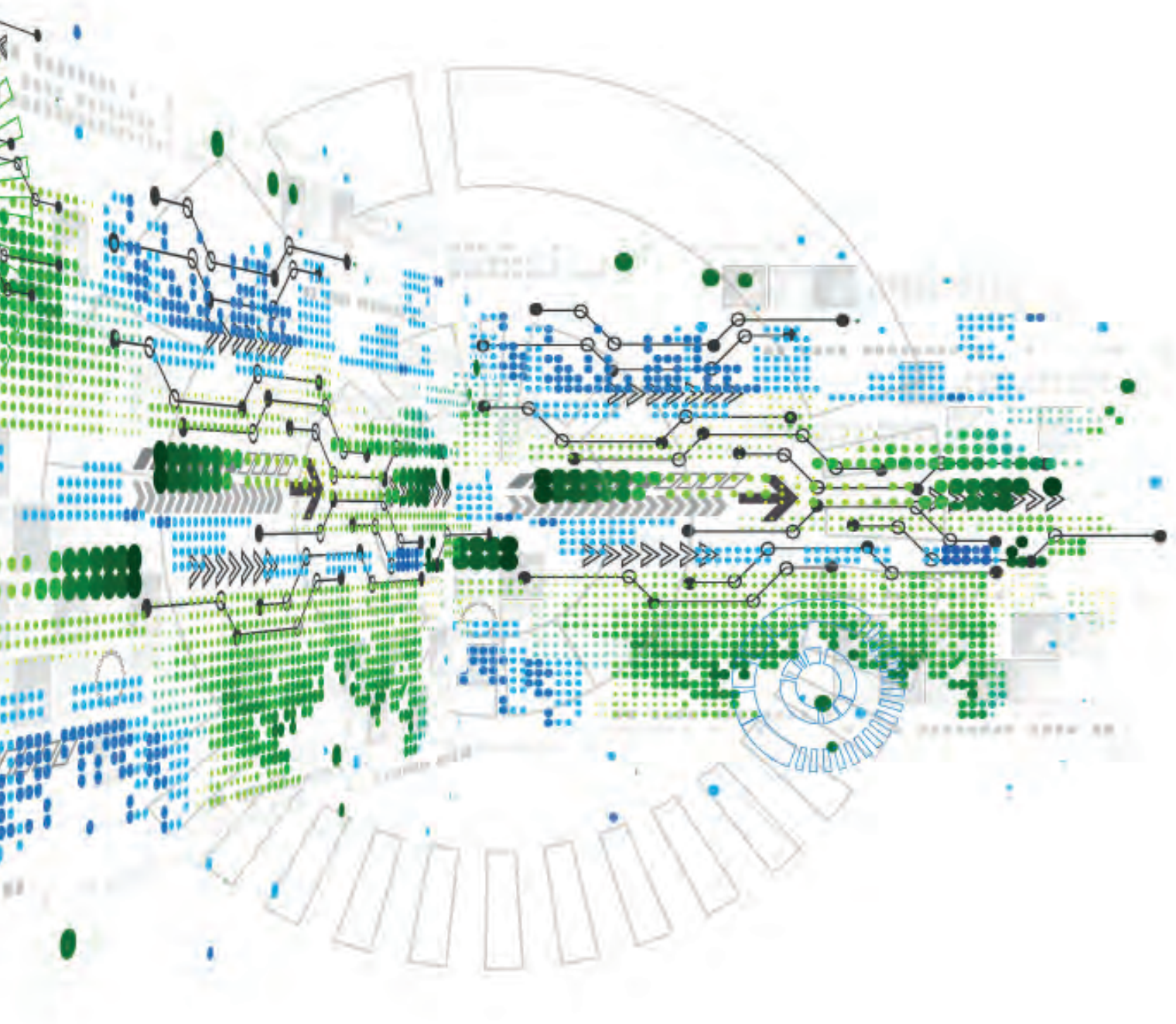
DRIVING DIGITAL INNOVATION

Project Profiles, Technology and Impact



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FOREWORD

PETER **CONNOCK**

Penta Director

In Europe, and indeed worldwide, Public funding support has long played a pivotal role in the development of advanced technology. It provides an important incentive that catalyses industrial activity in areas that are important to the economic and societal development of countries. International collaborative research and development is a powerful mechanism through which public support can be leveraged to gain maximum return on investment for both the industrial and public communities.

For over 35 years Eureka, an inter-governmental organisation of 45 countries, has stimulated technology development and innovation through a wide range of transnational collaborative programmes.

Now, and in the future, the digital transformation of our economy and services is a central requirement for international competitiveness, as well as addressing vital societal challenges. Increasingly, technology will be essential for addressing the global sustainability crisis now being faced by us all. Significant innovation will be required to ensure the efficient use of limited resources and the introduction of disruptive capabilities to address environmental and climate targets, while retaining economic growth and quality of life.

Almost no area of economic and social activity will be unaffected by the necessary changes that must be implemented to allow sustainable economic growth, while at the same time addressing the critical needs of the individual citizen. Digital Health, Precision Farming, Future Mobility, Smart Cities, Zero Carbon Energy are just a few applications that are being transformed though digital innovation. These applications are enabled by core technology development, supported by required capabilities in design, security, connectivity and manufacturing.

At the heart of digital transformation is the technology and related applications enabled by micro- and nanoelectronics. Penta, a Eureka Cluster, is the latest instrument designed to stimulate international collaborative research, development and innovation in the Electronic Components & Systems community. Penta was formed in 2015 to provide a specific support capability to address the huge

FOREWORD

challenges created by the rapid development of the global digital economy. Penta is a programme that is open to all elements of the Electronic Components & Systems Community: Large Enterprise, SME's, Research & Technology Organisations and Academic Institutions. It is a flexible, easy to use, nationally supported, funding instrument; stimulating collaborative innovation that is aligned to industrial and funding country priorities. The success of this approach is illustrated by high levels of SME participation at around 38% participation in projects.

Penta has now completed its 6th, and final, call for projects with applications over the lifetime of the programme exceeding €1bn. So far, this has resulted in 27 funded projects addressing a widely diverse range of technology and applications. For the last 3 Calls, Penta has been in a very successful partnership with Euripides, also serving the Electronic Components & Systems community. This has broadened opportunity for both industrial participants and public investors, as well as helping to simplify the funding landscape.

This brochure is designed to give a flavour of the extraordinary range of applications that have been addressed during these 3-year projects, and the significant advances in technology that have been made. Through a combination of written and Video material you will discover both the advances that have been made and the enthusiasm of the project leaders and teams that enabled them. Projects from earlier calls continue to reach their conclusion, and the impact that they make will be added to this portfolio of information.

I hope that you, either as a public investor, project participant or potential project partner appreciate this celebration of effort and achievement – highlighting what can be achieved through the close public-private partnership that Penta has been able to support.

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CosmoDU

16027

Direct integration of latest SiC power and IT electronics expected to produce unprecedented performance gains in smart drives

[CosmoDU]

As machines (such as robots or conveyor-belt systems) become more intelligent, electric drives – the most active parts of these machines – will also need to evolve in intelligence. To achieve this, the CosmoDU project (its name is derived from 'compact, highly smart, modular drive-control-unit, directly integrated in electric motors') will deliver the hardware platform of next-generation drive units for production machines. Notably, sensors, signal processing, secure communication and control and power electronics will be directly integrated in the housing of the motor, and this new drive unit will use its self-learning capabilities to adjust and improve its performance (at application-level) in the field.

The evolution of machines, from closed-loop-controlled to truly self-deciding automates, will require electric drives, the most active parts of these machines, to actively adjust their own key operational parameters (such as speed, direction and power) according to the local situation. This will be based on their cognitive abilities, like self-learning and condition monitoring, whereby they gain and apply their own experience, as well as information from similar systems. Smart motors can also easily form a comprehensive system of connected drives as they have bi-directional communication channels and are connected to the infrastructure through Wi-Fi and cable.

Of course, these next-generation devices do not exist yet. However, they are the future and we need to prepare for, and assist with, their arrival. They are essential for a wide variety of applications and should therefore be available on the market. Most importantly, these applications include fabrication processes, which need high flexibility in order to reach the mass-production efficiency envisaged in Industry 4.0.

Hardware platform for next-generation electric motors

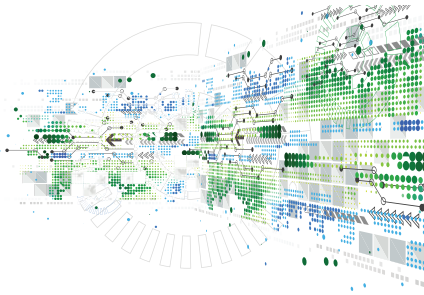
The CosmoDU project will develop and deliver the hardware platform for next-generation drive units required by fabrication machines, like intelligent industrial robots and conveyor belts. It will integrate – directly in the motor housing – sensors, signal processing, secure communication and control electronics (for comprehensive performance control and health monitoring), as well as the power and driver stages. Smart drives will have self-learning capabilities for adjusting and improving their performance at application level (such as the robot) in the field. A comprehensive system of sensors will also identify the actual needs of the drives, as reflected in their maintenance and safety status.

The project will first develop a modular hardware architecture for the integration of all sensors, microelectronics and power modules directly into the housing of an industrial synchronous motor-drive for conveyor belts or industrial robots as target applications. Based on this architecture, component development, module and system integration, as well as demonstrator development and validation testing, will be conducted.

The key technological features include:

- On the information technology (IT) side, highly dense, yet reliable, heterogeneous integration of MEMS, sensors, security, electronics and antenna structures using system-in-package (SiP) and 3D stacking technologies;
- On the power electronics side, wide-bandgap (WBG) devices, a direct combination of driver and power stages, as well as advanced cooling techniques;
- Developing a novel 3D multi-layer-planar integration technology for adding all sensors and signal processing;
- Communication interfaces for active health-monitoring of the power sub-module;
- The direct combination of the latest technologies from both fields – 1200V SiC (silicon carbide) power-electronics, and best-in-class IT electronics operating µV signals. This is the basis for an unprecedented gain in drive performance.

This project brings together 14 partners – three large companies, eight small and medium-sized enterprises (SMEs) and three research institutes or universities – from Germany and the Netherlands. This well-balanced consortium covers the whole value-chain: from investigating, designing and developing the new processes and equipment; to manufacturing the future smart motors; and finally to their end-use.



KEY APPLICATION AREAS

- Transport & Smart Mobility
- Health & Well-Being
- Energy
- Digital Industry
- Digital Life

ESSENTIAL CAPABILITIES

- Systems and Components Architecture, Design & Integration
- Connectivity & Interoperability
- Safety, Security & Reliability
- Computing & Storage
- ECS Process Technology, Equipment, Materials & Manufacturing

PARTNERS

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COUNTRIES INVOLVED

- Germany
- The Netherlands

PROJECT LEADER

Dr. Kai Kriegel Siemens AG

KEY PROJECT DATES

01 Mai 2017 - 30 April 2020

Project challenges, standards and European leadership

Together with functional performance, CosmoDU will also address new challenges of electro-magnetic compliance (EMC), thermo-electro-mechanical reliability, functional safety and system availability that specifically arise from an ultra-compact design. It will also develop proof-of-concept software for a functional demonstrator drive. Furthermore, project partners will make efficient and effective use of resources by focusing on their particular skills and specialisms: SMEs will be pilot investigators, employing their specific competencies (thus providing them with needed visibility and market acceptance to grow their business significantly); larger industrial firms will use their market knowledge and contacts; while research institutions provide their methodology-research findings.

CosmoDU's novel approach towards integration and self-learning will set the trend for next-generation industrial electric-drives. Its core advantages of flexibility, connectivity and system availability will ensure that the vision behind Industry 4.0 is realised. This project will also act as a template for similar efforts in neighbouring domains, such as electric-mobility, smart energy, and smart infrastructure. Furthermore, its aim to standardise key elements of the architecture, interfaces, and protocols will contribute substantially to strengthening the technological leadership position of the project partners, and of Europe as a whole.

Employment, financial and societal benefits

The self-learning feature will also provide flexibility and increase product quality. This will maintain – and even increase – European manufacturing jobs. While CosmoDU specifically focuses on next-generation electrical drives (for industrial robots or conveyor belts, for instance), this 'template' can easily be adopted and adapted subsequently by other industries and application areas. Tool machines, automated driving and full-scale electro-mobility can produce significant financial benefits, as can smart energy and smart infrastructure. What is more, societal needs for carbon-free and ultra-safe individual mobility and living are also addressed, as are those for resource-efficient production.

Healthy market outlook

According to IHS, industrial drives (including those used in pumps, fans, compressors and the like) have the highest market-share in terms of IGBT (insulated-gate bipolar transistor) applications. Here, huge potential savings with factory automation are possible by using variable-speed drives, where some 10% of worldwide electricity-consumption could be saved. Furthermore, combining the trend in factory automation towards Industry 4.0, with the large savings achievable by improved drives, industrial electric-drives seem most attractive, particularly when deployed in industrial robots. And basic economic numbers support this: the total market for 400-1200V powertrains relevant to industrial drives is about US$ 25 billion, compared with an annual growth of more than 10% for drives using conventional technology. With integrated power and IT technology, the market share of these ultra-intelligent integrated powertrains will grow even faster than the market itself. Therefore, the prospects for high return-of-investment (RoI) are good. However, while we see a large market potential, this integration still needs extensive research into such typical areas as feasibility and yield.

Work done on the CosmoDU project can also benefit directly from another strong trend: according to IHS, the number of internet-connected things will grow to 50 billion units by 2025, with the most dominant growth in industrial applications. The technological basis and drivers for this growth will come from smart sensors capable of detecting changes and anomalies in vibration, sound, temperature, humidity, pressure and other physical properties. IHS estimates that the revenue from semiconductor-based sensors alone will grow from US$8.9 billion in 2014, to more than US$10.6 billion by 2017.The future looks bright for CosmoDU.

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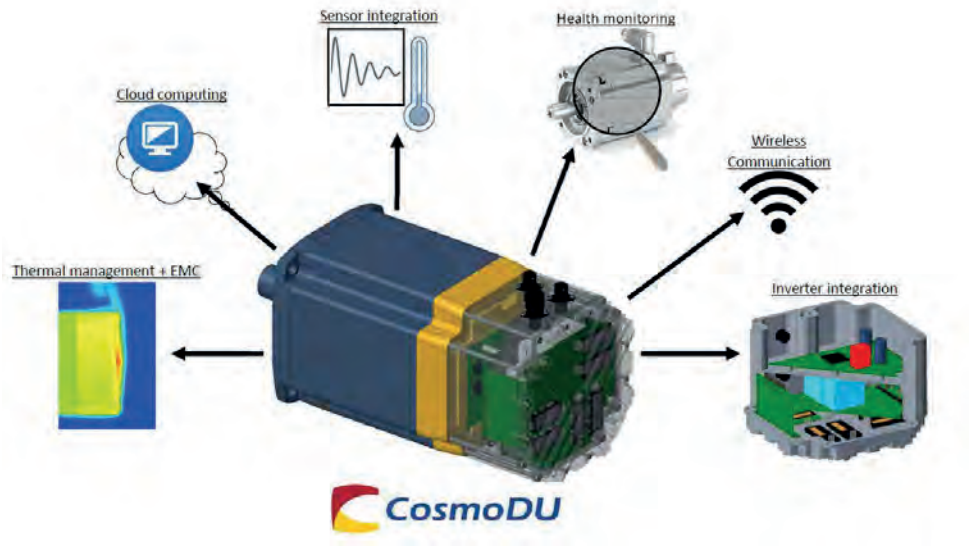
Penta (E! 9911), is EUREKA Cluster whose purpose is to catalyse research, development and innovation in areas of micro and nanoelectronics enabled systems and applications.

CosmoDU

CosmoDU: bringing intelligence to electric drives for Industry 4.0 manufacturing

A project within the EUREKA PENTA programme

Paris, September 27, 2018 – CosmoDU, a EUREKA PENTA cluster project managed by AENEAS, is bringing intelligence to the electric drives that control production machines such as industrial robots or conveyor belts. The project aims to create the first hardware platform able to implement self-learning capabilities within applications, allowing them to adjust and improve the performance of the applications during operation and to ensure timely preventive maintenance.



These smart intelligent electric drives will be key enablers for Industry 4.0. They will increase manufacturing flexibility and even have the ability to learn from identical units located elsewhere via secure communication links. Moreover they will maximise system availability by eliminating downtime due to unexpected servicing needs. Hence, CosmoDU will not only strengthen the technological leadership of the 14 partners involved, but also support European manufacturing and create new jobs through competitive, smart and highly flexible industrial production.

Highly market-focused, CosmoDU will help deliver mass production efficiency for small lot sizes ('Lot Size One') – a key element of the Industry 4.0 vision. In addition, the hardware platform – which will integrate sensors, signal processing, secure communication and control electronics as well as the power electronics and the driver stages directly in the housing of the motor – will be easily translatable to other domains including tooling machines, automated driving and full-scale electromobility, as well as smart energy and smart infrastructure solutions.

According to IMS Research, there are substantial prospects for a high return on investment from this research. The total market for 400-1200 V powertrains relevant to industrial drives is worth about 25

billion USD in year 2015, with annual growth of over 10% for drives using conventional technology. With integrated power and IT technology, the market share for intelligent integrated powertrains is expected to grow even faster. Furthermore, intelligent electric drives will enable major reductions in energy consumption in factory automation by reducing cabling as well as increasing the overall system efficiency. It is estimated that variable speed drives could cut approximately 10% of worldwide electrical energy consumption, with corresponding savings in costs and CO_2-emissions (Source: ABB).

Besides these economic and environmental benefits, the CosmoDU project will deliver benefits for its participants – three large companies, eight small and medium-sized enterprises (SMEs) and three research institutes and universities from Germany and the Netherlands. The market-leading OEMs and Tier 1 suppliers involved will be able to exploit the results immediately in their businesses. For the expert SMEs, this is an opportunity to employ and develop their expertise in key areas such as electromagnetic compliance (EMC), health monitoring of electronic systems, active performance control, packaging processes and equipment, motor control and system integration of the hardware and software. Similarly, the research organizations will gain valuable knowledge in industrial practice, which will both enrich academic knowledge and improve future research services to industry.

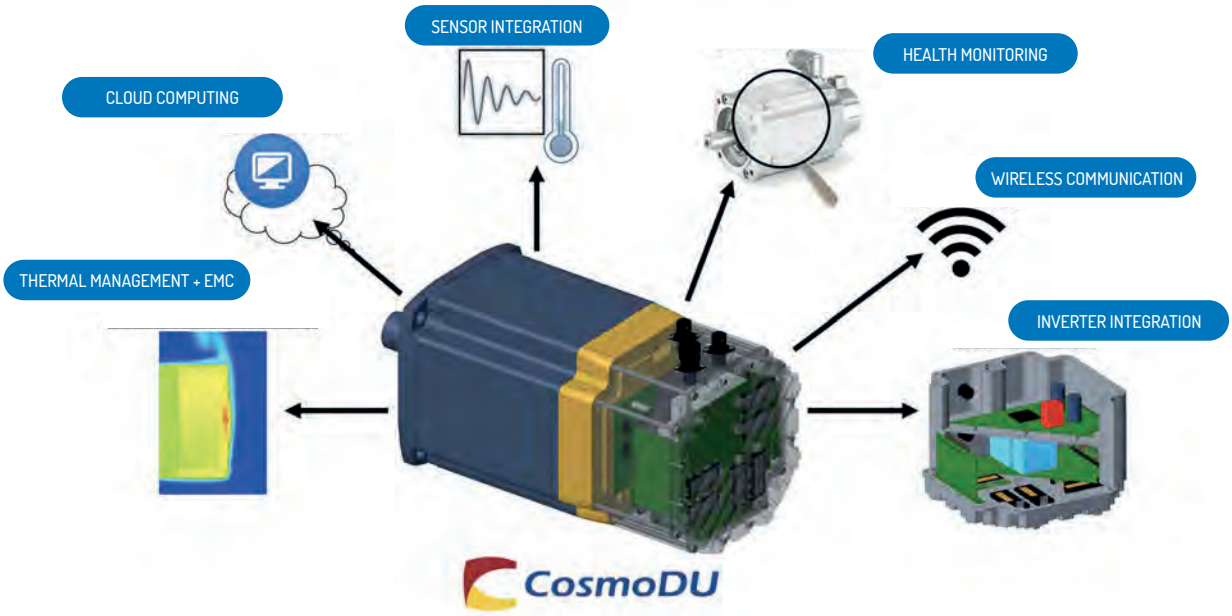
About the PENTA programme (managed by the AENEAS Industrial Association)

PENTA is a EUREKA cluster whose purpose is to catalyse research, development and innovation in areas of micro and nanoelectronics enabled systems and applications - where there is shared national and industrial interest. Based on three key application areas, Transport & Smart Mobility, Health & Well-Being and Digital Industry for the first 3 calls, PENTA programme contributes to the development of electronic solutions with the opportunity for rapid competitive exploitation and a strong impact on European societal challenges. The PENTA project team is supporting SMEs, large corporations, research organisations and universities by facilitating access to funding, fostering collaborative work and creating consortia.

PENTA is managed by AENEAS, the European industry association
About PENTA: http://www.PENTA-eureka.eu
About AENEAS: https://aeneas-office.org

About CosmoDU
CosmoDU is a RD&I project consortium involving 14 partners from 2 countries. The project partners are: Siemens AG (project leader), AAMITRONICS Angewandte Mikromechatronik GmbH, Advanced Packaging Center BV, Berliner Nanotest und Design GmbH, Boschman Technologies B.V., Catena Holding BV, Delft University of Technology, Fairchild Semiconductor, Fraunhofer Institute for Electronic Nano Systems (ENAS), Fraunhofer Institute for Integrated Systems and Device Technology (IISB), Heliox, Langer EMV-Technik GmbH, Robert Bosch GmbH, Technolution BV. National funding support is provided by Germany and the Netherlands.

CosmoDU



The evolution of machines requires electric drives to actively monitor and adjust their own key operational parameters such as speed, direction and power, in case of performance or environmental changes. CosmoDU has developed the hardware platform of next-generation drive units, where sensors, signal processing, secure communication and control and power electronics have been directly integrated in the housing of the motor. This new drive unit uses its self-learning capabilities to adjust and improve its performance.

Background, objectives of the project and faced challenges

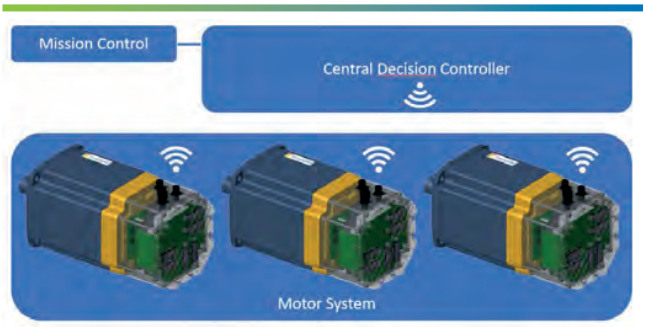
Today industrial drives consist of electric motors, inverters, and an additional control stage. Maintenance is done regularly independently from load and system condition. The smart intelligent electric drives developed within CosmoDU will be key enablers for Industry 4.0. They will increase manufacturing flexibility and even have the ability to learn and to communicate. Moreover, they will maximise system availability by eliminating downtime due to unexpected servicing needs. The objective was to develop a hardware platform which integrates sensors, signal processing, secure communication and control electronics as well as the power electronics and the driver stages directly in the housing of the motor. The platform should be used for different applications as conveyor belts, robotics, tooling machines, automated driving and full-scale electromobility, as well as smart energy

and smart infrastructure solutions. Together with functional performance, CosmoDU has addressed multiple challenges such as electro-magnetic compliance (EMC), thermal management, functional safety and system availability that specifically arise from an ultra-compact design. Indeed, fast switching power devices in the neighbourhood of low voltage components tend to cause EMC issues, while the limited cooling capability of the integrated system is highly demanding in terms of thermal management.

Technological achievements

System architecture

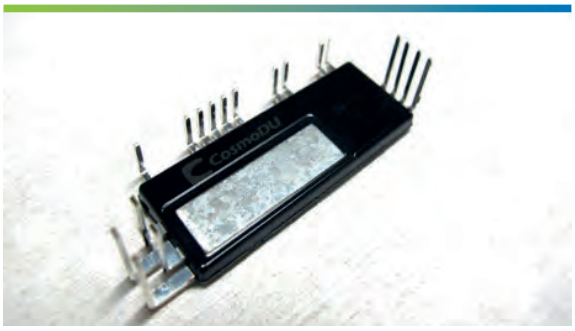
The CosmoDU consortium developed a modular hardware architecture for the integration of sensor, micro and power electronics modules to fit into the housing of a motor drive. A clear partitioning of functions is accomplished by considering the severe requirements related to thermal management and EMC. The architecture enables full integration of the inverter and the sensors for health monitoring and drive performance optimisation. All information is shared throughout the motor and with the higher system layers using a standard for data exchange (OPC UA). This provides a scalable and manufacturer independent way to disclose information towards the higher layers of the control and monitoring system.



CosmoDU system architecture

SiC power modules

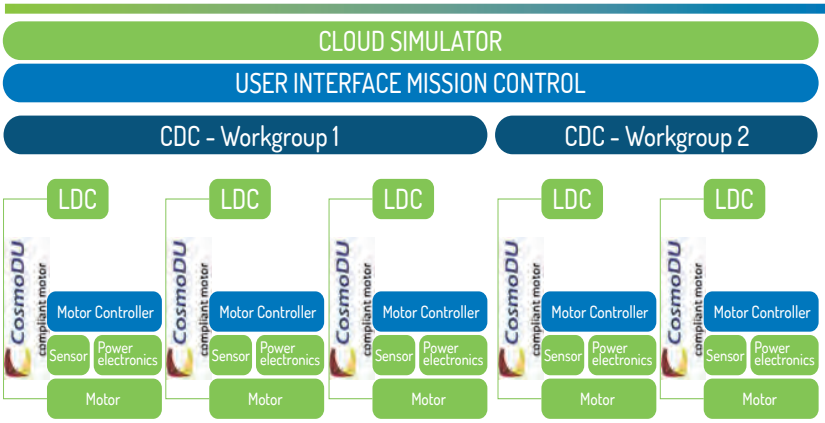
Saving energy is one key element in the efforts to reduce global warming. The use of new silicon carbide (SiC) semiconductors in inverters allows to significantly reduce conduction and switching losses compared to silicon (Si) based power semiconductors. The higher power density and higher temperature capabilities of SiC components were addressed with a power module design for dual side cooling. Better heat transfer and new assembly techniques enable to achieve not only good operational performance but also high reliability.



Encapsulated SiC power module

Condition and health monitoring

Each CosmoDU motor is equipped with its own thermal impedance spectroscopy (TIS) board, allowing to determine the health status of the power modules. The CosmoDU sensor module constantly records motor vibrations as well as sound and provides those data together with motor parameters to the Local Decision Controller. These data gathered in a feature vector are transferred to higher control levels, either to the Central Decision Controller or to the Cloud, for self-learning analysis. This allows the customers to replace components before they fail.



Main layers of the CosmoDU architecture

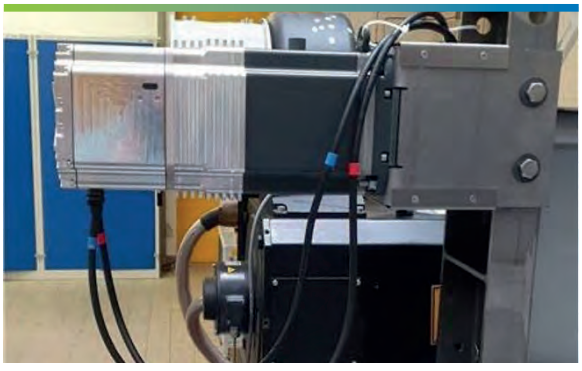
Secure wireless communication

The Wireless communication module shows a performance clearly surpassing the IEEE 802.11ac Wifi standard requirements, particularly in terms of reception quality and associated power usage. Moreover, the successful proper functioning of a prototype IEEE802.11ah Wifi system was shown in an industrial environment under harsh conditions regarding interferences, strange propagation path properties, reflections and damping factors between factory compartments with heavily disturbing motors.

Testing of prototype Wifi system in a harsh factory environment

Integrated smart motor drive

The motor is a series servo motor, on which the electronics housing is mounted. The electronics housing contains the high voltage power electronics as well as the low voltage control, sensor, and communication boards. The compact motor drive unit allows a versatile usage. The wireless communication link, the smart health monitoring and process diagnostics are especially beneficial in systems with decentralised drives, e.g. conveyor belts. The CosmoDU motor serves as sensor and communication hub of other adjacent components of an installation.



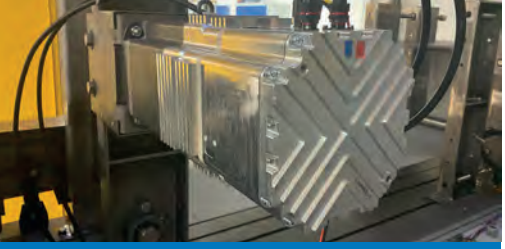
CosmoDU motor drive mounted at a demonstrator conveyor belt

Market Potential

CosmoDU is targeting to deliver a smart hardware platform for next generation electric drives with high efficiency, performance optimisation and health monitoring used in industrial automation systems. The total market for industrial power trains relevant to industrial drives is worth about 25 billion USD, with annual growth of over 10% for drives using conventional technology. With integrated power and IT technology, the market share for intelligent integrated powertrains is expected to grow even faster. More specialised markets are also relevant: e.g. the global conveyor belt market is forecasted to achieve at an annual growth rate of 3.7% during the period 2019-2025, leading to an expected total market size of 5 billion USD in 2025. For this market, the increasing demand partly comes from the mining industry, due to their significant requirements of longer distances, strength, flexibility, easy maintenance, and high-splice strength and safety. Promising demand trends can also be found such in the aviation business, automated production plants or warehousing and logistic systems.

The CosmoDU results will have an impact on the following products:

- Semiconductor, microelectromechanical systems (MEMS) sensors and power modules (ON Semiconductor, Bosch, APC, Boschmann)
- Electrical drives and control platforms (Siemens, Heliox, Technolution)
- Secure Wireless communication (Catena)



KEY APPLICATION AREAS

- Transport & Smart Mobility
- Health & Well-Being
- Energy
- Digital Industry
- Digital Life

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- Systems and Components Architecture, Design & Integration
- Connectivity & Interoperability
- Safety, Security & Reliability
- Computing & Storage
- ECS Process Technology, Equipment, Materials & Manufacturing

PARTNERS

Advanced Packaging Center BV
AMITRONICS Angewandte Mikromechatronik GmbH
Berliner Nanotest und Design GmbH
Boschman Technologies B.V.
Catena Holding BV
Delft University of Technology
Fraunhofer Gesellschaft- IISB
Fraunhofer Institute for Electronic Nano Systems (ENAS)
Heliox
Langer EMV-Technik GmbH
ON Semiconductor
Robert Bosch GmbH
Siemens AG
Technolution BV

COUNTRIES INVOLVED

- Germany
- The Netherlands

PROJECT LEADER

Dr. Kai Kriegel
Siemens AG

KEY PROJECT DATES

01 May 2017 - 31 October 2020

Societal & Economic Impact

Smart drives will enable major reductions in energy consumption in factory automation by reducing cabling as well as increasing the overall system efficiency. It is estimated that industrial drives could cut approximately 10% of worldwide electrical energy consumption, with corresponding savings in costs and CO2-emissions. Additionally, CosmoDU project will deliver benefits for its participants – three large companies, eight small and medium-sized enterprises (SMEs) and three research institutes and universities from Germany and the Netherlands. The market-leading original equipment manufacturer (OEMs) and Tier 1 suppliers involved will be able to exploit the results in their businesses. For the expert SMEs, this is an opportunity to employ and develop their expertise in key areas such as electromagnetic compliance (EMC), health monitoring of electronic systems, active performance control, packaging processes and equipment, motor control and system integration of the hardware and software. Similarly, the research organizations will gain valuable knowledge in industrial practice, which will both enrich academic knowledge and improve future research services to industry.

CosmoDU will not only strengthen the technological leadership of the involved partners, but also support European manufacturing and create new jobs through competitive, smart and highly flexible industrial production.

Patents/Standardisation/ Publications

The partners actively disseminated the results from CosmoDU project at several domestic and international events and workshops, including EFECS 2017/2018/2019 and Precisiebeurs 2018, in company with various demonstrating components, posters and oral presentations. Representatives of the ECSEL JU Lighthouse initiative Industry4.E have been contacted for additional dissemination opportunities and collaborative options. The project results will be presented with a booth at the EFECS 2020. The project delivered several papers to general public and published various press releases via social media including internal newsletter, partner's website, LinkedIn and Twitter.

Future Developments

The innovative approaches in CosmoDU are an important step to higher system integration and smarter ICT in the field of industrial automation. For further decarbonization, the number of efficient industrial drives needs to be increased. Moreover, in a sustainable environment a high reliability and a long lifetime are crucial. This means for future developments that the focus on efficient power devices, reliable packaging, compact design, improved 3D system integration, EMC, secure communication and the application of artificial intelligence will be enforced. To meet these goals, new follow-up projects are under discussion.

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CosmoDU

▶ **Video: https://www.youtube.com/watch?v=Jv8iu41AbmQ**

DISPERSE

16012

Electronic solutions for MRI scanning of patients with multiple implants drastically reduce examination time and increase accuracy [DISPERSE]

The occurrence of three or four concurrent medical conditions by the age of 70 is now common among an ageing population leading to more and more people wearing implanted medical-treatment devices. Unfortunately, current medical practice generally excludes patients with implants from access to magnetic resonance imaging (MRI). In the case of state-of-the-art implants, only patients with a single implant may be scanned, and even then under severe restrictions. This drastically increases examination time. The DISPERSE project does away with all these limitations, while delivering additional benefits.

What is most noticeable among an ageing population is a steep increase in the incidence of diabetes, musculoskeletal, cardiovascular and neurological diseases. Many of us will develop multiple clinical conditions, either chronic or acute. Studies on the prevalence of comorbidity show that at age 70, occurrence of three or four conditions is common. Treatment of many chronic conditions involves placement of implants or use of body-worn treatment-delivery devices. These electronic devices are mainly found in the elderly population. For numerous identified medical conditions, magnetic resonance imaging (or MRI, a way of obtaining detailed images of organs and tissues throughout the body without the need for X-rays or so-called 'ionizing' radiation) is required for diagnosis and treatment monitoring. As patients develop multiple medical conditions, many of those needing an MRI scan will have one or more implants.

Crucially, current medical practice excludes patients with one or more 'standard' active implantable medical devices (AIMDs) from access to MRI treatment, because MRI scanners need to use (electro-) magnetic fields which are far stronger than those encountered in everyday situations. This causes serious health inequalities for a rapidly growing group of patients. Now, scanning patients with a single, so-called state-of-the-art implant, is permitted under strict and limiting conditions. Unfortunately, these restrictions increase the typical examination time from 20 minutes (for a patient without an implant) to one hour (for patients with a single, advanced implant).

Reducing examination times, increasing scan accuracy

DISPERSE's key objective is therefore to develop the electronic means of reducing examination times of patients with multiple implants by a factor of three, while also improving scanning accuracy. This objective will be achieved by developing electronics for spatially distributed sensor and transducer arrays exploiting synergies with other domains, which in turn will optimise the workflow for MRI-scanning these patients.

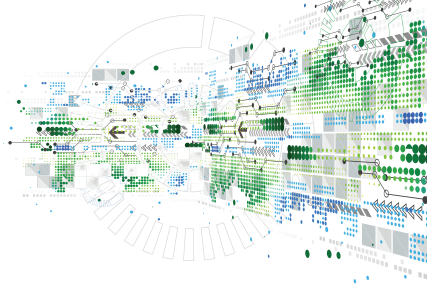
In particular, DISPERSE will develop:

- Improved MR conditional implants (safe under certain tested conditions);
- Multi-implant coexistence;
- Optimal MRI workflow for implants;
- New and improved components.

Tangible results include:

- AIMDs causing less MRI distortion;
- New methods for multi-implant testing;
- Sensor arrays with increased density;
- Miniaturised, low-power sensor and actuator electronics (ASICs);
- High-speed, low-power and low-volume (refers to their small size, not low production volume) photonic modules for data transmission.

DISPERSE will develop a technology value-chain for creating large distributed multiple sensing arrays, including low-latency, interference-free data communication. These sensing networks have a large application potential in other markets, such as smart cities and space. In particular, DISPERSE will demonstrate applications in radio telescopy and acoustic surveillance of public space.



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- Health & Well-Being
- Digital Life

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PARTNERS

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Firecomms Limited
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G-Therapeutics BV
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Technobis

COUNTRIES INVOLVED

- Belgium
- The Netherlands
- Ireland

PROJECT LEADER

Mark van Helvoort
Philips

www.disperse.eu

KEY PROJECT DATES

01 February 2017 - 31 January 2020

Finding the right expertise mix

In order to meet key objectives, the project consortium includes a clinical end-user, application partners, as well as technology and knowledge providers, working together on innovations in photonics, micro-electronic design and packaging. As such, DISPERSE brings together implant manufacturers, an MRI producer and a hospital, together with two acoustic specialists, to develop new acoustic monitoring solutions for detecting patient anxiety. This solution will operate in the harsh MRI acoustic environment. A research partner from the space domain will also provide the project consortium with valuable knowledge on distributed sensor networks.

Wider implications, broader applications

In addition to the strictly technical and technological benefits mentioned earlier, DISPERSE's focus on diagnosis and treatment, for example, fits perfectly in the 'Continuum of Care', a concept involving an integrated system of care that guides and tracks patient over time through a comprehensive array of health services spanning all levels of intensity of care.

On the financial side, the implant market is expected to grow by 71% in 2015-2020, according to US data, and an increasing likelihood that someone aged 70 will require an MRI within the next 10 years could drive the double-digit CAGR (compound annual growth rate) for DISPERSE AIMDs, leading to a total market size of €6.9 billion in 2020. In that same year, the MRI market is expected to expand to €6.1 billion, thanks to shorter examinations times and improved diagnostic capabilities.

Now, DISPERSE's innovative devices for the healthcare market – such as photonic transceivers, ASICs for sensor arrays, and solutions for acoustic observation – have significant potential in at least four other markets:

- **Brain monitoring:** expected to reach US$11.3 billion by 2020, from US$ 7.5 billion in 2015 at a CAGR of 7% over the forecast period. Factors – such as the increasing incidence and prevalence of neurological disorders; rising awareness about neurodegenerative diseases; technological advancements in devices; and growing incidence of traumatic brain-injuries – are driving market growth;
- **Smart cities and acoustic observation:** beyond acoustic patient observation, implementing an array of sound cameras will enable major breakthroughs in the emerging market of audio and classification for smart home (home care) and smart city applications, where there will be greater emphasis on the audio capabilities of video surveillance systems;
- **Space:** application activity focuses on the development of communication technology for a satellite-based radio telescope. Here there is interest in the communication module to be developed in DISPERSE. There is also interest in using DISPERSE as a model for EU-based companies to develop technology needed to build the future space telescope;
- **Photonic components and systems:** photonic data-transceiver technology and components developed in DISPERSE will address wide, lucrative and growing market-segments outside of the MRI application field, both within the healthcare domain, but importantly also in the industrial Internet of Things (IoT), a market which is predicted to reach $8.6 trillion by 2025.

And interestingly, DISPERSE is also expected to 'disrupt' the therapy market and break the dominance of large pharmaceutical companies by influencing factors that challenge the strong growth of AIMDs.

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DISPERSE

DISPERSE investigates solutions for MRI scanning of patients with multiple implants

A project in the EUREKA PENTA programme

Paris, January 18, 2018. The PENTA funding programme, managed by AENEAS, today highlights the DISPERSE project. This project aims to extend Magnetic Resonance Imaging (MRI) scanning to people who currently cannot benefit from this non-invasive technique due to multiple medical implants in their body.

With an aging population, ever more people with implants are likely to require medical scans for conditions such as cancer, neurodegenerative and musculoskeletal diseases. Today, many such patients cannot have MRI scans because their medical devices significantly distort images. Some patients with what are known as 'conditional implants' can have MRI scans, but the scan time is longer than normal. With the use of photonics, micro-electronic devices and innovative packaging solutions, the DISPERSE project is seeking to overcome these limitations and allow patients with multiple implants to be scanned in much faster and more accurately.

The project is also developing innovative techniques to monitor patient anxiety during the exam. An acoustic system based on multiple microphones detects patients' reactions in order to trigger adjustment of the operator workflow. In addition, this acoustic monitoring (enabled by integrated photonics) has the potential to be used in detection and surveillance systems in smart cities, smart homes and automotive applications.

Photo credit: Philips

About the PENTA programme (managed by the AENEAS Industrial Association)

PENTA is a EUREKA cluster whose purpose is to catalyse research, development and innovation in areas of micro and nanoelectronics enabled systems and applications - where there is shared national and industrial interest. Based on three key application areas, Transport & Smart Mobility, Health & Well-Being and Digital Industry for the first 3 calls, PENTA programme contributes to the development of electronic solutions with the opportunity for rapid competitive exploitation and a strong impact on European societal challenges. The PENTA project team is supporting SMEs, large corporations, research organisations and universities by facilitating access to funding, fostering collaborative work and creating consortia.

PENTA is managed by AENEAS, the European industry association.

About PENTA: http://www.PENTA-eureka.eu

About AENEAS: https://aeneas-office.org

About the DISPERSE project

DISPERSE is a RD&I project consortium involving 12 partners from 3 countries. The project partners are: Philips (project leader), Astron Netherlands Institute for Radio Astronomy, G-Therapeutics, Sorama, Sound Intelligence, Technobis, Cochlear, Gasthuisberg UZ Leuven, Luceda Photonics, MinDCet, Firecomms, Tyndall National Institute. National funding support is provided by the Netherlands, Belgium and Ireland.

About DISPERSE: http://disperse.eu

DISPERSE

▶ **Video: https://www.youtube.com/watch?v=OWc2lMoJ3KM&feature=youtu.be**

HADES

16003

Versatile test facility improves system and product quality while reducing design and operational costs [HADES]

The smooth operation of mission- and safety-critical systems calls for early detection of potential problems to avoid safety-related issues and to control costs. The versatile test facilities developed in the HADES project will go a long way to ensure systems are more robust and safer over the complete product lifetime, and help avoid dangerous and costly system breakdowns due to integrated circuit (IC) failures.

Failure in an electronic system could impact it in several ways, notably operational disruption, economic loss or questionable data-integrity. Importantly, mission- and safety-critical systems (like those deployed in the space, automotive, health care or avionic sectors) require early detection of potential problems to avoid safety-related issues and to control costs. In order to guarantee that these systems operate at optimal performance levels calls for the use of a network of embedded test instruments to monitor the status and operation of 'building blocks' or the entire system, providing key data for optimising performance and ensuring proper operation, or to predict future failures. In addition, extracted data must be handled using a standardised and secure interface; and firmware in mobile systems must be online tested and updated securely in real-time.

Unfortunately, current industrial test-technologies cannot handle the needs of a large variety of Internet of Things (IoT) devices that are just appearing on the market, for which large amounts of data must be handled in a secure way. Furthermore, despite the existence of industry standards for IC testing, there are no regulated standards, methodologies and tools that address all these requirements.

Developing a hierarchical and versatile test-infrastructure

HADES will develop and deliver a secure, hierarchical test-infrastructure based on existing standards. This test facility will be versatile and reusable and offer better system monitoring, resulting in reduced test and design costs. It will not only increase dependability through a standardised framework for handling numerous embedded test instruments (ETIs) at the electronic control system (ECS) level; but also on-chip-reliability monitoring and electronic design automation (EDA) tools with diagnostics and online self-repair capabilities. And all of this will be demonstrated at a component and system level.

The project will target the following domains:

- Machine-to-machine and connected systems;
- Remote-controlled systems;
- Smart homes and mobile phones;
- Safety-critical systems (typically found in the automotive and avionics sectors);
- Mission-critical systems (such as in space and security applications).

HADES will deliver the following:

- Test capabilities and reusability throughout the product lifecycle;
- Test bus access at the required security level;
- Limited test costs compatible with IoT low-cost devices and high volumes;
- Online monitoring to enable prognostics and diagnostics, and improve dependability;
- Online monitoring for system power-management.

Core competencies

The project consortium is pan-European (from France and the Netherlands) and comprises five large companies; four small and medium-sized enterprises (SMEs); five academic and research institutions; as well as several OEMS. The consortium also provides the necessary expertise and experience needed to deliver a secure hierarchical online testing facility through ETIs. The large enterprises are already active in such areas as remote-controlled IoT systems, safety- and mission-critical systems, as well as automotive, smart homes and mobile applications. The SMEs, whose involvement is complementary to the work being done by the large companies, will focus on areas requiring their competencies. Academics and researchers will work on topics

KEY APPLICATION AREAS

- Transport & Smart Mobility
- Health & Well-Being
- Energy
- Digital Industry
- Digital Life

ESSENTIAL CAPABILITIES

- Systems and Components Architecture, Design & Integration
- Connectivity & Interoperability
- Safety, Security & Reliability
- Computing & Storage
- ECS Process Technology, Equipment, Materials & Manufacturing

PARTNERS

CEA / CNRS / Laboratoire d'Informatique de Robotique et Microélec IROC TECHNOLOGIES / ISSM / NXP Semiconductors France SAS / STMicroelectronics / TEMENTO SYSTEMS / Thales / TIMA Laboratory / Institut Polytechnique de Grenoble / Sorbonne University – LIP6 / D4T Systems / JTAG Technologies B.V. / NXP Semiconductor Netherlands BV / University of Twente

COUNTRIES INVOLVED

- France
- The Netherlands

PROJECT LEADER

Brigitte Descouts
STMicroelectronics

KEY PROJECT DATES

01 October 2017 - 30 September 2020

and challenges beyond state-of-the-art, and on unresolved technical and technological issues. This mix of project partners and expertise ensures that the project addresses relevant industrial problems and stays at the R&D cutting-edge throughout the project and beyond.

Improving quality, reliability and competitiveness

HADES not only supports failure detection, but also provides such capabilities as failure prevention, self-healing, self-repair and fault tolerance. In addition, it facilitates diagnosis and failure analysis and contributes to better system traceability. Furthermore, since ETIs will come with dedicated software, they will facilitate interaction and control across the complete ecosystem (such as IC manufacturer, system integrator and customer). Crucially, all concepts and techniques will be developed according to strict system-security principles. And by offering system developers greater robustness and dependability, HADES will make European products more competitive and ensure their wider use though improved quality (eliminating health hazards, for instance, will make them more attractive).

A promising market

It is important to point out that test tools are increasingly playing a key role in the overall manufacturing value-chain, regardless of product and its projected lifetime. Crucially, test is becoming a key enabler for IC and systems manufacturers to deliver products at the quality and cost-levels demanded by the market. In fact, without the backing of a powerful test architecture and test services, a product's sales potential will be reduced.

The global automated test equipment (ATE) market is expected to be valued at US$4.48 billion by 2020, according to Radiant Insights. In addition, increasing design complexity, coupled with the need for effective testing, is expected to drive demand in the global automated test-equipment market. Prime Research offers a broader view of the overall test market by including the electronic manufacturing segment, which is expected to represent another US$1.28 billion in 2014.

Furthermore, markets where HADES is expected to create added-value and enhance competitiveness are also growing, thereby also driving demand for this project's test deliverables. Gartner forecasts almost 30% growth through 2020 for IoT semiconductor revenue, which spans every industry and is driven by the immense scale of low-cost devices. Some in the industry even believe this growth will transform the semiconductor business. A case in point is automotive, which will see a significant rise in demand for semiconductors due to a 30% annual increase in networked cars, and where one in five automobiles will be receiving internet services by 2020. In fact, the total semiconductor revenue from electronic equipment is expected to reach US$45 billion in 2020, and with strong demand in the next ten years, IoT, which is at the heart of this growth, will generate revenues of US$11.5 billion in 2018.

Finally, consumers looking to enhance their lifestyles will also play a central role in growing IoT demand. In the home, where each household could contain more than 500 devices by 2022, demand will grow for semiconductors. Smart TV and set-top box (STB) revenues will continue to increase, and so will remote patient-monitoring for post-surgery or chronic-disease surveillance (in the USA, 86% of all health-care spending in 2010 was for people with one or more chronic medical conditions). Wearable systems are also expected to grow by more than 280% between 2015 and 2018. And other personal devices, like smart glasses, smart watches and mobile phones, will also be in greater demand as these devices start to play a bigger and more significant role in the life of the consumer.

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HADES

HADES project develops automated chip-level testing for safer, more reliable IoT systems at lower cost

A project within the EUREKA PENTA programme

Paris, Thursday 28 February 2019 - Increased safety, reliability and cost-control for Internet of Things (IoT) devices are the focus for HADES, a EUREKA PENTA Cluster project, managed by Industry Association AENEAS. Vast numbers of devices are becoming connected via the IoT, from smart phones and smart home systems to safety-critical systems in airplanes and road vehicles. Indeed, every household could contain 500 connected IoT devices by 2022. This ever-increasing complexity calls for a new generation of miniature electronics test instruments that can be built into devices and systems to keep them operating safely, dependably and with optimal performance. HADES's next-generation test facilities will go beyond current solutions, leading to systems that are more robust and safer over the complete product lifetime. They will also help avoid dangerous and costly system breakdowns due to integrated circuit (IC) failures.

The market potential for HADES test facilities is huge covering IoT, automation and consumer devices. By 2020, the global automated test equipment (ATE) market is expected to be worth US$4.48 billion[1]. Specifically, the project will address machine-to-machine and connected systems, remote-controlled systems, smart homes and mobile phones, safety-critical systems (typically found in the automotive and avionics sectors) and mission-critical systems (such as in space and security applications). For IC and systems manufacturers, test is becoming a key enabler to create products at the quality and cost-levels demanded by the market. By offering system developers greater robustness and dependability, HADES will help make European products more competitive and attractive though improved quality.

The test capabilities delivered by HADES will be based on existing standards and provide a standardized framework for numerous embedded test instruments (ETIs) at the electronic control system (ECS) level. These will be versatile and reusable throughout the product lifecycle, which is key to reduced test and design costs – an important advantage for high-volume, low-cost IoT devices. They will also allow for online monitoring for prognostics, diagnostics and power-management, which means devices will operate more dependably and with greater energy efficiency.

The HADES project consortium is pan-European, comprising five large companies, four small and medium-sized enterprises (SMEs), four academic and research institutions, and several OEMS. This mix of project partners and expertise will ensure that the project addresses relevant industrial problems and stays at the cutting-edge of R&D throughout the project and beyond.

[1] Source: Radiant Insights Oct 2015 https://www.radiantinsights.com/press-release/global-ate-market

About the PENTA programme (managed by the AENEAS Industrial Association)

PENTA is a EUREKA cluster whose purpose is to catalyse research, development and innovation in areas of micro and nanoelectronics enabled systems and applications - where there is shared national and industrial interest. Based on the Electronic Components & Systems (ECS) Strategic Research Agenda (SRA) key areas and essential capabilities, PENTA programme contributes to the development of electronic solutions with the opportunity for rapid competitive exploitation and a strong impact on European societal challenges. The PENTA project team is supporting SMEs, large corporations, research organisations and universities by facilitating access to funding, fostering collaborative work and creating consortia.

PENTA is managed by AENEAS.
More on PENTA: http://www.penta-eureka.eu
More on AENEAS: https://aeneas-office.org

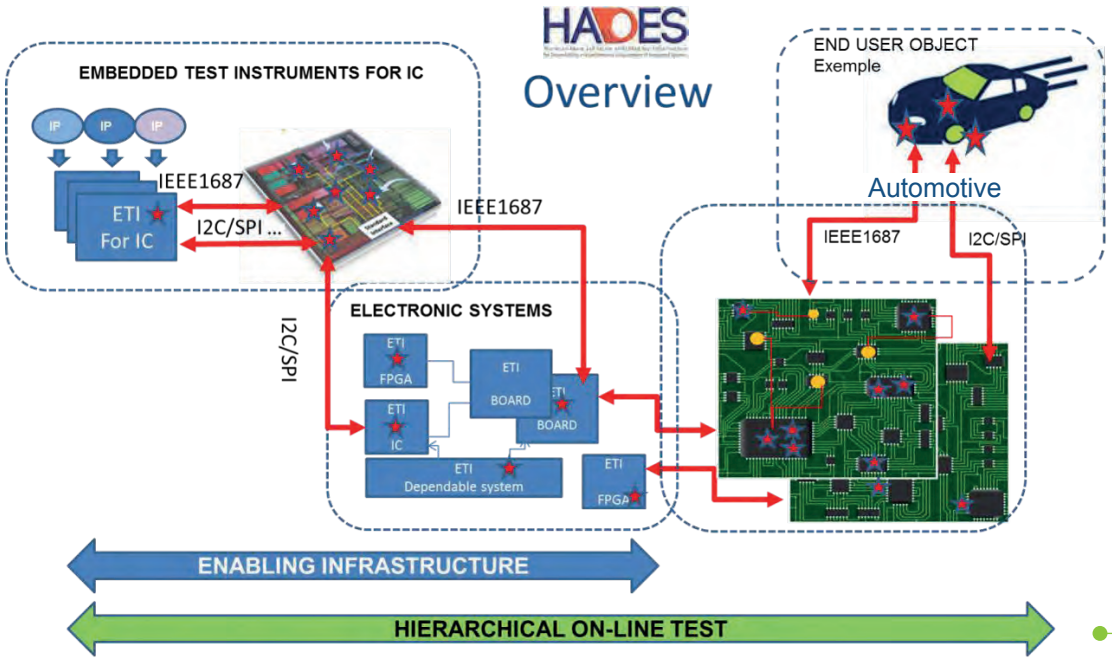
About HADES

HADES is a RD&I project consortium involving 14 partners from 2 countries. The project partners are: CEA, CNRS-LIRMM, D4T Systems, IROC, INVIA-ISSM, JTAG Technologies, NXP Semiconductors (France and Netherlands), STMicroelectronics, TEMENTO Systems, Thales, TIMA Laboratory, University of Twente and UPMC. National funding support is provided by France and The Netherlands.

HADES
Hierarchy-Aware and secure embedded test infrastructure for Dependability and performance Enhancement of integrated Systems

16003

HADES (Hierarchy-Aware embedded test infrastructure for Dependability and performance Enhancement of Systems) has improved the functional safety of Electronics Components and Systems in order to prevent dangerous failures or to control them as they occur. [HADES]



Today's electronic systems require high reliability and functional safety. The "Manufacture and forget" approach has been phased out and equipment vendors are expected to provide support through the entire lifetime of their products. The solution is to use test features to manage reliability challenges, increase operational lifetime and support extended operating environments and dynamic applications.

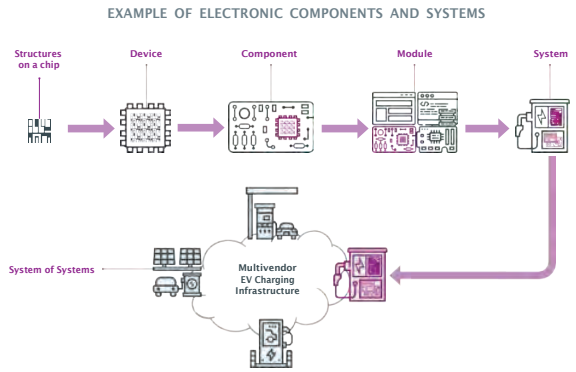
Background, objectives of the project and challenges

HADES provides solutions for self-test and self-diagnosis of Systems-on-Chips (SoCs) while improving their dependability. More specifically, the project aims at embedding into SoC networks multiple embedded test instruments (ETIs) for both analog and digital Intellectual Property (IP) cores that are interfaced to a common digital test infrastructure. The ETIs equip the SoC with key capabilities such as reliability monitoring to alert the end-users before the failures occur, on-line self-test to detect failures due to latent defects and aging, and data collection for failure diagnosis purposes. ETIs also offer feedback for self-repair, performance optimisation, and reliability enhancement. The goal is to design flexible ETIs that are reusable from post-manufacturing testing to on-line testing in the field of operation.

