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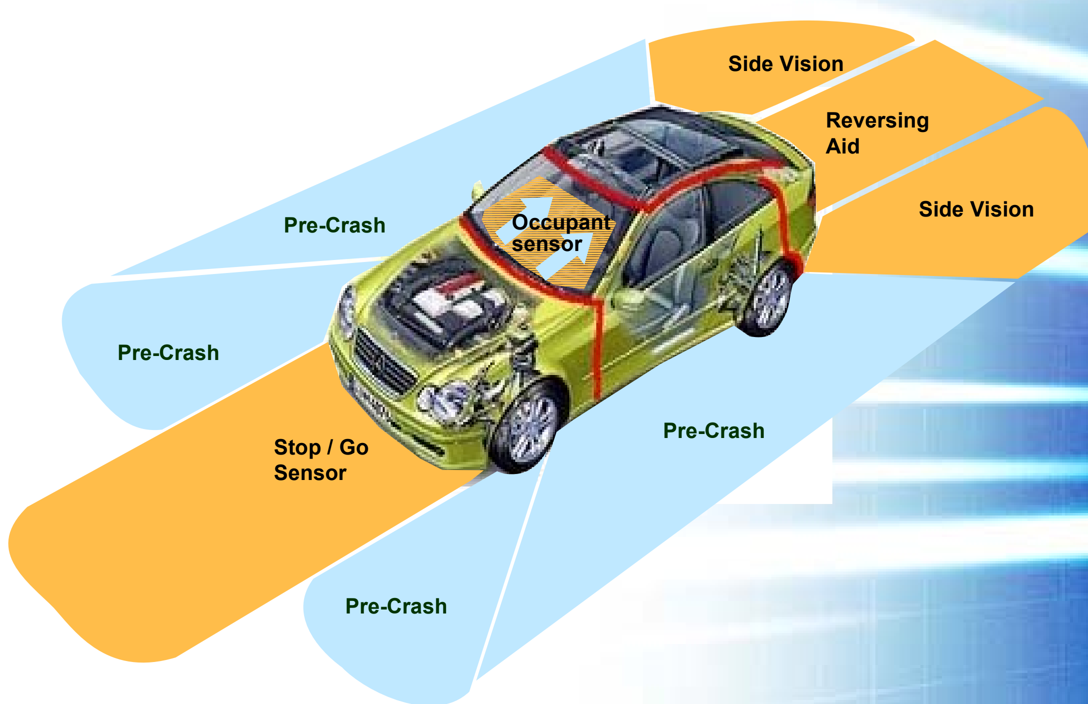

Affordable Collision Avoidance for Mass Market Vehicles

Closing the cost / performance gap

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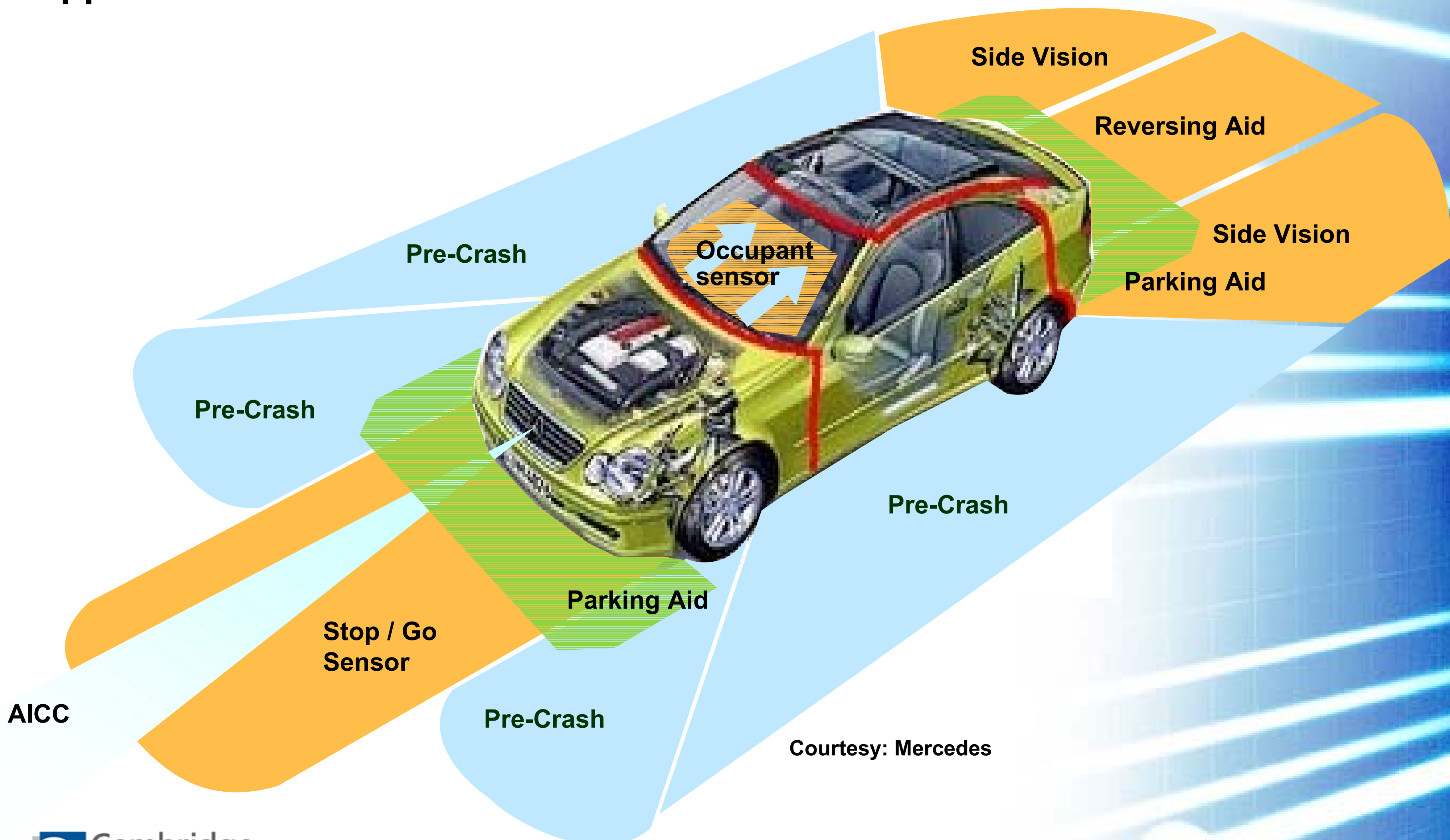
The aim of this presentation is to provide a roadmap of how collision avoidance systems will develop to provide affordable solutions for mass market vehicles

