



Future developments of ADAS systems

Claudio Hartzstein Ph.D.

claudio.hartzstein@gmail.com



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ADAS Functionalities

- In-vehicle navigation system (GPS and TMC for providing up-to-date traffic information).
- Adaptive cruise control (ACC)
- Lane departure warning system / Lane keeping system
- Lane change assistance
- Collision avoidance system (Pre-crash system)
- Intelligent speed adaptation or intelligent speed advice (ISA)
- Night Vision
- Adaptive light control
- Pedestrian protection system
- Automatic parking
- Traffic sign recognition
- Blind spot detection
- Driver drowsiness and inattention detection
- Vehicular communication systems (V2V and V2I)
- Hill descent control
- ...



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ADAS Sensors and Technologies

Sensors:

- Multi-beam long range radars (76.5 ± 0.5 GHz)
- Single beam/Monopulse Short Range Radars (24 ± 2 GHz \rightarrow 79 ± 2 GHz)
- Video Cameras (Mono and Stereo, Visible and Infrared)
- Ladar/Lidar
- Head Up Displays
- Rate Gyros, Accelerometers.
- Interior cameras (Visible, IR) for drowsiness/inattention detection
- ...



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ADAS Technologies

- Millimeter Wave Transceivers
- Single and Multi-Beam Antennas.
- mmw Phased Array Antennas
- Radar Waveform Design and Processing
- Signal and Image Processing
- Sensor and Information Fusion
- Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) Communications
- Augmented Reality
- Simulation, Testing and Validation
- ...



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Future ...

And the “Holy Grail”: Autonomous Vehicle



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Ubiquitous Radar – Merrill Skolnik

ATTRIBUTES OF THE UBIQUITOUS PHASED ARRAY RADAR

Merrill Skolnik

Systems Directorate, Naval Research Laboratory, Washington, D.C.
IEEE Phased Array Systems and Technology Symposium, Oct. 14-17, 2003

Abstract: This paper reviews the concept and properties of a ubiquitous radar, one that looks everywhere all the time....

Systems Aspects of Digital Beam Forming Ubiquitous Radar

Abstract: This paper describes the general characteristics and potential capabilities of digital beam forming (DBF) ubiquitous radar, one that looks everywhere all the time. In a ubiquitous radar, the receiving antenna consists of a number of fixed contiguous high-gain beams that cover the same region as a fixed low gain (quasi-omnidirectional) transmitting antenna....



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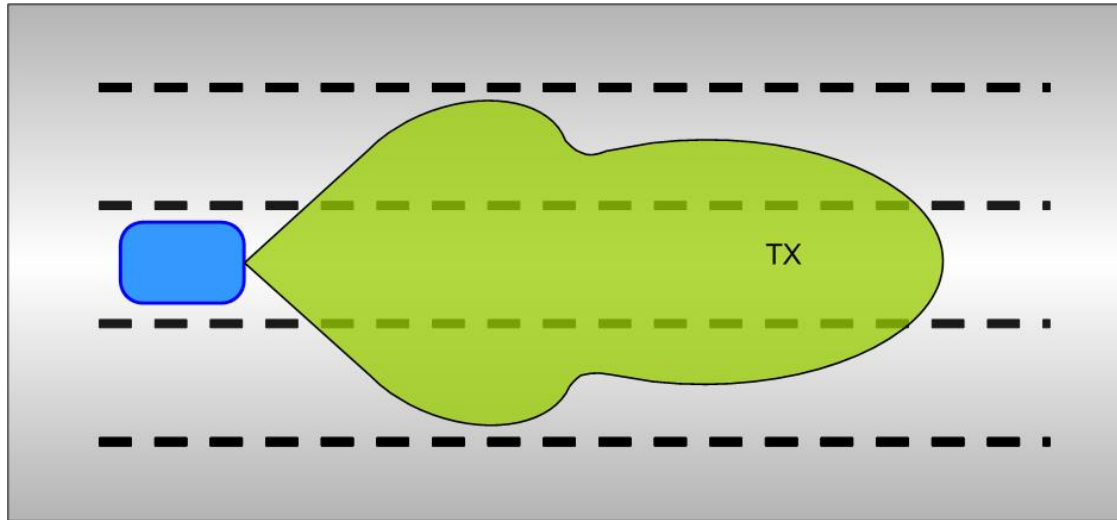
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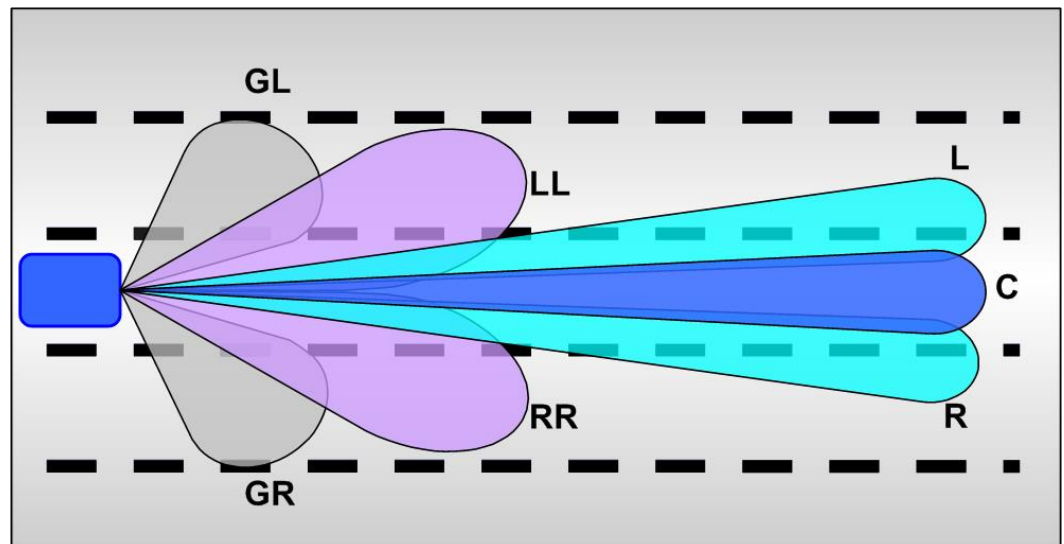


Ubiquitous Radar – RoadEye FLR



←Single wide
transmitt beam --
Illuminator

Multiplicity of receive
real beams →



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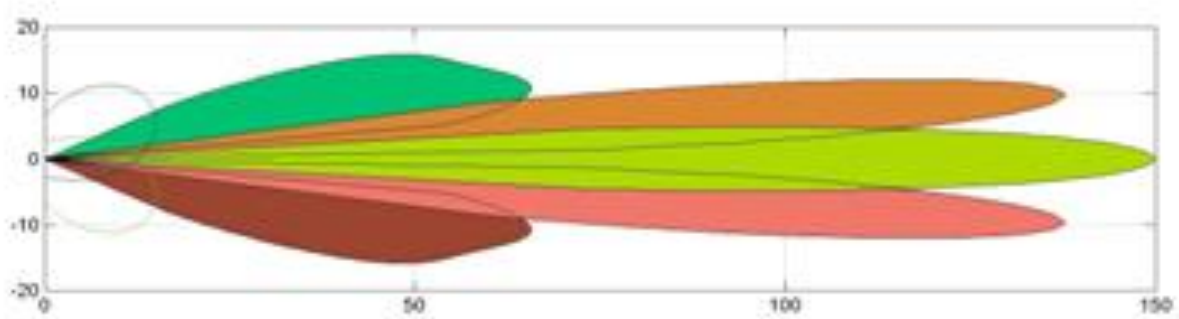
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Ubiquitous Radar – RoadEye FLR

Transmit-Receive Patterns



Physical Implementation

DenseTraffic *IST-2000-29638* “Final Report”
and “Forward-looking radar system”
United States Patent 7420502



