIW RF feeding



Dual-chip 4D RADAR



-  **120 / 30 deg**
FoV(AZ/EL)
-  **2 / 4 deg**
AZ/EL Resolution
-  **0.2 / 0.2 deg**
AZ/EL Precision
-  **300 m**
MAX Range



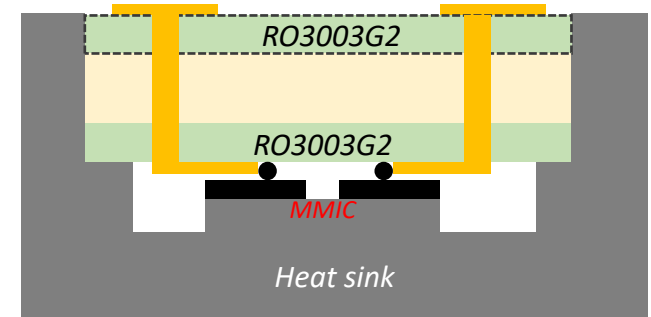
LEVEL 2/3
SAE DAS

Key Features

- ◆ Max point cloud: **1024** per frame
- ◆ Front: ACC/AEB/AEB-P
- ◆ Object/Point cloud (**ETH**/CAN-FD)
- ◆ Front / **rear** selection
- ◆ Environment detecting
(Guardrail/boundary/tunnel)
- ◆ Classification
- ◆ 2D auto alignment
- ◆ Freespace and R-SLAM (ext.)

New Techs

- ◆ DDMA
- ◆ Low SLL DoA
- ◆ Multi operation mode
- ◆ 3D RF feeding
- ◆ 1 or 2 boards alternatives



