

Front long range radar

Automotive Imaging Radar for ADAS Applications

Front Radar Trends

The AEB function is becoming standard in mid-class

SAE INTERNATIONAL		Feature	AD time	AD condition	Actuation type	Sensing technology		
MIND-OFF	5	AD VPA				3-7 8	5-6 4	
MIND-OFF	4	AD				3-7 8	5-6 2	
EYES-OFF	3	TJA HP DM				3-7 8	5-6 1	
HANDS-OFF	2	LKA ACC				3-7 8	1-3	
FEET-OFF	1	LKA ACC				1-3 6	1-3 1-3	
Caution	0	BSD FCW/AEB LDW				1-3 6	1-3 1-3	

- ✓ Automotive radar implementation is driven by safety requirements by NCAP and NHTSA as most car manufacturers use this sensor for front obstacle detection (AEB). Radar remains the best available sensing technology to measure relative distance and speed.
- ✓ ACC is a premium feature that can be easily added by the Tier-1s for a cost adder

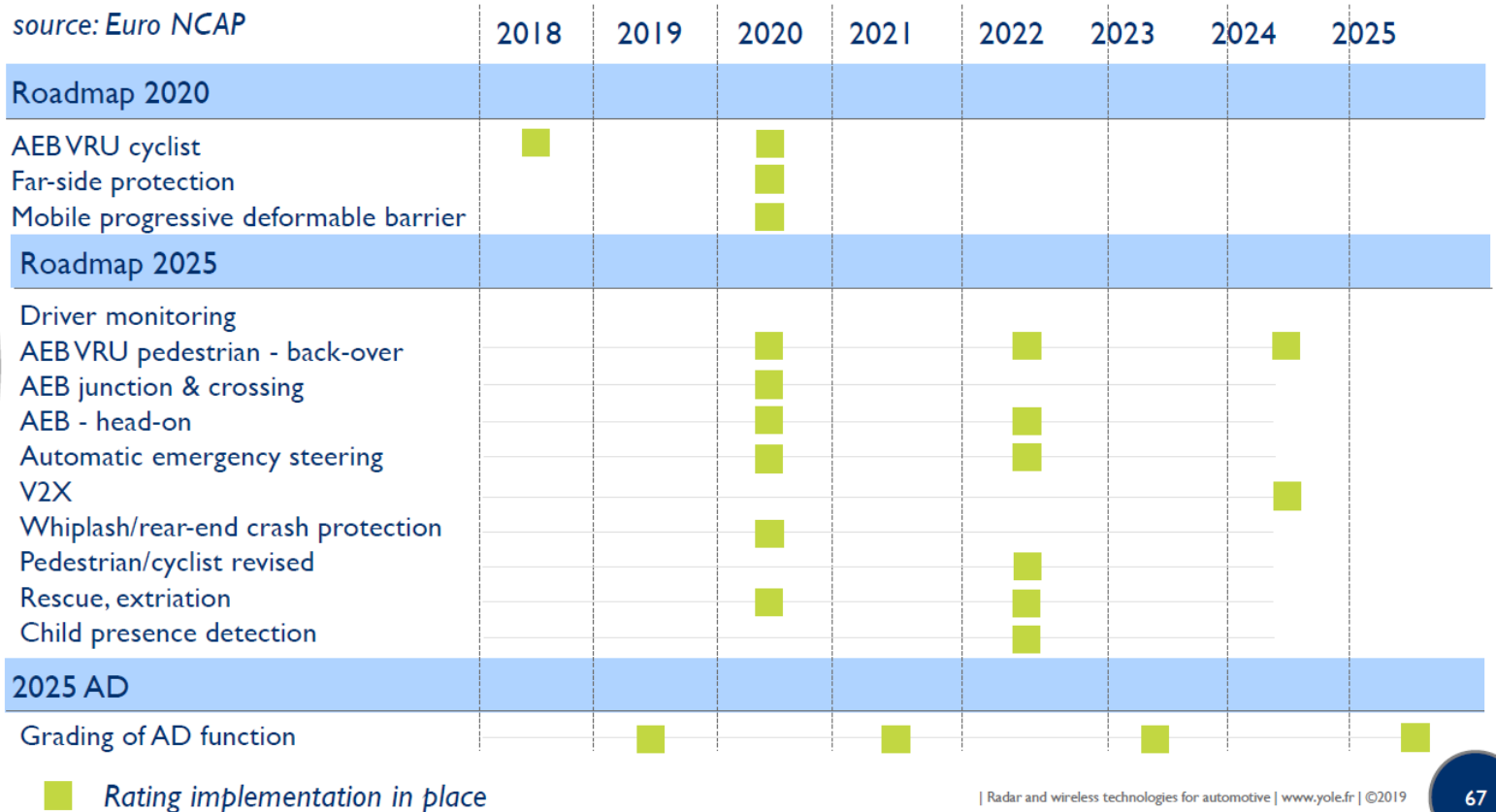
Front Radar Trends

The AEB function is becoming standard in mid-class

SAFETY INCENTIVE

Euro NCAP 2025 roadmap - in pursuit of “vision zero”

