Software Center

Mälardalen University

# Software Center Cybersecurity Workshop

## Mälardalen University, Västerås
## April 27, 2022


www.software-center.se

# Content

Welcome to a

# Software Center Cybersecurity Workshop

**April 27, 2022**

At the Software Center/Mälardalen University workshop we will bring together experts from academia and industry to talk about the problems, challenges, and solutions in the domain of cybersecurity. The workshop is an open hybrid event and will take place at Mälardalen University.

**Time:** **13:00 – 17:00**

**Place:** **Mälardalen University, Västerås, Sweden – room Omega (and digitally, over Teams: links will be distributed after registration)**

**Agenda:** **https://www.software-center.se/event/cyber-security/**

## Agenda

| | |
|---|---|
| **13:00** | Welcome: Marjan Sirjani (Mälardalen University, Sweden) |
| **13:05** | Digitalization: The Driver for Cybersecurity: Jan Bosch (Chalmers & Software Center, Sweden) |
| **13:25** | Cybersecurity, Safety and Resilience: Marjan Sirjani (Mälardalen University, Sweden) |
| **13:45** | Automotive Cybersecurity - The Challenges: Nasser Nowdehi (Volvo Cars, Sweden) |
| **14:10** | Automotive Security Cybersecurity Verification – the Past, the Present, the Future: Stefan Marksteiner (AVL/AT, Austria) |
| **14:30** | Automotive Cybersecurity: yet another concern, set of standards and regulations! Let's take a multi-concern perspective: Barbara Gallina (Mälardalen University, Sweden) |
| **14:45** | Break |
| **15:00** | Reflections on Supply Chain Attack Risk Mitigation: Kim Hyldgaard (Grundfos, Denmark) |
| **15:25** | Cybersecurity in Construction Machinery: Sheela Hariharan, Talvén Jarmo (Volvo Construction Equipment, Sweden) |
| **15:40** | Intrusion Detection Systems using Tiny Twins: Fereidoun Moradi (Mälardalen University, Sweden) |
| **16:00** | Trading off Consistency and Availability in Cyber-Physical Systems: Edward Lee (UC Berkeley, USA) |
| **16:30** | Predictable Coordination for Safety-Critical Real-Time Systems: Soroush Bateni (University of Texas, Dallas, USA) |
| **16:55** | Closing |

Software Center

# Software Center Workshop

April 27, 2022

## Speakers and topics

At the workshop, **Jan Bosch (Chalmers)** talks about how digitalization makes cybersecurity important; and he will highlight cases from the 17 member companies of Software Center (www.software-center.se). **Marjan Sirjani (Mälardalen University)** talks about cybersecurity, safety, and resilience and the ongoing research in some of the projects on cybersecurity at Mälardalen University.

There will be talks on automotive cybersecurity, **Nasser Nowdehi (Volvo Cars)** explores the current and future state of automotive cybersecurity and its challenges; **Stefan Marksteiner (AVL/AT)** talks about automated cybersecurity testing, and **Barbara Gallina (Mälardalen University)** talks about the automotive standards and regulations from a multi-concern perspective.

**Kim Hyldgaard (Grundfos)** explains how in a supply chain attack it is difficult to deal with the vast attack surface, and he will look at some of the challenges and a few mitigating initiatives. **Sheela Hariharan** and **Talvén Jarmo (VCE)** will talk about cybersecurity in construction machinery. **Fereidoun Moradi (Mälardalen University)** will explain how a tiny digital twin can improve attack detection at runtime and help in cyber-resilience.

**Edward Lee (UC Berkeley)** talks about consistency and availability in cyber-physical systems and how that affects safety. **Soroush Bateni (UT Dallas)** uses an open-source full-stack autonomous driving software, Autoware. Auto 1.0, which relies on ROS 2 to demonstrate how the arbitrary ordering in the handling of messages (caused by communication timing not handled properly by the ROS 2 framework) can be a significant problem. He presents an alternative framework for real-time distributed embedded systems.