The test interface is based on the new standard IEEE1687 which has allowed the possibility to build advanced hardware-software environments to monitor and control many different embedded instruments and related applications. Securing the test infrastructure has been of main concern to prevent unauthorised access that could result in stealing secret keys, performing memory dumping, and modifying memory values to get a privilege escalation.

HADES goes beyond the state-of-the-art by moving from a classic design approach, based on a post-silicon fabrication test paradigm, to a new more efficient, scalable and low-cost on-line test approach.

The scope of HADES has been to develop a comprehensive environment to perform the testing of the electronics systems. The range of Electronic Components and Systems (ECS) is very wide, going from transistors in silicon chips acting as individual electrical switches, through the integration in smart systems, up to global System of Systems (SoS) performing complex cognitive tasks and interacting with numerous humans and machines. A very simplified view of this ECS "stack" or "Russian dolls" is shown in the Figure below:



The Proliferation and Imbrication of ECS in the Electric Vehicle charging infrastructure

Source: Eurotech- Illustration from ECS SRIA 2021 page 14

Ensuring the reliability, safety and security of ECS has become a major challenge since the simultaneous demand for increased functionalities and continuous miniaturisation of ECS causes interactions on multiple levels.

Technological achievements

Implementation of the standard IEEE 1687

This required a hierarchical approach for testing all the components of the system. Temento Systems, Tima Laboratory and STMicroelectronics have demonstrated the capability of the IEEE1687 standard to monitor a board and a chip, as well as NXP Semiconductors Netherlands on another demonstrator. They have also implemented a limited pin test interface with an analog test bus, which resulted in the filing of a patent.

TIMA Laboratory, University of Twente and JTAG technologies have developed efficient algorithms and extended their software with IEEE1687 support, achieving scalability, interactive behaviour and lifetime portability.

D4T Systems has developed basic compatibility in their software tools for the new IEEE1687 standard.

Development of Embedded Test Instruments (ETIs)

NXP Semiconductors France and CNRS-LIRMM have developed ETIs that enable testing of Radio Frequency devices using standard digital Automatic Test Equipment. Targeted Application: Smart Home ZigBee Transceiver (2.4GHz) from NXP Semiconductors intended for the IoT market.

TIMA Laboratory and STMicroelectronics have demonstrated an ETI that achieves the static linearity built-in self-test of Successive-Approximation-Register (SAR) analog-to-digital converters (ADCs). A dramatic test time reduction has been achieved.

Université Pierre et Marie Curie (UPMC) newly Sorbonne University has developed low-overhead ETIs for analog and mixed-signal IP cores, also ETIs for fault-tolerance in hardware accelerators for Spiking Neural Networks (SNNs), which constitute the third generation of neural networks aiming at bridging the gap between biology and machine learning.

iROC Technologies has developed a complete library of ETIs and infrastructure for a systematic technology qualification and measurements of the chips. The effectiveness of these ETIs has been demonstrated on CMOS 65 and 28 nm, up to FinFET technologies. An Electronic Design Automation (EDA) platform was built to validate the functional safety of complex circuits targeting ISO26262 certification.

D4T Systems, in collaboration with University of Twente, has developed a new software add-on to quickly analyse the performance of ETIs in a system model simulation.

CNRS-LIRMM and CEA have developed low-overhead ETIs (reliability, area and power overhead trade-off) based on approximate computing circuits to tolerate faults in advanced ICs.

LIRMM and STMicroelectronics have developed a learning-guided approach for diagnosis of mission mode failures. Proposed solution provides reduce and accurate list of candidates to guide the failure analysis phase.

The University of Twente has developed an aging-aware standard cell CMOS library at Spice-level, to simulate the aging of critical paths in processors to locate SD-ETIs. In addition, several AI algorithms suitable for an embedded processor were used to predict in real-time from ETIs, the life-time of a SoC. They also designed, verified and implemented six fully IJTAG-compatible embedded test instruments. Five of them were partly implemented in a 40nm CMOS ASIC and FPGAs.

Security of test infrastructure

The aim is to provide a practical path toward better security by protecting electronic systems test bus access from any evil-minded intrusion while maintaining strict compliance with test standards and without affecting test economics and quality.

TIMA Laboratory, CNRS-LIRMM and JTAG Technologies have worked on the security of test infrastructure access and Secure Data transfer. They have succeeded in integrating data scan encryption in a standard test flow, successfully implemented on Xilinx boards and on a JTAG Technologies JT 2156 training board.

JT 2156 training board

Copyright JTAG technologies

Some functionalities on a SoC can operate at specific cycle time, while other functionalities may operate at cycle times n/2, n/3, etc. Thales SIX GTS was able to develop a unique Logic built-in self-test (LBIST) on several clock domains, instead of testing each individual domain, by themselves, at that domain frequency. This LBIST will be soon embedded in a big Application Specific Integrated Circuit ASIC (230mm2) taped out in a 65 nm technology.

Thales-Design Services (DIS), ex INVIA, has investigated and developed a flexible ABIST to process internal (CPU driven) or external (Software driven) test, increasing the reliability and security of Integrated Circuits (ICs). It is designed to get a single signature from the test of multiple analog IPs present in an IC. It allows detecting defects or physical attacks in analog modules when the Automatic Built-In Self-Test ABIST system is launched during production test or on the customer side depending on configurations.

Demonstrators

iROC Technologies has developed methodologies and set-ups for complete reliability and functional safety assessment before and during chip design (through EDA) and after chip manufacturing through a test set-up able to submit a chip to multiple variety of tests: radiation, environmental testing as well as hardware fault injection.

A video that shows TIMA laboratory ETI for SAR ADCs static linearity test is available on public platforms: https://hades.iroctech.com/videos/

TIMA Laboratory has also developed methods and a digital core for image quality evaluation and optimisation loop for detection and correction of defective pixels in CMOS imagers, paving the way for self-healing imagers.

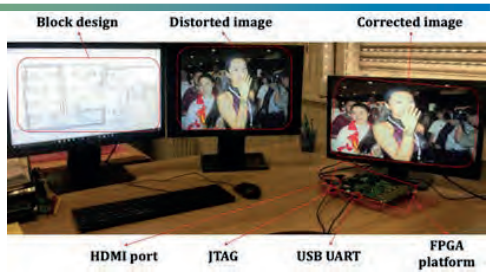
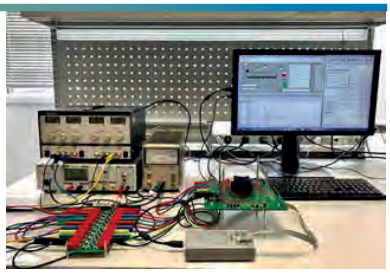


Image Quality Optimisation

Copyright TIMA Laboratory/Institut Polytechnique de Grenoble

NXP Semiconductors France and CNRS-LIRMM have developed an indirect test strategy that considerably lowers the cost of the industrial testing phase of RF circuits. This generic framework approach was successfully tested on NXP products and will soon be further extended for the lifetime verification of RF circuits.

STMicroelectronics, TIMA Laboratory and Temento Systems have developed a 1687 demonstrator based on a SOC processor silicon product. The SoC embeds the state-of-the-art of different elements of the safety mechanism, including the basics like SRAM BIST or more advanced ones like in-situ slack monitors.



IEEE 1687 demonstrator based on a SOC processor silicon product

Copyright Temento Systems

Market Potential

With a forecast of more than 40 billion of connected devices in the world in 2025, the market for IOT-dedicated integrated circuits is getting very competitive. Typical examples of such circuits are Systems on Chip that integrate the application processor together with embedded RF front-end. Along with the growth of industrial and home appliances, protocols such as BLE and Zigbee® have become ubiquitous for short-range communicating devices.

NXP is one of the leaders of the home automation and the IoT semiconductor market. To be able to keep this leadership, the testability, quality and features of those products must be improved constantly. The impact of HADES is essential in terms of quality, test cost, time to market, and its results help improve two main fields:

1. An auto-test feature is essential to guarantee the proper functionality of safety critical products such as fire detectors, entrance access control, smart metering and even healthcare devices.
2. An improved production cost together with new application features help maintain research and development activities in France. HADES innovation is also deployed within other European sites and at NXP worldwide.

The expected impact is the improvement of quality (Parts Per Million) by a factor of 2 for the production test. In term of test cost, a reduction of 30% on test equipment cost is expected, thus improving market share in this highly competitive consumer market.

The automotive transformation will boost the silicon value in the car, which is expected to reach 45 Billion $ in 2023 (Source: IHS – Automotive semiconductor market tracker – June 2020).

The heart of the ADAS applications (Advanced Driver Assistance System) is a system on chip whose ultimate goal is to transform the car into an autonomous vehicle. ADAS has to be 100% dependable and the ETIs developed in HADES demonstrated a proof of concept in hierarchical tests of the SoC that will be a differentiator with respect to the competition.

NXP Semiconductors Netherlands is a major industrial player in the car digitisation and developed an enhanced design automation for on-chip instrument infrastructure using IEEE 1687 ICL. They issued the European patent 82154724 "Limited Pin Test Interface with Analog Test Bus". The innovation will reduce the test effort by 60%, thereby reducing the time to market and lowering the production test cost.

Thales SIX GTS developed a new LBIST insertion flow, using also the IEEE1687 standard, and the LBIST management module is expected to be reused in future ICs embedded in a range of products delivered by THALES.

THALES DIS, has developed a flexible ABIST controller to process internal (CPU driven) or external (Software driven) test, increasing the reliability (defects) and security of ICs. This ABIST controller will be embedded on secure ICs products, especially when Machine-to-Machine (low defect rate) type of products are required and in secure and certified IPs (used for System On Chip securitisation) type of product.

Spill overs have also benefited SMEs: D4T Systems software solution is positioned between chip design and manufacturing with an impact on more robust, more reliable applications for several high-quality end markets. The compliance to standards makes this new product scalable to other application domains increasing the impact of HADES developments to a wider variety of system products.

JTAG Technologies enlarged the use of their IEEE 1687 tool to reach all the test instruments, and this improvement will further promote JTAG Technologies existing tool chain to support more customers that exploit the IEE 1687 capabilities.

TEMENTO enriched their software existing product with a set of ETIs based on the 1687 standard and demonstrated it while running fault injection.

Exploitation is promising with a first beta site expected in 2021. iROC Technologies currently hold a leading position with their SoCFIT EDA platform and new capabilities have been added, targeting the certification for ISO26262 Tool Confidence Level 3, key to address the electrical cars and ADAS market. 2 to 3 new licenses per year are expected.

Societal & Economic Impact

The semiconductor total available market grew by 7.3% in 2020 compared to 2019, despite the Covid-19 pandemic and the political conflict between the United States and China. This demonstrated to politicians, key decision-makers and the general public that semiconductors are a Key Enabling Technology in a digitised society. More and more cars are

KEY APPLICATION AREAS

- Transport & Smart Mobility
- Health & Well-Being
- Energy
- Digital Industry
- Digital Life

ESSENTIAL CAPABILITIES

- Systems and Components Architecture, Design & Integration
- Connectivity & Interoperability
- Safety, Security & Reliability
- Computing & Storage
- ECS Process Technology, Equipment, Materials & Manufacturing

PARTNERS

CEA

CNRS - Laboratoire d'Informatique, de Robotique et Microélectronique de Montpellier (LIRMM)

D4T Systems BV

iRoC Technologies SA

JTAG Technologies BV

NXP Semiconductors France SAS

NXP Semiconductors Netherlands BV

STMicroelectronics

Temento Systems SAS

THALES DIS DESIGN SERVICES SAS

THALES SIX GTS FRANCE

TIMA Laboratory/ Institut Polytechnique de Grenoble

University of Twente

UPMC - Université Pierre et Marie Curie newly Sorbonne University

COUNTRIES INVOLVED

- France
- The Netherlands

PROJECT LEADER

Jean-Luc Bataillon
STMicroelectronics

now equipped with several image sensors and algorithms, powered by artificial intelligence to capture the environment around the car and take action, like emergency breaking. Such features will have to be adopted by a large majority of drivers if the objective is to move to autonomous driving, and the sine qua non condition is to develop electronic system and software with a 100% reliable functional safety that, for example, will be able to alert the driver and pull over the vehicle in case of a failure of the autonomous driving controller.

The quality, reliability, safety and cybersecurity of electronic components and systems are, and will be, fundamental to a society that is more and more digitised This key domain of the ECS was strengthened by HADES, as well as the technological leadership of the involved partners.

Similarly, the research organisations, e.g. CNRS-LIRMM, Sorbonne University, TIMA Laboratory, and University of Twente, have gained valuable knowledge working together and with industry towards functional safety solutions for microelectronics. Some of the material that was developed during the course of the project is already included in M.Sc. programme curricula of Universities in France and the Netherlands. Research organisations have also offered several tutorials in international conferences and summer schools on topics related to the project. 14 PhD theses have been carried out within the framework of the project, enhancing significantly the labour force in this domain.

Patents/Standardisation/ Publications

The project results from HADES featured strong dissemination activity and achieved considerable publicity, targeting high-impact and world-class conferences and journals. 56 international conference articles, 17 journal articles, 17 workshop articles were published, together with 8 invited talks and 6 keynote talks presented in conferences. The project results were presented at EFECS 2020, with posters and videos made available in the virtual booth. The partners also delivered a Special Session dedicated to the project at the IEEE conference IOLTS'20.

The implemented innovations are protected by 3 patent applications:

- NXP Semiconductors Netherlands European Patent 82154724 "Limited Pin Test Interface with Analog Test Bus"
- TIMA Laboratory: M Portolan "Test apparatus and method for testing an integrated circuit". Patent No. FR3066606A. 23 March 2018.
- CEA: M. Seif and V. Gherman, "Device And Method For Controlling Refresh Cycles Of Non-volatile Memories", FR1658135 (070550 US FLO/VBO)

3 MSc thesis / 14 PhD dissertations were produced.

NXP Semiconductors NL was active in IEEE P1500, IEEE P1687.1 and IEEE P1687.2 workgroups to drive third party silicon IP and EDA. iROC Technologies is a member of French ISO 26262 committee and a member of the Working Group for the JEDEC JESD89B revision. University of Twente was also very active in TESTA (TEst STandard) workshops on (mixed-signal) IJTAG (IEEE 1687.1/2) standardization. TIMA Laboratory participated in the leading standardisation proposal for support of non-JTAG interfaces inside the IEEE P1687.1. Sorbonne University was active in the working group activities of the 2 standards IEEE P1687.2 (Standard for Describing Analog Test Access and Control) and IEEE P2427 (Standard for Analog Defect Modelling and Coverage).

Future Developments

Today, most applications and standards in the electronics components and systems domain require high reliability, security and functional safety. As such, the topics explored in HADES are, and will be, fundamental to digitised society.

HADES can be considered a precursor project and the numerous activities & innovations demonstrated in HADES established the foundations for going even further to develop new disruptive applications related to electrical cars and ADAS, Advanced Space missions and Medical - especially Implantable devices. The markets in these 3 sectors, in which Europe already has a strong share, will experience spectacular growth.

Novel ETIs will be needed to focus on automated intelligent insertion, using on-chip Intelligence techniques based on Machine Learning, to extend the applicability and usefulness of physical data. The support of new and upcoming standards for the IoT, for reliability, for functional safety, for security, such as ISO 26262, IEEE P2851, IEEE 1687, will need close collaboration among all players to build leadership going forward in this coming generation of advanced Components and Electronic Systems.

Novel Software and EDA are needed to manage FuSa/R and complexity of novel applications:

- Massive use of Machine Learning techniques
- Introduction of a novel concept "Design for Functional Safety and Reliability (FuSa/R)", in line with the existing DFM/ DFR (Design for Manufacturing/Reliability)
- Sensor data fusion for data presentation.

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Hyb-Man

16013

Integrating design and production into a single end-to-end process creates flexible manufacturing and a quicker response to market demands

[Hyb-Man]

The Hybrid 3D Manufacturing of Smart Systems project (or Hyb-Man) will impact the European electronics manufacturing industry by delivering expertise in the individual technologies, integrating them into one, end-to-end hybrid 3D manufacturing process. This will create value in European manufacturing.

Producing today's electronic products is generally an assembly of separate parts: housings, structural elements, populated PCBs and discrete devices, brought together in a complex sequence of semi-automated steps and then tested as a complete assembly. Furthermore, the drive to reduce cost and improve quality has resulted in standardised components and sub-assemblies that are made into mass-produced products.

Unfortunately, this approach requires large, separate production lines for the sub-assemblies (such as PCB and housing); high investment levels for equipment/tooling; and substantial labour overheads for the manufacturing of the final product, including handling, assembly, interconnect and process control. Furthermore, the value chain is fragmented, with substantial 'parts tourism' (components are often shipped over long distances to different process steps in the value chain). This increases lead-times and has a negative environmental impact. Moreover, in the past decades we have seen a major part of electronics mass-manufacturing migrate from Europe to Asia, where low-wage economies and the availability of human capital resonate well with the requirements of fixed-configuration, mass electronics-manufacturing.

Implementing flexible, first-time-right production

Hyb-Man will respond to these drawbacks by developing innovative hybrid 3D manufacturing methods with the objectives of attaining high flexibility and first-time-right production. These methods are based on multi-material additive manufacturing (AM) – also referred to as 3D printing – as a core production technology, combined with automated assembly and the integration of electronic parts.

The project will first develop individual processes, and subsequently combine them into a single, integrated production chain that includes design rules, in-line testing and quality monitoring to a high-technology readiness level. The resulting production process will be highly flexible, because it is a digital process driven by data, which does not require product-specific equipment, tooling or moulds. This migration from tool-centricity to data-centricity is the key factor that impacts cycle times, process-setup costs and design/product flexibility.

Key project activities and deliverables will be:

- Developing end-user/product specifications from the LED lighting and automotive-sensor applications to be used to derive process and metrology requirements;
- Developing hybrid 3D manufacturing technologies which meet these requirements and are mutually compatible;
- Developing materials for electrical conductive, insulating and structural elements in parallel with these processes;
- Developing design rules for products and processes, based on the relationship between the processes, materials and product properties;
- Integrating these technologies and in-line control methods into a single, process-flow architecture, including the required hardware/software to be used for process-tuning and optimisation;
- Producing demonstrators and prototypes for the LED lighting and automotive-sensor application use-cases, using the integrated process flow-architecture;
- Evaluating the demonstrators to provide feedback on the process performance and to identify improvements.

Key project competencies

To make AM suitable for electronic end-products, individual and combined processes, quality standards, reliability and integration with current methods, all of these need to be brought to a higher maturity level. The project consortium provides the technical competencies required across the complete value-chain: materials, processes, equipment, products and applications. This

KEY APPLICATION AREAS

- Digital industry
- Digital Life

ESSENTIAL CAPABILITIES

- Systems and Components : Architecture, Design & Integration
- ECS Process Technology, Equipment, Materials & Manufacturing

PARTNERS

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Henkel AG & Co
KGaA, Neotech AMT GmbH
Robert Bosch GmbH
XENON Automatisierungstechnik GmbH
Eindhoven University of Technology
Philips Lighting B.V
Reden BV
Technolution BV
TNO - Nederlandse Organisatie voor Toegepast Natuurwetenschap
VSL

COUNTRIES INVOLVED

- Germany
- The Netherlands

PROJECT LEADER

Rob van Asselt
Philips Lighting B.V.

http://hybman.eu

KEY PROJECT DATES

1 April 2017 - 31 March 2020

consortium will also have considerable market impact, not only on the integrated electronic end-products, but also on new materials, processes and equipment, software and simulation tools, as well as knowledge/design rules.

Flexible production creates key business advantages

Flexible production is achieved through the removal of product-specific tooling; the absence of large stocks of end products; local production; and form-freedom in production. This will lead to such substantial business benefits as:

- Faster response to changes in the market, with localised production and reduced component and tooling lead times;
- Increased product diversity by adopting flexible manufacturing technologies;
- Cost-effective manufacturing of small series and customer-centric (semi-bespoke) solutions;
- New product designs offering improved functionality and new form factors not previously possible.

Now, these business benefits will give European electronics-manufacturing companies the ability to maintain their leading position in the rapidly changing market for electronic products, which increasingly demand optimised and semi-bespoke solutions. The constraints of current manufacturing infrastructure, optimised for low-cost/high-quality products that are mass produced in enormous quantities in Asia, result in standardised components and product designs. They also lead to limited shape freedom and a rigid supply chain; as well as pressure to minimise variation and allow high fixed-manufacturing costs to be amortised over many produced units.

Opportunities in flourishing markets

The AM global market is expected to grow to €6.5 billion in 2016 and exceed €19 billion in 2020. Current developments in AM for medical, automotive and aerospace applications are significant. The global market for electronics manufacturing services was €1,200 billion in 2014, with an expected growth to €1,600 billion in 2019. Two important trends relevant to Hyb-Man are the increasing demand to produce embedded electronics; and the market penetration of printed electronics and hybrid systems – signifying integration of printed and silicon-based components. Products that combine both technologies will increasingly drive a printed-electronics market. Assuming hybrid manufacturing in Europe can capture 1% of the AM market, this would already represent a potential market value of €200m in 2020.

Finally, significant advances in information and communication technology, combined with sensor technology and robotics, open up new opportunities in what is called Internet of Things (IoT). This is a very wide market and includes consumer, industrial and government applications. It is estimated that by 2020, dozens of devices per human being will be connected to the internet. This means an annual growth of 20% and a potential value of €12 trillion in terms of IoT. The demand for connected devices spans multiple industries, and is also seen as an opportunity for reshoring manufacturing. Notably, Europe has potentially a full eco-system for IoT, ranging from market leaders in smart sensors, embedded systems, software, network vendors and telecommunication, to application integrators, dynamic small- and medium-sized enterprises and industrial early-adopters.

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Hyb-Man

Hyb-Man to transform production of smart electronic systems using 3D manufacturing methods

A project within the EUREKA PENTA programme

Paris, 5 April 2018 – The EUREKA PENTA funding programme, managed by AENEAS, today highlights the Hyb-Man project. The Hyb-Man (Hybrid 3D Manufacturing of Smart Systems) project is developing additive manufacturing methods (also known as 3D printing) to enable flexible, first-time-right production of smart systems for lighting and automotive applications. Partners in Hyb-Man aim to develop 3D manufacturing as a core production technology. This will be combined with automated assembly and integration of electronic parts, design rules, in-line testing and quality monitoring. Together, these will make the entire production process more flexible. Manufacturers will be able to respond rapidly to changing market demand, expand their product diversity, offer cost-effective manufacturing of small product runs, and produce designs and form factors currently not possible.

The market for electronic products is evolving, with growing demand from manufacturers for customised and semi-bespoke solutions. However, up to now, the emphasis has been on mass production of standardised components and assemblies. Electronic products are made from separate devices and components, in a series of semi-automated processes, and then tested as a complete assembly. This requires dedicated production lines and specialised tooling. In addition, such manufacturing often relies on low-wage economy labour and transportation of parts around the world. Hyb-Man will transform this situation by basing core production on the digital processes of 3D printing which eliminate the need for dedicated manufacturing lines and product-specific tools.

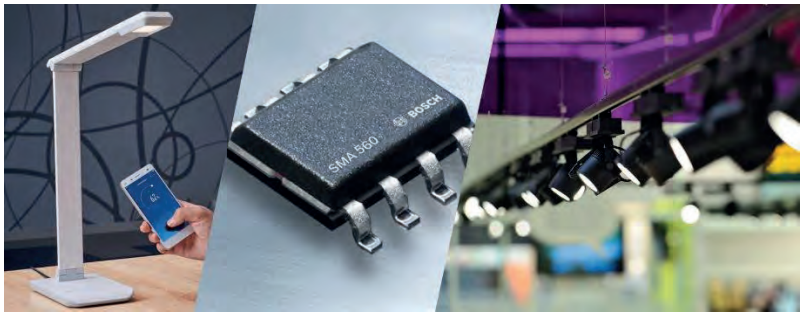


Photo credit: Philips Lighting and Bosch

The project has major potential for European industry and involves partners from across the entire electronic components and systems value chain. Hyb-Man methods will boost Europe's ability to compete in the global market for electronics manufacturing services, which was worth €1,200 billion in 2014 and is expected to grow to €1,600 billion in 2019[1]. They will enable European industry to bring back production from others part of the world, as well as reducing environmental impact and increasing opportunities for recycling. Europe's manufacturers will also be able to respond to the increasing demand for embedded electronics[2], and the emergence of printed electronics and hybrid systems (printed and silicon-based

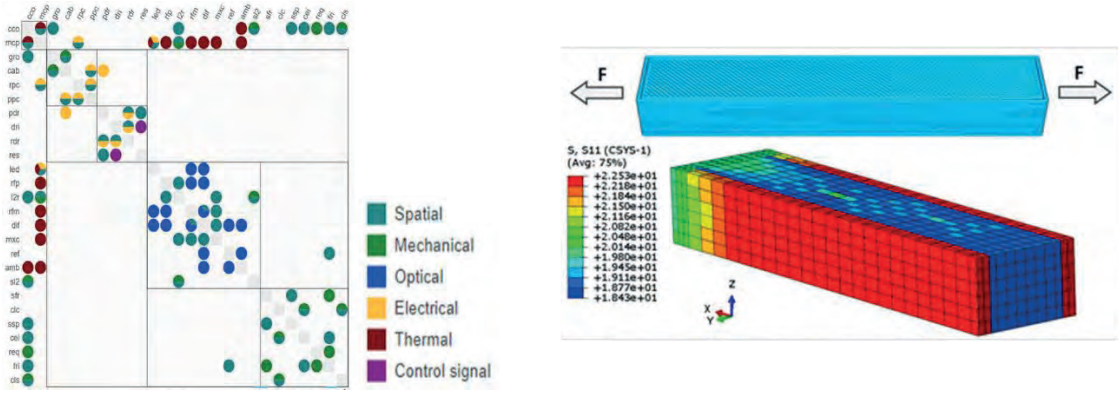
[1] http://www.researchandmarkets.com/reports/3340028/the-worldwide-electronics-manufacturing-services
[2] http://www.rm-platform.com/linkdoc/AM%20SRA%20-%20February%202014.pdf

components). These benefits are likely to be significant: just 1% of the additive manufacturing market is predicted to be worth €200 million in 2020.[3]

The benefits from the cross functional cooperation between different organisations in Hyb-Man is already clear in the first year of the project. Product specifications from end users were translated to technology requirements and first demonstrators are produced to investigate hybrid manufacturing challenges.

Examples of hybrid manufactured electronic structures: in-plane, embedded and 3D structures
Photo credit: Bosch, Philips Lighting and Neotech

An important aspect of the project is to increase product and process understanding by modelling and experimental validation. A Design Structure Matrix approach is used to visualise and optimise the relations between product properties, components and functionalities. For a more detailed understanding of process influences on product properties, a method has been developed to create simulations models automatically from the code used to drive the FDM (Fused Deposition Modeling) printer. The created models have demonstrated that in a FDM process, the orientation of the filaments have a significant effect on the local stiffness.



Design structure matrix and stress models - Photo credit: TU Eindhoven and Reden

[3] http://www.wohlersassociates.com/2015report.htm

About the PENTA programme (managed by the AENEAS Industrial Association)

PENTA is a EUREKA cluster whose purpose is to catalyse research, development and innovation in areas of micro and nanoelectronics enabled systems and applications - where there is shared national and industrial interest. Based on three key application areas, Transport & Smart Mobility, Health & Well-Being and Digital Industry for the first 3 calls, PENTA programme contributes to the development of electronic solutions with the opportunity for rapid competitive exploitation and a strong impact on European societal challenges. The PENTA project team is supporting SMEs, large corporations, research organisations and universities by facilitating access to funding, fostering collaborative work and creating consortia.

PENTA is managed by AENEAS, the European industry association

About PENTA: http://www.PENTA-eureka.eu

About AENEAS: https://aeneas-office.org

About Hyb-Man

Hyb-Man is a RD&I project consortium involving 11 partners from 2 countries. The project partners are: Philips Lighting B.V (project leader), Eindhoven University of Technology, Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V, Henkel AG & Co, KGaA, Neotech AMT GmbH, Reden BV, Robert Bosch GmbH, Technolution BV, TNO - Nederlandse Organisatie voor Toegepast Natuurwetenschap, VSL, XENON Automatisierungstechnik GmbH. National funding support is provided by Germany and the Netherlands.

About Hyb-Man: http://hybman.eu/

Hyb-Man

Ambition	Hyb-Man	Develop hybrid 3D manufacturing methods to enable flexible first time right production of smart systems	
Objectives	1. Essential technologies	2. First time right production	3. Demonstration in innovative products
Activities	• AM/3D printing • 3D electronics processing • 3D assembly & interconnect	• Process integration • Metrology and control platform • Knowledge and design rules	• Product specifications and process requirements • Demonstrator realization and evaluation

Hyb-Man develops hybrid digital manufacturing technologies to produce three-dimensional electronic functions integrated in the structural parts. Hybrid digital manufacturing encompasses the combination of additive manufacturing (3D printing) with assembly and 3D integration of electronic parts, and in-line quality monitoring into one integral production chain. Major opportunities are in flexible and cost-effective production of smart systems, enabling customised electronics for new lighting and automotive products.

Background, objectives of the project and challenges

To achieve the ambitions of the Hyb-Man project, three objectives have been formulated which address the major challenges.

The first objective is to develop the technologies needed for hybrid 3D manufacturing. This includes 3D printing of mechanical structures that meet the requirements for use in end products, printing of electrical structures in horizontal and vertical directions, and placement and electrical connection of standard components such as LEDs and sensors. Special emphasis is on the mutual compatibility of the technologies, and the inclusion of methods to monitor the progress and quality during manufacturing.

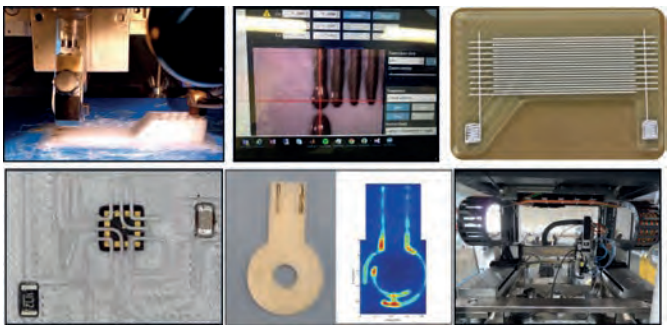
The second objective is to enable first-time-right production of systems with integrated mechanical and electrical functionality. First-time-right refers to both product designs and controlled processes. This requires deep understanding of the relation between the product properties and the processes, documented in design guidelines. This understanding is created by a combination of numerical modelling and process investigations. Process control is achieved by the integration and combination of various technologies in the proper way, including methods for in-line inspection and control.

The third objective is to demonstrate the hybrid 3D manufacturing approach in two innovative product cases: LED lighting and automotive acceleration sensors. The specifications of these products determine the technology requirements. Dedicated product designs are made, which fit with the selected technologies. Products are manufactured and evaluated against the requirements. This includes environmental and stress testing, to mimic the long-time use in actual products.

Technological achievements

Hybrid manufacturing technologies, materials and processes

Technologies to print electronics in 3D developed in the project, resulted in new and improved processes and materials. 3D printing structural materials based on extrusion (FFF) and photo-polymerisation (SLA), were combined with pick and place (P&P) of standard components, and direct write techniques of curable conductive inks and pastes. Better process understanding was generated to allow printing of fully integrated three-dimensional systems, and to improve process stability and reproducibility.



Technologies developed in the Hyb-Man project (Fraunhofer IFAM, TNO, Bosch, Neotech, VSL, Xenon, Signify)

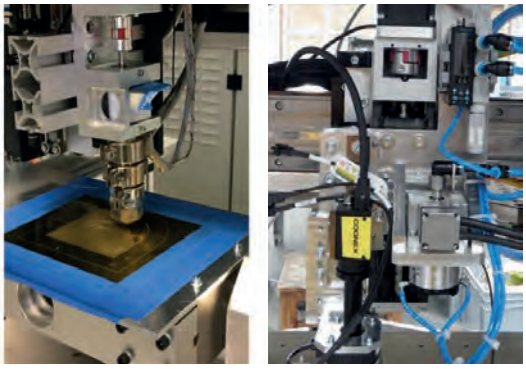
Metrology and in-line control technologies

In-line inspection and control methods were developed, including contactless resistance measurement based on Eddy-current sensing, and a vision-based pick and place system for component embedding.

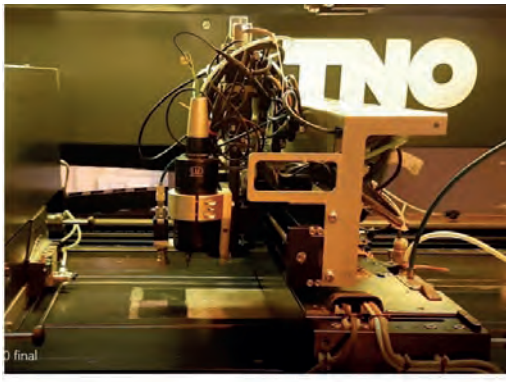
Manufacturing systems combining 3D printing, printed electronics and pick & place

The partners successfully implemented these new technologies into two prototype manufacturing systems, based on FFF and SLA technology combined with P&P. These systems can produce functional electronic products that are completely hybrid manufactured. Monitoring and control have been implemented for integrated temperature control, level sensing and camera inspection.

Manufacturing technologies developed during Hyb-Man (Neotech, TNO, Xenon)



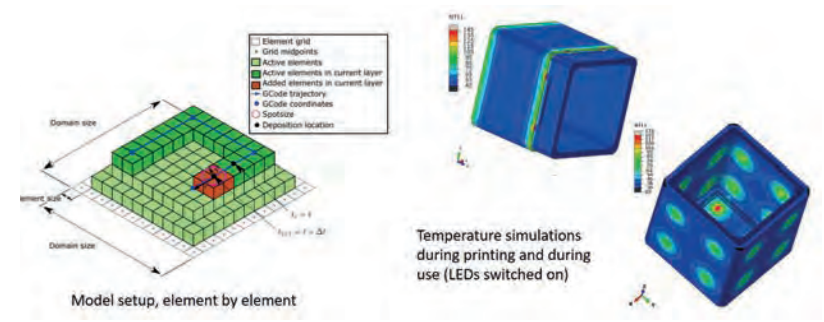
FFF based machine (left) and P&P Unit (right)



SLA based machine

Modeling and design rules

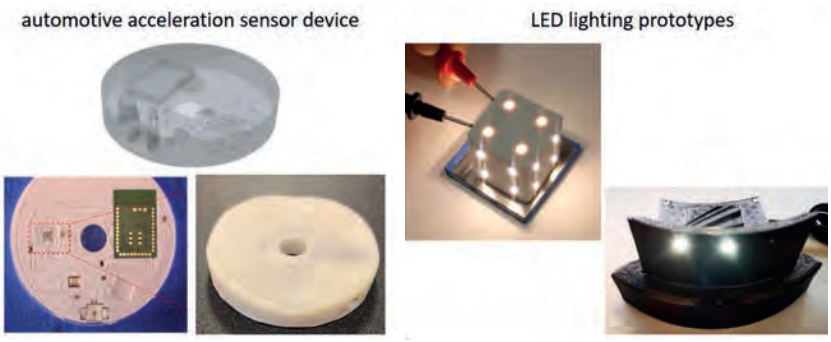
Simulation tools and strategies have been developed to model mechanical properties, stress, and temperature profiles during printing and product use. The models are dynamic and add elements in time, like in 3D printing, and achieve the right level of accuracy which is validated by experiments. Basic design guidelines are explored by implementing exemplary cases in the Reves design exploration software.



Example of simulation method and results (Reden, TU Eindhoven)

Demonstrators: automotive, LED lighting

LED lighting and automotive demonstrators including embedded tracks, connectors, LEDs, sensors and Bluetooth modules have been made by both process routes. The key electrical and geometrical properties have been reached: conductivity up to 20% of bulk copper was achieved, which is suitable for medium power applications.



Printed product demonstrators (Bosch, Neotech, TNO, Signify, Fraunhofer IFAM)

The project demonstrators have been used extensively: they are well received and clearly show the properties and opportunities to various stakeholders. Several ideas for further improvement of processes, designs and applications have been generated, to make the next step towards end-user products that benefit from the design freedom enabled by 3D embedded electronics.

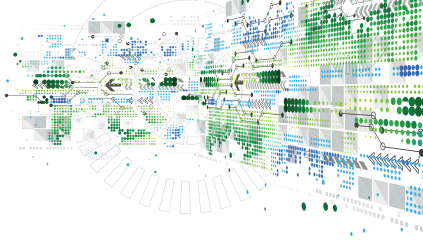
Market Potential

Additive manufacturing and 3D printed electronics markets are forecasted to grow 13-26% per year up to 2028. The 3D printing electronics market is still small and will grow as technology matures, cost is reduced, and technical specifications are met.

Up to now significant interest has been raised for the Hyb-Man demonstrators, materials, process chains, process control and modelling methods. The innovation achieved reinforces the competitive position of all partners in 3D printed electronics. Neotech has received first requests for R&D production systems and Technolution has started deploying parts of the control platform in customer projects.

The Hyb-Man market impact is expected to reach 10-100 M€ per year, based on:

- end products for automotive (Bosch), LED lighting (Signify, extension of 3D printed LED lightings), as well as other applications
- new materials (Henkel, Fraunhofer IFAM), processes and equipment (Neotech, Xenon, TNO)
- metrology (VSL) and control platforms (Technolution) to improve process control
- modelling tools and support (Reden, TU Eindhoven)



KEY APPLICATION AREAS

- Digital industry
- Digital Life

ESSENTIAL CAPABILITIES

- Systems and Components : Architecture, Design & Integration
- ECS Process Technology, Equipmen Materials & Manufacturing

PARTNERS

Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V
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Neotech AMT GmbH
Robert Bosch GmbH
XENON Automatisierungstechnik GmbH
Eindhoven University of Technology
Signify BV
Reden BV
Technolution BV
TNO - Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek
VSL

COUNTRIES INVOLVED

- Germany
- The Netherlands

PROJECT LEADER

Rob van Asselt
Signify BV

www.hybman.eu

KEY PROJECT DATES

1 April 2017 - 31 March 2020

Societal & Economic Impact

The Hyb-Man project enables the capability to bring electronics manufacturing back to Europe, by mastering a complex set of technologies. We brought together material, process, modelling, and design expertise from different partners to develop the combined technologies to the next level. Together the partners have created an eco-system which covers the complete value chain of materials, equipment, product manufacturers/OEMs and end users, which is key to realise commercial manufacturing and to drive market adaptation of 3D embedded electronics. This eco-system provides Europe with a world-leading position which will be difficult to replicate. Economic growth in Europe is further driven by the fact that the manufacturing processes are first-time-right and highly digitised, enabling cost-effective local production of high-tech electronic products in small series.

During the project an end to end approach towards first time-right production has been developed, from material to process to simulation to product. The Hyb-Man partners have demonstrated technical leadership in their field of expertise, which helps to attract talented scientists, designers, developers, and partners, thereby driving further economic growth and impact. In the coming years 7-10 new job positions per year are anticipated in the areas of material and process development, manufacturing, product design, process control, simulation tools and software. This number will increase when applications expand to other areas.

Hyb-Man also creates significant environmental benefits, because material usage is reduced, less transportation is needed due to local production, products can be recycled, and materials reused at end of life. Material usage is reduced by first-time-right production (no need for multiple print runs and less process failures), product designs optimised to achieve the functionality with minimum amount of material, and products made to order (no obsolescence or waste of products on stock).

Consumers will benefit from these developments by getting access to new smart products with additional capabilities, new form factors and a reduced environmental footprint.

Patents/Standardisation/ Publications

The partners actively disseminated the project results at various events, including large conferences such as IDTechEx, LOPEC and Productronica/ Semicon. In total 58 events were visited, and 42 oral presentations given. The know how created in the project has resulted in three patent applications.

Products manufactured by the new hybrid manufacturing methods will follow existing standards for e.g. LED lighting and automotive applications.

Future Developments

The great progress and insights generated in Hyb-Man resulted in the aim to evolve into a follow-up project, to move forward in the following areas:

- Use of functional materials and material combinations to further increase integration of electrical, mechanical, and optical functionality.
- Process industrialisation towards scalable volumes, reduced cost and cycle times, and closed loop control.
- Improved models, faster calculations and integration of simulation and design software.
- New applications that benefit from customisation and miniaturisation, using improved 3D electronics design tools and easier conversion to process settings.

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Penta (E! 9911), is EUREKA Cluster whose purpose is to catalyse research, development and innovation in areas of micro and nanoelectronics enabled systems and applications.

MIRS

16014

Infrared-sensing platform will grow detection markets and drive smart applications in medical, lighting and automotive [MIRS]

MIRS (Midget InfraRed-based Sensor systems) is developing a generic technology platform to reduce the cost of infrared (IR) sensing systems through extreme miniaturisation, and to enable the mass-manufacturing of low-cost, high-volume infrared-detector devices. This project will demonstrate this technology platform with the creation of a highly accurate contactless spot thermometer for mobile devices, as well as a demonstrator of a low-resolution infrared focal plane-array to track and count people in a smart building. This will prepare the ground for advanced automotive and other detection applications.

As markets and technical requirements grow, smart systems for people detection, activity-context interpretation, as well as, surveillance and gesture recognition, are becoming increasingly sophisticated. Although wafer-level cameras have become relatively cheap, their application still suffers from inherent problems. Fortunately, far-infrared (FIR) sensors have a high potential to resolve these issues, but technologically they lag behind consumer cameras. However, although bolometer arrays are still on the higher-end of many mass applications, thermopile sensors have the best chance to provide functional enhancements for increased ambient intelligence, smart vehicles and a broad variety of other applications.

Developing core technologies for healthcare and people detection

Project MIRS' main goals are to develop a generic innovative technology platform in order to reduce the cost of infrared (IR) sensing systems, and ultimately enable the low-cost mass manufacturing of emerging, high-volume infrared-detectors. In order to address these challenges and bring technology to a higher system-level, the MIRS project will investigate key enablers: from wafer to application system.

To achieve this, MIRS will focus on the development of a general infrared-sensor MEMS (micro-electro-mechanical system) technology platform to enable two distinct types of infrared sensors: a single-pixel infrared spot thermometer with narrow optical field-of-view (FOV); and an infrared pixel-array detector for people detection, which can ultimately be integrated in a smart building's lighting system. Now, the strength of the project is that both types of sensors are served with the same main MEMS technology platform (70% of the required modules are common to both types of sensors).

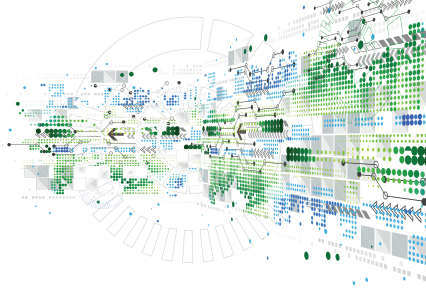
The main project element is the thermopile sensor, used to develop and deliver the two types of infrared-sensor applications:

Spot thermometer: using a single-pixel infrared thermopile sensor in combination with current applications, such as the ear-thermometer. An application demonstrator will also be developed to show the workings (on a component level) of a small-footprint, low-cost, single-pixel infrared sensor, the core of the spot thermometer. It should be noted that sensors currently available don't yet use the wafer-level-packaging (WLP) technology, but instead use a large TO39 package. This makes the end product both bulky and pricey. The large packaging is required because CMOS and the infrared sensors are not integrated, and because the pixel size of the infrared sensor is a bit large. These issues impede the integration of this kind of sensor in high-volume applications, like mobile devices.

People-detection sensor: using an infrared thermopile pixel-array and discrete optical lens, working together with such current applications, as heating, ventilation and air-conditioning (HVAC) systems. Similarly, these sensors don't yet use WLP technology, which means bulky TO39 packaging is also deployed. The current limitation of these detectors is their high cost, which impedes their use in high-volume applications, like smart building. An application demonstrator will be developed to show the workings of an infrared pixel array to track and count people in a smart building.

Prepared for challenges

The project consortium has the necessary experience and expertise to deal with key advanced concepts, such as sensor design, CMOS and MEMS integration, and wafer-level packaging with optical integration, as well as, final assembly, packaging and innovative signal processing. It is also prepared to respond creatively to typical challenges – such



KEY APPLICATION AREAS

- Transport & Smart Mobility
- Health & Well-Being
- Digital Life

ESSENTIAL CAPABILITIES

- Systems and Components Architecture, Design & Integration
- Safety, Security & Reliability
- Computing & Storage
- ECS Process Technology, Equipment, Materials & Manufacturing

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aixACCT Systems GmbH
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X-FAB MEMS Foundry GmbH
X-FAB MEMS Foundry Itzehoe GmbH

COUNTRIES INVOLVED

- Belgium
- Germany

PROJECT LEADER

Carl Van Buggenhout
Melexis

KEY PROJECT DATES

01 May 2017 - 30 April 2020

as miniaturisation of detectors using deep-vacuum eutectic wafer-bonding technology; integrating optics using silicon lenses; and moulding with packaging and assembly.

Exploiting the temperature market

Infrared temperature detectors have very broad application and market potential. That is not surprising considering temperature is a fundamental variable which plays a key role in numerous mechanical, chemical, physical, industrial and medical processes. Two technologies – pyroelectric and thermopile, which MIRS is exploiting – can be found in this market. Thermopile technology can serve almost all market segments, but in monetary value represents a smaller market share (US$82m in 2014). Although applicable in a lot more market segments, thermopile technology is currently more expensive, thus limiting penetration in massive-volume, low-cost markets. That said, growth in the thermopile market – with an estimated compound annual growth rate (CAGR) of 30% – is expected to improve in 2015-2020, thanks to smart buildings and mobile devices. The sales forecast for contactless spot thermometers for mobile devices is US$108m by 2020.

Opportunities in lighting and detection

People-detection sensors have targeted applications in smart lighting systems for office or home, and a market forecast of US$34m by 2020. It is therefore useful to look at the total lighting market for professional luminaires, systems and services, which is expected to grow from €32.5 billion in 2014 to €39.7 billion in 2020, representing a 3% CAGR over the same period. The expected growth in the professional market is primarily driven by the transition to LED and connected lighting, where professional customers are rapidly replacing conventional luminaires with LED ones, and where a significant part of the connected lighting systems will have infrared-based presence sensors embedded.

The growth of professional connected lighting systems is expected to create new opportunities in high-end, professional services. As a result, the total market size for systems and services is expected to grow from €5 billion in 2014 to €10.6 billion in 2020, measured by sales. This represents a 13% CAGR over the same period, with systems and services representing approximately 20% of the total professional market by 2020. This corresponds to a similar growth in the volume of integrated sensors.

One of the contributing factors to the increased use of LED technologies is the expanding offering of systems with sensors and networks. This trend can be defined as digital light, connected lighting systems or smart systems, which offer multiple applications for professionals and consumers, and which deliver energy-savings, among other benefits. However, these applications currently deploy pyroelectric sensors

A new emerging market is the illumination market that goes beyond providing energy savings, and addresses applications, like optimisation of office space and overall safety. Both markets are highly competitive. With new innovations in infrared-sensor technologies targeted in MIRS, European lighting suppliers can outpace the industry and offer new systems and services to defend and further grow their global leading position.

And there is an interesting spin-off from this project. Thanks to application similarities, detection sensors used to track and count people will in fact prepare the ground for advanced automotive scene detection in assisted or autonomous driving, and other applications involving motion detection.

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MIRS

MIRS infrared-sensing technology platform cuts cost of infrared sensors for growing applications in mobile, digital lighting and automotive markets

A project within the EUREKA PENTA programme

Paris, 4 April 2019: MIRS (Midget InfraRed-based Sensor systems), a EUREKA PENTA Cluster project, operated by Industry Association AENEAS, is addressing growing demand for low-cost infrared (IR) sensing systems through development of a technology platform that enables high-volume manufacturing. From thermometers built into smartphones to the detection of people in buildings via sensors integrated in digital lighting systems, IR sensing has vast potential. Sales for infrared detectors are expected to reach approximately 500Mio USD by 2020 with "smart building" and "smart heating, ventilating, and air conditioning (HVAC)" being principle drivers for growth[1].

Furthermore, because the ability to detect heat via IR sensing is so widely applicable, it can be used in many other situations as well. These include medical processes, warning of dangers in the environment, contactless detection of unwanted heat losses or generation in buildings, and detection of pedestrians by self-driving cars. The MIRS project aims to address the many market opportunities by delivering a combination of very small size, high performance and low-cost based on its generic technology platform and extreme miniaturization.

Specifically, MIRS is developing a MEMS (micro-electro-mechanical system) platform that integrates IR sensors and the necessary optics at wafer level (i.e. on the silicon wafers on which chips are made). This platform will provide 70% of the required modules for two key types of sensor: single pixel infrared spot thermometers and infrared pixel-array detectors for people detection.

Moreover, by combining both pyroelectric and thermopile sensing, the MIRS platform will open the way to new business opportunities. Thermopile sensors measure radiated energy and are widely applicable, whereas pyroelectric sensors detect changes in radiation and are principally used for motion detection. Bringing them together in a single platform will enable applications in areas such as low-energy products and movement detection without the need for digital signal processing. Furthermore, while the thermopile market is currently relatively small, it is expected to grow at an estimated compound annual growth rate of 30% or more, if costs and size can be reduced.

The MIRS consortium pursuing these goals forms an innovation partnership that spans the entire value chain. It includes organisations and companies from research (CAU, ISIT) and production (XMF, MFI, AIX) through to the market (MELEXIS). Its members bring expertise in all areas from sensor design and CMOS and MEMS integration through to wafer-level packaging with optical integration, as well as know-how in final assembly, packaging, testing and innovative signal processing.

[1] Source : Yole Development estimates, November 2015

About the PENTA programme (managed by the AENEAS Industrial Association)

PENTA is a EUREKA cluster whose purpose is to catalyse research, development and innovation in areas of micro and nanoelectronics enabled systems and applications - where there is shared national and industrial interest. Based on the Electronic Components & Systems (ECS) Strategic Research Agenda (SRA) key areas and essential capabilities, PENTA programme contributes to the development of electronic solutions with the opportunity for rapid competitive exploitation and a strong impact on European societal challenges. The PENTA project team is supporting SMEs, large corporations, research organisations and universities by facilitating access to funding, fostering collaborative work and creating consortia.

PENTA is managed by AENEAS.
More on PENTA: http://www.penta-eureka.eu
More on AENEAS: https://aeneas-office.org

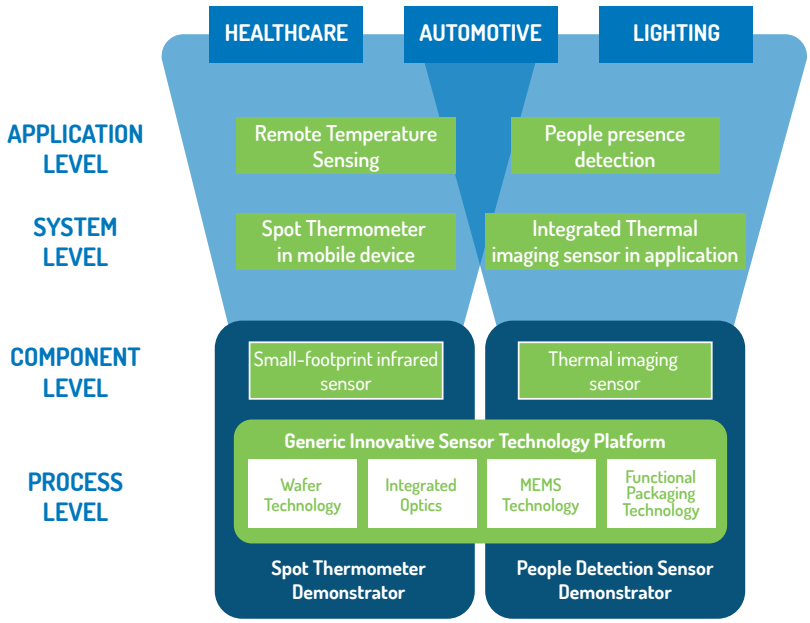
About MIRS

MIRS is a RD&I project consortium involving 6 partners from 2 countries. The project partners are: Melexis (Project leader), aixACCT Systems GmbH (AIX), Christian-Albrechts-Universität Kiel (CAU), Fraunhofer-Institut für Siliziumtechnologie ISIT, X-FAB MEMS Foundry GmbH (XMF), X-FAB MEMS Foundry Itzehoe GmbH (MFI). National funding support is provided by Belgium and Germany.

More on MIRS: http://www.penta-eureka.eu/downloads/ProjectProfiles/penta-project-profile-16014-mirs.pdf

16014

An Infrared-sensing platform that will grow detection markets and drive smart applications in medical, lighting and automotive. [MIRS]



Scope of the MIRS project – including the three targeted application domains of Healthcare, Automotive and Lighting

MIRS (Midget InfraRed-based Sensor systems) has developed a generic technology platform to reduce the cost of infrared (IR) sensing systems through extreme miniaturisation, and to enable the mass-manufacturing of low-cost, high-volume infrared-detector devices. The project has demonstrated this technology platform with the creation of a highly accurate contactless spot thermometer for mobile devices and wearables, as well as a demonstrator of a low-resolution infrared focal plane-array to track and count people in a smart building. This will prepare the ground for advanced automotive and other detection applications.

Background, objectives of the project and faced challenges

Infrared (IR) sensors for temperature measurements that are responsive in the wavelength domain from 3µm to 15µm suffer today from expensive optical elements and packaging solutions.

There are two main reasons why infrared detectors are not yet integrated as temperature measurement systems in high-volume applications:

- Optical integration costs. Suitable long-wave infrared transparent materials like ZnSe, CaF or Ge are expensive and not always robust for the target application.
- Packaging cost and size. The state-of-the-art package of this kind of sensors is bulky and doesn't allow an easy integration in many products.

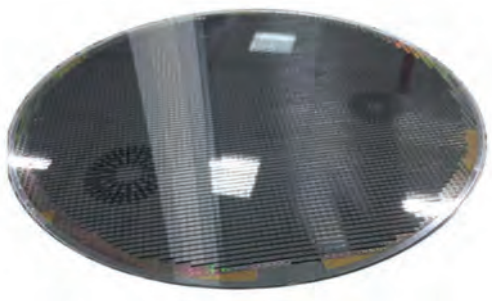
The primary goal of the MIRS project was to develop a generic innovative technology platform in order to reduce the cost of the IR sensing systems by extreme miniaturization, with the final objective to enable low-cost mass manufacturing for emerging high volume infrared detector markets.

The challenges lay in the process integration of the key technology building blocks that were envisioned in this project, such as: the deep vacuum wafer-level bonding of cap wafers to monolithically integrated MEMS-CMOS silicon wafers; the integration of a novel optical silicon lens technology with cap wafers; the integration of pyroelectric elements on MEMS-CMOS silicon wafers; and the compatibility of Through-Silicon Vias (TSVs) into permanently cap-bonded monolithically integrated MEMS-CMOS silicon wafers.

Technological achievements

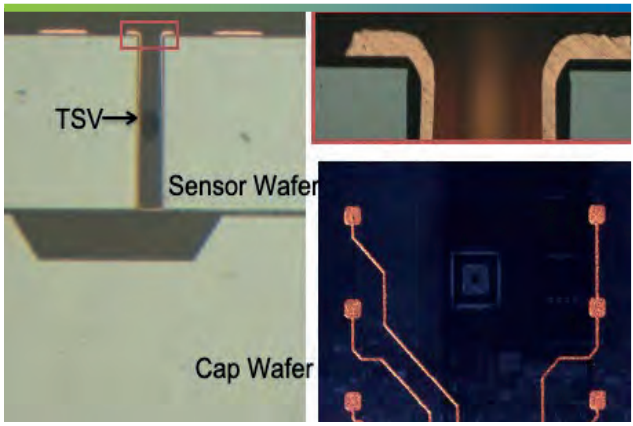
Within the MIRS project, 4 key technological innovations have been achieved.