source: Euro NCAP

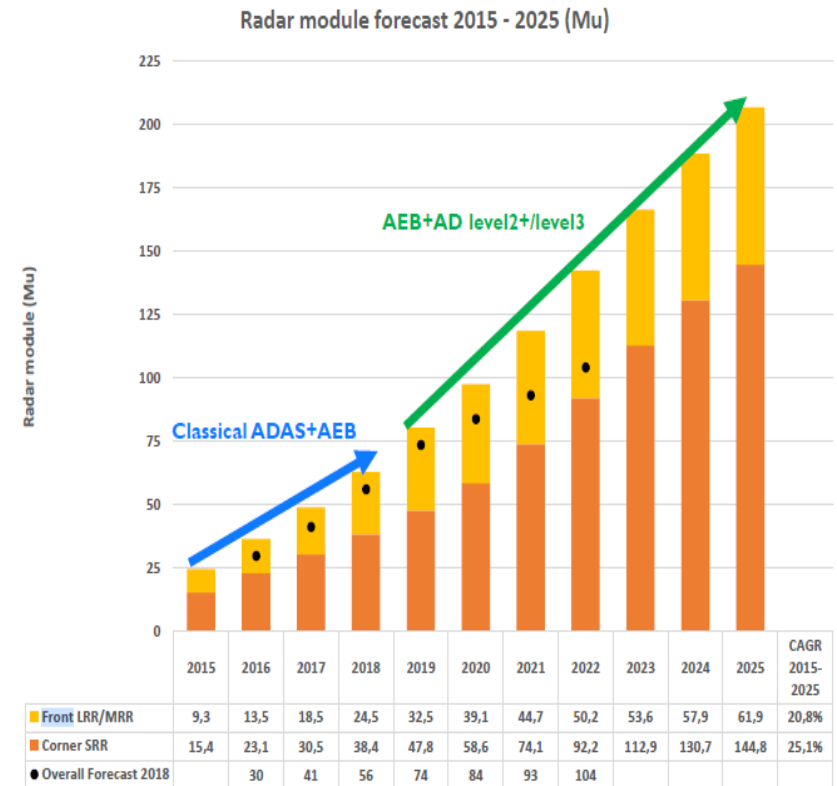
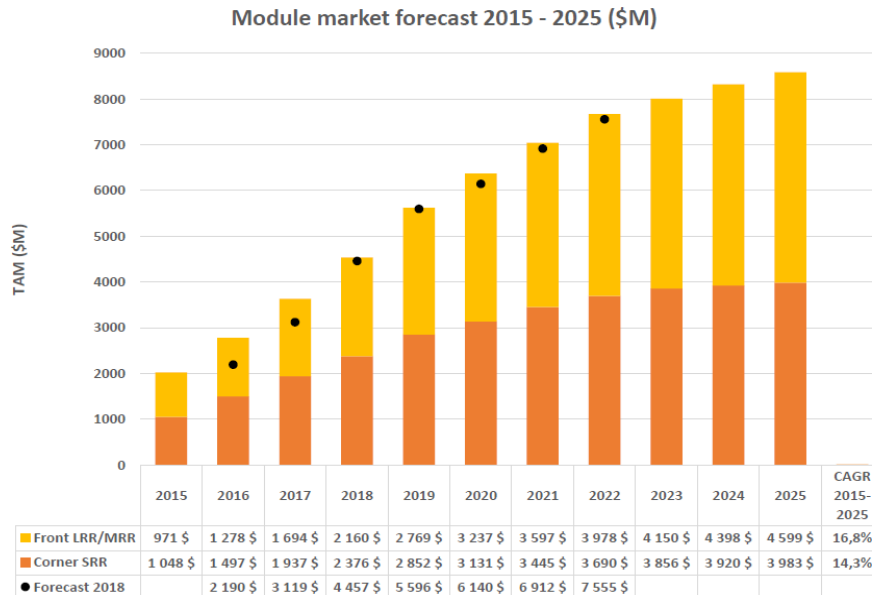


Euro NCAP 2025 will reinforce the AEB scenario, and AES too. Child presence detection will be rated by 2022, and the first AD rating will come in 2019.

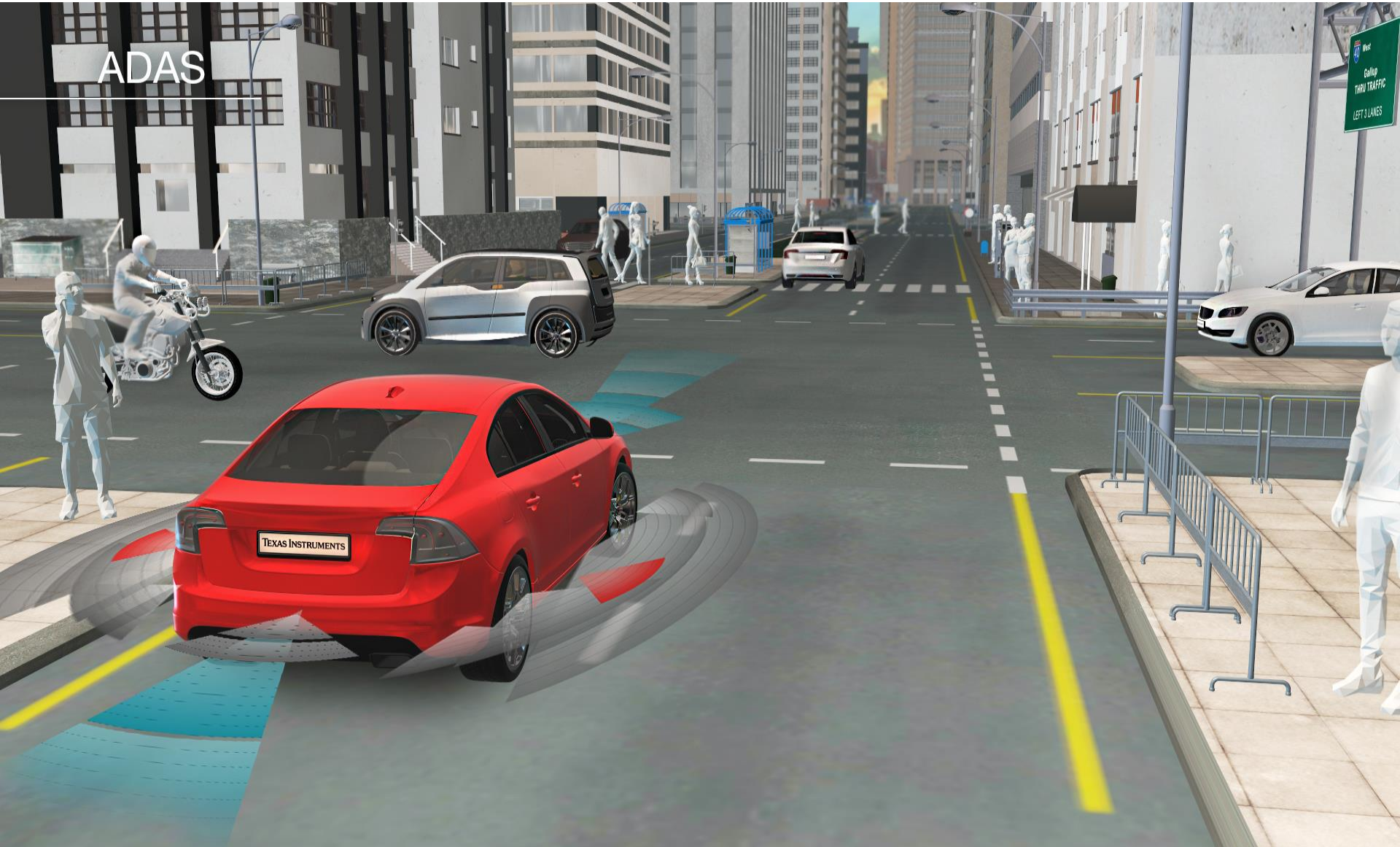
20 OEMs are already committed to add AEB system as a standard Safety equipment

Front Radar - Market Overview & Trends

- ✓ A rapidly growing market with a 21% CAGR
- ✓ Still very concentrated by 4-5 Tier-1s but start changing.



