AUTOMOTIVE RADAR TEACH-IN

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Executive Vice President & General Manager RF Processing

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RADAR SYSTEMS: AVOIDING ACCIDENTS AND SAVING LIVES
WHAT IS A RADAR NODE – NXP’S SYSTEM VIEW

RADAR NODE
COMPLETE AUTOMOTIVE SYSTEM SOLUTION FROM NXP

RADAR TRANSCIEVER

RADAR PROCESSOR

PROCESSOR
- Radar Processing Unit + Accelerator
- Safe CPU
- Security Engine
- Functional Safety ASIL D

PMIC

CAN

ETHERNET

SAFE POWER MANAGEMENT

IN-VEHICLE NETWORKING
RECONFIRMING ATTRACTIVENESS OF THE AUTOMOTIVE RADAR MARKET OPPORTUNITY

SEPT 2018 ESTIMATE
INVESTOR DAY 2018

AUTOMOTIVE RADAR SAM

2018E 2019E 2020E 2021E

$1.2B 19% CAGR $2.0B

NXP GROWTH ESTIMATED 2018-2021

25-30% CAGR

2018E 2021E

AUGUST 2020 ESTIMATE
RADAR TEACH-IN 2020

NXP GROWTH ESTIMATED 2020-2023

25-30% CAGR

$1.2B 20% CAGR


$1.2B $2.0B $2.2B

2018E 2021E 2020E 2023E

NXP RADAR REVENUE GROWTH

Source: Yole 2020, IHS Car Production 8/2020, NXP CMI
VEHICLE OWNERSHIP: TRENDING TOWARDS HIGHER AUTOMATION

LEVEL 1
DRIVER ASSISTANCE

LEVEL 2
PARTIAL AUTOMATION

LEVEL 2+ TO 3
CONDITIONAL AUTOMATION

LEVEL 4 TO 5
HIGH/FULL AUTOMATION

MOBILITY AS A SERVICE
~60% OF ALL NEW VEHICLES IN 2023 WILL BE PARTLY AUTOMATED AND CONTAIN RADAR

LEVEL 1
DRIVER ASSISTANCE

LEVEL 2
PARTIAL AUTOMATION

LEVEL 2+ TO 3
CONDITIONAL AUTOMATION

LEVEL 4 TO 5
HIGH/FULL AUTOMATION

VEHICLE OWNERSHIP: TRENDING TOWARDS HIGHER AUTOMATION

MOBILITY AS A SERVICE

Source: NXP CMI
99% of VALUE in 2023 for ADAS semiconductors represented by Level 1-3

VEHICLE OWNERSHIP: TRENDING TOWARDS HIGHER AUTOMATION

99% OF THE ADAS SEMICONDUCTOR VALUE IN 2023 IN LEVELS 1-3

- LEVEL 1: DRIVER ASSISTANCE
  - ~40% of CARS '23
- LEVEL 2: PARTIAL AUTOMATION
  - ~15% of CARS '23
- LEVEL 2+ TO 3: CONDITIONAL AUTOMATION
  - ~5% of CARS '23
- LEVEL 4 TO 5: HIGH/FULL AUTOMATION
  - <1% of CARS '23

MOBILITY AS A SERVICE

Source: NXP CMI
RADAR ADOPTION ACCELERATED BY MANDATES & NCAP; L2+ EVOLVING AS L3 “LIGHT”

L2+ AUTONOMOUS DRIVING CLOSE TO L3

Semi content and features of L3 with driver responsibility

Significant safety & comfort while avoiding L3 liability concerns

From basic driver support to highway & urban pilot

SAFETY RATINGS

Driving Radar Adoption globally

2018

EU legislation 24 GHz → 77 GHz

Increasing autonomous emergency braking specification

2020

Autonomous emergency braking mandatory for trucks and increasing spec for 5★ cars

Source: Strategy Analytics ADAS Mandate NCAP Tracker, NXP CMI

2022

Autonomous emergency braking: Pedestrians & cyclists (low light) & reverse

2024

20 car makers in US voluntarily at 100% autonomous emergency braking

Already from 2021 new cars need front & rear autonomous emergency braking

Autonomous emergency braking mandatory
DRIVER ASSISTANCE REQUIRES MULTIPLE COMPLEMENTARY SENSORS
RADAR IS FUNDAMENTAL AND COMPLEMENTARY TO CAMERA FOR SAFETY