The first key innovation relates to the technology required to manufacture infrared sensors. Due to the nature of the infrared sensor as a micro-electro-mechanical system (MEMS) sensor, it must be embedded in a hermetic housing, with a low pressure inside that housing, in order to maximize the sensitivity of the sensor. To achieve the lowest-cost manufacturing technology, that hermetic housing with low pressure is created on the wafer-level, whereby a silicon cap wafer is hermetically bonded to a silicon sensor-CMOS wafer. MIRS-partner XFAB has demonstrated a major improvement of the Technology Readiness Level (TRL) of their hermetic wafer-level bonding technology which enabled to create demonstrators on the product-level by MIRS-partner Melexis.



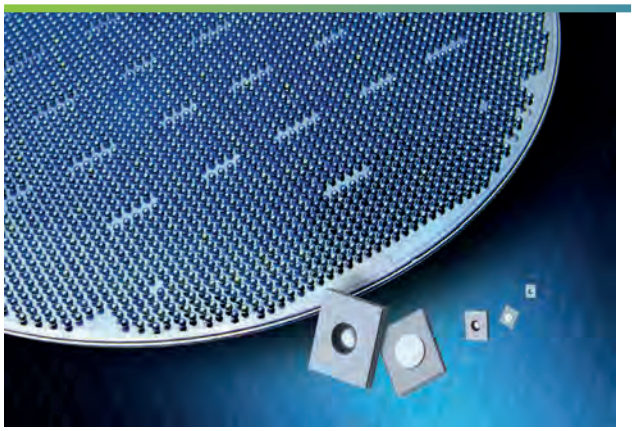
Wafer-level hermetic sealing of more than 5000 infrared sensor chips under deep vacuum
Copyright XFAB

The second key innovation concerns the integration of Through-Silicon Vias (TSVs) inside permanently bonded infrared sensor wafers, with the goal to create infrared sensor systems with a reduced footprint by enabling chip-scale packages. MIRS-partner X-FAB MEMS Foundry GmbH (XMF) has advanced their TRL to demonstrate a wafer-level feasibility of integrated TSVs inside infrared sensor wafers with permanently bonded cap wafers.



Wafer-level integration of Through-Silicon Vias (TSVs) inside permanently bonded infrared sensor wafers
Copyright XFAB

For the third key technology innovation, MIRS-partner Fraunhofer-Institute for Silicon Technology (ISIT) has developed a patented approach to integrate high-end silicon planoconvex lenses inside cap wafers by using silicon balls with a pre-sorted Radius-of-Curvature (ROC). A video that shows the fabrication and demonstration is available on public platforms: https://www.youtube.com/watch?v=lXm9ALz89Qc



Demonstrator of a cap wafer with more than 5000 silicon lenses on a wafer

The inset shows singulated caps with planarized silicon ball lenses resulting in a planoconvex silicon lens inside a cap for integration with an IR sensor.
Copyright Fraunhofer ISIT

Within the fourth key technology innovation pillar of the MIRS project, MIRS-partners Fraunhofer ISIT and University of Kiel (CAU) have integrated AlScN pyroelectric elements on a CMOS-MEMS wafer. MIRS-partner aixACCT has developed a laser-based measurement tool in order to characterize those AlScN layers, which was successfully used to assess the performance of the AlScN pyroelectric elements that were integrated on the CMOS-MEMS wafer in the project.

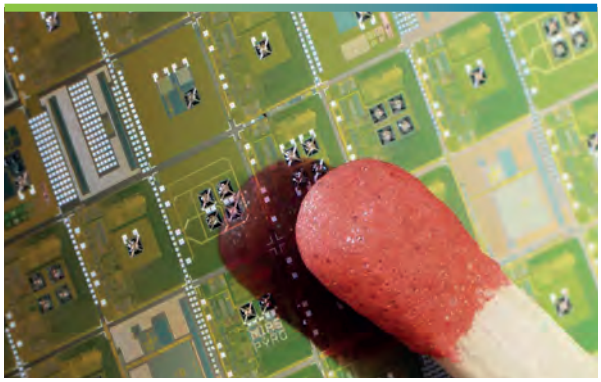


Illustration of the integrated AlScN pyroelectric elements on a CMOS-MEMS wafer

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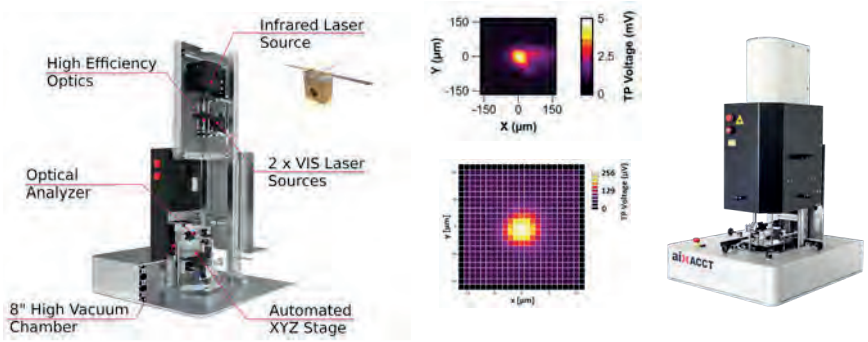

Illustration of the measurement tool developed by aixACCT for the characterization of pyroelectric materials

The measurement tool developed by aixACCT consists of an infrared laser source, coupled with fiber optics to create an illumination spot on a test wafer, located in an 8" vacuum chamber on a chuck, coupled to an automated XYZ stage.

Copyright: aixACCT

Market Potential

With the core technology advancements that had been reached in the project, the complete MIRS consortium built two important demonstrators: a contactless single-pixel IR temperature sensor as well as a multi-pixel IR detector. The high-sensitivity single-pixel IR temperature sensor can be combined with the innovative lens approach to result in a sensor with a narrow optical Field of View (FOV) which enables contactless fever thermometer applications without the need to approach the sensor close to the target person. This enables the device-maker Melexis to approach multiple markets in the mobile health domain, like fever thermometers as well as mobile devices for continuous health monitoring, such as smart watches, sports watches and medical wearable devices.

The multi-pixel IR array detector has large potential in fever screening access control applications – which is a booming COVID19-driven market, but also serves emerging markets like people detection applications for smart buildings. Lower-cost systems could drive up the volumes from high to mid-end systems in Heating, Ventilation and Air-Conditioning (HVAC) applications, in which Melexis has further enhanced its position. Also, other small appliances and industrial applications, such as cook top safety monitoring, electrical cabinets safety monitoring or production parameters monitoring (e.g. for 3D-printer materials) are expected to see a further growth, albeit not as fast as for the consumer, medical and smart building markets.

Last but not least, the automotive trends of electrification, personalization and autonomous driving requires IR temperature sensors for better personalized thermal comfort inside the car, for driver/passenger monitoring to detect (e.g. occupancy, potentially nausea, drowsiness and others). Device-maker Melexis has an excellent position as one of the key suppliers to the automotive market with an average of 11 Melexis chips in every new car.

Application domains of IR temperature sensors

The left picture shows a potential people detection sensor in smart buildings, in which smart building algorithms can be applied to count the amount of people in meeting rooms, thereby enabling to better regulate the Heating, Ventilation and Air Conditioning (HVAC) system, as well as detecting unoccupied or over-dimensioned spaces in smart offices – all contributing to reduce our common environmental footprint as well as at the same time provide comfort for people.

The right picture illustrates an in-cabin automotive application in which the multi-pixel IR array detector can support the driver-assistance system for a more accurate feedback signal of the driver temperature in the regulating loop of the HVAC system.

Copyright Melexis

KEY APPLICATION AREAS

- Transport & Smart Mobility
- Health & Well-Being
- Digital Life

ESSENTIAL CAPABILITIES

- Systems and Components Architecture, Design & Integration
- Safety, Security & Reliability
- Computing & Storage
- ECS Process Technology, Equipment, Materials & Manufacturing

PARTNERS

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Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V.
University of Kiel
X-FAB MEMS Foundry GmbH
X-FAB MEMS Foundry Itzehoe GmbH

COUNTRIES INVOLVED

- Belgium
- Germany

PROJECT LEADER

Carl Van Buggenhout
Melexis

KEY PROJECT DATES

01 May 2017 - 31 July 2020

Societal & Economic Impact

The societal impact of IR temperature sensors can be split into two domains. The first domain comprises contactless body-core thermometers with medical accuracy for healthcare applications (like fever thermometers). The current COVID19 pandemic has massively boosted the need for contactless thermometers in medical wearable devices, which requires these IR temperature sensors to be small, lightweight and low-cost – yet very accurate – in order to determine a person's body-core temperature. Within the MIRS project, the team has focussed on miniaturizing IR temperature sensors with these objectives, and they have successfully created a demonstrator of such an IR temperature sensor.

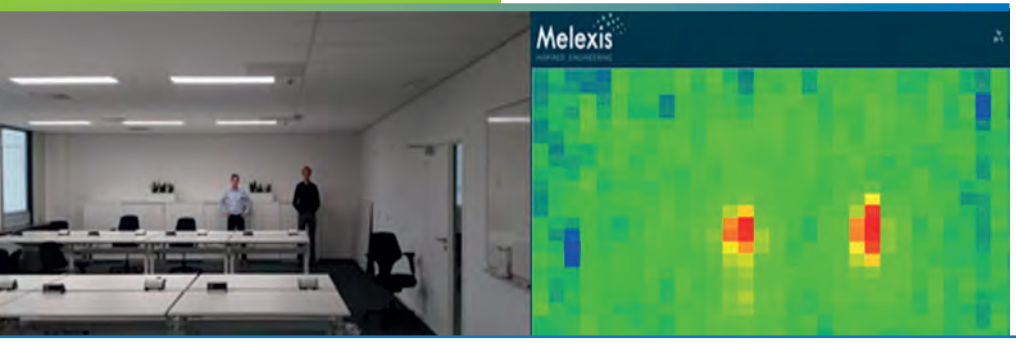
The second domain of interest is attributed to a growing market of smart systems for people detection, activity context interpretation, surveillance and gesture recognition – which all are becoming increasingly sophisticated. Although standard cameras have become relatively cheap, their application still suffers from two major problems. Above all, privacy concerns of people feeling observed need to be seen as a social requirement that technologists have to fulfil. Secondly, the need for external light with CMOS/CCD imagers is often an unresolvable problem. IR detectors don't require external light because all objects emit IR radiation, which can be detected with these IR detectors. This kind of IR detectors can only detect but not recognize people because they only measure differences in temperature. As such, IR detectors have a high potential to resolve these issues. The MIRS demonstrator of an IR detector also prepares the ground for advanced automotive scene detection in assisted or autonomous driving.

Patents/Standardisation/ Publications

Throughout the execution of the project, the university of Kiel (CAU) has discovered ferroelectricity in AlScN – which to the best knowledge of the MIRS team hadn't been reported upfront – and which could enable novel microelectronic applications. The Fraunhofer-Institute for Silicon Technology in Itzehoe (ISIT) has been granted a patent on their novel method of integrating silicon optical lenses in cap wafers, which can be wafer-bonded to IR sensor-CMOS wafers. That achievement enables them to further develop their technology, which has the potential to drastically reduce the cost of infrared silicon optics. In the MIRS project patent applications have been generated by XMF which are now being assessed by the patent offices. Besides, also many technical papers have been published and presentations have been given on the key technology building blocks which were scoped in the project.

Future Developments

The MIRS project delivered very exciting results, which will be exploited by further advancing these innovative technologies, towards achieving a Technology Readiness Level (TRL) that enables mass production of new improved products. The Christian-Albrechts-University of Kiel (CAU) has decided to continue their explorative work on ferroelectricity of AlScN with the aim to enable novel microelectronics applications, and the measurement tool of aixACCT will be further extended to other applications.



Demonstrator of an IR People Detection Sensor for smart building applications

On the left: image of a scene as captured by a standard camera; on the right: visualized image of the same scene as detected by the MIRS IR People Detection Sensor. The two people in the scene are detected by the MIRS IR People Detection Sensor as two individual hotspots in the room, but they can't be identified, which resolves the privacy concern of standard cameras.
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Serene-IoT

16004

Remote care and diagnostic tools offer patients better, longer and autonomous 'active life' at a much lower price

[SERENE-IoT: **S**ecured &**E**ne**R**gy **E**ffici**N**t h**E**alth-care solutions using **IoT** technologies]

With a growing ageing population (in which many could experience multiple chronic diseases), governments and health authorities in the European Union are rightly concerned with rising health-care costs. Remote health-care offers a way of alleviating this problem and the SERENE-IoT project supports this approach through quality remote-care and diagnostic tools based on advanced, smart health-care, and the internet of things.

Medical progress in last decades have significantly fallen mortality rates and have staidly improved our global health and this transformation is impacting seriously our health and social care systems. Some 30% of the population in the European Union (EU) will be over 65 by 2030; two out of three people of retirement age will have at least two chronic illnesses. Currently, 70% of health-care are on chronic illnesses and 41% on hospital care; and health-care costs in the EU represent 9% of GDP and are expected to reach 10.5% in 2060. Fortunately, the convergence of the health-care and the high-tech mass-market ecosystems is coming to a point where things and people are increasingly connected, as with the internet of things (IoT), and where health-care is partly divided between hospital and home. Impacting our health models, the Internet of Medical Things (IoMT) is born. Unsurprisingly, the economic and social impact due to chronic diseases in Europe will make this move mandatory in order to keep medical and social services sustainable and improve patients' quality of life.

Remote health-care and diagnosis through the internet of things

SERENE_IoT will focus on benefiting the patient with an improved quality of life and better access to health-care in general, as well as reducing health-care costs. It will achieve this by addressing the specific needs of patients being handled remotely by professional caregivers through the development, by European companies and research institutions, of smart e-health IoT devices and an advanced architectures.

The core values of this project are:

- High quality of health-care services;
- High level of trust (security, safety, privacy, robustness);
- Efficient execution of required tasks;
- Interoperable and compatible information technology (IT) systems;
- Reduced costs compared to current traditional care.

Major project outcomes and deliverables will be three Clinical Prototypes that will validate benefits derived from remote-care scenarios. In line with the so-called medical innovation cycle (up to 'clinical prototype' level), SERENE-IoT will develop three medical devices to meet the following medical challenges:

1. Providing homebased health-care services remotely: by developing the first low-power medical IoT module validated with two class IIx medical devices;
2. Early detection of Methicillin-resistant bacteria: by developing the first low-power mobile detector for MRSA (antibiotic-resistant bacteria);
3. Fall prevention: by developing a fully wireless insole for fall detection and risk monitoring.

These medical devices will be validated in real clinical environments under mono-centric and multi-centric clinical conditions. Importantly, the three demonstrators will be used to provide the necessary validation of advanced concepts needed by European industry for the development and manufacture of products and services in the area of remote medical-care.

Importantly, SERENE-IoT will contribute to the evaluation of a secure, end-to-end, IoT system platform in 'real-life' scenarios (including the use of the proposed health-care data structure), while demonstrating the resulting benefits. Certification and industrialisation phases will follow the SERENE-IoT project.

The right mix means a balanced and holistic approach

The SERENE-IoT consortium – from France, Germany and Spain – provides a balanced and holistic approach to this project, thanks to the mix of project partners (large firms, SMEs and academia) which covers the health IoT ecosystem – from integrated device manufacturer (IDM) and original equipment manufacturer (OEM), to end-user service-provider. And the involvement of industrial supply-chain and health-care providers ensures the right devices and services are developed. In addition, the consortium, specifically the academics, will be involved in promoting standards, sharing technical material and raising awareness of the achieved results through international journals,

KEY APPLICATION AREAS

- Health & Well-Being
- Energy
- Digital Industry
- Digital Life

ESSENTIAL CAPABILITIES

- Systems and Components Architecture, Design & Integration
- Connectivity & Interoperability
- Safety, Security & Reliability
- Computing & Storage
- ECS Process Technology, Equipment, Materials & Manufacturing

PARTNERS

CHU Grenoble / CEA LETI/LIST / Flavia IT / Fraunhofer / Fresenius Kabi / Grenoble INP - LCIS / LMU Klinik / Maatel / Medtronic / Idemia / Orange Labs / Seidor / SensingTex / SGS-TÜV Saar / Spring Techno / STMicroelectronics / UAB / XFAB

COUNTRIES INVOLVED

- France
- Germany
- Spain

PROJECT LEADER

Armand Castillejo
STMicroelectronics

Twitter: https://twitter.com/SereneIoT

KEY PROJECT DATES

01 June 2017 - 30 November 2020

publications, as well as conferences and exhibitions.

Thanks to SERENE-IoT, project partners – who are also stakeholders from across the healthcare value-chain – will validate new advanced IoT-based technical concepts, and subsequently create new market opportunities in the European health-care industry, paving the way for the deployment of such connected devices in the EU.

The health-care industry is expected to evolve towards a more competitive and efficient marketplace as a result of new flourishing business models based on remote health-care and diagnostics. Now, while the process to reach this goal will further evolve, it could also be slow, nonlinear and include parallel initiatives. That is why supply-chain members need to contribute to a common, acceptable solution, and why such a consortium – which covers the complete supply-chain and works in a collaborative way – was formed initially.

Benefiting health and health-care stakeholders

Techniques developed in this project could synergistically improve energy efficiency, as well as, safety and security, of IoT systems. SERENE-IoT will also impact all stakeholders in the very complex health and health-care ecosystem. The health-care market has a particularly high number of stakeholders with complex 'interactions', which vary according to country, culture and local laws. IoT systems will collect, process and make available several types of information: not only medical data related to a patient (caregiver's concern), but also device-related information, such as device status and location (manufacturer's concern) and medical consumables (purchasing department's concern) and the like. Importantly, the introduction of IoT technologies in the medical field could also open up new application areas. However, exploiting this data properly will require reorganising the market value-chain in order to provide new and innovative services.

Healthy IoT and health-care markets

Several IoT surveys forecast up to 50 billion connected objects in 2020, with an exchange of more than 50 trillion gigabits of data (according to IDC). This is what is termed the third wave of the internet, which is expected to have a tremendous impact at different levels. At the technological/scientific level, drivers will be new scientific developments (like 'big data') through multiple, connected smart objects with safety, privacy, security and power constraints. At the societal level, our daily lives will be improved by such innovations as smart health, smart cars and smart energy. And on the industrial/economic level, there will be a continual creation of new business opportunities for established companies, SMEs and start-ups in multiple innovation domains.

According to the 'Yole Development' report issued in September 2017, analysts estimate that there are today more than 45 million IoMT devices and more than 235 million in 2020. Based on this report, two major medical devices can benefit from the connectivity: the existing medical devices moving to connected medical devices and the new connected medical devices created on purpose. This market is distributed in the 4 following segments: implanted patients, professional monitoring, self-quantified patients, lack of autonomy patient assistance.

The global Connected medical devices market represents $9.6B revenues in 2017 and will grow to reach more than $23.7B in 2022. Thanks to IoT technology the patient become a genuine actor of his own care and of his social environment, and thus shaking up our current social representation of a dependent person.

The clinical prototypes produced by SERENE-IoT illustrate perfectly the picture depicted in Yole report. Adding connectivity on already existing medical devices and developing medical devices on purpose thanks to connectivity, the clinical prototypes address the three segments having the best perspectives in the IoMT market:

- Professional monitoring segment with CAGR: 21.4%
- Self-quantified segment: 18.7%
- Assistance segment: 15.5%

Finally, a June 2015 report from McKinsey Global Institute, estimates that 89% of the potential annual economic-impact of health-care IoT applications in 2025 will be in advanced economies, versus 11% in developing ones; and Europe will be one of the first to deploy these new technologies.

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Serene-Iot

SERENE-IoT: creating secured connected healthcare devices for higher patient quality of life at lower cost for health services

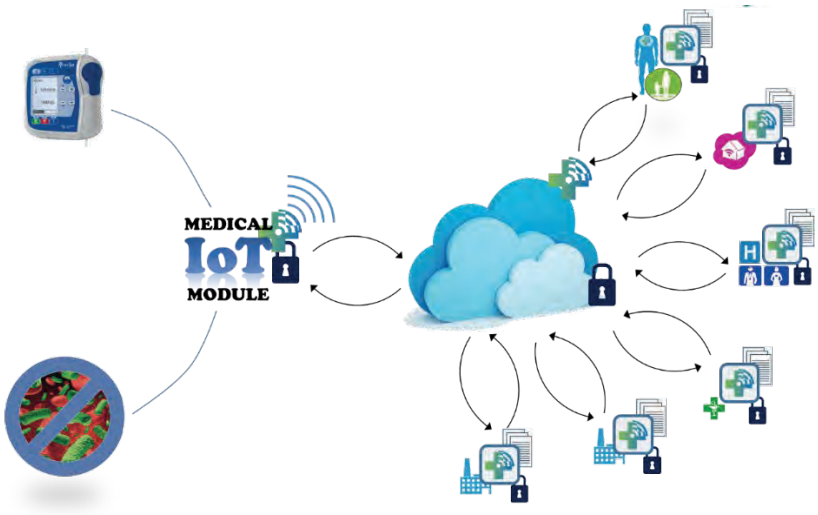
A project within the EUREKA PENTA programme

Paris, XX November 2018 – SERENE IoT, a project within the EUREKA PENTA Cluster managed by the Industry Association AENEAS, is developing clinical prototype solutions for connected healthcare services and diagnosis at home, based on Internet of Things (IoT) devices. Aging populations, a rise in chronic disease and a shortage of healthcare professionals in developed and developing countries are putting severe strains on healthcare systems. SERENE-IoT is focusing on solutions that will have positive impacts on quality of life and cost reduction in three domains. The first is remote healthcare ('hospital at home') based on an internet-connected infusion / nutrition pump. The second is rapid, early detection of antibiotic resistant infection (Methicillin-resistant bacteria) and the third is fall prevention via a device that monitors the wearer's gait.

In the European Union alone, estimates indicate that 30% of the population will be over 65 years-old by 2030, and two out of three people in retirement age will have at least two chronic diseases. Currently, 70% of health care costs are spent on chronic diseases, and 41% are dedicated to hospital care. By supporting the shift towards 'hospital at home' care, early detection and prevention, SERENE-IoT seeks to reduce healthcare expenses in its three domains by 50%, as well as promoting lifelong health and high-quality long-term support for people with chronic and / or advanced disease.

Security, safety and privacy are central to the SERENE-IoT project, ensuring that the devices will fully protect sensitive medical data within an end-to-end IoT system platform. In addition, the project will tackle other technical challenges to create devices that are easy to use, interoperable, small, and low power so they can operate for extended periods without recharging. Overall, the project aims to deliver societal and economic benefits, while opening market opportunities for European companies – globally, the healthcare IoT market is expected to grow from USD 32 billion in 2015 to USD 163 billion by 2020[1].

The SERENE-IoT consortium brings together key players from across the value chain, which allows for a shared understanding of needs, development of complementary technologies and a common vision for connected healthcare and the 'hospital at home' concept. The consortium comprises two care givers, seven large enterprises, five SMEs and five university labs and research institutes from three countries. These include specialists in telecommunications and safety-security systems providers, as well as healthcare solutions manufacturers.



Remote Healthcare flowsheet diagram

About the PENTA programme (managed by the AENEAS Industrial Association)

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PENTA is managed by AENEAS, the European industry association
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About AENEAS: https://aeneas-office.org

About SERENE-IoT

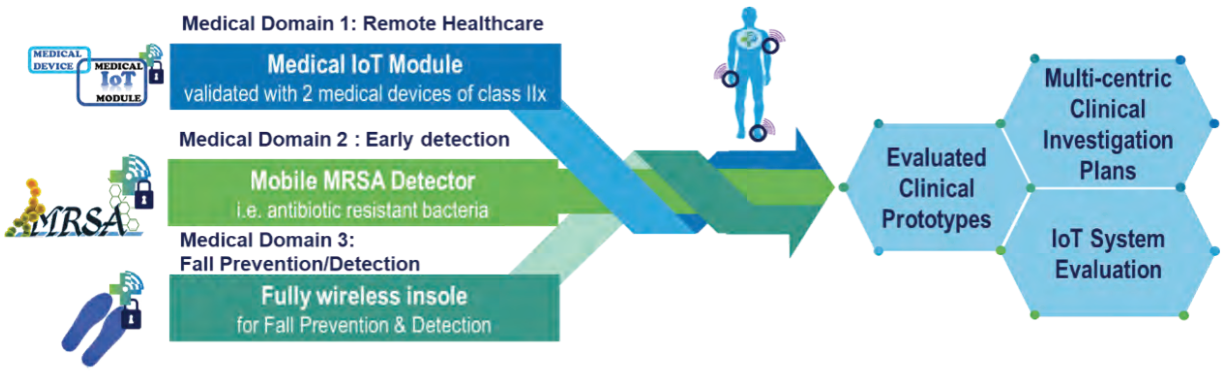
SERENE-IoT is a RD&I project consortium involving 19 partners in 3 countries. The project partners are: STMicroelectronics (Project leader), CEA LETI, CHU Grenoble, Flavia IT, Fraunhofer, Fresenius Kabi, Grenoble INP- LCIS, Idemia, LIST, LMU Klinik, Maatel, Medtronic, Orange Labs, Seidor, SensingTex, SGS-TÜV Saar, Spring Techno, UAB, XFAB.

16004

SERENE-IoT addressed the needs of patients being followed remotely by healthcare professionals by developing, in Europe, advanced smart e-health IoT medical devices & an end-to-end architecture.

[**S**ecured & **E**ne**R**gy **E**fficie**N**t h**E**alth-care solutions using **IoT** technologies]

The SERENE-IoT project contributed to the development of high-quality connected healthcare services and diagnostic tools based on advanced smart healthcare Internet of Things (IoT) devices, fully manufactured in Europe. It thereby enabled a high level of 'quality of service' for patients being followed remotely by professional caregivers, and at a lower cost than traditional care provided today.



SERENE-IoT objectives

Background, objectives of the project and challenges

Regarding the introduction of IoT technologies, the major project objectives were:

1. development of three clinical prototypes of new medical devices supporting security, safety and privacy, and their complete validation within a secured end-to-end IoT system platform
2. provision of clinical investigation plans associated with each device
3. implementation of a secured IoT system platform to validate the three prototypes in real-world scenarios, including the proposed healthcare data structure
4. demonstration and evaluation of the benefits obtained from this new secure, remote healthcare control and monitoring system. It should be noted that a reduction in healthcare expenses was expected.

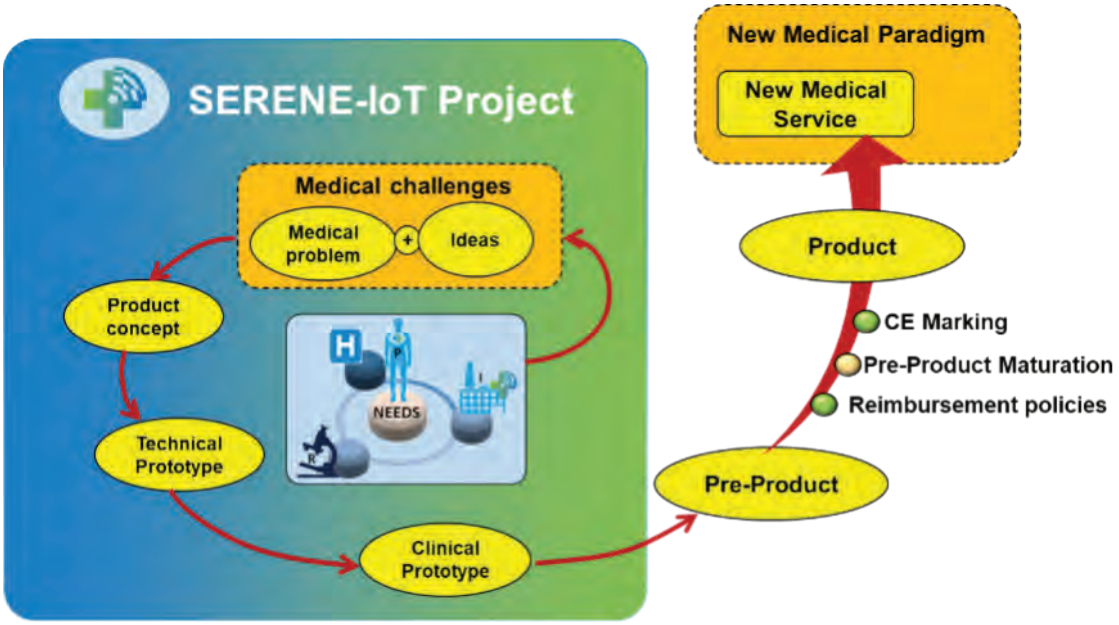
These objectives will lead to new market opportunities for the European healthcare industry by establishing a basis for the creation of new business models.

SERENE-IoT addressed three main medical challenges in the following domains:

- Remote healthcare – by moving care services from hospital to home and investigating two medical use-cases: (1) the first wearable low-power 'Medical IoT Module', bringing connectivity to connected infusion / nutrition pump systems in Medical Device class IIx, and (2) a post-surgery infection detection system
- Early detection – investigating a methicillin-resistant bacteria (MRSA) mobile diagnostic device
- Fall prevention – by investigating wireless insoles for gait analysis and fall prediction

In line with the medical innovation cycle up to the clinical prototype stage, three devices, one per domain (as described below), were developed and subsequently validated by healthcare professionals over the course of the project. The certification and industrialisation phases will follow the end of SERENE-IoT project under the responsibility of the relevant MedTech OEM.

The main technology aspects addressed by the project were low-power, multi-protocol connectivity, end-to-end system security, interoperability, and more adequate computing power.



SERENE-IoT within the medical innovation cycle

Technological achievements

SERENE-IoT delivered the three following technical prototypes:

1. A Medical IoT Module, investigated in two different medical devices (class IIx)
2. A connected methicillin-resistant staphylococcus aureus (MRSA) detector
3. A pair of wireless insoles for fall prevention

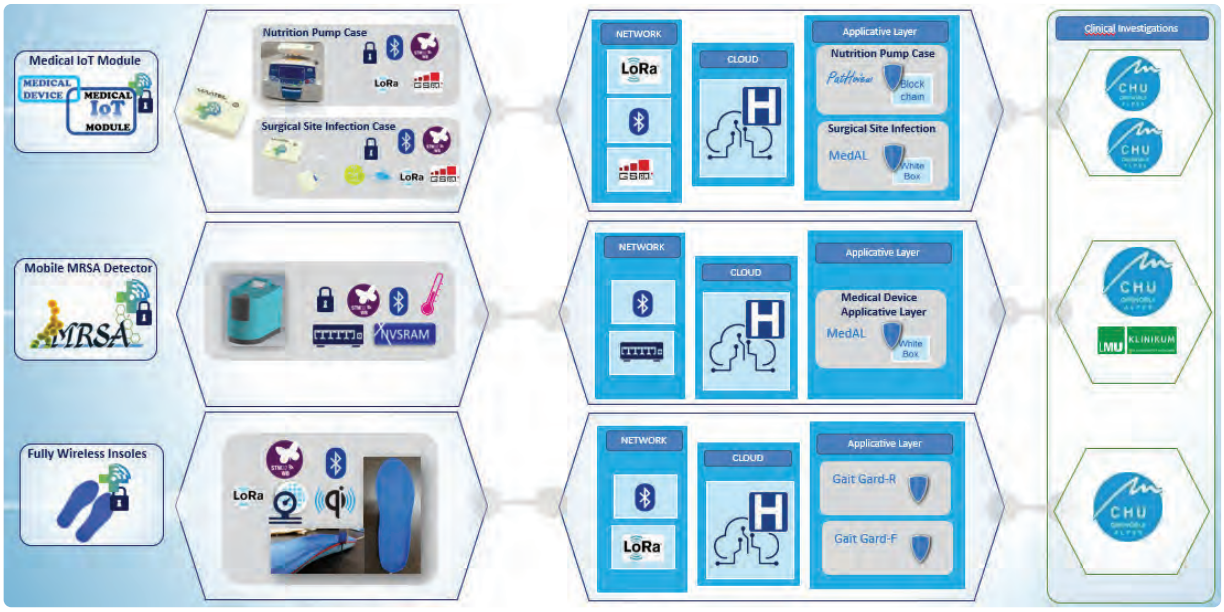
The three technical prototypes were integrated into an installation, along with the relevant dedicated platforms, at the Grenoble University Hospital (CHUGA). The complete solution, dedicated to real world use of the three prototypes, was installed in the hospital infrastructure to carry out an end-to-end demonstration in clinical settings with dedicated application layers. The Medical IoT Module was integrated with two different application layers: 'PatHView' dedicated to the nutrition pump case, and 'MedAL' for the surgical site infection (SSI) detection case. MedAL was also used with the connected MRSA detector. For the wireless insoles, the 'Gait-F' application layer for fall prevention was also duplicated into a 'Gait-R' version which was implemented in a rehabilitation use-case proposed thanks to the project collaboration.

All three technical prototypes received feedback from clinicians to enable continuation of the medical innovation cycle.

The Medical IoT Module received feedback from the artificial nutrition unit and the digestive surgery unit (of CHUGA) regarding both use cases (the nutrition pump and the SSI case). Clinical investigations on real patients continue even after at the end of the SERENE-IoT project in the nutrition pump case (Medical IoT Module), highlighting the strong level of clinician interest in this prototype. The connected MRSA detector received feedback from the Hospital Hygiene Dept (CHUGA) and from KUM (University Hospital of Munich), while the wireless insoles received feedback from the Geriatrics and Ortho-geriatrics departments in CHUGA. For all the prototypes, next project plans are being finalised to continue climbing the stairs of the medical innovation cycle.

All the pre-clinical and clinical evaluations have provided All the pre-clinical and clinical evaluations have provided key functional, usability and clinical feedback to manufacturers by focusing on critical points. This will allow improvement of these devices and development of final products optimised for clinical usage. Usually, six years are needed to go from initial idea to first prototype. In the SERENE-IoT project, this time has been cut in half.

Thanks to the project, academic partners have also offered access to a platform that allows for the exploration of security issues. The platform illustrates security threats on medical devices which do not have proper countermeasures and validates software and hardware countermeasures for specific use cases (such as SecPump developments).



End-to-end synoptics

Market Potential

The MedTech partners in the SERENE-IoT project are active in the global IoT in healthcare market, a market expected to grow from USD 72.5 billion in 2020 to USD 188.2 billion by 2025 (CAGR:21.0%). The Medical IoT Module from Maatel addresses this full spectrum. During the project, it was investigated in two different medical devices (a nutrition pump from Fresenius consolidating their position in this market, and a post-operative surgical site infection (SSI) device from Medtronic creating a new market opportunity. The second prototype, the MRSA detector will create new market opportunities in the diagnosis market (CAGR 10.5%) while enabling creation of a start -up. Thirdly, the wireless insoles will create new market opportunities for SensingTex in various market segments (elderly, rehabilitation ...) with a CAGR from 4 to 20%.

High-tech project partners will obviously benefit from these market opportunities for their hardware or software building blocks, but also from other application domains where healthcare is just one of the possible verticals (especially since it represents a less and less negligible part over the years). The technology markets concerned are Bluetooth Low Energy, embedded security, nonvolatile (NV) memory, software security and IT.

Societal & Economic Impact

All the stakeholders around the patient and patients themselves are expected to profit from SERENE-IoT developments.

Patients are expected to receive remote follow-up that results in reduced hospital visits or stays. By being able to be at home with their family and be active at work, the patients can benefit from an improved quality of life along with a high level of quality of care. They can be treated effectively in their normal home and/or work environment.

Thanks to the organisation of care enabled by the SERENE-IoT technology, Medtech partners estimate cost savings of between 25 and 50% depending on the medical use case.

One of the most important impacts of SERENE-IoT is the impressive innovation acceleration enabled by the project. The medical innovation cycle is quite long – it usually requires 10 years to bring a new service into medical practice. SERENE-IoT provided feedback on clinical prototypes after three years instead of the six years typically needed.

In addition, SERENE-IoT has positively impacted most of the partners, with around new 10 experts hired, expanding their teams specialized at this innovation.

The recent outbreak of COVID-19 has led IoT healthcare solution providers to quickly deliver solutions to tackle the rising demand for high-quality remote services.

KEY APPLICATION AREAS

- Health & Well-Being
- Energy
- Digital Industry
- Digital Life

ESSENTIAL CAPABILITIES

- Systems and Components Architecture, Design & Integration
- Connectivity & Interoperability
- Safety, Security & Reliability
- Computing & Storage
- ECS Process Technology, Equipment, Materials & Manufacturing

PARTNERS

Autonomous University of Barcelona
CEA
CHU Grenoble Alpes
Flavia IT
Fraunhofer EMFT
FRESENIUS-VIAL
Idemia France
Klinikum der Universität München
LCIS / Institut Polytechnique de Grenoble
Maatel
Medtronic - Sofradim Production
Morpho
Orange Labs
SensingTex
SGS-TÜV Saar
Spring Techno
STMicroelectronics
XFAB

COUNTRIES INVOLVED

- France
- Germany
- Spain

PROJECT LEADER

Armand Castillejo - STMicroelectronics

KEY PROJECT DATES

Start: 01-06-2017 - End: 31-03-2021

PROJECT TWITTER

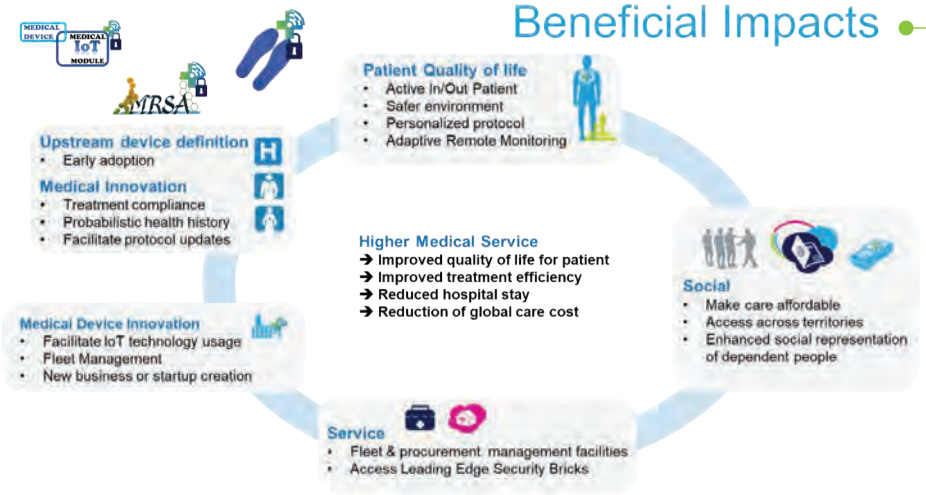
https://twitter.com/SereneIoT

Applications, such as telemedicine, remote patient monitoring and interactive medicine, along with in-patient monitoring, are expected to gain traction during this time.

The new Covid-19 reality is accelerating drivers to digital transformations in healthcare:

- Telemedicine demonstrates industry-altering benefits
- Patient care involvement
- Acceptance of technologies & demand from patients & doctors
- Shortages of healthcare professionals
- Budget pressures
- Dynamic medical regulations updates
- Governmental funding initiatives around the world

Beneficial Impacts



Patents/Standardisation/ Publications

SERENE-IoT achieved 7 patents and engaged in 60 dissemination opportunities during project period:

- Patents: Idemia(2), CEA(2), LCIS(2), ST(1)
- IEEE publications: 11
- Other publications: 15
- Conference/Talks: 29
- Public Webinars: 5

Future Developments

Several further developments are ongoing. First, benefitting from the SERENE-IoT acceleration, its Medtech partners will pursue the remaining steps of the medical innovation cycle to bring their products and services into medical practice.

In the short term, several projects will be submitted to continue clinical investigations (MRSA detector, wireless insoles).

STMicroelectronics is continuing to support the medical partners in the use of its technologies, helping to structure the European healthcare value chain. With its R&D and medical application ecosystem, STMicroelectronics is looking to submit a new acceleration initiative currently named SERENE-AI.

More about patents and dissemination activities

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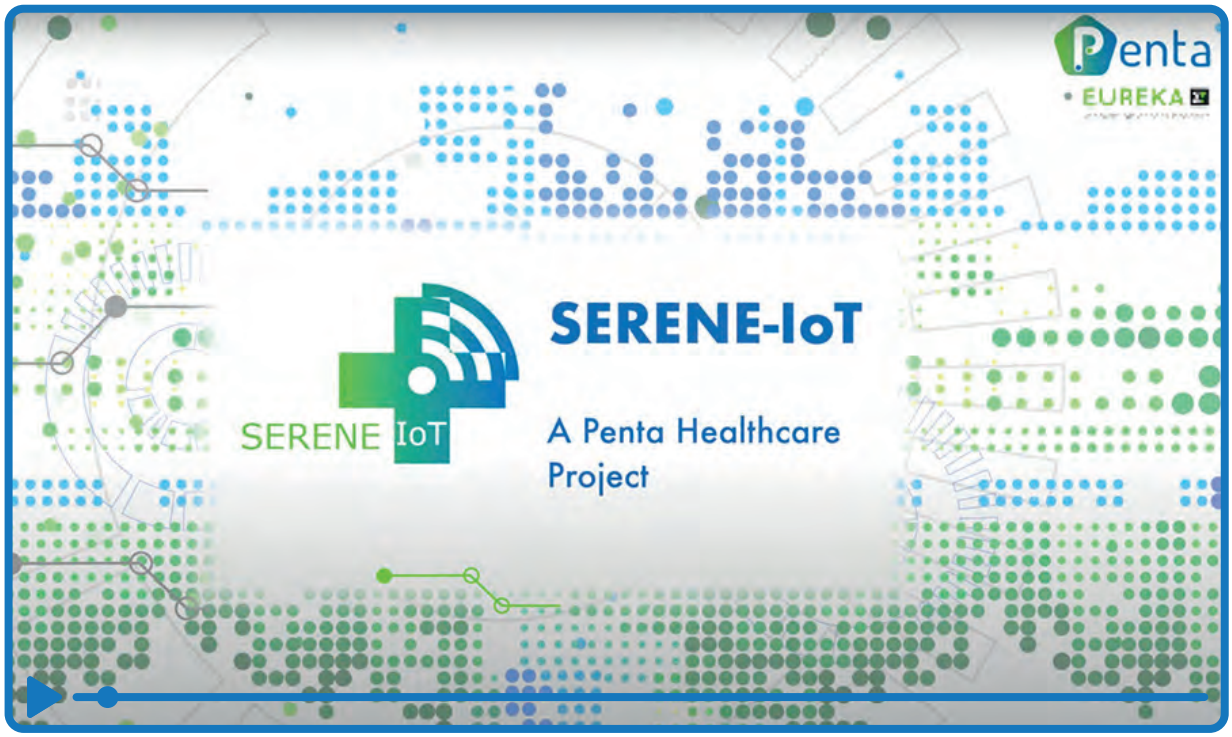
Serene-Iot



▶ **Video: https://youtu.be/c02-twSdywQ**

ESAIRQ

16113 Low-cost sensor technologies for measuring and monitoring air quality will impact health, societal and environmental issues [ESAIRQ]

Driven by a growing demand for sensors and the potential of using semiconductor technologies in this application space, the Environmental Sensors for Air Quality (ESAIRQ) project focuses on developing essential technologies for gas sensing, while researching selective, sensitive and reliable sensors at affordable costs for mass exploitation. ESAIRQ's deliverables, notably its gas, fine-particle and pathogen-sensing technologies, will have a significant health, societal and environmental impact.

Society is paying increasing attention to air quality since air pollution is growing and its negative impact understood, thanks to publications and environmental regulations. Importantly, with more and more highly isolated buildings, indoor air exchange is limited and the monitoring and control of air quality will be crucial. This is especially true since formaldehyde emissions from furniture and new building interiors, as well as volatile organic compounds (VOCs), are becoming a health hazard. The change in buildings and the awareness of health risks underscore the importance of monitoring environmental air quality. All of this, together with new applications, is triggering demand for sensors to measure air quality.

Researching and developing sensor technologies for mass gas-sensing

With the growing demand for sensor technologies and the potential of semiconductor technologies in this application area, ESAIRQ aims at further developing essential technologies for gas sensing with research in selective, sensitive and reliable sensors at affordable costs for mass exploitation. The miniaturised sensor technologies developed in this project will be key enablers for creating sensor networks for air-quality monitoring which can be formed either by embedding sensors in the basic infrastructure, or even in mobile devices. The gas, fine-particle and pathogen-sensing technologies will have a significant impact on measures based on known air-quality and composition.

The realisation of low-cost, affordable sensors that fulfil the requirements of size, sensitivity, selectivity and lifetime will need to deal with technological challenges to:

- Increase the selectivity of sensors, especially to particle matter and polluting organic and inorganic gases when offered as gas mixtures;
- Miniaturise in the functional integration of, for example, emitters and detectors or circuits needed to control absorption and desorption;
- Profit from cost and quality advantages of the semiconductor process-technologies for high-volumes and low-cost compatible processes which will be developed;
- Enable low-power integration of sensors in connected solutions, and establish services.

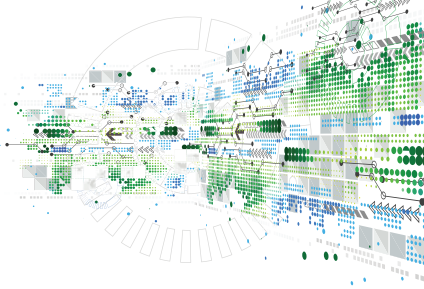
With the planned research, ESAIRQ aims to realise:

- Miniaturisation and functional integration of infrared spectral sensors;
- Functional integration on a chip-level, leading to decrease in power consumption;
- Miniaturisation of fine-particle sensing/fire detection;
- Functional integration of thin membrane layers and sandwich-layer structures, together with innovative gas-sensitive layer systems;
- Sensor arrays and control algorithms leading to selective gas sensors;
- A miniaturised device for airborne pathogen detection.

Societal, economic and environmental impacts

ESAIRQ will develop essential technologies for gas sensing, focusing on research in selective, sensitive and reliable sensors at affordable costs for mass exploitation. These miniaturised sensor platforms developed in this project are key enablers for highly sensitive and selective sensor-systems or sensor-networks for air-quality monitoring.

The mobile gas and fine-particle sensing platforms will have a significant societal impact in reducing mortality rates and health-care costs in polluted environments. In addition, results of the project will strengthen the European landscape in terms of sensor technologies, and manufacturing and application know-how. They will also generate new markets. Importantly, education and the drive for new start-ups will be supported by European-wide collaboration.



KEY APPLICATION AREAS

- Health & Well-Being
- Automotive and Transport (future)

ESSENTIAL CAPABILITIES

- Systems and Components Architecture, Design & Integration
- Connectivity & Interoperability
- Safety, Security & Reliability
- ECS Process Technology, Equipment, Materials & Manufacturing

PARTNERS

INSTITUT MIKROELEKTRONICKYCH APLIKACI S.R.O / Afore Oy / Gasera Ltd. / Pegasor Oy / Vaisala Oyj / VTT Technical Research Centre of Finland Ltd / Aryballe Technologies SA / Asygn SAS / CEA / FARE / mirSense SAS / Soitec / EC-Sense GmbH / eesy-innovation GmbH / Fraunhofer ENAS / Infineon Technologies AG / Infineon Technologies Dresden GmbH / InfraTec GmbH Infrarotsensorik und Messtechnik / University of Regensburg / UST / Umweltsensortechnik GmbH / University of Malta / Technische Universiteit Eindhoven / Stichting IMEC Nederland / Philips Electronics Nederland BV / Philips Consumer Lifestyle B.V. / Qmicro BV / University of Twente / AlphaSIP Aragón

COUNTRIES INVOLVED

- Czech Republic
- Finland
- France
- Germany
- Malta
- Netherlands
- Spain

PROJECT LEADER

Dr Wolfgang Dettmann
Infineon Technologies AG

www.project-ESAIRQ.com

KEY PROJECT DATES

21 June 2018 to 20 June 2021

Future outlook looks promising

The market for environmental MEMS sensors was reported in 2015 to be worth $28 million and 35m units, and expected to reach $155m in 2021, with 256m units at a compound annual growth rate (CAGR) of 39% from 2015-2021.

Wearables are one of the platforms ripe for new sensor integration, and also a basis for new service offerings. The most significant market-analysis data was found for smart watches and glasses. Here, major growth rates were expected in 2015, when shipments were expected to increase from around 100m units, to around 200m in 2019. This high-growth rate indicates a highly attractive and competitive future market.

Demand for air purifiers in Asia is skyrocketing. The forecast for sensor shipments presented at the European MEMS Summit in September 2016 predicts high growth of over 5m units in 2021.

Finally, the hospital-acquired infections (HAI) diagnostics market is projected to grow to $83m by 2020, with a CAGR of 8.5%, mainly driven by public and government awareness which is pushing technological developments in this sector. The overall food pathogen testing market is expected to grow to $17.16 billion in 2021, with a CAGR of 4.6%. Even though this market is less demanding than the clinical one, commercialisation of biosensors for the food-safety industry is growing as legislation creates new standards for microbial monitoring. With quicker detection time and reusable features, biosensors will be important to those activities whose revenues can be affected by pathogen contamination.

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ESAIRQ

As air quality becomes a global issue, the ESAIRQ project innovates new chip-based technologies for low-cost sensitive air quality sensors

A project within the EUREKA PENTA programme

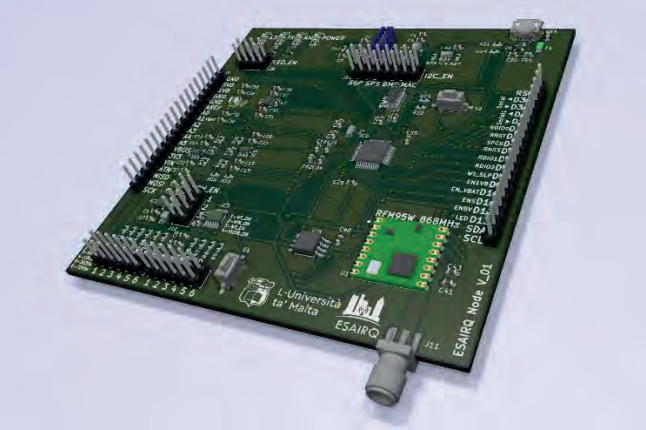
Paris, Thursday 12 September 2019 -With growing global awareness of air quality and its impact on human health, ESAIRQ (Environmental Sensors for Air Quality) is developing essential technologies for gas sensing. ESAIRQ is a project within the EUREKA PENTA Cluster, managed by Industry Association AENEAS, aimed at delivering selective, sensitive and reliable sensors at affordable cost for mass markets. New platforms for gas and fine-particle sensing have the potential for significant societal impact through a reduction in mortality rates and health-care costs in polluted environments. This is reflected in expansion of the market for environmental MEMS sensors. Reported to be worth USD 28 million in 2015, this market is expected to reach a value of USD 155 million by 2021, at a compound annual growth rate (CAGR) of 39%.[1]

A better understanding of the health implications of air quality is also leading to stricter measurement and regulation. Buildings are particularly coming under the spotlight as improved insulation and limited air exchange with outside air can lead to build-ups of emissions of harmful volatile organic compounds (VOC) such as formaldehyde from furniture and interiors. ESAIRQ is developing miniaturised sensor technologies that will be key to sensor systems or sensor networks that monitor air quality and composition in such applications. The sensors could be embedded in basic infrastructure or in mobile devices, including as connected solutions. In addition, these technologies could be applied in other domains, for instance, medical environments and food safety to detect and identify air-borne pathogens.

Specifically, ESAIRQ is seeking to increase the selectivity of sensors to particle matter and to enhance detection of polluting organic and inorganic matter within gas mixtures. Research will focus strongly on miniaturisation and functional integration of components at chip-level to lower costs and energy consumption, while allowing for capabilities such as fine particle / fire detection and pathogen detection. The project will also apply semiconductor process technologies normally used for high volume, low cost manufacturing to deliver further cost and quality advantages.

The ESAIRQ consortium consists of twenty-six businesses and academic research organizations from six different EU countries. Their combined know-how will allow Europe to gain a strong position in the market for gas, fine-particle and pathogen-sensing technologies with potential to bring positive benefits for health, society and the environment. Several industry and SME partners have the approach to manufacture in Europe. Infineon targets the market of highly miniaturized sensors and will manufacture miniaturised sensors or components for sensor systems. Umweltsensortechnik GmbH is a successful medium sized enterprise with a development and production of ceramic sensor technology.

[1] Yole development 2016- MEMS industry 2016



UM sensor node
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PENTA is managed by AENEAS.
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About ESAIRQ

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National funding support is provided by Czech Republic, Finland, France, Germany, Malta and The Netherlands.
More on ESAIRQ: https://www.project-esairq.com/

ESAIRQ addressed the need for affordable air quality sensors by developing essential technologies.

[ESAIRQ]

With growing pollution, societal awareness of air quality is increasing and its negative impacts are more and more understood. Therefore, research and development of competitive solutions are essential to improve and further develop the technological capabilities to tackle global air pollution. ESAIRQ contributed to the environmental sensor market by developing essential technologies for affordable gas sensors.

Background, objectives of the project and challenges

The overall objectives of the project ESAIRQ are mainly to increase the selectivity of sensors, especially of particle matter and polluting organic and inorganic gases when offered as gas mixtures. Also, the aim was to realize miniaturization with functional integration of e.g. the emitters and detectors or circuits to control absorption and desorption. Compatible processes have been developed to benefit from the cost and quality advantages of the semiconductor process technologies for high volumes and low cost. The developed technologies enable low power integration of sensors in connected solutions and the setup of services. The key to achieving competitiveness is the use of high-volume semiconductor manufacturing processes to reach the highest quality and lowest costs due to scaling effects and standardized processes.

The technical value chain is illustrated in the graphic below:

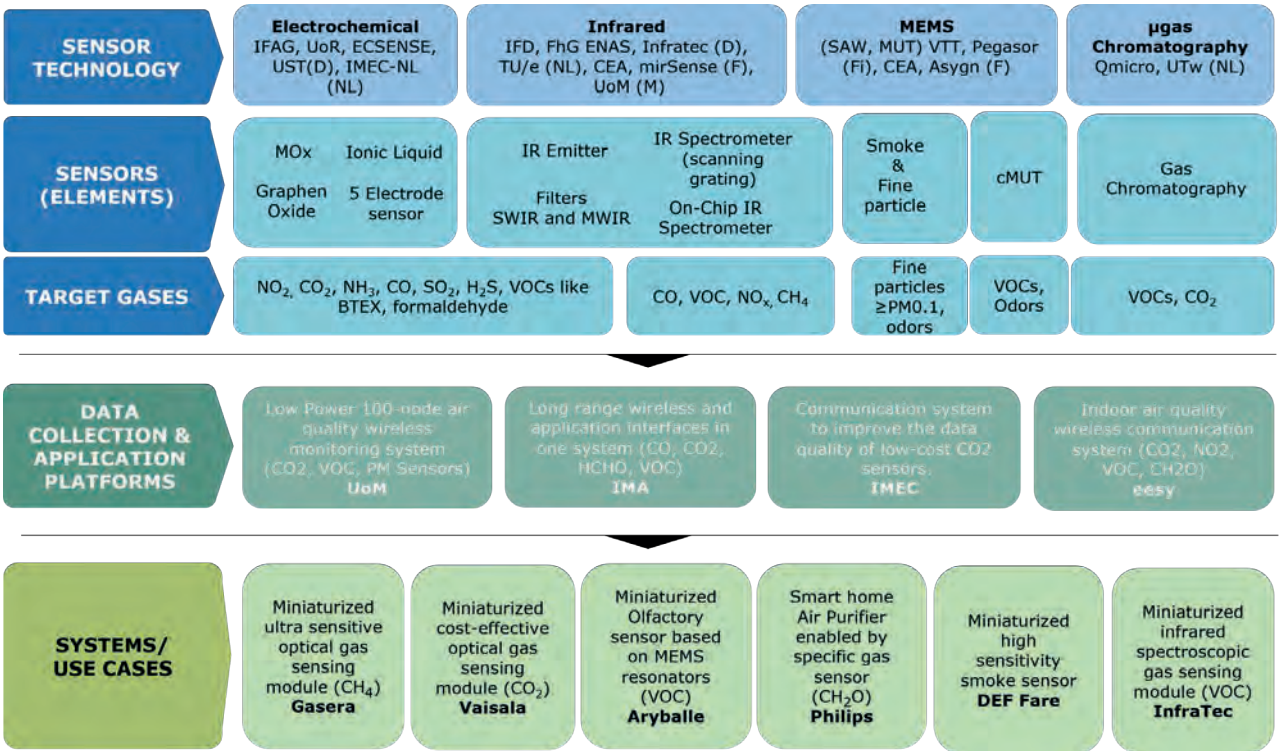

Figure 1: ESAIRQ Value Chain

Summarized, the technical objectives of ESAIRQ are:

- To research and develop highly miniaturized gas sensors to increase selectivity and sensitivity to toxic and harmful gases, allergens, pathogens, particulates and particulate matter.
- The research and development of sensor packaging and heterogeneous integration technologies for miniaturized low-power sensor systems.
- Research of signal algorithms for highly selective multi-gas sensors.
- Elimination of cross-sensitivities.