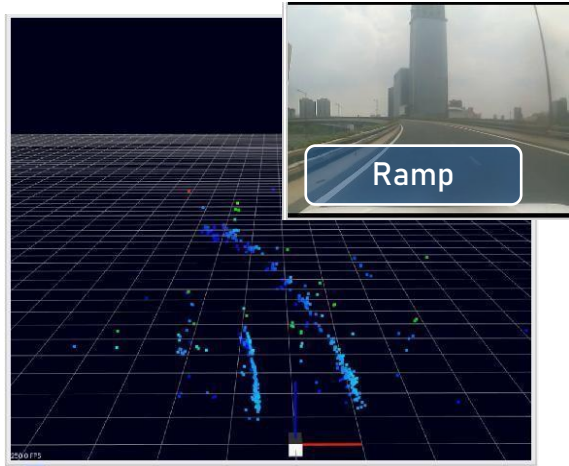
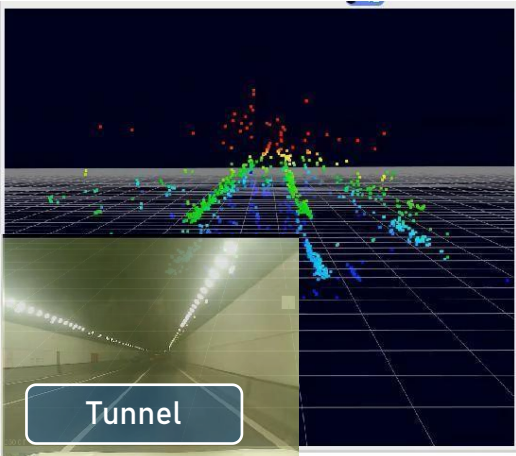
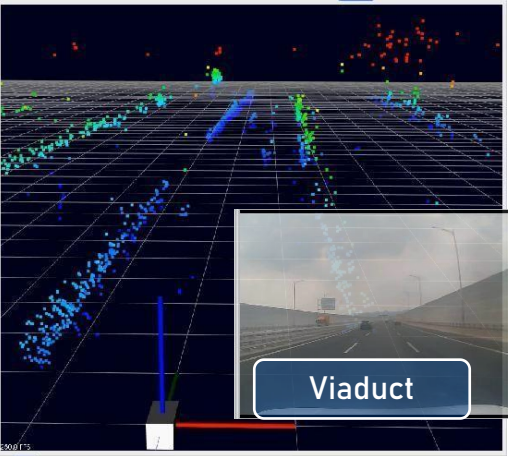
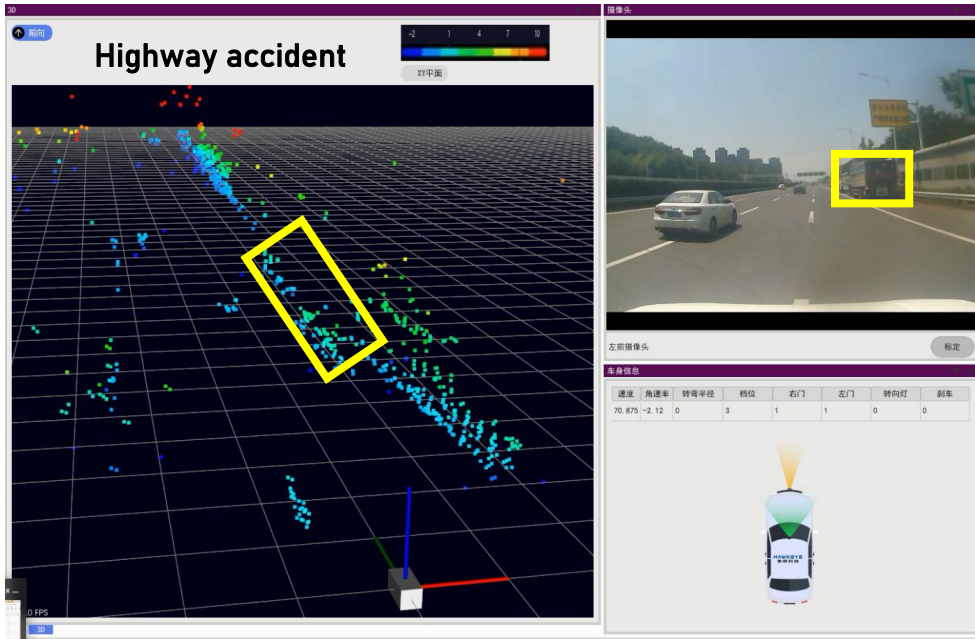
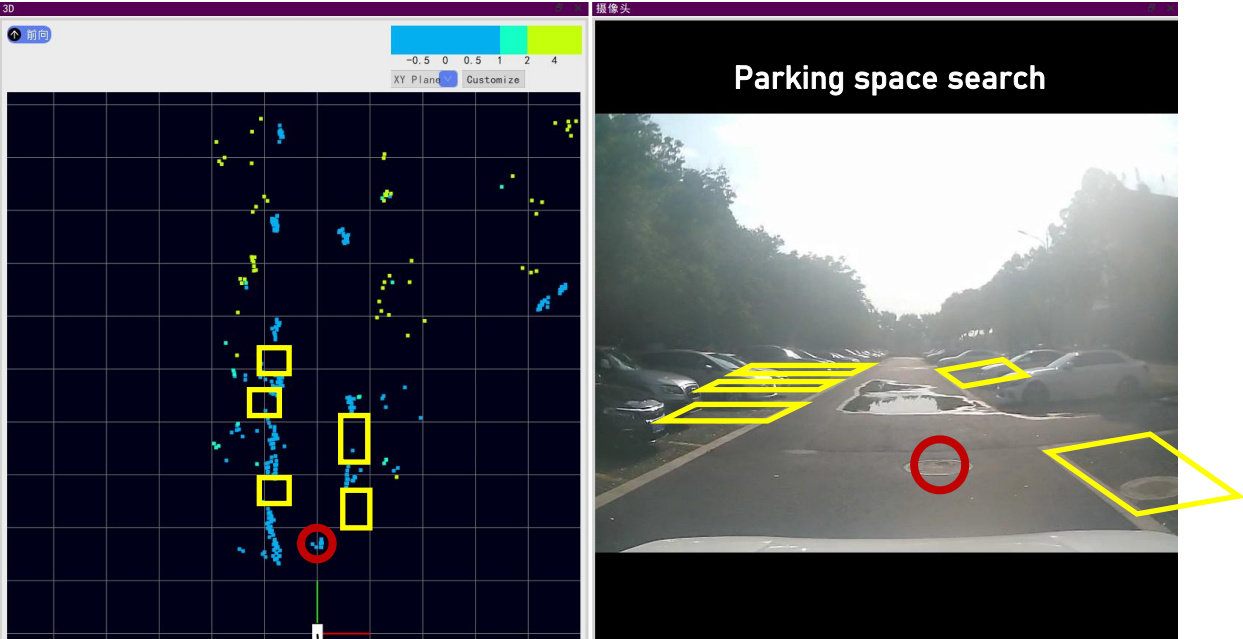
RADAR benefits

