



AI for 4D Radars

Smart Software for Smart Hardware

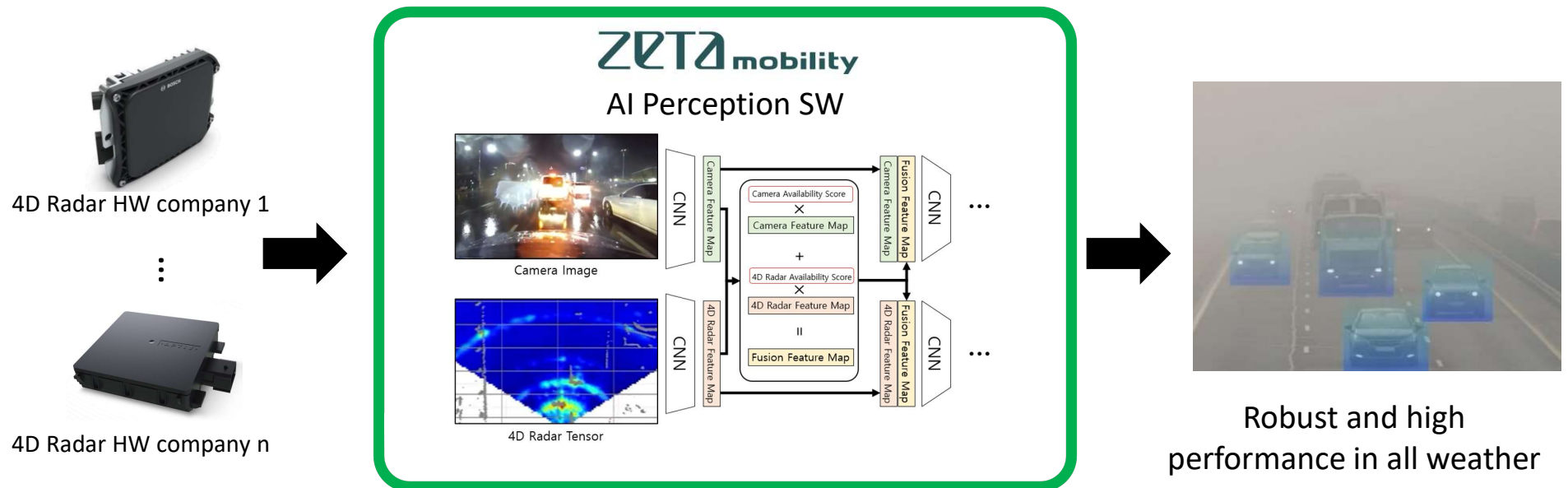


<https://www.youtube.com/watch?v=V2u3dcH2VGM>

GCCW
Sept 2023

World Best AI Perception SW for 4D Radars

- **Product:** World best **AI-based Perception SW** for 4D Imaging Radars (Average Precision of 62%)
 - Object detection / perception SW for 4D imaging radars with best performance
 - 4D radars are similar in performance to Lidars, but robust in adverse weather; a must for Autonomous Driving
 - Radar + Camera sensor fusion for next level perception in development
 - Plan to expand to autonomous driving SW platform
- **Market:** explosive growth expected for 4D Radars (CAGR 109%)
- **Customers:** already strong interests from **defense, automotive OEMs and mobility** companies



Team Bio



Hong Bae, PhD, CEO, Co-founder

- VinFast CTO (2021~22)
- Samsung Electronics, VP, Autonomous Driving, (2018~21)
- Faraday Future, Dir of ADAS / Self Driving (2015~18)
- Fisker Automotive, Dir of Elec Engr (2012~15)
- General Motors (2005~09)
2007 DARPA Urban Challenge Winner (GM+CMU)
- PhD in Mechanical Engineering, Stanford University



SH Kong, CTO, Co-founder

- Professor, KAIST (2010~)
- Qualcomm Research Center, Staff Researcher (2007~09)
- Nexipilot, Founder / CTO (2000~04),
3G-based wireless localization / GPS. World-first 2G CDMA cellular phone positioning under ground (subway stations)
- Samsung Electronics, Telecommunications Research Center (1997~2000)
- PhD in Aeronautics and Astronautics, Stanford University



Problem: Limitations of Cameras and Lidars

Camera / Lidar sensors cannot guarantee safety due to fundamental limitations



Tesla uses camera-only sensor systems



Waymo relies heavy on lidars

Camera sensor limitations

1. **Fragile in bad weather** such as fog, snow, rain, dust (fundamental limitation in visible light spectrum sensor)
2. Lighting negatively affects (low light at night, direct light during day)
3. Accurate distance measurement difficult (high computing load)

