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Drive360™
AUTONOMOUS DRIVING SOLUTIONS

Automotive RADAR Market

ROHDE & SCHWARZ
Automotive Technology Day

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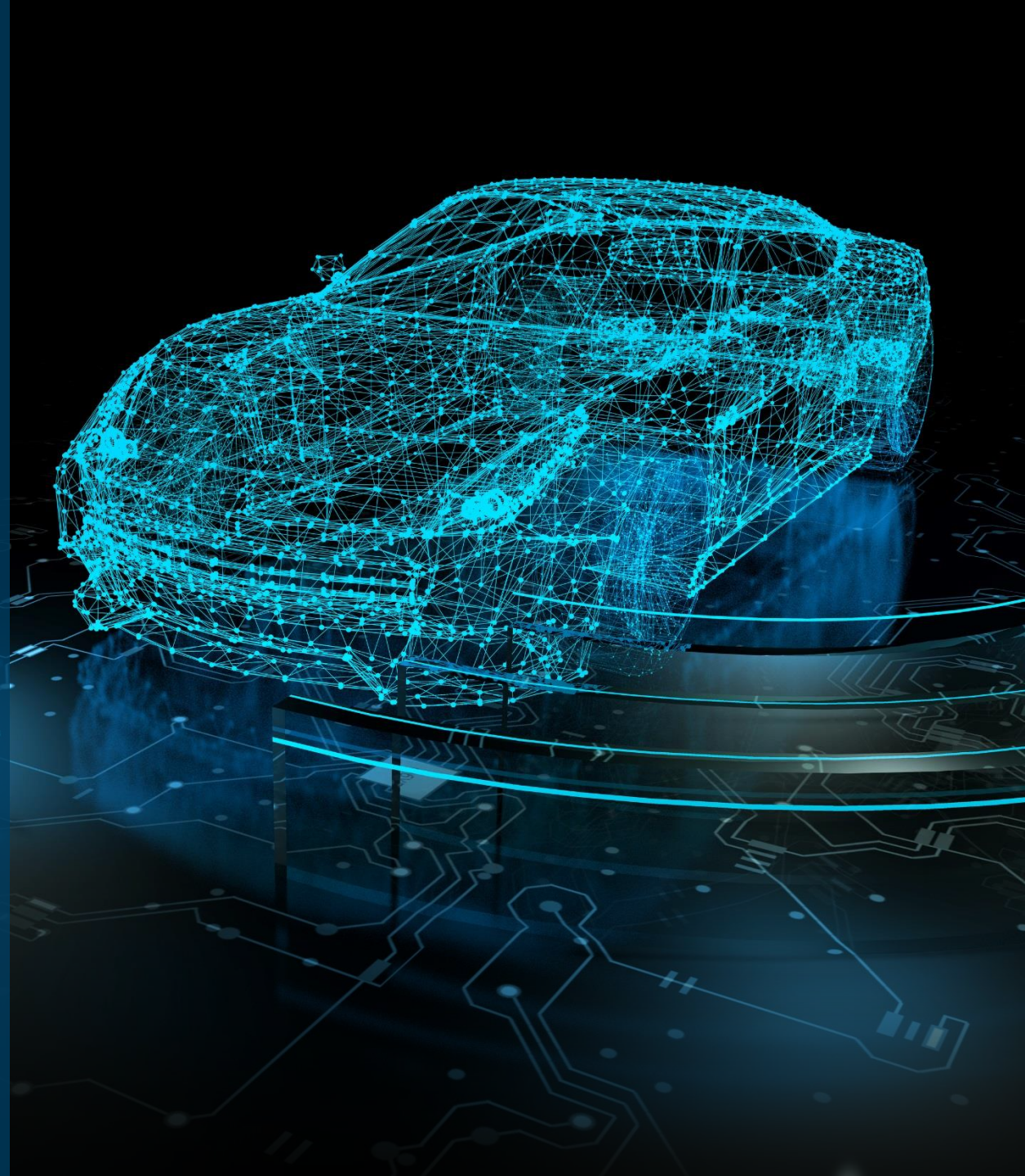
Global Marketing Manager, Automotive RADAR
Analog Devices - Munich