ADAS



Front Radar - Technology Trends

3D
Measure height



4D
Discriminate nearby objects



Classification, labelling

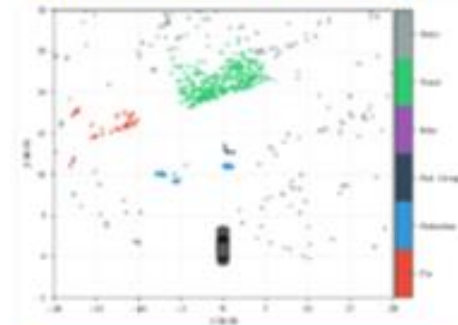


Image processing
AI/deep learning

Sensor data
fusion

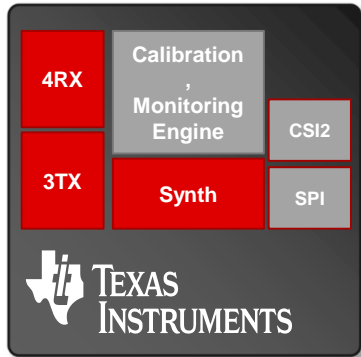
Elevation capability

High resolution

More enhance
resolution radar
solutions hit the
market this year

76 – 81 GHz mmWave Sensors

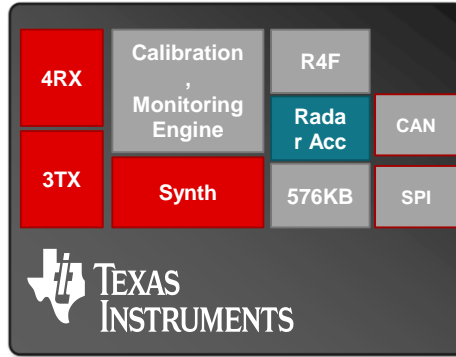
AWR1243



Radar Front-End

- **Use Cases**
 - Imaging Radar Sensor
 - 2x or 4x AWR1243 + External DSP
 - MRR and LRR
- **ASIL-B capable**
- **In Production**

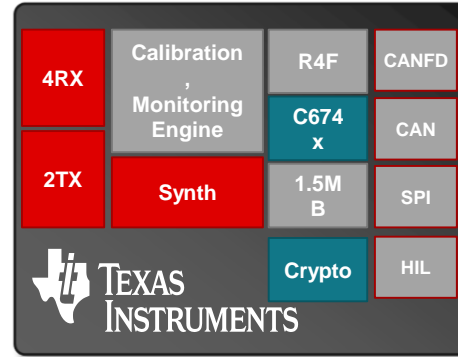
AWR1443



Single Chip Radar

- **Use Cases**
 - Proximity Sensor
 - Obstacle detection sensor
 - Occupant detection
 - Driver monitoring
- **In Production**

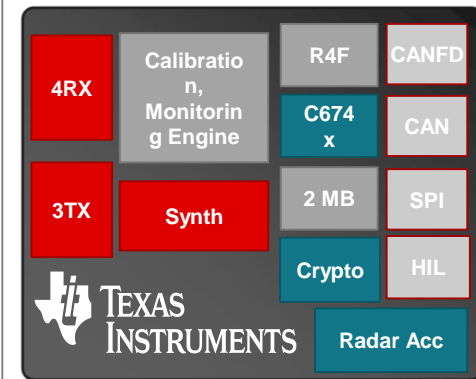
AWR1642



Single Chip Radar

- **Use Cases**
 - USRR Single Chip Radar
 - 160 Degree, 40m
 - SRR Single chip Radar
- **ASIL-B capable**
- **In Production**

AWR1843



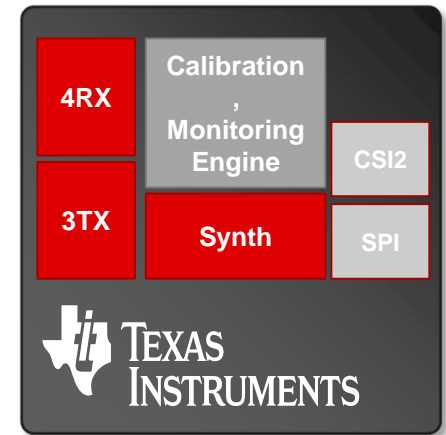
Single Chip Radar

- **Use Cases**
 - Parking w/ height measurement
 - MRR single chip radar
- **ASIL-B capable**
- **In Production**

RF and SW compatible through all platforms
Sensor cost optimization through antenna and package technology

AWR1243p – High Performance Front End

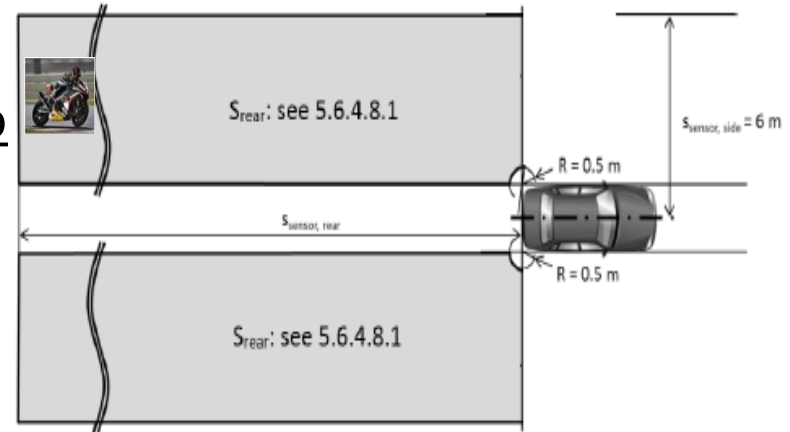
- Integrated transceiver with 4 Rx and 3 Tx (Simultaneous)
- Built-in per Tx phase shifters for beam steering
- High sampling frequency & IF BW (15 MHz)
- Enhanced RF performance
 - Better phase noise
 - Lower noise figure
 - Higher Output Power
- 0.65 mm 10.4x10.4 mm² FCBGA
- ASIL-B capable
- Use cases:
 - Corner Radar : 1x **AWR1243** + External MCU
 - Front Radar, Imaging Radar : 2x or 4x **AWR2243** (cascade)
+ External MCU



