European Commission
Information Society and Media

ADOSE

Reliable Application specific Detection of road users with vehicle On-board Sensors

NEWS ! The third Review Meeting of the ADOSE project will take place on 3rd of May 2011 at EC in Brussels. The development phase of the addressed ADOSE sensors (MFOS sensor, FIR imager, 3D camera, harmonic radar and tags, SRS sensor) has been almost completed and the project has fully achieved its objectives and technical goals for the relevant period. Testing of sensor prototypes is in progress.

AT A GLANCE

Project:
Reliable application specific detection of road users with vehicle on-board sensors (ADOSE).

Project coordinator:
1. Centro Ricerche Fiat (IT)

Partners:
2. Robert Bosch (DE)
3. Magneti Marelli (IT)
4. STMicroelectronics (IT)
5. Triad AS (NO)
6. Umicore sa/nv (BE)
7. Paragon S.A. (GR)
8. IMEC (BE)
9. VTT (FI)
10. Austrian Institute of Technology (AT)
11. IZM (DE)
12. Uppsala Universitet (SE)

Duration: 45 months

Programme: ICT Challenge 6: Mobility, environmental sustainability & energy efficiency

Website: www.adose-eu.org

Contact details:
Pallaro Nereo (Project Coordinator)
Centro Ricerche Fiat S.C.p.A.
Email: nereo.pallaro@crf.it

Irmgard Heiber (Project Officer)
European Commission, DG INFSO, Unit G4

OVERVIEW

ADOSE is a Collaborative Project (STREP), started in January 2008 and co-funded by the European Commission Information Society and Media in the strategic objective "ICT for Intelligent Vehicles and Mobility Services".
The goal is the development of high performance and low cost sensing technologies, suitable for preventive and active safety systems.
Novel concepts and sensory systems will be developed based on Far Infrared cameras, CMOS imagers, 3D packaging technologies, ranging techniques, bio-inspired silicon retina sensors, harmonic microwave radar and tags.

CHALLENGES

ADOSE addresses research challenges in the area of accident prevention through improved-sensing technologies and sensor fusion. The focus is on functional, performance and cost limits of current sensors and Advanced Driver Assistance Systems for their extensive market penetration.
ADOSE has been set up in the context of the "European Technology Platform on Smart Systems Integration" (EPoSS) and it aims at being a product driven project by the development and integration of Smart Systems

and Technologies for Preventive and Active Safety.
The goal is the enhancement of safety functions through the development of high performance and low cost sensing technologies suitable for reliable detection and classification of obstacles and vulnerable road users in hostile environments. ADOSE is focused mainly on sensing elements and their pre-processing hardware, as a complementary project to system oriented projects (e.g. PReVENT).

PROJECT OBJECTIVES

Specific objectives

ADOSE addresses five breakthrough sensing technologies, with the goal to improve the current state-of-the-art in terms of costs, performance and reliability:

- IR-add-on sensor (FIR), with sufficiently good thermal & spatial resolution at lower cost, to be combined to a high resolution imager for enhanced night vision applications to enable a more reliable obstacle detection and classification.

- Low-cost multi-functional and multi-spectral CMOS vision sensor (MFOS), detecting critical environmental parameters (fog, rain, …) and providing, at the same time, information on the driving scenario (oncoming vehicles, VRUs in night conditions, …).

- High spatial resolution and low-cost 3D range camera (3DCAM), by the integration of 3D packaging, optical CMOS and laser radar technologies for short range ADAS requirements (high-speed object recognition and distance measurement, e.g. for Pre-crash).

- Harmonic radar combined to passive nonlinear reflector and active tags (HR-PTAG and HR-ATAG), enabling easy detection of traffic obstacles and vulnerable road users, and their identification, even in dark or adverse weather conditions.

- High temporal resolution and low-cost bio-inspired silicon retina stereo sensor, addressing time critical decision applications (SRS).

ADOSE will have impact on the "virtual safety belt" around the vehicle by offering different sensing technologies for a set of complementary safety functions.

Only 'technology-dependent' pre-processing algorithms will be developed for each sensor: (a) algorithms implemented into the sensor hardware; (b) algorithms on raw data, coming from the sensor hardware, implemented on a PC-based processing hardware, strictly related to the sensing technology and its demonstration. Algorithm developments will not be extended to Sensor Data Fusion.