June 8th, 2017
Vélizy-Villacoublay



ADAS & Autonomous Driving Sensors

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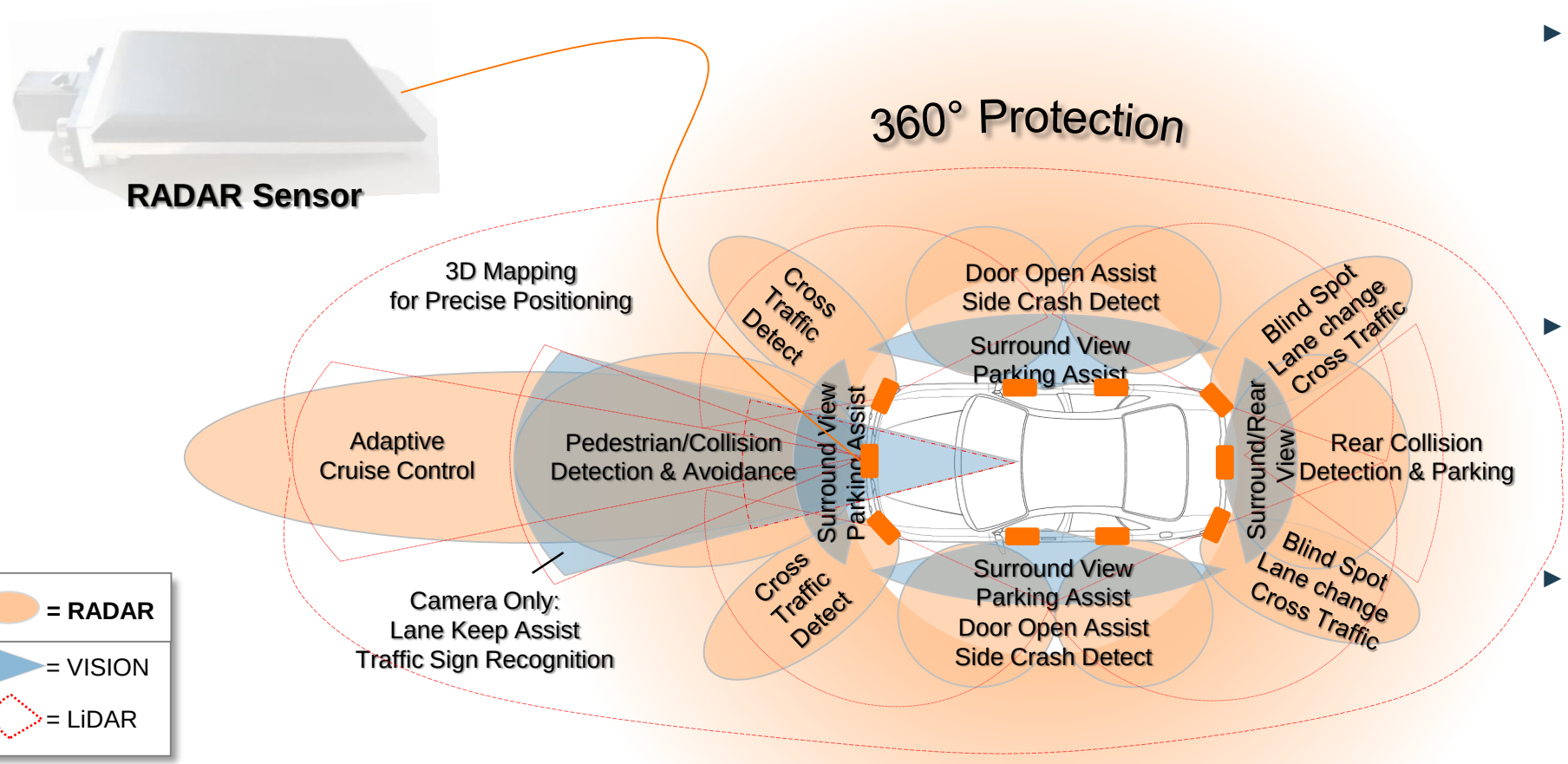