- What do we mean by collision avoidance?
- Current collision avoidance products
- Market Requirements for Mass Market Vehicles
- Medium Term Solutions (MY2007 onwards)
- Future enhancements

Collision Avoidance covers a large number of convenience and safety applications



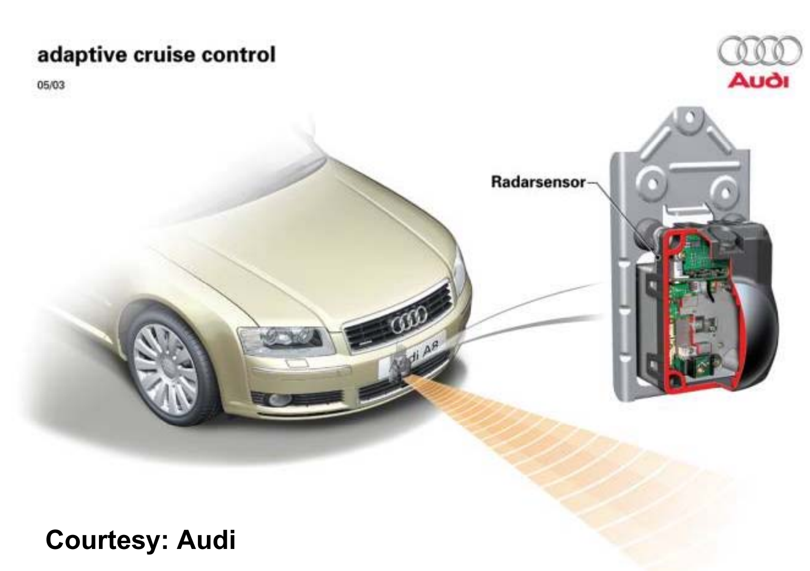
Courtesy: Mercedes

Collision Avoidance covers many types of systems with different requirements and market drivers between US and Europe

Application	Range (m)	Rate (m/s)	Zone Width (m)	Benefit	Introduction Date	Technology
Parking Aid	2	2	2	Reduced accident risk	~ Mid 90's (ITT / Valeo)	Ultrasonic
Autonomous Intelliegent Cruise Control (AICC)	120	50	10	Reduced driver workload and added convenience	2000 Mercedes S Class / ADC 2000 Jaguar XKR / Delphi 2003 Cadillac XLR / Delphi	77GHz Radar
Backup Aid (Hybrid Ultrasonic / Radar)	5	5	2 - 3	Reduced accident risk	2001 Ford / Lincoln / Delphi (US Market only)	17GHz Radar
Lane departure	50	35	10	Reduced accident risk	2000 Mercedes Truck /Iteris	Vision
Blind Spot Aid	5	15	3.5	Reduced accident risk	MY 2006 European OEM	24GHz radar
Rear Approach System	25	25	3.5	Reduced accident risk	MY 2006 European OEM	24GHz radar
Pre-Crash System	25	70	10	Increased warning time and additional information regarding impact	MY 2004 Lexus / Unknown supplier MY 2005 Pre-Safe II Mercedes S Class / Bosch / Tyco	77GHz radar 24GHz radar
Stop-Go / Urban Cruise Control	25	15	10	Reduced driver workload	MY 2006 European OEM	24GHz radar
Side Impact Pre-Crash	5	35	10	Increased warning time	MY 2008	24GHz radar

