

Kackertstr. 7, 52072 Aachen, Tel.: +49 (0) 241 80 23830, Fax: +49 (0) 241 80 623830

**GOR-Arbeitsgruppe: Praxis der Mathematischen Optimierung**

Prof. Dr. Josef Kallrath,  
Am Mahlstein 8  
D-67273 Weisenheim am Berg  
Tel: +49 172 747-0689  
Fax: +49 621 60-6678297

Herewith we would like to invite you to the 100<sup>th</sup> meeting of the GOR working group "Real World Mathematical Optimization" at Schloß Spindlhof ([www.schloss-spindlhof.de](http://www.schloss-spindlhof.de)) in Regenstauf, Germany. This meeting is sponsored by GAMS GmbH (Cologne, Germany) and is being held as a symposium with the topic

## Mathematical Optimization in the Real World

The workshop takes place on April 12<sup>th</sup> and 13<sup>th</sup> in 2018. The event will take place in German language (abstracts and presentations are also accepted in English). We appreciate your participation in an informal get-together at April 11, 2018.

Please note that the participation in a GOR-AG-Workshop for non-members is subject to a registration fee, unless you are a speaker or a host.

Please register yourself online using <https://www.redseat.de/pmo100/> as soon as possible, but ideally not later than Apr 01<sup>st</sup>, 2018. The latest information on available on the homepage of the GOR (<http://www.gor-ev.de/arbeitsgruppen/praxis-der-mathematischen-optimierung>).

Yours sincerely,

Josef Kallrath

Jens Schulz

Julia Kallrath

(GOR AG)

[josef.kallrath@web.de](mailto:josef.kallrath@web.de) [jens.je.schulz@deutschebahn.com](mailto:jens.je.schulz@deutschebahn.com) [julia.kallrath@h-da.de](mailto:julia.kallrath@h-da.de)

**Vorstand:**

Prof. Dr. Alf Kimms (Vorsitz)  
Dr. Ulrich Dorndorf (Finanzen)  
Prof. Dr. Alf Kimms (Tagungen)  
Prof. Dr. Anita Schöbel (Arbeitsgruppen)

**Kontakt:**

geschäftsstelle@gor-ev.de  
[www.gor-ev.de](http://www.gor-ev.de)  
Tel.: +49 (0) 241 80-23830  
Fax: +49 (0) 241 80-623830

**Bankverbindung:**

Konto: 1 465 160  
BLZ: 430 500 01 Sparkasse Bochum  
IBAN: DE82430500010001465160  
BIC: WELADED1BOC

## Mathematical Optimization in the Real World

This event will be 100th anniversary of the working group and we want to make it a special one. In cooperation with GAMS GmbH (Cologne), which supports this event financially, we have prepared a special program. The event will take place on April 12-13 at Schloss Spindelfhof ([www.schloss-spindelfhof.de](http://www.schloss-spindelfhof.de)) in Regenstauf. It would be great if many participants are able to spend already the evening of April 11th with us there. Schloß Spindelfhof is a neo-gothic castle in the South of Germany and will host this event with its pleasant ambience. Several well-known speakers will present topics around Mathematical Optimization in a historical and applied context and in particular such with visionary prospect.

The working group has been founded in 1968 by Prof. Dr. Peter Stahlknecht. The founder will hold the opening lecture of this event.

Since the early days in the 1950ties, Operations Research (OR) and especially Mathematical Optimisation has been an important differentiator in various industries and society. Because companies offer similar products, have comparable technology and compete on a global scale, high performance business processes are among the last differentiators. As UPS mentioned: "In God we trust, everything else we measure and improve", underpinning the importance of Operation Research and mathematical optimization as an enabler for creating that competitive edge. In these times of Digitization, Industry 4.0, and BigData great and new opportunities for Mathematical Optimization and Operations Research are at the horizon. It gives guidance to management on where to invest and where to scale down, making the operation more agile.

This two-days event will attempt to combine historical elements of the working group and its focus with a vision for the future as well as to provide an overview of the current state of the art of mathematical optimization. In talks, each approx. 15+5, 25+5, or 40+5 minutes experts from practice, research institutions or software companies, will present selected problems and the corresponding solutions.