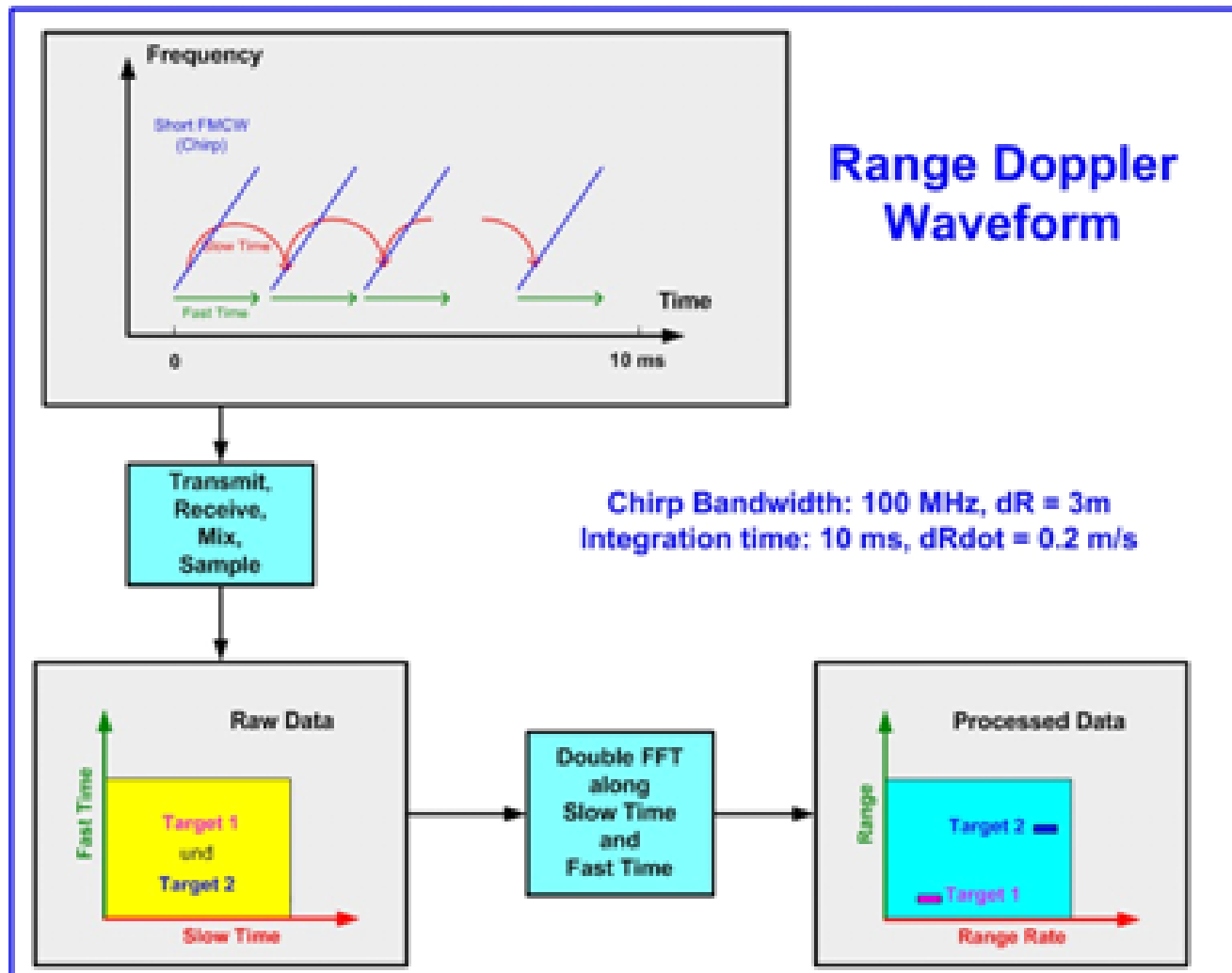
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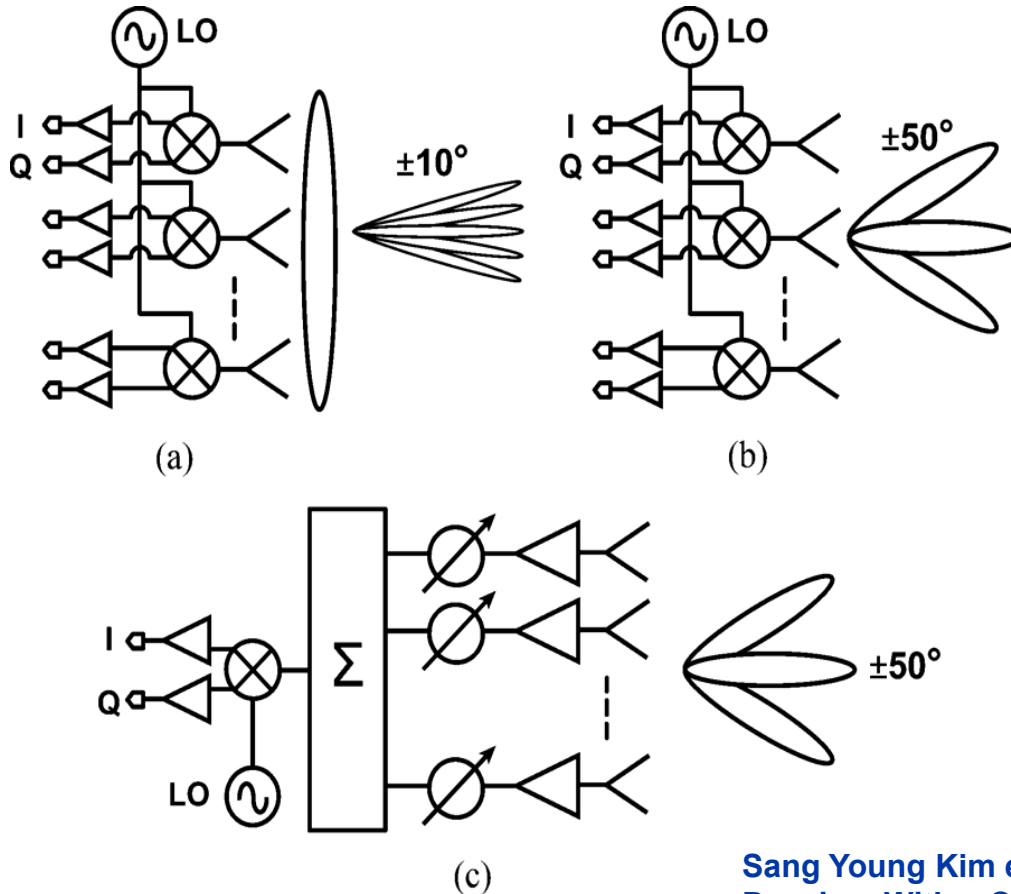
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RoadEye FLR -- Waveform and Signal Processing



Advanced Radars – Phased Array Antennas

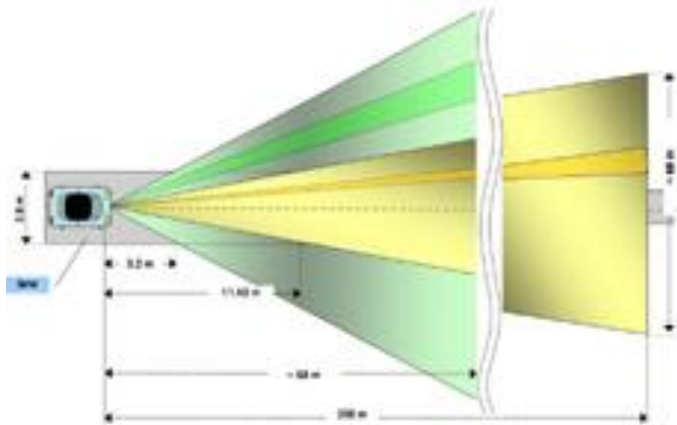


- a) Every channel should be transmit and receive (Switching Real Beams).
- b) **Wide transmit antenna and digital beam forming receiver (Array on Receive: AoR).**
- c) Every channel has to transmit and receive also (Full Electronically Scanned Array).