The innovation strength for new solutions was enhanced by the cooperation between applications owners (e.g. air purifiers) & SME companies with new business models and leading-edge providers for technology (sensors, connectivity). Therefore, the project enables new sensor technologies to be available in the European manufacturing landscape. Also, it improves system knowledge for connected sensor systems and related applications. The outcomes are, thus, strengthening the further research based on first successful implementations and will stimulate the development of new applications.

Technological achievements

ESAIRQ delivered technical prototypes for electrochemical gas sensors, micro gas chromatography, smoke and fine particle sensors, photoacoustic detection, resonant cMUT sensors, as well as infrared spectrometer technologies.

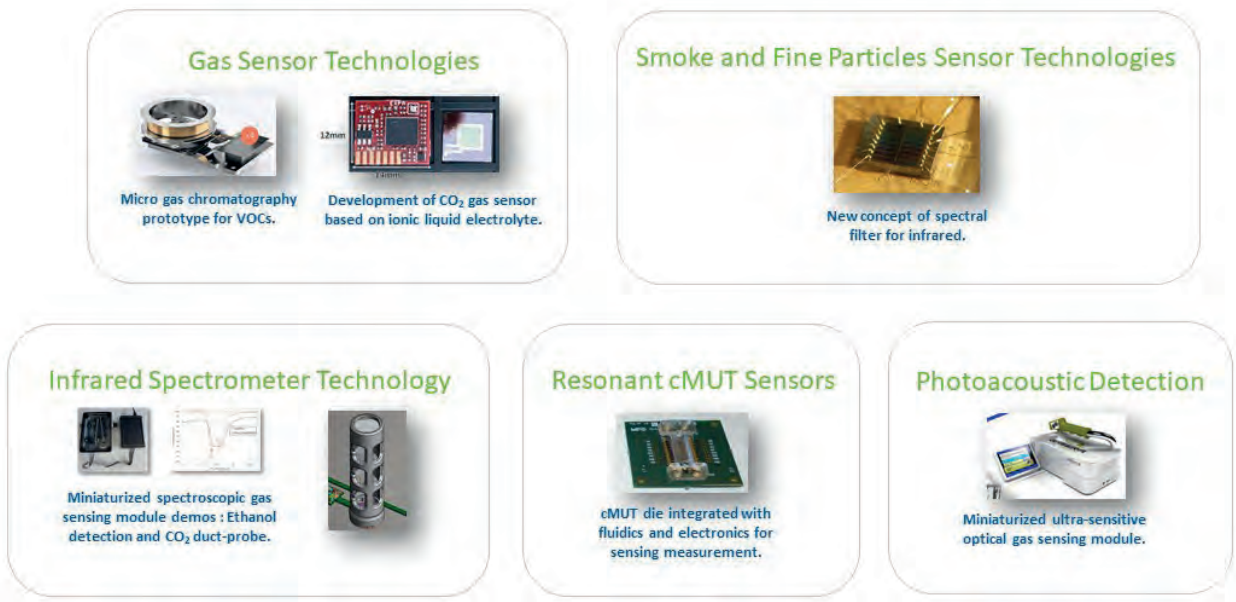

Figure 2: A selection of the developed sensor technologies within ESAIRQ

Therefore, technology breakthroughs are achieved for the following applications:

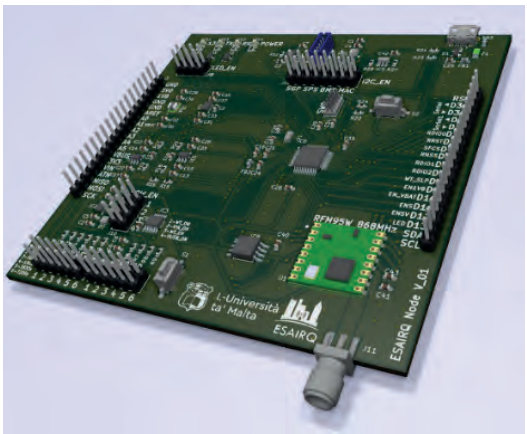

Figure 3: A selection of the developed sensor technologies within ESAIRQ

1. Smart Home – air purifier application:
Target gases are formaldehyde, benzene, toluene, xylene. Guideline is the Chinese standard GB/T 18883-2002. Detection limits 10 times lower than the limits in this standard are required, for formaldehyde, benzene, and for toluene and xylene.

2. Smart Home – Indoor Connectivity:
Target gases are VOC, CO^2, CO, NOx, and the sensor advancements were achieved in the domains of sensitivity, selectivity, power consumption, battery lifetime, as well as costs and form factor.

3. Smoke detection:
Technological breakthroughs were achieved in a better selectivity and reliability, development of an assembly procedure following System-in-Packaging integration approaches, as well as reducing form factor, power consumption, and fab costs.

4. Odor detection:
Electronic noses can play a fundamental role by identifying leakage from chemical plants, changes in the organic content of waste water, water contamination. Sensor arrays and control algorithms will lead to selective and miniaturized gas sensors, including MUT (Micromachined Ultrasonic Transducers) based components, allowing obtaining the "signature" of a set of gases associated with an odour.

5. Industrial application:
Development of an efficient, low-power, and robust air quality monitoring system, consisting of a smart wireless network of gas sensors and associated data storage and analysis.

NDIR gas detection has previously exploited full-plastic modules with whole system open to the measured space. In ESAIRQ, IR-window sealing of the detection electronics, in a duct probe, was introduced in cost-effective plastic molding. Plastic optics was further brought into chip-level IR-signal collection. A wide-band reflector component replaces the dispersive IR lens and expands the wavelength range in NDIR gas-detection.

Figure 4: Indoor Air Quality Sensor with integrated micropumping system to enable HVAC applications for industrial use cases / pegasor

Miniaturization leads to a decrease in power consumption and a good application perspective for mobile devices. The functional integration enhances the detection capabilities (number of accessible gases) and leads to more selective sensors. Both applied to infrared spectral sensors on-chip level enable more selectivity and extended detection capabilities (number of accessible gases). Sensor arrays and control algorithms applied to selective gas sensors, including MUT-based components, allow obtaining the "signature" of a set of gases associated with an odor. Based on available connectivity solutions, the new sensors have been integrated with a focus on high-efficiency performance, which means low energy consumption and a highly efficient wireless communication protocol. The development of common communication interfaces ensures the proper interoperability of different sensors and systems. Close cooperation will minimize the efforts to set up networked sensor solutions with the previously mentioned characteristics.

Market Potential

The COVID-19 pandemic has significantly increased the demand and importance of indoor air quality monitoring. Although the market for environmental sensors and applications around air quality is a relatively new, it is a rapidly growing market. The air quality monitoring market is expected to register a CAGR of 5.79% during the forecast period of 2021 – 2026 and is expected to value USD 5.79 billion in 2026 from USD 4.20 billion in 2020. The global market for air treatment in 2020 was 3 billion US$. Air Purifier products account for the majority of this by growing 5% per year. (Source: Mordor Intelligence 2020, Air Quality Monitoring Market). Since the WHO has sharpened the air quality guidelines, technologies that lead to a drastic reduction in cost and enable high-volume manufacturability for selective sensors are needed and enable new application scenarios. This holds a high exploitation potential for all European partners who are on the one hand on the manufacturer side and on the other hand in the field of application. Target markets are the environmental MEMS sensor market, gas and temperature sensor market as well as new applications such as smart homes. An example of emerging market is the regulated vehicle inspection, starting in July 2022 in Netherlands and expected to expand to other EU countries.

Nanoparticle detection technology developed in the project was adopted to an inspection instrument and has been already certified for the market.

Societal & Economic Impact

The miniaturized sensor platforms developed in this project are key enablers for highly sensitive and selective sensor systems or sensor networks for air quality monitoring. The mobile gas and fine particle sensing platforms will have a significant societal impact in case measures are derived based on the known air quality. Depending on the measures, a reduction of mortality rates and healthcare costs in polluted environments, as well as a healthier indoor climate (Fig. 5) can be achieved.

Also, the project has a positive impact on future manufacturing in Europe and on the global competitiveness, on the creation of new business based on closed gaps between technology and applications, as well as have an impact on SMEs and future perspectives for scientists by strengthening research in the specified area.

The successful conclusion of the project will enable new sensor technologies to be available in the European manufacturing landscape. It enhanced system knowledge for connected sensor systems and related applications. Therefore, it contributes to the discovery of new services based on European technologies in Europe and the rest of the world, stimulating new application developments, new business models, and new application possibilities.

KEY APPLICATION AREAS

- Health & Well-Being
- Automotive and Transport (future)

ESSENTIAL CAPABILITIES

- Systems and Components Architecture, Design & Integration
- Connectivity & Interoperability
- Safety, Security & Reliability
- ECS Process Technology, Equipment, Materials & Manufacturing

PARTNERS

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EC-Sense GmbH
Eesy-innovation GmbH
Eindhoven University of Technology
FARE
Fraunhofer ENAS
Gasera Ltd
IMEC Holst Centre
Infineon Dresden
Infineon Technologies AG
InfraTec GmbH Infrarotsensorik und Messtechnik
INSTITUT MIKROELEKTRONICKYCH APLIKACI S.R.O.
mirSense SAS
Pegasor Oy
Philips Consumer Lifestyle B.V.
Philips Electronics Nederland BV
Qmicro BV
Soitec SA
University of Malta
University of Regensburg
University of Twente
UST Umweltsensortechnik GmbH
Vaisala Oyj
VTT Technical Research Centre of Finland Ltd

COUNTRIES INVOLVED

Czech republic
Germany
The Netherlands
Malta
France
Finland

PROJECT LEADER

Fabiola Bermudez-Elsinger
Infineon

KEY PROJECT DATES

Start date: 21 Jun 2018
End date: 20 Dec 2021

PROJECT TWITTER

https://www.project-esairq.com/

Figure 5: Children in a classroom with an air-quality sensor
Schmidt Media Design AG

Patents/Standardisation/ Publications

Regarding patents, a patent from the TU Eindhoven has been submitted for a multi-pixel spectral sensor. Two intended patents are currently discussed internally within VTT.

Standardization activities also took place within the project, where project partners were involved in international standardization for electrical products and components on behalf of the Netherlands.

In total, 12 scientific papers have been published so far, and 3 more are planned after the end of the project. 10 Ph.D.-students were involved in the project.

Future Developments

The demand for gas detection systems in the industrial sector will increase (monitoring and detection of toxic & combustible gases in the processing plants) due to the introduction of guidelines and regulations in several nations as well as sharper guidelines from the WHO. Also, there is increasing demand for controlling air quality in-cabin and for building automation. Areas of future application for exploitation are air monitoring in public and private buildings, as well as private and public transport. In this context, the early detection of dangerous situations (e.g. smoldering fires, chemical accidents, leaks) is important and needs further development. Also, the development of algorithms and software to solve the multiple gas detection is still challenging.

Regarding climate change, advancing technologies to find greenhouse gas leaks, especially for SF6 (electrical insulation), CH4 (natural gas mining and transport), is crucial to fight global warming.

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MuSiC

16105

An affordable, open, modular reference-platform to protect critical services on shared networks [MuSiC]

MuSiC (or Multi-level Security for Critical services) provides scalable and certifiable security to devices within the mid- to high-data-rate, cost-effective range. In particular, this project secures against threats related to applications, operating systems, the web and networks, with the prime purpose of protecting critical services on shared networks.

Cybersecurity Ventures (a cybersecurity researcher) predicts that global annual cybercrime costs will grow from $3 trillion in 2015 to $6 trillion annually by 2021. This includes data damage and destruction, lost productivity, embezzlement, fraud, as well as, post-attack disruption to the normal course of business, and theft of intellectual property and personal and financial data. Consequently, integrity and confidentiality of all handled information are becoming increasingly crucial.

The development of internet and mobile communications, and the increasing number and diversity of connected devices, are all making digital services ubiquitous. High-end devices—like smartphones, PCs and tablets in the consumer market—are becoming more secured. However, mid-to high-data-rate, cost-effective devices (such as IP cameras and routers) are still vulnerable due to a lack of certification and off-the-shelf-secured solutions.

Innovative way to secure critical services on shared networks

The goal of MuSiC is to develop an affordable, open, modular reference-platform providing a scalable and certifiable solution for any connected device (including mid- to high-data-rate ones) that secures against any threats related to applications, operating systems, networks and the Web, by protecting critical services on shared networks.

One technological innovation is to develop a novel architecture (both hardware and software), which is optimised for low-power and a cost-efficient IoT (internet of things), as well as, communication devices supporting the security mechanisms existing today on high-end computing and mobile devices. MuSiC plans to target several markets where trusted devices and digital services are required.

The major project outcomes will be:

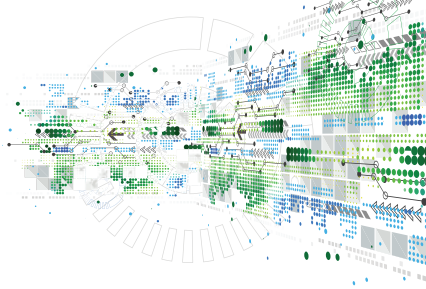
- A scalable secure solution for the development of trusted devices offering adequate processing capabilities to support multimedia services, protecting against various kinds of attack covering secure access and sensitive data protection;
- Cost-effective, common-criteria security-certification paths up to the level required by mission-critical services in order to give users and manufacturers confidence in these trusted devices;
- Demonstrators for representative use-cases within Smart City and public protection and disaster relief applications, integrating these trusted devices and validating their security and performance requirements.

Outputs of the demonstrators using trusted devices will be:

- New services for Smart City applications based on public lighting and traffic monitoring demonstrated in France and/or in the Czech Republic;
- Secure UWB (ultra-wideband), a precise and fast location-detection system which integrates comprehensive security features, including an advanced encryption algorithm for data links;
- High-fidelity simulators to generate the scenarios and test the MuSiC approach;
- Demonstrator to validate optimal network communications during an emergency situation with an unmanned aerial vehicle (UAV);
- Real-time multimedia communication services;
- Built-in adaptive reconfiguration that ensures that the most resource-efficient versions of algorithms are used, based on the context of use;
- Improved IoT platform ready for diverse Smart City scenarios.

The project consortium is a good example of European collaboration. It is composed of 15 partners, with expertise in security and safety, and covering both the project technology and market value-chains. The consortium includes large- and small-enterprises strongly committed to promoting and disseminating industrial standards.

Penta



KEY APPLICATION AREAS

- Transport & Smart Mobility
- Health & Well-Being
- Energy
- Digital Industry
- Digital Life

ESSENTIAL CAPABILITIES

- Systems and Components Architecture, Design & Integration
- Connectivity & Interoperability
- Safety, Security & Reliability
- Computing & Storage
- ECS Process Technology, Equipment, Materials & Manufacturing

PARTNERS

STMicroelectronics / Prove & Run / CEA LIST / CEA LETI / AIRBUS Defense and Space / ADWAVE / FIT of Brno University of Technology / CAMEA / Enigmedia / HI-Iberia Ingeniería y Proyectos / Quobis Networks SL / Tecnologías Servicios Telemáticos y Sistemas SA

COUNTRIES INVOLVED

- Czech Republic
- France
- Spain

PROJECT LEADER

Marcello Coppola
STMicroelectronics Grenoble2 SA

KEY PROJECT DATES

01 June 2018 to 30 May 2021

Expected market impact

Several key markets, which could be impacted by MuSiC, need attention. The first is the cybersecurity and IoT market one. Here, global spending on cybersecurity products and services for defending against cybercrime is projected to exceed $1 trillion cumulatively between 2017 and 2021. The global IoT security market was valued at $4.83 billion in 2015 and will reach $43.23 billion by 2020, growing at a compound annual growth rate (CAGR) of 55.01%.

Looking at the Smart City market, there are 315m street lights in the world, growing to 359m by 2026. LED (light-emitting diode, a semiconductor light source) and smart street- lighting will cumulatively represent a $69.5 billion market opportunity over the next decade, as many cities replace their high-pressure sodium street lights with LEDs. And a growing number of cities are also discovering the benefits of incorporating new sensors and networked control into their new lights. Networked street lights provide an ideal platform for a range of innovative Smart City applications. The global homeland security surveillance-camera-market is expected to reach $6.64 billion by 2021. The increase in traffic surveillance is one of the key factors driving growth in this market. Furthermore, the number of online traffic cameras used to monitor traffic flow on our roads is doubling every two-and-a-half years.

Public safety agencies around the world are echoing demands for the deployment of cost-effective broadband services. The total broadband LTE (long term evolution, a wireless communications standard) public-safety market is expected to grow at a CAGR of 44% over the next six years. Migration toward broadband LTE public-safety brings a new type of competition across the value chain, from content delivery device-providers to infrastructure/service providers. By 2024, there will be over 12m public safety broadband users using LTE-based devices.

Finally, the secure IC (integrated circuit) market will expand from $1.8 billion units in 2016 to 3.5 billion units in 2021. However, this market will not be driven by a single type of solution. A layered security approach, as proposed by MuSiC, will result in OEMs (original equipment manufacturers) and service providers utilising a combination of hardware- and software-based mechanisms. And as 'things' functions become more standalone, the demand for hardware-based security will increase.

Removing the barriers

Unfortunately, market barriers exist because security has been largely considered a secondary issue. Not all applications require the same levels of security and cost-to-risk analysis. Minor things have low-costs, leading to low-power/memory requirements, thus limiting possible solutions. In addition, new OEMs lack the expertise, manpower or budgets. And fragmentation from an architecture perspective (hardware, software, operating system) is not helping either. Crucially, MuSiC will remove these barriers by offering an affordable open, modular and secure reference-platform.

MuSiC will achieve this by:

- Supporting the competiveness of major European security-solutions actors;
- Growing the market for trusted devices, thus addressing OEMs and service providers, including emerging IoT suppliers who are often small medium enterprises lacking the required expertise in security;
- Protecting data and privacy of European citizens while reducing cybercrime costs;
- Promoting and extending existing security standards.

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Penta (E! 9911), is EUREKA Cluster whose purpose is to catalyse research, development and innovation in areas of micro and nanoelectronics enabled systems and applications.

MuSiC

▶ **Video: https://youtu.be/6PLEy6lz-y0**

SENSATION

16106

Developments in machine vision and ultra-HDTV broadcast will significantly improve resolution, colour gamut, dynamic range and image quality

[SENSATION]

Cameras with higher resolution, increased speed, and wider dynamic range and colour gamut are needed to fulfil the needs of next- generation machine-vision and ultra-HDTV broadcast systems. These are key challenges the SENSATION project addresses through and improvements to existing components, and new developments.

Image capture and transmission are generic technologies that are deployed in a multitude of business applications, including manufacturing, health-care, security, automotive, TV broadcast, digital entertainment (such as digital cinema and gaming) and, more recently, agriculture. In order to improve product quality and increase productivity, the resolution and speed of systems have to increase continually, under constraints of power consumption and thermal performance. In addition, vision-based professional applications will require higher spatial and temporal resolutions and improved image quality, especially in broadcast.

Help is at hand. Modern CMOS (complementary metal oxide semiconductor) image sensors have already started replacing the older, slower and power-hungry CCD (charged coupled device) ones. However, more needs to be done. Current machine-vision systems are mostly based on the industrial PC, where image processing takes place. In order to be able to process ever-increasing pixel rates, future machine vision will be based on embedded systems, which are not only smaller and more cost-effective than PCs; but also faster and consume less power thanks to highly optimised architectures. These are compelling benefits.

Developing next-generation machine vision and broadcast systems

The overall goal of the SENSATION project is to develop technologies and improve building blocks needed for the next generations of CMOS image sensors, video processing and transmission. Responding to the market trend of vision-based professional applications in image capture – that is, the move towards higher spatial and temporal resolutions, wider colour gamut, higher dynamic range and improved image quality – new and improved building elements will be developed to drive and address these trends in production technologies, as well as connectivity and digital networks.

This project investigates such innovations as image processing, image compression and transmission that are needed for future machine-vision systems. This is in line with Industry 4.0, the name given to the current trend of automation and data exchange in manufacturing technologies. Specialists in all these areas will work together creatively to develop the necessary elements of the value-chain. And, because standardisation is of paramount importance in the machine-vision market, there will also be collaboration with standards groups in Europe, USA, Japan and China.

On another front, the broadcast market is starting to migrate from HDTV to ultra-HDTV, a standard which supports 4Kx2K and 8Kx4K resolutions; 12 bits per pixel (versus 10 bits in HDTV); and a wider colour gamut and an increased dynamic range. Another aim of this project is to develop new and improved image processing (IP) in image sensors (moving from the 0.18µm/110nm to the 65nm technology node), and to bring UHDTV to a higher specification level.

It is worth noting that, though products associated with the high-end machine-vision and broadcast target markets are quite different, the technical challenges are very similar. It is therefore very beneficial to do R&D for both markets in the same project. This not only helps to share knowledge and designs between project partners, but it also helps develop and apply new standards that can be deployed in both markets.

Key project developments and deliverables are:

- Building blocks for CMOS image sensors: smaller global shutter pixels; increased dynamic range; increased data rates; auto-focus pixels; improved ultra-high-speed architectures; and high-speed serial interfaces;
- New solutions for camera transmission;
- Demonstration of results in cameras for machine vision and broadcast, and image-sensor evaluation set-ups;
- Standards for a high-speed serial interface for image sensors, image compression and camera interfaces. Here the broadcast development team will work with the SMPTE standardisation body.

Creative players needed

In order to meet future market requirements, innovations are required in products of all companies in the machine-vision and broadcast value-chains. A highly qualified and multi-disciplinary team is therefore required to develop the various aspects of the technologies, such as optics, image capture,

KEY APPLICATION AREAS

- Transport & Smart Mobility
- Health & Well-Being
- Digital Industry
- Digital Life

ESSENTIAL CAPABILITIES

- Systems and Components Architecture, Design & Integration
- Connectivity & Interoperability
- Safety, Security & Reliability
- ECS Process Technology, Equipment, Materials & Manufacturing

PARTNERS

Caeleste CVBA
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ON Semiconductor Belgium BVBA
Adimec Advanced Image Systems BV
Delft University of Technology
Grass Valley Nederland BV

COUNTRIES INVOLVED

- Belgium
- Netherlands

PROJECT LEADER

Jochem Herrmann
Adimec

www.project-sensation.eu

KEY PROJECT DATES

01 January 2018 - 31 December 2020

video processing and transmission, and to optimise these technologies. This is why leading European companies in the imaging industry with proven track-records are part of the SENSATION project, jointly working on the required innovations. The project consortium consists of an R&D institute; fabless (without in-house chip production) design houses; semiconductor manufacturers and system integrators advanced in image sensor technologies, as well as design, video processing, transmission and camera integration.

Demonstrators will be developed, not only to verify functionality and performance, but also to demonstrate to potential customers the outcome of the project. This will also allow project partners to stay in the forefront of their markets and further improve their market position. Unusually, not only is there collaboration within the same value chain, but with outside ones as well. Partners collaborating in the SENSATION project face, for example, the same technological challenges found in different non-competitive markets. This not only drives information sharing (in experience, designs, best practices), but also joint developments and cooperation in standardisation.

Market growth

Taking a look at the markets in which SENSATION will play a role, the main growth areas for machine-vision products (which focus on high resolution, high frame-rate, and area scan) are North America and EMEA (Europe, Middle East and Africa). However, significant growth is also expected in Asia and China. The market size in 2015 for machine-vision cameras was put at US$650m (excluding smart cameras and smart sensors). The compound annual growth rate (CAGR) for cameras is about 2%, several times that for industrial image-sensors which are also deployed outside the machine-vision-camera market.

In the next five years, the machine-vision market is expected to be driven by the following:

- Industry 4.0 in general, and regional initiatives like 'made in China 2025' will stimulate smart manufacturing where robotics and smart vision will play a key role;
- In the high-end market, the combination of ever-more demanding inspection tasks and the continual push for lower overall cost-of-ownership drive the need for small pixel, high resolution sensors that can perform high quality inspection at reasonable frame-rates, thereby reducing the overall inspection time (and cost);
- This trend sets new challenges throughout the vision system, including the smaller sensor-pixels which need to deliver improved optical performance;
- New camera-interface standards enable the move of sharply increased bit-rates from camera to centralised vision-systems. In parallel, there is also a trend towards on- camera 'smart' or 'embedded' vision, resulting in distributed image processing and a localised inspection decision process.

In 2015, the outside-broadcast market was US$58m and the studio market US$100m. The main growth areas are Asia-Pacific, Latin America and Russia. These markets will in the coming years be mainly driven by the following:

- Content creators are moving towards higher-resolution formats for sports broadcast television and cinema, to create premium-quality content in a market with intense competition from Web content, pay-TV, and video-on-demand. Japan is the first country to roll out UHDTV in 4K and 8K. The 2020 Olympics will be partly broadcast in 8K;
- Even though many TV programmes are being watched on-demand, consumption of live events is growing globally and will continue to increase, resulting in continual investment in cameras for live-event production and broadcasting;
- Slow-motion will continue to increase in popularity. Broadcasters will be using more cameras with slow-motion features in a wider range of applications (programmes). The trend is towards multi-purpose cameras instead of specialty cameras for each application;
- And equipment prices and operational cost will decrease giving content-creators faster return on investment.

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Penta (E! 9911), is EUREKA Cluster whose purpose is to catalyse research, development and innovation in areas of micro and nanoelectronics enabled systems and applications.

SENSATION

SENSATION new technologies and building blocks for machine vision and Ultra-HDTV broadcast

A project within the EUREKA PENTA programme

Paris, November 8, 2018 – SENSATION, a project within the EUREKA PENTA Cluster managed by AENEAS Industry Association, is developing innovative image capture, transmission and processing technologies for high-end Machine Vision and Broadcast applications. The project focuses on key requirements common to all professional vision-based applications namely: higher spatial resolution, higher temporal resolution (frame-rate), wider colour gamut, higher dynamic range and improved image quality.

Image capture, processing and transmission technologies are used in numerous applications from manufacturing to healthcare, security, automotive, digital entertainment (TV broadcast, digital cinema, gaming) and even agriculture. Moreover, while machine vision for industrial production processes and broadcast are extremely different markets, the technical challenges are fundamentally the same. By collaborating on key building blocks, the partners in the SENSATION project are sharing knowledge and opening the way to creating standards relevant to both application areas.

Machine vision is an important technology for modern production processes, with manufacturers looking for solutions for ever-more demanding inspection tasks to improve product quality and increase productivity. This calls for small pixel, high resolution sensors that can perform high quality inspection at high speeds. To meet these requirements, along with faster image processing and lower costs, SENSATION is working on the next generation of CMOS (Complementary Metal Oxide Semiconductor) image sensors with higher data rates, smaller pixels with global shutter capability and high dynamic range, as well as serial I/O to allow for easier interfacing and power reduction. It is also developing embedded systems that can process image data faster than the current systems which rely on external PCs, as well as on faster transmission of data to centralized vision systems.

In the broadcast market, demand is being driven by the migration from HDTV to ultra HDTV (UHDTV). The UHDTV standard supports 4K and 8K resolutions, 12 bits per pixel (compared to 10 bits in HDTV), a wider colour gamut and an increased dynamic range. Meeting the standard calls for improvements in all aspects of image capture and processing. Although new, UHDTV is already attracting attention particularly for live events and sports broadcasting. Japan is one of the first countries to roll out UHDTV and part of the Olympic Games 2020 in Japan will be broadcast in 8K.

The SENSATION project brings together key European players with proven track records in the imaging industry including R&D institutes specialised in image sensor technologies, image sensor designs and video processing; fabless design houses; a semiconductor manufacturer; image compression experts and system integrators. Through this collaboration the partners can speed innovation, drive standardisation and strengthen Europe's ability to compete in global markets for image capture, processing and transmission.

About the PENTA programme (managed by the AENEAS Industry Association)

PENTA is a EUREKA cluster whose purpose is to catalyse research, development and innovation in areas of micro and nanoelectronics enabled systems and applications - where there is shared national and industrial interest. Based on the Electronic Components & Systems (ECS) Strategic Research Agenda (SRA) key areas and essential capabilities, PENTA programme contributes to the development of electronic solutions with the opportunity for rapid competitive exploitation and a strong impact on European societal challenges. The PENTA project team is supporting SMEs, large corporations, research organisations and universities by facilitating access to funding, fostering collaborative work and creating consortia.

PENTA is managed by AENEAS.

About PENTA: http://www.penta-eureka.eu
About AENEAS: https://aeneas-office.org

About SENSATION

SENSATION is a RD&I project consortium involving 6 partners from 2 countries. The project partners are: Adimec Advanced Image Systems BV (Project leader), Caeleste CVBA, intoPIX, ON Semiconductor Belgium, Delft University of Technology and Grass Valley Nederland BV. National funding support is provided by Belgium (Flanders region) and The Netherlands.

About SENSATION: https://www.project-sensation.eu

The SENSATION project developed and demonstrated technologies and building blocks for CMOS image sensors, image sensor interface standards, video processing, video compression and transmission.

In all vision based professional applications the trend in image capture is towards higher spatial and temporal resolutions, wider colour gamut, higher dynamic range and improved image quality.

In SENSATION, 6 world-class partners cooperated to develop and optimize the next generation of technologies for professional products for use in Television Broadcast, Machine Vision and Automotive markets.

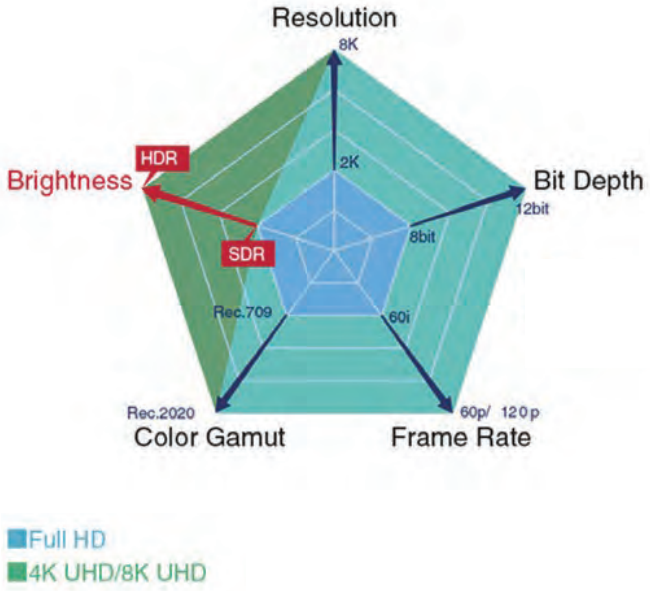
Background, objectives of the project and challenges

Image capture and transmission are generic technologies used in a multitude of business applications, including Production Technologies, Healthcare, Security, Automotive and Digital Entertainment (TV Broadcast, Digital Cinema, Gaming). In all vision based professional applications the trend in image capture is towards higher spatial and temporal resolutions, wider colour gamut including the use of non-visible spectral domains, higher dynamic range and improved image quality.

The overall goal of the SENSATION project was to develop technologies and improved building blocks necessary for CMOS image sensors, image sensor interface standards, video processing, and video compression and transmission. These technologies and building blocks are required to address the needs of the next generation imaging systems for the Television Broadcast, Machine Vision and Automotive markets.

To develop and optimize this next generation of technologies for professional products, a consortium with a critical mass of world class engineering and research skills is required. Neither of the partners is large enough and has the skills available to develop these technologies alone.

The SENSATION project was formed around partners that are leaders in the world-wide markets in which they operate, without being competitors. Through cooperation in this project, technologies and building blocks have been developed that would not be possible without cooperation. This allows all partners to stay in the forefront of their markets and further improve their market position.

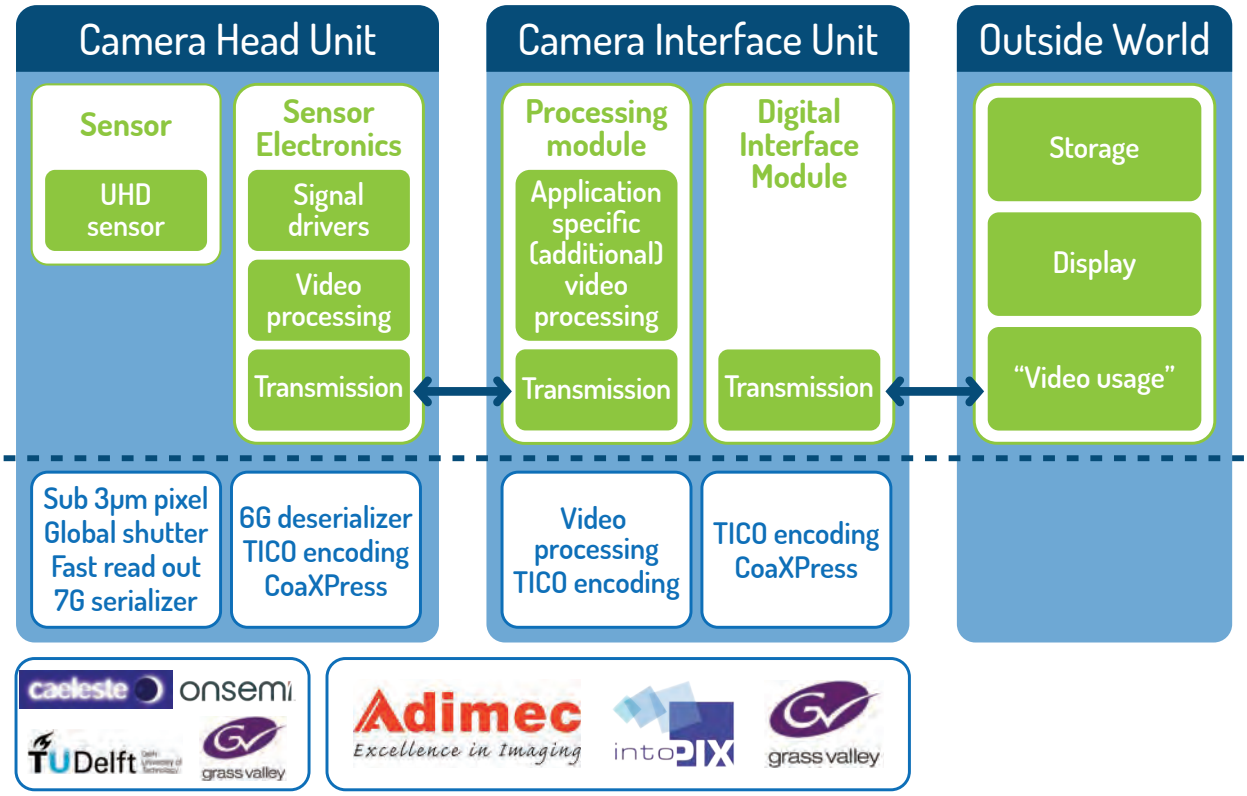


The five elements of increased image quality. Broadly speaking, increased image quality involves five factors: resolution, bit depth, frame rate, colour gamut, and brightness. Of these, the first three are all related to pixel density, and they have all gradually evolved over time. For a long time, colour gamut has been at a standstill, but a few years ago the Rec. 2020 wide colour gamut was established. That means that the only factor left is brightness, and HDR represents an evolution over the existing technology.

Source: https://www.eizo.lv/knowledge/monitor-expertise/age-of-hdr/

Technological achievements

The figure below shows a diagram of the technological building blocks of the project and developments.



CMOS Image Sensor achievements

The project worked on next generation CMOS image sensors, including a 4K UHDTV sensor with 2.5µm Global Shutter pixels for broadcast applications, a new image sensor platform with sub-3 µm Global Shutter pixels for machine vision applications, and new High Dynamic Range pixel architectures for e.g. automotive and scientific applications. New high speed serial interfaces (up to 7.2Gbps; the fastest in the world today) have been integrated to deal with the very high data rate of the image sensors while limiting the number of I/O pins and power dissipation.

Furthermore, research has been performed on new ADC concepts, a pixel test container to allow for easier testing of new pixel concepts, and a new method of Region of Interest management for significantly faster sensor readout.

Advances in image compression

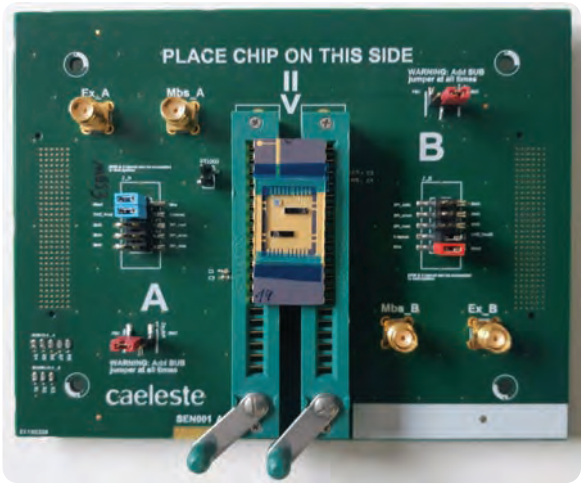
To efficiently deal with the ever-increasing pixel data rates, work has been performed on the development, evaluation, and standardisation of a new (semi) lossless image compression method: Tico-RAW. This compression algorithm has been optimized for applications where low image latency, high image quality and low power operation are required.

New camera platform for Machine Vision

A new camera platform has been developed for use in high-end Machine Vision applications. A first camera prototype uses a 65 Mpixel CMOS imager running at a sustained speed of 70 frames per second - an industry first. The camera can accept various image sensors, supports the new high-speed sensor interface standard SLVS-EC, performs real-time pixel non-uniformity corrections, and is interfaced using the new CoaXPress V2.0 video standard.

4K HDTV Broadcast camera with Global Shutter (GS) sensor

The 2/3", GS image sensor developed during this project has been integrated in a 4K UHDTV broadcast camera. This sensor will allow the market introduction of the first UHDTV camera for the 2/3" optical format, offering GS in triple frame speed and offering all signals over IP. This will allow for remote productions and distortion-free, slow-motion playback of footage shot at for example sports events.



Two Caeleste test pixel container ICs assembled into a DIL package and mounted onto an interface board. Besides of a faster turn-around time between idea and silicon implementation, this setup allows easy and flexible testing of new pixel architectures and topologies

Copyright: Caeleste

Adimec's S-65A70 camera delivers 65 Mpixel images at a sustained speed of 70 frames per second. The new CXP-12 video interface uses 4 coaxial cables for power, communication, triggering, and video data transfer at 5 Gpixel/second.

Copyright: Adimec

Grass Valley's highest performing live broadcast camera. LDX 150 NativeIP cameras use a new 2/3-inch Xenios imager – developed in SENSATION - to capture Ultra High Definition (UHD) High Dynamic Range (HDR) images at 3X high speed for slow motion replay.

Copyright: Grass Valley

Market Potential

Grass Valley will launch a new 4K UHDTV camera for 2/3"optics during the second half of 2021. The image sensor with global shutter pixels and the triple speed acquisition capability makes the camera a perfect choice for e.g. sports events. Field tests are done with multiple key customers worldwide, and negotiations are ongoing for the use of this new camera at different big sports events.

At the end of 2020, Adimec introduced a new camera platform for high-speed, high-resolution Machine Vision applications like semiconductor manufacturing and display inspection. The first version of this product uses a 65 Mpixel sensor, while versions using 21 and 150 Mpixel sensors are under development. This new line of products will further strengthen Adimec market leader position and result in a yearly double-digit revenue growth.

For Caeleste the new, fast ADC has in the meantime become a standard IP block that is being included in new chip designs for various customers. The pixel test container is being rolled out as general monitoring tool and being added to practically every IC tape-out, allowing a continuous evaluation of pixel modifications and new architectures. It also allows Caeleste to test much faster innovative pixel concepts; this approach is being used in 2 other pixel validation concepts.

intoPIX has launched the new lightweight TICO-RAW codec. TICO-RAW IP blocks enables to directly compress the RAW Bayer data coming from the sensor. It allows to efficiently capture, transmit, store, and analyse the RAW Bayer data with a much smaller bandwidth and file size than regular RAW while preserving its quality and flexibility. TICO-RAW uses a lightweight and low power processing that needs only few micro-seconds of latency. It can be integrated in any type of cameras for human or vision applications: Live IP production, DSLRs, Advanced driver-assistance systems (ADAS), machine vision, medical systems (microscopes, endoscopy cameras, etc.).

(source : https://www.intopix.com/tico-raw)

KEY APPLICATION AREAS

- Transport & Smart Mobility
- Health & Well-Being
- Digital Industry
- Digital Life

ESSENTIAL CAPABILITIES

- Systems and Components Architecture, Design & Integration
- Connectivity & Interoperability
- Safety, Security & Reliability
- ECS Process Technology, Equipment, Materials & Manufacturing

PARTNERS

ADIMEC ADVANCED IMAGE SYSTEMS BV
CAELESTE CVBA
DELFT UNIVERSITY OF TECHNOLOGY
GRASS VALLEY NEDERLAND BV
ON SEMICONDUCTOR TECHNOLOGY BV
INTOPIX SA

COUNTRIES INVOLVED

- Belgium
- The Netherlands

PROJECT LEADER

Jochem Herrmann -Adimec

KEY PROJECT DATES

Start: 01-01-2018 - End: 30-06-2021

PROJECT WEBSITE

https://www.project-sensation.eu

For onsemi the SENSATION project developed image sensor architecture is being used in multiple image sensor products under development. Those will be used to strengthen the portfolio, targeting various Machine Vision markets. In addition, the developed Global Shutter HDR 4.2um pixel is being used to expand into markets like high-end security and automotive that require the combination of Global Shutter and High Dynamic Range operation to allow for artifact-free acquisition of fast moving objects under difficult lighting conditions.

Societal & Economic Impact

Machine Vision is an important technology for modern production lines. To keep up with the ever-increasing demands for higher image resolution and speed, the project worked on all aspects of the image acquisition chain: CMOS image sensors, video processing, image compression and video transmission, to make the next generation production lines more flexible, more accurate and faster than before. The technologies developed have been integrated in a new camera platform for high-end Machine Vision applications and were successfully integrated and tested by customers in the field of manufacturing of high value consumer goods like computer displays, tablets and mobile phones. Although the production of these consumer goods mostly take place in the far east, critical sub-systems of the production equipment are developed and manufactured in Europe!

Apart from the benefits identified for each of the partners, the project strengthened the position of Europe in the field of development and production of CMOS image sensors. Through the successful cooperation between the project's partners, important knowledge has been shared which improved the competitiveness of all.

Collaboration on individual technical issues has enabled partners to mature their designs faster, and to find root causes for / potential problems in an early stage.

Patents/Standardisation/ Publications

Protection of the IP developed during the project is of key importance to the partners. During the project in total 14 patents have been granted, filed or are still under preparation.

Partners have been active in many standardisation groups: SMPTE, AIMS, EMVA1288, CoaXPress, emVision, GenICam and SLVS-EC. Partner intoPIX co-chairs the JPEG XS work group and works on the addition of TICO-RAW to the JPEG-XS standard.

To disseminate the results of the project the partners organised 2 workshops, published and presented several papers during conferences, exhibited during trade shows, and performed product demonstrations and field tests at many potential customers world-wide.

Finally, research of Delft University of Technology will result in a PhD thesis planned for 2023.

Future Developments

R&D performed in the SENSATION project is an excellent basis for new products that will be launched by the commercial partners to fully harvest the market potential, and follow-up research in the years to come. For example, TUD will continue with the project, and at the end of 2021 a new tape-out is planned for the sensor with a high-speed region-of-interest readout.

The good results of the project and the excellent cooperation made the partners decide to submit a follow-up PENTA project proposal: IMAGINATION. For this project the existing team will be extended with three new partners extending the machine vision value chain.

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SENSATION

▶ **Video: https://www.youtube.com/watch?v=NUjEn3fky5k**

ULIMPIA

16101

Technology and fabrication methods are making ultra-sound diagnostics affordable and impacting continuous medical care [ULIMPIA]

ULIMPIA combines state-of-the-art MEMS ultra-sound technology with innovations in conformably patch technology to create an open platform for diagnostic ultra-sound patches. These body patches will enable continuous monitoring of bodily functions, making ultra-sound diagnostics affordable to the consumer, but also keeping health costs down by moving continuous medical care from the hospital to the home.

Back in the early the 1990's, practically all electronic cameras were based on so-called plumbicon recording tubes. These tubes were bulky and needed high voltages, as well as, magnetic focusing and deflection coils, making electronic cameras expensive and mainly reserved for the professional market. Within a decade that situation changed completely. With the introduction of silicon-based CCD (charge-coupled device) and CMOS (complementary metal-oxide-semiconductor) image sensors, the price of electronic cameras drastically went down, while at the same time quality increased with a dramatic reduction in size.

Significantly, this has consequences for medical ultra-sound imaging and therapy. Until now, most ultra-sound diagnostics were based on traditional piezo ceramic ultra-sound transducers. These are labour-intensive to fabricate and therefore expensive, limiting the use of ultra-sound diagnostic to professional users. Now, this situation is set to change dramatically during the next decade because exactly the same development in electronic cameras is at the moment taking place in medical ultra-sound diagnostics. After 60 years, during which it has proven its immense clinical value, ultra-sound is now ready to enter the consumer marketspace, thanks to projects such as ULIMPIA.

Open platform with continuous monitoring

ULIMPIA will combine state-of-the-art MEMS (micro-electro-mechanical systems) ultra-sound technology with innovations in conformably patches to create an open platform for diagnostic ultra-sound patches. These body patches will enable the continuous monitoring of bodily functions on the surface of the skin, but also deep inside the body. ULIMPIA will also demonstrate such applications as blood-pressure measurement; bladder monitoring; blood-vessel inspection of diabetes patients; early breast-cancer detection; needle guidance; and wound monitoring. The resulting platform will be accessible to multiple users, enabling them to concentrate on application development, rather than on the development of technological point-solutions.

A large European consortium consisting of 28 partners from seven countries will develop the necessary technological building blocks, which include: a programmable universal ultra-sound engine, conformable patch technologies and functional adhesive and bio-compatible materials.

The objectives of ULIMPIA are to:

- Enable ultra-sound diagnostics to become a consumer commodity;
- Create new markets, encompassing micro-fabrication, patch fabrication and applications;
- Fuel the market for large-area conformable assembly technologies;
- Help manage the cost of health care, by bringing point-of-care diagnosis to the patient.

Spreading the word

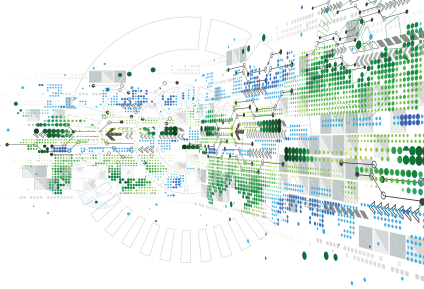
Dissemination of the project results to be delivered by the ULIMPIA consortium constitutes a key aspect of the project. Relevant activities are foreseen to ensure the visibility and public awareness of the project, and to support the adoption of its results in industry and its related research communities.

Dissemination activities will include:

- Workshops and demonstration events;
- Journal publications and conference contributions;
- A special session at the annual 'Be-Flexible' forum;
- Press releases;
- White papers and brochures;
- A web platform.

Medical, commercial and financial gains

The cost of health care in Europe amounted to $383 billion in 2016, and it is expected to grow to $425 billion in 2025. This expenditure is exacerbated by a rapidly ageing population. With ageing, the occurrence of many chronic diseases increases exponentially.



KEY APPLICATION AREAS

- Health & Well-Being
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- Systems and Components Architecture, Design & Integration
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- Computing & Storage
- ECS Process Technology, Equipment, Materials & Manufacturing

PARTNERS

IMEC VZW / MEPY BENELUX / PICOSUN OY / VTT Technical Research Centre of Finland Ltd / LINXENS France / Fraunhofer EMFT / GED Gesellschaft für Elektronik und Design mbH / Henkel AG & Co KGaA / Institutes of Textile and Fiber Research Denkendorf (DITF) / KARL OTTO BRAUN GmbH & Co. KG / NXP Semiconductors Germany GmbH / warmX GmbH / Delft University of Technology / Novioscan BV / Philips Electronics Nederland BV / TNO / Eurecat

COUNTRIES INVOLVED

- Belgium
- Finland
- France
- Germany
- Netherlands
- Spain

PROJECT LEADER

Ad de Beer
Philips Electronics Nederland BV

http://ulimpia-project.eu/

KEY PROJECT DATES

01 April 2018 to 31 March 2021

The ULIMPIA project will be vital in:

- Accelerating the current paradigm shift from large diagnostic equipment in hospitals to point- of-care diagnostics;
- Shifting continuous medical care from the hospital to the home environment, thus reducing the cost of health care and alleviating the socioeconomic burden;
- Enabling European players to capture substantial market share in consumer and clinical-grade, smart-body patches;
- Enhancing Europe's competitive advantage in the ultra-sound diagnostics and imaging;
- Consolidating Europe's leading position as a high-end semiconductor and MEMS supplier.

Diverse market opportunities

The global market for point-of-care diagnostics in 2015 was valued at nearly $18 billion. This market is expected to grow from $19.3 billion in 2016, to $28.3 billion in 2021, at a compound annual growth rate (CAGR) of 8%. This growth, which is expected to continue for the coming years, is substantially fuelling the growth in the entire in-vitro diagnostics industry. In recent years, the market has witnessed an exponential increase in technological innovations in wearable electronics by the incorporation of sensors and wireless connectivity. This will play a crucial role in the growth of personalised diagnostics and monitoring markets.

The global market for wearable health-care devices is expected to reach a revenue level of $18.9 billion in 2020, growing at a CAGR of about 30%. The consumer-health market, including wellness, fitness, and sport wearables, is expected to grow at a CAGR of 27.8% (2015-2020). And medical and clinical-grade wearables, the most promising product segment within health-care wearables, is expected to grow at a CAGR of 32.9% between 2015-2020.

Smart on-body conformable patches will be attractive candidates to boost the wearables health-care market. It is envisioned that they will record a mass-market proliferation in the near future due tothea growing interest from end-users, such as manufacturers of medical equipment and bandages, and pharmaceutical companies. The market size for "traditional, non-ultra-sound" smart patches has been estimated at over $12 billion in 2015 with a CAGR of 11%.

It is relevant to also review the traditional ultra-sound imaging market. Europe accounted for the largest share of the global ultra-sound market in 2015, in which the second largest manufacturer of ultra-sound equipment globally had a market share of 20% and a turnover close to $800m. Globally, the ultra-sound imaging segment is growing, and is expected to reach $6.9 billion by 2020, at a CAGR of 5.5% from 2015.

Finally, the semiconductor market for health care in Europe is expected to reach $3.4 billion in 2018 with a CAGR of 5.5%. This market consists of medical imaging (CAGR of 3.6%), clinical diagnostics and therapy (1.1%), and consumer medical electronics (8.7%). Importantly, the advent of consumer ultra-sound applications is expected to significantly grow this segment of the MEMS industry. MEMS processing and design knowledge is highly specialised and relatively scarce. Europe currently holds a leading position in the worldwide strongly growing €10 billion MEMS market, which has a CAGR of 13%9. The medical MEMS market will account for $7.25 billion in 2019 with the highest CAGR of 23.9% in the global MEMS market (2012).

Continuity and growth ensured

At completion, the project consortium will ensure that the open platform is maintained and will continue to be available for validation and prototyping. This arrangement will be in place until the start of a venture that will own and exploit this platform. Here, project partners will have the opportunity to participate in the venture (owned by the participating partners) to exploit the pilot line. Initially, it will make use of the manufacturing facilities and pilot lines of project partners.

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ULIMPIA

ULIMPIA enables smart body-patches for ultra-sound monitoring at home

A project within the EUREKA PENTA programme

Paris, 23 October 2018 – ULIMPIA, a project within the EUREKA PENTA cluster managed by AENEAS Industry Association, is breaking new ground in health care by enabling ultra-sound monitoring at home through smart body patches.

The ULIMPIA technology goes beyond existing body patches that measure only parameters on the surface of the skin - temperature and humidity, for instance. ULIMPIA's new MEMS (Microelectromechanical systems) -based technology can look inside the body and continuously monitor and diagnose processes going on under the skin, or even deep within the body, such as blood pressure or bladder function. This will allow many more patients to stay at home instead of requiring hospital-based monitoring, while health services will benefit from reduced costs. In addition, the project's open platform approach will allow application developers to enter this entirely new consumer healthcare market by creating their own applications based on the ULIMPIA technology.

With an ageing population and rising rates of chronic diseases such as cardiac vascular diseases (CVD), obesity, diabetes and chronic obstructive pulmonary disease (COPD), Europe is facing significant increases in healthcare costs – from USD 383 billion in 2016 to an expected USD 425 billion in 2025[1]. ULIMPIA aims to provide point-of-care diagnostic solutions that will both reduce the cost of continuous (remote) on-body diagnostics and empower patients to better manage their health at home. The patches will be wirelessly connected to a peripheral device such as a mobile phone, which analyses and displays the data to give real-time feedback to the user. Applications could include blood pressure measurement, bladder monitoring, blood vessel inspection of diabetes patients, early breast cancer detection, needle guidance and wound monitoring.

The ULIMPIA project represents a continuation and consolidation of Europe's strength in ultra-sound diagnostics. A large European consortium consisting of 17 partners in six countries will develop the necessary technological building blocks including: a programmable universal ultra-sound engine, conformable patch technologies (that adapt to the form of the human body) and functional adhesive and bio-compatible materials. By bringing ultra-sound to the consumer market, ULIMPIA is expected to drive high production volumes and fuel further innovation in MEMS ultra-sound technologies to support Europe's existing leading role in professional ultra-sound diagnostics.

[1] Vision 2025 – The future of healthcare, Frost &Sullivan, 2016

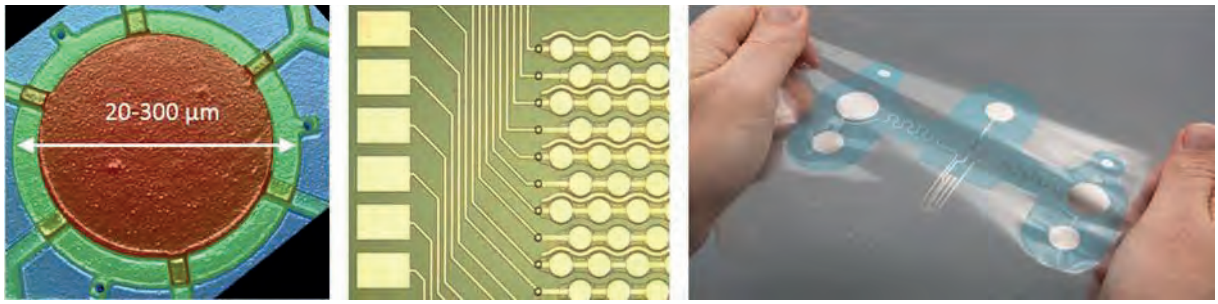


Figure. Left CMUT MEMS ultra-sound transducers are made using micro-fabrication. They can be fabricated on top of the ASICs that drive them (middle). Combined with innovations in conformable substrate technology they enable on-body personal ultra-sound diagnostics (photo: Philips, Holst).