Please contact:

Jens Schulz ([jens.je.schulz@deutschebahn.com](mailto:jens.je.schulz@deutschebahn.com)), Julia Kallrath ([julia.kallrath@h-da.de](mailto:julia.kallrath@h-da.de)) or Josef Kallrath ([josef.kallrath@web.de](mailto:josef.kallrath@web.de)) if you are interested in presenting.

Presentations from the following speakers have been confirmed or are in the pipe:

Lucia Bäuml (Friedrich-Alexander-Universität Erlangen-Nürnberg & Continental Automotive GmbH, Erlangen & Regensburg)  
*Automotive Life Cycle Assessment*

Dr. Michael Bussieck (GAMS GmbH, Cologne)  
*Enhanced Model Deployment and Solution in GAMS*

Prof. Dr. Gustav Feichtinger (Technical University of Vienna, Vienna, Austria)  
*Optimizing Terror Queues*

Fabian Friese/Andre Schnabel (Leibniz Universität Hannover, Hannover, Germany)  
*Lehre von Theorie und Praxis der Mathematischen Optimierung mit modernen Methoden und Inhalten*

Dr. Hermann Gold (Infineon Technologies AG, Regensburg, Germany)  
*Queueing Theory in Practice at Semiconductor Manufacturing*

Prof. Dr. Knut Haase (University of Hamburg, Hamburg, Germany)  
*A Pilgrim Scheduling Approach to Increase Public Safety During Hajj*

Dr. Susanne Heipcke (FICO, Birmingham, UK)  
*Modelling for Mathematical Optimization: Historical Notes and Current Trends*

Prof. Dr. Siegfried Jetzke (Ostfalia Hochschule für Angewandte Wissenschaften, Salzgitter)  
*Gibt es optimale Lösungen in der Logistik? Does Logistics allow for optimal solutions?*

Prof. Dr. Josef Kallrath (GOR Working Group "Real World Optimization", Germany)  
*The Pleasure to Solve Real World Optimization Problems*

Prof. Dr. Thorsten Koch (Zuse Institute Berlin, Berlin, Germany)  
*20 years Mathematical Optimization in the Real World or how to Survive Industry Projects as a Mathematician*

Prof. Dr. Karl-Heinz Küfer (Fraunhofer-Institut für Techno- und Wirtschaftsmathematik ITWM, Kaiserslautern)  
*Optimizing yields in gemstone cutting - mathematics as a driver of process innovation*

Prof. Dr. Anita Schöbel (University Göttingen, Göttingen, Germany)  
*Towards Integrated Planning in Public Transportation*

Dr. Anna Schreieck (BASF SE, Ludwigshafen, Germany)  
*Operations Research at BASF – New Opportunities in the Time of Digitization*

Andreas Söhlke (Lufthansa Systems GmbH & Co. KG, Berlin, Germany)  
*From Planning to Real Time: The Challenges of applying Optimization in Airline Operations*

Matthias Spreitzenbarth (Spreitzenbarth Consultants, Ludwigshafen, Germany)  
*The Happy Marriage of Digitization and Mathematical Optimization*

Prof. Dr. Peter Stahlknecht (Hannover, Germany)  
*Von den Anwendungen zur Arbeitsgruppe – Erinnerungen des Gründers*

Robert Schwarz (LITIC Software, Chiang Mai, Thailand)  
*LITIC: From a model to a graphical end-user application*

Dr. Roland Wunderling (IBM, Vienna, Austria)  
*A Historic Voyage on Solving Optimization Problems with CPLEX*

## Location

Schloss Spindlhof  
Spindlhofstraße 23  
93128 Regenstauf

Fon: +49 (0) 94 02 93 54 0  
Fax: +49 (0) 94 02 93 54 11

[info@spindlhof.de](mailto:info@spindlhof.de)  
[www.schloss-spindlhof.de](http://www.schloss-spindlhof.de)

**1h10m away from Munich International airport.**

## Excursion:

On Thursday afternoon, an excursion will be arranged for up to 60 participants (first registered, first served). The conference dinner will take place in "Schloß Spindlhof.

