

Automotive Radar Basics & NXP Solutions

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SECURE CONNECTIONS
FOR A SMARTER WORLD

PUBLIC

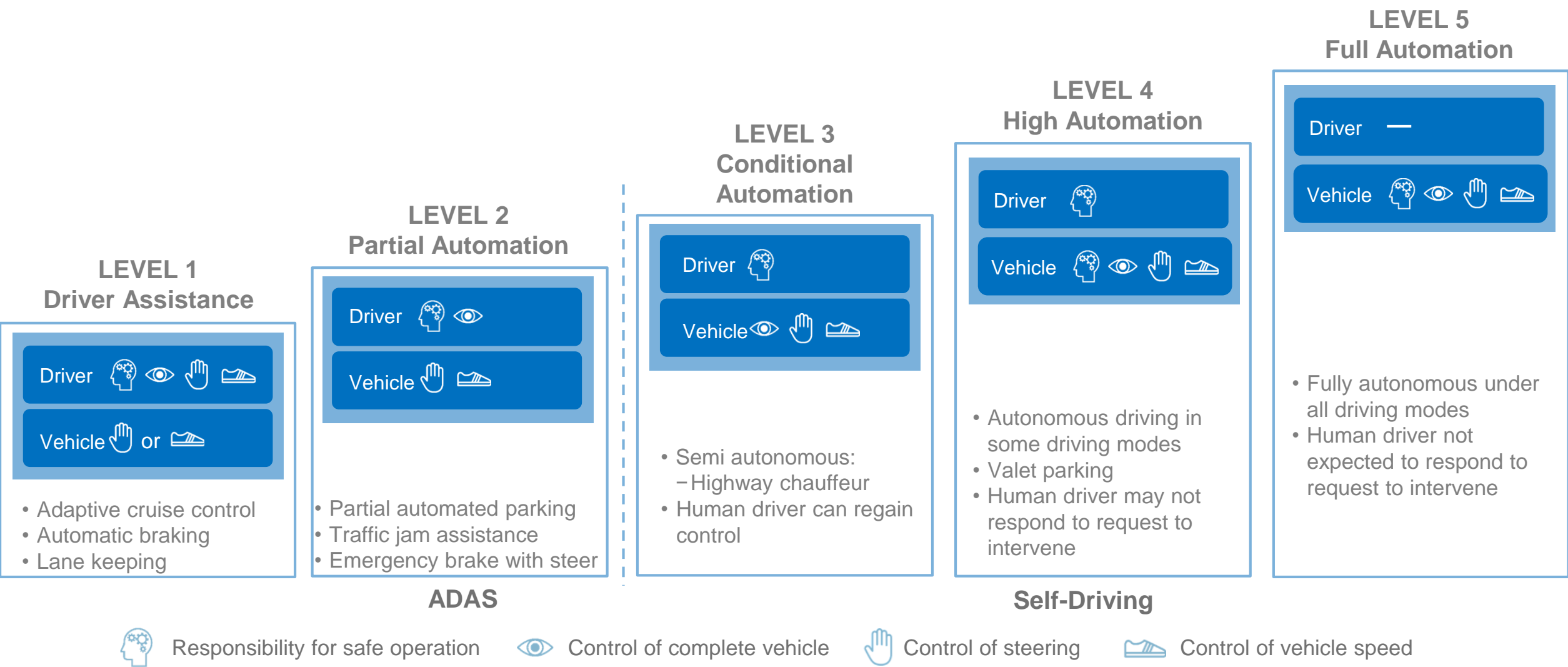
Agenda

- ADAS Overview
- Automotive Radar Basics
- NXP Radar Solutions



ADAS OVERVIEW

Race to Self-Driving: Revolution and Evolution

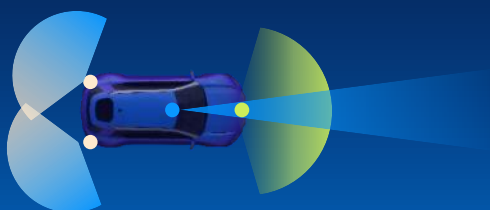


SAE. (2014). AUTOMATED DRIVING LEVELS OF DRIVING AUTOMATION. [SAE INTERNATIONAL STANDARD J3016](#).