About the PENTA programme (managed by the AENEAS Industrial Association)

PENTA is a EUREKA cluster whose purpose is to catalyse research, development and innovation in areas of micro and nanoelectronics enabled systems and applications - where there is shared national and industrial interest. Based on the Electronic Components & Systems (ECS) Strategic Research Agenda (SRA) key areas and essential capabilities, PENTA programme contributes to the development of electronic solutions with the opportunity for rapid competitive exploitation and a strong impact on European societal challenges. The PENTA project team is supporting SMEs, large corporations, research organisations and universities by facilitating access to funding, fostering collaborative work and creating consortia.

PENTA is managed by AENEAS, the European industry association
About PENTA: http://www.penta-eureka.eu
About AENEAS: https://aeneas-office.org

About ULIMPIA

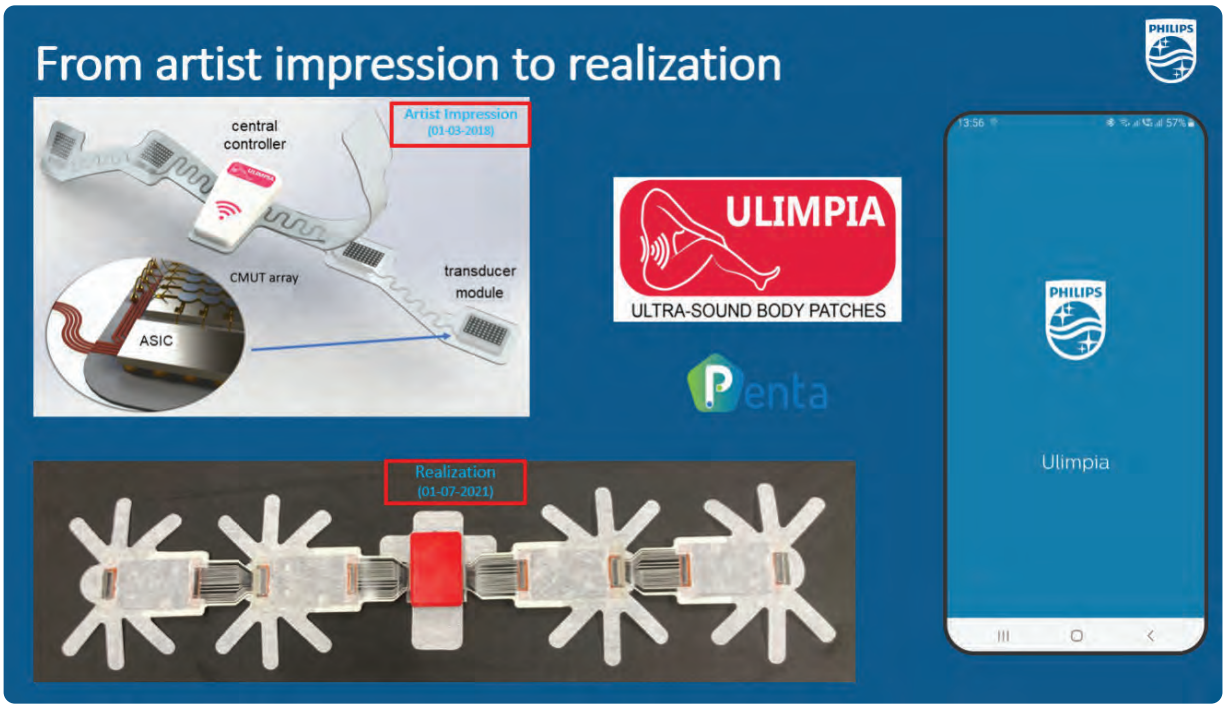
Ulimpia is a RD&I project consortium involving 17 partners in six countries. The project partners are: Philips Electronics Netherlands BV (Project leader), Philips Electronics Netherlands BV, TNO, Novioscan, TU Delft, IMEC, Mepy, Fraunhofer EMFT, Karl Otto Braun (KOB) GmbH, WarmX, Henkel, Institute for textile and fiber research denkendorf, Institute for textile and fiber research denkendorf, NXP Germany, GED Gesellschaft für Elektronik und Design GmbH, VTT, Picosun, Linxens, Eurecat. National funding support is provided by Finland, Germany, the Netherlands and Spain.

About ULIMPIA: http://ulimpia-project.eu/

Ulimpia has created the world's first smart, wearable ultrasound patch for diagnosis and health monitoring at home, using an open platform approach.

[Ulimpia]

ULIMPIA's MEMS (Microelectromechanical systems)-based technology can continuously monitor and diagnose processes under the skin or even deep within the body, such as blood pressure or bladder function. So, more patients can stay at home, reducing hospital costs. In addition, ULIMPIA'S open platform allows other developers to create new applications for the growing consumer healthcare market.



From artist impression to realisation. Copyright Philips

Background, objectives of the project and challenges

Faced with aging populations and rising chronic disease, healthcare systems worldwide are looking for solutions to improve care and limit costs. ULIMPIA aimed to address these needs by developing point-of-care monitoring and diagnostic solutions that enable affordable continuous on-body monitoring and empower patients to better manage their health at home.

The project partners ranged from leading companies in the fields of semiconductor devices (MEMS, ASIC design), materials and packaging, medical devices and wearables manufacturing to world-class medical institutions.

The technological challenge was to create the world's first universal programmable ultrasound engine building block. This engine would be the basis for an open platform (in the form of a body patch) that would be accessible to multiple users, and which could lead to an industry standard. Achieving these ambitions called for innovation in areas from MEMS and ASICs to yarns and materials tailored to specific end-user requirements and specific algorithms. The electronics on the platform had to carry out sensing reliably, and the patch had to be adhesive, stretchable and long-life but non-irritating to the skin.

The project envisaged numerous potential applications: blood pressure measurement, bladder monitoring, inspection of blood vessels in diabetes patients, early

breast cancer detection, needle guidance and wound monitoring. Its work resulted in a demonstration body patch platform that could be wirelessly connected to a peripheral device such as a mobile phone. The mobile device then analyzed and displayed the data to give real-time feedback to the user.

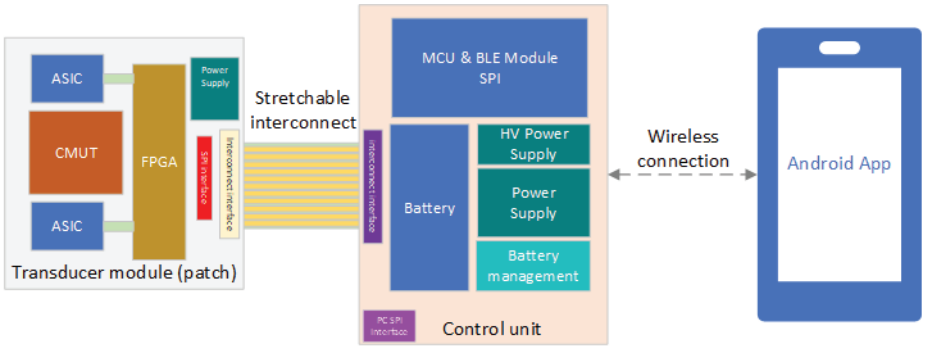
ULIMPIA achieved this successful result despite the constraints of the COVID-19 pandemic. A combination of strong cooperation and detailed planning helped the partners involved collaborate effectively even under such difficult conditions.

Technological achievements

Ultrasound-based continuous on-body monitoring is a major technological breakthrough from the Ulimpia project, delivering several key innovations:

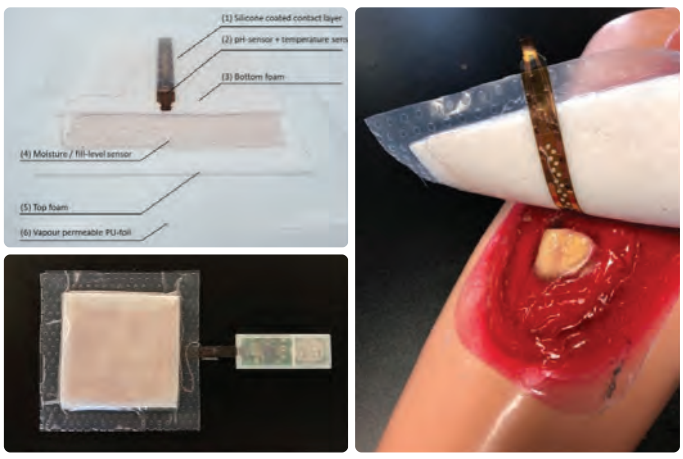
- Programmable ultrasound module
- Universal controller, power management and wireless connectivity module (Android app)
- Conformable patch technology connecting one or more ultrasound modules to the universal controller module
- Flexible/knitted interconnect.

Ulimpia developed and prototyped a 2D version of the ULIMPIA ultrasound module including a front-end ASIC and supporting FPGA. Bluetooth Low Energy (BTLE) provided connectivity to back-end applications. The battery-powered patch platform was implemented in various demonstrators with sensors and interconnectors, showing the potential of the modular approach and innovations such as gel-free contact with the skin. Specially created 20-30 µm polyamide multi-filament yarns with silver coating were integrated into the demonstrators together with a purpose-designed interposer housing.



Block diagram of the Ulimpia patch showing the individual parts: transducer module, control unit, stretchable interconnect and the android app.

One demonstrator focused on novel **wound condition monitoring** capability for long-term chronic wounds, integrating pH and wound temperature sensors, basic electronic interconnects and BTLE connectivity, a specially developed integrated moisture sensor and an engineering-level Android app.

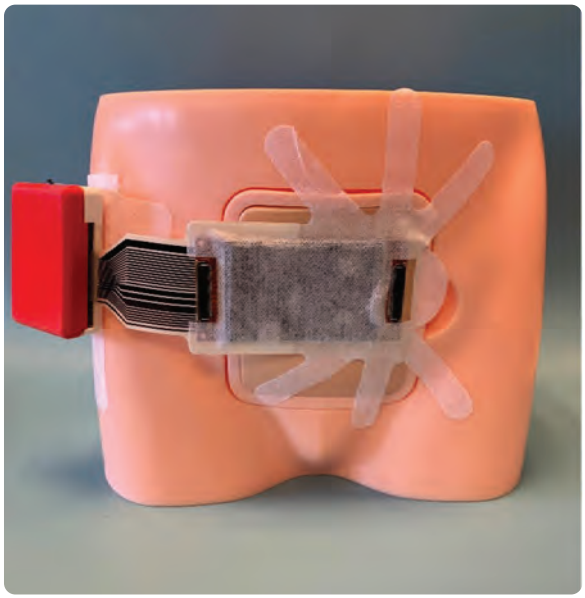


Pictures, showing the wound monitoring patch, are taken form the public Deliverable, D6.4.

The partners assessed a **smart comfort patch** made with knitted yarns placed on a 'skin phantom' exploring monitoring vasomotor symptoms and development of a calorimeter to measure human body heat generation. Uncorrupted data readings were obtained even when sensors are close to the warmth of the body, a vital precursor for moving to clinical trials.

The project successfully measured **blood pressure**, comparing the performance of two emerging technologies: CMUT and PMUT. It conducted a 'phantom' measurement of adult **bladder fullness** using CMUT prototypes to a good level of accuracy.

An unforeseen application arose – **COVID testing**. This use case provided an early indicator of the value of the project's open approach.



Ulimpia patch used as bladder monitor on a Phantom from Novioscan.

Picture is taken from public Ulimpia movie.

Market Potential

ULIMPIA's results address growing global trends. Personal/portable ultrasound technology is emerging, with early market entrants demonstrating systems using Edge AI and cloud-based services. There are moves towards the decentralization of healthcare, personalized therapies and individualized, self-administered diagnostics. COVID-19 accelerated these trends, increasing demand for smart, low-cost healthcare devices for easy use at home. The market for medical wearables is predicted to grow by a CAGR of 40%[1]. By bringing ultrasound to this market, ULIMPIA is expected to drive high production volumes and fuel further innovation in MEMS technologies to reinforce Europe's strength in professional ultrasound diagnostics. As MEMS-based ultrasound matures it will compete with current more expensive technologies, creating market opportunities for low power, reduced data rate wearable ultrasound devices driven by AI algorithms that interpret data without the need for a medical specialist.

Societal & Economic Impact

The emergence of personal / portable ultrasound has been enabled by innovations in areas such as MEMS, Edge AI and cloud technologies. Meanwhile, the applications focus on pressing needs within healthcare systems worldwide. With an ageing population and rising rates of chronic diseases such as cardiac vascular diseases (CVD), obesity, diabetes and chronic obstructive pulmonary disease (COPD), Europe alone is facing significant increases in healthcare costs – from USD 383 billion in 2016 to an expected USD 425 billion in 2025[2]. The COVID-19 pandemic has only increased these pressures.

It is these demands that are driving the shift towards more home-based care; lower-cost diagnostics that need less professional involvement; personalized therapies; and payments based on cure and prevention, rather than simply treatment.

ULIMPIA has contributed to potential solutions by opening the way to relatively low-cost, mass-producible, portable and wearable ultrasound devices that support the needs of both patients and healthcare systems.

Currently, opportunities are being explored for further development of the Ulimpia platform. First discussions with potential partners have at least resulted in enthusiastic reactions and very positive feedback to the Ulimpia achievements. These discussions will be followed-up soon.

Patents/Standardisation/ Publications

The ULIMPIA project has been presented at more than 39 conferences and symposia and lead to 7 peer reviewed academic papers, 4 articles as well as other communications such as videos for the general public. In total more than 50 publications were realized during the Ulimpia project, while more publications are expected after the end of the project. Next to this several announcements on the Ulimpia results have been posted on social media, in particular on LinkedIn.

[1] Yole Developpement, Medical Wearables: Market & Technology Analysis 2019

[2] Vision 2025 – The future of healthcare, Frost &Sullivan, 2016

KEY APPLICATION AREAS

- Health & Well-Being
- Digital Industry
- Digital Life

ESSENTIAL CAPABILITIES

- Systems and Components Architecture, Design & Integration
- Connectivity & Interoperability
- Safety, Security & Reliability
- Computing & Storage
- ECS Process Technology, Equipment, Materials & Manufacturing

PARTNERS

Delft University of Technology
Fraunhofer EMFT
Fundació Eurecat - Technology Centre of Catalonia
GED Gesellschaft für Elektronik und Design mbH
Henkel AG and Co KGaA
IMEC
Institutes of Textile and Fiber Research Denkendorf (DITF)
KOB - Karl Otto Braun GmbH & Co KG
LINXENS France
MEPY BENELUX
NXP Semiconductors Germany GmbH
Novioscan BV
Philips Electronics Nederland BV
Picosun Oy
TNO
VTT Technical Research Centre of Finland Ltd
warmX GmbH

COUNTRIES INVOLVED

- Belgium
- France
- Finland
- Germany
- Spain
- The Netherlands

PROJECT LEADER

Ad de Beer
Philips Electronics Nederland BV

KEY PROJECT DATES

Start: 01 Apr 2018 - End: 31 May 2021

PROJECT TWITTER

http://ulimpia-project.eu

Future Developments

The work will continue on integration, miniaturization and power reduction to achieve a small, unobtrusive patch on a coin-sized battery. Efforts will focus on improving signal quality for deep-in-body monitoring and on cloud and app connectivity for data collection and continuous patient monitoring. New projects are being explored such as continuous thorax monitoring for heart failure and remote, non-invasive monitoring of mothers and babies before and after birth in at-risk pregnancies. The latter would be based on a multi-sensor patch featuring ULIMPIA CMUT and patch technologies.

Newlife initiative- New remote non-invasive solutions for ensuring the health of mothers and babies before and after birth

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ULIMPIA

▶ **Interview Video: https://youtu.be/6-oQ9Mfj4k8**

ULIMPIA

▶ **Promotional Video: https://youtu.be/bO-CggEcpn8**

CAVIAR

17003

Improved image capture technology will address key economic and societal demands and challenges

[CAVIAR: Cmos imAge sensor and VIdeo reseARch]

The CAVIAR project brings together important players with proven track records to improve system-level image capture for medical diagnostics, sustainable agriculture, live television productions, and safety and security. It will also extend the functionality of professional CMOS image sensors for multiple applications.

We are facing several economic and societal challenges. Firstly, society is ageing, leading to an increase in chronic diseases requiring intensive healthcare, which drives the need for change to keep treatment affordable. Improved diagnostics reliability can shorten turn-around times. Then there is agriculture. To make the agro-food industry sustainable, new 'precision agriculture' solutions are needed to deal with, for example, early detection of possible food-related causes of ill-health in order to reduce the burden of such diseases on our healthcare services. Thirdly, consumers are looking for ways of improving their viewing pleasure through Ultra-High-Definition (UHD) TV and High-Dynamic-Range (HDR) pictures, forcing media content creators to move to UHD slow motion. The result is a continuing altering of the broadcasting landscape, in which camera operators will need better means to focus on UHDTV and ensure a healthy and comfortable working space. Finally, the digital-component industry is also coming under pressure to develop general-purpose image-sensors for use in industrial vision, but also in safety and security applications (where cameras trigger early-warnings) and in automotive for driver and passenger monitoring.

The common technology for addressing all these application demands is image capture. However, current image-capture and processing systems have to be improved beyond the state-of-the-art in spatial-, temporal-, and spectral resolutions that enable better diagnostics, and or perception. What's more, in the case of picture performance, not only better image sensors are needed; but also new hardware, image-processing capabilities and high-data-rate handling need to be developed. That's where the CAVIAR project can provide the necessary answers.

Developing image-capture technologies for key application domains

CAVIAR will develop various aspects of image capture technologies, such as optics, image capture, video processing and transmission, needed for these applications. These features will improve system-level image capture for medical diagnostics, sustainable agriculture, live television productions, and safety and security, as well as, extend the functionality of professional CMOS image sensors for multiple applications.

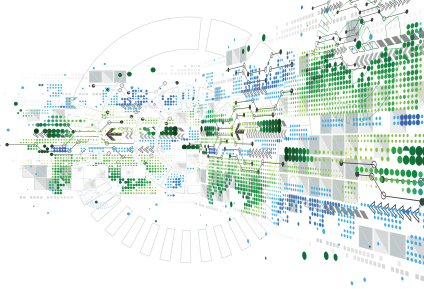
In particular, key project goals, deliverables and activities are as follows:

- Designing new image sensors and developing application demonstrators, including new hardware and firmware/software algorithms;
- Enhancing image performance by extending the light spectrum that can be captured, thus increasing pixel performance and enabling higher frame rates in UHDTV resolution;
- Developing image capture systems for digital pathology, Next-Generation Sequencing (NGS), operating room-assisted imaging and life-cell imaging to enable better diagnostics and shorter turn-around times in hospitals;
- Developing a multispectral camera for precision agriculture and food sorting, providing solutions for a sustainable agri-food industry and slow-motion image-capture for live television;
- Supporting content creators to transition from HDTV to UHDTV;
- Complying with the EMVA 1288, CoaXPress and SMPTE standards.

Additional benefits for Europe

Project research and results (mainly shared at conferences and trade shows) will close the knowledge gaps across the European value-chain for micro- and nanoelectronics-based components and systems, from technology providers to end-users. Importantly, project partners and their European business peers can use this market and application experience and expertise to define and specify next-generation CMOS image-sensor systems.

In addition, research conducted in CAVIAR will also reinforce and enhance existing strengths in Europe's micro- and nanoelectronics industries. To stay ahead of foreign competition in these markets, it is crucial to select and develop the right differentiating functionalities and



KEY APPLICATION AREAS

- Health & Well-Being
- Safety & Security
- Digital Industry
- Digital Life (Agriculture)

ESSENTIAL CAPABILITIES

- Systems and Components Architecture, Design & Integration
- Connectivity & Interoperability
- Safety, Security & Reliability
- Computing & Storage
- ECS Process Technology, Equipment, Materials & Manufacturing

PARTNERS

Adimec Advanced Image Systems BV
AMS Sensors
CEA
EVS Broadcast Equipment Brussels
EVS Broadcast Equipment Liège
Grass Valley Nederland BV
Institut Langevin
MsEyeTech
TNO (Netherlands)
Université de Bourgogne

COUNTRIES INVOLVED

- Belgium
- France
- Netherlands

PROJECT LEADER

Klaas Jan Damstra
Grass Valley Nederland BV

www.caviar-project.org

KEY PROJECT DATES

01 March 2019 to 28 February 2022

to optimise technologies used in end-user applications. More to the point, sharing and deploying these requirements will help optimise performance and functionality in line with what is really needed in image-capture systems, instead of a more general optimisation for wider, but average use.

Bright market outlook

Main medical-market drivers in the coming years will be faster diagnosis for more patient-friendly treatment; higher diagnosis quality in having fewer false-positives and false-negatives; and a lower total cost of ownership for the overall diagnostics workflow and supply chain. In digital pathology, the number of oncology incidences is expected to grow, while the number of pathologists across countries declines. Surgery repeat-rate is 23% with an average cost of US$13,500, resulting in an average savings of US$3,000 per surgery, for an annual total of US$325m. Tele-pathology consultation services will increase and regulatory approval of digital pathology products for primary diagnosis will be given. In NGS, the cost of human genome sequencing will come down, making personally targeted medicines and treatment feasible. The world-wide NGS market is expected to double in value during 2016–2021, to US$6.5 billion.

For precision agriculture, the main market drivers in the coming years will be an increasing use of multispectral imaging system technology in research, and new emerging technologies to make smaller portable multispectral cameras with advanced imaging capabilities and an increase in accuracy and consistency in captured data. The multispectral imaging systems market is expected to grow worldwide, from US$7.41 billion in 2016, to US$12.71 billion by 2021 (with a CAGR of 11.4%).

Regarding broadcasting, consumption of live events is growing globally and will continue to increase, resulting in a continuous investment in cameras. Slow motion will continue to grow in popularity. Broadcasters will be using more slow-motion cameras in a wider range of applications/programmes. Equipment prices and operational costs will decrease, giving content creators a faster return on investment. In the coming years (according to research published by Frost & Sullivan, IABM and Devoncroft), content creators will continue to move towards higher-resolution formats for sports television and cinema, to create premium-quality content in a market with intense competition (with Japan being the first to roll out UHDTV in 4K and 8K for the Olympics in 2020).

Finally, investigating the digital-component market for image sensors in industry, market reports (by Yole Développement) expect machine vision and inspection image-sensor demand to grow with a CAGR of 13.5% to 4m units in 2021, resulting in an overall market size of approximately €300 million in 2021.

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CAVIAR

CAVIAR improves image sensing for healthcare, sustainable agriculture, industry and entertainment

A project within the EUREKA PENTA programme

Paris, 7 November 2019 -CAVIAR (Cmos imAge sensor and VIdeo research), a project within the EUREKA PENTA Cluster and managed by industry association AENEAS, is developing new image capture technologies that will deliver benefits for healthcare, sustainable agriculture, digital industry and entertainment. By bringing together world-class engineering and research skills from across Europe, the CAVIAR project aims to enable higher imaging performance and new capabilities for these economically and socially important application domains. CAVIAR will develop image sensors and application demonstrators, including hardware and firmware / software algorithms, with the goal of improving system-level image capture and extending the functionality of professional CMOS image sensors for multiple applications.

Given the challenges of providing affordable and accessible healthcare as the world population ages and chronic diseases increase, healthcare is a key focus for the CAVIAR project. Improved imaging in diagnostics can improve reliability (fewer false negatives / positives) and support quicker, more effective and efficient patient-focused care. In particular, CAVIAR aims to deliver advances in image capture for digital pathology, Operation Room assisted imaging, cell imaging, ophthalmology and Next Generation Sequencing (NGS), which will be key for personalized medicine. Overall, the market opportunities in healthcare are enormous, with NGS alone expected to double from 2016 to 2021 to reach USD 6.5 billion a year.

CAVIAR's improved sensor technologies will also be applicable in multi-spectral imaging (i.e. capturing specific wavelengths of the electro-magnetic spectrum). Multi-spectral imaging is central to precision agriculture, which supports sustainable practices by providing farmers with detailed information about plants and conditions at a highly local scale. This can result in reduced inputs, better resource protection and increased traceability, and can help the expansion of organic agriculture which is highly recommended by the UN FAO (United Nations Food and Agriculture Organization).

In the fiercely competitive digital entertainment market, CAVIAR's innovations will support the move to higher-resolution formats for cinema and sports television. The project will develop image capture and replay for slow motion UHD (Ultra-High Definition) TV and optimizations from image capture to transmission. These will be particularly relevant as demand for live events continues to grow worldwide, and with Japan's roll-out of 4K and 8K UHD TV for the 2020 Olympic Games.

The CAVIAR project brings together 10 European organisations, including leading players in CMOS sensor manufacture and imaging applications, as well as world-class research institutions. This breadth of partners allows for a sharing of market, application and user expertise, and input into CMOS sensor design and manufacture for future systems. As a result, the project will be able to develop solutions across the entire value chain, covering requirements from technology providers to end-users and filling gaps in Europe's capabilities in these domains.

About the PENTA programme

PENTA is a EUREKA cluster whose purpose is to catalyse research, development and innovation in areas of micro and nanoelectronics enabled systems and applications - where there is shared national and industrial interest. Based on the Electronic Components & Systems (ECS) Strategic Research Agenda (SRA) key areas and essential capabilities, PENTA programme contributes to the development of electronic solutions with the opportunity for rapid competitive exploitation and a strong impact on European societal challenges. The PENTA project team is supporting SMEs, large corporations, research organisations and universities by facilitating access to funding, fostering collaborative work and creating consortia.

PENTA is operated by AENEAS.
More on PENTA: http://www.penta-eureka.eu
More on AENEAS: https://aeneas-office.org

About CAVIAR

CAVIAR is a RD&I project consortium involving 10 partners from 4 countries. The project partners are: Grass Valley Nederland BV (project leader), 3DHISTECH, Adimec Advanced Image Systems BV, AMS Sensors, EVS Broadcast Equipment (Brussels, Liège), CEA, Institut Langevin, MsEyeTech, TNO (Netherlands) and Université de Bourgogne

More on CAVIAR: http://caviar-project.org

CAVIAR

PENTA CAVIAR project brings added UHD-4K TV viewing excitement for sports fans

Super slow-motion UHD-4K over 100G ST 2110

Paris 27 May 2021- Over the past five years, 4K Ultra HD TV (UHD-4K) has been rolled out worldwide bringing viewers four times higher resolution, higher dynamic range (higher contrast and picture quality) and a wider colour gamut. But until now, UHD-4K TV could not show the slow-motion replays that are such as big part of watching sport on TV. So, EVS and Grass Valley teamed up in this CAVIAR project. They combined Grass Valley's new camera with EVS's digital production and server technology to make slow motion in 4K a reality. The result – UHD-4K TV has got even better for sports fans.

Slow-motion replays are an integral part of TV sports coverage. Many sports rely on replays to show viewers critical action in more detail and to help match officials to judge these actions. And it's not just technical, slow motion brings emotion. However, creating smooth slow motion requires a camera and a recording system that can shoot faster than the normal rate of 50 or 60 frames per second. Capturing more pictures than normal, then playing them out at the normal rate means the viewer sees them as slow motion: smooth motion at a slower speed.

In this project, the partners aimed to enable 4K Ultra HD TV slow motion at the 'sweet spot' for replays, where images are captured at three times slower than the normal frame rate. The technical challenge was to connect the output from Grass Valley's camera which supports this frame rate to EVS' digital video production systems and servers. This combination would allow broadcasters with EVS systems to receive images from the camera via a cable or fibre IP network and then broadcast them on to viewers.

The project built on two elements. Firstly, the EVS XT-VIA video servers, which have been able to support Slow Motion with a 3 times slower frame rate configurations in UHD-4K format since early 2019. Secondly, the Grass Valley LDX100 camera, which became available at the end of 2020, and was the industry's first camera to support broadcast quality three times UHD-4K. The camera can transmit images over coax cable (12G-SDI) and via IP protocols on 100GE fibre (ST 2110). By transmitting digital data over IP networks using industry IP-standard SMPTE 2110 streams, the camera allows for 'flexible topologies': that is, it can be part of readily expandable cable and fibre broadcasting networks.

Although the video server existed already, integrating the Grass Valley camera with the EVS XT-VIA server called for new technical solutions. The issue lay in volumes of data being transmitted: under the ST 2110 protocol, each UHD-4K phase is transported in full resolution, which exceeded the bandwidth of the 10G Ethernet interface of the XT-VIA IP rear panel (in 59.94Hz).

To solve this challenge, the project partners turned to the EVS-built XHub-VIA switch. This switch was already being used as a Live IP Aggregator (a technology that dynamically routes live TV digital data over networks in the most efficient way). This helped overcome the bandwidth limitations, but only up to a maximum three streams of full resolution HDTV (9G in total) – still not enough for UHD-4K when transported over a single fibre cable. The ultimate solution was for the XHub-VIA IP Aggregator to remap the incoming triple speed 4K streams of 36 giga bits per second (Gb/s) to three non-conventional 12.5 Gb/s interfaces of the XT-VIA server. With this solution in place, the XHub-VIA can connect to the Live IP fabric (its collection of switches) at the necessary 100G speed.

The diagram shows the complete LDX 100 – XHub-VIA IP Aggregator – XT-VIA workflow. At the top left is the LDX 100 which generates the triple speed and live feed streams (3 phases and 1 combined signal to create the normal single-speed UHD-4K signal) and receives back the normal speed UHD-4K playout of the XT server. A 100G Mellanox switch (top centre) dispatches those streams between the LDX 100 camera and the XHub-VIA IP Aggregator, as well as the PTP (Precision Time Protocol) messages generated by the Meinberg PTP to synchronize all parts in the system. The video/audio content arrives at the EVS XT server through the XHub-VIA IP Aggregator.

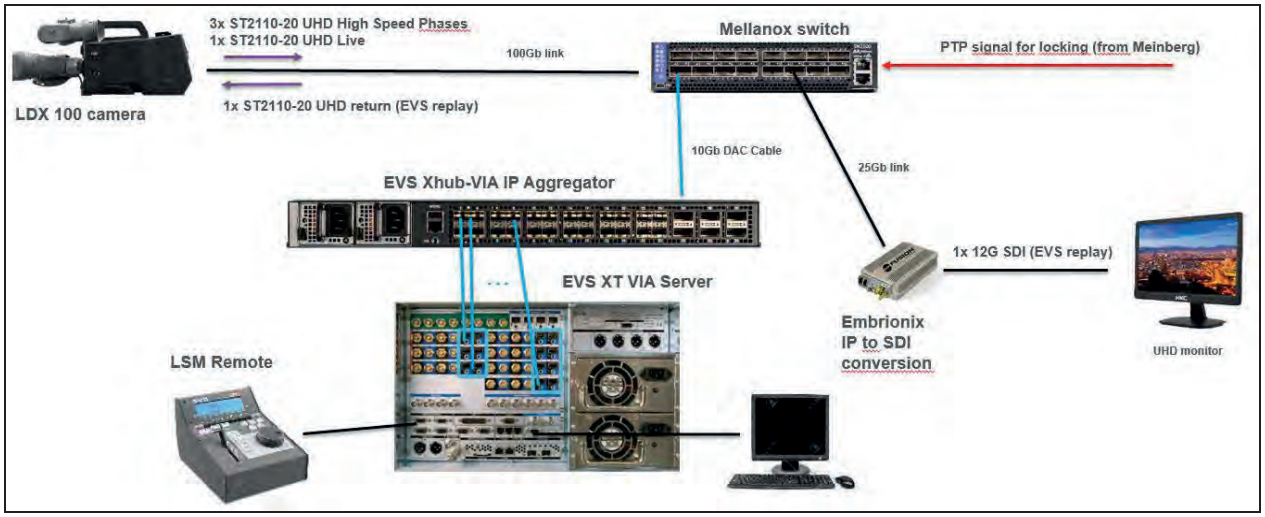

Figure 1 – LDX 100 / XHub-VIA / XT-VIA workflow

Even though the XHub-VIA is another physical device, when used as an IP Aggregator, it becomes part of the EVS XT/XS system. A Multicam application, which is running on the XT server, manages both the XHub-VIA and the XT-VIA server through a dedicated management connection.

The new LDX 100 generates IP directly in the camera body. Open (SMPTE) protocols transmit and receive audio, video and intercom streams, and industry standard AMWA-NMOS (Networked Media Open Specifications) protocols are used for the device connection management, while PTP synchronizes the camera with the rest of the network.

EVS and Grass Valley have worked closely to integrate the new system elements on all levels: compatibility of the ST 2110-20 streams, synchronization through PTP and control through NMOS IS-04 and IS-05, and in particular, compatibility between Session Description Protocols generated by the LDX 100 and the XT-VIA server. This collaboration has led to a major advance in UHD-4K TV, providing opportunities for content providers/broadcasters to deliver slow motion and for viewers, especially sports fans, to be able to relive memorable moments in all their exciting detail.

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More on PENTA: http://www.penta-eureka.eu
More on AENEAS: https://aeneas-office.org

About the CAVIAR project

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More about CAVIAR: https://caviar-project.org/

CAVIAR

PENTA CAVIAR project contributes to agriculture of the future

Algorithms based on machine learning for separation of crop and weeds in images

Paris, 20 May- Within CAVIAR, ImViA and MsEyeTech are developing software that can detect and localize crops and weeds for agricultural applications. Their project is based on multi-spectral (MS) imaging that uses visible and near-infrared (NIR) light, and a variety of techniques and methods for MS image analysis. Most important, it is using segmentation – a crucial image processing step that can separate weeds from crops even in complex images. The final goal is to create MS cameras for agricultural applications that can support more efficient and sustainable food production.

Worldwide, the agricultural industry faces demands for higher yields but also greater environmental protection. Precision agriculture, which uses technology to produce more crop with less water and fewer chemicals, and automating certain agricultural tasks, can help meet these challenges. But for both, imaging the crop and identifying what is in the images is a basic requirement. Here, segmentation is key for scene understanding ('seeing' what is visible in the image) and for agronomic analysis – for detecting crops, weeds and soil, as well as for image-guided operations in the field.

Indeed, agronomic image analysis – the processing of images taken in agricultural fields or greenhouses – is one of the major challenges in computer vision, particularly machine learning based approaches to the segmentation of these images. The project partners chose to use 'semantic segmentation' based on deep learning because it provides an accurate and effective segmentation of the crop and weeds. The process seeks to label different elements of the image into semantically meaningful objects (i.e. crop, leaves, connections etc...) and to classify and categorize each object into one of a set of pre-determined classes (e.g. crop, soil, weed). This results in a semantic relationship between the crop and weeds.

The process is challenging because each image contains several semantic relationships. The algorithm developed in this CAVIAR project begins by removing (visually) the soil from the images. It then separates the crop from the weed. This is an especially difficult task as crops and weeds are similar in shape and color, so this is where the deep semantic segmentation algorithm, based on deep learning techniques, is applied: the convolutional neural network is trained and then asked to do the separation.

The figure below illustrates how this works. An original color image containing a crop plant and a weed is given to the algorithm which, at the end of the process, returns two separate images: one of the crop plant and one of the weed. These images are then ready to be used in agricultural applications or by agricultural robots.

Fig. 1. Separation of crop and weed using the proposed algorithm (More details: https://www.youtube.com/watch?v=dNR4dE2Cp_M&t=2s).

Building on these processes, the project aims to develop MS systems that capture images in the visible and NIR ranges, de-mosaic and de-noise them, segment them into crop and weeds, and then provide localisation information for other machines, whether software applications or agricultural robots.

In creating these MS systems, the project is directly addressing the fundamental requirement for detection and monitoring systems in the growing areas of precision agriculture and automated agricultural operations. With MS imaging having proven its ability to extract important information, the software and techniques developed will enable weeds to be detected quickly and accurately – making a significant contribution to the use of new technologies in feeding the world and protecting natural resources.

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More about CAVIAR: https://caviar-project.org/

The CAVIAR project developed and demonstrated technologies and building blocks for CMOS image sensors, video processing hardware and algorithms, video data reduction and transmission. [CAVIAR]

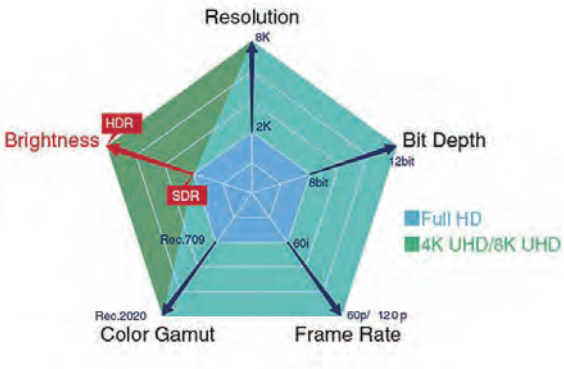
May 2022

In all vision based professional applications the trend in image capture is towards higher spatial and temporal resolutions, wider colour gamut, higher dynamic range and improved image quality.

In CAVIAR, 7 partners cooperated to develop and optimize the next generation of technologies for professional products for use in Medical, Television Broadcast, Precision Agriculture, Mobile and (in cabin) Automotive markets.

Background, objectives of the project and challenges

Image capture and transmission are generic technologies used in a multitude of business applications, including Healthcare, Precision Agriculture, Security, Automotive and Digital Entertainment. In all vision based professional applications, the trend in image capture is towards higher spatial and temporal resolutions, wider colour gamut including the use of non-visible spectral domains, higher dynamic range and improved image quality. The goal of the CAVIAR project was to collaborate on these technologies to address needs in several markets.



Five elements of increased image quality. Source: https://www.eizo.lv/knowledge/monitor-expertise/age-of-hdr/

Given the challenges of providing affordable and accessible healthcare as the world population ages and chronic diseases increase, healthcare was a key focus for the project. Improved imaging in diagnostics was researched to improve reliability (fewer false negatives/positives) and support quicker, more effective and efficient patient-focused care.

CAVIAR also improved sensor technologies in multi-spectral imaging. Multi-spectral imaging is central to Precision Agriculture to support sustainable practices by providing farmers with detailed information about plants, weeds and conditions at a highly local scale. This can result in reduced inputs (water, chemicals), better resource protection and increased traceability, and can help the expansion of organic agriculture.

In the fiercely competitive digital entertainment market, CAVIAR's innovations support the move to higher-resolution formats for cinema and television. The project developed image capture and replay for slow motion Ultra-High Definition TV and optimizations from image capture to transmission. These will be particularly relevant as demand for live events continues to grow worldwide. The project moved from market specific interfaces to open standards IP transmission enabling remote productions, increasing cost efficiency and reducing the carbon footprint of live television productions, as less people and equipment have to travel to the live event.

For in cabin security applications in automotive the NIR efficiency of global shutter CMOS image sensors was extended.

Technological achievements

CMOS Image Sensor achievements

The project worked on next generation CMOS image sensors. For broadcast a 4K UHDTV sensor with 2.5µm global shutter pixels was designed to provide 4K streams in full resolution at 180 frames per second to create, when played back, slow motion in 4K detail. For Precision Agriculture, an existing monochrome CMOS image sensor with a pixel pitch of 4.5µm has been equipped with a 4x4 filter array to create 16 bands ranging from 400nm to 940 nm. For face recognition and authentication in mobile, as well as in cabin safety

features in automotive, a 2M pixel global shutter CMOS image sensor was developed with improved near infrared sensitivity for better operation under bad lighting conditions.

Advances in image processing

To process multi-spectral images in Precision Agriculture, a deep learning algorithm was developed. A colour image containing a crop plant and a weed is given to the algorithm which returns two separate images: one of the crop plant and one of the weed. These images are then ready to be used in agricultural applications or by agricultural robots.

To benefit from the full 4K UHDTV specification, High Dynamic Range processing that can handle up to 15 F-stops of video, and conversion towards the smaller dynamic range in HDTV have been researched. Also an improved focus assist algorithm was developed to help the camera operator properly focus on a display with a lower spatial resolution than that of the camera.

Video data reduction and transmission

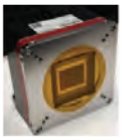
An automated ROI segmentation of Electron Microscopy images with annotation effort of less than 5 minutes was developed, saving hours in training a model to automatically segment cellular structures of interest, speeding up the digital pathology processing pipeline.

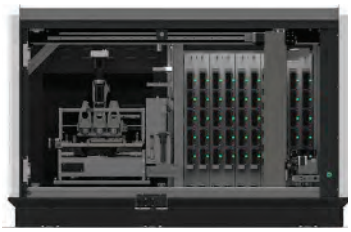
For security an edge processing pipeline was developed for high resolution, high framerate imagery in aerial surveillance on a drone with limited processing power and low transmission bandwidth. A data reduction of 99% was achieved.

To enable transmission of triple speed 4K video streams next to normal 4K and HDTV (2K) outputs on the camera towards the replay server, 100G Ethernet transmission using open IP standards was developed.

Hardware demonstrators

For all four applications hardware demonstrators have been developed that will result in commercial products or a demonstration kit for potential customers (automotive).

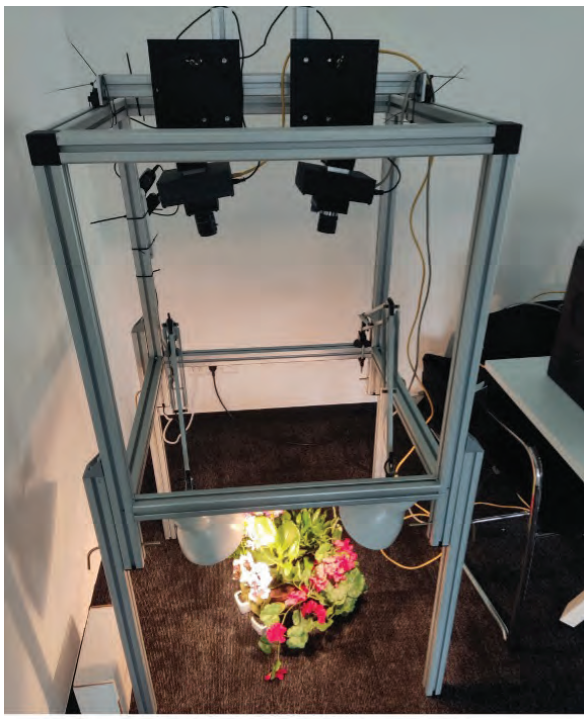




A new colour camera from Adimec is used at 230fps in a digital pathology scanner of 3DHistech.

Re-using the existing zoom optics and scanning mechanism allows a fast integration into the system while reducing the scan time of histology slides.

TNO contributed with a fast annotation algorithm, reducing annotation time from 8 hours to 5 minutes.



ImVia & MsEyeTech solution. Two single-shot MS cameras cover the VIS and NIR spectrum. Each camera provides 8-band images.

Specific demosaicking algorithm provided to extract different image bands. Using semantic segmentation, plants and weeds are detected and separated.

AMS demo kit. The NIR-enhanced sensor combined with a NIR light source shows the capability to detect drowsiness of a car driver, sending a warning signal.

The demo kit uses a compact EVK kit and requires minimal illumination power thanks to its high quantum efficiency at NIR.

Grass Valley's new live broadcast camera, the LDX 150 NativeIP camera together with the XT-VIA production server from EVS. The system can capture Ultra High Definition, High Dynamic Range images at triple speed for slow motion replay.

The LDX150 and XT-VIA production server are designed to meet the most demanding live broadcast production requirements, integrating all new formats and protocols from HD to 8K, SDR to HDR, and SDI to IP in a single versatile solution.

TNO and Grass Valley jointly developed a focus assist algorithm to enable focusing on displays with resolutions lower than the image capture resolution.

Market Potential

With the 4K slow motion image capture system EVS and Grass Valley have completed the basic 4K toolset for content creators to secure their service available market.

The 21M pixel camera reduces the scan time of histology slides in the P1000 scanner. Allowing new and existing scanners to increase the scan capabilities in digital pathology labs. With introduction planned in 2022 by 3DHistech, the new scan capability will find its way to hundreds of systems on yearly basis.

The multispectral camera from ImViA and MsEyeTech provides VIS and NIR imaging for several agricultural applications. Monitoring plants growth, optimization of growth process, and detection of weeds and diseases are the potential usages of the system. The MS camera can be mounted on a tractor to take photos of the field while tractor is being used for other agricultural operations and provide information about the situation of the field and newly-growing weeds.

The NIR-enhanced global shutter image sensor with high QE at NIR allows AMS to penetrate consumer and automotive markets while keeping the lead in the industrial global shutter market. High QE at NIR allows high image quality with 5 to 10x less light power compared to existing solutions. This is key for battery-powered applications such as consumer/mobile 3D authentication, AR/VR, in- cabin driver monitor. Most industrial applications make use of global shutter.

Societal & Economic Impact

To improve Health & Well Being, CAVIAR improved diagnostic capabilities in digital pathology to support our society's increasing need for more, better and faster patient diagnostics at lower cost per diagnosis.

The agricultural industry faces worldwide demands for higher yields and greater environmental protection. The CAVIAR technology for precision agriculture can enable production of more crop with less water and fewer chemicals. It can be used for image-guided operations in the field to help feed the world in a more economic and environment-friendly way.

Broadcast television moves to ever higher resolutions and frame rates. The technology developed in CAVIAR makes this possible. Addition of slow motion to ultra HDTV will make it possible to place audiences in the middle of the action. Furthermore, the IP transmission developed to enable remote productions will result in less staff and equipment traveling, thus lowering the carbon foot print of live television productions, and improving the social life of content creators who can be home more often.

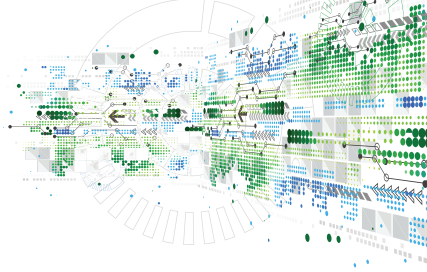
For a secure society, CAVIAR demonstrated technology which allows to apply high-resolution cameras in drone applications. This allows for a less operator-intensive monitoring solution, leading to a more secure society.

NIR-enhanced cameras for in-cabin monitoring are essential tools to detect the status of the driver and other car occupants. NIR detection is necessary especially during night driving when indoor light is off. The car processor determines if the driver is in good driving shape. If not, alert messages are sent to the driver and ultimately the car stops. Global shutter and high quantum efficiency at NIR are required, as they allow the illuminator to be active for much shorter time (hence sparing considerable power and illuminator lifetime) compared to traditional rolling shutter sensors with low NIR QE.

Apart from the benefits identified above, the project has strenghtened the position of Europe in the field of CMOS image sensors, cameras and image processing. Through the successful cooperation, important knowledge has been shared to improve the competitiveness of all. Collaboration on individual technical issues enabled partners to mature their designs faster, and find root causes for potential problems in an early stage.

Patents/Standardisation/ Publications

Protection of the IP developed in the project is of key importance to the partners; in total 6 patents have been filled.



KEY APPLICATION AREAS

- Health & Well-Being
- Safety & Security
- Digital Industry
- Digital Life (Agriculture)

ESSENTIAL CAPABILITIES

- Systems and Components Architecture, Design & Integration
- Connectivity & Interoperability
- Safety, Security & Reliability
- Computing & Storage
- ECS Process Technology, Equipment, Materials & Manufacturing

PARTNERS

Adimec Advanced Image Systems BV
AMS Sensors
CEA
EVS Broadcast Equipment Brussels
EVS Broadcast Equipment Liège
Grass Valley Nederland BV
Institut Langevin
MsEyeTech
TNO (Netherlands)
Université de Bourgogne

COUNTRIES INVOLVED

- Belgium
- France
- Netherlands

PROJECT LEADER

Klaas Jan Damstra
Grass Valley Nederland BV

www.caviar-project.eu

KEY PROJECT DATES

01 March 2019 to 28 February 2022

Partners have been active in the following standardisation groups either contributing or actively following: SMPTE, AIMS, CoaXPress, GenICam and MIPI. Grass Valley chaired AIMS.

To disseminate the results partners organised a promotion campaign in 2021 together with the Aeneas office, published and presented several papers during conferences, exhibited during trade shows, and performed product demonstrations and field tests at many potential customers world-wide, as well as online during covid-19 restrictions.

Future Developments

The R&D performed in the CAVIAR project is an excellent basis for new products that will be launched by the commercial partners to fully harvest the market potential, and for follow-up research in the years to come.

The good results of the project and the excellent cooperation made part of the partners decide to collaborate in a next PENTA project called Mantis Vision, which already started mid 2021.

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CAVIAR

▶ **Video: https://www.youtube.com/watch?v=0T5l4FEU7Bk**

HiPer

17006

Providing on-board computational and communication power and functionality for safe autonomous driving [HiPer]

The HiPer project will develop an automotive-grade HPVC computer system capable of handling level 5 autonomous driving and providing new electrical architectures which ensure sufficient compute power and the necessary communication interfaces. This will also mean fundamental changes to connectivity, computational power and safety in vehicle technologies.

Road travel and transportation are notoriously disadvantaged by the effects of traffic and congestion: not only the pressure and irritation caused to drivers and passengers, but also energy inefficiencies and, crucially, accidents and fatalities. Even though the newer generation of vehicles already support drivers with such niceties as route planning and guidance, assisted or automated parking and real-time traffic information, these functions and features do not go far enough: they cannot replace the human driver or provide highly flexible, efficient and safe travel; and neither do they really contain the volume of traffic. To address these issues and also create a new quality of driving comfort, autonomous driving (AD) could be the answer.

The Society of Automotive Engineers defines six levels of automation for autonomous cars, where each level has a specific set of requirements that a vehicle must meet before it can be considered to operate at that level. AD at level 5 requires truly high-performance vehicle computers (HPVC) to perform a multitude of complex functions, such as comprehensive vision processing, object recognition, intelligent traffic system and task dispatch between different electronic control units (ECUs) in the car. The HPVC system must be capable of safely handling all driving situations autonomously.

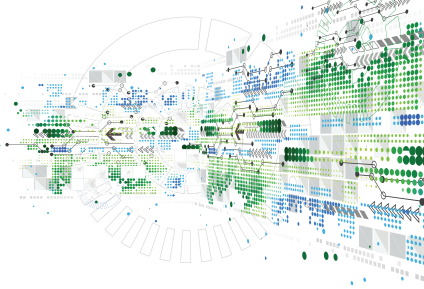
However, there are no automotive-grade HPVC modules and systems, and even though the first necessary components could become available shortly, they are not expected to be designed for the use in the harsh conditions of real vehicles. Furthermore, essential technological obstacles need to be overcome before solutions can qualify as 'regular' products at affordable prices. These are typical areas the HiPer project will focus on in its work to close these gaps.

Delivering automotive grade level-5 HPVC computer system

The main deliverable of HiPer will be an automotive-grade HPVC computer system capable of handling level 5 autonomous driving and providing new electrical architectures which ensure sufficient compute power and the necessary communication interfaces. This will mean fundamental changes in vehicle technologies with respect to connectivity, computational power and safety. Importantly, the project consortium will also validate all of this by demonstrating the HPVC system in a passenger car by creating an HPVC demonstrator and an automotive-grade, in-car, high-speed network.

This calls for three tightly linked innovation paths and validation activities:

1. Computation path: will tackle the thermal challenges by new highly reliable automotive-grade cooling concepts based on advanced heat-path engineering with integrated spreader and heat-pipe technologies, as well as, novel 3D-printed micro channel and direct liquid cooling approaches. The work in this innovation path will require the introduction of new materials, and new heat transfer components and technologies in the vehicle;
2. Communication electrical connectivity path: will develop new HPVC interfaces that allow a data throughput of more than 10 Gbit/s as required on-board for all time-critical applications. New multi-channel, high-speed connectors and wiring harnesses solutions will become the future standard in autonomous cars. Furthermore, Ethernet chips, high-speed AD converters and a time-sensitive networking (TSN) protocol suite will be developed to increase the quality of service through, for example, high bandwidth, predictable low latency, and prioritisation of data streams;
3. System integration path: will improve HPVC thermo-mechanical reliability and functional safety in harsh automotive environments, achieving a lifetime of 50,000 hours in contrast to the current 8,800 hours. This will include: the development of an innovative mould underfill technology (equipment, process and simulation); the application of new accelerated testing and qualification methods; functional safety by prognostics and health management (PHM); new design for reliability (DfR) simulations; and reliability concepts developed in intense cooperation with the computational/thermal innovation path.



KEY APPLICATION AREAS

- Transport & Smart Mobility
- Safety & Security

ESSENTIAL CAPABILITIES

- Systems and Components Architecture, Design & Integration
- ECS Process Technology, Equipment, Materials & Manufacturing

PARTNERS

IMEC - Interuniversitair Micro-Electronica Centrum vzw
Interflux Electronics nv
Materialise
AUDI AG
CHEMNITZER WERKSTOFFMECHANIK
Dynardo GmbH
Fraunhofer Institute for Electronic Nano Systems
GLÜCK Industrie-Elektronik GmbH
NXP Semiconductors Germany GmbH
Robert Bosch GmbH
Technical University of Chemnitz
Advanced Packaging Center BV
Boschman Technologies BV
Delft University of Technology
Eindhoven University of Technology
Fastree3D
NXP SEMICONDUCTORS NETHERLANDS BV

COUNTRIES INVOLVED

- Belgium
- Germany
- Netherlands

PROJECT LEADER

Frank Pelz
Robert Bosch GmbH

KEY PROJECT DATES

June 24, 2019 to June 23, 2022

In particular, the following key requirements will be addressed:

- Much higher computational power at the highest functional safety-level. Based on most modern technologies, powerful processors generate up to 300W;
- Comprehensive perception of the surrounding environment in real-time. This can only be achieved by deploying multiple video/radar/lidar/ultrasonic sensors in the car, which will generate much more data than in today's vehicles. Final data fusion will be done in centralised HPVC units. Therefore, the on-board communication network needs to ensure much higher data-rates and guarantee quality of service (QOS). New connectors, wiring harness solutions, as well as, communication chips and AD converters, are needed;
- On-board communication system and HPVC electronics need higher reliability and security/safety than currently available to protect human life in routine, and also difficult, traffic situations. This means that reliability and functional safety of AD electronic-systems must be increased substantially because the active human driver, who is constantly monitoring the driving behaviour of the car, will be replaced by a passive passenger, who leaves all control functions to the electronic system.

Societal, economic and environmental benefits

European society will massively benefit from AD technologies: reduced numbers of accidents and fatalities; better deployment of existing road infrastructure through harmonised and increased traffic flows; and a new quality in driving comfort and reduced fuel consumption and emissions. Europe will also benefit economically from the wealth generated by the continuing success of its automotive industry – in which it has a leading position and must be defended.

Engaging European industry

Fundamental changes have strong impact on the European automotive industry. European OEMs (or original equipment manufacturers, companies that produce parts and equipment that may be marketed by other manufacturers) need to be able to offer AD cars, so as not to lose their important market positions to America or Asia. Hence, European suppliers and OEMs need to firmly support and push towards new car IT architectures. Thanks to decades of experience and expertise in integrating electronic devices into vehicles, these newly centralised, standardised, safe secure HPVCs will be Europe-first creations.

According to MarketWatch's 2018 report, the global self-driving car market is expected to expand at a CAGR of 36.2%, leading to global revenue of US$173.15 billion by 2023. By creating an HPVC demonstrator and an automotive-grade, in-car, high-speed network – the two key technologies required for AD cars – the HiPer project will enable European car manufacturers to offer new efficient mobility solutions, and enable the European automotive industry to stay at the leading edge of this worldwide market.