100th Meeting of the GOR Working Group  
„Real World Mathematical Optimization“

## Mathematical Optimization in the Real World

Regenstauf, April 12 & 13, 2018  
Schloss Spindelhof, Spindlhofstraße 23, 93128 Regenstauf

---

Thursday, April 12 - 2018: 09:30 – 18:00

08:00-09:15 ----- Breakfast -----

09:30-09:40 **Opening and Welcome** (Josef Kallrath & Michael Bussieck)

09:40-09:50 **Michael Fischer** (Schloß Spindlhof, Regenstauf)  
*Welcome and information about Schloß Spindlhof*

09:50-10:20 **Prof. Dr. Josef Kallrath** (GOR AG “Real World Optimization”)  
*The Pleasure to Solve Real World Optimization Problems*

10:20-10:45 ----- Coffee Break -----

10:45-11:30 **Prof. Dr. Thorsten Koch** (Zuse Institut Berlin, Berlin)  
*20 years of Mathematical Optimization in the Real World or how to  
Survive Industry Projects as a Mathematician*

11:30-12:00 **Dr. Susanne Heipcke** (FICO, Birmingham, UK)  
*Modelling for Mathematical Optimization: Historical Notes and Current  
Trends*

12:00-13:00 ----- Lunch Break -----

13:00-13:30 **Dr. Andreas Söhlke** (Lufthansa Systems, Berlin)  
*From Planning to Real Time: The Challenges of applying Optimization in  
Airline Operations.*

13:30-14:00 **Prof. Dr. Anita Schöbel** (University Göttingen, Göttingen)  
*Towards Integrated Planning in Public Transportation*

14:00-14:20 **Ingo Bremer** (WIAS, Berlin)  
*Using an SQP-Solver for Nonlinear Optimization under Probabilistic  
Constraints*

- 14:20-16:15 -----Excursion: Hiking to Schloßberg -----  
-----or at your choice (around the castle) -----
- 16:15-16:30 **Dr. Anna Schreieck** (*BASF SE, Ludwigshafen*)  
*Operations Research at BASF – New Opportunities in the Time of Digitization*
- 16:30-17:05 **Dr. Michael Bussieck** (*GAMS GmbH, Cologne*)  
*Enhanced Model Deployment and Solution in GAMS*
- 17:05-17:50 **Fabian Friese/Andre Schnabel** (*Leibniz Universität Hannover, Hannover*)  
*Lehre von Theorie und Praxis der Mathematischen Optimierung mit modernen Methoden und Inhalten*
- 18:00-18:20 GOR-Internal – Elections within working group
- 18:30-22:00 **Conference Dinner** at “Schloß Spindlhof”  
- *Celebrating the 100th meeting of our GOR Working Group* -  
----- Taking a Group Photograph for the OR News and Press -----

## Friday, April 13 - 2018: 09:30 – 15:00

- 07:30-08:45 ----- Breakfast -----
- 09:00-09:30 **Michael Fischer** (Schloß Spindlhof)  
*Guided castle tour*
- 09:30-09:50 **Robert Schwarz** (LITIC Software, Chiang Mai, Thailand)  
*LITIC: From a model to a graphical end-user application*
- 09:50-10:10 **Dr. Roland Wunderling** (IBM, Vienna, Austria)  
*A Historic Voyage on Solving Optimization Problems with CPLEX*
- 10:10-10:30 ----- Coffee Break -----
- 10:30-11:15 **Prof. Dr. Siegfried Jetzke** (Ostfalia Hochschule für Angewandte  
Wissenschaften, Salzgitter)  
*Gibt es optimale Lösungen in der Logistik? Does Logistics allow for  
optimal solutions?*
- 11:15-11:35 **Lucia Bäuml** (FAU & Continental Automotive GmbH, Erlangen)  
*Automotive Life Cycle*
- 11:35-12:05 **Prof. Dr. Karl-Heinz Küfer** (Fraunhofer ITWM, Kaiserslautern)  
*Optimizing yields in gemstone cutting - mathematics as a driver of  
process innovation*
- 12:05-13:05 ----- Lunch Break -----
- 13:05-13:25 **Dr. Hermann Gold** (Infineon Technologies AG, Regensburg )  
*Queueing Theory in Practice at Semiconductor Manufacturing*
- 13:25-14:10 **Prof. Gustav Feichtinger** (Technical University of Vienna, Vienna, Austria)  
*Optimizing Terror Queues*
- 14:10-14:40 **Prof. Dr. Knut Haase** (University of Hamburg, Hamburg, Germany)  
*A Pilgrim Scheduling Approach to Increase Public Safety During Hajj*
- 14:40-15:00 **Final Discussion – End of the Workshop – Coffee Break**