Ultrasonic Park Assist and Autonomous Intelligent Cruise Control (AICC) systems are currently in the market

Courtesy: Buick



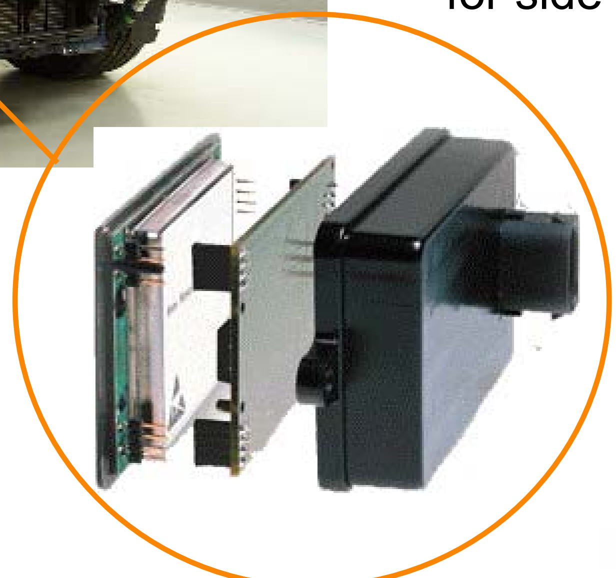
Courtesy: Audi

- Systems in their 4th Generation
- BoM cost around $50 for rear system
- Selling price ~$200 to customers
- Becoming standard on mid / high end vehicles
- Front systems also added on high end cars
- Extension to provide parking space measurement and “auto park” in development

- Systems in their 2nd Generation
- BoM cost around $400 for system
- Selling Price around $1600 to customers
- Mainly an option on high end vehicles
- Extension to provide limited pre-crash functionality
- Requires wide beam sensor to operate in stop/start traffic

The next major development will be the introduction of Short Range Radar Sensing (SRRS) systems operating at 24GHz in model year 2005

Courtesy: Tyco



- Operate with an architecture similar to ultrasonic sensors
- Range up to 25 metres
- 4 sensors required per bumper
- Additional sensors required for side looking applications

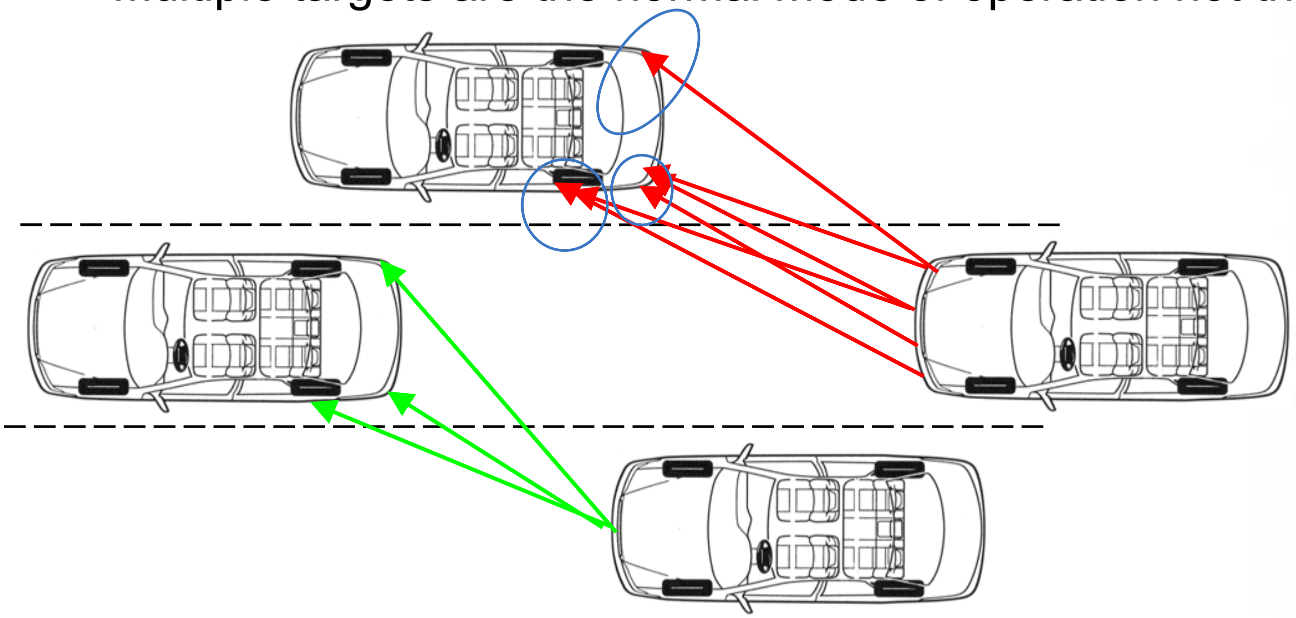
First generation SRRS systems should be on the market by MY 2005. However, their market penetration is constrained by several factors:

- System performance aspirations exceed sensor/processor capabilities
- Sensor costs are high due to exotic materials and components
- System costs are high for multiple sensors
- EMC regulations

In order for these systems to become widely employed in mass market applications the above issues have to be addressed

The SRRS system has to cope with a number of complex scenarios where multiple targets may exist

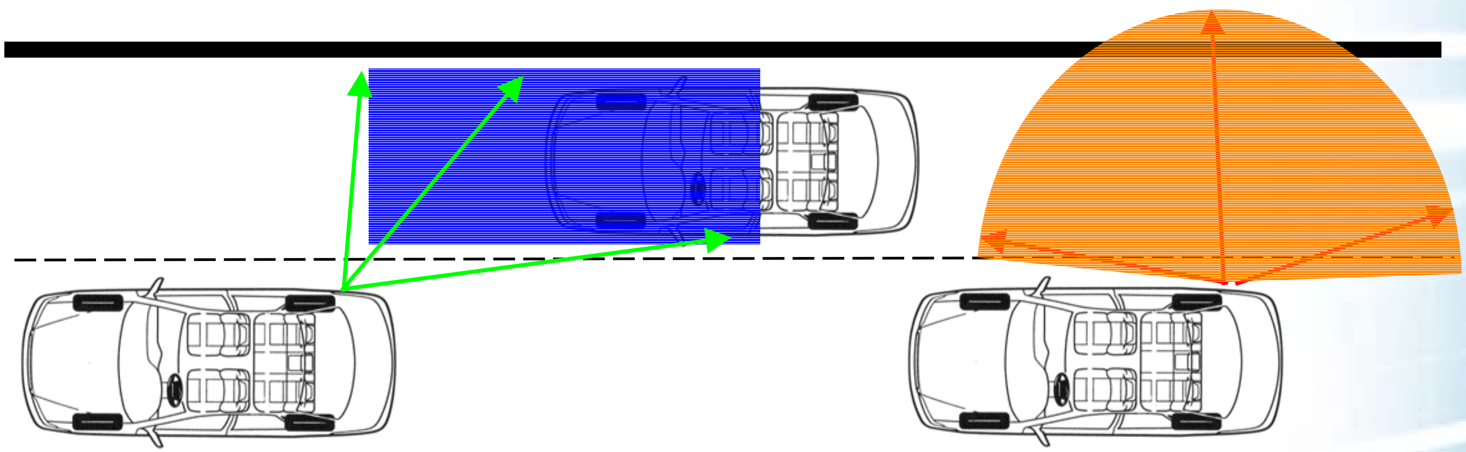
- System requires good angular resolution of targets, even when the observed radar scattering position changes with observation point
- Multiple targets are the normal mode of operation not the exception



Radar sensor should provide a distance and angle measurement from a single point

Warning zones have to be well defined and are normally rectangular in shape, and not the typical shape of antenna beam-patterns