<table>
<thead>
<tr>
<th></th>
<th>KEY MEASUREMENT</th>
<th>ENVIRONMENTAL LIMITATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RADAR</strong></td>
<td>Speed, distance</td>
<td>Insignificant</td>
</tr>
<tr>
<td><strong>CAMERA</strong></td>
<td>Object, pattern, color</td>
<td>Rain, fog, night, sun</td>
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<td>Angle, distance</td>
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Source: NXP CMI
### RADAR TECHNOLOGY

<table>
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<tr>
<th><strong>KEY MEASUREMENT</strong></th>
<th><strong>ENVIRONMENTAL LIMITATIONS</strong></th>
<th><strong>BULKY MODULES</strong></th>
<th><strong>POWER HUNGRY</strong></th>
<th><strong>LOW RANGE RESOLUTION</strong></th>
<th><strong>LOW ANGULAR RESOLUTION</strong></th>
</tr>
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<tbody>
<tr>
<td>Speed, distance</td>
<td>Insignificant</td>
<td>24 GHz</td>
<td>SiGe</td>
<td>Low channel count</td>
<td>0.7*°</td>
</tr>
<tr>
<td></td>
<td></td>
<td>77 GHz</td>
<td>RFCMOS</td>
<td>High channel MIMO</td>
<td></td>
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**SMALL MODULES**
- 3x smaller antennas

**POWER EFFICIENT**
- 30% lower power

**HIGH RESOLUTION**
- 20x range resolution

**LIDAR LIKE**
- OBJECT SEPARATION
- <1° angular resolution

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### PRECISE MAP OF ENVIRONMENT

- RADAR IS EVOLVING TOWARDS PRECISE MAPPING OF ENVIRONMENT

**Source:** NXP CMI
The transition to 77GHz is the key to growth.

- NXP is #1 in 77 GHz Radar Core value
- NXP leading in RFCMOS & processing

Source: Yole 2020, IHS Car Production 8/2020, IHS Competitive Landscaping 2020, NXP CMI
TRIPLE ACCELERATION OF THE RADAR MARKET

More Cars With Radar
Largely 77 GHz

More Radar Nodes per Car
360° view - from 24 GHz to 77 GHz

More SemiconDUCTor Content & $ per Node
High resolution imaging radar

IMAGING RADAR
Precise environment map and localization

Front Radar
Blind spot, front & rear cross traffic / people detection

Autonomous emergency brake & adaptive cruise control
TRIPLE ACCELERATION OF THE RADAR MARKET: JUST GETTING STARTED

More Cars With Radar
Largely 77 GHz

More Radar Nodes per Car
360° view - from 24 GHz to 77 GHz

More Semiconductor Content & $ per Node
High resolution imaging radar

IMAGING RADAR
Precise environment map and localization

Blind spot, front & rear cross traffic / people detection

Autonomous emergency brake & adaptive cruise control

Average Radar nodes per cars produced globally

TOWARDS ≥ 5 Radar nodes/car

2025 ~2 Radar nodes/car

2020 ~1 Radar node/car

Average Radar nodes per car

Source: Yole 2020, IHS Car Production 8/2020, NXP CMI
RADAR TECHNOLOGY EVOLUTION TOWARDS ZERO ACCIDENTS
RADAR EVOLUTION: PROCESSOR & TRANSCEIVER TECHNOLOGY ENHANCES SAFETY

SEEING OTHER CARS

24 GHz SiGe
LOW RESOLUTION

77 GHz SiGe
HIGHER RESOLUTION

77 GHz RFCMOS + ADVANCED PROCESSING
HIGHER INTEGRATION RESOLUTION BOOST

PEDESTRIANS, BICYCLES
Radar Evolution: More Market Segments Evolving – 360° & Higher Performance

- Seeing Other Cars
  - 24 GHz SiGe
  - Low Resolution

- Pedestrians, Bicycles
  - 77 GHz RFCMOS SiGe
  - Higher Resolution
  - Advanced Processing
  - Higher Integration Resolution Boost

