RETHINKING THE SYSTEM

The fifth edition of the DSPE Conference on Precision Mechatronics on 26-27 September 2023 will be completely live. Once again, the stage will be set in hotel De Ruwenberg in Sint-Michielsgestel (NL), which provides an inspiring and relaxed atmosphere for meeting peers in precision mechatronics. The theme of this fifth edition is 'Rethinking the system' and registration is still open.

The DSPE Conference on Precision Mechatronics is organised by and for technologists, designers and architects in precision mechatronics. It is targeted at companies and professionals who are members of DSPE, Brainport Industries, Mechatronics Contact Group (MCG), Mechatronic Systems Knowledge Exchange (MSKE), System Architecture Study Group (SASG), and selected companies/institutes. Besides oral presentations, posters and demonstrations, the conference programme features ample opportunities for discussions, networking, and sharing ideas and experiences. Venue for the conference is hotel De Ruwenberg in Sint-Michielsgestel (Figure 1).

Registration is open

The organising committee – Adrian Rankers, Marc Vermeulen and Annemarie Schrauwen – invites interested professionals to register. The number of registered participants to date (mid-June) is 120, so registration is still open given that the maximum capacity is 150. The rewards will be high, Rankers and Vermeulen assure. "The event is a real treat for the precision engineering community. Two days packed with in-depth presentations and the evening in between with an attractive social programme. We only have plenary sessions, so the participants will not miss out on anything and all have the same information basis for networking and sparring about the latest developments. In the same vein, the poster and demo sessions are held during the coffee and extra-long lunch breaks to facilitate maximum interaction."

The conference location: hotel De Ruwenberg.

Rethinking the system

The conference theme, 'Rethinking the system', is inspired by current global issues, such as the drive for sustainability, the footprint of our modern society, and the scarcity of energy and resources. There is a growing awareness that, in order to make a bright and healthy future possible, we need to rethink the current systems of production, consumption and disposal. It is encouraging to see a growing number of initiatives to search for novel manufacturing methods, alternative resources, energy-saving options and refurbishment approaches. As a result, system boundaries within which companies are operating shift and their business models are changing. In this transition, precision mechatronics can play an important role, not only by enabling research and development of novel technologies, but also by reflecting on system thinking.

Three keynotes

The three keynote presentations in particular will centre around the conference theme. The first one is by Christian Kromme (Figure 2a), who is a trendwatcher and a recognised authority in speaking about technological disruption and exponential technologies. His mission is to inspire people and organisations with the idea that mankind can foresee an optimistic and bright future by harmonising with the inherent patterns and principles in nature.

The three keynote speakers at the DSPE Conference on Precision Mechatronics 2023.
(a) Christian Kromme, trendwatcher. (Photo: Adrian Kuipers)
(b) Joost Smits, EVP D&E at ASML
(c) Martijn Heck, professor of Photonic Integration at TU/e. (Photo: Angeline Swinkels)

The second keynote presentation is by Joost Smits (Figure 2b), executive vice president of Development & Engineering at ASML. He will start from the observation that the development of high-tech machines is not just about performance, but also about complexity and costs, and how to organise ourselves, since more and more people are needed to design and realise such a machine. There are also increasing challenges due to upcoming requirements for reuse, refurbishment and sustainability. Development is now a matter of balancing performance together with all these aspects and that may require rethinking the system.

The third keynote is presented by Martijn Heck (Figure 2c), professor in the Photonic Integration group at Eindhoven University of Technology and scientific director of the Eindhoven Hendrik Casimir Institute. As a generalist with strong experience in photonic integration, his experience spans the whole chain of optical chip design, fabrication and characterisation. He will explain the integrated photonics technology as a key enabling technology for the future information society.