Automation Multiplies Sensors and Silicon Content

In Production Level 1/2

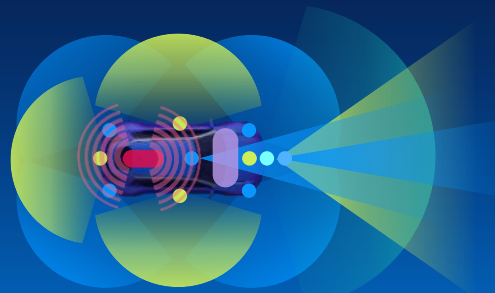


\$100-\$150
Silicon Value

Radar 1-3
Camera 1
Lidar
V2X
Fusion

units

In Development Level 3

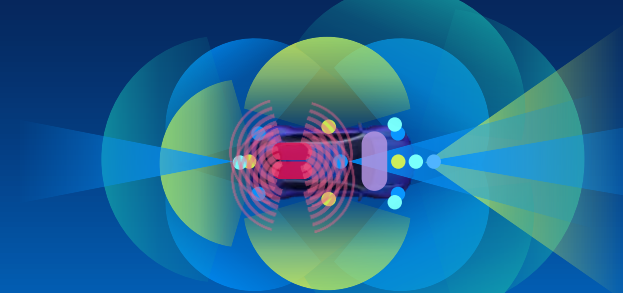


\$600
Silicon Value

Radar 4-6
Camera ≥4
Lidar 0-1
V2X 0-1
Fusion 1

units

New Entrants Level 4/5



\$900-\$1200
Silicon Value

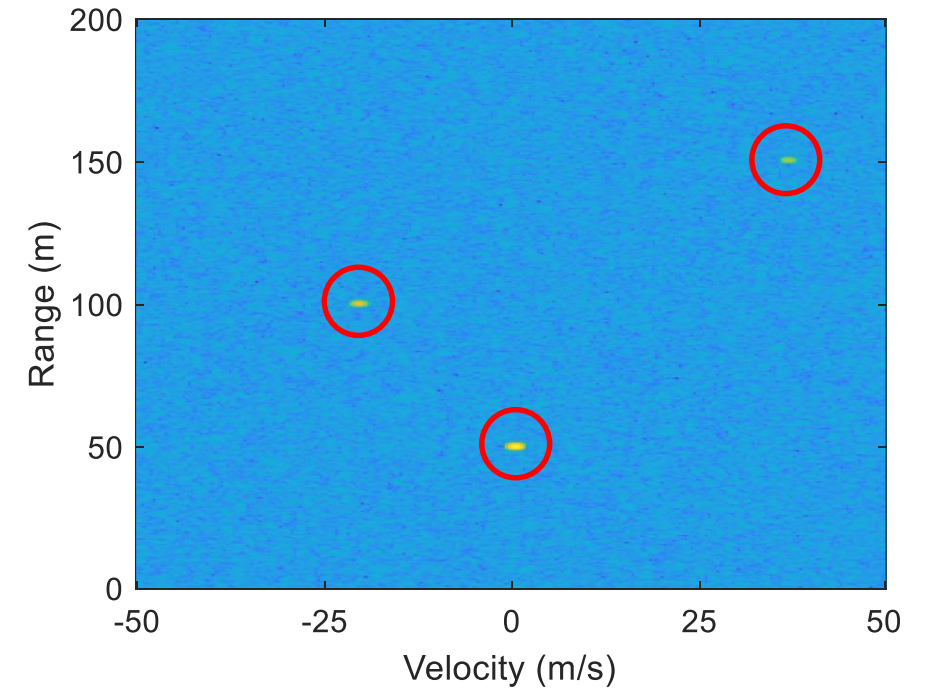
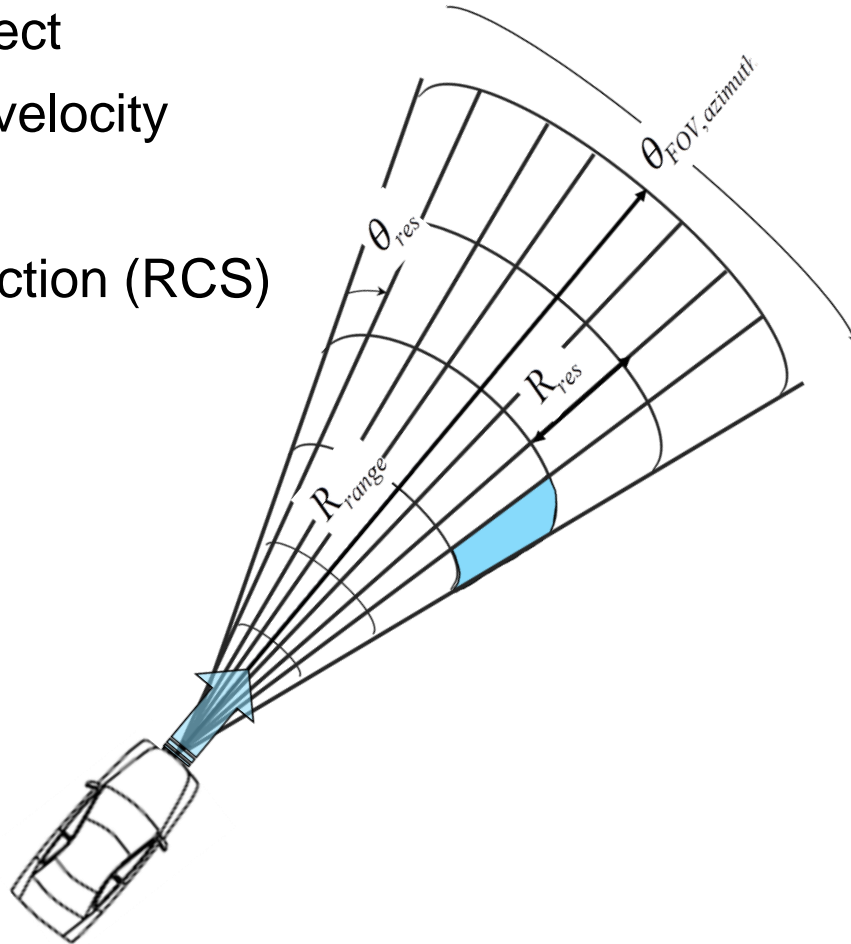
Radar 6-10
Camera 6-8
Lidar 1-3
V2X 1-2
Fusion 1