- **RADAR systems until recently were customer options only**
  - Volumes marginal
  - Basic performance sufficient
  - 24GHz mid range and 77GHz Long Range systems
- **NCAP is indirectly "forcing" OEMs to include RADAR sensors by default**
  - Boost of volumes expected.
  - Pressure on sensor cost does increase
- **AUTONOMOUS DRIVING will demand highest sensor performance at small form factors to support high channel count system**
  - Focus on 77/79GHz systems
  - Innovative technology required

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AUTONOMOUS DRIVING Levels and Sensor Requirements
Market Size and likely Segmentation

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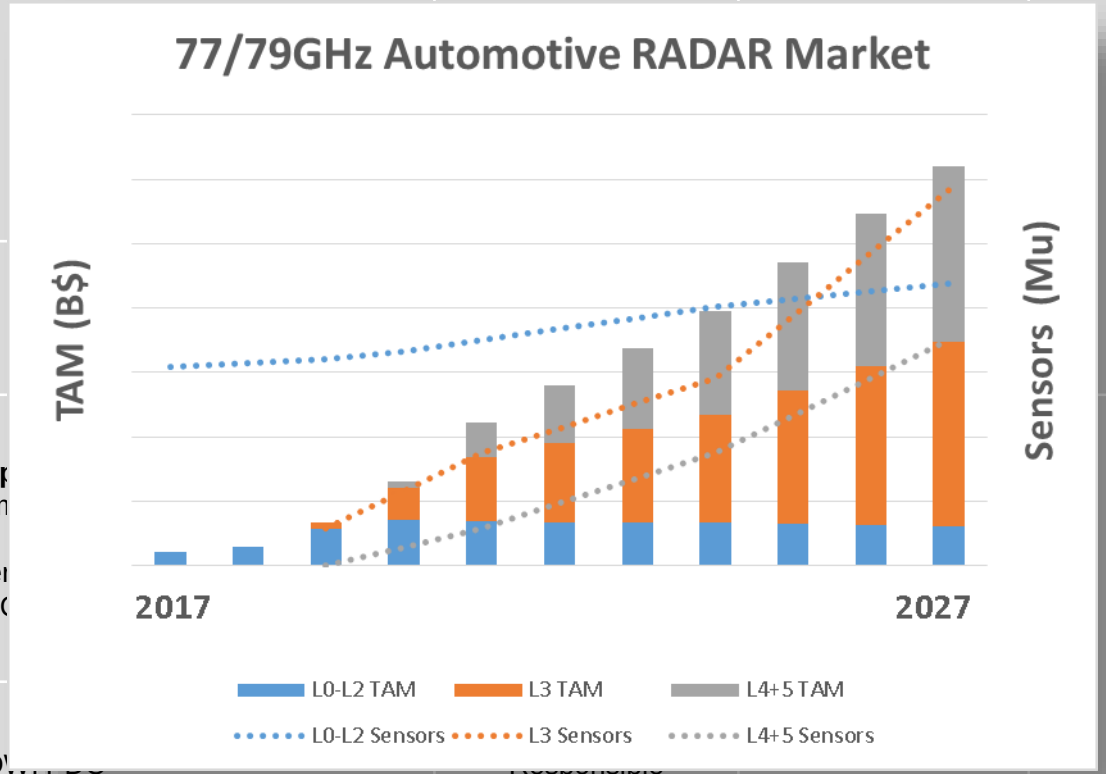
	AD Levels	Use-case examples	Driver Tasks	# of Sensors/ car	Key Value
Full Autonomy	5				
	4				
Semi Autonomy	3				
Foundational ADAS	2	**NCAP 5 Star Comp** • Required perform achieve this • Cost but also per Today: BSD, LCA,			
	1				
	0	Warning Only • BSD, CTA, LDW,			



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Higher Performance RADARs are needed for Autonomous Driving

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Advanced requirements for Autonomous Driving sensor requirements

- More warning time and 360° detection
  - More power on target, lower NF & phase noise
- High resolution & high unambiguity → superior imaging
  - Many hits per target R,V, θ, ϕ
  - More detailed information of the scene and content
- Interference Mitigation
- Solution scalability → to adopt to evolving requirements
- Highest levels of Functional Safety