Sang Young Kim et al., "A 76–84-GHz 16-Element Phased-Array Receiver With a Chip-Level Built-In Self-Test System", IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES, VOL. 61, NO. 8, AUGUST 2013



Advanced Radars – ADC ARS 300



The rugged ARS 300 sensor from A.D.C. measures independent the distance and velocity (Doppler's principle) to objects without reflector in one measuring cycle due basis of FMCW (Frequency Modulated Continuous Wave) with very fast ramps, with a real time scanning of 15 / sec.

A special feature of the device is the simultaneously measurement of great distances up to 200 m, relative velocity and the angle relation between 2 objects.

Transmit/Receive Beamwidth 1°!!



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Advanced Radars – Azimuth Scanning

U.S. Patent

Sep. 29, 1998

Sheet 3 of 4

5,815,124

Evanescent coupling antenna and method for use therewith

US 5815124 A, US5572228

Inventors:

Vladimir A. Manasson, Lev S. Sadovnik, Paul I. Shnitser

Original Assignee:

Physical Optics Corporation

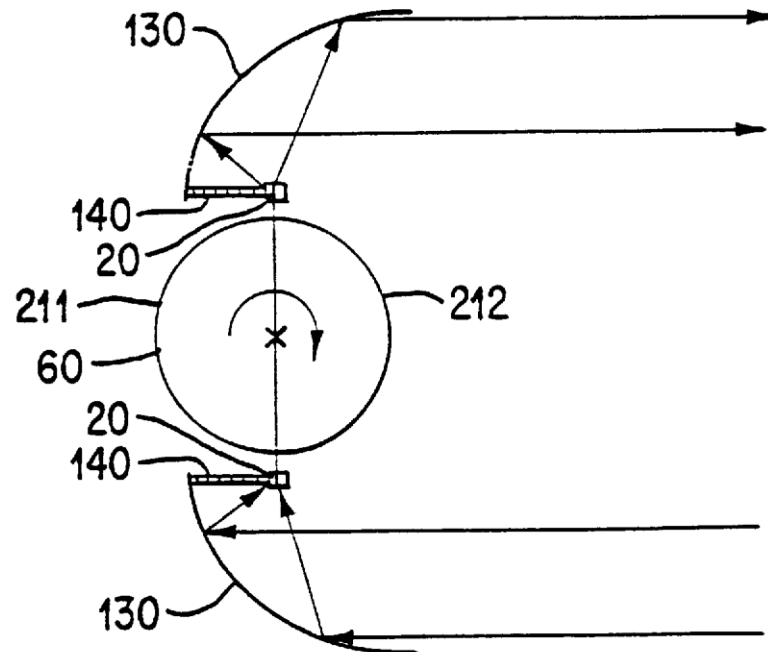


FIG. 5



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Advanced Radars – Azimuth Scanning

U.S. Patent

Sep. 29, 1998

Sheet 2 of 4

5,815,124

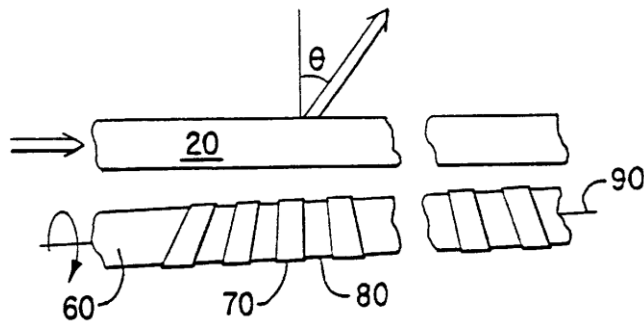


FIG. 3

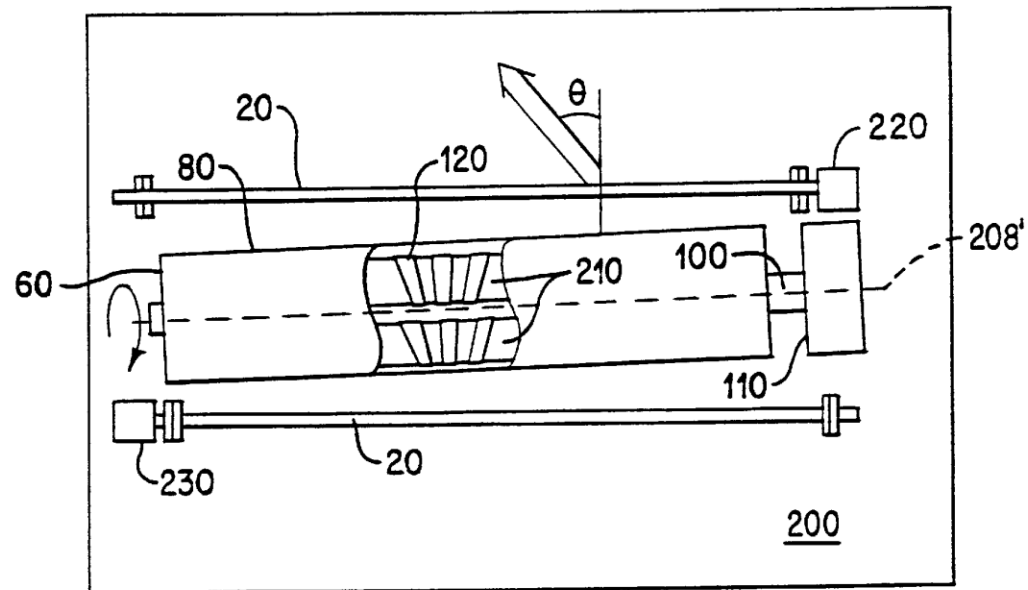


FIG. 4



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Advanced Radars – Azimuth Scanning

MMW Scanning Antenna

Vladimir Manasson, Lev Sadovnik and Robert Mino,
WaveBand Corporation

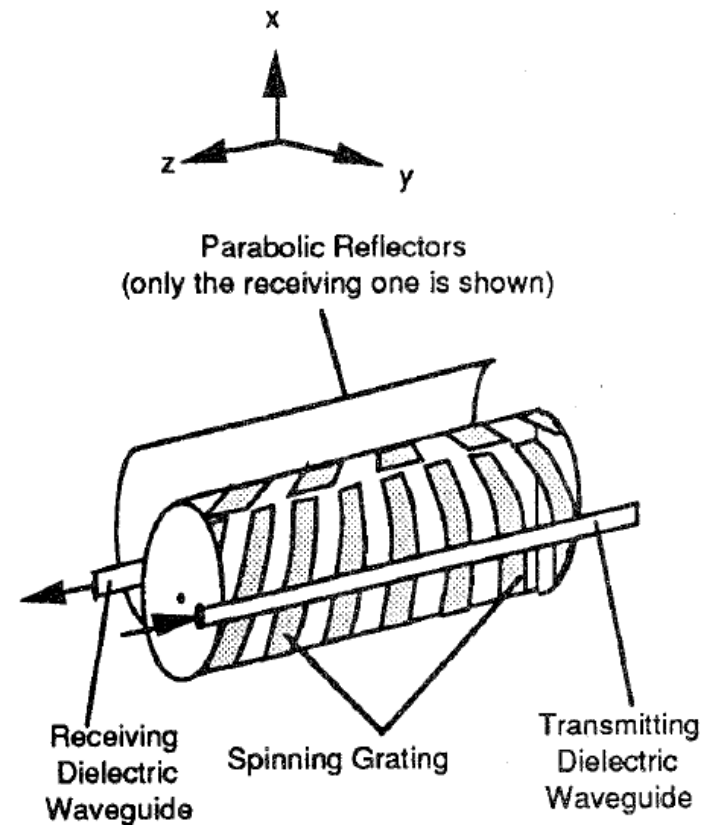


Fig. 1. The Spinning Grating Consists of Two Identical Semi-Cylinders; The Grating Periods in the Immediate Proximity of the Two Waveguides Are Exactly The Same.