units

AUTOMOTIVE RADAR BASICS

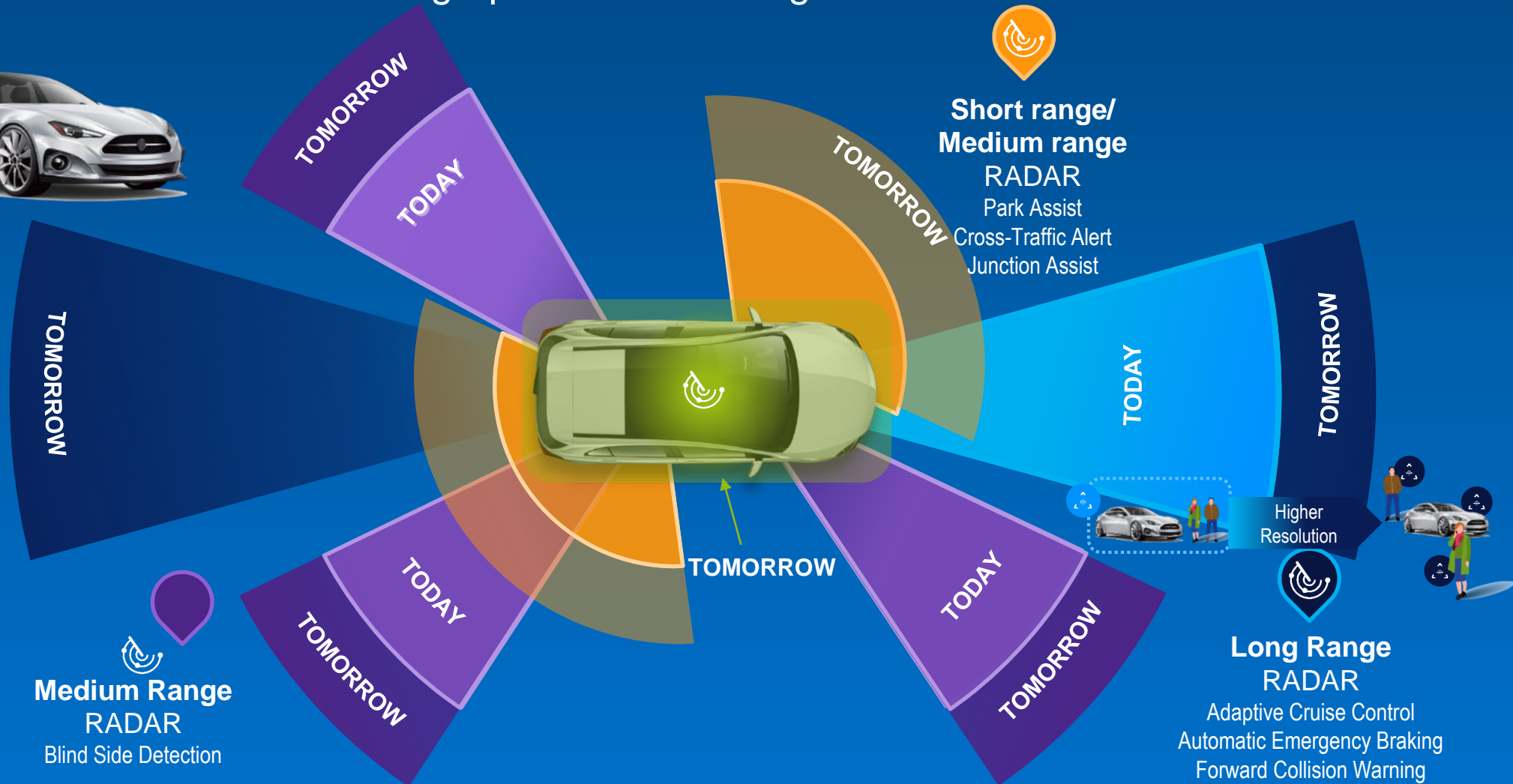
Radar Functionality

- **RA**dio **D**etection **A**nd **R**anging
- Measure:
 - Distance to object
 - Relative radial velocity
 - Angle of arrival
 - Radar cross section (RCS)



Radar Applications

Evolves to 360° view with high-performance integration



Why Radar?

- ▶ Competing and complementary technologies: Camera, LIDAR, Ultrasonic.
- ▶ Radar advantages:
 - Robust against weather influences and pollution
 - Unaffected by light
 - Direct distance and speed measurement

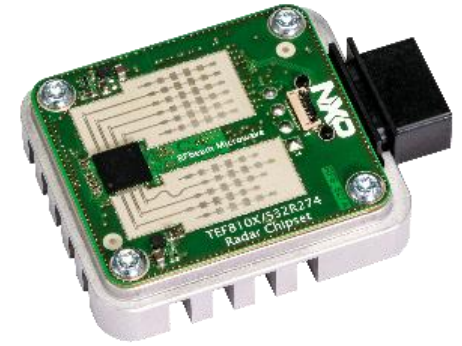
	Radar	Ultrasonic	Camera	Lidar
Distance	Long	Short	Medium	Long
Night	Good	Good	Bad	Good
Rain & Fog	Good	Affected	Bad	Bad
Classification	Medium	Bad	Good	Medium
Resolution	Medium	Bad	Medium	Good
Cost	Medium	Low	Medium	High



mmWave Frequency Band

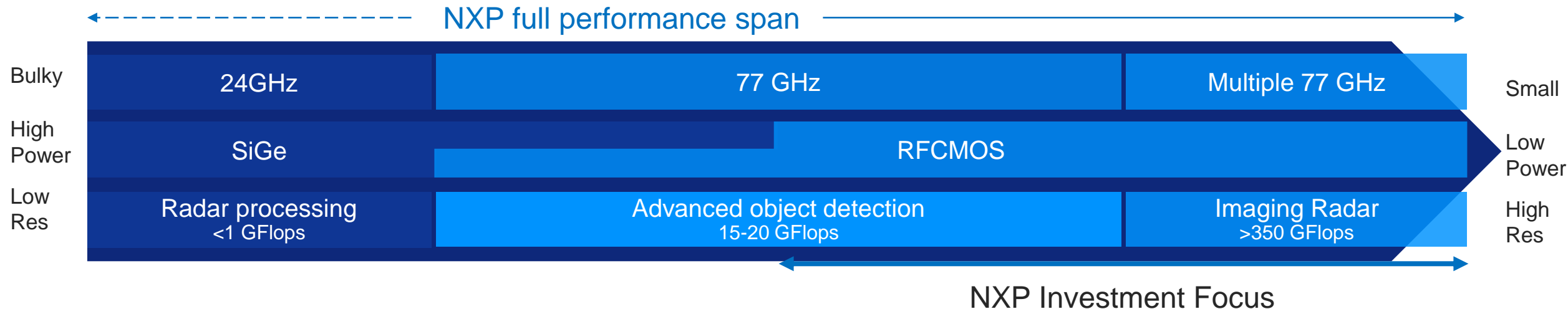
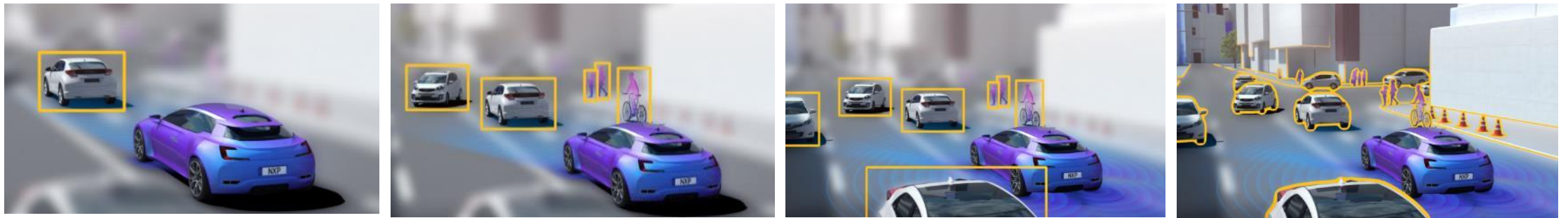
- Millimeter wave (mmWave) frequency band: 30 GHz – 300 GHz
- Wavelength of mmWave frequency: 10 mm – 1 mm
- Wavelength in free space = speed of light / frequency $\lambda_0 = c_0/f$