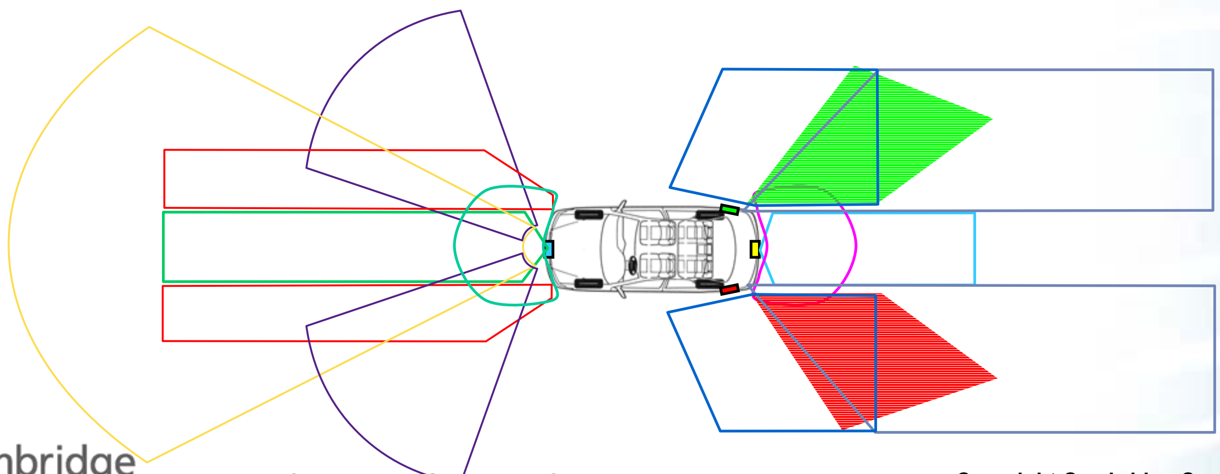
- Sensor requires good angular resolution to accurate position objects to minimise false alarms
- Without a single point sensor, the sensors would have to be distributed down the side of the vehicle
- Ideally the system should be programmable for maximum flexibility



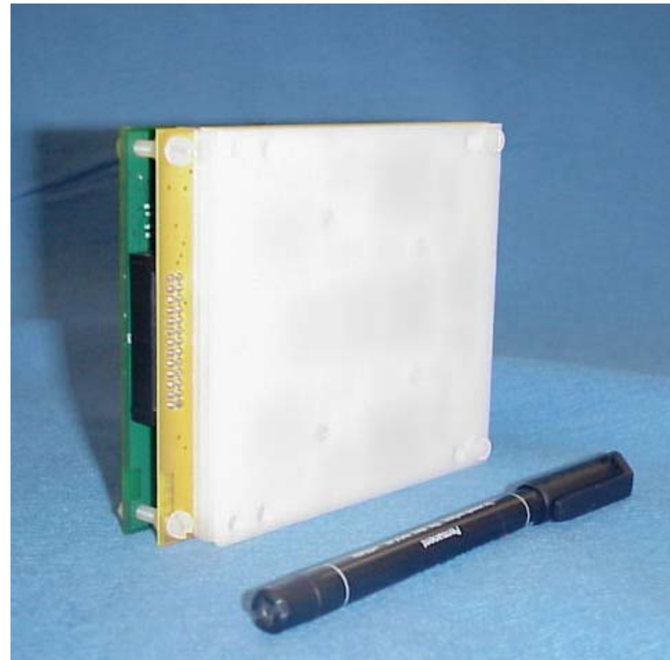
Radar sensor should provide better than 2° accuracy

In order for SRRS systems to succeed in the long term, the system costs have to be minimised by

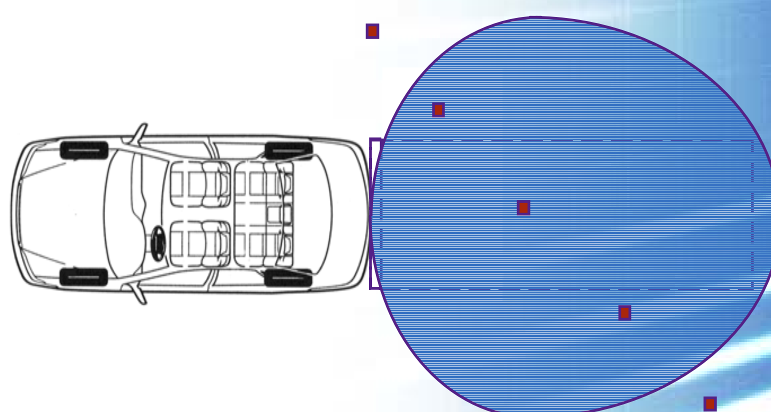
- Reducing the number of sensors required to cover multiple applications
  - Conventional approach will require up to 12 to 14 sensors
  - Single point sensing can reduce this to 4 units
  - minimising installation costs and impact on styling
- Reducing the sensor costs
  - use of lower frequency components
  - use of conventional materials and manufacturing techniques



CCL has designed a sensor that meets the requirements for a second generation SRRS