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HiPer

HiPer creates High Performance Vehicle Computer and Communication System for Autonomous Driving

A project within the EUREKA PENTA programme

Paris, 31 October 2019 -HiPer, a project in the EUREKA PENTA Cluster and managed by industry association AENEAS, is building on Europe's leading position in automotive semiconductors (chips) to create electronics vital for the future of road travel. By creating an advanced High-Performance Vehicle Computer (HPVC) and Communication System, HiPer will fill a vital need for computer processors and electronic control units with the safety, performance, security and reliability necessary for real-world self-driving vehicles ('Autonomous Driving', also known as 'Level 5 automation').

The market for partially and fully autonomous vehicles is expected to rise from USD 42 billion in 2025 to nearly USD 77 billion in 2035[1], with the first virtually autonomous driving cars on sale by 2021. These vehicles will need to handle complex tasks such as vision processing, object recognition and interaction with intelligent traffic systems with complete reliability in real-time. However, electronic systems with the necessary processing power and speed of communication that can also withstand harsh vehicle conditions, such as heat and humidity, do not yet exist. HiPer intends to fill this gap through innovations in semiconductor design, manufacturing and packaging to create automotive grade solutions in three key areas: computation, communication and integration.

Among key innovations, HiPer will develop new cooling technologies for processors with a heat dissipation of 300 W and novel Automotive Ethernet technology to support high data rates, high data integrity and high-speed communication to systems outside the vehicle. The project will also work on new detectors and new chip packaging techniques to improve the thermo-mechanical reliability and functional safety of the HPVC in automotive environments, increasing operational lifetimes to 50,000 hours from today's 8,800 hours.

To achieve these goals, the HiPer consortium brings together industry, SME and research organisations from Belgium, Germany and the Netherlands, with expertise along the entire automotive value chain. Partners include Audi, a world leading premium car manufacturer; Robert Bosch GmbH, a leading global supplier of technology and services; and NXP, a leading manufacturer of high-performance IT platforms, vehicle electronics and communication solutions. The consortium aims to deliver market leading solutions for centralized, safe and secure HPVCs at affordable prices, based on architectures and concepts that can lead to new standards. These results will strengthen Europe's competitiveness and its ability to lead the world in the transition to electric vehicles and autonomous driving.

[1] www.bcg.com/de-de/industries/automotive/autonomous-vehicle-adoption-study.aspx

About the PENTA programme (managed by the AENEAS Industrial Association)

PENTA is a EUREKA cluster whose purpose is to catalyse research, development and innovation in areas of micro and nanoelectronics enabled systems and applications - where there is shared national and industrial interest. Based on the Electronic Components & Systems (ECS) Strategic Research Agenda (SRA) key areas and essential capabilities, PENTA programme contributes to the development of electronic solutions with the opportunity for rapid competitive exploitation and a strong impact on European societal challenges. The PENTA project team is supporting SMEs, large corporations, research organisations and universities by facilitating access to funding, fostering collaborative work and creating consortia.

PENTA is managed by AENEAS.
More on PENTA: http://www.penta-eureka.eu
More on AENEAS: https://aeneas-office.org

About HiPer

HiPer is a RD&I project consortium involving 17 partners from 3 countries. The project partners are: Robert Bosch GmbH (project leader), Advanced Packaging Center B.V., Audi AG, Boschman Technologies B.V., Technische Universität Chemnitz, Chemnitzer Werkstoffmechanik, Technische Universiteit Delft, Dynardo GmbH, Technische Universiteit Eindhoven, FastTree3D, Fraunhofer Institut für Elektronik und Nanosysteme, Glück Industrie-Elektronik GmbH, imec, Interflux Electronics, Materialise, NXP Semiconductors Netherlands B.V., NXP Semiconductors Germany GmbH.

National funding support is provided by Belgium, Germany and the Netherlands.

HIPer

▶ Video: https://youtu.be/cB2tHLotzbo

SunRISE

17004

AI and privacy-enhancing -technologies to enhance internet interoperability, resiliency and security for business and industry

[SunRISE]

The SunRISE project will implement a comprehensive security solution, concentrating on aspects and issues critical to future systems related to the internet of things (IoT). Advanced digital technologies, such as artificial intelligence (AI), machine learning and privacy-enhancing technologies (PETs), together with security-data sharing, will be deployed to implement such system-security features as intrusion and anomaly-detection.

In recent years, the internet of things (IoT) revolution has been transforming our world, as we move towards one where everything is interconnected, everything is smart, and everything is – or should be – secure. Sensors, actuators, processors, networks and radios are crucial in building smart connected-devices enabling real-time sensing, contextual understanding, environment manipulation, and communication. Today, 2.9 billion people are online, 40% of the world's population. And by 2020 we expect about 50 billion devices to be connected.

While delivering clear benefits, these devices also increase the risk of data manipulation, data theft and cyberattacks. In 2015, European enterprises had at least a one-in-five chance of losing data through a targeted cyberattack. There is a severe risk that the European economy is falling behind in exploiting opportunities in emerging IoT markets. The lack of trust by businesses and consumers in smart connected-devices is a clear barrier to growth and jobs. At this point, it is no longer sufficient to provide ad hoc 'semiconductor' responses to these issues. Essentially, we need well-structured, interoperable and resilient secure solutions and systems.

AI and machine learning crucial to comprehensive IoT security

The SunRISE project will deal with one of the major challenges for the digital industry, namely IoT security. To obtain a comprehensive security solution, this project will address the following critical aspects in future IoT systems:

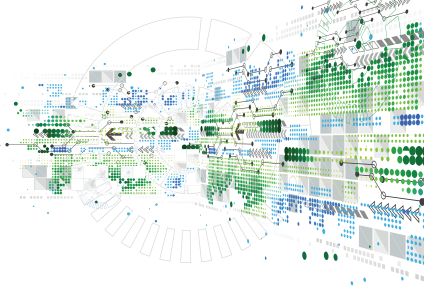
- Design of intrusion and anomaly-detection: by using machine learning (and the latest results) on IoT edge nodes;
- Sharing of security intelligence data (from IoT nodes to cloud back-ends): by creating a community with reference structures. Based on the larger dataset, machine learning can be accelerated and overall system security increased. This should result in security turning into a shared responsibility, interest and effort, but also into improved efficiency, cost and resource usage;
- Lack of trust by fearing the loss of confidential data: can be overcome by using privacy-enhancing technologies (PETs), like homomorphic encryption and secure multi-party computation (MPC);
- Efficient and cost-effective introduction of PET: by designing and manufacturing hardware which supports and accelerates AI specific to IoT end-nodes.

SunRISE activities will result in the following deliverables:

- A reference cloud-based platform for sharing security intelligence;
- Novel homomorphic encryption hardware accelerators and secure multi-party computation PET technologies;
- Efficient hardware for PET technologies and machine learning;
- A reference platform for secure IoT device identity and life-cycle management;
- Highly secure and cost-efficient root-of-trust hardware for IoT devices.

Crucially, this project will be guided by PENTA's three key objectives:

1. To reinforce existing strengths in Europe: SunRISE will use existing European expertise and experience in AI and machine learning to monitor the security of IoT devices and detect anomalies, thus preventing attacks or further shortcomings. The project will also develop tools capable of fixing detected errors and/or bringing the entire IoT system operation into a safe mode;
2. To close gaps across the European value-chain: To meet the high technological risk posed by this project's approach, SunRISE brings together experienced partners from three countries, all experts in their specific field.



KEY APPLICATION AREAS

- Health & Well-Being
- Digital Industry

ESSENTIAL CAPABILITIES

- Connectivity & Interoperability
- Safety, Security & Reliability
- Computing & Storage

PARTNERS

Ancud IT Beratung GmbH
AnyWi Technologies
Cloud&Heat Technologies GmbH
Delft University of Technology
Eindhoven University of Technology
ENGIE – Laborelec
Fraunhofer IIS/EAS
NXP Semiconductors Belgium NV
NXP Semiconductors Germany GmbH
Philips Electronics Nederland B.V
Philips Medical Systems
Sandgrain
SIRRIS HET COLLECTIEF CENTRUM VAN DE TECHNOLOGISCHE INDUSTRIE
Stichting IMEC Nederland
Technical University of Munich
Technolution BV
University of Ulm

COUNTRIES INVOLVED

- Belgium
- Germany
- Netherlands

PROJECT LEADER

Christopher Nigischer
NXP Semiconductors GmbH

KEY PROJECT DATES

August 01, 2019 to July 31, 2022

The innovation strength for novel solutions will be enhanced by the cooperation between application owners (like smart grids, industry, eHealth) and leading-edge providers (of secure IC and sensors, security, AI/ machine learning);

3. To identify and develop new European market-leadership opportunities: SunRISE's use of disruptive security-oriented technologies (such as homomorphic encryption, lithography, AI and machine learning) in IoT-related domains (like intrusion-detection mechanisms) will improve European strengths. These technologies, together with the project's disruptive approach to business and markets, will also help the micro and nanoelectronics industry and associated sectors create and support future European champions.

The project will be executed by partners from the entire market value-chain. Significantly, they will offer a balanced effort between industry and academia, working towards a shared, integrated security-solution by contributing in such essential areas as security technology and related tools; secure IC and sensor component-building; and IoT systems.

Spreading the news

Effective dissemination, vital in ensuring results are well-tailored to various target-groups, will take place throughout the duration of the project. SunRISE will undertake a series of dissemination initiatives to ensure the sustainability of deployment actions. These will include organising special sessions at major European and international events to maximise the impact and reach the community at large. Project partners will publish in the most representative journals and participate in important conferences. And thanks to the interdisciplinary nature of the project, they will also ensure that they cross the different research domains and communities. In addition, white papers, workshops and presentations will be used to communicate results and findings – including those from participating PhD and Master's candidates – to other relevant industry, scientific and academic players and communities.

A thriving IoT

Gartner Inc. predicted in 2017 that 8.4 billion connected things will be in use worldwide in 2017 and this number will be increase to 20.4 billion by 2020. Based on this forecast, the total spending on endpoints and services could reach almost US$2 trillion in 2017. Regionally, Greater China, North America and Western Europe are the main drivers of connected things and these three regions are predicted to represent 67% of the total IoT in 2017.

Global investments in IoT security was estimated at US$703m for 2017 and is predicted to grow at a CAR (compound annual rate) of 44% to a US$4.4 billion by 2023. These forecasts are based on IoT-security-relevant revenue of major technology companies across 12 industries and 21 technologies.

Importantly, McKinsey & Company reported in 2017 that IoT lacks well-established, overarching standards that describe how the different parts of the technology stack should interact. In other words, there is no standard approach for ensuring the security of critical IoT applications and large players and industry organisations all use their individual approaches. Some segments, such as industrial, still use a small set of proprietary, incompatible technology standards originating from major players. In other segments, such as automotive or smart buildings, standards for interoperable devices are very rudimentary, leading to high security risks and costs.

These are typical issues SunRISE is already anticipating. The best way of ensuring various international standards are implemented is through regular contacts with such regulatory, standards and certification organisations as ECSO, Eurosmart, AIOTI and ENISA.

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SunRISE

SunRISE project develops new approach to IoT security based on machine learning and trusted data sharing

A project within the EUREKA PENTA programme

Paris, 12 November 2019 - SunRISE, a project in the EUREKA PENTA Cluster and managed by industry association AENEAS, aims to transform Internet of Things (IoT) security through machine learning and data sharing. Existing IoT security is limited by proprietary solutions and standards, and an unwillingness of companies to share sensitive data related to security incidents. In contrast, SunRISE's platform approach is based on privacy enhancing technologies (PETs) that create trust in data sharing. As a result, vast amounts of data on security incidents will be available for machine learning, with the analysis feeding into a complete security chain. Innovative technologies and reference platforms will establish trusted identities and end-to-end security for IoT devices. They will securely manage devices over their entire lifetime, enable data sharing to detect anomalous behaviour and network intrusions, and recover devices to a secure state once a security issue has been detected.

The innovations delivered by SunRISE will have major importance as IoT systems are increasingly used in critical economic and social domains including Industry 4.0, automotive, energy and healthcare. By 2025, the annual economic impact of IoT is expected to be between USD 4 trillion and USD 11.0 trillion worldwide[1]. However, this interconnectedness brings risks of data manipulation, data theft and cyberattack. For instance, in 2015, European enterprises had at least a 1 in 5 chance of losing data through a targeted cyberattack. Such attacks pose financial and reputational threats; they may endanger privacy and even human lives.

SunRISE is addressing fundamental technical challenges to tackle these security issues. Firstly, it will implement machine learning and security incident management on edge nodes (i.e. where IoT devices connect to the cloud, not in the cloud). This ensures that decisions on how to handle incidents can be made in real-time – essential for time critical applications such as autonomous driving. Secondly, it will develop PETs, particularly homomorphic encryption (a new technique that ensures no data needs to be shared in plain text), so companies feel confident to share security incident related data on a cloud-platform. This is a vital step in allowing the benefits of machine learning to be applied to evolving IoT security risks. Thirdly, SunRISE will develop new manufacturing technologies for low-cost, high-volume, secure ASICs (dedicated semiconductor chips) both for machine learning acceleration and for unique identification of individual devices.

[1] https://www.mckinsey.com/industries/semiconductors/our-insights/whats-new-with-the-internet-of-things of May 2017

The SunRISE consortium comprises 17 industry-leading partners including large enterprises, SMEs, and 6 academic and research institutions. It will also engage with standards bodies and application owners in fields such as smart grids, industry and eHealth, as well as with leading providers of secure ICs and sensors, security, and AI and machine learning technologies. The resulting technologies, guidelines and hardware for IoT security and privacy, will allow Europe to reinforce and expand its leading market position in cybersecurity solutions.

About the PENTA programme (managed by the AENEAS Industrial Association)

PENTA is a EUREKA cluster whose purpose is to catalyse research, development and innovation in areas of micro and nanoelectronics enabled systems and applications - where there is shared national and industrial interest. Based on the Electronic Components & Systems (ECS) Strategic Research Agenda (SRA) key areas and essential capabilities, PENTA programme contributes to the development of electronic solutions with the opportunity for rapid competitive exploitation and a strong impact on European societal challenges. The PENTA project team is supporting SMEs, large corporations, research organisations and universities by facilitating access to funding, fostering collaborative work and creating consortia.

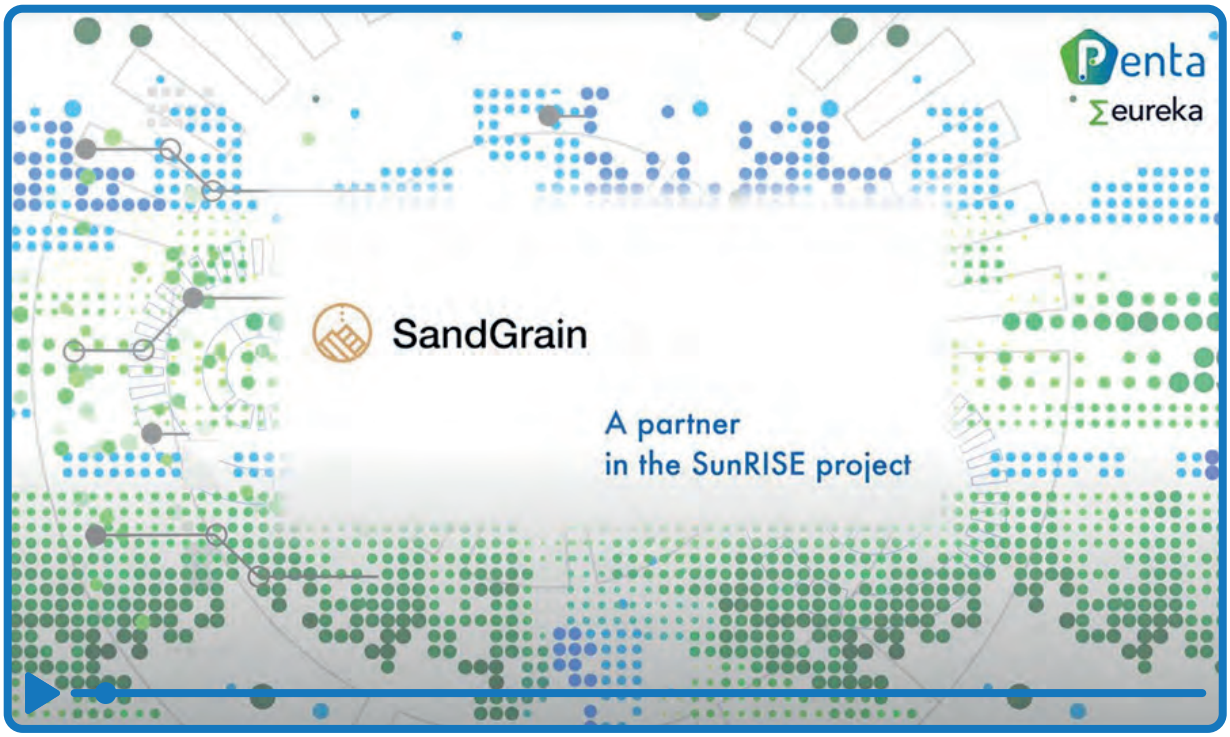
PENTA is managed by AENEAS.
More on PENTA: http://www.penta-eureka.eu
More on AENEAS: https://aeneas-office.org

About SunRISE

SunRISE is a RD&I project consortium involving 17 partners from 3 countries. The project partners are: NXP Semiconductors Germany GmbH (project leader), Ancud IT Beratung GmbH, AnyWi Technologies, Cloud&Heat Technologies GmbH, Delft University of Technology, Eindhoven University of Technology, ENGIE – Laborelec, Fraunhofer IIS/EAS, Sandgrain, NXP Semiconductors Belgium NV, Philips Electronics Nederland B.V, Philips Medical Systems, SIRRIS HET COLLECTIEF CENTRUM VAN DE TECHNOLOGISCHE INDUSTRIE, Stichting IMEC Nederland, Technical University of Munich, Technolution BV and University of Ulm.

National funding support is provided by Belgium, Germany and The Netherlands.

SunRISE



▶ **Video: https://youtu.be/VyYImCZVNzo**

XSR-FMC

17013 Developing a secure, reliable and ultra-low power flash-memory controller for key industrial users [XSR-FMC]

The 'eXtra'-Low Power, Secure and Reliable Flash-Memory Controller (XSR-FMC) project will focus on developing secure memory storage with high reliability and ultra-low power consumption. These are key requirement of demanding automotive, Industrial Internet of Things (IIoT) and Industry 4.0 markets.

Electronic devices require an increasing amount of storage as distributed intelligence spreads. These storage devices control sensitive and vulnerable social investments and infrastructure, making security an increasing concern as these devices become exposed to failure and hacking. Unfortunately, emerging Industrial Internet of Things (IIoT), Industry 4.0 (part of the fourth industrial revolution which deploys digital technologies to produce higher-quality goods at reduced costs), automotive and many other sensitive applications and industries are using storage that has not been designed with proper security.

Aside from implementing security features as proposed by the European Union Agency for Cybersecurity (ENISA), it is also essential to provide the highest reliability to protect related investments, as well as, ultra-low power consumption to promote sustainability. Different aspects of computing demand different solutions pertaining to bandwidth and memory-system capacity, regardless of the type of computing, such as local, cloud or fog (extending cloud computing to the edge of a network).

NAND flash memory system requirements for automotive, IIoT and Industry 4.0 are positioned between the industrial market (high reliability) and the consumer market (low cost, high volume), with both markets offering attractive opportunities. Crucially, however, neither has the necessary eco-system for these new markets, an essential ingredient XSR-FMC intends to develop.

Eco-system to create the right flash-memory controller

The XSR-FMC project will address the shortcomings of current flash memory controllers for two key highly demanding markets: IIoT and Industry 4.0. In particular, its goal is to build an eco-system to create, for those markets, flash memory controllers that offer: ultra-low power consumption; high reliability; and certifiable security for generations of flash memory to come. This will mean putting in place a development platform to build an eco-system to develop any kind of flash-memory controller. Crucially, the project consortium will deliver the necessary project expertise and experience.

As performance requirements increase, the high-speed, serial computer expansion bus standard called Peripheral Component Interconnect Express (PCIe) has constantly evolved and the PCIe gen4 standard is expected to strike the right balance between power and performance, alongside Non-volatile Memory Express (NVMe), a protocol designed to take full benefit of flash memories.

The technology used in flash-memory controllers are driven, on the one hand, by the evolutions of NAND flash technology and their new requirements of error-correction coding, interface and flash-management features; and on the other hand, by the type of demand for memory systems.

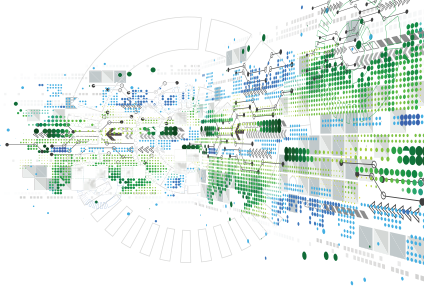
Key requirements of the target markets (as defined in this project) are summarised as follows:

- High reliability across large ambient temperature range (most likely -40°C to +105°C);
- Extended lifetime;
- Resilience to sudden power failures;
- Ultra-low power;
- Fast interfaces;
- High security;
- Industrial/Automotive packaging grade;
- Diagnostic and support eco-system.

XSR-FMC will develop a demonstrator to ensure a rapid product ramp-up and time-to-market, and hence a better return on investment (ROI). The choice of interface will most likely be PCIe, but this can be revised, based on market changes. Notably, this interface will be flexible enough to adapt to, making only the host interface subject to change (although unlikely).

Added-value consortium

In order to offer a full NAND flash-memory system, the controller and memory must work symbiotically, which needs a very strong eco-system and relationship with flash suppliers. And the only way for Europe to



KEY APPLICATION AREAS

- Computing and Storage
- Security and Reliability
- Digital Industry ECS Process
- Transport and Smart Mobility
- Equipment, Materials and Manufacturing Safety

ESSENTIAL CAPABILITIES

- Systems and Components Architecture, Design & Integration
- Connectivity & Interoperability
- Safety, Security & Reliability
- Computing & Storage
- ECS Process Technology, Equipment, Materials & Manufacturing

PARTNERS

Extoll / Fraunhofer-Institut für Zuverlässigkeit und Mikrointegration (IZM) / GLOBALFOUNDRIES Dresden Module One LLC & Co. KG / HTWG (Hochschule Technik, Wirtschaft und Gestaltung, Konstanz) / Hyperstone GmbH / Racyics GmbH / SILICONGATE LDA / TIEMPO

COUNTRIES INVOLVED

- France
- Germany
- Portugal

PROJECT LEADER

Damien Col
Hyperstone GmbH

KEY PROJECT DATES

15 November 2019 to 15 November 2022

successfully address those three markets is to join forces and foster partnerships. One way of achieving this is through a European project consortium comprising R&D-focused SMEs, research institutes and large manufacturing facilities, all capable of providing an ecosystem, a semiconductor product and platform, as well as, innovative, globally competitive intellectual property (IP) building-blocks. Importantly, several of these can be re-used and exploited independently in other future semiconductor designs, making them relevant to the ecosystem since they enable developments in semiconductor processes.

Furthermore, fostering cooperation between organisations that invest largely in R&D to develop state-of-the-art technology in their respective domains of expertise ensures the marketability of such a product. The consortium will also develop a reference design and packaging guidelines for a system-in-package (SiP) storage module, and deliver the necessary expertise to build a successful supply chain.

There are direct benefits for the entire consortium. XSR-FMC will provide project partners opportunities to address additional markets and applications outside their normal fields of operation. And relationships developed in this project could also trigger new opportunities.

What's in it for Europe?

With any flash-memory controller, there is a trade-off between cost, performance and reliability. Traditional Asia-based controller vendors tend to target consumer markets, and are therefore not interested in niche ones. However, opportunities arising from these key markets, together with their expected volumes, will encourage Asian and American suppliers to enter them. Europe can counter these moves with a good product and by partnering with experts.

Furthermore, providing such a technology platform will enable Europe to address different challenges within automotive, IIoT and Industry 4.0 with respect its storage requirements, and also strengthen Europe's leadership in highly demanding markets. The constant evolution of host and memory interfaces, and major flash-technology shifts, justify such a technology platform and partner ecosystem. Crucially, critical security elements, building blocks and developments will all be done in Europe, strengthening the overall European security infrastructure, especially related to data storage.

What's more, added-value features of reliability, ultra-low power and security, both for the chip, but also the value chain, will more than make up for the price of the controller, which Europe cannot compete on.

Promising markets

Such trends as IIoT and Industry 4.0 will diversely re-shape social life and professional collaboration: from enabling services for the elderly, to maximising efficiency of industrial processes. Importantly, secure storage is part of all electronic systems involved.

And with cars and sensitive infrastructure-equipment or machines connected to the internet, security, especially for data storage, is of extreme importance. Many semiconductor sectors will also benefit from the increase in electronics in vehicles. All of this is reflected in market statistics. According to LP Information, automotive, IIoT and industrial markets had a CAGR of 10.2% from 2015 to 2020, and the trend is predicted to continue. According to HIS Markit, semiconductor revenue in automotive is forecast at over US$ 40 billion by 2022. And Statista predicts global enterprise IIoT spending within automotive will be US$ 303.3 billion in 2020. Finally, the automotive supply chain is also evolving and increasing in entropy. This creates new opportunities for semiconductor companies, which in turn will promote partnerships upstream.

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XSR-FMC

Extra-Low Power, Secure and Reliable Flash-Memory Controller for Automotive, Industry 4.0 and Internet of Things

A project within the EUREKA PENTA program

XSR-FMC

Paris, 1 September 2020 - Within the European PENTA project, XSR-FMC, a new flash memory controller platform will be developed that will improve flash memory storage systems' security, safety and reliability. Furthermore, these controllers will significantly reduce energy consumption, contributing to greater sustainability.

Flash memory is part of everyday life. Widely used, it stores data in music players, memory sticks, and SSD in consumer applications. Currently, only flash controllers specifically developed for niche applications can offer the features targeted by the XSR-FMC project. However, with flash memories increasingly used in automotive electronics, digitally controlled machines in factories (Industry 4.0) and Industrial IoT, demand is growing for higher quality controllers in many applications and markets.[1]

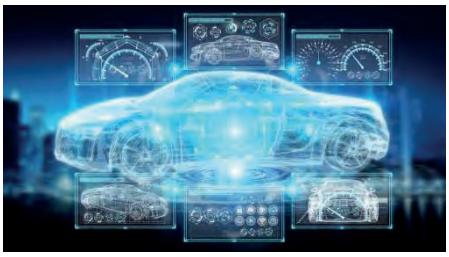

Photo by courtesy of Hyperstone

In many consumer devices, the 'controller' simply manages how data is stored and retrieved, with few capabilities to deal with errors or data protection. But in a car's electronic network or an industrial machine, failures could lead to breakdowns or even endanger human life. When devices are connected to the internet, unprotected storage systems are at risk of attacks – from intrusions over data privacy to disruption of vital functions such as a car's electronic controls.

The XSR-FMC consortium includes design and manufacturing specialists in flash controllers, semiconductor design and security to address these complex requirements. The initial design will offer high reliability for an extended temperature range, long life–time, ultra-low power consumption, certifiable security, error correction and robustness to sudden power failures.

This European collaboration will expand Europe's commercial position in technology required for new generation of flash memories and strengthen its capabilities in secure data infrastructure and storage.

[1] According to LP Information, automotive, IIoT and industrial markets had a CAGR of 10.2% from 2015 to 2020, and the trend is predicted to continue. According to HIS Markit, semiconductor revenue in automotive is forecast at over US$ 40 billion by 2022. Statista predicts global enterprise IIoT spending within automotive will be US$ 303.3 billion in 2020.

About the PENTA program

PENTA is a EUREKA cluster whose purpose is to catalyze research, development and innovation in areas of micro and nanoelectronics enabled systems and applications - where there is shared national and industrial interest. Based on the Electronic Components & Systems (ECS) Strategic Research Agenda (SRA) key areas and essential capabilities, PENTA program contributes to the development of electronic solutions with the opportunity for rapid competitive exploitation and a strong impact on European societal challenges. The PENTA project team is supporting SMEs, large corporations, research organizations and universities by facilitating access to funding, fostering collaborative work and creating consortia.

PENTA is operated by AENEAS.
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About XSR-FMC

XSR-FMC is an RD&I project consortium involving 8 partners from 3 countries, France, Germany, and Portugal. The project partners are: Hyperstone (project coordinator), Extoll, Fraunhofer Institute for Reliability and Micro-integration (IZM), GLOBALFOUNDRIES Dresden Module One LLC & Co. KG, HTWG Konstanz - University of Applied Sciences, Racyics GmbH, SiliconGate LDA, and TIEMPO SAS.

More on XSR-FMC: https://www.penta-eureka.eu/downloads/ProjectProfiles/penta-project-profilexsr-fmc.pdf

HEFPA

19011

Highly flexible and energy-efficient antennas can expand wireless comms market and attract smaller integrators and apps developers

[HEFPA]

The 'Flexible Phase Array System for High Efficiency and Scalable Millimeter Wave Wireless Communications' (HEFPA) project is developing scalable unit array front-end components. These can be used as flexible building-blocks in implementing larger and more diverse antenna arrays in the upper bands of Frequency Range 2 (FR2), which includes frequency bands from 24.25 GHz to 52.6 GHz.

Thanks to the rapid growth in wireless-data traffic, millimetre wave (mmW) communications are set to become a major data conduit for fifth generation (5G) wireless communication systems. That said, mmW signals are highly susceptible to blocking and tend to have communication limitations owing to their poor signal attenuation compared to, say, microwave signals. This factor necessitates the usage of phased-array antenna systems to overcome signal-path loss.

Antenna configurations and array sizes (determined by the target applications) may vary from large arrays (such as 512 x 512 antenna elements) to small ones (such as 2 x 8 elements) that are more suited to mobile handsets and IoT (internet of things) devices. The phase relationship of the radio frequency (RF) signal between adjacent antenna elements enables steerable directivity of the radio signal, as compared to an omni or parabolic antenna (often used in fixed-link microwave and mm-W communications). In addition, electronic control of the signal phase and amplitude at each antenna in the array enables beam steering and network control of the signal power, along with the tracking of mobile-radio users.

These are some of the issues the HEFPA project is set to address and resolve.

Scalable and efficient building-block

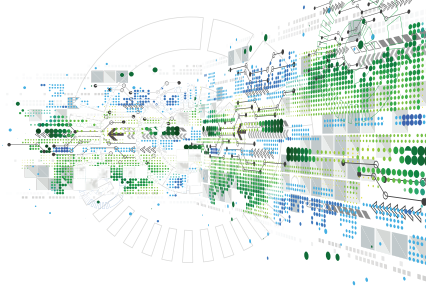
The strategic objective of HEFPA is a highly flexible and energy-efficient RF front-end component that enables the creation of mmW transceiver systems. Under radio standards, such as 5G, mmW communications will rely on phased-array antennas that focus the RF signal in one or more directions in order to improve radio-link margin.

In particular, HEFPA will develop scalable unit-array front-end components intellectual property (IP) that can be used as a flexible building-block in the implementation of larger and more diverse antenna arrays. Embedded within each HEFPA module will be highly efficient, mmW signal generation and conditioning power amplifiers, phase shifters, switching functions and low-noise amplifiers. In addition, new techniques to provide control, RF signal distribution, phase/time coherence and calibration among the unit elements, will be developed. These will ensure effective interaction between HEFPA components. Furthermore, the MIMO (multiple-input, multiple-output) order, link separation and the number of target users will be incorporated into a flexible scheme of analogue and digital communications between the respective HEFPA components.

Within a single HEFPA component, all the core RF functions for mmW (at 39GHz) radio signals are incorporated, including mmW signal-generation and conditioning, such as amplification, phase shifting and filtering, antenna elements and integrated circuit (IC) packaging. . More importantly, it can be placed into a cluster of other identical HEFPA components in order to create larger arrays. This modularity will enable mmW product-developers to quickly and flexibly build specific phased-array antenna configurations, as well as, hybrid combinations of phased arrays using MIMO technology by deploying a number of HEFPA modules.

The key innovations of HEFPA will be:

- A highly optimised and energy-efficient RF signal generation and amplification in a compact form factor. This will reduce energy consumption by 30% as compared to existing solutions in a multitude of radio links leveraging the mmW frequency bands;
- The implementation of a chip-on-board technology, which combines the technological advantages of conventional wafer-level-packaging approaches with the cost-efficiency and thermal-management capabilities of panel-level, printed-circuit-board fabrication (system-in-PCB);



KEY APPLICATION AREAS

- Energy
- Digital Industry

ESSENTIAL CAPABILITIES

- Systems and Components: Architecture, Design, and Automation
- Connectivity and Interoperability
- Process Technology, Equipment, Materials and Manufacturing for Electronic Components & Systems

PARTNERS

C-COM Satellite Systems Inc

Carleton University

Eindhoven University of Technology

NXP Semiconductors Netherlands BV

Semiconductor Ideas to the Market (ItoM) BV

Skyworks Solutions Canada Inc.

University of Waterloo

COUNTRIES INVOLVED

- Canada
- Netherlands

PROJECT LEADER

Estelle Holopherne & Dominique Defossez
NXP Semiconductors Netherlands BV

KEY PROJECT DATES

01 July 2020 to 30 June 2023

- System and digital integration of an arbitrary number of HEFPA components, working cooperatively to form the mmW beam(s).

There will be two main project deliverables:

- Pre-commercial prototypes of the HEFPA components, comprising all the integrated RF syntheses and front-end signal circuits, heat sinking-elements and integrated antennas;
- A system demonstration board with flexible MIMO order-forming and/or beam-forming capability, along with beam steering (+/- 45 degrees in azimuth and elevation). It will use project-developed hardware and software overlays, which enable HEFPA components to work collaboratively.

Notable project resources

The HEFPA project consortium will leverage its partners' strengths in use-case definition, IC design, packaging and system engineering in order to implement the core HEFPA building-block. Their expertise will also be used in deploying the antenna elements in various phased-array and hybrid-beam-forming configurations.

Technology drives business and markets

HEFPA will deliver a competitive advantage by combining several key component-innovations into a single RF front-end. Furthermore, this fully integrated assembly will also combine an innovative design with the best attributes of IC and low-loss packaging and thermal management to offer an additional advantage over other approaches.

Target markets will be very broad in the sense that any use-case, which is going to be reliant upon high-bandwidth and large data-throughput wireless communications, will benefit from being able to deploy HEFPA components in building phased arrays. Commercial impacts are primarily time-to-market, flexibility (including reuse of supporting infrastructure) and low energy consumption.

Significantly, the HEFPA IP and components will also reduce complexity in the formation and deployment of mmW radio-links, thereby expanding the market reach of data communications using this allocated band of RF spectrum. This will enable smaller system integrators and RF application developers to use HEFPA components to quickly build flexible phased-array antennas (with all the associated RF generation and signal-conditioning circuitry) using the upper band of FR2 frequency-bands (as allocated in each regional jurisdiction). New applications that will leverage high-bandwidth wireless communications will also be made possible through HEFPA components.

Finally, regarding future market numbers, we see that existing mmW base-station and point-to-point systems have unit deployments of, perhaps, several 100,000 systems per year. In contrast, consumer-grade cellular or WiFi systems have a market size of over one billion radio systems per year. It is anticipated that mmW-based radio handsets, for example, will be over 100m units per year by 2022. Even larger markets are anticipated for VR/AR (virtual reality/ augmented reality) systems, which leverage mmW radio systems for very-high-bandwidth data applications.

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HEFPA

HEFPA project to exploit full potential of 5G network with an energy efficient antenna solution

A project within the EUREKA PENTA program

Paris, 8 October 2020 - HEFPA (Highly Efficient and Flexible Phase Arrays), a project within the PENTA program, is developing IP and components that will reduce the complexity of building 'phased array antennas'. These are the electronic components required to receive and transmit radio waves in Satcom and 5G mmWave (millimeter Wave) mobile and infrastructure devices. In addition, the HEFPA components will boost energy efficiency, reducing consumption by 30% compared to existing solutions.

Think of downloading a full-length movie onto your phone in seconds or of a specialist surgeon using robotic arms to carry out a life-saving operation on a patient in another remote city by leveraging satellite communications. 5G (fifth generation) telecommunications and Satcom systems that will leverage the mmWave portion of the spectrum promises to turn such scenarios into reality. Industries and consumers will benefit from applications and services enabled by the Internet of Things (IoT), Artificial Intelligence (AI), Virtual and Augmented Reality (VR & AR) – from more energy-efficient manufacturing to personalized medicine, truly immersive entertainment, self-driving cars and more.

5G services currently being rolled out in Europe and elsewhere are based on updated 4G systems. In addition, a host of Low-Earth Orbit Satellite constellations are now in deployment that will leverage ubiquitous coverage between the north and south poles. However, the biggest gains will come from the introduction of new mmWave technologies, which use radio waves of much higher frequencies and shorter wavelengths. These technologies are the real key to improved network capacity, faster downloads (anywhere from 10 to 100 times) and reductions of up to 10-fold in 'latency' (i.e. the time to respond to an instruction or a command). Moreover, mmWave will leverage highly directional signal that can be steered to track moving objects with much reduced signal interference compared to sub-6 GHz frequency bands.

However, mmWave presents challenges. The RF signals experience higher path loss as they travel and are easily blocked by buildings, people and objects. New antenna technologies with 'beam forming' which focus signals in the direction of the intended user can overcome these limitations and deliver the full potential of 5G and Satcom applications. The HEFPA project aims to provide system integrators and product developers with a quick and flexible way to build such phased array antennas – with the further benefit of increased energy efficiency.

Bringing together an ecosystem of partners with experience in RF ICs (radio frequency chips), RF systems, chip packaging and PCBs (printed circuit boards), HEFPA will develop its modules for use in consumer user equipment. Current consumer grade mobile and WiFi markets account for over a billion radio systems a year, and mmW enablement in various RF communications subsystems is expected to reach 100 M units per year in 2022. An even larger market is anticipated for VR/AR systems that leverage mmW technology. Thus, HEFPA has major commercial potential, as well as playing its part in Europe's ambition to be a global leader in leveraging mmWaves as a strategic technology for the digital economy and society.

About the PENTA program

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About HEFPA

HEFPA is an RD&I project consortium involving 8 partners from 2 countries, Canada, and the Netherlands. The project partners are: NXP Semiconductors Netherlands BV (project coordinator), C-COM Satellite Systems Inc , Carleton University, Eindhoven University of Technology , Semiconductor Ideas to the Market (ItoM) BV, Skyworks Solutions Canada Inc., University of Waterloo.

More on HEFPA: https://penta-eureka.eu/project-overview/penta-call-4/hefpa/

GaNEXT

19009

Intelligent power module will increase efficiency, reliability and compactness of power systems [GaNext]

The Next Generation GaN Power Module project (GaNext) aims at removing the barriers to adopting Gallium Nitride (GaN) semiconductors and fully demonstrating the higher efficiency and compactness of GaN-based power systems. The main project deliverable will be an intelligent GaN power module where the gate drive, control and protection circuits are integrated or co-packaged with the power device.

Gallium Nitride (GaN) transistors are wide-bandgap compound semiconductor devices that enable compact power electronic systems with efficiencies and power densities that are impossible with today's silicon (Si) devices. This is due to the lower on-state resistance, shorter switching times and drastically reduced switching losses of GaN compared to today's silicon-based devices. These features enable much higher operation frequencies up to the MHz range. A higher frequency directly translates into smaller passive components, such as inductors and capacitors. And this leads to much smaller power electronic systems.

Furthermore, reductions in size and costs are achieved because the cooling system can be shrunk dramatically, due to the reduced losses and improved efficiency. Cooling solutions that today consist of a large heatsink and fans can be changed to a small heatsink with convective cooling only. This reduction in size and weight are particularly beneficial for many portable and mobile solutions, such as electric vehicles (EVs) or on-board chargers.

However, there is a downside to deploying GaN. Current state-of-the-art GaN devices have certain characteristics, such as the low gate-threshold voltage, as well as, electromagnetic interference (EMI) and oscillations caused by the fast switching that make them challenging to use. This is one of the main reasons these GaN devices do not have a larger market share yet, and the innovations from GaNext aim to solve these drawbacks.

Towards next-generation GaN power systems

The aim of GaNext is to remove the barriers to adoption for GaN, and to fully demonstrate the higher efficiency and compactness of GaN-based systems in a range of power systems. The heart of the project is the development of an intelligent GaN power module where the drive, control and protection circuits are integrated or co-packaged with the power device.

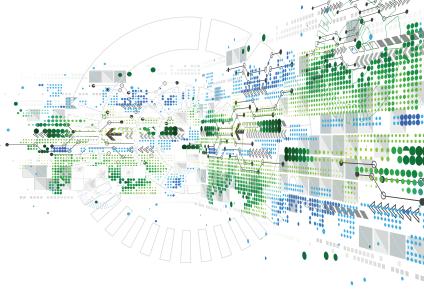
The proposed integrated power module will fundamentally improve the key issues with today's GaN-based circuits. Firstly, end-users currently lose part of the advantages of GaN since it is required to slow down the switching speed to avoid high-frequency oscillations. However, these oscillations can be drastically reduced by integrating part of the passive components into the module and the reducing EMI at the origin.

Secondly, the tailored design of the GaNext gate driver and the intimate integration in addition to the integration of auxiliary devices on the GaN integrated circuit (IC) will minimise any gate voltage distortions, which currently are a source of unreliable switching of the transistors. Furthermore, the full potential of GaN is unlocked by the added high-speed control IC with sophisticated safety features, in addition to an advanced heat- extraction technique.

Finally, integrating current and temperature sensors directly in the power module will significantly enlarge the safe operating area of the system. This multifaceted overall solution will position the GaNext module at the centre of next-generation GaN power systems.

All this will be achieved through the following:

- A GaN-on-Si power IC (650V) with integrated sensing and driving elements;
- Si and GaN low-voltage logic, control and level-shift silicon-on-insulator (SOI) gate drive circuitry;
- A dedicated package for the power module that will include the (GaN) power, control, and drive circuitry;



KEY APPLICATION AREAS

- Energy
- Transport and Smart Mobility
- ECS Process Technology, Equipment, Materials & Manufacturing

ESSENTIAL CAPABILITIES

- Systems and Components Architecture, Design & Integration
- Connectivity & Interoperability
- Safety, Security & Reliability
- Computing & Storage
- ECS Process Technology, Equipment, Materials & Manufacturing

PARTNERS

advICo microelectronics GmbH
Besi Netherlands B.V.
Cambridge GaN Devices Ltd
CSA Catapult
Eindhoven University of Technology
Fraunhofer IMS
Infineon Technologies AG
Lyra Electronics Ltd
MACCON Elektroniksysteme GmbH
Neways Technologies B.V.
SUMIDA Components & Modules GmbH
Signify B.V.
TU Dortmund

COUNTRIES INVOLVED

- Germany
- Netherlands
- United Kingdom

PROJECT LEADER

Cerdin Lee and Martin Arnold
Cambridge GaN Devices Ltd

KEY PROJECT DATES

01 February 2020 to 31 December 2022

- Demonstrating competitive advantage of the power module in power systems, such as EV charger, lighting, motor drive and PV inverter applications; featuring optimised magnetic components.

Well-suited project consortium

The project consortium will cover the entire technology chain required for developing the intelligent GaN power module. A deep synergistic and interdisciplinary approach is indeed key to achieving the GaNext objectives, and the consortium has been carefully assembled to satisfy this need. Its experience and expertise cover a large part of the power electronics and power devices market value-chain: from semiconductor device design to sales of power conversion systems. Crucially, it includes such areas as: semiconductor chips and devices; semiconductor packaging and integration; magnetic components (such as inductors and transformers, key components for any power electronic system); and power electronic systems and products.

Green issues and other market drivers

The market for GaNext-related products can be divided into the following sub-segments:

- GaN power devices and GaN power modules;
- Gate driver and control-IC;
- Packaging;
- Magnetics;
- Power electronics (which is further divided into the specific market segments addressed in GaNext).

Now, every electronic or electrical device today contains at least one power electronic system. Crucially, GaN technology has the potential to improve the energy efficiency of the largest part of these systems. This means that the GaNext project will help to reduce greenhouse gas emissions and energy consumption in Europe and beyond. Significantly, demonstrating this intelligent technology would be a breakthrough that will strongly support the clean-growth mission and electrification revolution that has started worldwide.

Environmental policy and regulations will further drive this market. Regulations set by Energy Star – an initiative of the U.S. Environmental Protection Agency and U.S. Department of Energy – that have also been adopted by the EU and Japan, are imposing higher energy efficiencies and therefore promoting GaN technology. Several governments have also announced ambitious targets for EV uptake in the next ten years, including the UK, Norway and Denmark. In addition, EV and the associated charging infrastructure are predicted to be strong drivers of GaN technology. Furthermore, the new JEDEC standard JC-70.1 on GaN devices will provide universal standards, another significant step forward in the adoption of GaN technologies.

This means that the overall power-electronics market this technology will address looks promising at over US$200 billion. More specifically, the GaN power-devices market, which is growing at an impressive CAGR of 91%, is expected to reach US$500m by 2022 with power supplies for EV and photovoltaic inverters sharing 60% of this market.

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GaNEXT

Intelligent GaN power modules to save energy and CO_2 in transport and industry

A project within the EUREKA PENTA programme

Paris, 17 July 2020 – A EUREKA PENTA project, GaNext, will have a major impact on global efforts to save energy and cut CO2 emissions by creating highly efficient, compact and reliable GaN power modules for power systems. Today, every electronic or electrical device contains at least one power system – for instance, to convert mains AC electricity to DC current to drive a motor. From laptops to industrial machines, power systems are everywhere. The partners in GaNext aim to deliver a technology breakthrough by developing a next generation of intelligent 'power modules' (electronic components in power systems) based on a semiconductor called gallium nitride (GaN). These will significantly increase energy efficiency over existing modules most of which are based on silicon.

As a result, the GaNext project will strongly support worldwide moves towards energy efficiency and electrification. Suited to a wide range of applications, especially in transport and industry, the new modules will provide ways to meet stringent energy efficiency regulations. They will also be crucial for electric vehicles and charging infrastructures, which countries such as Norway and the UK are promoting through ambitious legislation.

GaN technology is not new, but GaNext is working to unlock its full potential by bringing together the expertise of companies, large and small, from across the entire power module technology chain.

Current GaN transistors can operate at much higher switching frequency with lower losses and lower on-resistance than state-of-the-art silicon devices. In other words, they can deliver higher performance with lower energy usage. But they cause interference with other components in the power system and can be unreliable. By eliminating these obstacles, GaNext will enable modules with increased energy efficiency that will be easy to build into power systems.

As electrification advances worldwide, demand for such solutions is high. The GaN power-devices market is growing at a CAGR of 91% and is expected to reach US$ 500 million by 2022, with power supplies for electric vehicles and photovoltaic inverters sharing 60% of this market. Thus, the GaNext project will both make an important contribution to a low-carbon future and offer major commercial opportunities for European industry.

About the PENTA programme

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About GaNext Project

GaNext is a RD&I project consortium involving 13 partners from 3 countries, Germany, Netherlands, and United Kingdom. The project partners are: Cambridge GaN Devices Ltd (project leader), advlCo microelectronics GmbH, BESI Netherlands B.V., CSA Catapult, Eindhoven University of Technology, Fraunhofer IMS, Infineon Technologies AG, Lyra Electronics Ltd, MACCON Elektroniksysteme GmbH, Neways Technologies B.V., SUMIDA Components & Modules GmbH, Signify B.V., TU Dortmund University.

Sentinel

19017

Frequent biomarker monitoring by an autonomous wearable patch as practical tool for clinicians and nurses to improve early warning. Reducing critical complications, improving patient care and quality of life [Sentinel]

Hospitals lack an essential facility to monitor – in a semi-continuous fashion – biomarkers, in combination with physiological and contextual ones, without causing a major disruption to a hospital's workflow. Responding to this problem, the Sentinel project will significantly improve the hospital's' early warning system (EWS) targeting a reduction of serious complications and disabilities after their discharge.

According to the National Institute for Health and Care Excellence and the European Resuscitation Council (ERC) patients should be monitored to help identify those with a deteriorating clinical condition, or one at risk of deterioration. Regrettably, despite the deployment of early warning systems (EWSs), adverse events are currently estimated to affect a significant number of hospitalised patients, and to cause thousands of patient deaths every year – in the European Union (EU) alone.

Current EWSs are based on measuring physiological vital signs and consciousness levels. However, clinicians consider biomolecule markers to be valuable indicators of disorders. Efforts have been made to include these markers to improve EWSs, by either point-of-care (POC) testing or increased central lab testing. However, they have not been widely accepted, primarily because of poor integration into the workflow of the caregiver.

Therefore, to obtain a clinical-relevant scoring methodology with improved specificity to quantify the severity of these adverse effects, a technology should be available that:

- Simultaneously and in a timely manner measures relevant factors, hence in a semi-continuous way;
- Operates autonomously with minimum disruption to a nurse's workflow;
- Provides signal analysis and data analytics to discover clinically relevant relationships between the measured parameters and the above-mentioned health indicators.

Developing wearable device with hybrid marker sensing

The Sentinel project will address and resolve these issues by developing technologies which will result in a wearable solution – a hybrid patch – that integrates semi-continuous quantitative hybrid sensing of physiological, contextual and biomolecule markers, including affiliated algorithms, manufacturing technology and verified prototypes.

These technologies will be demonstrated in the area of patient monitoring by two clinical use cases: sepsis (including reduced peripheral perfusion) and delirium (including monitoring of stress). New developments in micro-nano technology will be needed, combined with microfluidics to interface with the person's bio-liquids and allow for (semi)continuous measurements for a week.

Sentinel will focus on seven areas:

1. Wearing formats:

- For many patients, an adhesive patch is acceptable, aided by the limited duration of use. For ones with frail skin, an attachment module will be developed that offers the wearer pressure relief.

2. Biomarker sample methods:

- Sweat is a non-invasive rich source of biomarkers. Since most patients do not undergo excessive physical strain, they have a low sweat rate of approximately 0.2 nl/min/gland. A complicating factor is that the concentration of so-called actively resorbed biomarkers not only depends on a disorder but also on the sweat rate per gland, not addressed by the state-of-the-art. Sentinel will develop high-end microfluidic designs for sampling sweat, capable of handling nanolitre volumes of bio-fluid.
- A small number of biomarkers may require sampling of interstitial fluid (ISF). If required, Sentinel will utilize miniature sensors for ISF sensing.

3. Sample methods for physiological and contextual markers:

- For sampling physiological and contextual markers, existing technology is used. This technology will be applied in synergistically manner for biomarker sample methods as well.

4. Sensor platform:

- Different use-cases will require the measurement of different markers in a semi-continuous manner, hence the need for semi-continuous and interchangeable sensors. Sweat and ISF sensor modules will be developed to accommodate various sensors without changing the architecture of the particular module.

5. Microfluidic flow:

- A previously developed continuous-flow-operation principle, is the starting point for the development of a hybrid patch; capable of semi-continuous monitoring patients for at least four days.

6. Signal acquisition and Data Analytics:

- An algorithm will be developed to improve the signal-to-noise ratio of biomarker detection

KEY APPLICATION AREAS

Health & Well-Being

ESSENTIAL CAPABILITIES

Systems and Components Architecture, Design & Integration

PARTNERS

AZ Turnhout
Catharina Ziekenhuis
Eindhoven University of Technology
Jobst Technologies GmbH
Micronit Microtechnologies BV
Philips Electronics Nederland BV
Sapienza University- Dept. Mech. Aerosp. Eng.
Tegema
Verhaert New Products & Services NV

COUNTRIES INVOLVED

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Germany
Italy
Netherlands

PROJECT LEADER

Eduard Pelssers
Philips Electronics Nederland BV

KEY PROJECT DATES

01 April 2020 to 31 March 2023

in sweat by considering physiological characteristics of sweat secretion in time and frequency;

- Data analytics algorithms will be developed to enhance the specificity and accuracy utilising the combination and synchronisation of physiological, contextual and biomarker signals; enabling studies to quantify the multifactorial phenomena;
- A data-quality Index toolbox will be built to produce a quality-scoring model for vital signs time series data through machine learning.

7. Manufacturing platform:

- Scalable and cost-effective foundry technologies will be applied for cost-effective manufacturing of the modules;
- Conflicting requirements, like cost price and use-case adaptability, will be addressed by standardising the module (miniaturised) dimensions, allowing various types of sensor modules to be integrated seamlessly on the so-called frames.

Advantageous position

Project partners are specialised in components (sensors and materials), integration (microfluidics and assembly), as well as, the signal chain (electronics, software, analytics, and clinical decision-support) of the Sentinel patch. This expertise combination puts them in an advantageous position to deal with user requirement provided by the clinical and medical industry, and to leverage existing state-of-the-art technologies around vital signs monitoring patches (energy, materials, and systems). Involvement of the end-user (clinical party) in the early phases of this project will improve the quality of the wearable patch requirements, as well as, provide relevant clinical results. These are essential and distinct advantages for market introduction and acceptance.

Impacting patients and the economy

Despite the use of EWS, adverse events are currently estimated to affect up to 12% of hospitalised patients and to cause up to 95,000 patient deaths per year in the European Union alone. In addition, infections associated with healthcare institutions affect an estimated 4.1 M patients. The United Kingdom National Audit Office estimates the cost of such conditions at £1 billion (US$1.2 billion) per year. Infections that are detected late will lead to fast patient deterioration. Similar numbers are seen in the United States. In ensuring semi-continuous monitoring in an autonomous and hybrid manner, Sentinel will decrease complications & mortality in hospitals and will reduce the number of permanent disabilities. This will not only improve the quality of life for patients after discharge, but will also reduce healthcare costs.

Promising market developments

Sentinel will target its products at these four market segments:

1. POC diagnostic market;
2. Healthcare wearable market;
3. Electrochemical-sensor technology market;
4. Main diagnostics market.

The global market for POC diagnostics in 2015 was valued at nearly US$18 billion. This market is predicted to grow from US$19.3 billion in 2016 to US$28.3 billion in 2021, at a CARG of 8%. This growth, which is expected to continue for the coming years, is substantially fuelling the growth in the entire in-vitro diagnostics industry.

The global market for wearable healthcare devices is anticipated to reach a revenue of US$18.9 billion in 2020, growing at a CAGR of about 30%. The consumer health market, including wellness, fitness, and sport-wearable segment, is expected to grow at a CAGR of 27.8% (2015-2020). Medical and clinical-grade wearables, the most promising product segment within healthcare wearables, is expected to grow with a CAGR of 32.9% (2015-2020).

Electrochemical sensors show strong growth due to the unique properties of continuous sensing (low cost per measurement). Moreover, the concentration range fits in well with the markers Sentinel is planning to measure. The rising ageing population and the increasing incidence of chronic ailments will boost the demand for precise diagnosis, and drive investments and adoption of use in other application domains, for example such as safe driving in the automotive market and promoting healthy living. The global biochemical sensor market is forecasted to reach US$58.48 billion by end-2025, a CAGR of 14.7% between 2016 and 2025.

Finally, main markets in clinical diagnostics (besides the already-mentioned POC one) are microbiology, molecular diagnostics, immunoassays, and flow cytometry, especially in preventing deterioration in the case of sepsis. This market is expected to grow at a CAGR of about 10% (2015-2022).