Frequency (GHz)	Wavelength in free space(mm)
2.4	125
24 – 24.25	12.5 – 12.4
76 – 77	3.95 – 3.9
77 – 81	3.9 – 3.7

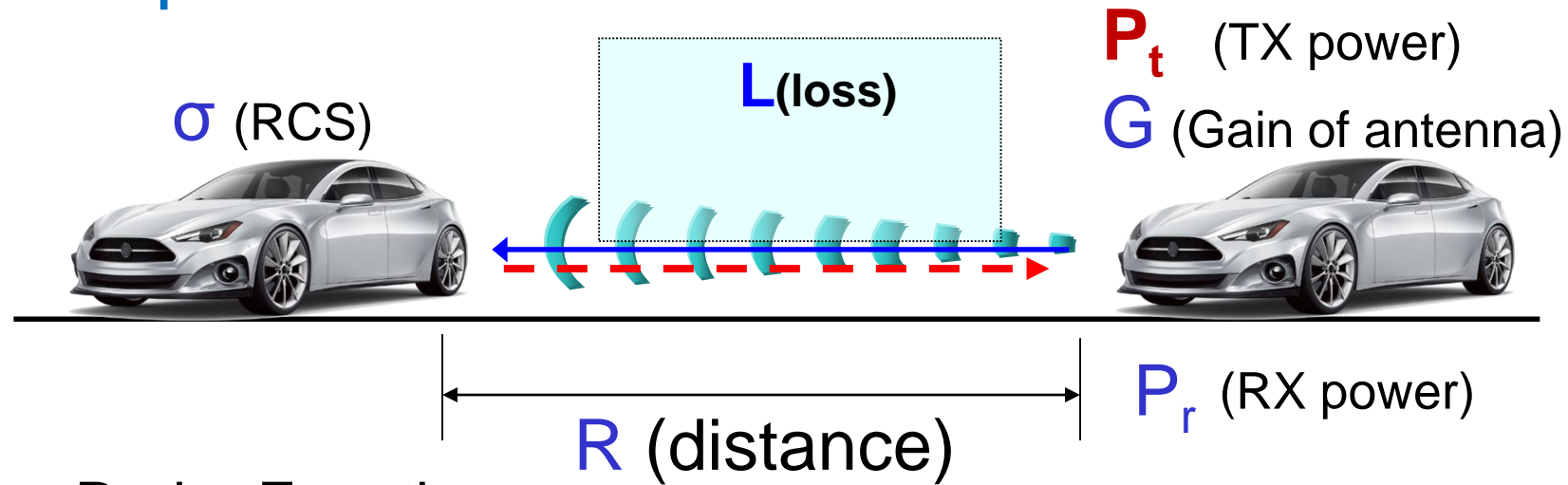


Radar: Taking Safety to New Levels – Saving Lives

Detecting other cars + Seeing pedestrians & bicycles + Full 360° surround view *small & low-power sensors* + Precise Environmental Map *e.g., curbstones & pylons in distance*