Integrated photonics has become a relevant technology in the broad set of semiconductor technologies. Optical functionalities, such as lasers, modulators, photodetectors, filters and waveguides, are integrated together on a semiconductor substrate, into a photonic integrated circuit, or optical chip.
Initially, integrated photonics was used to enable long-haul telecommunications, through optical fibres, connecting cities, countries and continents with the internet. Nowadays, such communication links are getting into the servers and even into the processors, to enable high-bandwidth and energy-efficient communication in our datacentres and supercomputers. It is thus a key enabler for big data and artificial intelligence. Moreover, with this advance and maturing of the technology, new opportunities have arisen. These include applications in fibre sensors, biomedical sensors, metrology and even quantum and optical computing.

Rejuvenation

This year's conference marks the transfer of the chairmanship of the organising committee from Rankers to Vermeulen. For this occasion, they are organising the conference together. "The collaboration is fantastic; the handover is smooth." According to them, there is no need to change the format of the conference. "This is the event where the community meets in an informal atmosphere and new relationships are forged. To keep the community alive and kicking, we expressly encourage junior researchers and engineers to participate; among them Ph.D. candidates and the nominees for the Wim van der Hoek Award, who are given the opportunity to present a poster."

Rejuvenation also pertains to the advisory board of the conference. "Together with them, we define the conference theme, we select the oral presentations from the submitted abstracts, and recruit participants. Most of the members are from the large companies in the precision engineering industry, such as Philips, ASML, Thermo Fisher Scientific, Canon Production Printing, VDL, applied research organisation TNO and others like them. But over the years we have seen the rise of new kids on the block. For example, we have recently invited Prodrive Technologies and Sioux to join our advisory board." To conclude, Rankers and Vermeulen have clear advice: "Join the DSPE Conference on Precision Mechatronics."

INFORMATION
REGISTRATION AND INFORMATION
ANNEMARIE.SCHRAUWEN@DSPE.NL
WWW.DSPE.NL/CONFERENCE

Programme

(see conference website for up-to-date version)

Tuesday 26 September

Keynote 1

- *Christian Kromme*
  Trendwatcher and a recognised authority in speaking about technological disruption and exponential technologies

Keynote 2

- *Joost Smits*
  EVP Development & Engineering at ASML

Session 1 – System Design 1

- **Next Generation Microsurgery**
  Martijn Chatrou and Richard van Lieshout
  Project manager at Microsure and CTO / senior system architect at MTA
  Microsure has successfully created a CE-marked microsurgical robot, MUSA2, a limited edition of which is now being deployed in hospitals for (pre) clinical trials. Based on initial customer feedback, Microsure has decided to engage with MTA for development of a next-generation system, MUSA3. Apart from improved functionality and workflow, a lot of emphasis is being put on aspects such as manufacturability, testability and serviceability. This presentation will give a sneak preview of design optimisations being made for MUSA3.

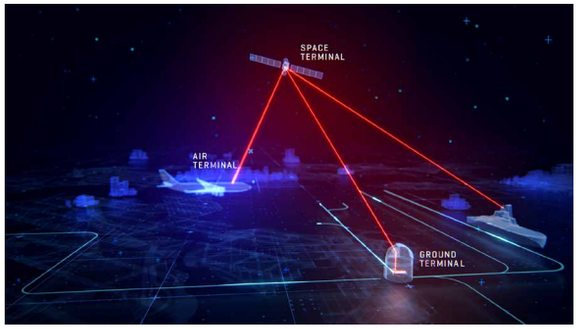
- **Multi-pipette placement head**
  Rik van der Burg
  Competence owner Motion Control at Kulicke & Soffa
  For the next generation of iFlex-based SMT pick & place machines, Kulicke & Soffa has developed a compact new multi-pipette placement head module. The system and module concept were defined by the K&S System Engineering team, detailed design and module realisation was provided by Prodrive Technologies. The major challenges in the new design were the small pitch size (12.5 mm), minimised module mass and demanding bill-of-material targets. This presentation will focus on the system architecture choices that led to the optimised design.