- ◆ Less system loss
- ◆ More range coverage
- ◆ Less RF radiation
- ◆ Better DoA accuracy

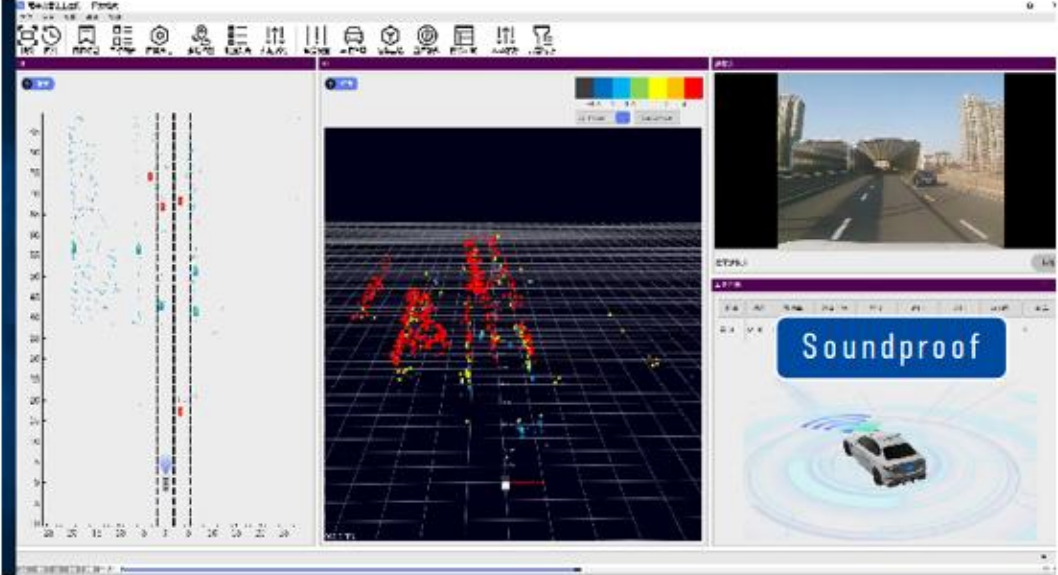
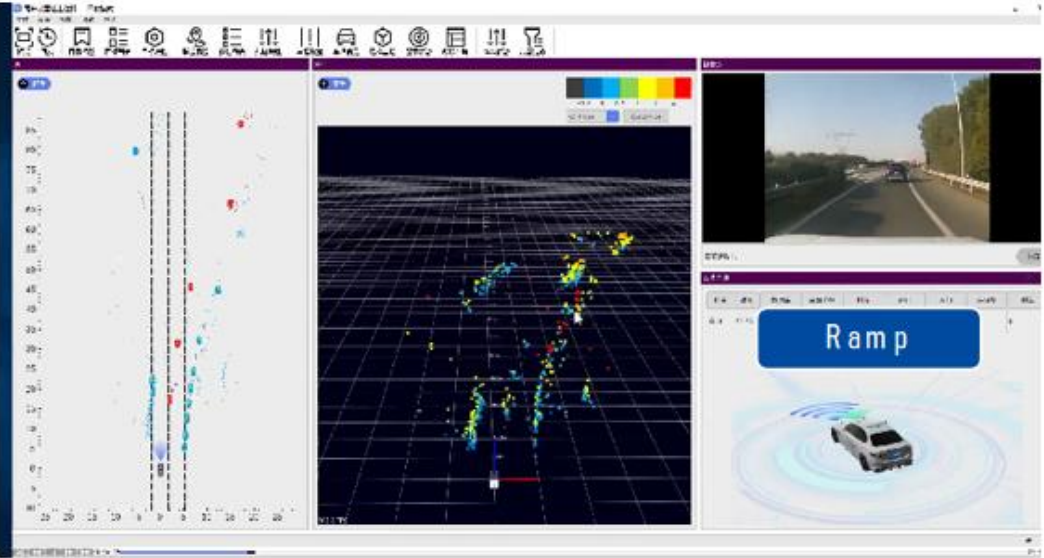