Radar Equation

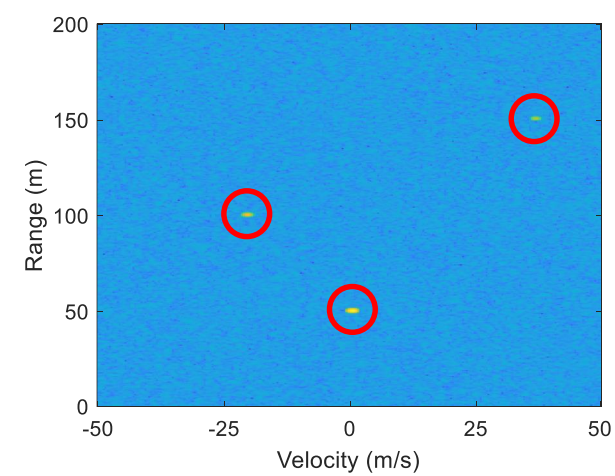
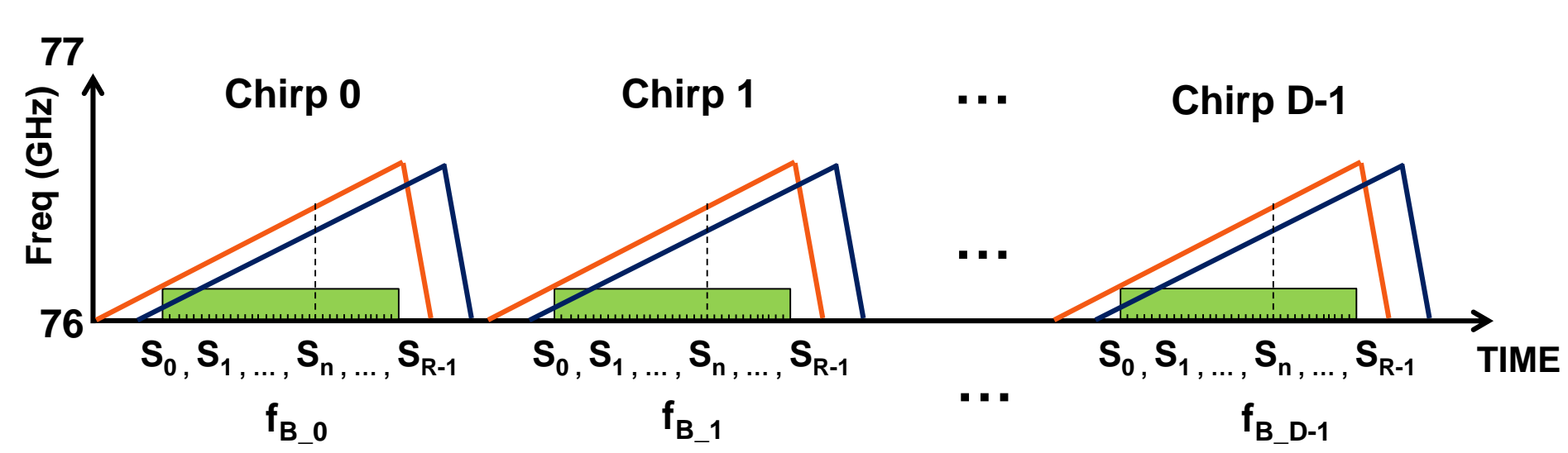
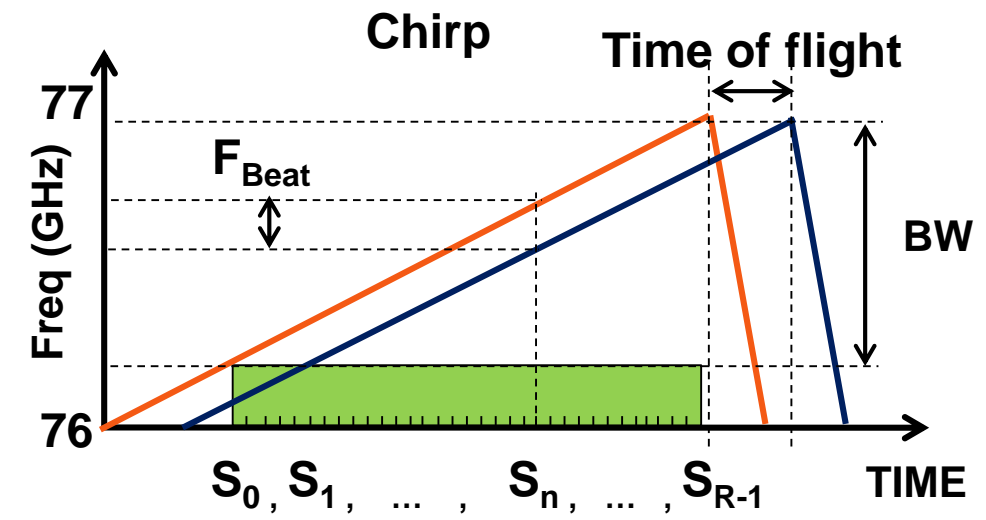
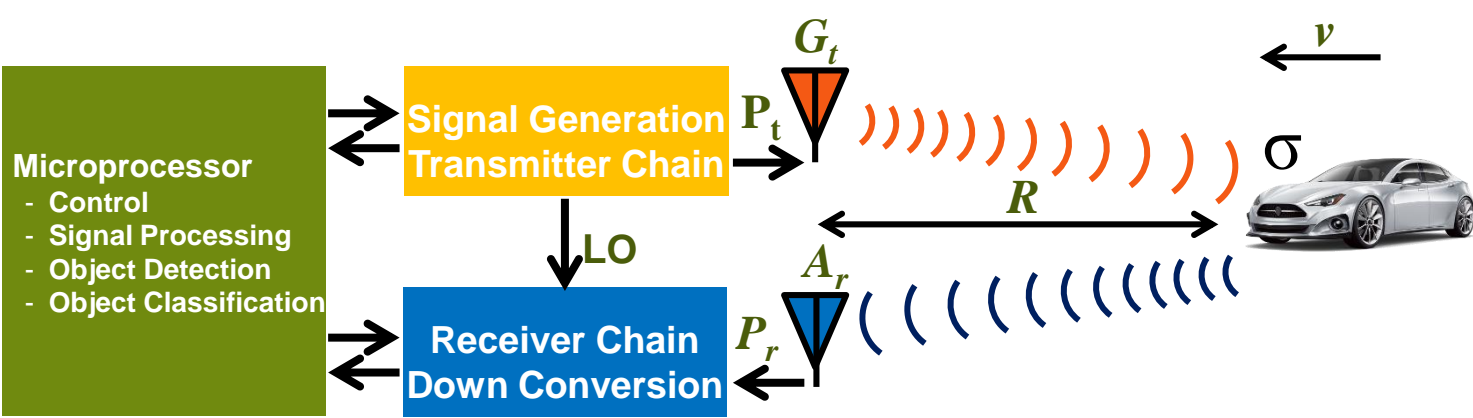