## Contact us

Software Center at Mälardalen University

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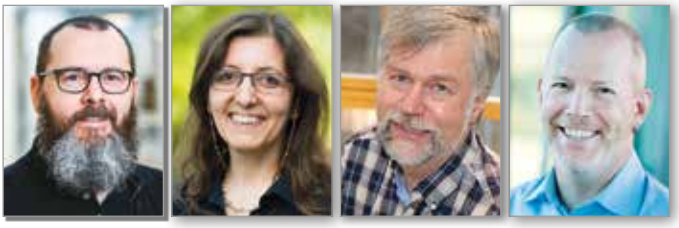

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**For agenda up-dates, visit the Software Center web site**
**www.software-center.se**

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## Speakers and abstracts

### Jan Bosch (Chalmers and Software Center)
### Title: Digitalization: The Driver for Cybersecurity

**Abstract:** Digitalization fundamentally changes the business model for many companies from transactional to continuous. As part of the continuous value delivery, we need to deploy new software and ML/DL models in products in the field and use the data coming from the field for analytics and training ML/DL models. This requires products to be connected, which immediately exposes many systems to cybersecurity threats. This talk is concerned with the drivers due to digitalization that cause cybersecurity to have become so important. The talk will highlight cases from the 17 member companies of Software Center (www.software-center.se).

**Bio:** Jan Bosch is professor at Chalmers University Technology in Gothenburg, Sweden and director of the Software Center (www.software-center.se), a strategic partner-funded collaboration between 17 large European companies (including Ericsson, Volvo Cars, Volvo Trucks, Saab Defense, Scania, Siemens and Bosch) and five universities focused on digitalization. Earlier, he worked as Vice President Engineering Process at Intuit Inc, as head of the Software and Application Technologies Laboratory at Nokia Research Center, Finland, and as the head of the software engineering research group at the University of Groningen, The Netherlands. His research activities include digitalisation, evidence-based development, business ecosystems, artificial intelligence and machine/deep learning, software architecture, software product families and software variability management. He is the author of several books including "Design and Use of Software Architectures: Adopting and Evolving a Product Line Approach" and "Speed, Data and Ecosystems: Excelling in a Software-Driven World".

### Marjan Sirjani (Mälardalen University)
### Title: Cybersecurity, Safety and Resilience

**Abstract:** In the era of digitalization and cyber-physical systems, the need for trustworthy systems is increasing fast. Trustworthiness includes reliability, safety, security, and resilience. In this talk I explain cyber-resiliency and its relation to safety and security. Cyber-resilience refers to a computer system's ability to continuously deliver the intended outcome, despite adverse cyber events. Cyber-resiliency emphasizes the advanced persistent threat, where an adversary has significant levels of expertise and resources that allow it to create opportunities to achieve its objectives by using multiple and coordinated attacks at both cyber and physical layers. Cyber-resilient systems have security measures "built in" as a foundational part of the architecture and design. There are multiple projects working on cybersecurity at Mälardalen University, like SACSys, Serendipity, VeriDevOps and InSecTT. I will briefly explain some of our research activities within such projects at Mälardalen University where we focus on safety and security of time sensitive and adaptive cyber-physical systems to assure cyber-resilience.

**Bio:** Marjan Sirjani is a Software Engineering Professor at Mälardalen University, and the leader of Cyber-Physical Systems Analysis research group. Her main research interest is applying formal methods in Software Engineering. She works on modeling and verification of concurrent, distributed, and self-adaptive systems. Her research is now focused on safety, cyber-security, and performance of self-adaptive systems. Marjan and her research group are pioneers in building model checking tools, compositional verification theories, and state-space reduction techniques for actor-based models. She is the founder of Rebeca Research group (http://www.rebeca-lang.org). Rebeca and its extensions are designed to bridge the gap between model-based software development and formal analysis, and has been used for analyzing different network and system applications since 2001. Marjan has been the PC member and PC chair of several international conferences including SEFM, iFM, Coordination, FM, FMICS, SAC, FSEN. She is an editor of the journal of Science of Computer Programming. Before joining academia as a full-time faculty, she has been the managing director of Behin System Company for more than ten years, developing software and providing system services.