Advanced Radars – Azimuth Scanning

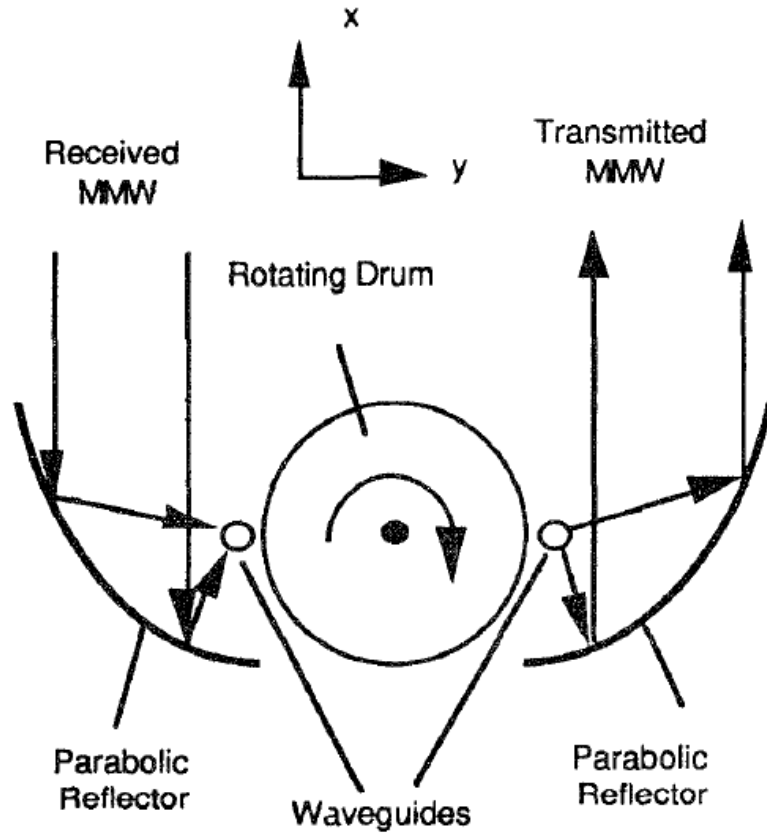


Fig. 3. Parabolic Mirrors Direct and Shape the Beams in the x-y Plane

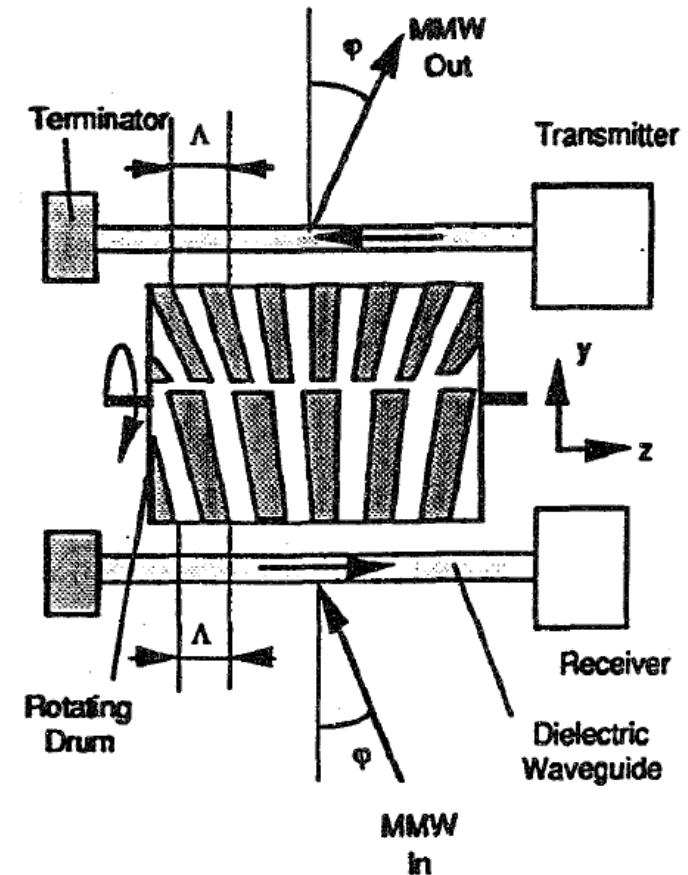


Fig. 2. Beam Tracing in the Y-Z Plane. The angle φ of emission and of reception is determined by the instantaneous value of the grating period Λ , which varies along the circumference of the drum.



Advanced Radars – Delphi RaCam

► Features

- Full-speed Adaptive Cruise Control
- Lane Departure Warning / Lane Keeping
- Headway Alert
- Forward Collision Warning
- Pre-crash Collision Mitigation
- Full Autonomous Braking
- Pedestrian Detection
- Enhanced Object Detection
- Headlight Control
- Traffic Sign Recognition



Benefits

As more active safety features move from optional content to standard fit, sensor fusion systems will help to keep cost down and are likely to become more prevalent in the market. RACam's small package size, 123mm x 68mm x 38mm, simplifies vehicle integration and allows for application on the windshield side of the rear view mirror, removing the sensor from the vehicle's crush zone and helping to reduce repair costs in the event of a frontal impact.



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Advanced Radars – Delphi RaCam

Phased Array Antenna?



An industry first, the Delphi RACam combines radar and vision sensing in a single module to enable multiple safety features at lower cost.



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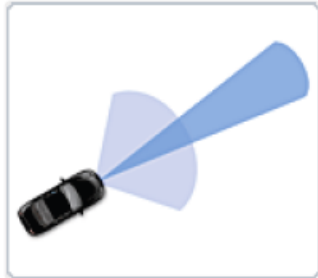
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Delphi Electronically Scanning Radar



Enlarge

systems more affordable in the automotive market.

Delphi has applied more than 20 years of radar experience to develop its award-winning electronically scanning radar (ESR). Leveraging expertise gained from radar production that began in 1999, Delphi brought ESR to market at a price that is helping make radar-based safety and convenience



Delphi's multimode ESR combines a wide field of view at mid-range with long-range coverage to provide two measurement modes simultaneously. While earlier forward looking radar systems used multiple beam radars with mechanical scanning or several fixed, overlapping beams to attain the view required for systems like adaptive cruise control, Delphi's multimode ESR provides wide coverage at mid range and high-resolution long-range coverage using a single radar. Wide, mid-range coverage not only allows vehicles cutting in from adjacent lanes to be detected but also identifies vehicles and pedestrians across the width of the equipped vehicle. Long-range coverage provides accurate range and speed data with powerful object discrimination that can identify up to 64 targets in the vehicle's path.

Delphi's technologically advanced ESR uses proven solid state technology plus class-leading performance, packaging and durability to offer customers game-changing forward radar detection. The quality of data provided by Delphi's system enables powerful functionality including adaptive cruise control, forward collision warning, brake support and headway alert.