Radar Equation

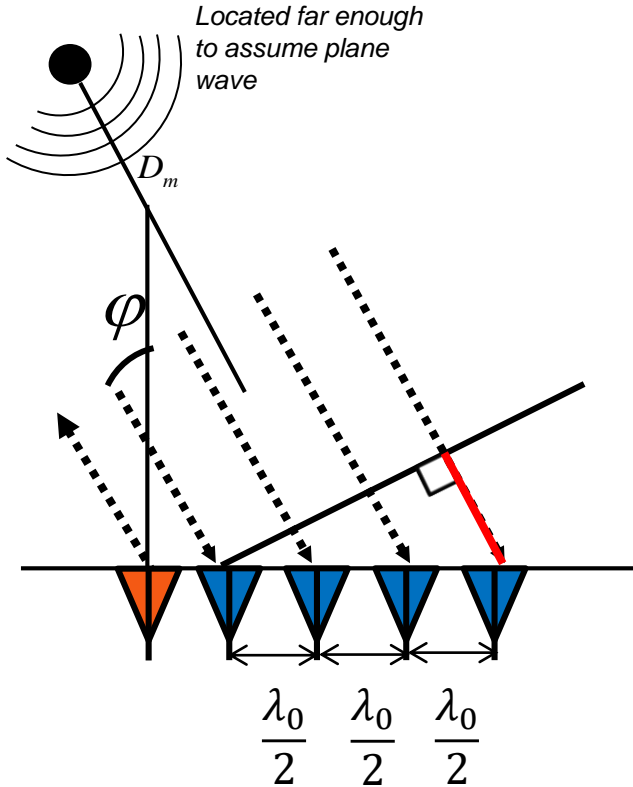
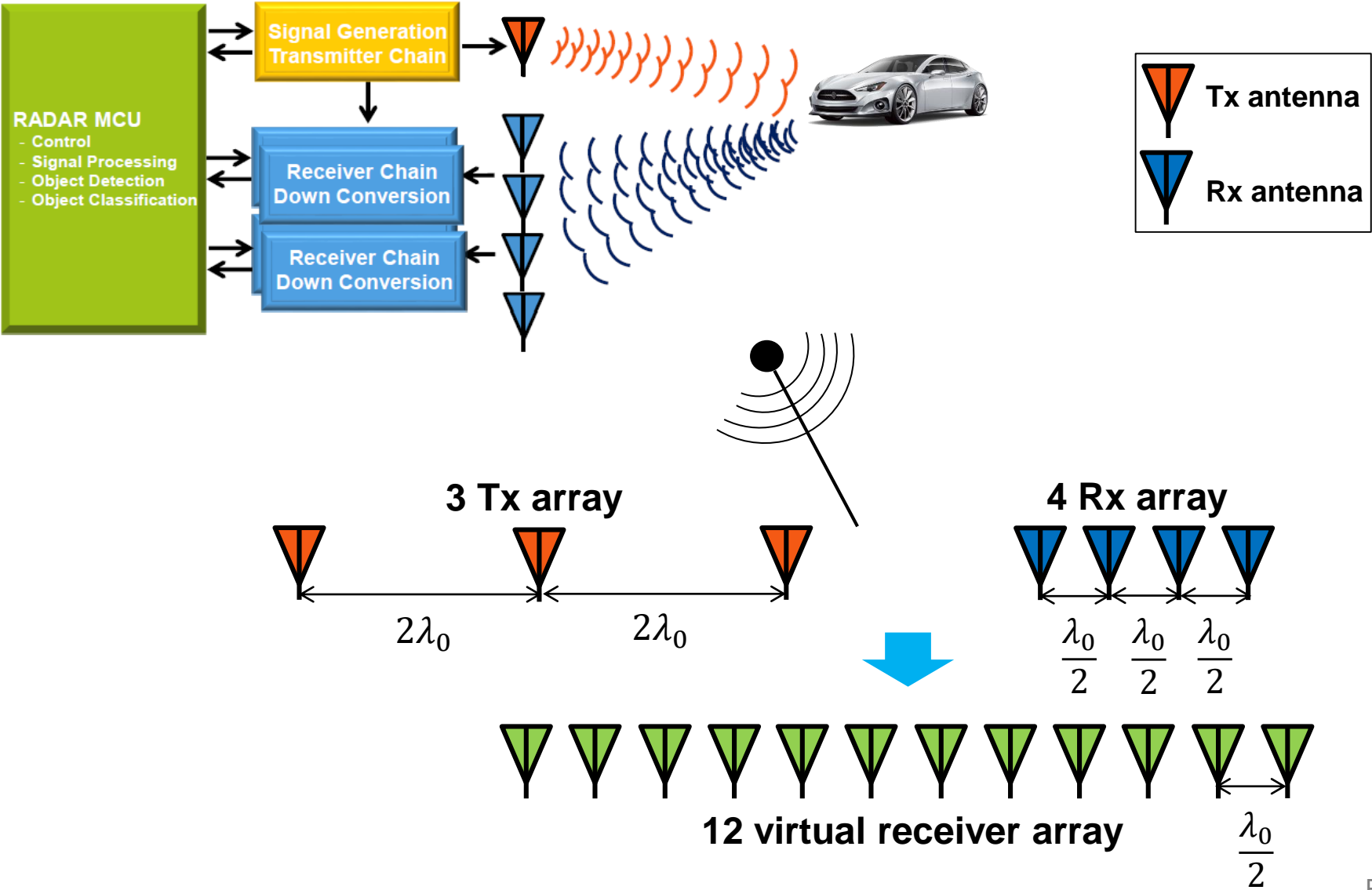
$$P_r = \frac{P_t G_t G_r \lambda^2 \sigma}{(4\pi)^3 R^4} \cdot \frac{1}{L}$$