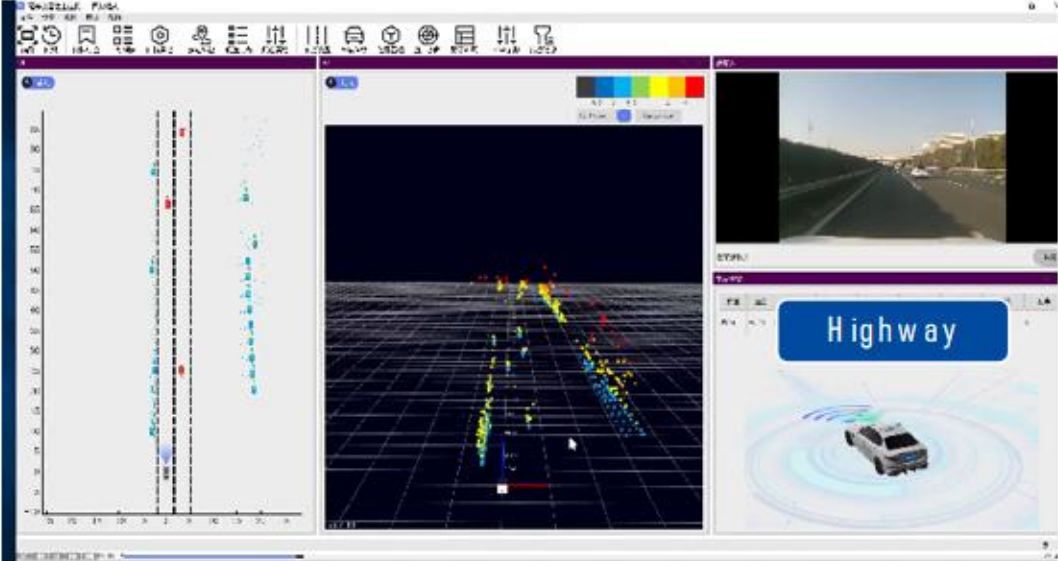
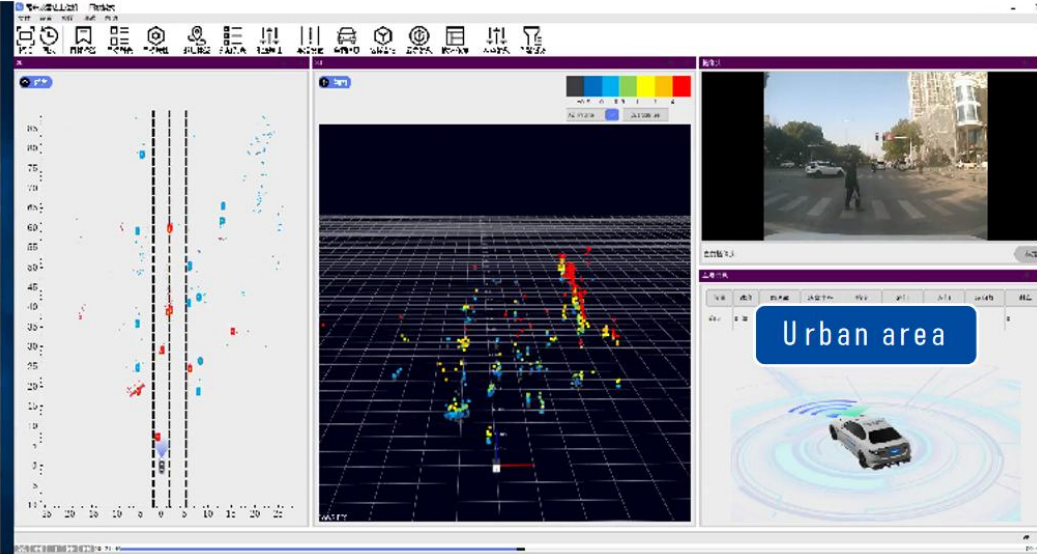
$$L_{\text{sys}} \downarrow 3\text{dB}, R_{\text{max}} \uparrow 20\%$$