- **EUV energy efficiency**
  Theo Thijssen
  System engineer EUV Sustainability at ASML
  In line with ASML's target to have net-zero emissions from product use by 2040, energy efficiency of its products has become an important performance indicator. Especially for EUV, which has a large energy consumption. The aim is to reduce energy use per wafer exposure in the 2025-2027 timeframe by a factor of three compared to 2018. Energy use can be reduced in two ways: by temporarily switching off modules that are not required or by improving the efficiency of modules. This presentation will elaborate on ASML's efforts to improve EUV energy efficiency and the technical challenges and solutions to achieve that goal without impacting system performance.

Session 2 – Sensing

- **Next-level flow controller combines the best of thermal- and pressure-based flow control**
  Gert Jan Snijders
  Manager R&D at Bronkhorst High-Tech
  Thermal flow controllers have been used since the late 1960s to control the gas atmosphere in chemical deposition and etch processes in semicon. Later followed by other applications where accurate gas flow control is required. Speed limitations and lack of a wide control range led to pressure-sensor-based flow controllers in the nineties. These have a strong dependency on gas properties and poor long-term stability as drawbacks. After a redesign of the thermal sensors to micron-thick tubes with platinum resistors, they have become as fast as pressure-based sensors, while maintaining all beneficial characteristics of traditional thermal flow sensors. This presentation will outline the thermal sensor redesign.

- **Low-noise, high-bandwidth acquisition and tracking sensor for airborne laser communication terminal**
  Max Geljon
  Systems engineer/integrator at TNO



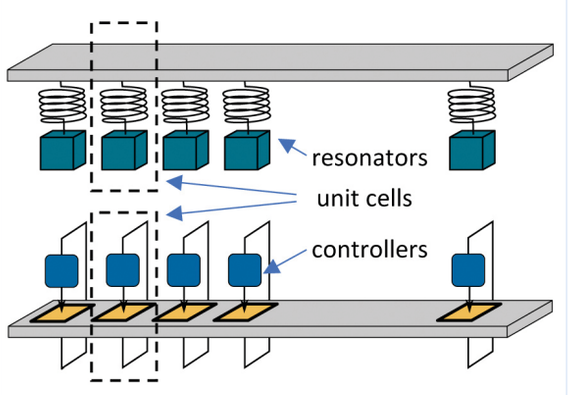
Airbus, TNO and VDL Group have joined forces to develop the technology for air-to-GEO laser communications in the UltraAir project. One of the challenges is the acquisition and tracking of the optical link between the two terminals in-flight, i.e. to compensate for aircraft vibrations and dynamics. TNO's high-bandwidth, compact fine-steering mechanism (FSM) would suit the job. To drive and control this FSM, an acquisition/tracking sensor is required to provide adequate input. The UltraAIR Fine Detector implements this sensor, capable of detecting and extracting the angle of the incoming optical beacon of the satellite terminal. It combines low-noise analogue electronic design with high-bandwidth precision AD conversion. This presentation will cover the UltraAIR Fine Detector design.

- **Measuring paper deformation in real time**
  René van Acquoij
  Domain architect Electronics at Canon Production Printing
  A system was developed to measure deformation characteristics of paper sheets processed in an inkjet printer. The system evolved from an initial research tool into a key product feature. Commercial off-the-shelf sensors were found to be insufficient to provide the required measurement accuracy. A better in-depth understanding of the sensor specifications was needed. Also, real-time compensation and correction algorithms had to be developed to compensate for system errors. The required accuracy requirements and real time performance were met. This presentation will outline the design of the measurement system.

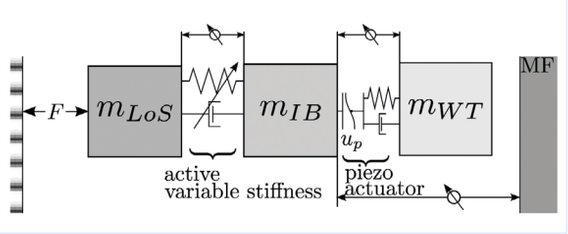
Session 3 – Piezoelectric actuation

- **Piezoelectric vibration suppression in a large-stroke flexure hinge**
  Bram Seinhorst
  Ph.D candidate at University of Twente
  Lightweight and stiff design is often used to ensure high parasitic resonance frequencies in flexure mechanisms. However, when larger deflections are required, it can be difficult to avoid resonances at relatively low frequency. Previously, we had shown through simulations that the problematic resonances in the deflected state can be damped by including active material in the flexures. This presentation will give the experimental results for a two-stage flexure mechanism. Piezoelectric patches on the leafsprings measure and actuate the parasitic resonance. It is shown that positive position feedback control can be used to suppress the resonance peak associated with the problematic modeshape, facilitating higher bandwidth.