$$R_{max} = \sqrt[4]{\frac{P_t G_t G_r \lambda^2 \sigma}{(4\pi)^3 P_{rmin} L}}$$

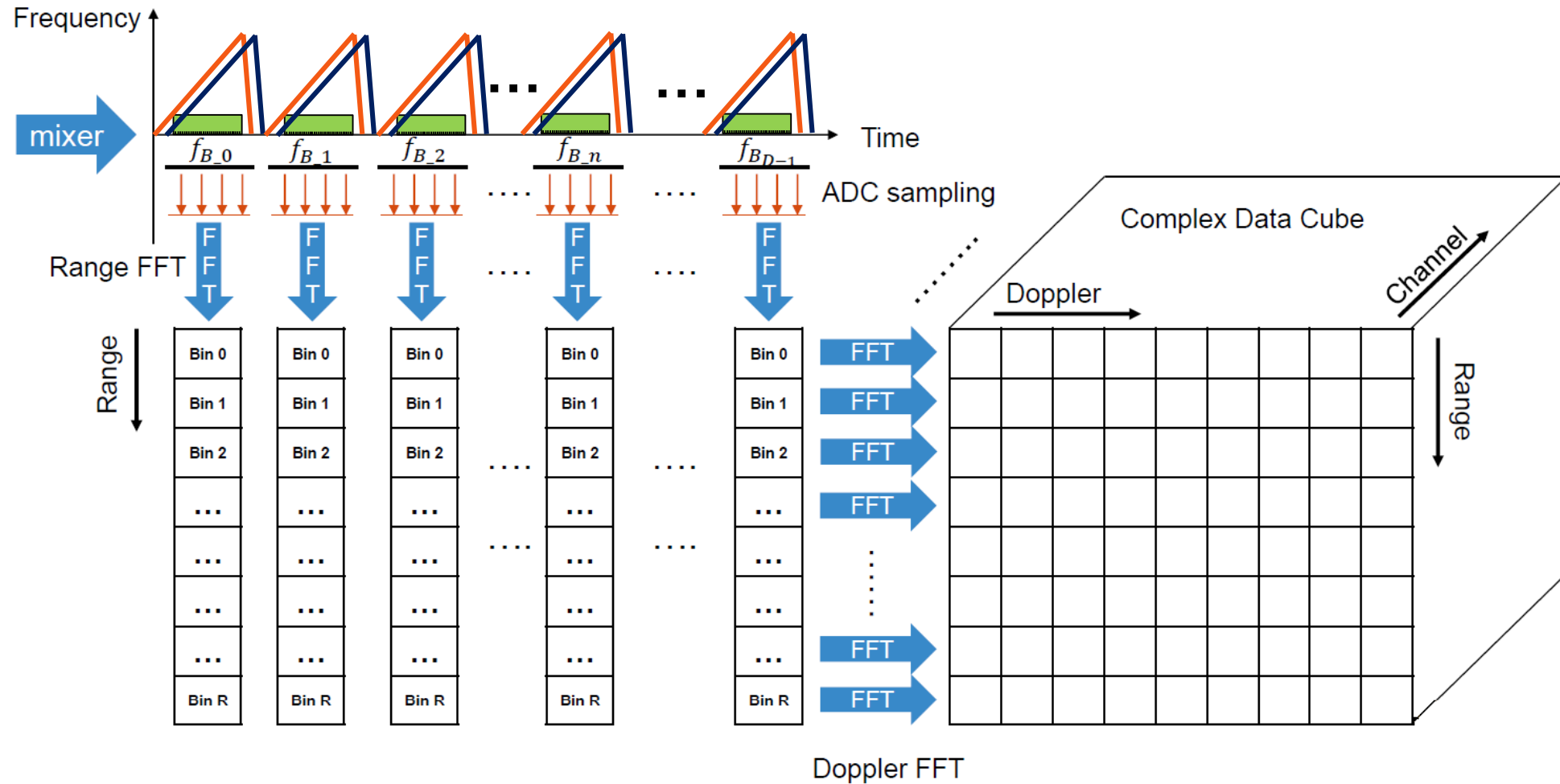
FMCW Radar Range/Velocity Measurement



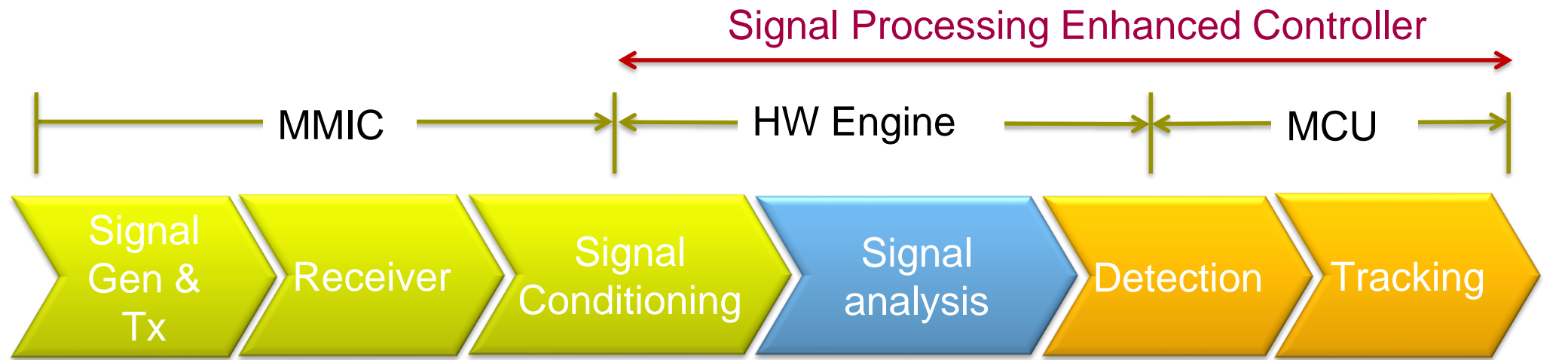
FMCW Radar Angle of Arrival Measurement



Summary of FMCW Radar Range Velocity Angle Measurement



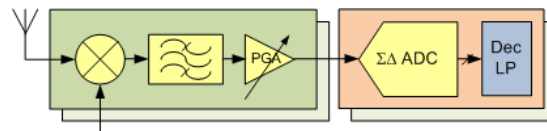
Radar Signal Processing



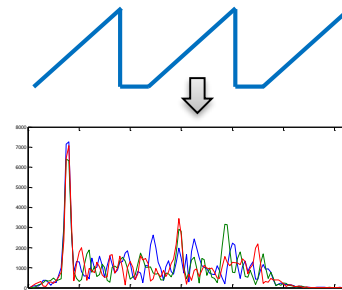
- Timing Engine
- Waveform generation
- PA
- Antenna