$$S_{\text{RF}} \downarrow 20\text{dB}, \epsilon_{\text{DOA}} \uparrow 100\%$$

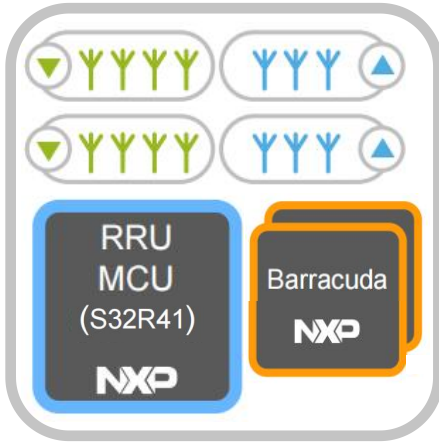
Automotive Scenarios



Automotive Scenarios

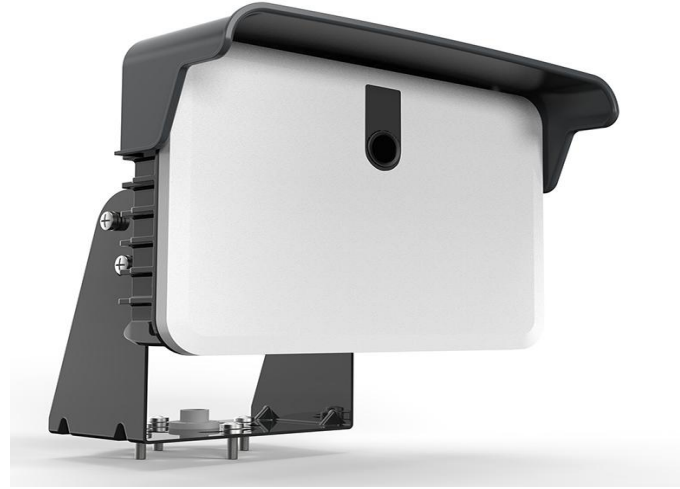


Dual-chip 4D RADAR



TRAFFIC

City / Tunnel



80 / 13 deg
FoV(AZ/EL)