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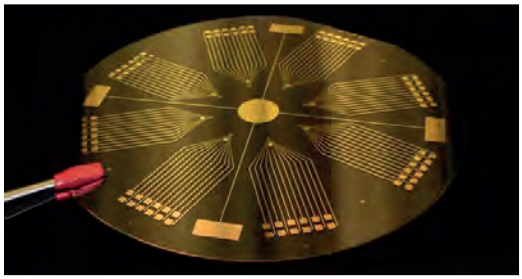
Sentinel

Improved wearable early warning patches to reduce serious complications and disabilities among hospital patients

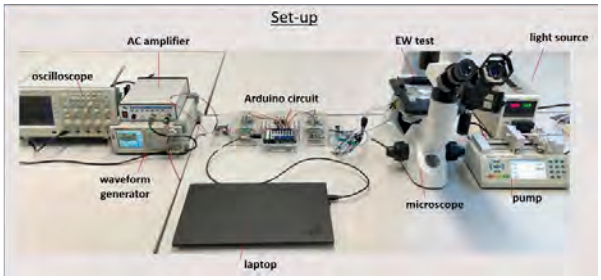
Paris, 14 September 2021- Every year thousands of patients in Europe and elsewhere die or suffer serious complications and / or disabilities following 'adverse events' during their stay in hospital or after discharge. The PENTA project, Sentinel, aims to reduce these risks to patients through an improved wearable early warning system (EWS) – a 'patch' – that detects when a patient's condition is deteriorating. Unlike existing EWS, the future Sentinel patch will measure biomarkers (biological molecules) as well as physiological and contextual indicators. In addition, Sentinel is seeking to increase use of EWS in hospitals by ensuring that its semi-continuous monitoring and results analysis fit with existing caregiver work routines.

Adverse events are estimated to affect up to 12% of hospitalized patients and to cause up to 95,000 patient deaths per year in the European Union alone. Current EWSs measure physiological vital signs (such as blood pressure and respiration rates) and levels of consciousness. However, clinicians consider that biomarkers contained in sweat and / or interstitial fluid (between body cells) can also be valuable indicators of deteriorating condition. Efforts have been made to include these markers to improve existing EWSs, either through point-of-care (POC) testing or increased central lab testing. But the lack of integration into caregiver workflows has prevented widespread take-up.

Sentinel is addressing these issues by realizing significant innovations in sweat rate and biomarker sensing technologies, that will enable a wearable solution based on semi-continuous quantitative sensing of all three indicators: physiological, contextual and biomarker. The project will focus on two key use cases, sepsis and delirium. And amongst a range of innovations, it will work on advances in micro/nano technologies and microfluidics, as well as manufacturing technologies and verified prototypes. Noteworthy is the research towards utilizing sweat as biomarker-rich biofluid with fully non-obtrusive access, however the sweat rate especially in sedentary state is very small, in the order of 0.2 nL/min per gland, insufficient to transport sweat even in small microfluidic channels in a clinical relevant timely manner to the biosensors. Sentinel is approaching this dilemma by an innovative active transport mechanism that can even accelerate the smallest amounts of sweat. One of the test platforms is depicted below.



TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY



To achieve its wide-ranging goals, the Sentinel project brings together partners with expertise spanning components (sensors and materials), integration (microfluidics and assembly) and the signal chain (electronics, software, analytics, and clinical decision-support). Besides being able to leverage state-of-the-art technologies around vital signs monitoring patches (energy, materials, and systems), the project will involve clinical end-users to help identify requirements and deliver relevant clinical results.

Together, the Sentinel partners will target four key market segments: POC diagnostics, wearables for healthcare, electrochemical sensor technologies and the wider diagnostics market. All of these represent significant commercial opportunities. For instance, the global market for POC diagnostics in 2015 was valued at nearly USD 18 billion, with predictions to grow to USD 28.3 billion in 2021[1]. Meanwhile, the global market for *wearable healthcare devices* was anticipated to reach a revenue of USD 18.9 billion in 2020[2]. Demand for electrochemical sensors is also set to grow strongly (particularly for continuous sensing) and the biochemical sensor market is forecasted to reach USD 58.48 billion by the end of 2025[3].

At a time of rising chronic illness and ageing populations, Sentinel enables European companies to deliver health, social and economic benefits. Plus, its outcomes will have potential in other areas from promoting healthy lifestyles to technologies for emerging applications such as safer driving.

About the PENTA programme

PENTA is a EUREKA cluster whose purpose is to catalyse research, development and innovation in areas of micro and nanoelectronics enabled systems and applications. Guided by the Electronic Components & Systems (ECS) Strategic Research and Innovation Agenda (SRIA) four technology layers, four cross-sectional technologies and six ECS key application areas, the PENTA programme enables the development of electronic solutions to help drive the digital economy through the formation of collaborative ecosystems along the ECS value chain. This creates the opportunity for rapid competitive exploitation and a strong impact on European societal challenges. PENTA supports SMEs, large corporations, research organisations and universities to work together in project consortia by facilitating access to funding, fostering collaborative work and creating consortia in areas of mutual industrial and National interest. PENTA is managed by the Industry Association AENEAS

More on PENTA: http://www.penta-eureka.eu
More on AENEAS: https://aeneas-office.org

About the Sentinel project:

Sentinel is a RD&I project consortium involving 9 partners from 4 countries. The project partners are: Philips Electronics Nederland BV (Project leader), AZ Turnhout, Catharina Ziekenhuis, Eindhoven University of Technology, Jobst Technologies GmbH, Micronit BV, Sapienza University- Dept. Mech Aerosp. Eng., TEGEMA and Verhaert New Products & Services NV. Sentinel consortium members are located in Belgium, Germany, Italy and the Netherlands.

More on Sentinel: https://penta-eureka.eu/project-overview/penta-call-4/sentinel/

[1] Western Europe Point-of Care Testing (POCT) market, Frost & Sullivan, 2016
[2] Wearable report, Frost & Sullivan, 2016
[3] Biochemical Sensor Market - Global Industry Analysis, Size, Share, Growth, Trends and Forecast 2017 – 2025

Vivaldy

19021

Efficient re-verification and re-validation to enable rapid dissemination of innovations for AI-enhanced CPS in professional healthcare

[Vivaldy]

The Vivaldy (VerIfication and Validation of Ai-enabLeD sYstems) project is developing efficient re-verification & re-validation strategies and effective regulatory approval guidelines for the incremental upgrade of class II[1], AI-enhanced CPSs in the professional healthcare domain. Based on a 'DevOps' approach, it will enable rapid incremental dissemination of innovations, increasing the frequency of major system upgrades from every three years to once a year, and module and/or AI upgrades from once a year to every six months. This will lead to better responses to fast-changing public health challenges, along with improved patient engagement and quality of care, while ensuring patient safety remains paramount.

Increasingly, products of all kinds – from consumer appliances to medical devices – are becoming intelligent, connected, and linked to the physical world. They incorporate Cyber Physical Systems (CPS) which interact directly both with embedded intelligence and with the real-world physical environment. Today, advanced CPS are characterized by frequent incremental upgrades (software, hardware and modules) after the initial product release, and by the addition of Artificial Intelligence (AI) to enhance their utility. This poses challenges in applications such as professional healthcare. With patient safety of paramount concern, class II medical devices must undergo certification to demonstrate that they comply with stringent safety requirements. However, there are currently no regulatory guidelines for incremental upgrades. This limits the ability of such devices to be upgraded rapidly to respond quickly to emerging public health challenges and to benefit from evolving advances in CPS and AI. Moreover, if upgrades are carried out, the evidential value of the initial verification and validation (V&V) required for certification is rapidly lost.

Enabling a DevOps approach to re-verification and re-validation

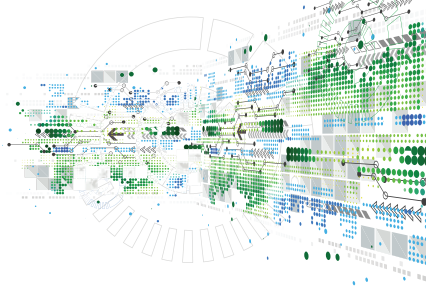
The Vivaldy project will address these issues by developing efficient, model-based (virtual) re-verification and re-validation techniques for rapidly evolving and AI-based CPSs. It will research practical guidelines, supporting tools and methodologies for the re-verification, re-validation and certification of three distinct kinds of incremental upgrades for healthcare class II CPSs in a 'DevOps oriented' total product lifecycle approach: (i) hardware upgrade, (ii) component upgrade and (iii) software/AI upgrade.

'DevOps' is set of practices that combines software development and IT operations in order to shorten the systems development life cycle and provide for continuous delivery of high-quality software. Regulatory authorities such as the FDA (US), Notified Bodies (EU) and the CFDA (China) recognize the advantage of a DevOps release cycle for (AI-enhanced) healthcare to achieve the goals of faster public health responses and improved patient engagement and quality of care. The Vivaldy project will enable this paradigm shift by offering a total solution and guidelines for the transitioning from today's product-oriented development cycles to a DevOps driven, upgrade-oriented development cycle for professional healthcare solutions.

Five key innovation areas will be addressed:

1. Analysis of field-obtained user/usage data for re-training and incremental upgrade of AI components for clinical decision support; and secondly, for selection of the most significant verification and validation (V&V) activities to safeguard patient safety;
2. Hardware upgrade strategy for efficient re-V&V while improving the effectiveness, reliability and safety of CPSs for clinicians and patients after the upgrade;
3. Change-based impact analysis combining patient risk-based analyses with analysis of potential impacts on functionality, reliability and patient's or clinician's safety of individual upgrades to minimize overall V&V effort for certification;
4. Integration and test framework combining virtual (simulation models / digital twins) and physical testing for V&V without compromising on product safety for patients and clinicians;
5. Guidelines for regulatory approval addressing the current lack of incremental upgrade guidelines in conjunction with a relevant user group.

[1] The FDA classifies medical devices based on (a) their intended use and (b) upon their potential harm to a patient. Clinical decision support systems (i.e. systems that provide recommendation to a healthcare professional on a health condition) are generally classified as class II medical devices and must comply with stringent patient-safety requirements.



KEY APPLICATION AREAS

- Healthcare
- Digital Industry

ESSENTIAL CAPABILITIES

- Systems and Components Architecture, Design & Integration
- Safety, security and reliability

PARTNERS

Barco
icometrix
Philips Medical Systems Nederland BV
TNO-ESI
TU Delft
Verum Software Tools BV
VITO NV
Unit040

COUNTRIES INVOLVED

- Belgium
- Netherlands

PROJECT LEADER

Mr. Dominique Segers
Barco, NV

www.vivaldy-penta.eu

KEY PROJECT DATES

01 February 2020 to 31 January 2023

The results will be proven on four industrial use cases each targeting a specific type of upgrade ranging from hardware and components to AI applications. In addition, the project consortium will involve regulatory authorities and partners active in other safety-critical industry domains in order to benefit from developments in various fields.

Shared vision

The partners in the Vivaldy consortium bring expertise from a wide range of relevant fields including medical devices, medical imaging analysis, visualization and simulations, software verification and impact analysis, and AI in medical applications. They will leverage this joint expertise to enable the necessary paradigm shift from today's development-centric engineering towards an approach that considers the development and operational phases of CPS in an integrated way.

Commercial opportunities and markets

The initial target for the Vivaldy project is the healthcare market which requires systems and solutions that must remain fit for purpose over a long lifecycle. In particular, the project will lead to exploitable results in minimally invasive diagnosis and treatment, AI-enhanced clinical decision support systems and visualization solutions. Its outcomes will support rapid, cost-efficient re-verification, re-validation, and certification of incremental CPS upgrades that will allow the industry to respond more quickly and efficiently to the needs of its customers. In many cases, this will provide a competitive edge for medical device makers in the huge global healthcare market.

Worldwide, healthcare expenditure is currently estimated at USD7.6 trillion and its growth will continue to be greater than that of GDP, reaching double the rate in some countries[2]. Within the EU, healthcare including health & wellness represents up to 25% of the economy. In the areas of diagnostic imaging and interventional radiology, where Vivaldy's results have major potential, markets are growing significantly. The worldwide diagnostic imaging market is expected to reach USD36.4 billion by 2021, at a CAGR of 6.6% from 2016 to 2021[3]; while the global interventional radiology market, covering the complete spectrum of medical imaging systems, is anticipated to reach USD22.9 billion by 2024, registering a CAGR of 5.8% over the period between 2016 and 2024[4]. Much of this growth derives from ageing populations, and the rise of chronic diseases, often resulting from lifestyle changes. In addition, AI is expected to bring important productivity gains in healthcare and AI applications could potentially create growth in the AI health market that could reach USD 6.6 billion by 2021 – a CAGR of 40%[5].

At the end of the project, the Vivaldy partners anticipate that its resulting innovations will be introduced step by step into product development processes. Consequently, AI-enhanced CPS medical devices that can be incrementally upgraded could be introduced on the market within three to four years. In the long term, through its interaction with the scientific community, industry, end-users, policymakers, regulatory and standardization bodies in various market segments, Vivaldy will help enable regulatory approval of AI-enhanced and incrementally upgradeable products in other safety-critical areas such as the automotive industry.

2 World Economic Forum, Value in Healthcare, Insight Report April 2017
3 Markets and markets – Diagnostic Imaging Market, February 2017
4 http://www.transparencymarketresearch.com/interventional-radiology-market.html
5 Frost and Sullivan, Cognitive Computing and Artificial Intelligence Systems in Healthcare, Dec 2015.

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Vivaldy

Bringing benefits to patients and public health through efficient and effective safety-certified upgrades for AI-enabled medical devices

Paris, 27 January 2021- The PENTA project, Vivaldy (VerIfication and Validation of Ai-enabLeD sYstems) aims to allow medical devices such as those used in the analysis of medical images and in minimally invasive surgery to be upgraded more easily and frequently, but with full safety certification. This will bring improved quality of care, help patients better engage with their care, and allow healthcare systems to adapt quicker to fast-changing public health challenges. In technical terms, its goal is to develop efficient re-verification and re-validation and effective regulatory approval guidelines for the incremental upgrade of class II[1], AI-enhanced Cyber Physical Systems (CPSs) in the professional healthcare domain.

Many of today's medical devices incorporate CPS – systems that interact both with computing capabilities built into the product and directly with the physical world (e.g. a monitoring system that reacts to sensors on the body). Often, these devices also include Artificial Intelligence (AI) which enhances their utility. For instance, AI helps doctors spot critical diagnostic information in scans, while CPS and AI in X-ray systems guide doctors during extremely precise minimally invasive procedures.

Given that patient safety is always paramount, these devices require lengthy certification by relevant authorities. However, CPS and AI are rapidly evolving fields and there are currently no guidelines to allow for frequent incremental upgrades so such medical devices can keep pace with the latest advances. The Vivaldy project seeks to solve this issue by developing techniques that enable upgrades to be implemented and re-certified more efficiently. Major system upgrades could happen once a year instead of every three years, and module and/or AI upgrades every six months instead of once a year.

To achieve these ambitions, the project partners bring expertise in medical devices, medical imaging analysis, visualization and simulations, software verification and impact analysis, and AI in medical applications. They aim to create a 'DevOps[2]' approach to verification and validation which involves integrating product development and the ability to deliver frequent upgrades into a single engineering approach.

Besides patient and healthcare provider benefits, the project will increase the competitiveness of European players in huge and growing global healthcare markets. The worldwide diagnostic imaging market is expected to

[1] The FDA classifies medical devices based on (a) their intended use and (b) upon their potential harm to a patient. Clinical decision support systems (i.e. systems that provide recommendation to a healthcare professional on a health condition) are generally classified as class II medical devices and must comply with stringent patient-safety requirements.

[2] DevOps integrates the two worlds of development and operations, using automated development, deployment, and infrastructure monitoring. It's an organizational shift in which, instead of distributed siloed groups performing functions separately, cross-functional teams work on continuous operational feature deliveries. This approach helps de-liver value faster and continuously, reducing problems due to miscommunication between team members and accelerating problem resolution

reach USD 36.4 billion by 2021, at a CAGR of 6.6% from 2016 to 2021[3]; while the global interventional radiology market, covering the complete spectrum of medical imaging systems, is anticipated to reach USD 22.9 billion by 2024, registering a CAGR of 5.8% over the period between 2016 and 2024[4]. In addition, the Vivaldy project will establish user groups with industry, regulators, researchers, and end-users to bring its results not only to healthcare but also to other safety-critical areas such as the automotive industry.

About the PENTA programme

PENTA is a EUREKA cluster whose purpose is to catalyse research, development and innovation in areas of micro and nanoelectronics enabled systems and applications. Guided by the Electronic Components & Systems (ECS) Strategic Research and Innovation Agenda (SRIA) four technology layers, four cross-sectional technologies and six ECS key application areas, the PENTA programme enables the development of electronic solutions to help drive the digital economy through the formation of collaborative ecosystems along the ECS value chain. This creates the opportunity for rapid competitive exploitation and a strong impact on European societal challenges. PENTA supports SMEs, large corporations, research organisations and universities to work together in project consortia by facilitating access to funding, fostering collaborative work and creating consortia in areas of mutual industrial and National interest.

PENTA is managed by the Industry Association AENEAS

More on PENTA: http://www.penta-eureka.eu
More on AENEAS: https://aeneas-office.org

About the Vivaldy project:

Vivaldy is a RD&I project consortium involving 8 partners from 2 countries. The project partners are: Barco (Project leader), icometrix, Philips Medical Systems Nederland BV, TNO-ESI, TU Delft, Verum Software Tools BV, VITO NV, and Unit040. National funding support is provided by Belgium and the Netherlands.

About Vivaldy: https://www.vivaldy-penta.eu/

[3] Markets and markets – Diagnostic Imaging Market, February 2017
[4] http://www.transparencymarketresearch.com/interventional-radiology-market.html

FA4.0

19007

Smart AI-based tools for ensuring reliable electronic devices for smart mobility and industrial production [Failure Analysis 4.0]

The Failure Analysis (FA) 4.0 project will address a fundamental challenge for the digital world: how to ensure that increasingly complex electronic systems operate with complete reliability and safety in daily use. This is essential in safety-critical applications such as autonomous vehicles and in digitalized industrial production (Industry 4.0). FA 4.0 will provide innovative AI-based tools and methods to analyse and avoid defects and failures during the development and manufacture of electronic components and systems. With its holistic approach spanning chip production, assembly & packaging, to board and system level, the project's outcomes will be crucial for the competitiveness of European electronic devices, especially in the demanding automotive and industrial sectors.

From self-driving cars to medical devices and smart homes, rapidly evolving digitalization and automation are transforming everyday life. Industrial production itself is becoming 'smarter' and ever-more automated. These trends offer enormous market potential for high-tech products based on increasingly complex electronic systems. However, these electronic components and systems (ECS) must combine advanced functionality with the ability to function faultlessly whenever required. Average usage of many electronic devices may rise from a few hours a day currently to over 20 hours a day. For instance, even when not on the road, the electronics in an electric vehicle will be active during the charging cycle. Thus, the electronics must not only reach rigorous automotive safety and quality standards, but also have a long lifetime.

At the same time, innovation in applications such as automotive electronics is very rapid and electronic systems are growing in complexity on many levels – in functional density, reduced footprint size, new materials and compositions, and the introduction of novel technologies including 3D integrated devices, hetero-integrated system in package, and high-density interconnects for printed circuit boards, to name a few. These developments are leading to extreme challenges for reliability, quality and manufacturing yield.

In applications where ECS are a key enabling technology, mastering the related reliability risks requires more effective process-related defect characterisation and failure analysis than currently exists. It also calls for holistic control of all the uncertainties along the process chain of component design, manufacture and quality management.

Today, however, failure analysis is carried out manually, driven by single tasks coming from production, reliability testing and field returns. This is time-consuming and does not allow for analysis of combined electrical and material testing and metrology data from along the manufacturing process flow. It is also susceptible to human error, and diagnostic tools are not linked to each other or a central database to provide information for the next steps in a failure analysis workflow.

Applying AI for smart failure analysis

To address these challenges, FA 4.0 will create cutting edge tools and methods for analysing, understanding and avoiding defect mechanisms and failure risks during development and manufacturing. It will develop a comprehensive, central recording analysis of metrology parameters and process-related inhomogeneities, tracked along the production process in correlation with existing failure catalogues. Newly discovered failure mechanisms identified in final components will be explored as part of a novel holistic approach for quality assurance and process improvement. This holistic analysis approach will be enabled by advanced FA tools with integrated smart preparation and signal analysis capabilities.

Above all, the project aims to apply breakthroughs in the field of AI research and data correlation to provide largely automated diagnostic tools combined in efficient failure analysis workflows. It will focus on two primary innovation areas 1) a next generation of efficient diagnostic tools and workflows, and 2) smart algorithms for failure identification and cataloguing.

COLABELED

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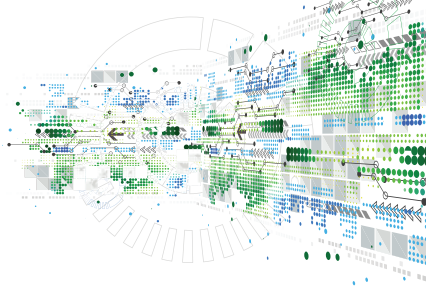


KEY APPLICATION AREAS

- Transport and Smart Mobility
- Digital Industry

ESSENTIAL CAPABILITIES

- ECS Process Technology, Equipment, Materials & Manufacturing

PARTNERS

cyberTECHNOLOGIES GmbH
Direct conversion AB
Ecole des Mines de Saint Etienne
Ericsson AB
Excillum AB
Fraunhofer Institute for Microstructure of Material and Systems IMWS
Gimic
Infineon Technologies AG
Jean Monnet University (Saint-Etienne) in Lyon University
Kern Microtechnik GmbH
Materiex AB
Matworks GmbH
Orsay Physics
PVA TePla Analytical Systems GmbH
RISE IVF AB
Robert Bosch GmbH
STMicroelectronics Grenoble 2 SAS
STMicroelectronics (Tour) SAS
STMicroelectronics (Rousset) SAS
TESCAN ORSAY HOLDING
University of Stuttgart

COUNTRIES INVOLVED

- Czech Republic
- Germany
- France
- Sweden

PROJECT LEADER

Dr. Klaus Pressel
Infineon Technologies AG

KEY PROJECT DATES

01 April 2020 - 31 March 2023

Using AI-based algorithms, targeted working hypotheses can be derived more quickly and confirmed with only a few analysis steps. New approaches in the fields of automated and self-learning image processing, measurement systems and failure analysis methods could also be utilized for defect control. Linking smart and more automated failure diagnostic tools along the process chain (in line with concepts derived from Industry 4.0) and correlating these with degradation mechanisms and failure catalogs offers great potential for improving the efficiency and quality of production and reducing manufacturing costs.

Furthermore, these fast and powerful tools for failure recognition and interpretation, as well as for correlation to available metrology and electrical testing data along the manufacturing process chain, will be key for further technological developments.

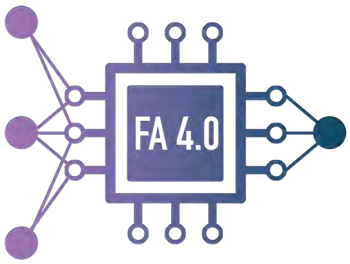
Expertise across the entire value chain

FA 4.0 is able to take its holistic approach by bringing together research institutes and companies from across the entire value chain, including leading semiconductor and electronic system suppliers and medium and small businesses (SMEs). The project will strengthen the strategic alliance of European semiconductor manufacturers, FA tool providers and research institutes, and leverage their combined expertise in failure analysis, methodologies and tool supply to develop these new solutions for smart failure analysis.

Strategic market access and new opportunities

The market importance of FA 4.0 is huge. As demand for high-tech products for applications like autonomous driving, electric vehicles, smart industry, energy efficiency, 5G telecommunications and Internet of Things (IoT), and medical applications grows, reliability and quality are no longer an 'add-on' to technological innovation but an essential requirement for market access. Experts in the field have stated that "Reliability is emerging as the top priority across the hottest growth markets for semiconductors, including automotive, industrial and cloud-based computing..." . Moreover, AI is seen as having a key role in enabling this reliability. Thus, the outcomes of FA 4.0 will be of crucial importance to ensuring the European electronics industry has access to the strategic markets of the future. In addition, the project will open up opportunities for European failure analysis equipment manufacturers.

In effect, the collaboration in FA 4.0 between semiconductor and system suppliers, diagnostic tool manufacturers and leading research institutes will strengthen the European ECS industry's global competitiveness to design and manufacture reliable, high quality and cost-effective products. The close cooperation between the partners in the consortium will allow European companies to deliver both innovative electronic products and the required failure analysis tools that increase reliability and quality and shorten product development cycle times.



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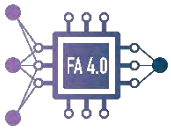
Penta (E! 9911), is EUREKA Cluster whose purpose is to catalyse research, development and innovation in areas of micro and nanoelectronics enabled systems and applications.

Failure Analysis 4.0

Smart AI-based tools for ensuring reliable electronic devices for smart mobility and industrial production

A project within the EUREKA EURIPIDES² & PENTA programmes



Paris, 9 March 2021 - The Failure Analysis (FA) 4.0, a co-labelled EURIPIDES² and PENTA project**,** is addressing a fundamental challenge for the digital world: how to ensure increasingly complex electronic systems operate with complete reliability and safety in daily use.

As digitalisation and automation rapidly advance, complex electronic systems and components will play an ever-bigger role in everyday life, enabling innovations from self-driving vehicles to smart homes. Even industrial production itself is becoming 'smarter' and more automated. These advances will help to improve the quality of life in our homes and cities; as well as making industry more efficient. However, to do this, the electronics at the heart of each product must operate safely and reliably at all times, especially in safety-critical applications such as automotive. In developing a smart approach to further improve failure analysis methods, tools and workflows by introducing Artificial Intelligence (AI) and sharing data throughout the design and manufacturing process, FA 4.0 will provide to tackle these crucial challenges.

Failure analysis is a process that allows the designers and manufacturers of semiconductor chips, printed circuit boards and other electronic components and systems to analyse, understand and avoid defects and failure risks during development and manufacture. However, failure analysis is currently a manual, time-consuming process, and test data is not shared between different design and manufacturing steps.

By applying breakthroughs in the field of AI research and data correlation, FA 4.0 intends to develop a holistic approach, that combines largely automated diagnostic tools in an efficient FA workflow process. The project will draw on the combined expertise of leading European electronics companies, SMEs and research institutes, to deliver key innovations in next generation diagnostic methods, tools and workflows as well as smart algorithms for identification and cataloguing of failures.

The challenge is both fundamental and highly demanding as the technologies used to create high performance electronic devices, components and systems (ECS) are constantly evolving. Devices are becoming ever smaller, with more densely packed functionality on each tiny device; plus, new materials, new types of assembly and packaging, and new ways of connecting devices into circuits are rapidly emerging.

At the same time, as demand for applications such as autonomous driving, smart industry, energy efficiency and medical applications grows, reliability and quality are becoming an essential requirement for high-tech products to enter the market. Thus, the outcomes of the FA 4.0 project will

be highly important to deliver the benefits of digitalisation for society and their resulting economic impact. They will allow European companies to create innovative electronic products and the failure analysis tools necessary to increase reliability and quality while reducing product development time and costs. The European electronics industry will be ensured to access the strategic future markets, particularly in safety critical applications. European failure analysis equipment manufacturers will have new opportunities in their global market segment of diagnostic tools as well.

About EURIPIDES

EURIPIDES² is a EUREKA Cluster promoting the generation of innovative, industry-driven, pre-competitive R&D projects in the area of Smart Electronic Systems. Guided by the Electronic Components & Systems (ECS) Strategic Research and Innovation Agenda (SRIA), EURIPIDES² is the innovation hub for smart sensors, smart power modules, electronic hardware platforms and more generally electronic product integration and embedded systems for automotive, aeronautics and space, security, medical electronics, smart everywhere (cities, home, wearable) and industrial electronics. EURIPIDES² facilitates access to national funding in Europe and beyond. As a EUREKA Cluster, the network is open to participants worldwide.

More on EURIPIDES²: https://www.euripides-eureka.eu

About PENTA

PENTA is a EUREKA cluster whose purpose is to catalyse research, development and innovation in areas of micro and nanoelectronics enabled systems and applications. Guided by the Electronic Components & Systems (ECS) Strategic Research and Innovation Agenda (SRIA) key application areas, foundational technology layers and cross-sectional technologies, the PENTA programme enables the development of electronic solutions to help drive the digital economy through the formation of collaborative ecosystems along the ECS value chain. This creates the opportunity for rapid competitive exploitation and a strong impact on European societal challenges. PENTA supports SMEs, large corporations, research organisations and universities to work together in project consortia by facilitating access to funding, fostering collaborative work and creating consortia in areas of mutual industrial and National interest.

More on PENTA: http://www.penta-eureka.eu

About FA4.0

FA4.0 is an RD&I project consortium involving 21 partners from 4 countries, Germany, France, Czech Republic and Sweden. The project partners are: Infineon Technologies AG (project coordinator), Direct conversion AB, Ecole des Mines de Saint Etienne , Ericsson AB, Excillum AB, Fraunhofer IMWS, Gimic, Jean Monnet University (Saint-Etienne), Kern Microtechnik GmbH, Materiex AB, Matworks GmbH, Orsay Physics, PVA TePla Analytical Systems GmbH, RISE IVF AB, Robert Bosch GmbH, STMicroelectronics (Rousset) SAS, STMicroelectronics (Tours) SAS, STMicroelectronics (Grenoble2) SAS, TESCAN ORSAY HOLDING and University of Stuttgart.

More on FA4.0: https://penta-eureka.eu/project-overview/penta-call-4/fa4-0/

WMC

19022

Europe's open, multi-application platform for wafer production with onsite configurability [WMC]

The Wafer Metrology Center (WMC) project will develop an open, modular metrology and inspection tool for wafer handling in a wide range of semiconductor applications, and which can be retooled onsite to deal with rapidly-changing requirements. Importantly, this platform will also establish a European foothold in a key marketplace.

Current semiconductor metrology and inspection tools are often too monolithic and cannot be reconfigured to many different and fast-changing requirements of emerging products. Even a minor retooling change in the field is, in most cases, not possible. Equally important, this lucrative market is currently dominated by five large companies, none of which are European.

What is needed is a European platform that not only offers flexibility in functionality and application, but also provides a 'framework' which is innovative and open in its approach to business, operational process and technology.

Building an open, flexible, multi-application wafer-handling platform

The goal of the WMC project is to develop an open, modular metrology and inspection platform for wafers in a wide range of semiconductor applications – especially for, but not limited to, wafer-level packaging. WMC will be innovative on three fronts: business, process and technology.

The WMC business model will attract innovative technology companies and research and development (R&D) institutions in the field of optical-sensor techniques, as well as, semiconductor customers. Manufacturing resellers (OEMs) will benefit from a technology, sales and distribution platform, while customers and users from a flexible, scalable, multi-application and cost-effective tool.

Operational processes, open and modular in concept, will deploy multiple sensors in a wide range of applications, which can be combined and retooled onsite – a unique capability in the semiconductor market. Even though there are systems currently available with multiple sensors, these platforms are mostly neither open nor reconfigurable.

Technology innovation will cover five areas of R&D:

1. Metrology and automation platform:

   Retooling of sensors requires a lot of engineering work, especially in the software architecture where sensor and automation components must be configurable; metrology recipes combined and linked together; and standardised Interfaces designed specifically for optoelectronics, mechatronics and software. Furthermore, data transfer, graphics programming and many other techniques will need to be considered. The same modularity provided for sensor technologies is also required for wafer handling to make this 'generic' platform deployable in a broad range of applications along the semiconductor value-chain.

2. Digital holography microscopy:

   The advantage of a digital holography microscope is that holograms may be captured with the frequency of a CMOS camera. Since there are no moving parts inside (for example gratings) like in phase-shift interferometers, measurement-taking is very fast. The challenge in semiconductor front-end applications is the transparent insulating layer, which usually causes false topography. The approach in this case is to measure the thin layer using the physics of reflectometry without any additional measuring.

3. Mid-IR reflectometry:

   This new sensor will be primarily dedicated to measuring the EPI (epitaxial) thickness of silicon (Si), silicon germanium (SiGe), silicon carbide (SiC) or gallium nitride (GaN) layers on wafers. The reflectometry sensor requires a spectrometer to measure the spectra. The main goal is to boost its throughput to a production-level standard. Both, Fourier transform infrared spectrometer and wavelength-swept quantum cascade laser will be evaluated to ensure this improvement. Notably, the laser approach will be emphasised to boost speed, but also accuracy and reliability.

4. Multi-wavelength interferometer (MWI):

   For 3D packaging inspection with structures in the micron range, the above-mentioned holography sensor does not work since its dynamic range is less than a couple of microns. The project will evaluate a new approach based on multi-wavelength interferometry (MWI), using a fast line-scan camera to speed up bump-profiling and improve its reliability, especially

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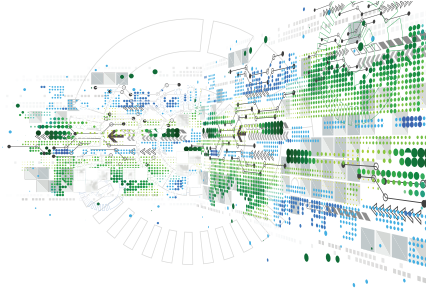

KEY APPLICATION AREAS

Semiconductor Fabrication

ESSENTIAL CAPABILITIES

ECS Process Technology, Equipment, Materials & Manufacturing

PARTNERS

CSEM

Lyncée Tec SA

Fraunhofer-Gesellschaft – the Instituts for reliability and microintegration (IZM), for production technology and automation (IPA) & for applied solid state physics (IAF)

Nedinsco B.V

Sentronics Metrology GmbH

COUNTRIES INVOLVED

Germany

Netherlands

Switzerland

PROJECT LEADER

Bernd Srocka
Sentronics Metrology GmbH

KEY PROJECT DATES

01 March 2020 to 28 February 2023

for the smaller µ-bumps. With this approach, the throughput can be increased significantly, and wafer-scanning to within one minute is made possible. Recently announced multi-line cameras should make this throughput-target possible.

5. Extended depth of focus (DOF) camera:

   Aspect ratios, especially in the advanced-packaging market, are growing constantly. At the same time, resolution requirements have reached levels around single microns, causing a principle issue with state-of-the-art camera techniques, limited in DOF by physics principles. Today, no system available can provide extended DOF while maintaining resolution. The project will extend the DOF of a camera-based imaging product by a factor of about 10, compared to currently available cameras. This will be achieved without any moving mechanics or liquids. The project aims to improve inspection performance, and especially 2-dimensional metrology for high aspect-ratio structures. A proof of concept has already been developed for this innovative optical system. It comprises a lens column, a mounted camera, and includes proprietary image-processing algorithms.

Critical success factors

In a nutshell, the project aims to deliver Europe's first open platform for metrology and inspection in the semiconductor industry that, at its launch, will already address nine different optical sensor technologies. It will deploy four new sensor technologies in combination with five existing ones, and aims to be open to further additions in the future. The platform will cover an extensive variety of wafer-manufacturing applications, including front-end, back-end, and packaging metrology and inspection ones.

WMC will also be unique since current metrology tools do not have the flexibility to be retooled in case of changing requirements,. What is more, WMC will allow European companies to compete in this important marketplace. Another key spin-off is the globalisation of intellectual property of scientists and engineers participating in semiconductor fabrication. This project will also create a symbiosis-like ecosystem of technology exchange, from which every project partner will benefit.

Standardisation is also key to this project, considering a critical project objective is to position the WMC platform as an open, highly standardised and flexible platform to a growing community of European (metrology) sensor-providers.

Crucially, building a product which faces competition dominating the current semiconductor metrology and Inspection market, also calls for a project consortium with the right experience, expertise and building blocks to collectively meet the technological and business challenges the WMC project faces.

State of the market

Five companies dominate the current US$ 6 billion semiconductor metrology and Inspection market, with a combined share of 87% in 2017, up from 75.3% in 2002, as the market consolidated from 37 companies to 20.

WMC's potential market can be divided into five main application groups: 1) layer metrology; 2) 3D surface metrology; 3) wafer geometry; 4) 2D Inspection; and 5) high-throughput 3D packaging inspection. The WMC project is expected to generate new opportunities for applications in various other fields also requiring the highly configurable, cost-effective WMC platform. Potential growth for project partners in a new market segment is US$ 600m, based on current conditions, growing with a 10% CAGR to US$ 880m in 2022.

Importantly, the WMC project's legacy will include an ecosystem of European high-tech companies and research centres that will continue to collaborate beyond the completion of this project.

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WMC

Wafer Metrology Centre (WMC) – an upgradeable solution for the challenging task of minute measurement in chip manufacturing

A project within the EUREKA EURIPIDES² & PENTA programmes

Paris, 13 October 2020 - The co-labeled EURIPIDES² and PENTA Wafer Metrology Centre (WMC) project led by an SME, aims to provide manufacturers with new and more flexible tools to check the miniscule features on electronic chips during the production process. Designed for measurements during quality control, the integrated WMC hardware and software platform will be easily able to evolve as new applications, designs and demands on performance continue to grow.

Silicon chips are everywhere in our digital world: in computers, phones, cars, medical devices, industrial machines, LED lights – the list is vast. And each of these tiny chips (or 'integrated circuits' (ICs)) contains hundreds of millions, or even billions, of electronic transistors, measuring just billionths of a meter (nanometers) in size.

Consequently, chip manufacturing is highly intricate, requiring extreme precision to ensure chips operate correctly and reliably. Yet there is constant pressure to deliver higher performance at lower cost, to produce ever-more complex chips based on new designs and materials, and to reduce production faults to just a few parts in million.

Wafer metrology plays a key role in achieving these goals. It is the technology used to measure the components and wires on chips as they are 'printed' or 'etched' onto pieces (wafers) of silicon or other materials. But current wafer metrology tools often lack the flexibility to evolve to meet changing requirements and new applications, which is where the WMC comes in.

The partners in the WMC consortium are developing a modular metrology and inspection tool platform for a wide range of semiconductor applications. They will also create new optical sensors which, combined with existing sensors, will allow the platform to cover a full range of production steps. These include wafer manufacturing processes, front-end, back-end and packaging metrology and inspection. In addition, the platform will provide a software editor to create customized filters, and a scalable interface which links to an advanced data-mining solution that turns raw data into meaningful input for decision-making.

Among key applications areas will be Si (silicon), SiC (silicon carbide) and GaN (gallium nitride) based ICs for power devices, LEDs and MEMS (micro electro-mechanical systems). Most importantly, a high degree of standardization in the platform will enable it to be quick and easy reconfigured even in the

field to meet changing requirements and applications. This is a unique advantage compared to existing metrology solutions and will allow the European project partners to compete effectively with incumbent global players in this important market.

About EURIPIDES

EURIPIDES² is a EUREKA Cluster promoting the generation of innovative, industry-driven, pre-competitive R&D projects in the area of Smart Electronic Systems.EURIPIDES² is the innovation hub for smart sensors, smart power modules, electronic hardware platforms and more generally electronic product integration and embedded systems for automotive, aeronautics and space, security, medical electronics, smart everywhere (cities, home, wearable) and industrial electronics.EURIPIDES² facilitates access to national funding in Europe and beyond. As a EUREKA Cluster, the network is open to participants worldwide.

More on EURIPIDES²: https://www.euripides-eureka.eu

About PENTA

PENTA is a EUREKA cluster whose purpose is to catalyse research, development and innovation in areas of micro and nanoelectronics enabled systems and applications. Guided by the Electronic Components & Systems (ECS) Strategic Research Agenda (SRA) key application areas and essential capabilities, the PENTA programme enables the development of electronic solutions to help drive the digital economy through the formation of collaborative ecosystems along the ECS value chain. This creates the opportunity for rapid competitive exploitation and a strong impact on European societal challenges. PENTA supports SMEs, large corporations, research organisations and universities to work together in project consortia by facilitating access to funding, fostering collaborative work and creating consortia in areas of mutual industrial and National interest.

PENTA is operated by AENEAS.
More on PENTA: http://www.penta-eureka.eu
More on AENEAS: https://aeneas-office.org

About WMC

WMC is an RD&I project consortium involving 5 partners from 3 countries, Germany, Switzerland, and the Netherlands. The project partners are: sentronics metrology GmbH (project coordinator), CSEM, Fraunhofer-Gesellschaft – institutes IZM ASSID, IAF and IPA, Lyncée Tec SA and Nedinsco B.V .

More on WMC: https://penta-eureka.eu/project-overview/penta-call-4/wafer-metrology-center/

PLANtar

19016

Miniaturized monitoring sensor systems for plants and agriculture [PLANtAR]

PLANtAR aims to develop cost-efficient, miniaturized, networked, biodegradable monitoring electronics to help tackle one of the world's biggest challenges: producing enough food over 9 billion people while also protecting the environment.

Since the start of the 20th century, technologies such as improved plant breeding, fertilizers and plant protection products (pesticides, herbicides and fungicides) have enabled farming to keep pace with constantly rising demand for food. However, intensive agricultural practices, just barely optimized for high-yield production, are unsustainable. Not only are they damaging to the environment, but they also require large quantities of clean water for irrigation – water that may no longer be available due to climate change. Yet with the global population set to grow from 8 billion in 2025 to 9.6 billion in 2050, the UN Food & Agriculture Organization (FAO) calculates that food production needs to increase by 70% in this period . Solving the dilemma between high-yield intensive agriculture and protecting the environment calls for cross-industry approaches, and digitalization has a key role to play.

New kinds of electronic sensors, actuators, networks and other digital technologies can increase efficiency and improve environmental sustainability in many agricultural applications. Whether in fields, in greenhouses or in the new domains of indoor and urban farming (which now accounts for 20% of global food production), digital technologies have the potential to enable holistic monitoring of production and growing conditions. Sensors can provide timely warnings of plant stress and / or diseases. By measuring factors such as soil moisture, EC and content of nitrogen, ammonia, surface temperature, solar radiation, CO2 and detecting pests and plant pathogens, digital technologies can help significantly increase yields per cultivated area. And at the same time, they can assist in reducing water, energy, fertilizer and pesticide use.

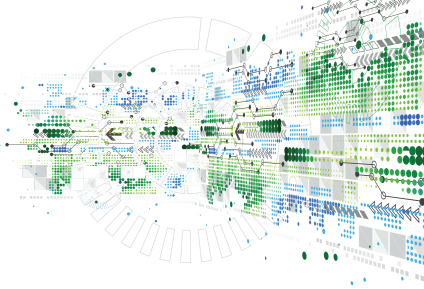
Although some of such sensors and sensor networks already exist, on the one hand, many are too expensive for large-scale use. On the other hand, more cost-effective sensors and measuring systems lack sufficient accuracy for professional applications. Moreover, since they can pollute the soil if left in place, existing sensor systems generate added costs and effort for producers because they have to be removed from the soil after use.

Affordable, highly integrated, biodegradable solutions

To address these issues, the PLANtAR project is focusing on development of affordable, highly integrated, miniaturized sensors and close-mesh sensor networks (including nano-sensors and paper-based microfluidic devices) and application intelligence in three areas: precision farming (field / urban), greenhouse / indoor farming and farm monitoring. In addition, it aims to reduce the environmental impact and 'de-installation' costs of these technologies by ensuring that the sensors are biodegradable, so they can be left in place after their use and simply ploughed back into the soil.

With its ambition to provide for high-volume markets, PLANtAR aims specifically to create low-cost sensors for the detection of pests and plant pathogens (putrefaction), soil moisture, leaf wetness, ammonia, CO2, electrical conductivity (EC) and nitrate content (NO3). It will also work on creating highly integrated circuits and interfaces including signal pre-processing and battery management for connected sensor systems. By creating an ultra-low power microcontroller with an integrated transceiver and suitable interfaces that connect to different sensors, the PLANtAR consortium will seek to achieve the highest levels of integration and signal analysis at low power operation. This work will also cover new combinations of interface materials and production technologies to meet the requirement for biodegradability.

Biodegradability is a key challenge within the project. As yet, biodegradable sensor nodes which include all the necessary wireless sensor components (substrate, microcontroller, sensors, antenna, power supply and housing) do not exist. The PLANtAR project will explore how printed electronics could be used to solve this challenge, creating devices that are almost fully biodegradable and have an adequate energy supply and data transmission capability. Its goal is to demonstrate a printed circuit board, antenna, battery, and certain sensors and their housings made of biodegradable materials which can be broken up by ploughing and harrowing and decompose into the soil.



KEY APPLICATION AREAS

Digital Industry

ESSENTIAL CAPABILITIES

Systems and Components: Architecture, Design & Integration

Process Technology, Equipment, Materials and Manufacturing for ECS

PARTNERS

Alianza Nanotecnología Diagnóstica ASJ, S.L.
ALPHASIP
Alteria Automation SL
COGNICASE MANAGEMENT CONSULTING S.L.
Evalan BV
Fraunhofer ENAS
Freudenberg Industrie Siebdruck GmbH,
HANSENHOF_electronic Entwicklung Fa. Steffen Schmieder
Infineon Technologies AG
Kurt-Schwabe-Institut für Mess- und Sensortechnik Meinsberg e.V.
Munisense BV
Rockwool B.V.
Stichting IMEC Nederland
Stichting Wageningen Research

COUNTRIES INVOLVED

Germany
The Netherlands
Spain

PROJECT LEADER

Ms. Ulrike Glock
Infineon Technologies AG

www.project-hades.eu

KEY PROJECT DATES

01 November 2020 - 31 October 2023

Expertise across the value chain

The PLANtAR consortium brings together partners from across the entire value chain. These include highly experienced technology and component providers as well as leading suppliers in agricultural applications and infrastructure who have direct contact with end-users. The extensive mix of industrial partners features a high number of SMEs and start-ups with know-how in sensors and other relevant technologies. Several research institutes with expertise and excellent market access are also involved. With this breadth of knowledge and resources in agriculture and semiconductor and sensor technologies, the consortium will strengthen knowledge transfer and cut development time and costs leading to a faster time-to-market.

Growing market opportunities

By minimizing risks and speeding development of new sensor technologies and communication networks, PLANtAR's collaborative approach will deliver competitive offerings to the environmental sensor market – at both component and solution level. It will allow European companies to maintain or achieve market leadership positions and enable end-users to install low-cost sensor networks or expand existing ones.

The opportunities are considerable. The market for IoT sensors in the smart farming segment is expected to rise from one million sensor systems in 2016 to 9.5 million in 2025[1]. In precision farming, the market for hardware and software was worth 2.3 billion Euros in 2014 and is expected to grow worldwide with a CAGR of 12% through 2020, with an even higher growth rate in Europe[2]. Demand for eco-friendly nano-sensors is likely to create a highly lucrative market (already worth 642 million USD in 2020). The greenhouse sector is also digitalizing rapidly and is predicted to double to 1.3 billion USD worldwide in the next 6 years[3]. Meanwhile, the market for printed electronics (primarily biodegradable) is expected to grow to a value of 30 billion USD in the next ten years.

Given the global need for sustainable, high-yield agriculture and the size of the markets, PLANtAR is a key project for Europe. It will ensure that Europe retains essential scientific research and strengthen European industry's ability to supply components for these vital new agricultural applications.

[1] IHS Markit Report 2018, Industrial Sensors in IoT: Review of key use cases and quantification of demand

[2] https://fticommunications.com/2016/11/europes-opportunity-digital-agriculture/

[3] "Smart Greenhouse Market (Hydroponic, Non-hydroponic) by Technology (HVAC, LED Grow Light, Communication Technology, Irrigation System, Material Handling, Valves & Pumps, Control System, and Others): Global Industry Perspective, Comprehensive Analysis, and Forecast, 2016 – 2022" report

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PLANtar

▶ **Video: https://www.youtube.com/watch?v=sMcuqN_2aDY**

AMPERE

20014

Additive Manufacturing based Production of Embedded Robust Electronics [AMPERE]

Current manufacturing production is optimised for high volumes of low cost, high quality products. Yet, as digitalization and Industry 4.0 (Smart Industry) expand, the drawbacks of this conventional manufacturing become clear. In particular, it leads to a lack of flexibility and highly standardised designs and components. The AMPERE project will develop reliable and scalable digital 4D manufacturing methods with embedded robust electronics. By combining Additive Manufacturing (also known as 3D printing) and the fourth dimension – the addition of electrical and optical functionalities, AMPERE aims to enable flexible, reliable production of smart systems with relevance for Industry 4.0 and smart industrial processes. These in turn will allow for new functionalities beyond those possible with conventional fabrication techniques in areas such as lighting, signal and power electronics, and medical devices.

Worldwide, the market for electronic products and manufacturing is evolving at unprecedented speed and in disparate directions, demanding optimized and customized solutions. This market is being shaped by increasing digitalization and in Europe, the industrial response to the ever-increasing digitization of society is found in initiatives such as Industry 4.0 which make intensive use of ICT. Such Smart Industry initiatives rely not only on ICT (data collection and analysis, sensor data, connectivity and IoT approaches), but also address the physical aspects of manufacturing such as Additive Manufacturing (AM) together with smart automation/robotics.

As these changing demands emerge, they are highlighting the limitations of current manufacturing infrastructure with its focus on mass production, much of which is in Asia. Specifically, this mass production has led to standardized components and designs, limited shape freedom, a rigid supply chain and pressure to minimize variation as associated fixed costs need to be amortized over many produced units.

AM techniques have the potential to enable flexible manufacturing processes better suited to the new demands of a digitalized society and smart industry. It could allow for the production of a wide range of mechatronic end-products. However, for this, the individual and combined processes, quality standards, reliability and integration with current methods need to be brought to a higher maturity level.

Bringing flexibility to mass manufacturing

AMPERE is responding to this challenge by creating new integrated manufacturing processes that enable 4D integration of mechanical, electrical, and optical functionalities into end-products. The project has four key objectives:

1. Develop and integrate Essential Technology for scalable hybrid 4D manufacturing that is both flexible and cost-effective, from small series mass customization through to higher production volumes whilst meeting the real needs of industry...
2. ... through digital Smart Processes of 4D products (integrated mechanical, electrical and optical functionalities)
3. Develop scalable and reliable Industrial Production Systems in combination with the essential technology and smart processes
4. Demonstrate the hybrid 4D manufacturing approach in three innovative product cases covering different applications and sectors: LED luminaires, signal and power electronics, medical devices.

AMPERE will deliver hybrid multi-material AM production methodologies, a demonstrated integrated production environment architecture, and prototypes of mechatronic products in the three application areas made using the hybrid manufacturing process. Besides multi-material AM

KEY APPLICATION AREAS

- Health & Well-Being
- Energy
- Digital Industry

ESSENTIAL CAPABILITIES

- Process Technology, Equipment, Materials and Manufacturing for Electronic Components & Systems

PARTNERS

Eindhoven University of Technology
Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V.
Neotech AMT GmbH
Philips Electronics Nederland BV
Reden BV
Signify
TNO
VSL BV
Würth Elektronik eiSos GmbH & Co.KG
XENON Automation GmbH

COUNTRIES INVOLVED

- Germany
- The Netherlands

PROJECT LEADER

Johan Klootwijk
Philips Electronics Nederland BV

KEY PROJECT DATES

Start: 2021-04-01
End: 2024-03-31

as a core production technology, the hybrid process will combine assembly and integration of electronic and optical functionality. Closed loop control utilising machine learning and artificial intelligence will also be an integral part of the complete production chain.

This hybrid approach offers significant business benefits including the ability to respond faster to changes in the market, increased product diversity, and cost-effective scalable manufacturing – from customer-centric (semi-bespoke) parts through to high volumes with features such as optical functionality, current carrying capability and miniaturized devices. Overall, this will allow new product designs offering improved functionality and new form factors not possible previously.

In lighting, it will enable combinations of shapes, optics, sensors and electronics to create new ambient experiences, connected lighting, and distributed electrical components (LEDs, drivers). For signal and power electronics, the results will allow increased system integration and more compact design, integration of board functions into housings, material savings, reductions in the number of steps in the production process, and an extension of the functions to power over data line. In medical devices, mechanical support combined with integrated electrical and optical functionality will allow the creation of ever-smaller, smart minimally invasive instruments.

Comprehensive expertise

Close cooperation across the entire value chain is key to achieving AMPERE's ambitions. Thus, the AMPERE project partners cover the whole range of necessary technical competences, as well as the complete value chain of materials, processes, equipment, product design, manufacturing, and applications.

Multi-billion euro markets

AMPERE's market impact will cover new materials, processes and smart equipment, software and simulation tools, and knowledge-based design tools, along with the integrated mechatronic end-products. It is also addressing several key aims of Industry 4.0 initiatives including resource efficiency, improved quality, customization and local production through the integration of multiple processes and products, including hardware and software platforms. In doing so, it will produce outcomes at the intersection of three multi-billion Euro markets: AM, printed electronics, and traditional manufacturing. The AM market is a dynamic, rapidly growing market (21% from 2017-2018) valued at USD 10 billion in 2019. 3D printed electronics is likewise a growing sector, expected to reach a total value in excess of USD 2 billion by 2029. Meanwhile, the global market for Electronic Manufacturing Services was USD 463.2 billion in 2019 with annual growth currently exceeding 10%.

AMPERE's market potential builds on Europe's existing strength in high quality equipment, materials and products and extends these to the digital domain. It will ensure European leadership in designing for digital manufacturing and digital service design. European electronics manufacturing companies will be able to retain their leading positions in the rapidly changing market for traditional electronic products and to compete in the emerging field of mechatronics with optimized solutions.

In the future, 4D manufacturing will play a key role in allowing customized and scalable production in Europe. It will not only enable manufacture of innovative products but also potentially pull back an important portion of the electronics manufacturing value chain to Europe. Tools and equipment developed in this project will be unique and help shape the future of microelectronics production worldwide. In short, by integrating manufacturing more closely with the design cycle, AMPERE will support Europe in creating world-leading capabilities sustainable for the long-term.

[1] Wohlers Report 2018
[2] 3D Printed Electronics and Circuit Prototyping 2019-2029, IDTechEx
[3] Electronic Manufacturing Services Market Analysis and Global Outlook, Beroe Report 2019

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pAvIs

20016

Patient and environment aware adaptive intelligent sensor systems [pAvIs]

The pAvIs project is developing innovative electronics and intelligent sensor systems for professional healthcare diagnostic and therapy applications such as scans and vital signs monitoring. It aims to deliver a paradigm shift from today's 'one-size fits all' to sensor-based systems with real-time adaptability to individual patients and the operating environment. These systems will employ embedded AI algorithms to modify both the settings of individual components and the complete signal acquisition system. Plus, by integrating high-efficiency AI (Artificial Intelligence) algorithms and hardware AI accelerators, the systems will be optimized for low-power usage as well as for optimal diagnosis and treatment of each patient.

Today, many medical devices use complex sensors to diagnose diseases, to monitor or enable restoration of physiological functions, or to treat adverse medical conditions. These applications range from medical imaging such as Magnetic Resonance Imaging (MRI), Computed Tomography (CT) and ultrasound imaging to vital signs detection and the sensing elements built into active implantable medical devices. Very often, the sensors are required to detect phenomena characterized by extremely small signals at the limits of their technological capabilities. As a result, the sensing function becomes extremely sensitive to a variety of factors including changes in the operating environment as well as to the patient's physical features and their physiological processes such as heartbeat and respiration.

However, in the current state-of-the-art, sensor-based diagnostic and therapy systems are designed with reference to an 'average' healthy person. The same set-up is expected to perform equally well on a 15-year-old girl of 1.60m and 50kg, her 25-year-old rugby-playing brother twice her size, and her 80-year-old grandfather with a deformed spine. Obviously, this is not realistic and does not deliver the best possible results. Moreover, current state-of-the-art smart sensors are not able to exploit their on-board logic functions and two-way communication capacity to adapt to their environment or to the individual person.

Improved diagnosis & treatment adapted to each patient

By overcoming these technological limitations, pAvIs seeks to make big steps forward in improved patient outcomes through personalized diagnosis and treatment. The project partners are developing a new architecture for intelligent sensor systems, including a sensor module with an embedded mixed-signal processing chain at its core. This chain will consist of new, adjustable components whose settings can be determined either by the sensor signal itself or via integrated auxiliary detectors. The architecture will also feature dedicated neuromorphic processors and / or AI hardware accelerators and embedded AI algorithms. These will support resource- and power-efficient execution in real-time with a novel, distributed, power management approach that can handle large fluctuations in power demand, while maintaining state-of-the-art performance in terms of computational efficiency and noise.