---

**Location: Schloß Spindlhof, Spindlhofstraße 23, 93128 Regenstauf**



Gesellschaft für Operations Research e.V.



## The Speakers

**Lucia Bäuml** is a PhD student at the Chair of Economics, Discrete Optimization, Mathematics at the University of Erlangen. She is employed at Continental Automotive GmbH in Regensburg in the department of Advance Development for CO<sub>2</sub> reduction technologies. She got her Master's degree in Mathematics in the field of Applied Analysis at the University of Regensburg in 2016.

**Ingo Bremer** is scientific collaborator at the Weierstrass-Institut for Applied Analysis and Stochastics in Berlin – Institute of the Leibnitz Association – since 1992. He received his Ph.D 1995 from the University of Heidelberg. He was responsible for several third party funded projects with application in industry: Simulation of CoPolymerization Processes (Bayer Leverkusen), Optimization of Distillation Columns (BASF Ludwigshafen) and Virtual Commissioning of Car Production Plants (Rückert EKS Weingarten) Since 3 years the focus is on the development of fast Algorithms for Solving Optimization Problems with Probabilistic Constraints in the field of Renewable Energy motivated by Collaborations with Electricity de France (EDF).

**Michael R. Bussieck** received a diploma degree and a PhD in Mathematics from Technical University of Braunschweig, Germany. He worked from 1998 to 2004 at GAMS Development Corp. in Washington DC, USA as a senior optimization analyst. During that time he worked on optimization projects with clients from industry (Energy, Automotive, and Chemical), the military, and government. In a joint project with ARKI Consulting (the home of the NLP solver CONOPT) he developed the MINLP solver SBB and was in charge of the GAMS/CONOPT link. Since 2004 he is a managing director of GAMS Software GmbH leading the development group for the GAMS software in Braunschweig, Germany. In addition to the development responsibilities, he frequently engages in customer optimization projects delivering cutting-edge optimization technology to clients all over Europe and the US. Michael has published in many first class optimization journals, frequently gives lectures at international conferences, and leads the academic outreach program at GAMS Software GmbH. He also serves as a member in the board of advisors of the German OR Society.

**Gustav Feichtinger** is Professor Emeritus for OR at the Institute of Statistics and Mathematical Methods in Economics, Research Group ORCOS (OR and Control Systems) at the Vienna University of Technology. He got his Ph.D. in Mathematics in the field of Group Theory at the University of Vienna in 1963 and his Habilitation in Statistics at the University of Bonn in 1969. His research interests are focused on the application of Optimal Control Theory and Differential Games to various fields of OR and economics, particularly to the economics of crime (illicit drugs, corruption and terror).

**Fabian Friese** is a PhD student at the Department of Production Management at the Leibniz University of Hanover. His research focuses on responsive methods for stochastic lot sizing. He holds courses in “Modeling economic optimization problems with GAMS” and tutorials in “Operations Management”, where he implemented new innovative teaching methods. He got his Master's degree in Business Administration and Engineering in the field of Operations Management at the Leibniz University of Hanover in 2015.

**Hermann Gold** is a Senior Staff Engineer at Infineon Technologies AG, where he is working on planning and scheduling problems in semiconductor manufacturing. He studied computer

science at the University of Erlangen and received a doctorate degree from the Faculty of Mathematics at the University of Würzburg. His special research interest is in the combination of queueing theory and optimization.

**Knut Haase** is the Director of the Institute for Transportation at the University of Hamburg since October 2010. At the University of Kiel, he received his diploma and doctoral degree and his lecture qualification (habilitation) in Business Administration. After two years as a professor at the University of Hohenheim (Stuttgart) he was Full Professor for Transportation and Logistics at the Technical University of Dresden for seven years. His research topics are focused on optimization approaches for solving large scale problems with applications in logistics and public transport.