- Seeing Smaller Objects

- Seeing Around the Car

Rad AR Evolution: More Market Segments Evolving – 360° & Higher Performance
SEEING OTHER CARS

24 GHz SiGe
LOW RESOLUTION

77 GHz SiGe
HIGHER RESOLUTION

SEEING SMALLER OBJECTS

PEDESTRIANS, BICYCLES

77 GHz RFCMOS + ADVANCED PROCESSING
HIGHER INTEGRATION RESOLUTION BOOST

SEEING AROUND THE CAR

IMAGING RADAR
77 GHz
HIGHEST RESOLUTION & PERFORMANCE

LONG-RANGE RADAR
77 GHz
FRONT & REAR HIGHER PERFORMANCE

CORNER RADAR
77 GHz
MULTIPLE SMALL MODULES

24 GHz SiGe
LOW RESOLUTION

77 GHz SiGe
HIGHER RESOLUTION

RADAR EVOLUTION: SEGMENTATION FROM TINY CORNER RADAR UP TO IMAGING RADAR
SEEING SMALLER OBJECTS

SEEING AROUND THE CAR

HIGHEST RESOLUTION & PERFORMANCE

FRONT & REAR HIGHER PERFORMANCE

MULTIPLE SMALL MODULES

IMAGING RADAR 77 GHz

LONG-RANGE RADAR 77 GHz

CORNER RADAR 77 GHz

24 GHz SiGe 77 GHz SiGe + ADVANCED PROCESSING

LOW RESOLUTION HIGHER RESOLUTION

SEEING OTHER CARS

PEDESTRIANS, BICYCLES

77 GHz RFCMOS

HIGHER INTEGRATION RESOLUTION BOOST

SEEING AROUND THE CAR

INCREASING CHANNEL COUNT NEW MODULATION

LONGER RANGE ELEVATION SENSING CASCADING

1-CHIP INTEGRATION ANTENNA IN PACKAGE

FULL SCALABILITY SOFTWARE REUSE

COST OPTIMIZED

PERFORMANCE OPTIMIZED

NXP COVERING FULL RANGE AND COMPLETE SYSTEM WITH MAXIMUM SCALABILITY
NXP RADAR SYSTEM PORTFOLIO SCALING ACROSS ENTIRE MARKET OPPORTUNITY

CORNER RADAR

FULL SYSTEM INCL. PERIPHERALS

RFCMOS TRANSCEIVER

RADAR PROCESSOR

NETWORKING

POWER MANAGEMENT

4x4.5cm

LONG-RANGE RADAR

1-2 x RFCMOS TRANSCEIVERS

+ ADVANCED RADAR PROCESSOR

+ POWER MANAGEMENT AND NETWORKING

IMAGING RADAR

5 x RFCMOS TRANSCEIVER

+ HIGH PERFORMANCE IMAGING RADAR PROCESSOR

+ POWER MANAGEMENT AND NETWORKING

FULL SCALABILITY - SAME TRANSCEIVER IC FAMILY

SOFTWARE REUSE - SAME PROCESSOR ARCHITECTURE

Source Long Range Radar Image: Hawkeye
NXP IS THE TRUSTED ADVISER AND INNOVATION PARTNER WITH OEMS AND TIER-1S

INNOVATION TRIANGLE

OEM

TIER-1

OEMs – NXP as trusted advisor
Close cooperation and joint innovation
Co-defining roadmaps and future architectures

TIER-1s – NXP as partner supplier
Accelerating time to market with lead customers
Deep cooperation and support on application level

DESIGNED IN AT 15 OF TOP 15 OEMS

Source: IHS car production ranking 2020, NXP CMI
85% of forward growth underpinned with confirmed design wins

**Strong Market Growth**

- $1.2B in 2020E
- 20% CAGR
- $2.2B in 2023E

**Outgrowing the Market**

- NXP Growth estimated 2020-2023
- 25-30% CAGR

**True Leader**

- ~10% of auto revenue
- #1
- Designed in at 15 of top 15 car makers
- >85% awarded today

- More cars with radar
- More radar nodes per car
- More semi content & $ per node

Source: Yole 2020, IHS Car Production 8/2020, NXP CMI