- +13dBm output power, over temperature
- Low phase noise (< -100dBc/Hz)
- Low NF (<=13dB SSB)
- Broad FOV of antenna elements
- Fast chirps with high linearity supports high unambiguous velocity (10us / 1GHz)
  - Ultra fast settling (< 1us) supports fastest retrace time
  - 4GHz chirp → 3.75cm resolution
- Flexible waveform generation
  - Beam steering, phase coding, etc.
- Scalable for higher channel count
  - Phase & ADC synchronization

This translates to high performance RADAR

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Automotive RADAR
Making Tomorrow's Cars Safer

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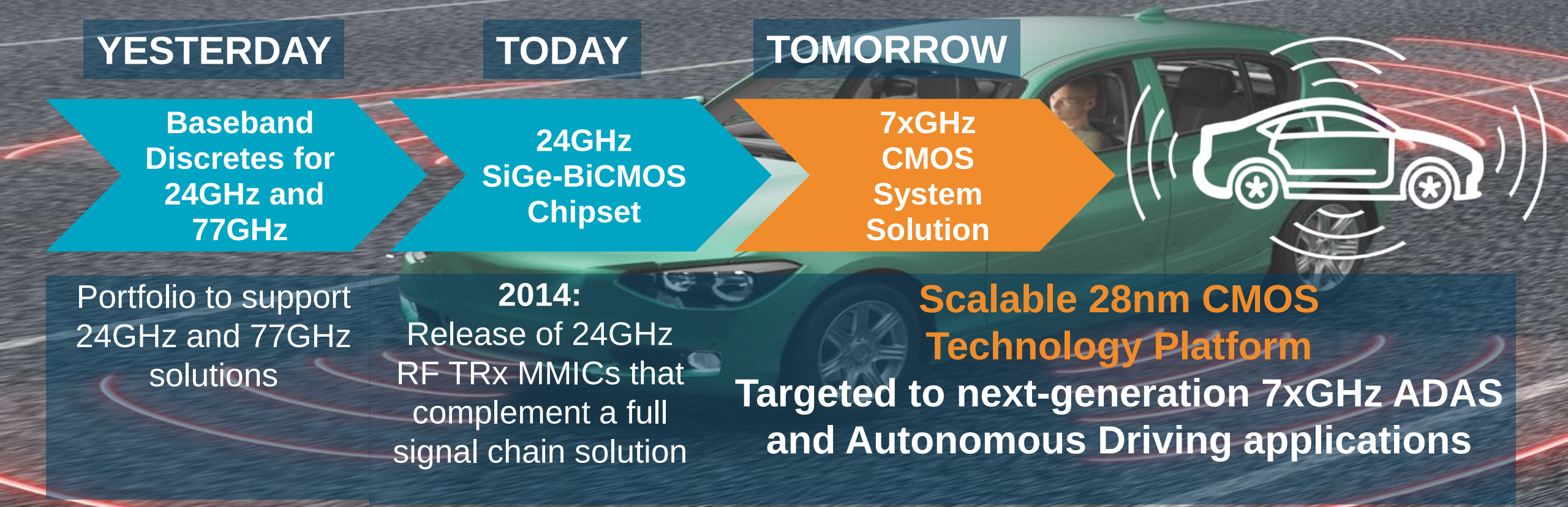

YESTERDAY	TODAY	TOMORROW
Baseband Discretes for 24GHz and 77GHz	24GHz SiGe-BiCMOS Chipset	7xGHz CMOS System Solution
Portfolio to support 24GHz and 77GHz solutions	**2014:** Release of 24GHz RF TRx MMICs that complement a full signal chain solution	**Scalable 28nm CMOS Technology Platform** **Targeted to next-generation 7xGHz ADAS and Autonomous Driving applications**

ADI products will more reliably detect smaller objects further away and in heavily congested areas – allowing critical extra time to execute evasive actions to avoid injuries or fatalities.