AWR1243p Ready For UN R79 Requirements

UN R79 Requirements for motorcycle detection

- > 170 meter detection range
- 130kmph speed



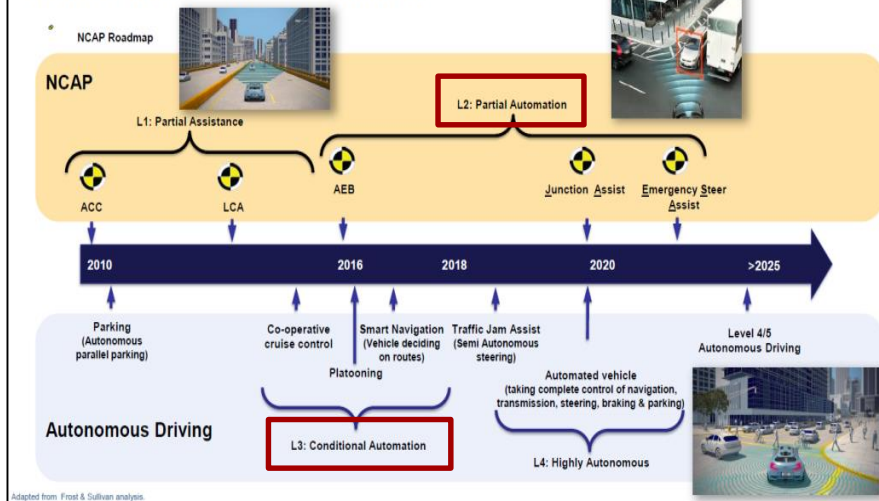
AWR1243p RFCMOS front-end meets and exceeds UN R79 requirements

- 200m+ detection range with 12dB noise figure, 12dBm output power & -95dBc/Hz @ 1MHz phase noise*
- Beam steering with built-in linear phase shifter capability in a multi mode sensor
- Wide 20MHz IF BW for maximum range and velocity

* Typical

Imaging Radar – Making ADAS Safer

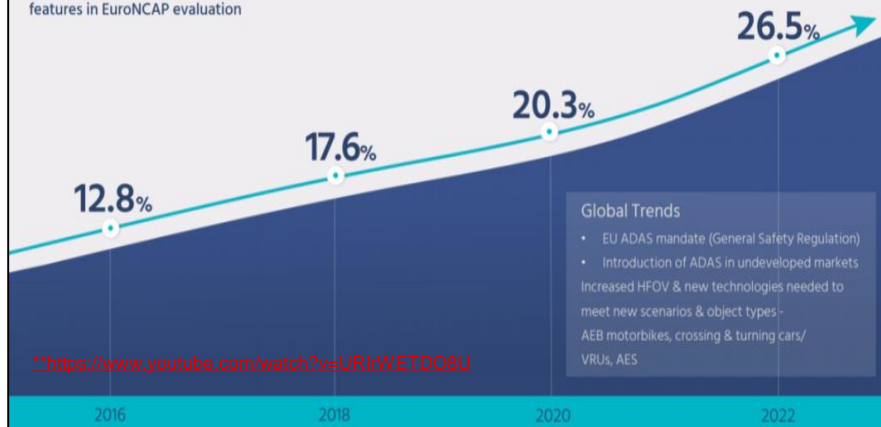
Trends: NCAP and Automation



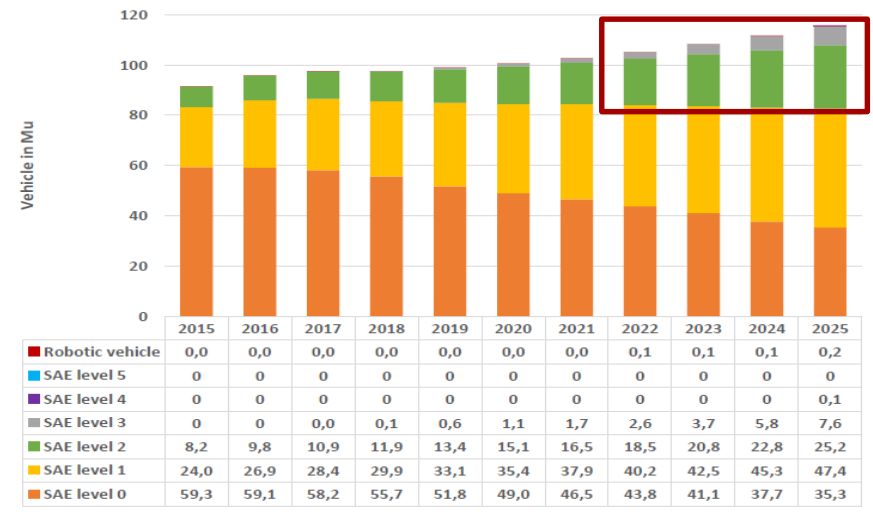
- ✓ Vision Zero NCAP* requirements for Level 2 – 3 driving OEMs to use Imaging Radar as primary sensor.
- ✓ Emphasis on ADAS in safety ratings driving OEMs to integrate ADAS functions even in entry level vehicles
- ✓ Imaging Radar is the most economical sensor for Level 2 – 3 with Lidar-like performance

Growing Emphasis on ADAS in Safety Ratings

% of points awarded for ADAS features in EuroNCAP evaluation



Overall vehicle forecast 2015 - 2025



* <https://www.euroncap.com/en/press-media/press-releases/euro-ncap-launches-road-map-2025-in-pursuit-of-vision-zero/>

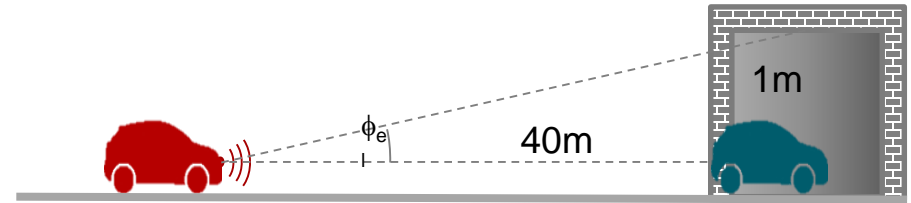
Why Imaging Radar is a Game Changer

Overhead bridges/tunnels



Today radar system is programmed to ignore high-mounted objects such as road signs and, possibly, the flanks of a semi truck, to avoid undesired braking events.