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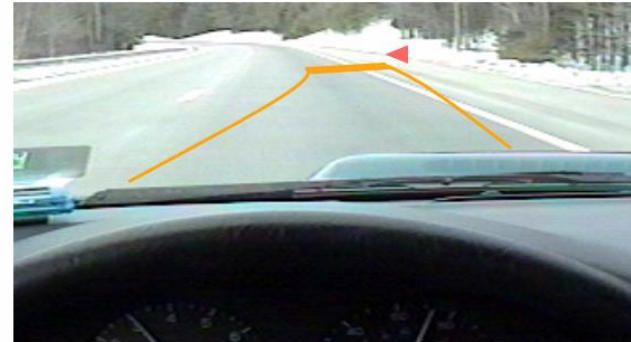
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Augmented Reality in a Vehicle

Navigation



ACC / LDW / HC



NiVi / Pedestrian Marking



NiVi / Lane Marking



Augmented Reality in a Vehicle

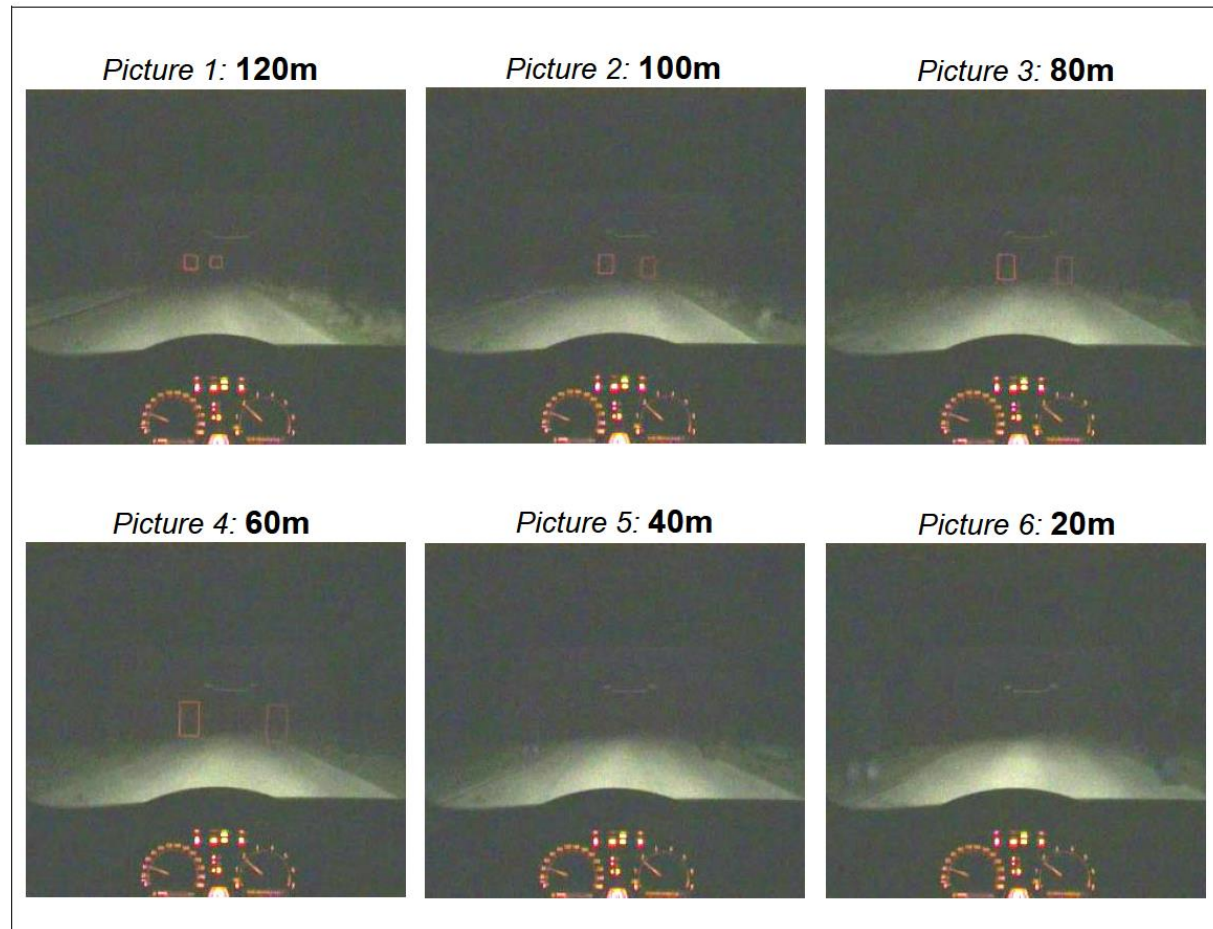


Figure 2: Contact analogue HUD in the experimental vehicle

Experimental vehicle: BMW Series 7



Augmented Reality

Contact-analog Information Representation in an Automotive Head-Up Display

T. Poitschke, M. Ablastmeier, and G. Rigoll*
Institute for Human-Machine Communication
Technische Universität München

S. Bardins, S. Kohlbecher, and E. Schneider†
Center for Sensorimotor Research
Ludwig-Maximilians-University Munich



(a) Guidance advices: taxiway concept.



(b) Concept of traffic sign visualization: stop.



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Augmented Reality – Daimler Benz

'Augmented-reality' windshields and the future of driving



By **Brandon Griggs**, CNN

January 13, 2012 -- Updated 1516 GMT (2316 HKT) | Filed under: **Innovations**



Mercedes showcases a prototype of an augmented reality, gesture-controlled [networking system](#) at CES.



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Augmented Reality – BMW

BMW to Introduce Augmented Reality Heads-Up Displays



OCT 12 • TECHNOLOGY • 66 VIEWS • 0 COMMENTS



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Augmented Reality – BMW



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Augmented Reality – BMW



“With the contact analogue HUD, we place the information at exactly that point in the driver’s field of view where it belongs and is required. The driver no longer has to correlate abstract information to the concrete driving situation. Since the display is directly congruent with the real world, we can also selectively direct the driver’s attention to specific information or hazards, so that he can respond quickly and in an appropriate manner.” (Dr Bernhard Niedermaier, Head of Human-Machine Interaction at BMW Group



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Augmented Reality – BMW



The bigger the display area, the more applications contact analogue display technologies can offer. Looking further ahead, the developers are therefore already aiming to increase the size of the displays as much as possible. In the first prototypes,



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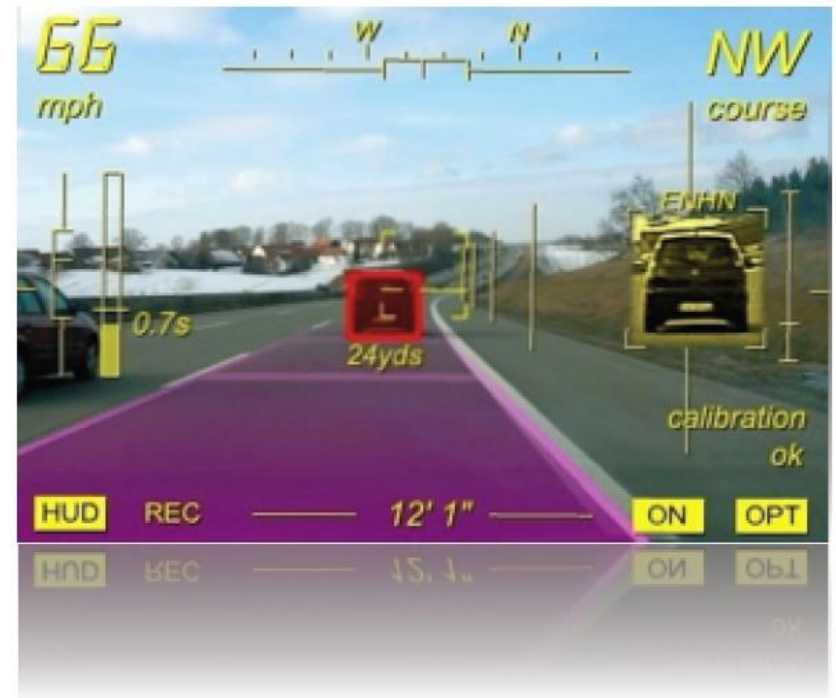
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Augmented Reality – Smart Phone Applications