Demonstration will be limited to functional sensor prototypes installed on concept cars without integrating the complete safety system.

Major final achievements

Five sensor module prototypes will be designed, fabricated and tested:

- FIR camera (FIR)
- Multifunctional CMOS vision sensor (MFOS)
- 3D range camera and eye-safety illuminator (3DCAM)
- Harmonic radar with passive and active tags (HR P-TAG, HR A-TAG)
- Silicon retina stereo sensor (SRS)

Technology-dependent pre-processing algorithms will be developed for each sensory system.

Two demonstrator vehicles will be set-up integrating two groups of sensors: (a) MFOS sensor, FIR and 3DCAM cameras; (b) SRS sensor and harmonic radar.

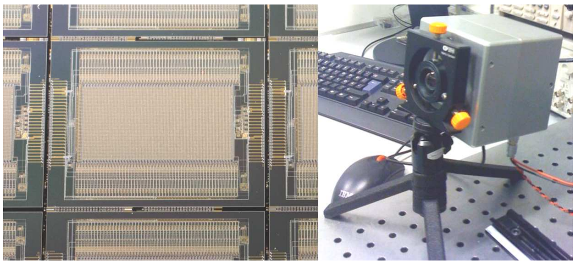
PROJECT ACTIVITIES

Work performed in the third year

<u>FIR imager (WP2, BOSCH)</u>

After verification of a new, low-cost FIR imager process and a first camera demonstration in the previous period, the FIR imager activities focussed on manufacturing the final integrated FIR array devices targeting the ADOSE specifications for an automotive night vision add-on sensor for hot-spot detection and combination with a NIR CMOS camera. The FIR chip uses micromechanically suspended and thermally insulated multiple thermo-diodes, manufactured simultaneously with the read-out IC. Mono-crystalline silicon as sensor material enables batch wafer-level vacuum packaging.
The signal processing of the FIR array with 100x50 active pixels is performed by parallel integration of all columns for the addressed row, followed by a sample & hold and multiplexing stage for serialized signal output

through a common gain stage after a dynamical offset correction.
The technological work was dedicated to process parameter optimization, wafer processing, test and characterization methods both on wafer-level and on the final FIR-chip setups.
A chip-on-board attachment concept, identified previously for low thermal gradients at low mechanical stress, was tested for bonding the FIR device directly on the camera electronics PCB.
Two versions of FIR optics with different apertures have been manufactured. A FPGA-based firmware for chip timing, offset correction and PC interfacing has been developed for the camera setup as well as a graphical PC user interface for FIR image assessment and chip performance testing.



ADOSE FIR imager chip and camera demonstrator setup

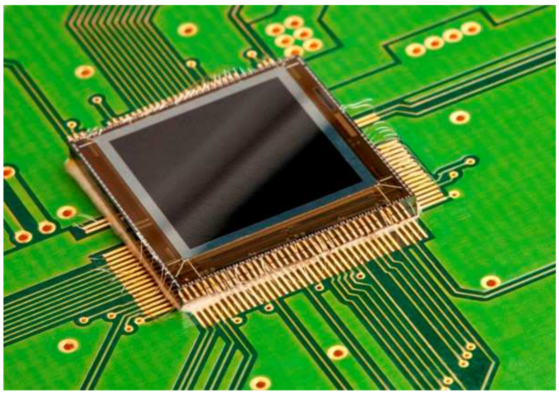
Multifunctional optical sensor (WP3, CRF)

Two MFOS sensor prototypes, enabling different functional integration, have been assembled and tested. The optical components (plastic lenses, lightguides, optical objective) and the IR illuminators have been characterised. Particularly, measurements were carried out to verify the optical channel efficiencies and the focusing properties of the lightguides. Since a main goal of the ADOSE project is the achievement of low cost sensors, the MFOS easy-to-assemble process has been evaluated with respect to the position tolerances between the imager and the optical lightguides affecting the performance reliability. The sensors were also tested at functional level in lab. Twilight and fog functionalities were evaluated by electro-optical measurements. Finally, the housing of one prototype sensor has been designed and fabricated and the sensor has been installed in the internal rear view mirror. Preliminary outdoor tests were performed on the twilight, tunnel/bridge and warning night vision functions.