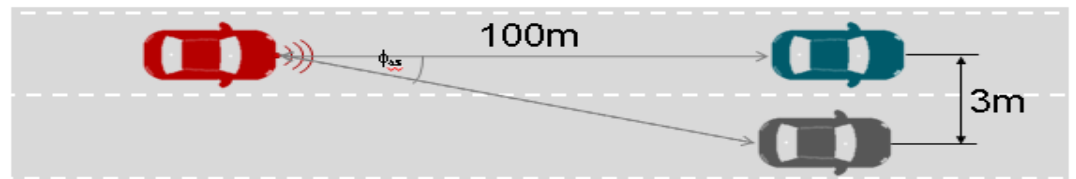
High Elevation Angle Resolution with MIMO



e.g. static truck stalled under a bridge

Angle Resolution required - $\phi_{el} < 1.4^\circ$

High Azimuth Angle Resolution with MIMO



Two cars in adjacent lanes 100m range

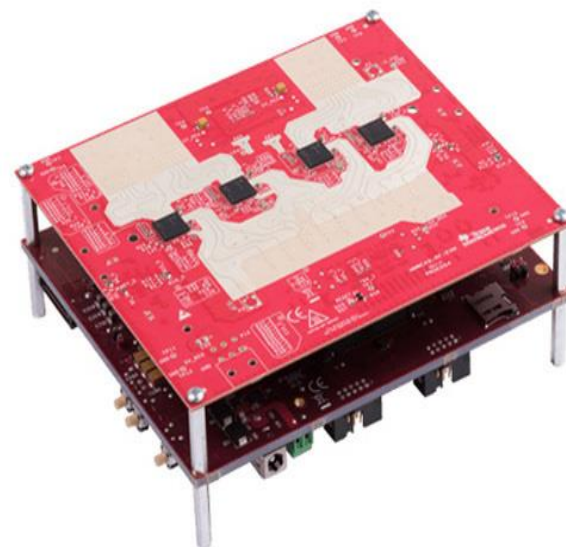
Angle Resolution required - $\phi_{az} < 1.7^\circ$

Imaging Radar ~ 1° both Azimuth & Elevation

The Radar Sensor will become the **primary** sensor in the car

Imaging Radar Development Kit Update

- **Development Kit**
 - AWR1243P RF EVM
 - TDA2 Capture/Processing EVM
 - Tools, algs, SDK, design guide, Performance data
- **Enables performance evaluation**
 - Long term (40 minutes driving) imaging radar raw data capture for post processing
 - Multi-mode (MIMO/Beamforming w/ beam steering) real time processing
- **Availability**
 - <http://www.ti.com/tool/MMWCAS-RF-EVM>
 - <http://www.ti.com/tool/MMWCAS-DSP-EVM>
 - TI Design – <http://www.ti.com/tool/TIDEP-01012#2>
 - **Video:** <http://www.ti.com/solution/imaging-radar>



Key Challenges - Embedded Cascade Radar System

System Architecture

- 4-chip cascade Radar, Support for upto 192 antennas
- Development kit Use Cases:
 1. **Real time processing of the raw ADC data**
 2. **Real time capture of raw ADC data for offline algorithm research.**

Processing Flow

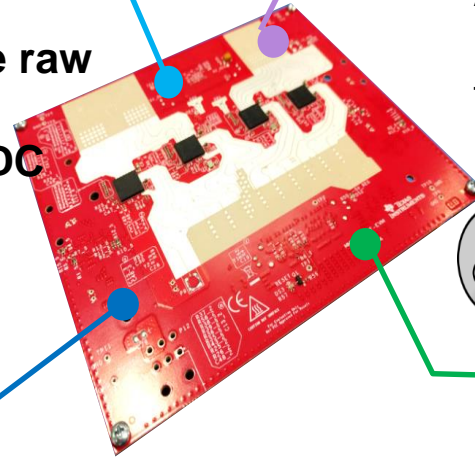
- Off line & Real time, low latency processing (Upto 60 FPS for 48 antenna configurations)

Synchronize Multiple Radar Front Ends

- What signals need to be connected across multiple AWR1243p to make them behave as a single synchronized front end.

Memory Bandwidth Requirement

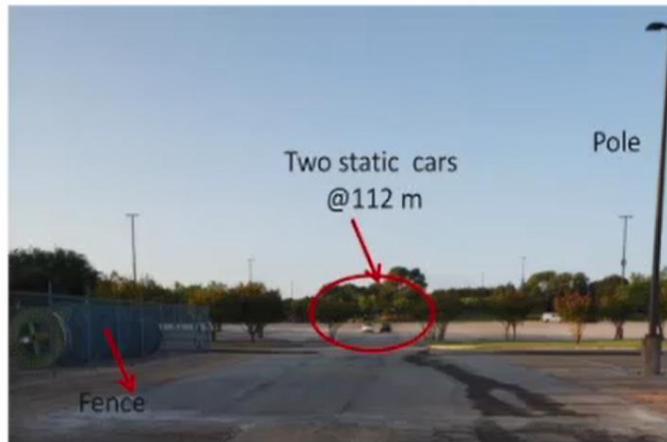
- With more antennas, Radar Cubes are in 10s of MBs. Need to make sure access across range, Doppler and antennas should be optimized.