250 m
MAX Range



1.5 / 2 deg
AZ/EL Resolution



8~10
Lanes



0.2 / 0.2 deg
AZ/EL Precision



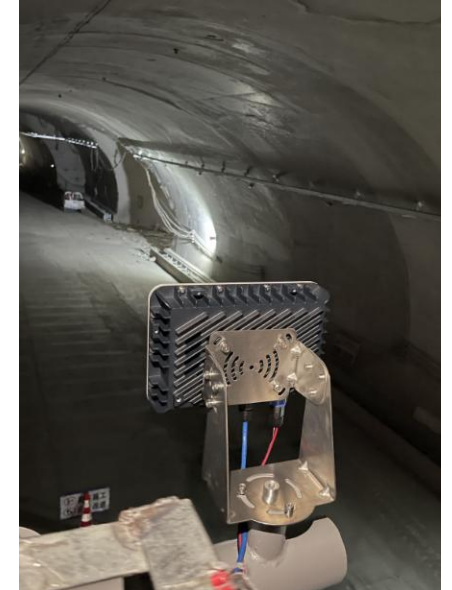
80 GHz
Frequency band

New Techs

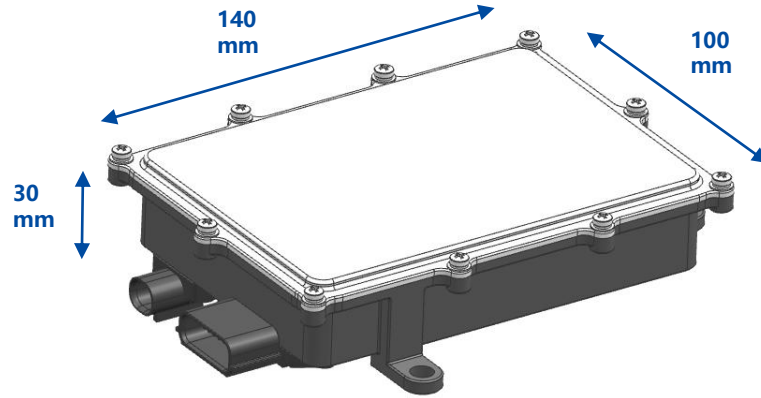
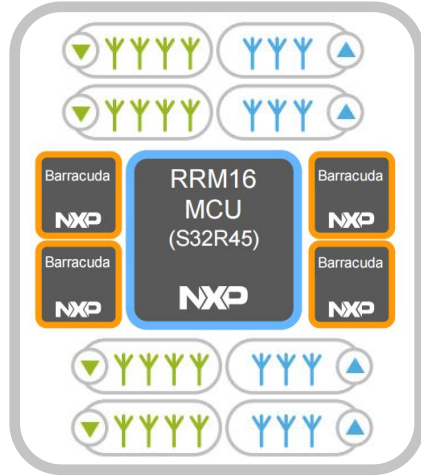
- ◆ DDMA
- ◆ Antenna beamforming
- ◆ Vision fusion
- ◆ De-reflection of multipath

Key Features

- ◆ Objects: **512** per frame (ETH)
- ◆ Minimum blind zone
- ◆ Classification
- ◆ **Traffic events**
- ◆ **Smart signal light**
- ◆ Holographic intersection



Quad-chip 4D Imaging RADAR



LEVEL 3+
SAE DAS

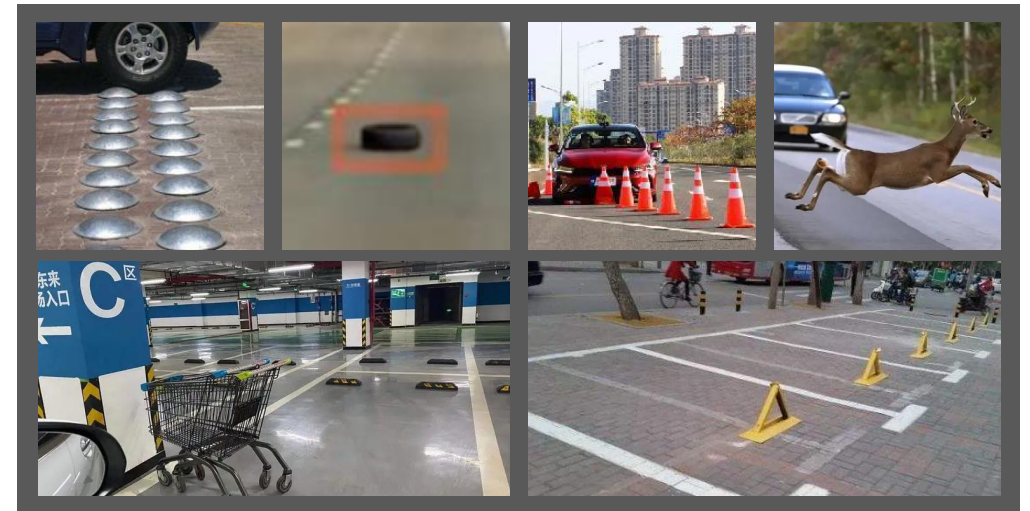
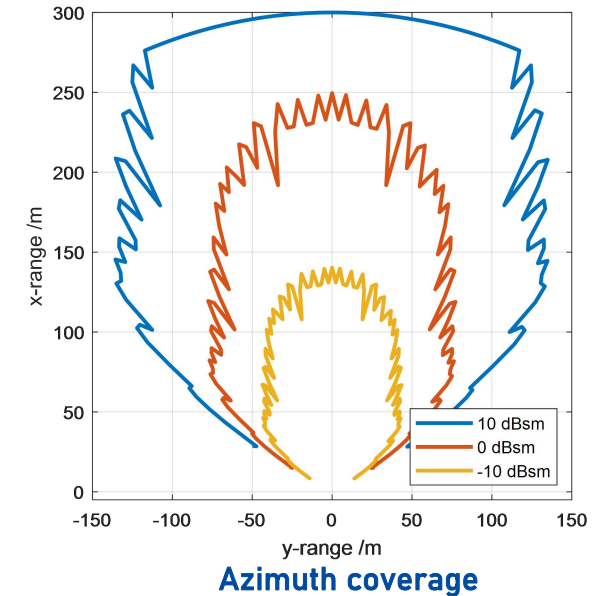
New Techs