MFOS sensor prototype integrated in the internal rearview mirror

3D range camera (WP4, IMEC)

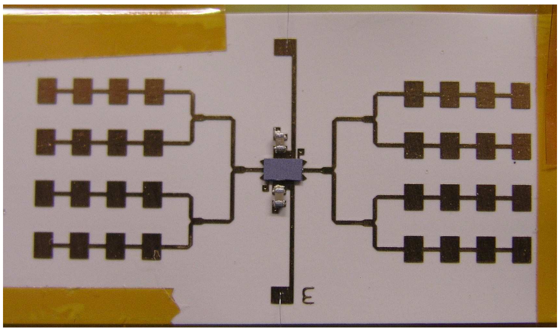
The different 3D imaging methods have been analysed and simulated. As outcome, the development of a range-imaging hybrid camera concept has started. The camera will consist of a photosensor and its corresponding readout electronics. These two components are hybridized using existing IMEC capabilities for wafer processing and flip-chip technology.
The photosensor uses back-side illuminated (BSI) technology to increase the quantum efficiency and the fill factor of the detector elements. The photosensor has been designed and fabricated at imec's facilities.
The readout electronics have been designed to be able to implement different range measurement methods in order to find the optimum one. It is currently being fabricated at a commercial CMOS foundry.
The system controlling the camera has been designed and fabricated and is currently under test. It comprises an FPGA implementing the control of the camera and the communication with the ADOSE central control system and software. It also contains the necessary power supply, bias and clocking sources.



Back-side illuminated imager mounted on a PCB

Harmonic radar and tags (WP5, VTT)

The radar relies on intermodulation principle, which provides smaller frequency offset as compared to the traditional harmonic radar. The radar prototype, which is being developed, transmits two nearby signals at the 77 GHz band allocated for automotive radars. Harmonic reflectors, or tags have a nonlinear components that create an intermodulation response at a nearby frequency. Because nonlinear reflections are rare in nature, tags can be easily identified from the radar reflection. If the tag is carried by a vulnerable road user, he/she can be detected even in dark or fog. Several nonlinear elements have been studied: Schottky diodes, ferroelectric varactors and MEMS resonators. For longer detection range, semipassive or active tags can be used. In these designs, a switch or an amplifier is switched on and off to achieve modulated backscattering. Tag antennas are developed on a flexible substrate, to make tag integration to textiles and curved surfaces easier. In the fourth year of the ADOSE project, the radar will be completed and it will be tested and demonstrated with the tags.

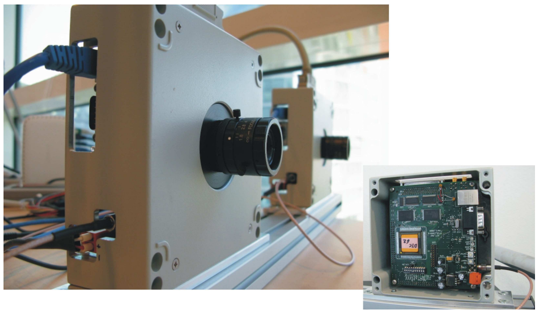


Active non-linear radar reflector.

Silicon retina stereo sensor (WP6, AIT)

The "silicon retina" sensor technology is based on bio-inspired analogue circuits that pre-process the visual information on-chip in parallel for each pixel. These optical sensors provide excellent temporal resolution, a wide dynamic range and have low power consumption.
Typical applications include vision systems for roadside traffic data acquisition, real-time stereo vision systems for reliable person counting and in ADOSE as high-speed and low-cost ranging sensors for time-critical decision making functions. In a first step the automotive requirements for such a sensor system were collected, and the technical specifications were determined. In ADOSE the stereo high resolution (304x240 Pixel) SRSS will be used as a pre-crash sensor for side-impact airbags control.