**Susanne Heipcke** is principal engineer at FICO, leading the Modelling Team of FICO Xpress Development. Her team is in charge of the development and design of the modelling tools of the Xpress suite (Mosel, BCL), the creation of productized optimization solutions (Decision Optimizer), as well as the design of application development toolkits and solution templates. Before joining Dash Optimization in 1998 she has worked for BASF-AG, Germany. Her Ph.D. research at the University of Buckingham focused on the solution of large-scale industrial problems by a combination of constraint programming and mixed integer programming.

Susanne Heipcke has authored the book “Applications of optimization with Xpress-MP” and a number of papers on various aspects of mathematical modelling. She enjoys teaching mathematical optimization, such as holding university courses on mathematical modelling and by regularly organizing specialist training events.

**Josef Kallrath** obtained his PhD in astrophysics from Bonn University (Germany) in 1989. He is professor at the University of (Gainesville, FL, [www.astro.ufl.edu/~kallrath](http://www.astro.ufl.edu/~kallrath)), and solves real-world problems in industry using a broad spectrum of methods in scientific computing, from modeling physical systems to supporting decisions processes by mathematical optimization. He has written review articles on the subject, about 100 research papers in astronomy and applied mathematics, and several books on mixed integer optimization, as well as one on eclipsing binary stars.

He leads the Real World Optimization Working Group of the German Operations Research Society. His current research interests are polyhedral modeling and solution approaches to solve large-scale or difficult optimization problems, for instance, by decomposition techniques such as column generation, or hybrid methods.

**Thorsten Koch** obtained his PhD in mathematics from TU Berlin (Germany) in 2004. He is professor for *Software and Algorithms for Discrete Optimization* at TU Berlin and director of the *Mathematical Optimization* and the *Scientific Information* departments at Zuse Institute Berlin. His research is in general related to industrial applications of discrete optimization, in particular mixed integer linear and non-linear optimization, modelling and optimization of planning and control of infrastructure networks, especially in natural gas and telecommunications. For his work he received two Google research awards and the *2016 EURO Excellence in Practice award*.

**Karl-Heinz Kuefer** obtained his PhD in mathematics from Kaiserslautern University (Germany) in 1992. He has served as Head of Department “Optimization” at Fraunhofer Institute for Industrial mathematics at Kaiserslautern since 2004. In his department, 42 researchers (most of them post docs) work on real world problems from industry and society, more than 60 percent of the budget is directly coming from industrial partners. As a math professor

he has advised 26 PhD students with topics in applied optimization most of them arising from industrial problems. Major research topic of the department is interactive multicriteria decision support, based on flexible discrete and nonlinear optimization models. The success of the department heavily relies on the development of dedicated and individual software components made for and deployed to industrial companies in order to strengthen their competitiveness in the market.

**Andre Schnabel** is a PhD student at the Department of Production Management at the Leibniz University of Hanover. He currently works on research projects in the areas of resource-constrained project scheduling as well as service portfolio optimization as part of the Collaborative Research Center (CRC) 871 “Regeneration of Complex Capital Goods”. He received his MSc. degree in computer science with a focus on software engineering at the Leibniz University of Hanover in 2013.

**Anita Schöbel** is head of the research group *Optimization* at the Faculty for Mathematics and Computer Science of the Georg-August University Göttingen. She received her PhD from the Technical University of Kaiserslautern and worked as postdoc at the Fraunhofer Institute for Industrial Mathematics for two years before she finished her Habilitation in 2003. She has been professor in Göttingen since 2004.

Her research interests focus on discrete optimization in public transportation, multi-objective robust optimization, and facility location. Anita Schöbel is the coordinator of the research unit on Integrated Transportation funded by the German Research Foundation (DFG). She currently is in the managing board of the German Society of Operations Research (GOR) and of the centre of Simulation Studies Clausthal-Göttingen (SWZ).

**Robert Schwarz** is product manager at LITIC Software in Chiang Mai, Thailand. Before, he applied mathematical optimization to challenging problems in gas pipeline planning at Zuse Institute Berlin.