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76-81GHz 28nm CMOS Radar Technology Platform

Ensuring Highest Performance while Reducing Risk and Development Time

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- **28nm Process Node**
  - Most aggressive process node for performance, power and cost
  - Ensures platform longevity
- **CMOS Technology**
  - Highest degree of application-level flexibility
  - Allows RF integration for processing or pre-processing on chip
  - Flexible data interfaces for both centralized and decentralized processing
- **Scalable Platform To Support USRR → LRR Applications**
  - Cascadable chip for ultrafine angular resolution and high channel count applications
- **76-81GHz Sweep Bandwidth**
  - 5GHz sweep yields 3cm range resolution for autonomous functions
- **Integrated Functional Safety Capability**

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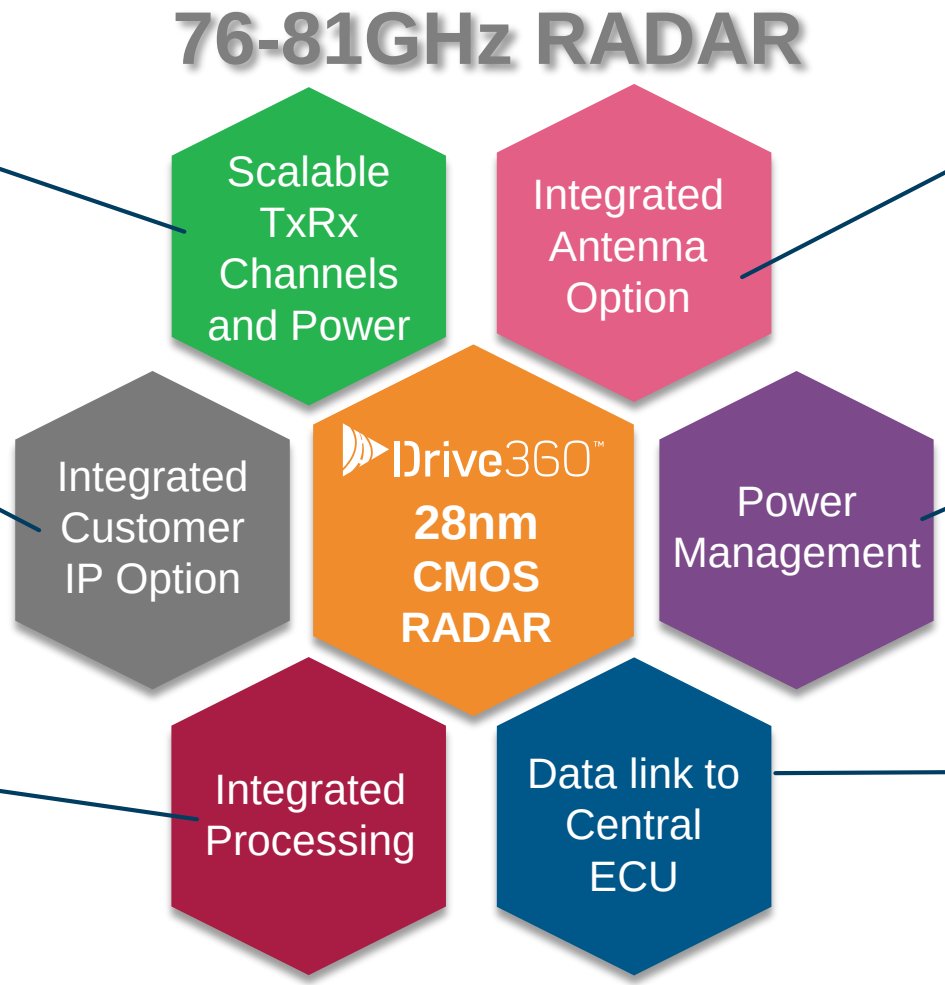
28nm CMOS RADAR Technology Platform

Modular approach to scale across ADAS and Autonomous Driving Applications

Customized transceiver channel configurations and output power to optimize for cost, size, and thermals

Enables customers to integrate customized IP to maintain differentiation

28nm process enables large scale digital integration—up to the complete RADAR processing at lowest power and cost



Nano-RADAR sensors enabled through integrated antennas

Dedicated power management solutions to ensure system integrity and system ISO26262 compliance

Low cost data transport to a center processor

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Key Differentiators with 28nm CMOS
Confirmed in Silicon

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ADI's Advantages	Customer (Tier1/OEM) Value
High PA output Power over Temp 13dBm	Longer detection range, targets seen sooner, better pedestrian detection, reduced false detects
Superior Phase Noise over Temp -100dBc/Hz@1MHz	Better detection of small objects (e.g. children) in presents of large objects, targets seen sooner
Highest Modulation BW 4+1GHz = 5GHz	Supports ultra high resolution apps like parking and door opening radars
Large Baseband BW 16b, 50MSPS/channel	Detects more targets at longer ranges, enables faster decision making, better tracking of objects for mid to short range