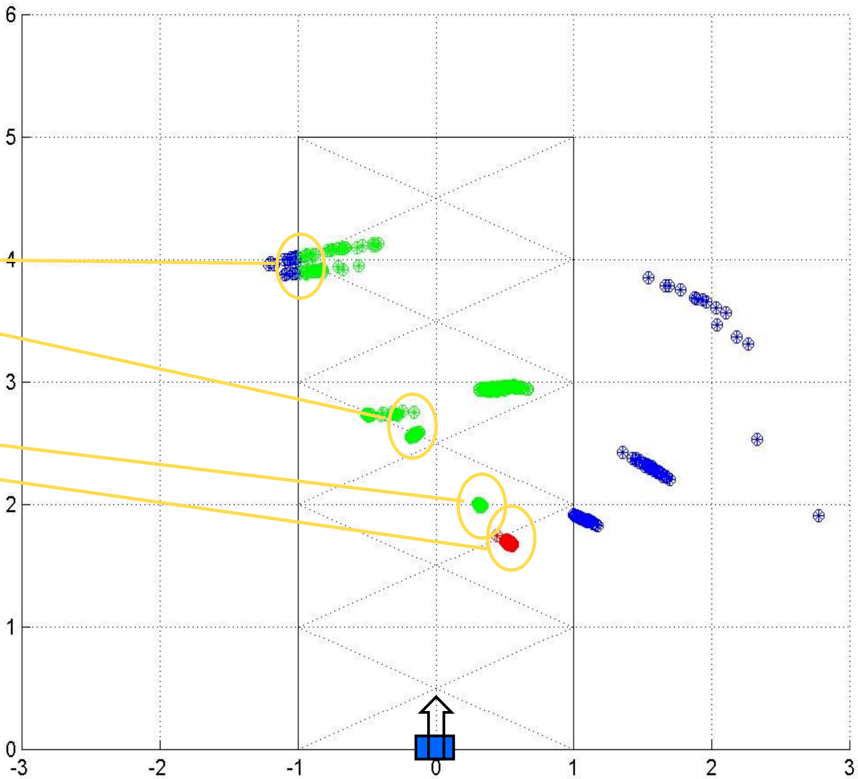


- 5.8GHz frequency uses conventional silicon components and manufacturing
- Measures positions in 3 dimensions
- Programmable functions within a wide Field of View: >150 x 90 degrees
- Range selectable, 5 metres or 25-50m
- Output parameters: 3D obstacle positions
Multiple target tracking
Intercept sensing
Vision cueing
- Dimensions:
  - Prototype: 100 x 110 x 50mm
  - Product: 80 x 150 x 25mm



The radar generates plan and elevation target maps and outputs on CAN bus

A vehicle provides responses from wheel wells, lights corners etc., providing an obstacle map