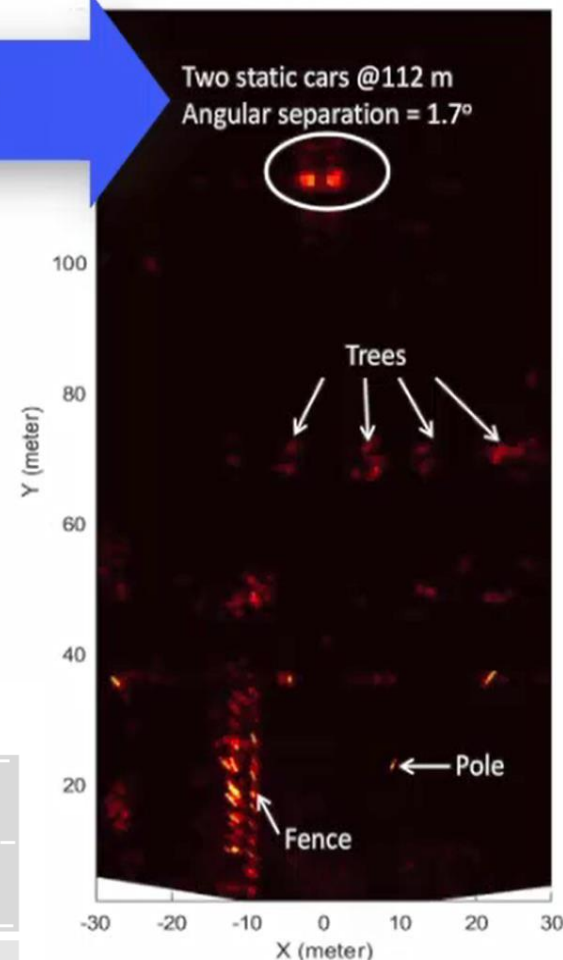
Why Cascading?