Augmented Driving 3.0 © by imaGinyze 2010-2012



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Autonomous Vehicles – Google's car



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Autonomous Vehicles – Rarities



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Optical Systems – 3D Ladar

Advances in Tactical Laser Radar

Adam MacDonald
US Air Force Test Pilot School
220 South Wolfe Ave.
Edwards Air Force Base, CA 93524
661-277-2125
adam.macdonald@edwards.af.mil^{1,2}

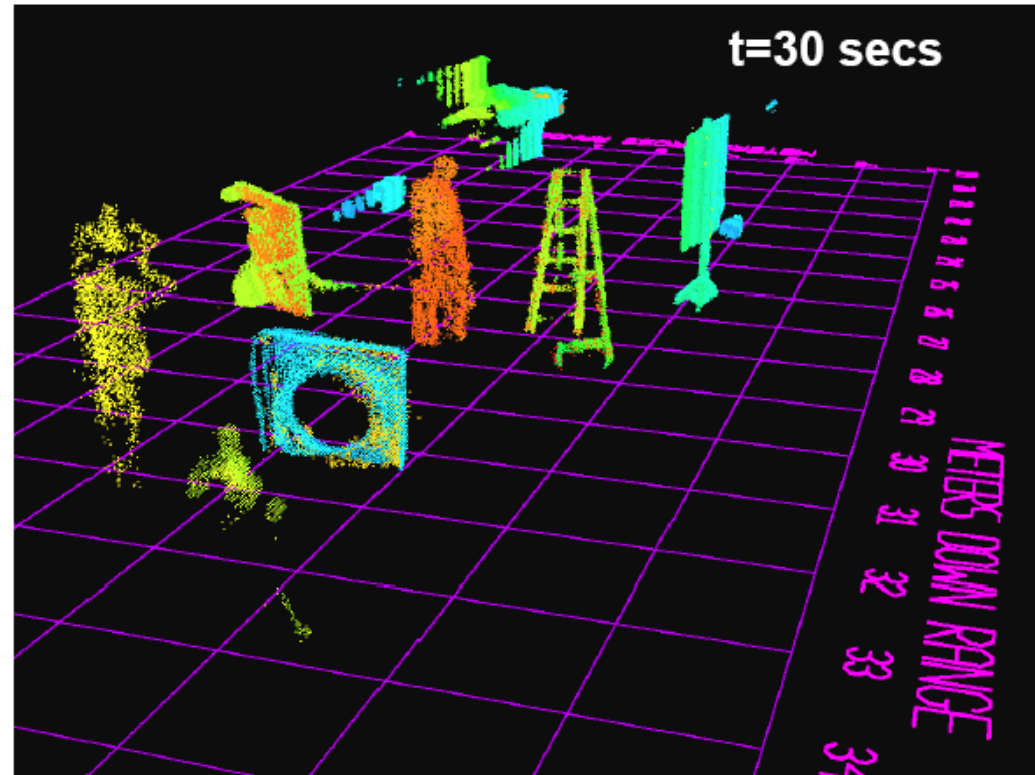


Figure 1 – 3-dimensional point cloud pseudo-color image of various targets arranged at Lincoln Laboratory's Optical System Test Range [21]. The image was assembled in 0.25 seconds after real-time processing of the 4000 images captured after each pulse of a high-PRF laser illuminator.



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Optical Systems – 3D Ladar

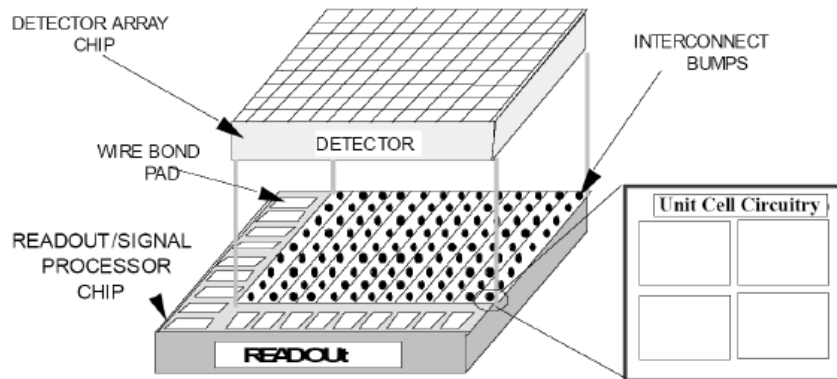


Figure 2 – Bonded avalanche photo-diode (APD) and read-out integrated circuit (ROIC) [10]. The APD detector converts photons to electrons with considerable gain, and timing circuitry on the ROIC provides an output of time-of-arrival and intensity at each pixel.



Figure 3 – Flash Laser Radar (LADAR) manufactured by Advanced Scientific Concepts of Santa Barbara California. The lower portion is a custom-developed 10 milliJoule class 1.54 μm laser illuminator. The actual camera is quite small, located directly behind the optical lens.



Optical Systems – 3D Ladar



128 x 32 Geiger-mode Avalanche Photodiode (GmAPD) Camera

The Princeton Lightwave 128 x 32 Geiger-mode [avalanche photodiode](#) (GmAPD) camera is a turn-key system containing a single-photon imaging sensor designed for three-dimensional laser radar (LADAR) imaging with time-of-flight information captured at every pixel in the array. The GmAPD pixels of this camera provide true [single photon](#) sensitivity in the wavelength range from 920 nm to 1140 nm, including common pulsed laser wavelengths at 1030 nm and 1064 nm.

The sensor engine of the camera is a 50 μm pixel pitch [focal plane array](#) (FPA) consisting of an InP/InGaAsP GmAPD detector array flip-chip bonded to a custom CMOS readout integrated circuit (ROIC). Every pixel contains an independent counter to provide per-pixel timestamps specifying photon detection events with time bin resolution as short as 250 ps. A GaP microlens array is attached to the GmAPD array to provide high fill factor, and the hermetically sealed FPA housing has an integrated twostage thermoelectric cooler to maintain appropriate operating temperatures. The GmAPD camera is supplied as a fully integrated system with a high-performance personal computer supporting an industrystandard data interface, RAID0 solid-state drive storage, and comprehensive GUI-driven control software.



10 cm x 10 cm x 9 cm
(without lens)

128 x 32 Geiger-mode Avalanche Photodiode (GmAPD) Camera



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High End Lidar – Velodyne HDL-64E

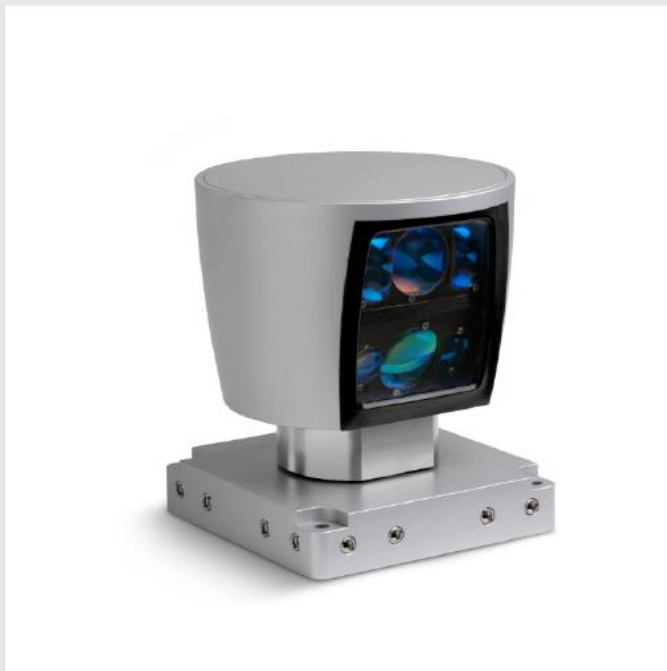


Figure 1: The sensor. The system at the core of LIDAR technology is a sensor called the HDL-64E, that uses 64 spinning lasers and accumulates 1.3 million points per second in order to reconstruct a virtual map of its surroundings. Picture courtesy: Velodyne Inc.