## Speakers and abstracts

### Nasser Nowdehi (Volvo Cars)

### Title: Automotive Cybersecurity: the Challenges!

**Abstract:** "Modern vehicles are computers on wheels exposed to the Internet, and to their surrounding environment via Vehicle-to-Everything (V2X) communication. The increased level of connectivity enables new applications for road safety and traffic efficiency, but it also makes vehicles prone to cyber threats. Moreover, the complexity of vehicle software is also drastically increasing, which means there are more software vulnerabilities that can potentially be exploited by adversaries. In this talk, we explore the current state of automotive cybersecurity and its challenges going forward."

**Bio:** "Nasser Nowdehi is an automotive cybersecurity technical specialist currently working at Volvo Cars. He has a Ph.D. degree in automotive cybersecurity from Chalmers University of Technology and a MSc. degree in computer systems and networks (specialized in cybersecurity). His main research interests include intrusion detection systems, V2X security, and cyber-resilient systems."

### Marksteiner, Stefan (AVL/AT)

### Title: Automotive Security Cybersecurity Verification – the Past, the Present, the Future

**Abstract:** The UNECE recently demands the management of cyber security risks in vehicle design and that the effectiveness of these measures is verified by testing. This mandates the introduction of industrial-grade cybersecurity management and verification in automotive development processes. The regulation demands also to keep the risk management current, which again creates the need of stretching the testing over the full life cycle of an automotive system. Both in the past and currently, the automotive cybersecurity testing procedures are not automated enough to be able to deliver tests in the amount and thoroughness needed to keep up with that regulation, let alone doing so in a cost-efficient manner. Therefore, a paradigm shift is necessary, introducing an automotive security life cycle governance approach, paired with semi-automated cybersecurity testing, that allows for satisfying the need for automotive cybersecurity assurance over the product life cycle by increasing the efficiency of testing procedures for automotive updates to an industrial-grade level.

**Bio:** Stefan Marksteiner is a Technology Scout for Cyber Security with the Global Research and Technology department of the Instrumentation and Test Systems (ITS) at AVL List GmbH, an automotive development company with around 10k employees worldwide. His current task is to coordinate ITS' research activities in the (automotive) cybersecurity domain and to pull cybersecurity knowledge from research and push it into ITS' development units. Before that, he was a key researcher with the Competence Group Cyber Security and Defence at the DIGITAL – Institute of Information and Communication Technologies of JOANNEUM RESEARCH. His further interests are security models, network security and cryptography. He has more than 15 years of experience in ICT security and earned a master's degree with honors in "IT Technologies & business informatics" with the thesis "An approach to Securing IPsec with Quantum Key Distribution". He conducted scientific studies and engineering conceptualizing work on cyber-physical systems, as well as published various papers on diverse ICT security topics. I am a Certified Ethical Hacker and earned an ISO 27001 Information Security Manager certificate. Furthermore, I am a member of the Austrian Standards Institute working group for secure web applications ISO's technical committee 22/SC32/WG11 (responsible WG for developing ISO 21434), as well as the IEEE and the ACM and have served as scientific conference and journal reviewer and as evaluator for an H2020 project's open call.

## Speakers and abstracts

### Barbara Gallina (Mälardalen University)

### Title: Automotive Cybersecurity: yet another concern, set of standards and regulations! Let's take a multi-concern perspective

**Abstract:** Given the increased connectivity of (road) vehicles, cybersecurity is booming. However, cybersecurity is not the only concern, but, yet another concern to be considered while developing an item, implying yet another set of standards and regulations to comply with. In this talk, roadvehicle cybersecurity will be recalled with the perspective of the state-of-the-art automotive standards and regulations. Then, a multi-concern perspective to co-engineer and co-assure the item will be proposed.

**Bio:** Barbara Gallina is Associate Professor of Dependable Software Engineering at Mälardalen University, Sweden, where she leads the Certifiable Evidences and Justification Engineering group. She holds a M.Sc. in Computer Science (Politecnico di Milano, Italy, 2003), a II-level Master in ICT (Politecnico di Milano/Cefriel, Italy, 2004), and a Ph.D. in Computer Science (University of Luxembourg, Luxembourg, 2010). Her research focuses on developing languages, techniques, metrics, and processes for engineering evidence (s) and justifications for the purpose of certification/self-assessment of complex dependable (computer-based) systems. Within EU-funded projects (CHESS, CONCERTO, SafeCer, AMASS), she has played various technical leadership roles at task/work-package and global project level. On a yearly basis, she is a member of the Program Committee of about 15 international conferences and workshops related to dependability and this year (2022) she serves as Co-Chair of ISSRE Workshops.