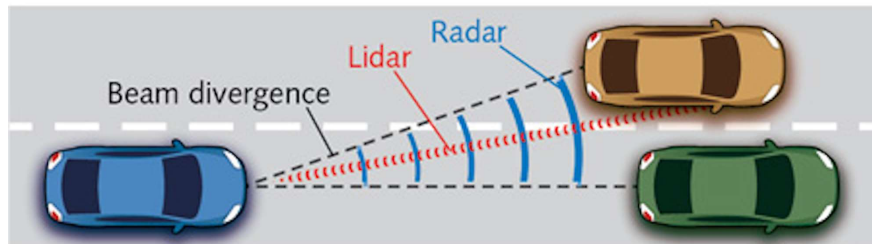
→ **Radar** is necessary for **robust sensing** in all weather

Lidar sensor limitations

1. **Fragile in bad weather** such as fog, snow, rain, dust (fundamental limitation in visible light spectrum sensor)
2. Expensive

→ **Radar** is necessary for **robust sensing** in all weather

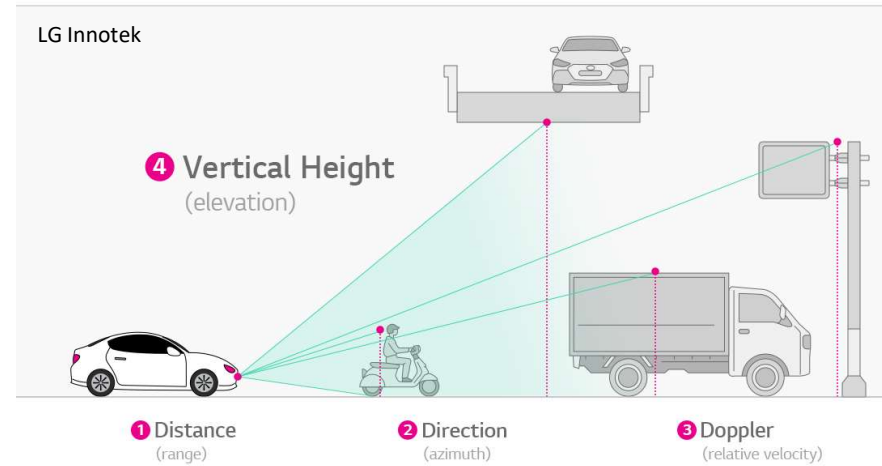
Solution: 3D Radars vs. 4D Imaging Radars



Imaging Radar provides high resolution data, enabling separation of objects close to each other

Old 3D Radar Attributes

- +** robust in all weather, low cost
 - low resolution
 - no object height/elevation data
- leads to unsafe situations



4D Imaging Radar (Range, Azimuth, Doppler + Elevation)

New 4D (Imaging) Radar Attributes

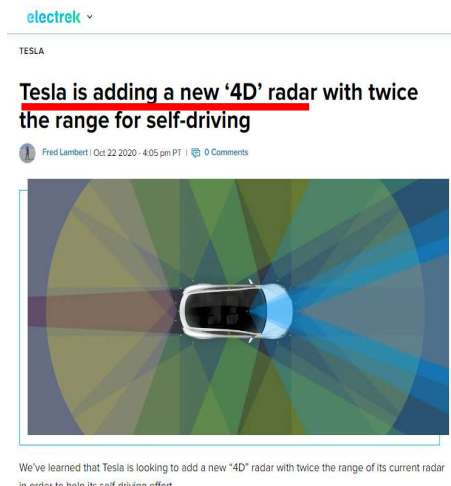
- +** robust in all weather
 - +** high resolution
 - +** height/elevation data
- robust and safe sensing in all weather conditions

Market: 4D Imaging Radars in Demand

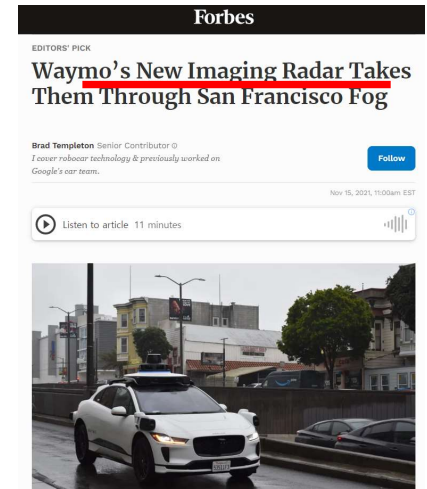
- Many automotive OEMs (Tesla, GM) are investigating 4D radars
 - Even multi-4D imaging radar systems under testing at GM
- Many robotaxi (Waymo, Motional) companies are also developing / investigating 4D radars.
- At CES 2023, many suppliers also showcased 4D radars (some already in production).
 - Bosch, Continental, Aptiv, Arbe Robotics