- ◆ TD/DDMA hybrid MIMO
- ◆ 2D Planar Array
- ◆ Expanded aperture DoA
- ◆ 3D Antenna
- ◆ Receiving DBF

Key Features

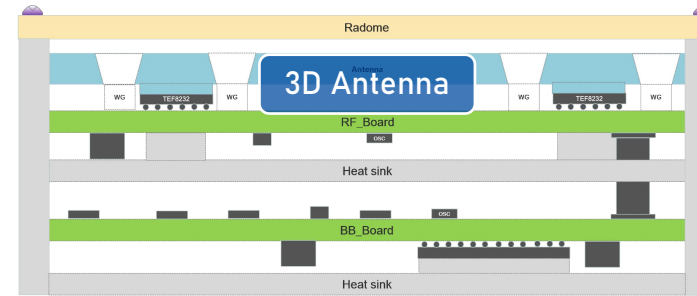
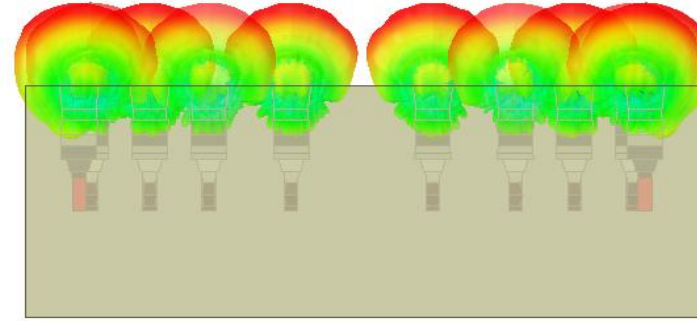
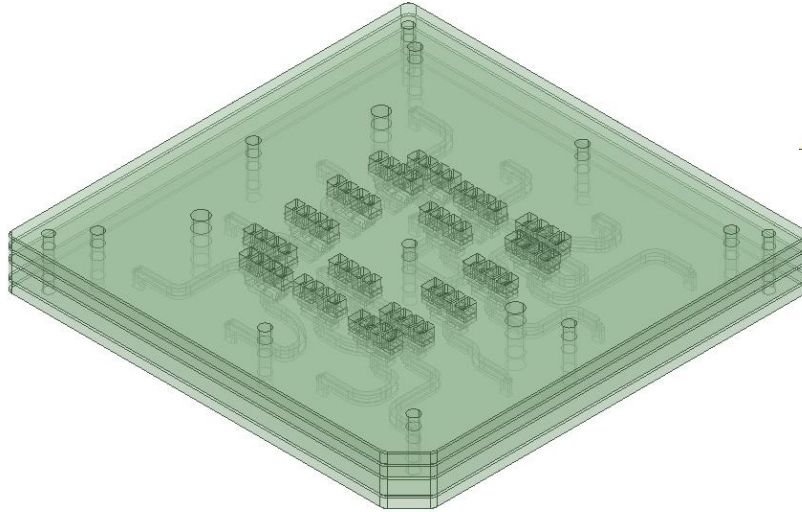
- ◆ Max point cloud: **3000** per frame
- ◆ Object/Point cloud (**ETH**)
- ◆ **Ego motion** estimation
- ◆ Environment detecting (Guardrail/boundary/tunnel)
- ◆ VRU/obstacle detecting
- ◆ Classification
- ◆ 2D auto alignment
- ◆ WG or PCB antenna alternatives

- 120 / 30 deg**
FoV(AZ/EL)
- 1 / 1 deg**
AZ/EL Resolution
- 0.1 / 0.1 deg**
AZ/EL Precision
- 300 m@40deg**
MAX Range
- 200 m**
MAX Range
- 400 to 200 kph**
Detecting Doppler