- Antenna
- LNA
- Mixer

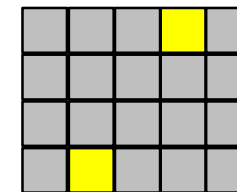
- HP/LPF
- AAF
- ADC



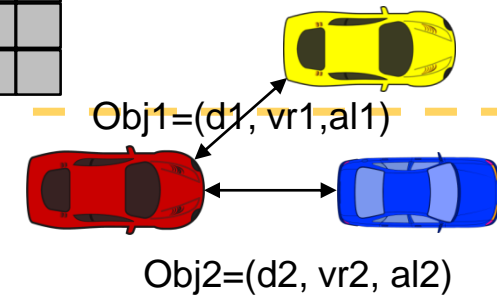
- Gain
- Window
- FFT
- Filter



- Power
- CFAR



- Clustering
- Kalman Filter



NXP RADAR SOLUTIONS



Radar: NXP's Unique Scalable Full System Solutions

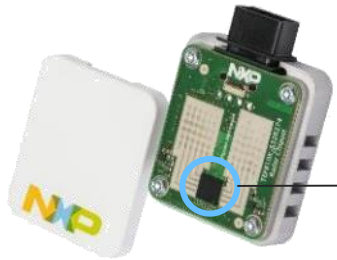
Full 77 GHz System Solution



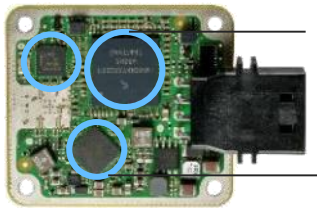
Full Performance Span



Winning Across All Segments



**RFCMOS
Transceiver
TEF810x**

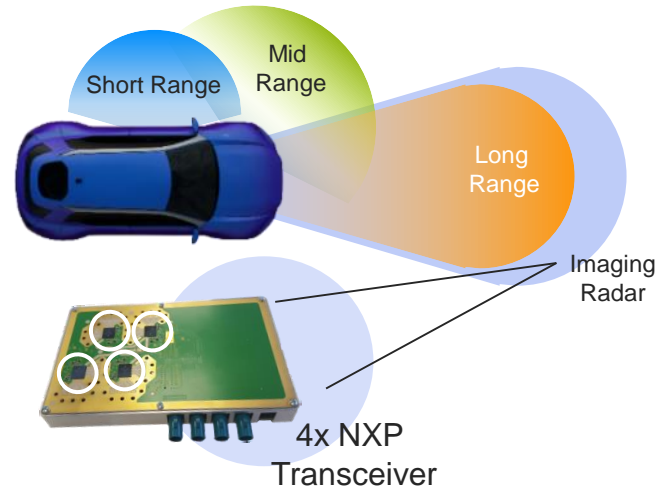


**Radar Processor
S32R27/37**

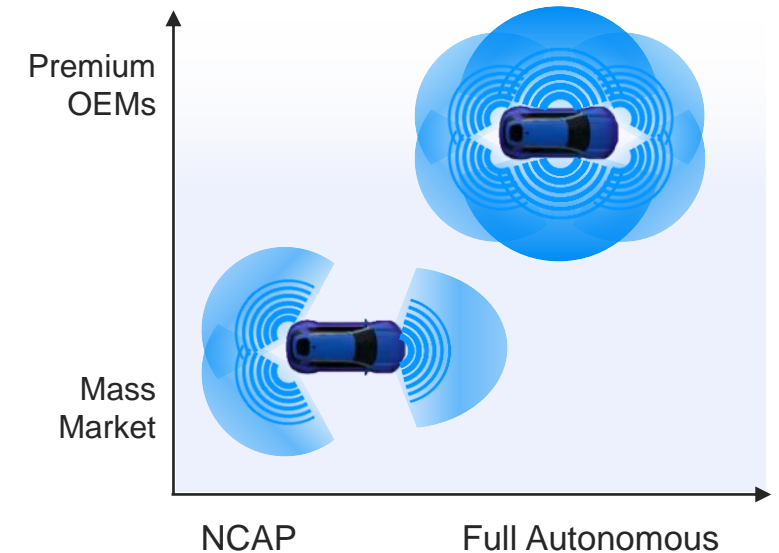
**Power Management
FS84**

**CAN TJA104x
Ethernet TJA110x**

Full reference design, all interfaces aligned, few components needed
Software development kit
System functional safety checked



- SiGe & RFCMOS transceiver portfolio
- Scalable processor families
- From simple sensor to imaging radar



Designed in with all top 10 OEMs...
...while also growing with new players
System solutions for China

Radar Software Enablement

Software & Enablement

- ✓ Automotive grade Radar SDK
- ✓ AUTOSAR safety MCAL and non-AUTOSAR MCAL
- ✓ S32 Design Studio IDE support with 3rd party plug-in support
- ✓ Compiler support (WindRiver, GreenHills)
- ✓ Extensive Debugger support
- ✓ Model based design in MATLAB™



Easy prototype

- ✓ S32 Design Studio IDE support
- ✓ 3rd party plug-in support
- ✓ Processor Expert based configuration
- ✓ Documented Source code and examples
- ✓ Eclipse or other IDEs
- ✓ Middleware stacks + FreeRTOS

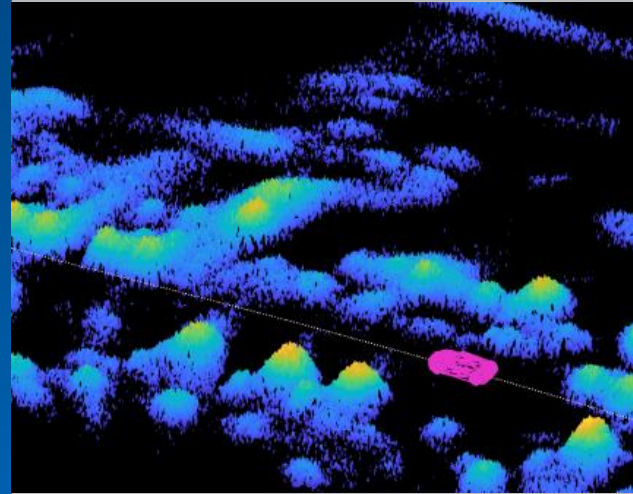
Easy production

- ✓ Quality level: SPICE/CMMI compliant (Class B), MISRA 2012 compliant
- ✓ Automotive-grade quality for low-level drivers code, headers and middleware
- ✓ Multiple toolchains supported

Enabling A/D Perception & Sensing Requirements in Radar

Detection & Tracking

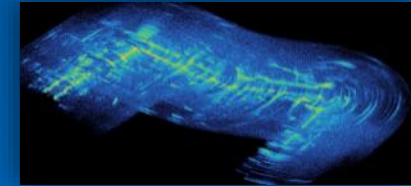
Resolve cluttered, hidden objects & track directionality



Mapping

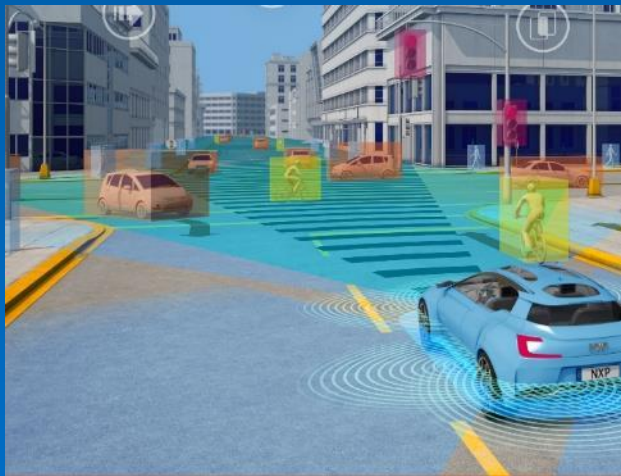
Static and Dynamic Object & Free Space detection (L4 functions)

3D Shapes (images) with classification (Deep Learning)



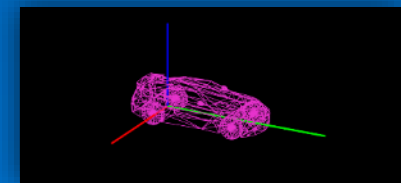
Classification & Segmentation

Pedestrians, Cars, Trucks, Motorcycles



Localization

Ego motion and pin-point position via map correlation or SLAM



for L3-4 vehicles

NXP - Making Safe & Secure Mobility a Reality

Solution Portfolio



The most complete system solutions for fastest time to market and scalability.

Innovation Power



In-house high performance processing, security and mobile eco-system capabilities.

Safe & Secure



Zero defect methodology. Leading with security and functional safety.