Dr. Gallina is the author of over 100 articles in the area of dependable software engineering and certification.

### Kim Hyldgaard (Grundfos)

### Title: Reflections on Supply Chain Attack Risk Mitigation

**Abstract:** Software supply chain attacks attracts more and more focus and the challenges protecting from them are quite big in IoT solutions. As cloud, phone apps, gateways, sensors, controllers and last but not least, pumps can all be targeted in a supply chain attack, it is quite difficult to deal with the vast attack surface. I will scratch the surface and look at some of the challenges and a few mitigating initiatives.

**Bio:** Kim Hyldgaard is a Lead Security Architect at Grundfos. He received his B.Sc. in Electrical Engineering, Data communications, and his MSc in Cryptology, both from Aarhus University. He worked for 10 years as a software developer in Ericsson, programming bit-stream processors, Voice-over-IP and xDSL solutions. He has been developing solutions for KK Wind Solutions and Siemens Gamesa in the wind turbine industry for 6 years. For the last 6 years he is working with Grundfos, currently heading the AppSec team (a security champions program) which includes ~30 scrum teams ranging from embedded software, native apps to cloud solutions.

## Speakers and abstracts

### Sheela Hariharan, Talvén Jarmo (Volvo Construction Equipment)

### Title: Cybersecurity in Construction Machinery

**Abstract:** As connected and automated features grow in construction industry, cyber risks increase. In this context, it is essential to keep Volvo CE products and services secure and safe when they are operating at customer business and society environment. Managing product cybersecurity is about to make it serve as a business and innovation enabler.

**Bio:** Sheela Hariharan is an Industrial PhD student at Mälardalen University and Diagnostics Engineer at VCE. She has been working on vehicle diagnostics for more than 10 years and started her research on product- based cybersecurity for construction machines. She had completed her master's on embedded systems and her thesis was on vehicle software security.

Jarmo Talvén is the Volvo CE Product Cyber Security Lead. His responsibility includes leading the development and deployment of product cyber security capabilities. He has been working with embedded system development for +20 years which included the role as global EE Architect.

### Fereidoun Moradi (Mälardalen University)

### Title: Intrusion Detection Systems using Tiny Digital Twins

**Abstract:** In this talk, I present our approach to detect cyber-attacks on cyber-physical systems at both the design time and runtime. At design time, I will describe how to classify the attacks using the Microsoft STRIDE threat model and perform security analysis using model checking. The behavioral model of an example system will be shown, and I explain our method in detecting some attacks on this example system. At runtime, I will show our developed monitor module that involves a Tiny Twin to detect false sensor data and faulty control commands. The Tiny Twin is an abstract behavioral model which is derived from a state space model generated by model checking. I will run a simulated attack scenario on an example system to illustrate the attack detection at runtime.

**Bio:** Fereidoun Moradi is a Ph.D. candidate at Mälardalen University in Sweden. His main research interests include network security, software system security and formal methods. He is currently focusing on the modeling and verification of safety and security requirements in cyber-physical systems. Fereidoun received his master's degree in information security from the University of Isfahan in 2015. Before starting his Ph.D. studies in 2019, he worked at Chavoosh company for almost 5 years. He now provides services as a co-reviewer in formal methods conferences including SEFM, iFM, FMICs, FSEN and SAC.

## Speakers and abstracts

### Edward Lee (University of California, Berkeley)

### Title: Trading off Consistency and Availability in Cyber-Physical Systems

**Abstract:** Cyber-physical systems (CPSs) are often safety-critical systems, where malfunctions imply risk to humans. As CPSs increasingly involve several components interacting over networks, it becomes imperative to devise strategies that preserve safety in the face of network disruptions, whether caused by malicious intent or malfunctions. The class "CAP Theorem," due to Eric Brewer, states that in the face of network partitions (P), a system must give up either consistency (C) or availability (A). We have recently generalized and quantified this theorem. The generalization, called the "CAL Theorem," gives a numerical relationship between network latency (L) and consistency (C) and availability (A). The CAL theorem shows that as network latency varies, for example when the network comes under attack, then either consistency or availability or both must also vary. I will show in this talk that a CPS must prioritize either availability or consistency and that which to prioritize depends very much on the application. I will show how the recently developed Lingua Franca coordination language enables designs that enforce these application-specific priorities.