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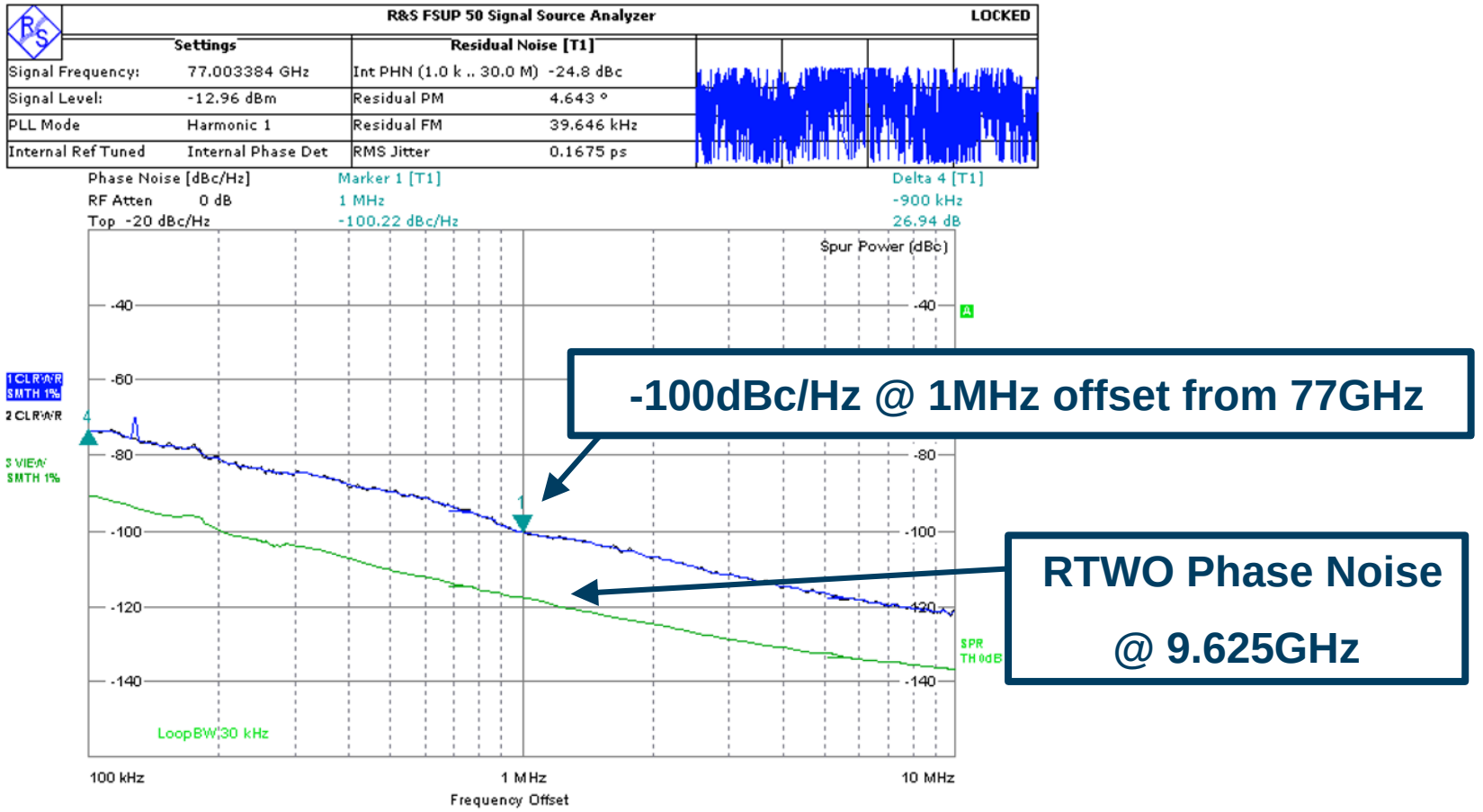
RTWO Open Loop Phase Noise @ 77GHz TX output