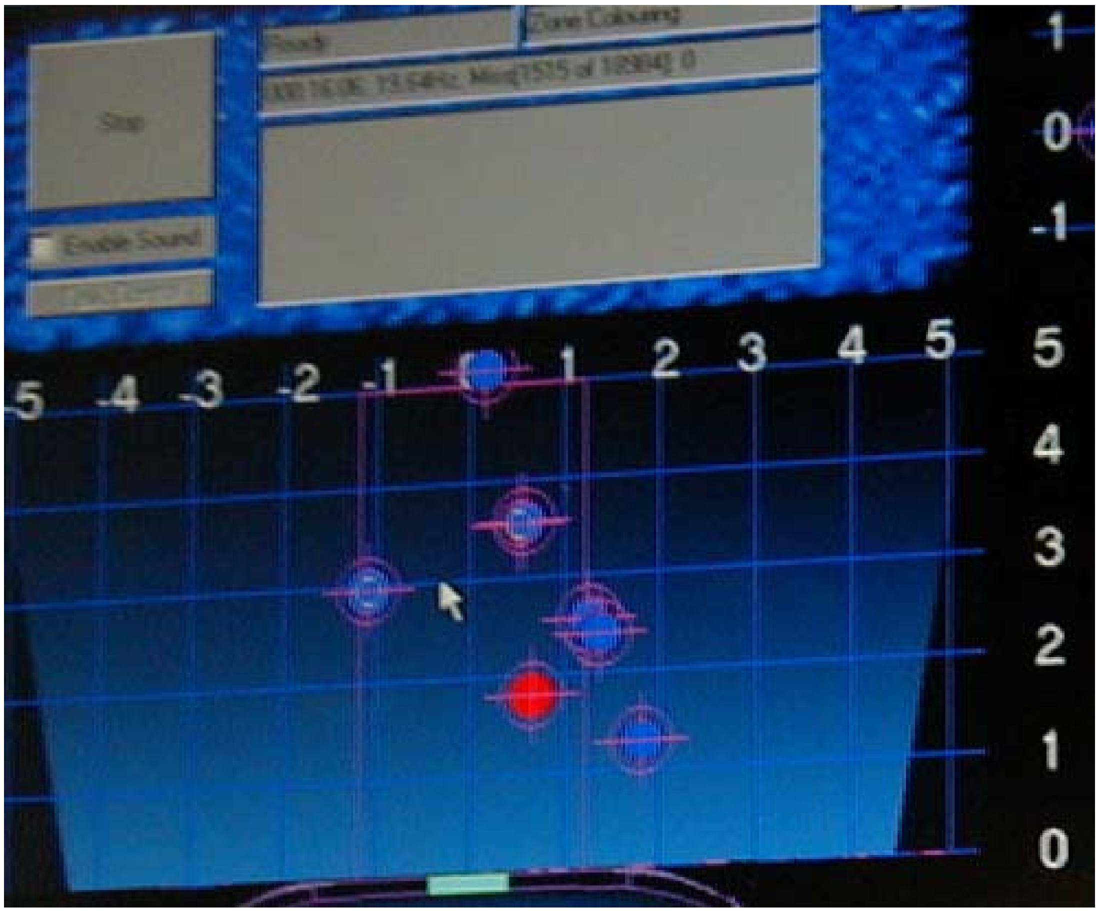
red: closest object in-zone

green: in-zone objects

blue: out of zone objects

CCL’s radar sensor has been integrated in a car for demonstrations

In this complex environment the radar sensor indicates (red) the closest obstacle (50mm plastic tube) within the programmed 3D alarm zone



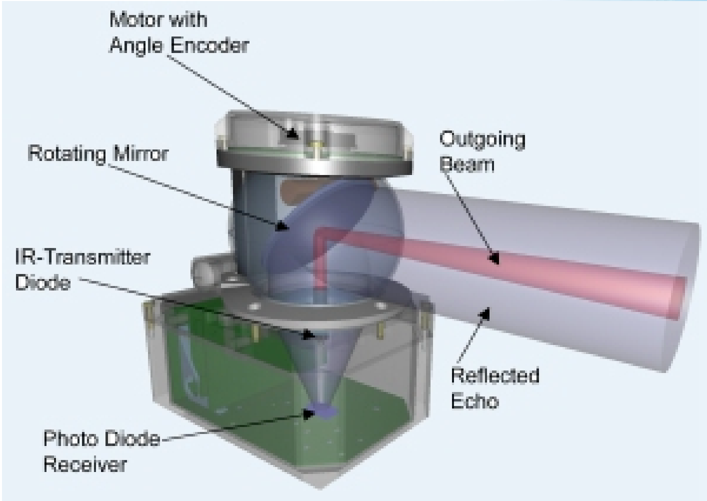
The majority of first generation SRRS systems operate at 24GHz with the SARA organisation co-ordinating industry efforts to agree the licencing position

- Automotive radar operation at 6GHz (under FCC Part 15 rules) and 24GHz (“Ultrawideband” Part 15 rules) meets US requirements
- European position is more complex
  - ETSI has been developing standards for automotive radar at 24GHz and around 79GHz (ETSI TG 31B)
  - Current proposal is for limited numbers (up to 10%) of vehicles to be equipped with 24GHz sensors but with a transition to 79GHz by 2014 due to concerns about interference to existing services
  - Standards for other UWB devices at similar power levels but in the band 3.1GHz to 10.6GHz are being developed by ETSI TG31A
- Adequate resolution can be achieved at 5.8GHz under the existing Short Range Devices allocations and harmonized standard
  - appropriate Ultrawideband approval will enable higher resolutions

We have concentrated on developments in radar technology, however, image processing and optical sensors are also under development

- These systems need to meet the same requirements of performance and cost as SRRS systems
- Examples of recent developments include
  - Iteris Lane Departure Warning system (initially introduced in the truck market)
  - Hella IR cruise control system, ALASCA[R] short range IR sensor

Courtesy: Iteris



Courtesy: Hella

Optimal collision avoidance performance is most likely to be met by a combination of sensor technologies

	Advantages	Disadvantages
Ultrasonics	• Low cost • Compact	• Obscured by dirt • Requires multiple sensors to extract target position • Range limited to 2 metres
Video	• Wide field of view • Good at target recognition and determining target extent • Potentially low cost implementation with CMOS sensors and processing	• Obscuration by dust and dirt • Requires multiple sensors to determine range • Poor speed measurement accuracy
Infra-red	• Good resolution in speed and range • Compact	• Obscuration by dust and dirt • Variable propagation conditions • Variability of target response
Radar	• Excellent speed and range accuracy • Robust - sensor can be mounted behind plastic panels • Insensitive to dust and dirt • Good sensitivity for a wide number of targets	• Potentially high relative cost to ultrasonics and video • EMC has to be considered during the design

Sensor fusion between radar and vision systems offers greatest promise given CMOS camera developments and availability of devices such as Alphamosaic's VideoCore^{TM} processor

Radar

Accurate determination of object position and velocity

Video

Ability to determine object extent and potential to classify into object type

Sensor Fusion

Radar directs the image processing algorithm to process a subset of the image posing the greatest danger to the vehicle