- **Metamaterials for integrated active damping and vibration isolation in mechatronic applications**
  Marcin Kaczmarek
  Ph.D. researcher at Delft University of Technology
  Metamaterials can be applied for active damping and vibration isolation in precision mechatronics. Of special interest is the creation of bandgaps, i.e. ranges of frequencies in which vibrations cannot propagate through a structure. The bandgaps can be created by embedding resonators within unit cells that constitute the metamaterial. Piezoelectric transducers and electronic resonators enable the creation of lightweight and stiff metamaterials suitable for precision applications. This presentation will outline the working principles of resonant metamaterials and relate them to common techniques from the field of active vibration control.



- **New wafer stage architecture based on piezoelectric actuators with highly variable stiffness**
  Ron de Bruijn
  Ph.D. candidate at Eindhoven University of Technology
  Piezoelectric actuators are under study in research at TU/e in collaboration with ASML as an alternative to Lorentz actuators for reasons of high force density, low dissipation and the absence of electromagnetic interference with scanning E-beams. A new stage architecture has been proposed with piezoelectric



actuators in combination with a highly variable stiffness device based on viscoelastic material. In view of the highly varying dynamics of the motion system, the application of switching controllers has been investigated. This presentation will show 1-DoF models and a test set-up for validation of the concept.

Wednesday 27 September

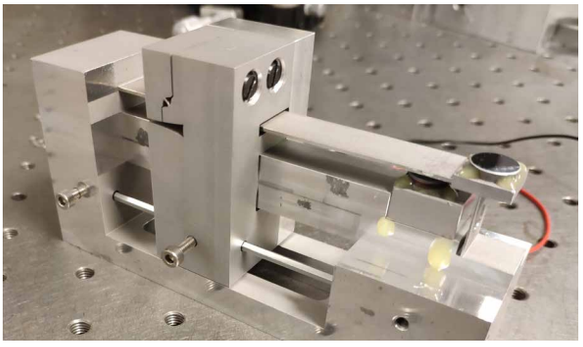
Keynote 3

- **Integrated Photonics for a Sustainable Information Society**
  Martijn Heck, full professor at Eindhoven University of Technology, scientific director at Eindhoven Hendrik Casimir Institute

Session 4 – Precision Mechanics

- **Design of a high-stiffness, high-repeatability kinematic coupling**
  Robin Trines
  Mechanical architect at JPE
  This presentation will cover the design and characterisation of a 6-DoF kinematic coupling used as a sample interface in a vacuum tribometer. In order to achieve the specified measurement accuracy, a high coupling stiffness (≈ $1 \cdot 10^8$ N/m) is required. Conventional kinematic mounts that employ permanent magnets for preload typically reach a repeatability in the micrometer range due to effects such as friction, contamination, and wear. Innovative solutions that can reach better repeatability exist, however; a custom development was needed to extend the concept from two to three bodies (force frame, metrology frame, and sample holder).

- **Design of a tunable resonant scanning mirror**
  Jiajin Li
  Mechatronics design engineer at ASML (on behalf of Hittech Multin)
  Scanning mirrors such as galvanometers and resonant scanners are intended for accurate positioning in the low-frequency range and fast scanning at the specified high frequency. However, they might not be able to fulfil requirements in case of a wide frequency range. A novel solution is tuning the resonant frequency and exciting higher-order modes to cover the intended frequency range of 500 Hz to 5 kHz. A flexure mechanism has been designed, with a cantilever as a resonator and a cut-leafspring as a hinge guiding to achieve 1-DoF resonant scanning. The resonant frequency is tuned by clamping different positions of the cantilever using a dedicated mechanism. This presentation will outline the concept and detailed design and give modelling and experimental results.