1.7° angular separation at 112 m

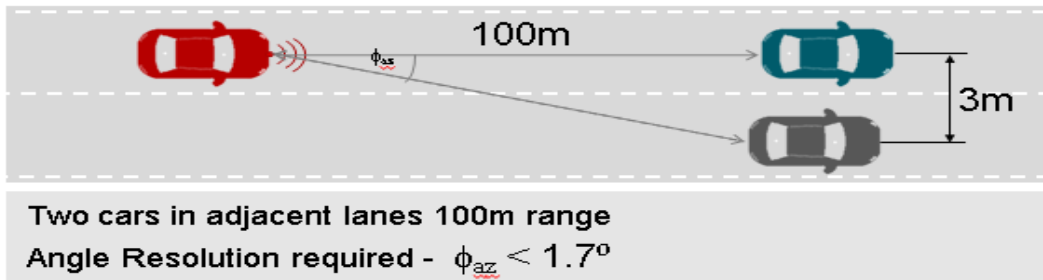
Camera View



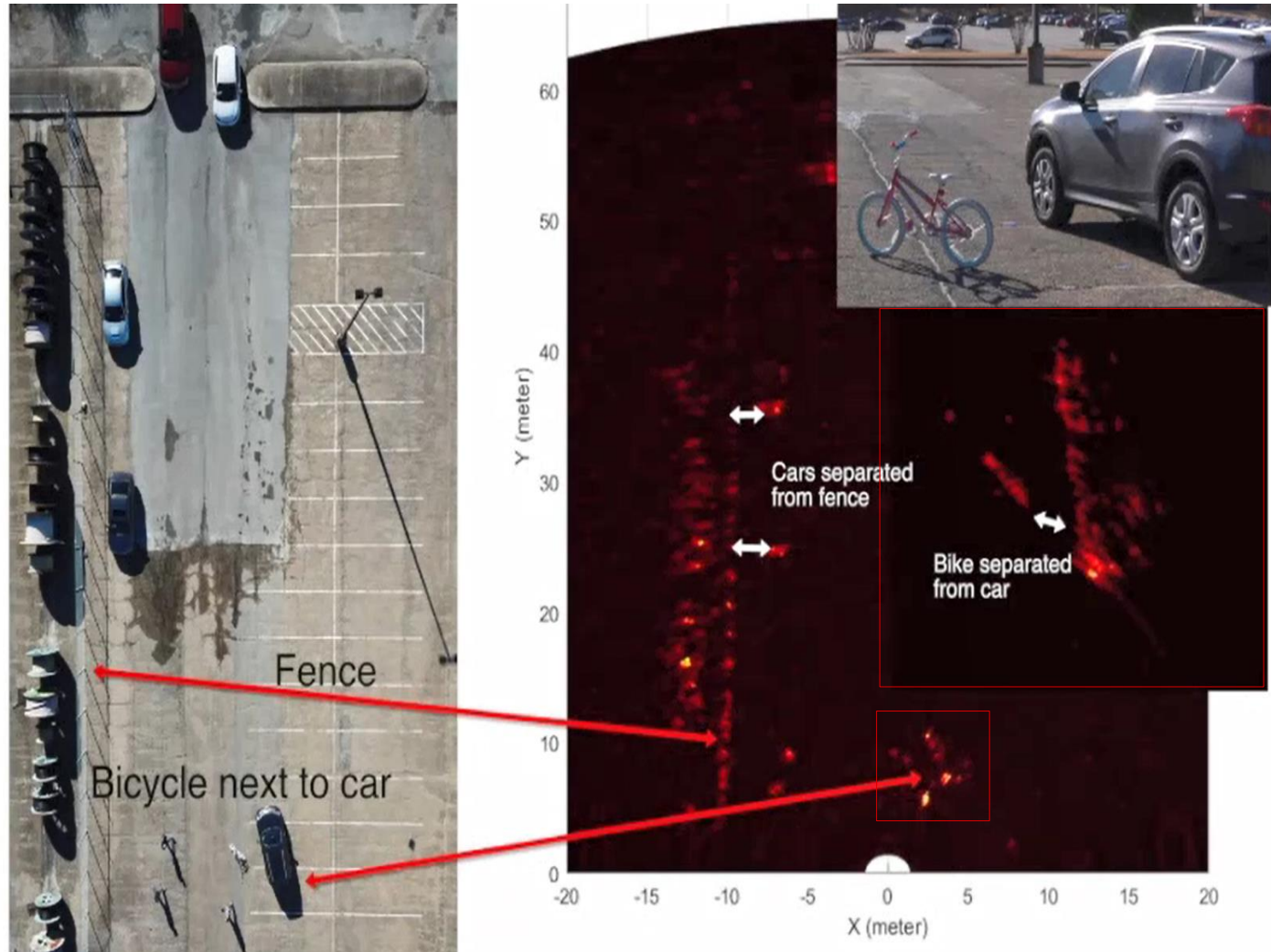
Radar View



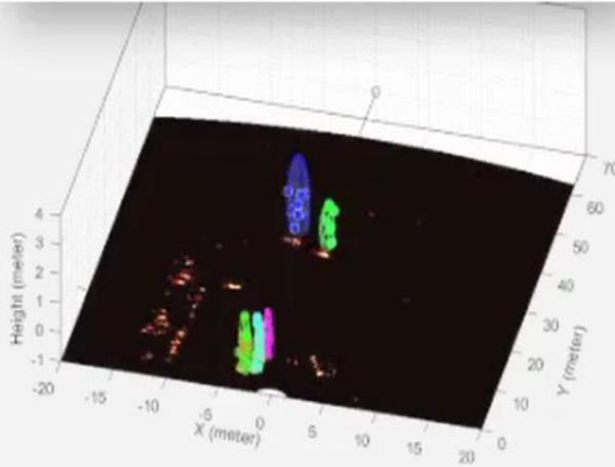
High Azimuth Angle Resolution with MIMO



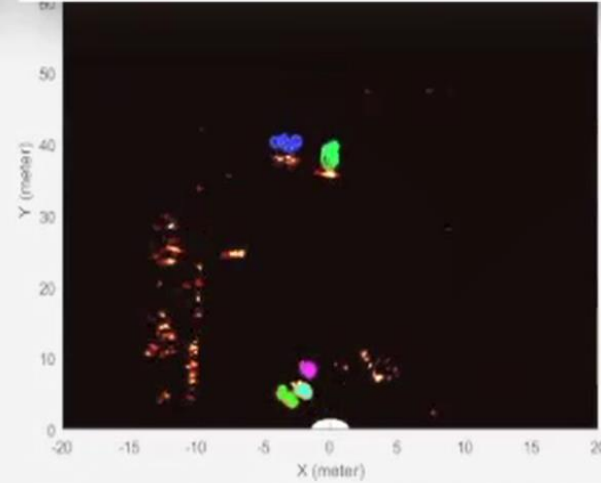
Enhance Angle Resolution – Radar Delivers Imaging - Static Scene