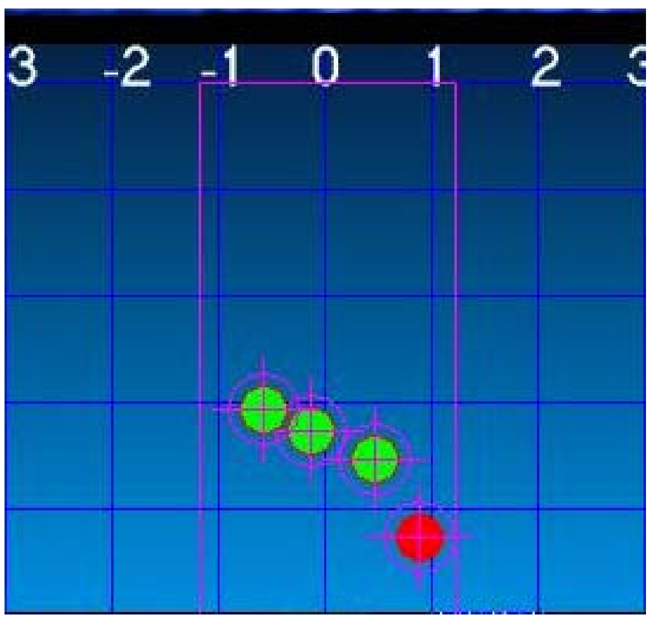
Processing and Control

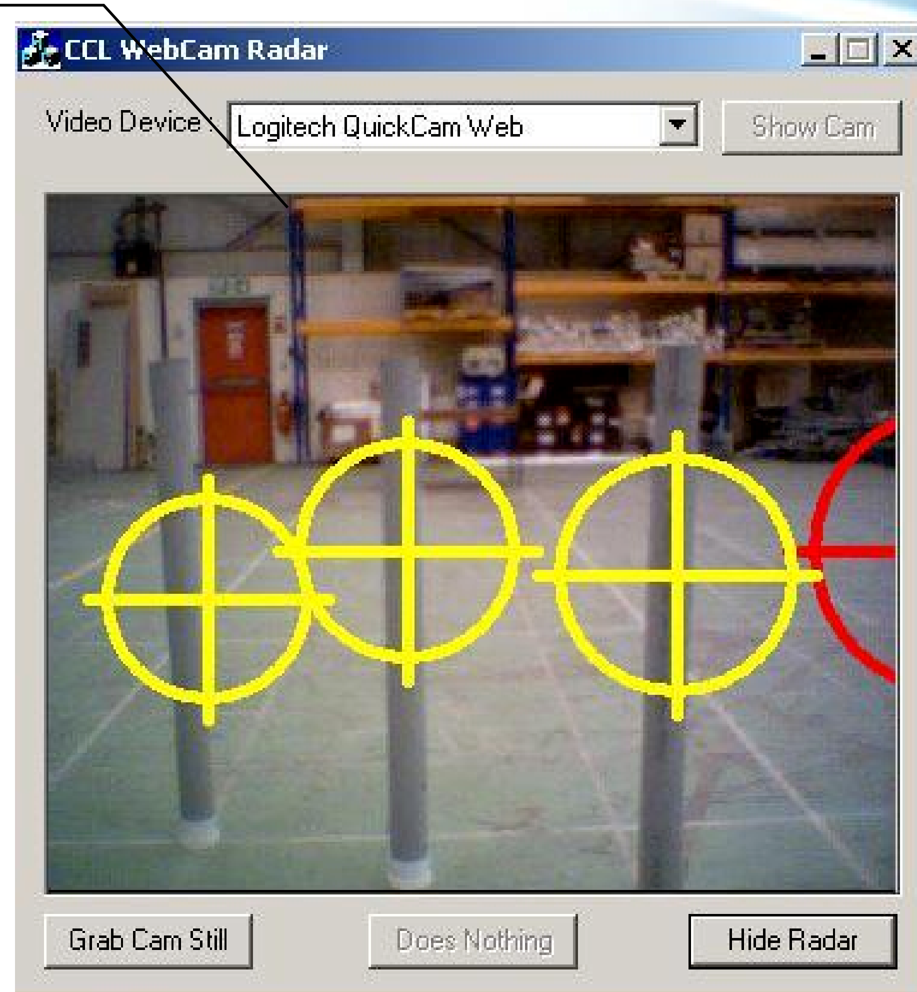
Example 1: Sensors feed the airbag ECU with the predicted crash severity to optimise the airbag settings

Example 2: ECU computes whether vehicle can be parked within the space and guides the driver into the space

A simple example demonstrates the advantages of the technique

Line based image processing algorithm may need to process the entire image detecting a number of unimportant targets





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