**Bio:** Edward A. Lee has been working on embedded software systems for 40 years, and after detours through Yale, MIT, and Bell Labs, landed at Berkeley, where he is now Professor of the Graduate School in EECS. His research is focused on cyber-physical systems. He is author of leading textbooks on embedded systems and digital communications, and has recently been writing books on philosophical and social implications of technology.

### Soroush Bateni (University of Texas at Dallas)

### Title: Predictable Coordination for Safety-Critical Real-Time Systems

**Abstract:** Asynchronous frameworks for distributed embedded systems, like ROS and MQTT, are increasingly used in safety-critical applications, where the cost of unintended behavior is high. The coordination mechanism between the components in these frameworks, however, gives rise to non-determinism, where factors such as communication timing can lead to arbitrary ordering in the handling of messages. In this talk, I will demonstrate the significance of this problem in an open-source full-stack autonomous driving software, Autoware. Auto 1.0, which relies on ROS 2. I present an alternative: Xronos, an open-source framework for real-time distributed embedded systems that has a novel coordination strategy with predictable properties under clearly stated assumptions. If these assumptions are violated, Xronos provides for application-specific fault handlers to be invoked. Our port of Autoware.Auto to Xronos shows that it avoids the identified problems.

**Bio:** Soroush Bateni is a Ph.D. candidate in the Real-Time Systems lab at the University of Texas at Dallas. His research centers around efficiency and predictability of autonomous embedded systems, with publications in venues such as RTSS, RTAS, and USENIX ATC. Prior to that, Soroush obtained his M.S. degree in Computer Science from the University of Texas at Dallas.


MÄLARDALENS HÖGSKOLA
ESKILSTUNA VÄSTERÅS

## Embedded Systems at Mälardalen University

Embedded Systems (ES@MDU) is the foremost research direction at Mälardalen University, and one of the larger integrated research environments in Sweden. The mission of ES@MDU is to conduct excellent research that enables industry to leverage the benefits of embedded software in products and production systems. ES@MDU is the national leader in embedded-systems research and also the largest and most research-intensive environment at Mälardalen University.

ES@MDU has world-leading competence in embedded-software development and real-time systems modelling and analysis. We have extensive experience in international projects, a professional research organization, and a proven track record of industrial cooperation and commercialization of research. ES@MDU collaborates widely with industry and international academia. Industrial partners include both major companies such as ABB, Alstom, Ericsson, Scania and Volvo and many smaller businesses, including several spin-off companies, e.g., Percepio and Unibap.

ES@MDU provides a stimulating international research environment characterized by its cooperative atmosphere, openness, and team spirit. We have a mix of established and young researchers, several of whom are employed or funded by industry. We also have strong traditions of persons moving back and forth between ES@MDU and industry as well as exchange with international academia. Thanks to the size of ES@MDU and the breadth of its work, we are uniquely capable of joining forces to cooperate across research areas and with industrial and other academic partners.

The research budget reaches over 120 MSEK. Of this, about 35 MSEK is direct university funding. This research budget is complemented by an additional 60 MSEK of in-kind research funding from industrial partners. For every 1 SEK of direct university funding, ES@MDU contributes to research worth over 5 SEK. Between 2015 and 2020 we awarded over 45 PhD degrees and published close to 1900 per reviewed publications.

ES@MDU contains four distinct research directions: Software and Systems Engineering, Computer Science, Electrical and Computer Engineering, and Medical and Health Engineering.