Figure 2: A driverless car. The Spirit of Berlin is an autonomous car based on the HDL-64E sensor, designed by the Artificial Intelligence Group at the Freie Universität Berlin in 2007. Picture courtesy: AutoNOMOS Project.



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Brent Schwarz
LIDAR: Mapping the world in 3D
Nature Photonics (2010) 4, 429-430.

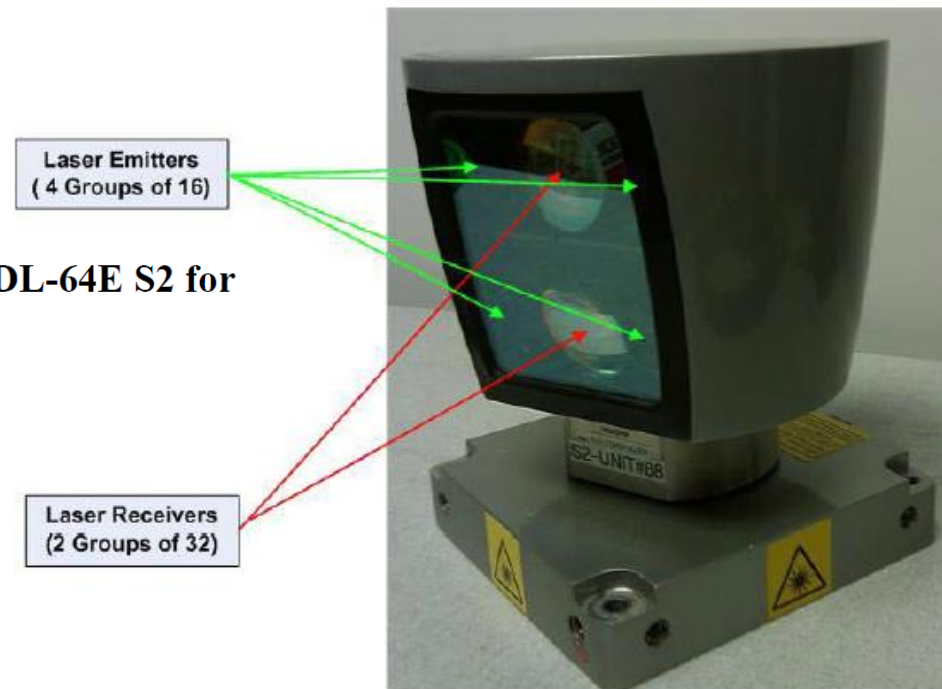


High End Lidar – Velodyne HDL-64E

Table 1. Manufacturer Specifications for the HDL-64E S2 Scanner [2].

Sensor	64 lasers
	360° (azimuth) by 26.8° (vertical) FOV
	range: 50 m (10% reflectivity) 120 m (80%)
	1.5 cm range accuracy (1 sigma)
	0.09° Horizontal Encoder Resolution
Laser	>1.3333 MHz
	Class 1
	905 nm wavelength
	5 nanosecond pulse
	2.0 mrad beam divergence

Figure 1. The Velodyne HDL-64E S2 Scanner.



Static Calibration and Analysis of the Velodyne HDL-64E S2 for High Accuracy Mobile Scanning

Craig Glennie ^{1,*} and Derek D. Lichti ²



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Drowsiness Detection – Attention Assist

Drowsiness-Detection System ATTENTION ASSIST Warns Drivers to Prevent Them Falling Asleep Momentarily

Drivers who do not take regular breaks when driving long distances run a high risk of becoming drowsy – a state which they often fail to recognise early enough according to the experts. Studies show that around one quarter of all serious motorway accidents are attributable to sleepy drivers in need of a rest, meaning that drowsiness causes more road accidents than drink-driving.

ATTENTION ASSIST can warn of inattentiveness and drowsiness in an extended speed range and notify drivers of their current state of fatigue and the driving time since the last break, offers adjustable sensitivity and, if a warning is emitted, indicates nearby service areas in the COMAND navigation system.



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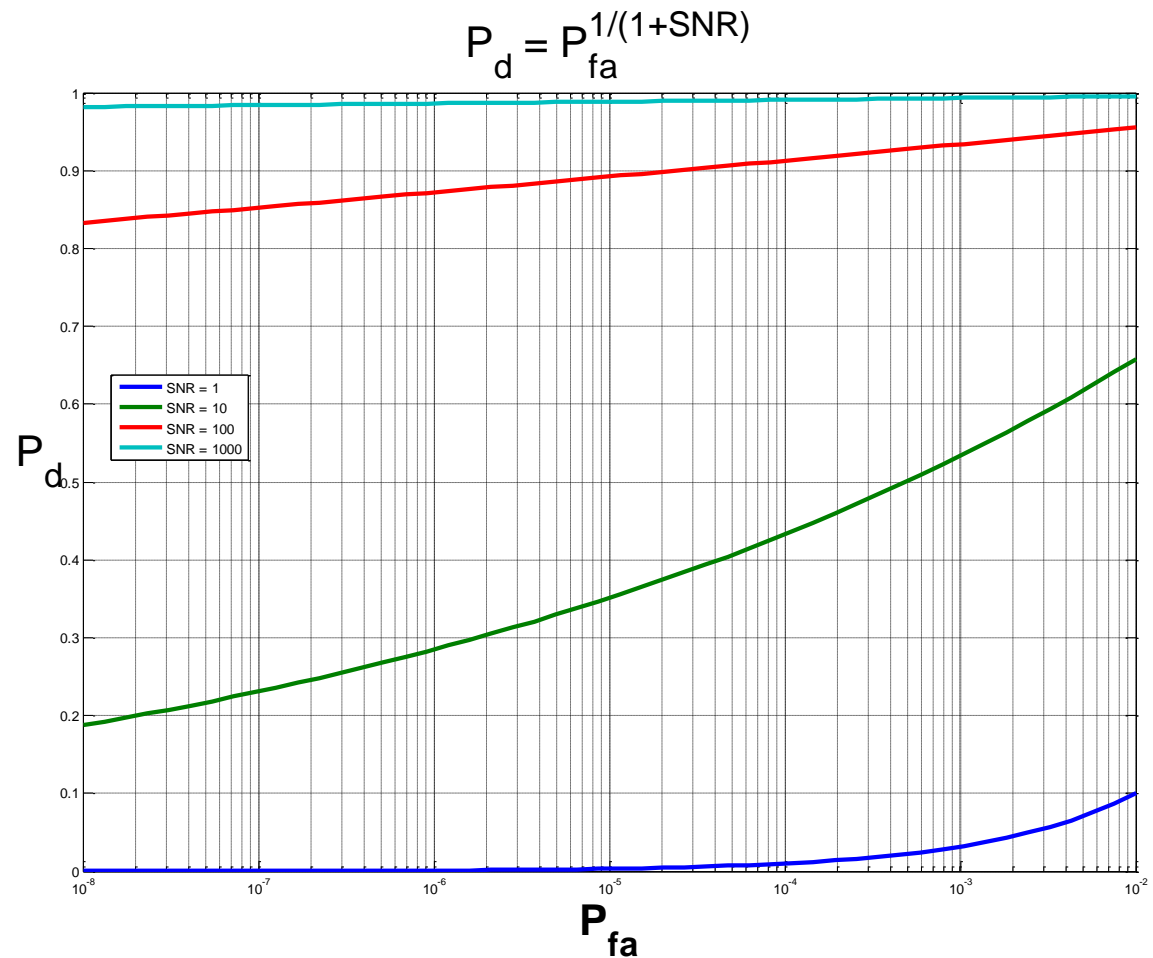
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Drowsiness Detection

Drowsiness detection depends on the SNR of the measured feature.