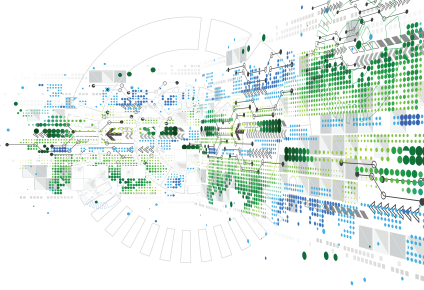
The architecture and its building blocks will be prototyped in two use cases:

1. **Adaptive sensor arrays for MRI (Magnetic Resonance Imaging)**

   The quality of imaging in current MRI systems can be affected by patient size and motion in the scanner. pAvIs will electronically optimize the signal acquisition chain to account for the size and weight of the patient and will be able to detect and process patient motion. In addition, the on-board digital processing will be used to generate and transmit system diagnostic data, so enabling predictive maintenance services.

2. **Adaptive, closed-loop, neuromodulation devices for cochlear implants, deep brain stimulation and non-invasive wearables**

   In an advance on existing systems, the pAvIs innovations will allow stimulation to be optimized to individual patients. Using input from neural biomarkers, the stimulation paradigm can be adapted and optimized based on electrical changes in cortical activity or tissue structure surrounding the sensor or implant site. The inputs can also be used to adaptively control power settings among different device subsystems to suit individual user needs.



KEY APPLICATION AREAS

Health & Well-Being

ESSENTIAL CAPABILITIES

Systems and Components: Architecture, Design and Integration

PARTNERS

Bit&Brain Technologies, S.L.
Cochlear Technology Centre Belgium
Eindhoven University of Technology
GrAI Matter Labs BV
HealthTech Connex Inc.
ICsense NV
INBRAIN Neuroelectronics
Instituto Superior Técnico, UTL
Philips Electronics Nederland BV
Philips Medical Systems
Silicongate LDA
SystematIC design
TransEON Inc.

COUNTRIES INVOLVED

Belgium
Canada
The Netherlands
Portugal
Spain

PROJECT LEADER

Dr. Mark van Helvoort
Philips Medical Systems

KEY PROJECT DATES

Start: 01-04-2021
End: 31-03-2024 (36 months)

PROJECT WEBSITE

www.pavis-project.eu

Importantly, these use cases are not stand-alone – the project aims to combine the results to increase its overall success. Besides improving patient outcomes, these combined project results will support the work of physicians, speed up procedures and help reduce the cost of healthcare.

A strong consortium covering the entire value chain

To deliver its target innovations and bring intelligent sensor systems to market, the pAvIs consortium has brought together a strong mix of partners covering the complete business and technology value chain. They consist of four large industries, six dynamic and innovative SMEs and two highly industry-oriented research organizations from five different countries.

Opportunities in established and new markets

The business outlook for these intelligent sensor systems is bright. The growing demand for smart sensors in the healthcare sector and in wearable technology provides many opportunities for the upsurge of the smart sensor market in the coming years. With advances in microcontroller functions, miniaturized circuits, wireless data transmission and front-end amplification, smart sensors will enable a digital health ecosystem to achieve a range of health outcomes.[2] The global smart sensor market was valued at B$36.6 in 2019 and is forecasted to reach B$102.1 by the end of 2025, registering a CAGR of 18.8% during this period.[3]

The global cochlear implants market is expected to grow at a CAGR of 11.9% between 2019 and 2027, to reach USD 4.1 billion by 2027.[4] Plus, the new field of bioelectronic medicine, or electroceuticals, at the intersection of molecular medicine, neuroscience and bioengineering, is emerging rapidly, valued at USD 20 billion today, the market is predicted to grow to up to USD 38 billion by 2025.[5]

pAvIs thus offers important opportunities for the consortium partners and the European industry as a whole. The consortium members will be especially well-placed in the two use case areas. Moreover, the basic technologies developed in pAvIs have a wide range of applications beyond exclusively healthcare, opening up an array of further possibilities for both hardware component suppliers and software developers.

[1] https://www.psmarketresearch.com/market-analysis/smart-intelligent-sensor-market

[2] Prescient & Strategic Intelligence, "Global Smart/Intelligent Sensor Market Size, Share, Development, Growth and Demand Forecast to 2024" (https://www.psmarketresearch.com/market-analysis/smart-intelligent-sensor-market)

[3] Mordor Intelligence, "Smart sensors market – growth, trends and forecast (2020-2025)", https://www.mordorintelligence.com/industry-reports/global-smart-sensors-market-industry

[4] The Insight Partners, "Cochlear Implants Market 2019", https://www.openpr.com/news/1879202/cochlear-implants-market-2019-growth-overview-and-forecast

[5] Reports & Data, May 2019

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MANTIS

20005

MANTIS vision [iMAgiNg Technologies of Industry and Security vision]

Image capture and image quality are hugely important in today's digital world. In recent years, image quality has made major leaps forward: moving from HDTV to 4k ultra-HD (and beyond) and with the introduction of High Dynamic Range (HDR) technology.

At the same time, a wider spectral range has enabled 3D ranging, infrared and thermal imaging. The MANTIS project focuses on broadcasting and security systems and aims to take current imaging applications to the next level by further improving image quality (spatial and temporal resolution, higher dynamic range), combining imaging modalities, creating new functionality with Artificial Intelligence (AI) algorithms, and optimising manufacture and application workflows to reduce costs while increasing performance. In pursuit of cost and system architecture optimisation, it will also explore if, and how much, intelligence can be integrated into image sensors.

As the digital transformation proceeds, society both wants and needs high-end technologies on a large scale and at affordable cost. Image capture with the necessary level of functionality and quality has a major role to play. In combination with image analysis and AI, image capture allows for the increasing 'smartness' of products. Indeed, improved, affordable image capture can bring disruptive innovations that benefit almost every aspect of life, and this in turn generates major market opportunities.

Among these many applications, MANTIS will focus on image capture systems for high-end security and live broadcasting, targeting lower costs and new functionality while maintaining ease of use.

Current challenges

Video security systems play an essential role in all kinds of situations from industrial settings to ensuring public spaces are safe and secure. However, current 2D systems still depend highly on the operator's attention span while watching the images. In future, 3D views and AI algorithms could raise the alert to potential risks more reliably and quickly. But for this digitalisation needs to go further.

IP-based digital technologies are still not fully rolled out, partly due to cost. Plus, technologies to enhance detection and prevention of risks which use centralised data and cloud computing need improvement and cost optimisation, as do spectrum range and video analysis algorithms. And while thermal imaging could be a valuable tool for 3D imaging, it calls for advances in small uncooled sensors for infrared imaging – particularly to reduce costs.

In live broadcasting, content creators are seeking to deliver compelling experiences for consumers in a changing market. They are looking for solutions that both reduce costs and allow for content delivery on multiple platforms, so they can compete with rights owners and 'on demand' providers. Improved image capture and innovations such as multiple micro cameras could place audiences right in the middle of the action and even deliver 'bird's eye flight' views of stadium events.

New solutions

Although these two markets are different, the technical challenges are similar. And through its cooperative approach, MANTIS will speed up development of solutions for both.

At the core of the project is the development of a multi-modal, multi micro camera system connected to an AI-capable edge processing box. The project will also design a new micro camera architecture that supports single- and dual modal capture and the combination of visual imaging with either NIR or LWIR (long wave infrared).

Key innovations include:

- A **micro camera demonstrator** with the ability to support various sensors matching 4k60 imaging capabilities in a Size Weight Power and Cost optimised implementation, targeting **high-end security applications**;
- A **multi camera demonstrator**, in which 2 or more of the micro cameras are connected to a newly defined processing box with inter-camera processing, combining visible and LWIR imaging. This processing will consist of applications such as of fusion enhanced imaging, real-time small object detection, tracking and/or re-identification for enhanced situational awareness in surveillance and high-end security and monocular depth-map generation in live sports (broadcast);

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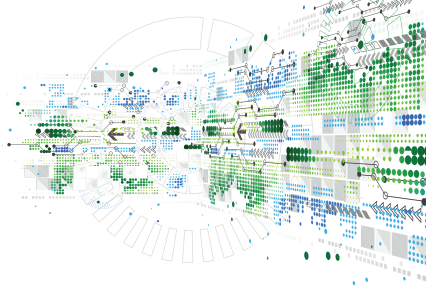

KEY APPLICATION AREAS

Digital society

Systems and Components: Architecture, Design and Integration

ESSENTIAL CAPABILITIES

Systems and Components: Architecture, Design and Integration

PARTNERS

AMS-OSRAM
ADIMEC ADVANCED IMAGE SYSTEMS BV
DELFT UNIVERSITY OF TECHNOLOGY
GRASS VALLEY NEDERLAND BV
INTEGRATED DETECTOR ELECTRONICS AS - IDEAS
TNO

COUNTRIES INVOLVED

Belgium
Netherlands
Norway

PROJECT LEADER

Name : Marcel Dijkema
Company: Adimec Advanced Image Systems

KEY PROJECT DATES

Start: 01 May 2021
End: 30 April 2024

PROJECT WEBSITE

https://project-mantis.eu/

- A **super 35mm, global shutter, HDR**, CMOS image sensor for visual applications with minimal colour cross-talk for better wide colour gamut representation, and a colour 2/3-inch CMOS image sensor based on the developments in the SENSATION project, both for new single sensor cameras;
- A **demonstrator IC** that combines small 2um global shutter pixel with high QE at **NIR wavelength in-pixel HDR, low power consumption and on-board intelligence** for new consumer and industrial applications; and
- A **LWIR thermal image sensor** with updated ROIC design, fabricated CMOS wafers with MEMS-based bolometers and cap wafers.

MANTIS will also deliver new **image sensor correction algorithms, a mathematical model** to describe the non-linearity and temperature dependence of the NIR sensitivity of the CMOS image sensors, and a **simulation tool** to optimise the electro-optical (EO) system design of the multi camera demonstrator including the new micro camera architecture.

World-leading resources

Developing and optimising these technologies calls for world-class engineering and research skills. The MANTIS consortium consists of six partners from three countries, all of whom bring industry-leading expertise. Together, they combine knowledge of technologies such as optics, image capture, video processing, and power consumption- and temperature management. And they will adopt a multi-disciplinary approach to enable rapid development of the systems and components targeted by the project.

Major market opportunities

Both of the MANTIS target markets are large and expanding. The global video surveillance equipment market was expected to reach a value of USD 19.9 billion in 2019[1]. In addition, the global Electro-Optical and Infrared Systems market was expected to grow at a CAGR of around 7% during 2016-2021[2]. Meanwhile, the uncooled thermal camera market is predicted to reach a total value of USD 8.7 billion by 2026 with a CAGR of 7.2% during 2021-2026[3].

In broadcasting, IABM estimated that the market for acquisition and production (professional cameras) reached USD 435M in 2017[4]. Going forward, market experts expect that content creators will continue to move towards higher-resolution formats for sports television and cinema. Plus, despite the growth of 'on demand' viewing, consumption of live events will continue to increase, resulting in a continuous investment in cameras. There is also a drive to lower production costs through cloud computing / virtualisation and AI / machine learning, along with a move to automatic workflows and remote productions[5].

The project's outcomes have potential in other expanding markets as well, such as automotive and smartphones. Indeed, the project will identify and develop new market leadership opportunities, thereby supporting the emergence of future European champions through disruptive business and / or market approaches. Crucially, by improving quality and reducing costs, it will enable the growth of applications that make life safer and bring exciting new experiences to citizens in Europe and worldwide.

[1] Video Surveillance & Analytics Intelligence Service- Copyright © 2020. All rights reserved. Informa Tech, a trading division of Informa PLC

[2] https://www.marketresearchfuture.com/reports/military-electro-optical-infrared-systems-market-1287

[3] http://www.yole.fr/Thermal_Imaging_And_Sensing_Yole_Nov2021.aspx

[4] IABM DC Global Market Valuation and Strategy Report 2017

[5] https://devoncroft.com/2018/08/16/the-most-commercially-important-trends-in-broadcast-and-media-technology-for-2018/

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TRUST-E

20006

TRUST-E [Trustable (sensor-driven) electronics – for Automotive, Aviation and Industrial Applications]

With the emergence of autonomous vehicles and smart mobility, transport and road travel are undergoing a transformation. New technologies are paving the way towards easier, more efficient journeys and the goal of zero traffic fatalities. As critical tasks are increasingly transferred to vehicles and machines, it is vital to have trust that they will operate safely and reliably at all times. This, in turn, implies that the electronic components and systems in these vehicles and machines must be completely 'trustable' (trustworthy). Safety and reliability are non-negotiable requirements. The TRUST-E project is addressing these needs through the development of methodologies and processes for trustable electronic components, modules, and systems that can be used in automotive and aviation applications, and in industrial settings. It will prove their effectiveness by means of three 'Digital Eye' demonstrators, covering each of the three application areas.

Trustworthiness at every level from components to system integration

Electronic systems for future vehicles and industrial machines must not only function flawlessly in harsh conditions but also have a long lifetime, which might be up to 30 years in some cases. Yet today, many of the necessary technologies still have critical limitations. Smart sensors, which 'see' their environment, provide signals that still are too fragmented and incompletely fused into information to be directly usable for decision-making and acting in real-time. In addition, usual methods for assessing which existing consumer components could be used in automotive and industrial applications cover only hardware not software. Moreover, there are no certification schemes for electronic systems that simultaneously assess both hardware and software. Consequently, smart approaches to functional safety for safe operation – such as predictive 'health management' for fault detection and AI algorithms tailored to local computing capabilities within vehicles or machines – are required.

Given these needs, TRUST-E is targeting a significantly increased trustworthiness of complex systems, focusing on advanced sensor systems across the whole chain from single components, via modules, to system integration. It will deliver innovations in hardware reliability, safety, health / lifetime monitoring, and the use of embedded AI techniques for highly demanding applications in sensing and Edge computing for mobility. These applications are, for example, autonomous vehicles and semi-automated wheelchairs, as well as aviation guidance systems, and collaborative industrial machines. The envisaged demonstrators will provide a holistic view of novel capabilities, with a focus on trustworthiness and AI that ensures the dependability of real-time responsiveness, fault tolerance, risk management and Automotive Safety Integrity Level (ASIL) conformity in resource- and energy-constrained embedded distributed systems and applications as mentioned above.

Among the many TRUST-E innovations will be: advanced components in 7 nm semiconductor technology; techniques for building trustable systems including simulation tools and testing; complete reliable and trustable sensor-based systems including deep-edge smartness or 'AI in a die' and computational empowerment of a sensor node; and embedded AI techniques for health information from sensor nodes based on data-driven models to complement physics-of-failure models, thereby enabling real-time health- and reliability assessments.

The demonstrators will incorporate TRUST-E innovations such as a high precision 6-D inertial measurement unit (IMU) and a combined Radar/LiDAR based sensor fusion automotive system in complex Digital Eye applications for seeing/perceiving the system's condition and environment:

- **Automotive Digital Eye: Environment Perception**
  - Safety relevant, high precision 6D (+ optional pressure) IMU for GPS-independent calculation of emergency brake trajectories (e.g. for tunnels)

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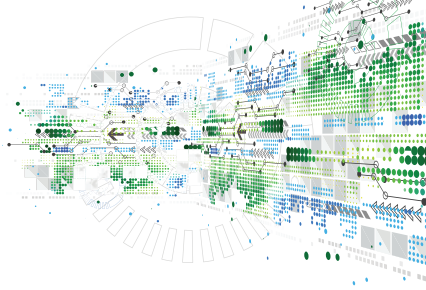

KEY APPLICATION AREAS

- Transport and Smart Mobility
- Digital Industry

ESSENTIAL CAPABILITIES

- Systems & Components: Architecture, Design and Integration
- Safety & Reliability

PARTNERS

Aptiv Contract Services
Berliner Nanotest und Design GmbH
CWM - Chemnitzer Werkstoffmechanik GmbH
edacentrum e.V.
Fraunhofer Institute IIS / EAS
Fraunhofer Institute for Electronic Nano Systems
FRT GmbH
imec
KTH Royal Institute of Technology
Mercedes-Benz AG
Nexperia Germany
Qamcom Research & Technology AB
RISE IVF AB
Robert Bosch GmbH
Saab AB
SABCA
scalable minds GmbH
Siemens AG
Synective Labs AB
University of Siegen
Volkswagen AG
XenomatiX

COUNTRIES INVOLVED

- Belgium
- Germany
- Sweden

PROJECT LEADER

Kai Kriegel
Siemens AG

KEY PROJECT DATES

Start: 1 April 2021
End: 31 March 2024

- Vulnerable road-user detection with LiDAR system to improve detection confidence

— **Industry Digital Eye: Trustable system of systems**

- Innovative sensors for electrically driven vehicles for all relevant markets
- Smart power module for condition monitoring of industrial drives (power + sensor + monitoring, i.e. sensing motor vibrations)
- Sensor network for condition monitoring of and around industrial drives

— **Alternative Mobility Digital Eye: Assistive autonomous electric wheelchair for healthcare applications**

- Improvement of the quality of life for the users by increasing their freedom to move by trustable electronics.
- New autonomous functions with self-diagnosis using AI.
- Certification process by experienced partners.

Beyond these specific goals, the project aims to deliver outcomes applicable in standardization, assessment, and certification across the value chain. It will develop common methods, innovative testing methodologies using AI, and guidelines for the design and self-diagnosis of trustworthy components, modules and full system integration, including AI-based optimization. A sensor framework for increased reliability of smart systems will also be developed.

Consortium covering technology knowledge to OEM requirements

Collaboration across the value chain is key for delivering the TRUST-E goals. Thus, the project partners range from (i) OEMs, (ii) system, module, and component suppliers to (iii) Research & Technology Organisations, representing a cross section of European industry in this field. Together they have the necessary market positions and knowledge to effectively and efficiently solve the problems along the way from first product ideas to fully reliable and functional safety solutions with embedded AI.

Strengthening Europe competitiveness

TRUST-E will strengthen the strategic alliance among semiconductor companies, equipment manufacturers, packaging service companies, module-/system-integrators, and leading European research institutes, thus providing new AI-based methods, tools, and trustable value chains from component to system integration. It will also enable many of the partners to reduce time-to-market and to offer better products or services. This will increase their competitiveness and market share, and reinforce Europe's leading positions in automotive, transport, and industrial applications from semiconductor- to system-level.

Among the numerous market opportunities, the global sensor market is expected to grow to USD 241 billion by 2022, registering a CAGR of 11.3% during the forecast period 2016 – 2022. Moreover, electromobility and ADAS are the two electronic segments with the highest growth rates in the semiconductor market, with the ADAS market expected to reach a volume of USD 16.307 million in 2026.

In addition, TRUST-E is a key technology enabler for Industry 4.0, offering solutions for competitive manufacturing in regions with relatively high labour costs such as the EU. The technological advances in sensors and sensor networks will also have a large impact on medical / healthcare mobility, offering both improved quality of life for large numbers of people and further opportunities for European industry to serve social as well as economic needs.

[1] https://www.alliedmarketresearch.com/sensor-market
[2] HIS Automotive Semiconductro Market Tracker, 2020-04

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AI-SEE

20008

AI-SEE [Artificial Intelligence enhancing vehicle vision in low visibility conditions]

The automotive industry is facing one of the most demanding challenges in its history: how to make automated travel safe in all conditions. There have been great advances towards automation with new vehicles increasingly equipped with driver assistance systems (ADAS). The biggest barrier now remaining to full automation is safe driving under poor weather and low visibility. The AI-SEE project aims to build a novel, robust sensing system supported by Artificial Intelligence (AI) that will enable automated travel in varied traffic, lighting and weather conditions. It will extend the Operational Design Domain (ODD) of automated vehicles (i.e. the scope of what they can do), taking the technology from SAE level 3 (conditional automation) to level 4 (high automation) where vehicles drive themselves with no human interaction in most circumstances.

With advanced and autonomous vehicles entering the market, solving problems linked to illumination and weather conditions such as rain, fog and snow is key to ensuring a safe environment for drivers, passengers and pedestrians. However, to move from level 3 to level 4 requires solutions to four key challenges: (i) mass-production of powerful computing platforms (ii) improved sensing capabilities and lower-cost sensors (iii) necessary technical standards and (iv) infrastructure. AI-SEE is focusing primarily on the second challenge by increasing the environmental and situational awareness of vehicles.

Humans 'see' by combining stored memories and sensory input to interpret events and anticipate upcoming scenarios. Today's automated vehicles cannot yet provide this inferential thinking, nor communicate in real-time with the environment. For automated vehicles to drive without human intervention, the information content from current sensors needs to be enhanced significantly. But this will create an increasingly large amount of data transmitted at huge data rates which, along with all the additional sensors, will quickly exceed the limits of in-vehicle storage space, and vehicle computational and energy resources.

Together, the high number of sensors needed for 360 degree environment perception and situation awareness and the high cost of LiDAR (Light Detection & Ranging) used for measuring distances to objects, represent significant barriers to the wider roll out of automated driving.[1]

Taking technologies to the next level

AI-SEE will address these challenges by combining complex hardware and software development, creating automotive perception systems that go beyond today's state-of-the-art. Its goal is to introduce reliable, secure, trustable sensors and software by implementing self-diagnosis, adaptation and robustness.

The AI-SEE concept is built on four main blocks:

1. A 24/365 high resolution adaptive all-weather sensor suite
2. An AI platform for predictive detection of prevailing environmental conditions including signal enhancement and sensor adaptation
3. Smart sensor data fusion to create the 24/365 adaptive all-weather robust perception system
4. A demonstrator and system validation plan, with testing carried out in simulations and in real-world environments in Northern Europe

The project will deliver the first high-resolution adaptive multi-sensor suite building on an innovative novel AI perception-processing scheme for low visibility conditions.

Specifically, AI-SEE will create novel sensor hardware comprising an active polarimetric imager and congruent LIDAR data; a short-wave infrared

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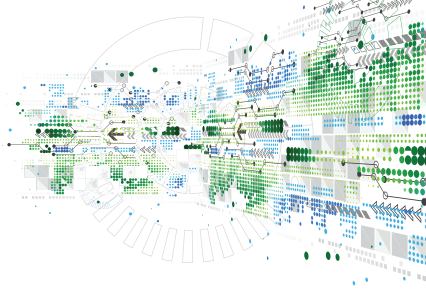

KEY APPLICATION AREAS

Transport and Smart Mobility

ESSENTIAL CAPABILITIES

Safety, Security and Reliability;

PARTNERS

Mercedes-Benz AG (Project Lead)
Algolux (Germany) GmbH
Algolux Inc.
ams AG
Ansys Germany GmbH,
AstaZero AB
AVL List GmbH
Basemark Oy
Brightway Vision Ltd.
FIFTY2 Technology GmbH
Ibeo Automotive Systems GmbH
Institut für Halbleitertechnik der Universität Stuttgart
Institut für Lasertechnologien in der Medizin und Meßtechnik an der Universität Ulm
Meluta Oy
OQmented GmbH
Patria Land Oy
Robert Bosch GmbH
Technische Hochschule Ingolstadt - CARISSMA Institute of Automated Driving
UNIKIE Oy
Veoneer Sweden AB
VTT Technical Research Centre of Finland Ltd

COUNTRIES INVOLVED

Austria
Canada
Finland
Germany
Israel
Sweden

PROJECT LEADER

Dr. Werner Ritter
Mercedes-Benz AG

KEY PROJECT DATES

Start: 2021-06-01
End: 2024-06-01

(SWIR) LIDAR with a novel SPAD receiver architecture; a high resolution 4D MIMO radar and a gated SWIR-camera. To support the novel sensing system and improve localization performance in poor weather, the project will also take high definition (HD) dynamic mapping to a new level. In addition, to handle the multisensory data fusion, an AI platform will be built to advance early signal enhancement for robust perception.

Importantly, the project will develop sensor-near simulation models for all active sensors for artificial generation of synthetic inclement weather datasets. This is expected to revolutionise simulation, with conversion of good weather neural network datasets into inclement weather datasets – thereby saving large amounts of money and time in testing and validating inclement weather sensor performance. Moreover, a large outdoor weather data bank for testing, modelling and validation will also be created. All of which will lead to a paradigm shift in signal enhancement techniques and a competitive advantage for the European automotive industry.

Partnership beyond traditional automotive networks

The AI-SEE fault tolerant environment perception system and its sub-system are highly complex. Bringing them to the market calls for partnership beyond the traditional network of automotive OEMs and Tier 1 suppliers. To tackle the challenges of new hardware, data collection, and AI-supported signal enhancement and simulations, the AI-SEE project includes OEMs; Tier 1, 2 and 3 suppliers; and smaller engineering companies as well as academic and research institutes. Together, these partners not only have the necessary expertise, but also unique testing and development capabilities not found in any one European country alone.

Positioned for rapidly evolving market opportunities

The emergence of AD is transforming the automotive industry, bringing in new players such as online service providers and IT and telecommunication suppliers. However, the market outlook remains unclear. Predictions range from sales of two million L3+ vehicles in 2030 to 63 million in the same time period. Nonetheless, automotive sensor sales are expected to grow at an average rate of 8%, with 14% growth in sales value, up to 2022. Overall, the sensor market was worth USD 11 billion in 2016 and it is expected to reach USD 23 billion by 2022, mainly due to the boom in imaging, radar and LiDAR sensors, which will respectively be worth USD 7.7 billion, USD 6.2 billion and USD 1.4 billion by 2022. [2]

Being fast and focused will be key for success in this rapidly evolving landscape. AI-SEE will contribute by giving Europe a vital first in cutting-edge technologies for environmental perception. It will also allow European companies to compete in the supply of sensors related to adverse weather conditions where US exports are limited by security (defence technology) concerns. Furthermore, it will help Europe maintain its strong position (close to 40%) in the fast-growing LIDAR market, expected to reach USD 2.6 billion by 2030[3], and to seize opportunities in areas such as automotive night vision systems and automotive radar. In addition, AI-SEE's results will support standardisation, which is essential for deployment of automated driving systems on a wide scale.

Automotive is one of Europe's key industries accounting for 6.8% of EU GDP and 13.3 million jobs. Through its outcomes, AI-SEE will help Europe to retain its world-leading strengths in this domain, thereby safeguarding high-value jobs, economic growth and indirectly the social well-being of EU citizens.

[1] Prices for individual LiDAR-sensors can reach up to 10 000 €. Garmin, 2019. LIDAR-Lite v3HP a Low-Cost Solution to Autonomous Building-Interior Mapping.

[2] Electronic Specifier (2020). Sensing changes in the automotive sensor market.

[3] KnowMade (2018). LiDAR for Automotive Patent Landscape.

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Penta (E! 9911), is EUREKA Cluster whose purpose is to catalyse research, development and innovation in areas of micro and nanoelectronics enabled systems and applications.

ECOMAI

2021028

ECOMAI [Ecological Motor Control and Predictive Maintenance with AI]

Electric motors are everywhere from laptop fans and dishwashers to industrial machinery, robots, public transport and more. A modern car can alone contain about 40 motors for various functions. But these valuable uses come at a cost. It has been calculated that electric motors account for 40% of worldwide power consumption and 20% of CO^2 emissions[1].

To address these issues, the ECOMAI project is developing technologies that enhance electric motor drive systems with an embedded AI system running on a specialised AI hardware platform. These technologies will optimise the efficiency and lifetime of electric motors, thereby reducing energy consumption and enabling development of more 'ecological' systems. They will also lead to market opportunities for applications in numerous sectors including automotive, medical and transportation.

A vital need

Given that electric motors are so ubiquitous, the potential for longer lifetimes and increased energy efficiency is significant. Some studies suggest energy efficiency gains could be as high as 30%[1].

Cars are a prime use case, but there are many others, such as the industrial sector. In the US, 70% of the total industrial electricity demand is generated by electric motors[2] and many of these are induction motors. Worldwide, 80 % of the total AC motors are induction motors[3] and a large proportion operate in harsh conditions that lead to numerous faults and downtime – in turn leading to economic costs and loss of effectiveness. Proper maintenance along with continuous monitoring, detection, and diagnosis of faults could limit these negative impacts. However, condition monitoring of electrical machines, drives and applications is rare. About 99.99% of all motors do not use a monitoring solution.

In industrial settings, and many other applications, electric motors with embedded AI systems provide an ideal solution for optimising motor control and enabling predictive maintenance (avoiding faults before they occur). AI-based solutions are so effective because they are inherently built on learning to facilitate the best possible response. However, there are few dedicated AI chips for motor control applications available, and none make full use of the possibilities AI offers.

AI-enhancement provides cost-effective, flexible solutions

To fill this gap, ECOMAI aims to enhance motor drive systems with an embedded AI system that can support fine-grain evaluation of the motor and drive state through smart sensing, data interpretation and short-time machine learning (ML), and condition monitoring. This will allow for more fine-tuned motor control and predictive maintenance, and so lower energy demand, reduce downtime and increase electrical drive lifetimes.

Moreover, ECOMAI will focus on developing an 'edge' solution. This will not only allow for operation when there is no connectivity for cloud-based solutions, but it will also keep costs competitive, reduce latency and increase security. The AI functions will be directly integrated in the motor control system using the specialised low-power AI hardware platform. This platform will provide both cost-efficient AI functionality and explore advanced accelerator and approximate computing principles.

Furthermore, ECOMAI will deliver an innovative Model-based Design and Automation Framework: a full development toolkit that combines model-based design and an AI compiler for the specialised hardware platform along with a full system modelling and simulation environment. This will make ECOMAI's technologies easily accessible, particularly for SMEs looking to apply them in specialist areas.

Other specific innovations will include:

- **Specialised motor control AI hardware**, including an AI compiler and TinyML methods for evaluating the performance of the ECOMAI **AI hardware chip prototype**.
- Demonstrations of the **ECOMAI Model Based Framework** implementing certain use cases and new modelling techniques.
- **A test environment for dynamic load change motor control applications.**

The ECOMAI technologies will also be tested in a range of use cases in applications in the transportation, power supply, medical and automotive domains.

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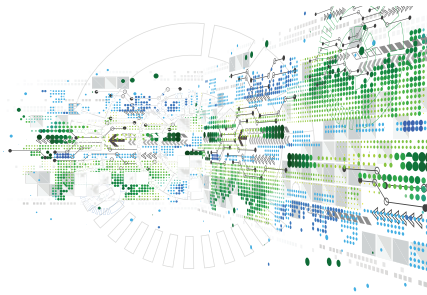

KEY APPLICATION AREAS

- Digital Industry
- Mobility
- Quality, Reliability, Safety and Cybersecurity

ESSENTIAL CAPABILITIES

- Architecture and Design: Methods and Tools
- Artificial Intelligence, Edge Computing and Advanced Control
- Components, Modules and Systems Integration

PARTNERS

ALBAYRAK Makine Elektronik Sanayi ve Ticaret A.S.
FEAAM
Ilmenau University of Technology
Infineon Technologies AG
Moteon GmbH
neuroConn GmbH
SparxSystems Software GmbH
Technical University of Munich
usePAT GmbH

COUNTRIES INVOLVED

- Austria
- Germany
- Turkey

PROJECT LEADER

Fabiola Bermudez-Elsinger
Company : Infineon

KEY PROJECT DATES

Start: 01 May 2022
End: 31 April 2025

'Ecological' use cases:

- An **automotive compressor system** demonstrating the potential of AI to deliver better control performance.
- An **electrical bike testbench** for intelligent sensorless electric bike traction applications, incorporating an AI-based torque control algorithm.
- A **test environment for a robotic rehabilitation system for mobility impaired people**, exploring, amongst other functionality, capabilities for neuro-feedback.

Condition monitoring and predictive maintenance:

- A **railway Platform Screen Door (PSD) system**, including AI-enhanced PdM algorithms and the TinyML edge device developed by ECOMAI to prolong operational availability.
- An ultrasonic traducer, using AI to understand which changes of the driving signal will be the result of certain alterations in a structure or volume when excited by the ultrasound: a motor, a battery or another complex medium for ultrasonic-based condition monitoring.

Collaboration from research to end-products

To meet its ambitious goals, ECOMAI brings together expertise spanning hardware design, edge AI, AI applications, electrical motor drive system design and predictive maintenance. Moreover, with partners ranging from research institutions to suppliers of end-products, the project's innovations will have potential to move quickly into commercial applications.

Growing markets and greener drive systems

Indeed, as there are currently very few motor and drive systems that provide AI enhancements at the drive control level, ECOMAI offers excellent business opportunities. Moreover, by creating a solution based on a specialised AI hardware platform, the project is following the wider move away from GPU AI chips to dedicated ASICs. It is likewise aligned with the shift to edge computing – the market for AI accelerators on the edge / customer premises is predicted to exceed the market for accelerators in the cloud by a factor of 3.5 in 2025[4].

Overall, the market for AI chips, motor control chips and motor systems in general is expected to grow rapidly as electric motor and drive systems are fundamental to all modern systems that involve movement. For instance, the number of electronically controlled electric motors in passenger cars is expected to grow from 2.53 billion motors per year in 2021 (approximately 30 motors per car) to 3.74 billion per year in 2030[5]. More widely, recent studies indicate that the global electric motor sales market will reach 155 billion Euro in 2025, which represents an annual growth rate of almost 8%[6]. All this suggests strong market demand for the technologies delivered by ECOMAI and the products it enables.

Importantly, the ECOMAI project will also contribute to the objectives of the European Green Deal by enabling more 'ecological' solutions now and paving the way to further energy saving options in the future.

In short, ECOMAI offers a basis for Europe to establish a leading role in AI-enhanced electrical motor drive technology – from hardware to applications – through solutions that support the green and digital transitions.

[1] D. W. E. Dr. Patrick Plötz, „Zukunftsmarkt Effiziente Elektromotoren (German), Fraunhofer Institut für System - und Innovationsforschung (ISI)," 10 2011. [Online]. Available: https://www.hannover.ihk.de/fileadmin/data/Dokumente/Themen/Energie/Fallstudie_Elektromotoren.pdf.

[2] L. Bin and V. C. Gungor, "Online and Remote Motor Energy Monitoring and Fault Diagnostics Using Wireless Sensor Networks," IEEE Transactions on Industrial Electronics, vol. 56, no. 11, pp. 4651-4659, 2009.

[3] Z. Hosseinpoor, M. M. Arefi, R. Razavi-Far, N. Mozafari, and S. Hazbavi, "Virtual Sensors for Fault Diagnosis: A Case of Induction Motor Broken Rotor Bar," IEEE Sensors Journal, pp. 1-1, 2020.

[4] Semiconductor Engineering, "AI Chip architectures race to the edge", https://semiengineering.com/ai-chip-architectures-race-to-the-edge/

[5] Based on consolidated market studies from Infineon Technologies AG

[6] https://www.grandviewresearch.com/press-release/global-electric-motor-market

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HyPerStripes

2021018

HyPerStripes [Hybrid integrated high performance electronic stripes]

In a number of today's miniaturised electronics applications, conventional cable wiring is both costly and wasteful of materials. It also restricts scope to innovate and increase product performance. The HyPerStripes project is addressing these limitations by developing technologies and production techniques for long, smart, flexible electronic systems ('hyperstripes') that can replace traditional cables. It will focus on two key applications: medical instruments used in minimally invasive procedures (e.g. catheters and implants) and eco-friendly LED lighting surfaces.

The partners will create a technology platform and manufacturing techniques for roll-to-roll (R2R) processing and integration of electronic components onto very long ('endless') flexible web substrates. This will open the way to higher performance products and new applications, while also reducing the cost and environmental impact of manufacturing. Plus, it will enable Europe to compete globally in the production of flexible electronics, with significant advances for sustainability in production and products.

Reducing costs and materials, increasing performance

In healthcare, miniaturisation and flexible electronics have brought valuable benefits. Minimally invasive procedures offer a way to investigate or treat many conditions without major surgery. However, despite the sophistication of devices such as smart catheters, they still rely on 'old fashioned' wiring to connect the numerous electrical (and sometimes optical) fibres to the rigid tip of the device. The wiring is done by hand and can represent up to 80% of the product cost. It also affects reliability, manufacturing yields, weight and use of resources.

A flexible, thin stripe with the various hybrid electronic components integrated on it could avoid these connection problems. Also new healthcare applications, especially in the area of patient monitoring, will be enabled, where the stripes addresses todays lack of long, stretchable and robust PCBs and connections.

Similarly, long, flexible stripes would enable new applications in LED lighting. For instance, it would be possible to create large, flat light surfaces that could be fully integrated in the glazing of buildings and ultimately mimic natural light. New manufacturing techniques could also cut the amount of copper used (reducing the cupper thickness from as much as 35 µm to 1 µm). This would further add to the versatility and sustainability of LED solutions, which already offer major savings in energy and CO^2 emissions.

Moving from R&D to industrialisation

Currently, microelectronic system integration is done either on rigid boards or flexible films each with a limited size, typically about 60 cm x 40 cm. By enabling R2R processing and electronics integration on very long flexible substrates, HyPerStripes will overcome these limitations. It will allow manufacture of cost-effective, high-performance stripes that can be shaped into a helix for integration or they can be used in their flat shape.

This will directly address requirements for next generation medical instruments and LED lighting. In addition, many more applications could benefit as well: from health monitoring, Secure electronics (e.g. seals that prevent tampering with goods in shipment) and condition monitoring in industrial infrastructures to automotive.

Europe already has R&D knowledge in this domain, so a key goal for HyPerStripes is to transfer this know-how to industrial production. It will do this via an open sustainable technology platform that will offer printing technologies, lithographically patterned copper wiring systems and low temperature assembly steps – all in one-stop consulting and manufacturing platform.

Other deliverables will be:

- Roll-to-roll processing on flexible and stretchable web substrates that allows for practically 'endless' electronics with integrated components
- Design and simulation procedures for flexible systems which include a focus on sustainability and reliability

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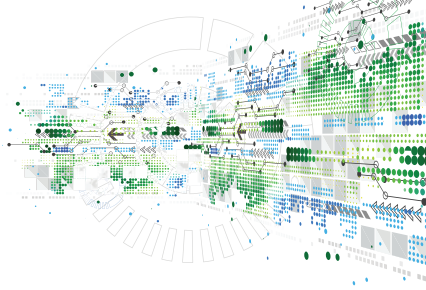

KEY APPLICATION AREAS

- Connectivity
- Health and Wellbeing (SRIA)

ESSENTIAL CAPABILITIES

- Components, Modules and Systems Integration
- Connectivity
- Process Technology, Equipment, Materials and Manufacturing

PARTNERS

Capical GmbH
Fraunhofer EMFT
IMS CHIPS - Institut fuer Mikroelektronik Stuttgart
Integer
Irish Manufacturing Research
NanoWired GmbH
OSYPKA AG
Philips Electronics Nederland BV
Philips Healthcare
Reden BV
Salvia BioElectronics BV
Schmoll Maschinen GmbH
Signify
Technische Universität Dresden
TNO Holst Centre
Würth Elektronik GmbH & Co. KG

COUNTRIES INVOLVED

- Germany
- Ireland
- Netherlands

PROJECT LEADER

Volker Franco Steier
Company : OSYPKA AG

KEY PROJECT DATES

Start: 01 April 2022
End: 31 March 2025

- Highly reliable chip interconnects for bare die integration at low temperatures based on nanostructures and innovative soldering technologies (to create electrical interconnects on heat-sensitive substrate materials such as polyurethanes)
- Digital algorithms for lithographic patterning and auto-correction of dimensional distortions in flexible and stretchable film substrates.

Importantly, the HyPerStripes technologies will be generally applicable, independent of the specific requirements of the use case. This means, for instance, the long stripes for endoscopes could be manufactured on the same technology platform as LED surfaces.

Expertise from research to end products

HyPerStripes brings together academic, RTO and industry players including major international companies and SMEs. Together, they cover the entire value chain including R2R equipment manufacturing, materials and process technologies, design and simulation tools, technology providers, research expertise and infrastructure, as well as flexible electronic systems production and manufacture of products for end-markets. This wide-ranging cooperation creates synergies and will ensure a leading position for European industry in flexible and stretchable systems. Plus, several partners will be able to move rapidly into mass production of foil-based systems and stretchable substrates with embedded devices.

Strong market potential

The HyPerStripes project will bring many benefits for European industry, employment and socially valuable applications. It will enable European companies to maintain their leadership in specific healthcare and lighting applications. It will also create an ecosystem that allows European companies to compete globally in the domain of R2R printed circuit board (PCB) production. Currently dominated by Asian manufacturers, the global flexible PCB market is expected to reach a CAGR of 11.9% during the period 2019-2027[1].

In healthcare, European companies will be able to reinforce their leadership in areas such as smart catheters through lower costs and higher performance. Furthermore, they can extend these advantages to new areas such as smart implants. Demand for such applications is being driven by aging populations, the rise of chronic diseases and the risk of further pandemics, all creating the need for innovative and cost-saving therapies. Indeed, the market for minimally invasive surgical instruments alone is expected to grow from USD 20 billion in 2019 to USD 33 billion in 2025[2].

Likewise, the LED light market is expected to see strong growth. Valued at EUR 63 billion in 2020 it is expected to reach USD 132 billion by 2026 at a CAGR of 14.25% over the forecast period 2021 - 2026. This will have an important impact for sustainability leading to a reduction of 160 million metric tons of CO^2 emissions. HyPerStripes will further add to these 'green' benefits by cutting the amount of copper and plastic used in manufacturing.

More widely, HyPerStripes will position Europe to be a global leader in the young and dynamic market of flexible hybrid electronics. By building an ecosystem for flexible electronics 'Made in Europe' that inherently incorporate sustainability concerns, the project will bring the advantages of lightweight, compact and cost-effective electronics to a host of current and future applications.

[1] Forecasts by Research Nester

[2] Frost & Sullivan Minimally Invasive Medical Technologies Market - An Outlook, 2013

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Penta (E! 9911), is EUREKA Cluster whose purpose is to catalyse research, development and innovation in areas of micro and nanoelectronics enabled systems and applications.

InnoStar

2021007

InnoStar [Innovative Systems and Automated Design for 5G/6G Connectivity and Radar Applications]

Wireless communications are crucial to our daily lives. They are fundamental to current and future phone networks (5G/6G), enablers for the digitalisation of industry and the Internet of Things, and essential for advanced driver-assistance systems (ADAS), automotive radar sensors and autonomous driving. All of which is driving massive demand for data bandwidth and a shift to new wireless frequencies. Known as "mmWave" (millimetre-wave) bands, these frequencies of 100 GHz and above can support large bandwidths and high data rates. mmWave requires new methods, algorithms, and tools, for designing, simulating, and testing the 100+ GHz technologies implemented in semiconductors, antennas, and systems. This is the challenge InnoStar is addressing. Its outcomes will reinforce European leadership in mmWave technologies and lead to economic and social opportunities in vast global 5G/6G infrastructure, automotive radar markets, and beyond.

Growing worldwide demand for data bandwidth puts increasing strain on network use of the available wireless spectrum. 5G communication systems currently operate in the 24+ GHz spectrum, but capacity needs to go beyond the 100 GHz spectrum range for 6G applications. Similarly, car radar systems, which typically operate at 77 GHz, lack the resolution levels required by future applications.

By exploring 100+ GHz mmWave components and their manufacturing challenges, InnoStar aims to meet the need for high-performance by 2030 – as well as maintain Europe's leading position in today's mmWave technologies based on its expertise in analogue, RF and mixed-signal semiconductor, transmission, and systems design.

The vital need for new technologies

As novel mmWave applications emerge, so do the technological challenges. Integrating mmWave devices into complex systems demands higher bandwidth, performance, speed, and power than existing technologies can fulfil. Plus, new types of antennas, integrated circuit (IC) modules, and systems are required to overcome the mmWave power generation limitations at 100+ GHz. There are further challenges related to high-performance lower frequency applications.

However, current architectures, methodologies, and tools cannot deliver the required technology levels. The industry needs new processes and materials to address complex design issues and enable co-design, co-integration and scaling to improve system performance and overall manufacturing yield. Component companies, system integrators, and testing companies will need to work closely to meet capacity, cost, performance, yield and reliability challenges. At the same time, new solutions will be required from electronic design automation (EDA) tools and intellectual property (IP) providers to meet the challenges related to circuits, systems architecture, and methodologies for mmWave systems.

Innovations that will translate into commercial solutions

InnoStar combines expertise and collaboration to develop new methods, algorithms and tools for design, simulation and testing. These innovations will be later used as commercial tools by designers and manufacturers to create enhanced mmWave systems in a sustainable technology ecosystem. In particular, the project will develop new, missing EDA building blocks, designs, characterisation methods, and co-integration activities to overcome critical challenges posed by high frequencies beyond 5G/6G telecom and radar mmWave applications.

InnoStar will target new types of antennas, IC modules and systems required to enable mass coverage and overcome propagation loss and mmWave power generation limitations at 100+ GHz:

- 100+ GHz mmWave and high-performance lower-frequency alternative antenna and electronics technologies
- System design-flow simulation methods and tools
- RF front-end integration solutions
- Next-generation measurement techniques and platforms, including Over-The-Air (OTA) characterisation.

The project's outcomes will include two mmWave hardware system demonstrations centred on 6G communication and car-radar sensing performance metrics:

- 100 GHz antenna array-in-package (AiP) and an active hybrid dielectric resonator antenna array for telecommunication applications with superior performance at 28 GHz and 100 GHz
- 160 GHz SiGe BiCMOS AiP and an advanced Si analogue front end for car radar.

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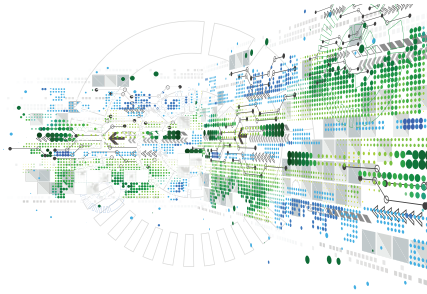

KEY APPLICATION AREAS

- Digital society
- Mobility

ESSENTIAL CAPABILITIES

- Connectivity
- Architecture and Design: Methods and Tools
- Process Technologies, Equipment, Materials and Manufacturing
- Components, Modules and Systems Integration
- Digital society
- Mobility

PARTNERS

Bluetest AB
CEMWorks Inc.
Chalmers Tekniska Hoegskola
Eindhoven University of Technology
Ericsson AB
Fraunhofer ENAS
Fraunhofer IIS/EAS
Gotmic AB
IMST GmbH
Infineon Technologies AG
MunEDA GmbH
NXP Semiconductors Netherlands BV
NXP Sweden
Stichting Chip Integration Technology Center
The Antenna Company Nederland BV

COUNTRIES INVOLVED

- Canada
- Germany
- Netherlands
- Sweden

PROJECT LEADER

Name : Dr Jonatan Aronsson
Company: CEMWorks Inc.

KEY PROJECT DATES

Start: 01 January 2022
End: 31 December 2024

The demonstrations will target energy efficiency, reliability, robustness, security, and higher technology readiness levels (TRL).

Overall, the project aims to deliver simulation and design tools that will improve performance prediction by an estimated 20-30%, reduce the component area by 10-20% and reduce power dissipation by up to 60%. For the demonstrators, it targets a 50% reduction in power consumption per antenna array and a doubling of the efficiency of the simulation and testing processes compared to those delivered by today's state of the art devices and tools.[1]

Collaboration across the value chain

The breadth of expertise is key to the InnoStar project. Its partners cover the entire technology and business high-frequency mmWave value chain, including global industry leaders, specialised small to medium enterprises (SMEs), and research institutes and academia with knowledge of communication technologies, semiconductors, antennas, and EDA. Each will contribute to its area of expertise from tools, design, and layout to manufacturing, packaging, integration and testing.

Vast market opportunities and social impact

Ultimately, InnoStar aims to enable its consortium partners to bring to market mmWave products with a revolutionary performance at lower cost and lower energy consumption – and do this faster than the competition. The project will enable industry leaders who usually compete in the same markets to collaborate towards European leadership and supply chain independence.

The opportunities are enormous. The demand for mmWave technology is embedded in global markets for electronics components and applications with submarkets in semiconductor IP, antennas, and EDA tools. On its own, the mmWave technology market is expected to grow at a compound annual growth rate (CAGR) of 26.2%, from Euros 2 billion (2020) to Euros 6 billion 2027[2]; while the worldwide semiconductor, EDA, and antenna markets are worth Euros 350 billion. The project's ultimate target market is the global electronic market currently worth USD 4.5 trillion with double-digit growth in automotive, industrial, medical, consumer, artificial intelligence, B2B, B2C, and other applications[3].

However, InnoStar wil first focus is on telecommunications and automotive. Its semiconductor methodology, processes, packaging, and antenna technology will allow project partners to capture valuable market share in wireless communications and automotive verticals – both of which are predicted to grow strongly. For instance, the global 5G/6G infrastructure market is anticipated to grow from around USD 2.5 billion in 2020 with a CAGR of 60% to nearly USD 50 billion in 2027. In automotive semiconductor products5, European companies are world leaders and the market for automotive semiconductors is expected to grow with a CAGR of 18% in automotive semiconductors to around USD 130 billion in 2026[4].

In an increasingly digital world, these applications will bring many social and environmental benefits and economic growth. For instance, 5G/6G enabled IoT devices will help reduce accidents and vehicle emissions through improved traffic management. And universal access to mobile communication will be pivotal to improving the delivery of services within smart cities, transportation accessibility (autonomous vehicles, mobility-as-a-service), traffic flow, surveillance, and safety. Going even further, the technologies developed within InnoStar will be transferable into many new applications of benefit to people everywhere in health, education, commerce, banking and community building.

[1] A. Pärssinen et al., "White paper on RF enabling 6G - Opportunities and challenges from technology to spectrum," 6G Res. Visions, no. 13, Apr. 2021

[2] Millimeter wave technology market: summary," Forensic Research, Rep. SC 089, 2020.

[3] "Estimated growth rates for the global electronics industry from 2019 to 2021," Statista, 2021.

[4] "Telecom services market size, share & trends analysis report and segment forecasts, 2020–2027," Grand View Research, San Francisco, CA, Rep. GVR-4-68038-518-2, 2020.

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AQUA

202001 AQUA [Aquatic Qualification with AI]

Fresh water is essential to human life. Yet only a small fraction of water on Earth (2.5%) is potable (suitable for drinking). Moreover, this vital fresh water can be contaminated with naturally occurring pollutants or chemicals produced by human activity. This makes reliable water quality monitoring in water distribution networks of the utmost importance. However, while existing water quality monitoring systems can help spot problems, they cannot determine and classify the specific type of contaminants present in real-time.

The AQUA project partners aim to take water monitoring to a new level, so water companies can detect, classify and react to problems rapidly, and more generally, improve incident prevention. AQUA will achieve this through the application of Artificial Intelligence (AI) and the creation of novel online sensor systems that support new data analytics and classification technology. Ultimately, the project's outcomes will benefit society worldwide by helping to ensure supplies of safe, clean drinking water through AI-based systems and services.

The need for faster, classified contaminant detection

The quality of potable water can fluctuate during both production and distribution, due to contaminants from the source water and other sources such as pipeline leakages or mixing of water streams. There are also risks from deliberate contamination, for instance, as an act of terrorism.

Hence, the crucial importance of monitoring potable water quality throughout the entire production and distribution infrastructure. Indeed, water utilities are typically under a legal obligation to conduct quality monitoring. Mostly, this is done through 'grab sampling' – taking a sample of the water over a short period of time then analysing it in a laboratory. However, this provides only a 'snapshot' of water composition, with no indication of variations over a longer time. Plus, it may take hours or days to get the analysis results. This limits water companies' ability to take timely action, and it also limits their ability to conduct pro-active network maintenance.

In effect, water utility companies need real-time contamination detection based on acquiring, analysing, and classifying high-quality real-time data on deviations from required norms. This monitoring would be able to discriminate between acceptable operationally induced changes in water quality and changes due to contaminants or adverse incidents. However, no such monitoring tool that can provide this actionable information currently exists.

AQUA takes monitoring to a new level

AQUA will transform this situation by developing advanced machine learning (ML) frameworks that use today's conventional sensor systems, but which go beyond current capabilities to enable this crucial, advanced real-time event detection and classification.

In particular, the AQUA ML frameworks will be integrated into two existing sensor systems, which in turn will be integrated into a single system (the AQUA platform). Overall, the consortium will develop innovations along the complete technology value chain from sensor components and ML frameworks to industrial-grade monitoring systems that are part of a larger sensor network.

These include:

1. A ML framework that will allow an existing commercial sensor platform to perform **ultra-sensitive local water quality monitoring** based on optical refractive index sensing
2. A ML framework that will allow an existing commercial sensor platform, based on a Fish Activity Monitoring System, to perform **local monitoring of physiologically relevant changes** in water quality
3. A ML-framework that can be used to interpret the **water quality in decentralised production**
4. The **AQUA platform**, a modular **integrated monitoring system using ML**

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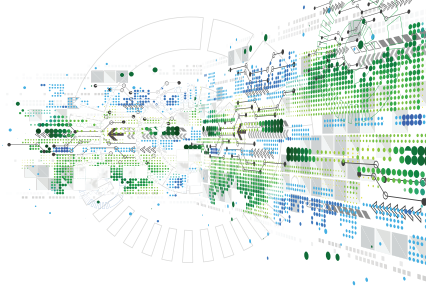
AI CALL 2020



KEY APPLICATION AREAS

- Digital society
- Health and Wellbeing

PARTNERS

DE WATERGROEP
DEMCON
HAL24K
OPTIQUA
ZWEEC ANALYTICS

COUNTRIES INVOLVED

- Belgium
- Netherlands
- Singapore

PROJECT LEADER

Gido Akse
Company : DEMCON.

KEY PROJECT DATES

Start: 01-03-2021
End: 29-02-2024

5. A ML-based **data analysis and event classification system** utilising a proven platform that can interpret sensor data on the **water network level**
6. An automated **water sampler prototype** to take on-site water quality samples to generate sensor data for ML training and validation
7. A **water quality monitoring pilot**, integrating the two sensor platforms, that will be tested in the water distribution network of two water distribution companies

From the outset, the partners will pay special attention to end-users needs. Together, they will develop tools and methodologies to verify sensor data that have been processed with AI.. The partners will also build demonstrators to help technology and industrial end-product suppliers within the project to develop a strong market proposition.

In short, AQUA will provide water utility companies with novel ML-based analytical toolsets and sensor systems that can act as an early warning system allowing them to rapidly respond to adverse (or even toxic) water quality events, and thereby maintain production and distribution of the highest quality potable water to consumers. This will represent a major step towards the ultimate monitoring goal – a digital twin capable of monitoring all process and quality parameters within the entire water production and distribution network.

Experienced partners: from technology providers to utility companies

To do all this, the AQUA consortium brings together an experienced engineering company, a data intelligence scale-up, two technology providers, and a large water company. Together, they combine the necessary innovation expertise and real-world experience spanning research, technology and industrial end-product supply and end-users. Moreover, they all are active in RD&I: every partner has developed unique knowledge over many years that together forms the foundation of the project.

Huge and growing market

AQUA's outcomes will meet the needs of a vast market. Annual global expenditure on drinking water production and distribution currently exceeds 180 billion USD. Within this, the segment for water quality monitoring and analysis constitutes an estimated volume of 3.75 billion USD for 2020 and is expected to reach USD 4.68 billion by 2025.

The market is being driven by a range of factors including increasing industrial activities that spur demand for water monitoring products, greater government funding for pollution monitoring and control, the growth of smart city concepts, and the emergence of ML-enhanced water quality monitoring itself. In Europe alone, the water quality monitoring market is expected to grow exponentially based on increased awareness of water pollution and contamination.

AQUA's primary focus will be on utilities and industrial applications. However, the AQUA platform will have added value in terms of individual components and of a complete and integrated solution, covering local and network-wide, centralised and decentralised production needs.

In the short term, AQUA's novel ML-based sensor platforms will be applied by water distribution companies in Singapore and Taiwan. Further ahead, in the mid-to long-term, the project's outcomes are expected to help ensure safe, clean drinking water in monitoring applications worldwide.

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Penta

Penta (E! 9911), is EUREKA Cluster whose purpose is to catalyse research, development and innovation in areas of micro and nanoelectronics enabled systems and applications.

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