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## Software and Systems Engineering

Software and Systems Engineering (SSE) conducts research on theory, methods, processes, algorithms, and tools to support the design, development, testing and maintenance of high-quality industrial software and software-intensive systems. Software has become a key enabler for innovation and software-intensive systems are found in practically all industrial domains, as well as beyond. However, the complexity, criticality and expected adaptability of these systems make them increasingly challenging to develop and continuously evolve throughout their lifetime. Our research in model-based development simplifies development and operation of complex industrial systems through modeling, analysis and automation at higher levels of abstraction. Another important research focus is related to dependability concerns such as safety and security, addressing how to assure that systems are sufficiently dependable. We also investigate novel approaches to improve and automate software testing, addressing quality attributes needed for dependability assurance as well as, for example, performance.

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## Computer Science

Computer Science unit conducts research on novel approaches, algorithms, techniques and tools in AI (Artificial Intelligence) and machine learning, optimization techniques, heterogeneous data from various sensing devices, hardware and software specialization for AI, using AI for accelerating AI execution, brain-like computing (neuromorphic), formal methods, static program analysis, and programming languages. The research ranges from theoretical contributions to applied ones in close collaboration with industry. The unit focuses on how to design, optimize, and analyze systems composed of many parts that may interact with one another, as well as systems that perceive and respond to the world around them. Such systems are often characterized by increased heterogeneity: they mix different programming languages and programming concepts, combine computations happening in various places, contain both discrete and continuous behavior, contain environmental sources of heterogeneity, or rely on heterogeneous sensor data for decision making. Examples of such heterogeneous systems are autonomous systems of all kinds, cloud infrastructures, hybrid (discrete and continuous) systems etc. In addition, autonomy focuses on developing embodied intelligent systems, ranging from autonomous drones to self-driving cars and robots, which can physically operate in complex environments with minimal human supervision. Decision-making employs models and artificial intelligence algorithms that make predictions about physical and environmental phenomena. Moreover, many of these algorithms are data driven, that is, autonomous systems need the ability to acquire data about their environments and adapt or refine their behavior in real-time. Most often, these systems are safety critical, hence we need rigorous ways to ensure their dependable and correct operation, by employing formal methods.

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## Electrical and Computer Engineering

Electrical and Computer Engineering (ECE) conducts research in electrical and computer engineering, with a focus on the (embedded) system's run-time platform including execution of software, communication of data, and the automatic control and runtime adaptation mechanisms. The research conducted at ECE addresses systems that are integrated into a physical, computing, or electrical environment, and that have different levels of criticality, thus requiring high reliability, high degree of safety and security, predictable timing and performance, and often have limited resources for computation, communication, and energy. Such systems typically combine analog and digital hardware with software devoted to controlling the functionality of the system. Our research application domains include vehicular systems, process automation, and industrial robotics, where several solutions are developed in close collaboration with industrial partners.

Specifically, we contribute to research and education to the following topics: computer architectures; real-time systems; operating systems; run-time mechanisms; protocols; computer networks; parallel and distributed systems; databases; computer security; performance monitoring; communication systems; data communication; control engineering; reconfigurable computing; heterogenous integration; hardware/software co-design;

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## Medical and Health Engineering

Medical and Health Engineering (MHE) conducts system-oriented research of true cross-disciplinary nature, spanning from biomedical engineering and physiology, physics, data communication, over electrical and computer engineering to artificial intelligence and human-system interaction. The integration of these competences gives an opportunity to solve complex and multi-disciplinary research challenges and should thus not be seen as different research branches. Research conducted include new approaches to microwave measurements for tumor and stroke detection including polarized microwave applicators, EEG-based neurofeedback systems for clinical applications within cognitive and stroke rehabilitation, adoption of user-centered design processes to gather information on functional requirements and user experience and development of systems for fall prevention. Examples of results include a wearable pedobarographic system, a system for driver sleepiness detection, a system to detect breath alcohol, and an ECG system for long-term monitoring which is certified as a class IIa medical device. In addition, MHE researchers have presented techniques to reduce risk of security network traffic attacks, a necessity for this target domain.