- **Particle contamination transport at low pressure**
  Dmitri Shestakov
  Senior functional analyst at VDL ETG
  High-tech manufacturing processes can be extremely sensitive to particle contamination at ever-reducing size scales, down to 1-100 nm. The use of complex mechatronic systems unavoidably results in the transport of such particles by means of gas drag force, inertia, turbulent diffusion, electrostatic force and thermodiffusion. The role of these forces is particle-size-, material- and condition-dependent. While the transport mechanism for particles size > ~10 µm at normal conditions is quite well understood, the dynamics for sub-micron particles (< 100 nm) is still a big challenge. This presentation will address some of these challenges and progress on experimental and numeric studies.

Session 5 – Thermomechanics

- **Thermal contact conductance: relation between surface topography and heat transfer**
  Joris Oosterhuis
  Senior technologist Thermal & Flow at Philips Engineering Solutions
  The thermal contact conductance (TCC) is a lumped parameter to explain the heat transfer between two solid surfaces in contact through microscopic asperities at both sides. It depends on the average roughness of the surfaces in contact as well as the microscopic topography. Literature shows a wide spread in TCC depending on test settings and large deviations against some of the often-used models. The macroscopic TCC between metallic surfaces of different roughness and

materials has been investigated through topographic study of surfaces with microscopic imaging, in order to find effective heat transfer coefficients for thermal modelling of such contacts. This presentation will also feature the measurement set-up that was developed.

- **Thermal path optimization between cryocooler and sample**
  Rens van Alebeek
  Thermodynamical engineer at Thermo Fisher Scientific
  In a new development, the thermal connection between the cooler and the sample in a transmission electron microscope brought new challenges, such as the lower temperature, the dynamics induced by the thermal connection, and the environmental requirements (UHV, electrical isolation and non-magnetic materials). There were several components in the thermal path from the cooler to the sample: an electrical insulator, a thermal interface, a braid, and the sample stage. Furthermore, some of the parts are shielded against radiation with a cryogenic cooled shield around it. This presentation will cover the design and test results, focusing on the thermal problems that were encountered and the improvements that were tested and implemented in the design.

- **Pitfalls in the experimental and numerical validation of a forced air-cooling heat sink**
  Bart Koolmees
  System lead engineer at NTS-Group
  When the flow and thermal performance of a forced air-cooling heat sink was evaluated by means of both computational fluid dynamics (CFD) and experimental measurements, large deviations were observed between the CFD-predicted and the measured pressure drop. Pitfalls might have existed in either the CFD model or the measurement, or both. This presentation will discuss the causes, providing the critical details required to predict the performance of forced air cooling with sufficient accuracy. For example, swirl effects generated by the fan blades attracted attention considering the fan-anemometer relative orientation and relatively small distance. Based on CFD model studies, a new test set-up was built, resulting in an acceptable agreement between measurement and CFD modelling.

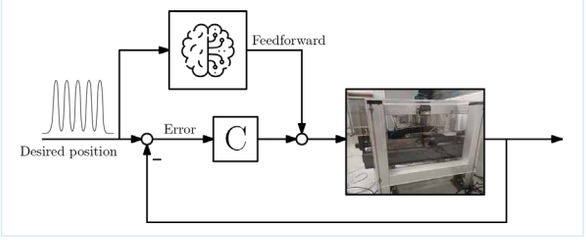
Session 6 - Modelling and Control

- **Model-Based Systems Engineering coupled with Model-Based Design**
  Pieter de Jong
  Technologist Dynamics at Philips Engineering Solutions
  In model-based design (MBD), information management is moving towards model-based systems engineering (MBSE), using system modelling tools to support system requirements definition, design, analysis, verification, and validation activities in a single system model. Both the documentation and simulation models are obtained from a single source of truth. This presentation will outline a case that was worked out to investigate the possibility and power of coupling MBD with MBSE. Part of the systems engineering was performed in an MBSE tool, Cameo Systems Modeler. The systems engineering part consists of requirement breakdown, systems context description, logical decomposition, and verification based on the MBD output. The design model output is fed back to the systems engineering model for requirement verification.