3D radar object detection



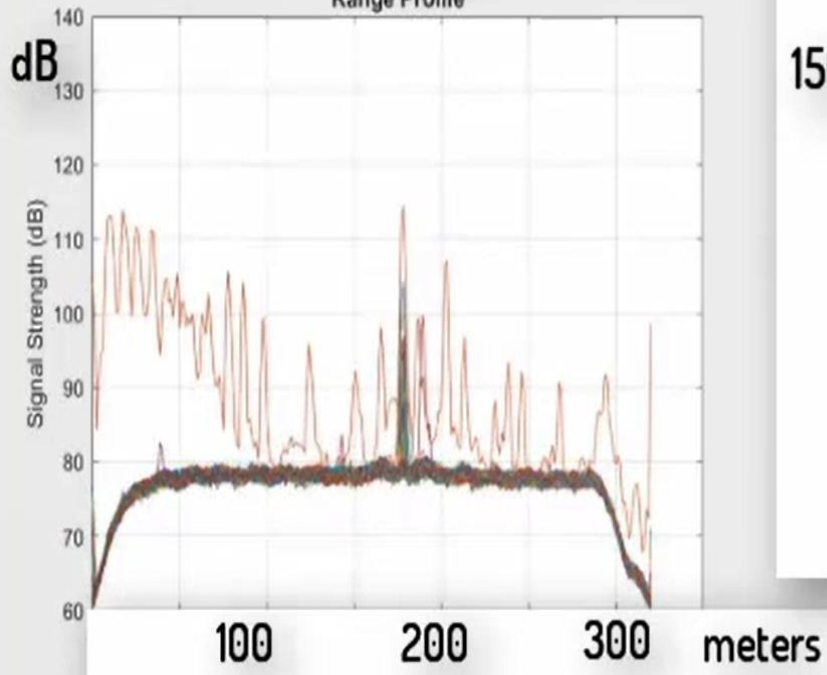
Top view of identified objects



Dual mode long range and mid range radar

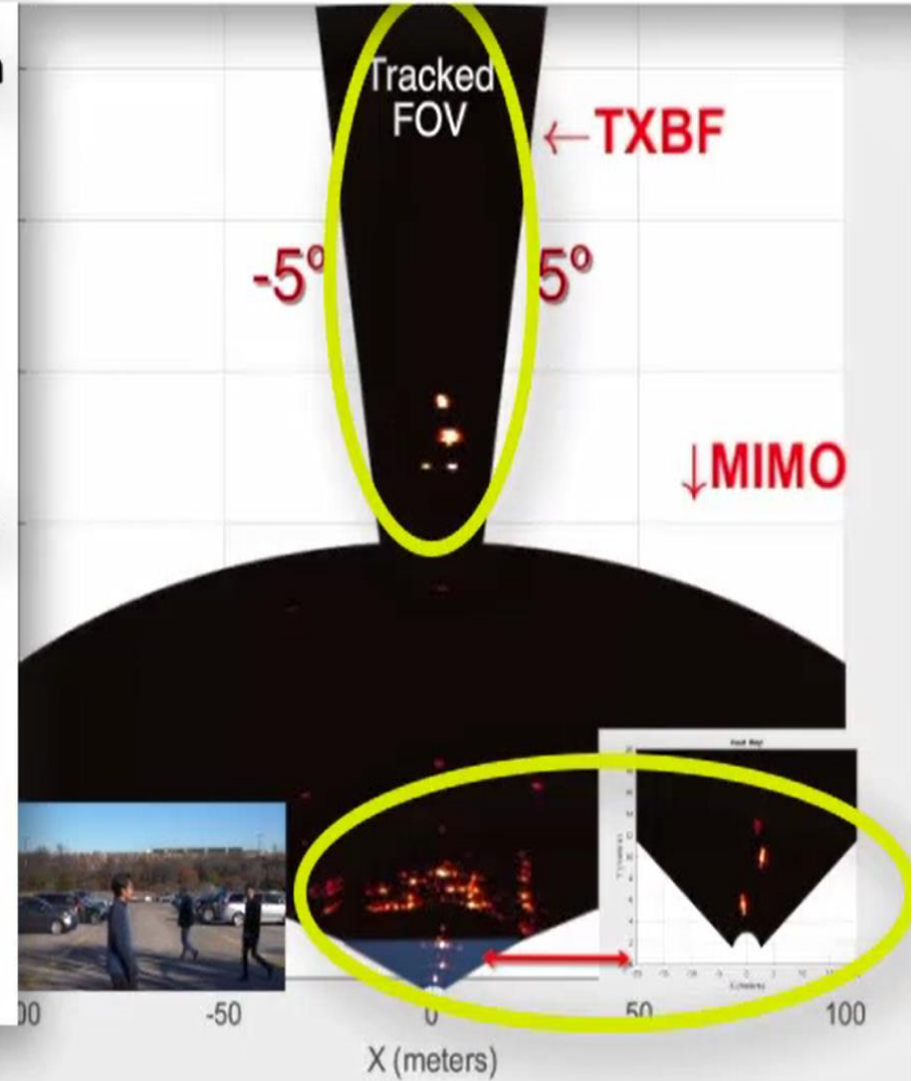


Range Profile



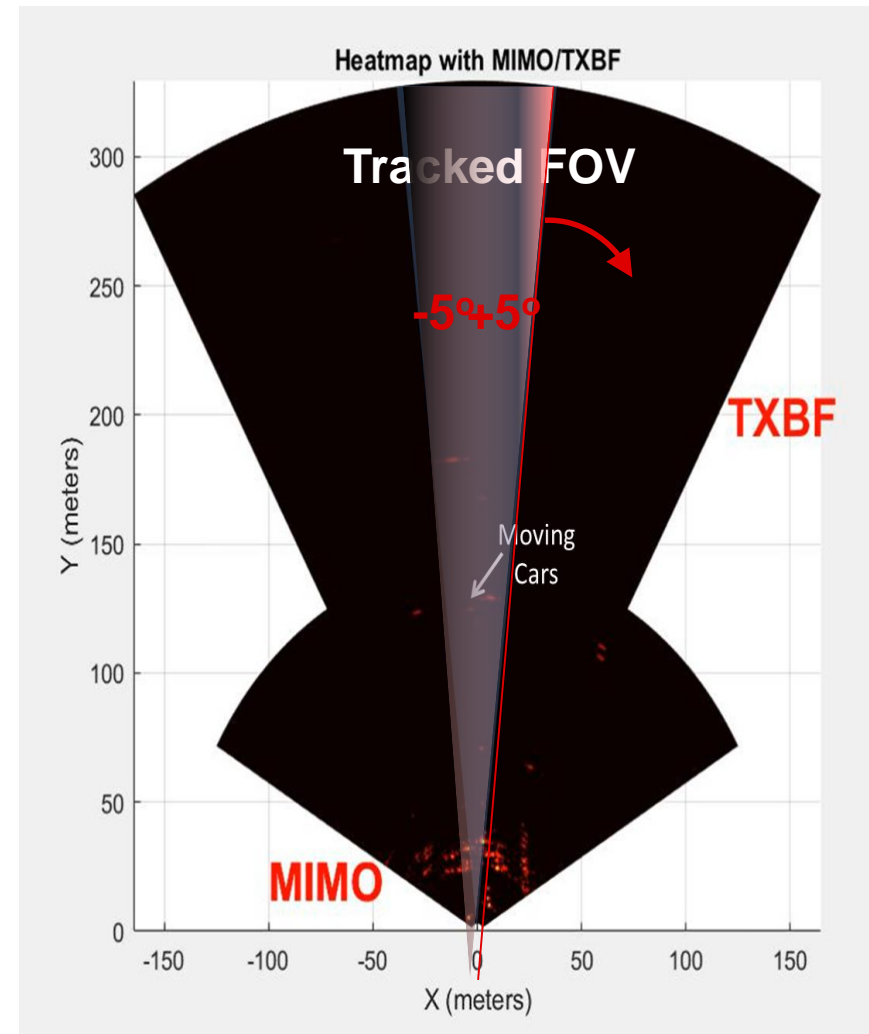
300m

150m



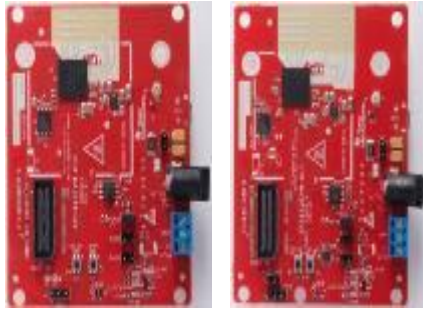
Dual Mode Cascade: MIMO & TX Beamforming

- Alternating MIMO and TX Beamforming
 - MIMO covers $[-60\ 60]$ degrees FOV and 150 meter in range
 - TX beamforming covers narrower field of view (programmable) and 350 meters in range
 - Flexible and accurate beamforming steering for target tracking
 - Flexible frontend configurability supports mode switching



Hardware Platforms

AWR1443/AWR1642 EVM



85 x 65mm

- Enables evaluation of single chip radar
- Proximity sensor demo on AWR1443 EVM
- SRR demo on AWR1642 EVM
- Environment: mmWave-SDK

AWR1x + TSW1400



- Enables RF performance evaluation
- Raw ADC capture into PC and then post process
- mmWave Studio to visualize object range/velocity/angle
- Environment: DFP and mmWave Studio

AWR1243 + TDA3x



- Enables radar algorithm and MRR/LRR application development on TDA3x
- Enables vehicle validation/demonstration
- Environment: DFP and TDA3x Radar SDK

AWR1x sensor module AWR1x starter kit



34 x 38mm

- Enables radar algorithm and proximity/SRR application development on AWR1443/AWR1642
- Enables vehicle validation/demonstration

mmWave Ecosystem

Antenna

Antenna design services

79GHz Modules available to deploy quickly

Application specific SW solutions



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[link](#)



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TI Radar Solutions – Competitive Advantage



Performance

- **RF performance** for range, resolution and accuracy, performance behind bumper
- **Signal Processing** capabilities with DSP and HWA
- Built-in **Safety** monitoring to eliminate external components
- Built-in **Security** features to protect against unauthorized access and IP theft

Scalability

- Portfolio **scales** from high performance transceiver to radar SoC with processing capabilities
- **Pin-to-pin** compatibility across devices within sub-family
- Software **scalability** with one SDK across all devices
- Software **portability** with API compatibility across portfolio

Time to Market

- **Comprehensive** whole product offering including software, tools, collaterals and training
- Algorithms and example applications based on 2+ years of **systems** work
- **Ready-to-use** labs and experiments

Reliability

- Test coverage for a target of 0 DPPM with extensive **RF testing** than traditional data sheet tests
- Extensive **PVT characterization** across all blocks and IPs
- AEC-Q100 **qualification**
- **Mature** 45nm process technology with 10+yrs in production, 700M+ units shipped with <10DPPM

Questions?