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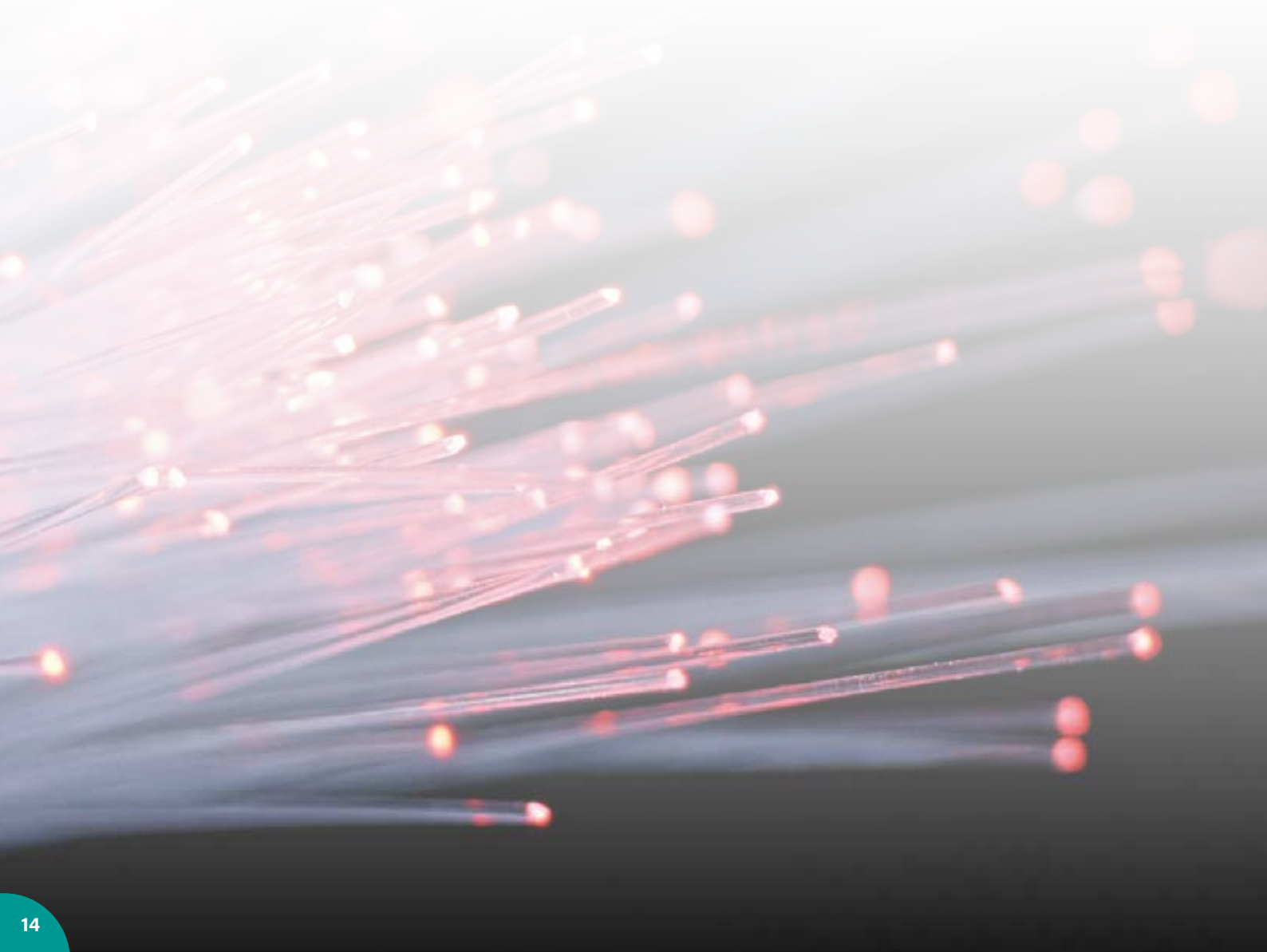

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## Technology themes

### Theme 1: Continuous Delivery

Theme leader: Professor Kristian Sandahl, Linköping University
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Theme web page: https://www.software-center.se/research-themes/technology-themes/continuous-delivery/

### Theme 2: Continuous Architecture

Theme leader: Professor Jan Carlson, Mälardalen University
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### Theme 3: Metrics

Theme leader: Professor Miroslaw Staron, Chalmers & University of Gothenburg
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### Theme 4: Customer Data- and Ecosystem-Driven Development

Theme leader: Professor Helena Holmström Olsson, Malmö University
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### Theme 5: AI Engineering

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