- **The role of VR and digital twins in the system design of mechatronic medical devices**
  Jesper Huijgens and Martijn Wijns
  Software engineer and software architect at Sioux Technologies
  Rethinking the current system of cancer treatment has instigated a transition towards more personalised medicine prescriptions. Consequently, the field of pathology, including both structural and molecular analysis, is transforming from analogue into digital. Such a transformation includes mechanisation and automation of visual and manual functions. This presentation will report about the Tissector device for automated tissue dissection as a representative example of this transformation, focusing on the system architecture aspects. Particularly, the process validation and quality assurance were of main interest. The use of a digital twin in a virtual reality (VR) environment played an important role in the system design verification strategy.

- **Physics-guided neural networks for feedforward control: with application to an industrial linear motor**
  Nard Strijbosch
  System engineer at IBS Precision Engineering
  To compensate for all known disturbances to a system, a feedforward controller is designed as an inverse model of the system, which in practice is derived from first-principles physics. The performance achieved by exploiting a feedforward controller hinges upon the model quality. For example, hard-to-model dynamics, such as nonlinear friction, are often neglected. This presentation will discuss the compensation for these hard-to-model dynamic effects using a novel feed-forward controller that exploits a neural network in

addition to a physics-based model, also known as physics-guided neural networks. The parameters that define both the neural network and the physics-based model are optimised in parallel. The addition of the neural network enables unprecedented performance levels as is demonstrated on an industrial linear stage.



Session 7 – System Design 2

- **The HD-DCM – a high-performance precision-mechatronics instrument for synchrotron X-ray beamlines**
  Ricardo Caliari
  Senior mechatronics engineer at ASML (on behalf of Eindhoven University of Technology)
  X-ray double-crystal monochromators (DCMs) in synchrotron beamlines are used to filter the incoming photon beam to the desired energy/wavelength and bandwidth for the particular use case. The geometrical arrangement is such that the exit beam can be kept at a fixed position regardless of the specific energy selection. This presentation will describe the High-Dynamic Double-Crystal Monochromator (HD-DCM), for which a complete conceptual review with a mechatronic paradigm shift was proposed with respect to standard DCM designs to overcome the previous technological bottleneck regarding positioning control. With concepts borrowed from modern lithography machines, a control-based high-bandwidth closed-loop solution was created.

- **Modular wafer handler platform**
  Joost Lobbezoo
  Mechatronic system engineer at VDL ETG T&D
  Over the past decades, the number of wafer handler types and their modules and building blocks has increased. Maintaining and producing this growing complexity has contributed to the growth of the VDL ETG organisation. A new strategy has been chosen to counteract the negative effects. Introducing a modular architecture with a large common base will lead to, a.o., reducing the number of wafer handler configurations, help to increase engineering development efficiency and have a more predictable time-to-market, and ultimately reduce the total cost of ownership. This presentation paper will give an overview of wafer handler complexity, the reduction of the number of configurations due to the modularisation of the architecture, and the software architecture for a modular platform.

- **Integrating APT on TEM**
  Hugo van Leeuwen
  Principal systems architect at Thermo Fisher Scientific
  Unprecedented volumetric representation at the atomic scale can be achieved, e.g., by integrating two currently existing tools into one. A transmission electron microscope (TEM) can routinely deliver atomic resolution for 2D images, atom probe tomography (APT) can deliver nm resolution for 3D structures, and the combination of the two should be able to deliver 3D atomic resolution of a volume of over 1,000 x 1,000 x 1,000 atoms. From engineering perspective, this meant that the requirements of both tools had to be combined, which brought some challenges. Some were specific to the integration, while other challenges also served broader needs on the TEM roadmap. We therefore choose to distinguish the 'one-off needs' from 'platform opportunities' for a next generation of TEM tools. This presentation will describe where the cut between the two was laid and touch upon technology developments.