- A new class of oscillator - scales better than LC-VCO on CMOS Technology
- Enables industry leading phase noise across complete 5GHz tuning range



Shows expected $20\log_{10}8$ = 18dB delta from RTWO phase noise

→ No additional degradation through 8x multiplier chain

Conclusion

- The 77/79GHz Automotive RADAR market will see huge growth rates propelled by Autonomous Driving deployments
- Autonomous Driving applications will demand high quality sensor data covering 360° view around the car
- Todays “Foundational ADAS systems” help to field-test new technology in preparation for Autonomous Driving.
- Innovative solutions need to be presented to allow scalable systems meeting highest sensor performance.
- Analog Devices is sampling such a solution on a future prove, highly integratable 28nm CMOS technology today.
- R&S innovative Test equipment suite is helping ADI to faster finalize our 28nm CMOS RADAR evaluation prior to hitting production.

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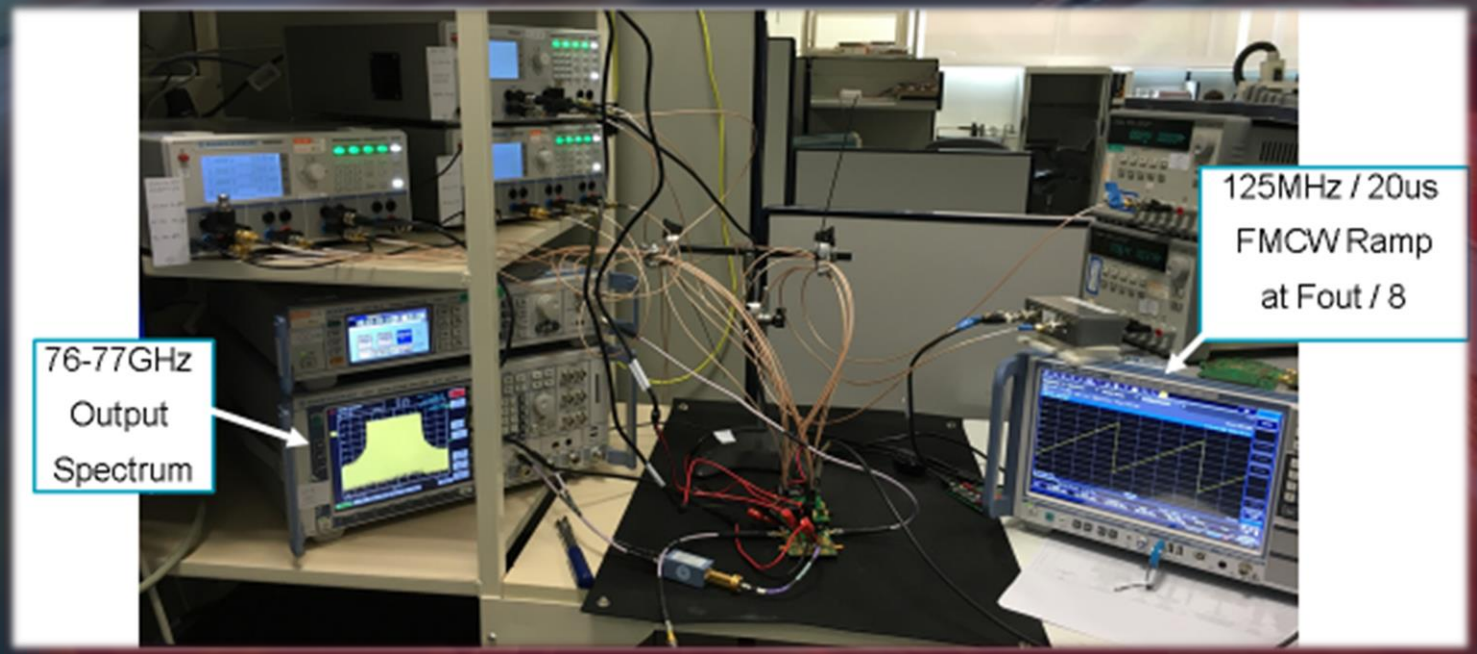
Thank You



77/79GHz 28nm CMOS RADAR Test chip evaluation (2016) with R&S equipment suite

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