Major Tier-1 Radar Makers Producing 4D Radars



Tesla and Waymo are developing 4D radars

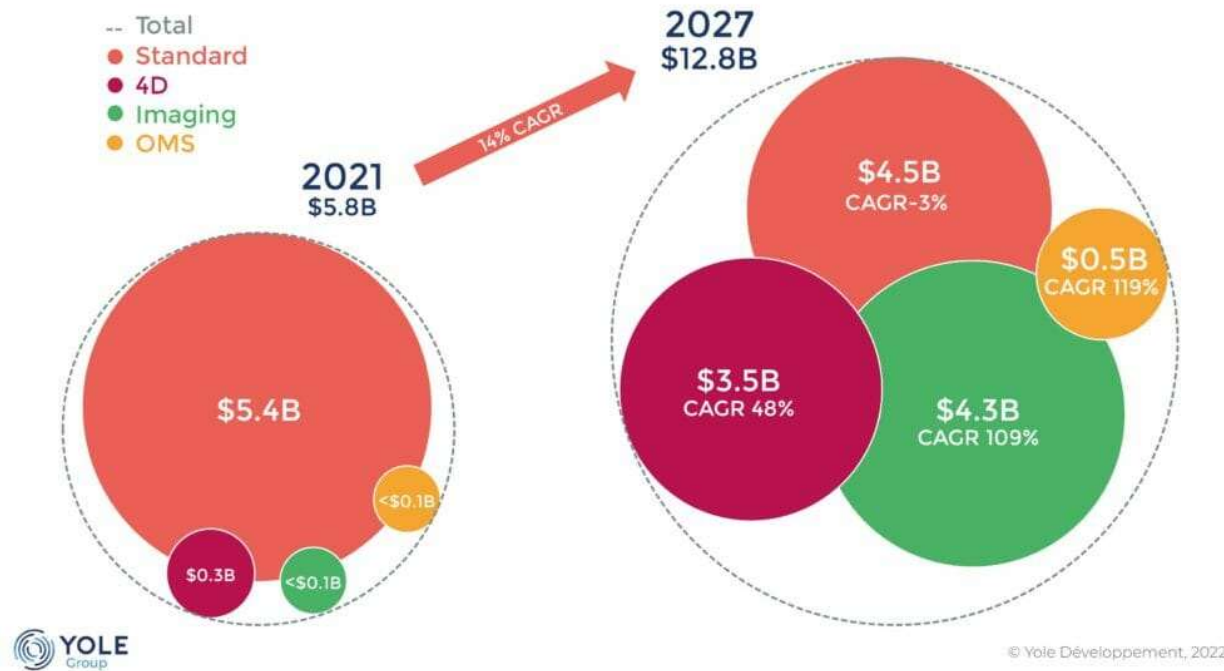


Market: 4D Radars To Grow Fast

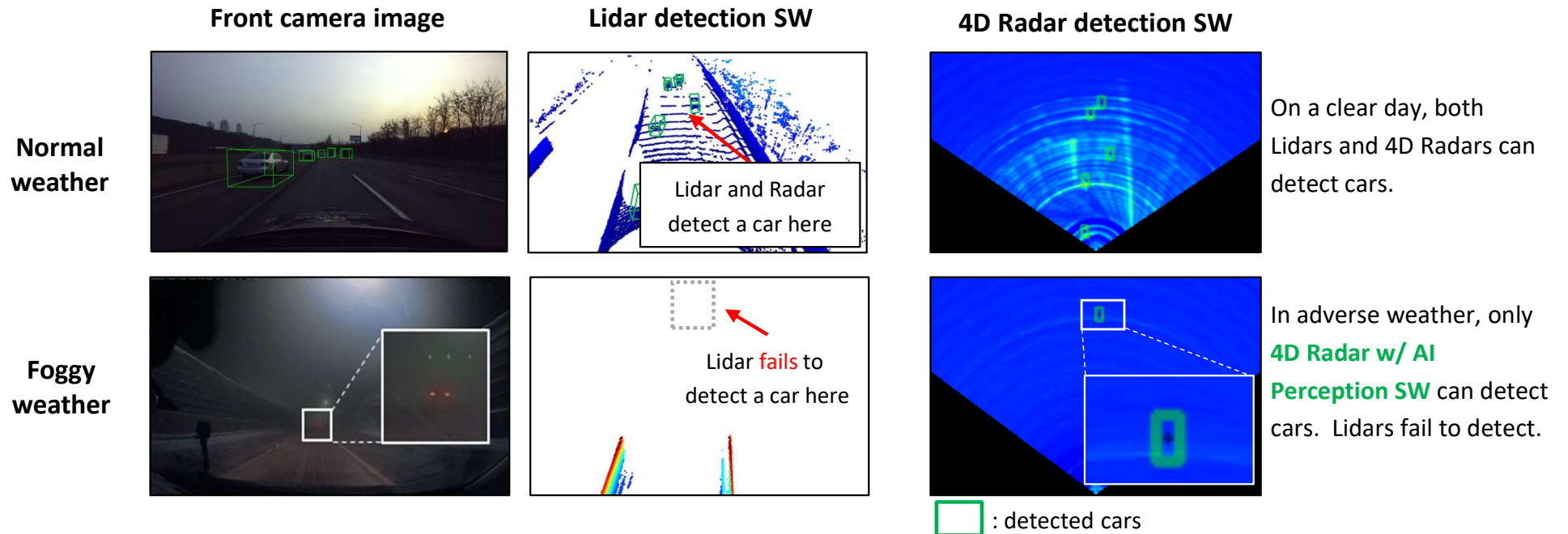
- 4D Imaging Radar market is expected to show up to **CAGR 109%**.
 - The current (3D) radar market is estimated to grow at CAGR 14% (Yole Group, 2022)
- Current 3D Radar market is under strong cost pressure (thus, low sensor performance). However, as ADAS and Autonomous Driving expand, the market is moving towards **high performance (high price) 4D radars**.

2021-2027 AUTOMOTIVE RADAR PLATFORM MARKET FORECAST

Source: Radar for Automotive 2022 report, Yole Développement, 2022



Technology: AI Perception SW for 4D Radars



Zeta Mobility's 4D Radar AI Perception SW shows the best performance

- World best 4D Imaging Radar AI-based Object Detection SW (Single Frame Average Precision of 62%)
 - Pre-processing technology for 4D radars based on neural network (completed)
 - Largest training dataset built (completed)
 - AI-based Object detection SW for 4D Radars (completed)
- Strong interests from defense, automotive OEMs and mobility companies

Customer Analysis (1/3): Military and Defense

- Military and Defense

- Autonomous supply vehicles, automated tanks / armored infantry vehicles, surveillance systems
- Med/large revenue + revenue at 3 yrs after contract / design-win
- High performance (all weather) / high reliability + Low price pressure
- ZetaM's strategy:
 - Leverage R&D projects to production design-wins / contracts
 - Two (2) R&D projects in discussion. Multi-year projects for:
 1. 4D Radar Sensing system, 2. Autonomous driving system for military trucks



Customer Analysis (2/3) : Automotive

- Automotive OEMs / Tier-1 Suppliers
 - GM, Mercedes-Benz, VW, Hyundai Motors, etc.
 - Large revenue + 3-4 yrs after contract / design-win
 - High cost pressure + reliability
 - ZetaM's strategy:
 - Direct collaboration with OEMs to prove perception performance. Then, ZetaM to supply to OEMs via Tier-1s (successful strategy proven by Mobileye, #1 front ADAS camera SW maker)
 - 4D radar perception SW to large OEMs (GM, VW, Hyundai Motors, etc.)
 - Full perception SW (fusion of 4D radars + cameras) for small / medium / startup OEMs (they lack internal resources for development)



Customer Analysis (3/3) : Mobility and Robots

- Mobility : robotaxi, roboshuttle
 - Motional, Cruise Automation, etc.
 - Med-size revenue + 1-2 yr after contract
 - Med/low cost pressure + low level reliability
 - ZetaM's strategy:
 - Leverage products for auto OEMs with lower reliability for low cost
- Delivery robots, serving robots
 - Med-sized revenue + < 1 yr after contract
 - Med cost pressure
 - ZetaM's strategy:
 - Standardized solution for all robots to lower cost



Product and Business Strategy: SW for SDV

- Industry is moving towards SDV – Software Defined Vehicle
 - SW is core strategy at Zeta Mobility
- 4D Radar AI Perception SW and Autonomous Driving SW Platform
 1. 4D Radar AI Perception Software
 - 4D radar SW + Camera sensor fusion and perception software
 2. Autonomous Driving SW Platform
 - Expand best perception SW to autonomous driving SW platform