3D Waveguide Antenna

Dual-chip 8T8R WG Array

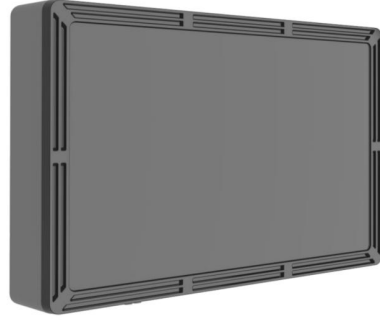
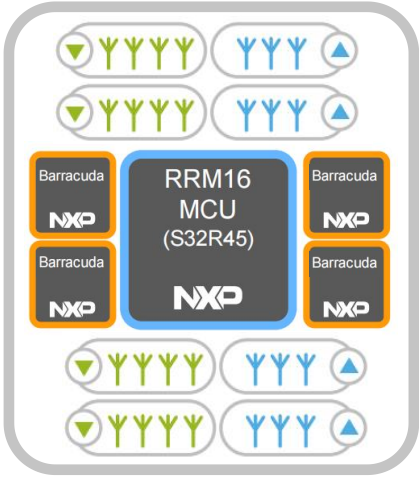


Metallized plastic WG + mmW CCL

Waveguide Antenna Processing

- ◆ Step1: High Precision Molding
- ◆ Step2: Plating (PVD)
- ◆ Step3: Solder paste printing
- ◆ Step4: SMT

Quad-chip 5H RADAR



Highway 3000



10~14
Lanes



0.5 deg
AZ Resolution



0.1 deg
AZ Precision



1.5 km
MAX Range



80 GHz
Frequency band

TRAFFIC
Highway

Hyper Range

Hyper Resolution

Hyper Precision

Hyper Intelligence

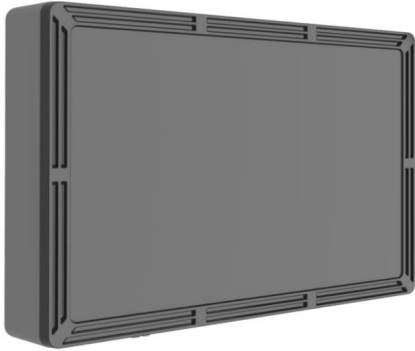
Holographic Perception

New Techs

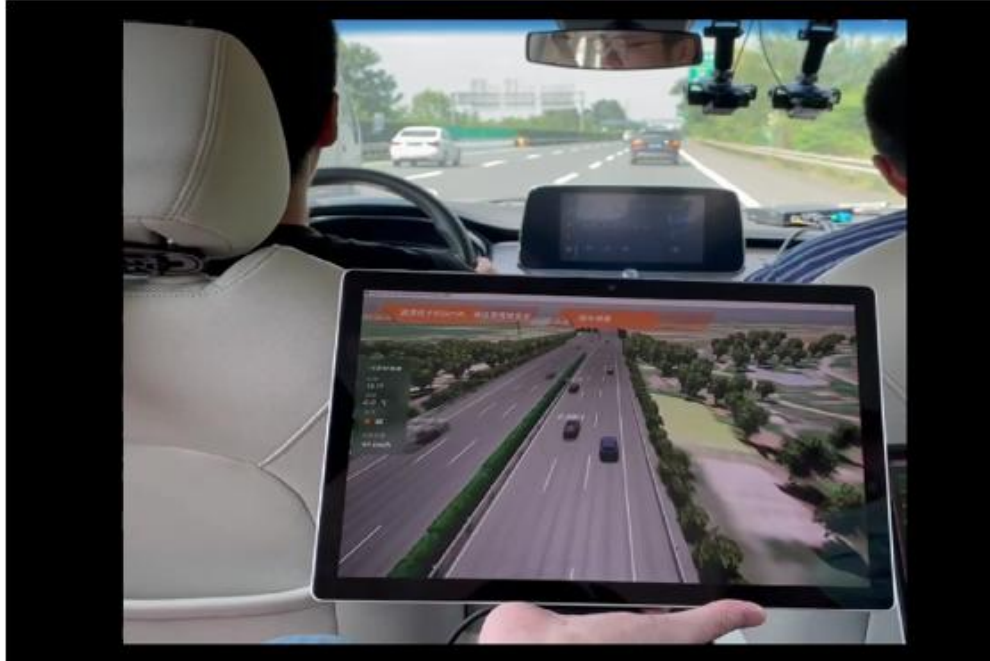
- ◆ TD/DDMA hybrid MIMO
- ◆ ML RADAR recognition
- ◆ Fast azimuth auto alignment



Highway Scenario



Highway 1500





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