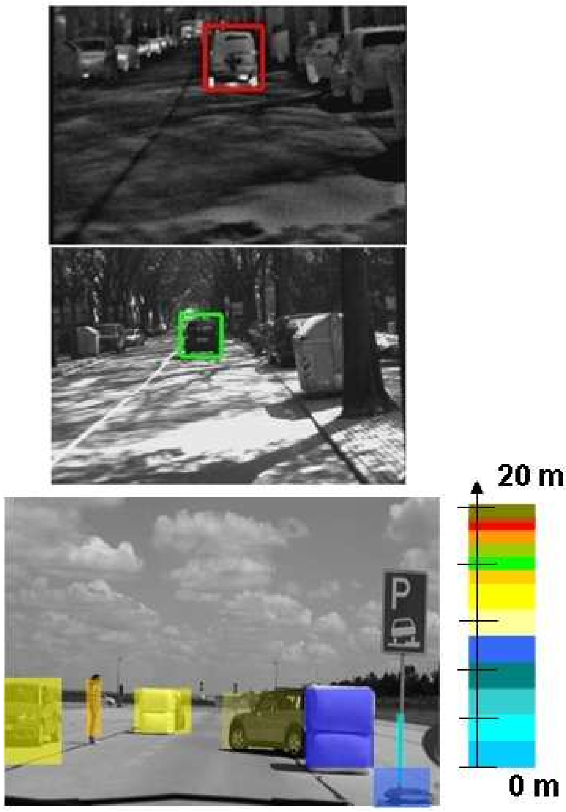
Novel algorithms based on locality and timely correlation of asynchronous data streams have developed in order to fully exploit the advantages of the silicon retina technology for safety-critical automotive applications.



High resolution SR Stereo sensor demonstrator.

Data processing and functional system integration (WP6, MM)

The ADOSE sensor specifications (related to the communication bus, protocol and data format), the software architectures to be developed within the project and the test plans have been defined in D6.2 deliverable report.
Preliminary algorithms for pre-processing of raw data have been defined in deliverable D6.5 in terms of high level (flow chart) and low level (pseudo-code) design.



FIR/NIR/3DCAM output examples.

The development of such algorithms (based on features extraction, timing and spatial common reference between FIR and NIR sensors) has been completed with real data for MFOS and NIR sensors (tuning phase is ongoing).
Application oriented algorithm (AdaBoost) for vehicle classification has been defined and developed. Such algorithm needs a training phase that is ongoing.
Test (indoor, outdoor, static and dynamic) procedures, test cases, and dynamic laser testing technology have been defined. Test execution has been started with indoor and outdoor static tests. Software for integration of dynamic testing technology is under development.

Dissemination and exploitation (WP8, CRF)

The ADOSE web site (http://www.adose-eu.org/) was established in 2008 and the maintenance phase is ongoing. A public area for dissemination purposes and a private area for file recording and sharing are available.
A *News&Events* section includes all related major events in a standardized, very concise format with text and associated picture or logo.
The project dissemination continued at several national and international events, conferences, workshops and seminars. The basic dissemination documents can be downloaded from the website: project logo, factsheet, presentation, leaflet, etc.
A multi-annual dissemination roadmap and plan is included in D8.3c deliverable report focused on *Dissemination and Use Plan*.

Homepage of ADOSE website

Main results in the third year

The main project results* relevant to the third year are as follows:

- Hardware components for FIR-camera (D2.4, P+R, CO)
- Packaging concept for FIR camera subsystem (D2.5, R, CO)
- FIR-camera module with electronics and interface (D2.6, D+R, CO+**PU**) – *Draft version*
- Prototype of multifunctional imager (D3.8, P+R, CO+**PU**)
- Prototype of multifunctional imager - Planar lightguide (D3.10, P+R, CO+**PU**)
- Detailed Design report for 3D ranging camera detector (D4.3, R, CO).
- Advanced prototypes of radar system and tags (D5.6, R, CO)
- Definition of sensor specifications, software architecture and test plans (D6.2, R, **PU**)
- Preliminary algorithms for pre-processing of raw data (D6.5, R, CO)
- Demonstrator of silicon retina stereo sensor (D6.7, D+R, CO+**PU**)
- Dissemination and use plan (D8.3c, R, **PU**)

Public deliverables can be downloaded at the following link:
http://www.adose-eu.org/result.html

***** Codes about nature of the deliverable and dissemination level:

R=Report, **P**=Prototype, **D**=Demonstrator, **O**=Other

PU=Public, **CO**=Confidential, only for members of the consortium (including the Commission Services).