Many times the threshold is so high that the detection takes place **after** the accident.



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Distracted Driving

WASHINGTON, D.C., – Hands-free technologies might make it easier for motorists to text, talk on the phone, or even use Facebook while they drive, but new findings from the AAA Foundation for Traffic Safety show dangerous mental distractions exist even when drivers keep their hands on the wheel and their eyes on the road. The research found that as mental workload and distractions increase reaction time slows, brain function is compromised, drivers scan the road less and miss visual cues, potentially resulting in drivers not seeing items right in front of them including stop signs and pedestrians. This is the most comprehensive study of its kind to look at the mental distraction of drivers and arms AAA with evidence to appeal to the public to not use these voice-to-text features while their vehicle is in motion.



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Distracted Driving

Attractive Women Cause Men To Lose Focus The Huffington Post

Have you ever told your husband to keep his eyes on the road? Well, there may be a reason he's often distracted while driving.

A survey of 11,211 drivers aged 50 and older for Saga Car Insurance in Britain found that two thirds of men admitted losing their focus in the past year while driving -- with one fourth naming attractive women as the main reason.

At the same time, women are twice as good at concentrating on the road, with only 1 percent of women saying they've done a double-take from behind the wheel after spotting an attractive man.



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Military Radars – Elta



Iron Dome



FLIR



Green Pine



Tactical Radar



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Military Systems – Elbit HUD

Round-the-Clock Mission Solution

ANVIS/HUD®24 offers round-the-clock mission solution with advanced day and night display capabilities. Both the day and night displays operate as a single integrated system. The night display is mounted on the NVG and the day display is mounted on the same NVG helmet mount, offering a seamless solution for day and night operations.

Enhanced safety and situational awareness

ANVIS/HUD®24 improves flight safety and situational awareness by reducing the pilot's head and eye motion for cockpit scanning. Complicated maneuvers in bad weather and low visibility conditions, low altitudes (NoE) or during night can be performed safely with enhanced survivability. Customizable display symbols With independent displays for each pilot displaying critical flight information and multiple symbols related to the specific mission, the ANVIS/HUD®24 offers a customizable solution that is compatible to the cockpit's instrumentation and displays.



ANVIS/HUD®24 New-Generation Day/Night HUD System



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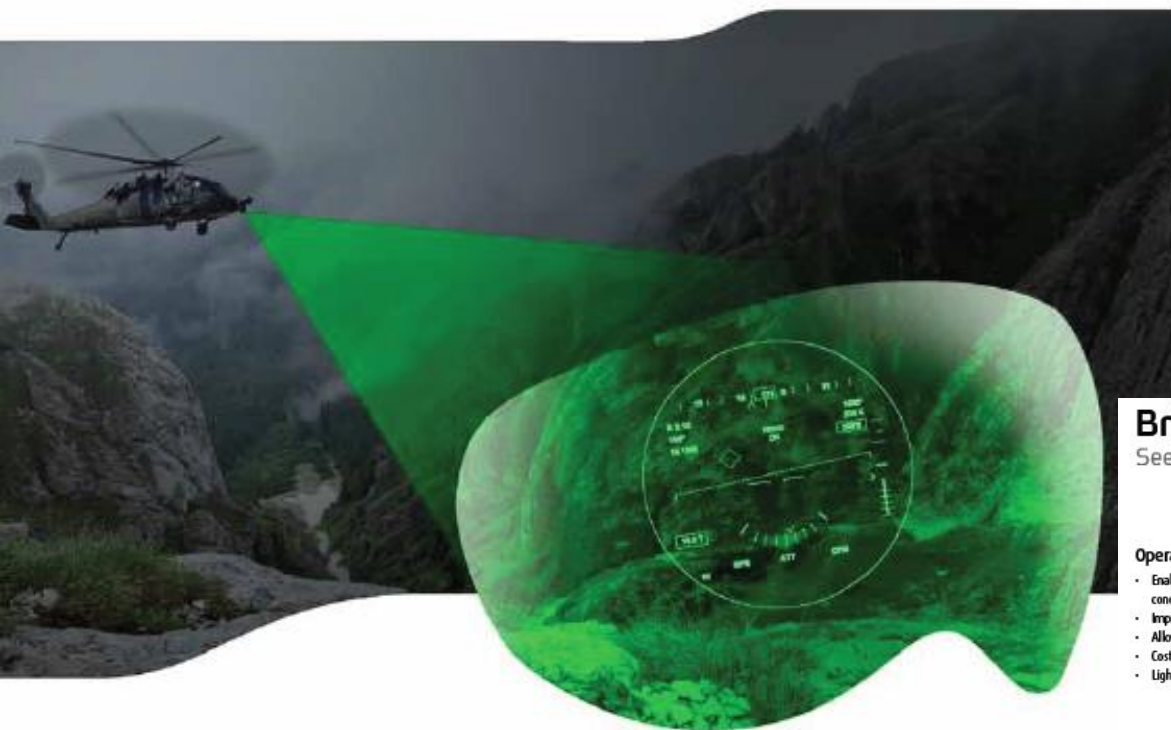
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Brightnite™

See what you have been missing



Brightnite™

See what you have been missing

Operational Benefits

- Enables aircraft operations in all night & low-visibility conditions
- Improves mission effectiveness and flight safety
- Allows pilots to fly in a head-up, eyes-out position
- Cost effective
- Lightweight and compact system

Key Features

- Degraded Visual Environment (DVE) capabilities
- Serves multiple users simultaneously
- Includes ultra-wide FOV - 220°/ 90°
- Zero latency display
- Incorporates 3D symbology
- Provides high-resolution 3D images
- Completely upgradable
- Integrates with existing helmets



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JEDEYE® HMD



Brightnite™ Sensor



ANVIS/HUD*24T



Trophy Active Protection System – Rafael



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Trophy Active Protection System – Rafael

Trophy Active Protection System



The Trophy active protection system creates a hemispheric protected zone around the vehicle where incoming threats are intercepted and defeated. It has three elements providing – Threat Detection and Tracking, Launching and Intercept functions. The Threat Detection and Warning subsystem consists of several sensors, including flat-panel radars, placed at strategic locations around the protected vehicle, to provide full hemispherical coverage. Once an incoming threat is detected identified and verified, the Countermeasure Assembly is opened, the countermeasure device is positioned in the direction where it can effectively intercept the threat. Then, it is launched automatically into a ballistic trajectory to intercept the incoming threat at a relatively long distance.



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Defense vs. Automotive Industries

Defense	Automotive (Tier 1)
100 M€ --1,000 M€ Projects	10 M€ Projects
Highly qualified development engineers and scientists	Better Paid
100 – 1000 units	100 – 1000 kunits
Low probability of malfunction	Negligible probability of malfunction
Highly complex scenarios	Extremely high complex scenarios
...	...



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Additional Resources

Highway Loss Data Institute:

- Bulletin Vol. 29, No. 5 : April 2012: “Volvo collision avoidance features: initial results”.
- Bulletin Vol. 29, No. 7 : April 2012: “Mercedes-Benz collision avoidance features: initial results”.

“Future Evolution of Advanced Driver Assistance Systems in Europe”. Nick Ford, FROST & SULLIVAN (2008).

“Advanced Driver Assistance Systems -- Past, Present and Future”, Adnan Shaout, Dominic Colella, S. Awad.

SBD Telematics and ITS research, “Latest market status and future trends in ADAS technology”.

“79 GHz High Resolution Short Range Automotive Radar Evolution”, Davide Brizzolara
ERTICO - ITS Europe, Belgium. MICROWAVE JOURNAL , SEPTEMBER 2013.

“Contact-analog Information Representation in an Automotive Head-Up Display”, T. Poitschke
et al.



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Additional Resources

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