**Andreas Söhlke** is a product manager responsible for the airline crew pairing and rostering optimizers in Lufthansa Systems NetLine/Crew product. He has more than 15 years experience in applying optimization theory to real-world airline problems.

**Roland Wunderling** obtained his PhD in mathematics from TU Berlin (Germany) in 1997 for the development of SoPlex, a Simplex algorithm still being maintained and used today. After his PhD he joined CPLEX as LP developer. He maintained his position at CPLEX through its acquisition by ILOG in 1997 and by IBM in 2009, where he held the position as CPLEX architect until 2017.

# Automotive Life Cycle Assessment

Lucia Bäuml

Friedrich-Alexander-Universität Erlangen-Nürnberg / Continental Automotive GmbH  
Cauerstraße 11, 91058 Erlangen / Siemensstraße 12, 93055 Regensburg  
e-mail: [lucia.baeuml@fau.de](mailto:lucia.baeuml@fau.de)

Continental is among the leading automotive suppliers worldwide and currently employs more than 220,000 employees in 56 countries. It is an example for optimization in real world. In the scope of automobility a lot of mathematical optimization problems appear in the research and development department. Many mathematicians are employed to solve these issues.

Automotive Life Cycle Assessment is one of these optimization fields. We look at environmental aspects (e.g. CO<sub>2</sub>-emissions) over the whole life cycle of products and cars and try to minimize them applying mathematical algorithms in cooperation with the Friedrich-Alexander-Universität Erlangen-Nürnberg.

# Using an SQP-Solver for Nonlinear Optimization under Probabilistic Constraints

Ingo Bremer

WIAS

Mohrenstr. 39, 10117 Berlin, Germany

e-mail: [bremer@wias-berlin.de](mailto:bremer@wias-berlin.de)

Motivated by challenging practical problems in the area of wind and water power management, we have applied prediction models with uncertain data, which result in optimization problems with probabilistic constraints, so called chance constraints.

Using the analytic expression of the distribution function of the probabilistic part, the problem can be transformed to a deterministic one at the expense of a very high-dimensional integral.

In case of multivariate normally distributed values there are reasonable numerical approximation schemes for these integrals.

We present a method based on a standard SQP solver, which allows to treat realistic problems in an industrial simulation environment.

A simplified concrete example is based on a model and data from EDF France.

A second example was published 2015 and serves as a proof of concept for an abstract scenario with wind data from Kap Arkona and a day-ahead price from the electricity stock exchange in Leipzig.

# Enhanced Model Deployment and Solution in GAMS

Michael R. Bussieck  
GAMS Software GmbH  
P.O. Box 4059, 50216 Frechen, Germany  
e-mail: MBussieck@gams.com

In most cases, using GAMS in the typical fashion - i.e. defining data, variables, equations and models in a declarative way and solving the models sequentially - presents a very efficient way to solve optimization models and holds few performance issues for models that can be solved by today's state-of-the-art mathematical programming solvers. In some cases, though (e.g. when analyzing multiple scenarios or when implementing polyhedral models like decomposition schemes), performance can be dramatically improved using newer GAMS capabilities. In this talk, we first review classic features of GAMS and how they are used to build an application using multiple models and (sequential) solves. We build on that by showing different techniques to implement the same application using parallel solves on a typical desktop computer or on a high-performance computational cluster.

# Optimizing Terror Queues

Jonathan P. Caulkins, Edward H. Kaplan, Gustav Feichtinger, Andrea Seidl, and Stefan Wrzaczek  
Technical University of Vienna  
Wiedner Hauptstrae 8-10, Freihaus, Vienna, Austria  
e-mail: [gustav@eos.tuwien.ac.at](mailto:gustav@eos.tuwien.ac.at)

The task of covert intelligence agents is to detect and interdict terror plots. Kaplan(2010) treats terror plots as customers and intelligence agents as servers in a queuing model. We extend Kaplans insight to a dynamic model that analyzes the inter-temporal trade-off between damage caused by terror attacks and prevention costs to address the question of how many agents to optimally assign to such counter-terror measures. We compare scenarios which differ with respect to the extent of the initial terror threat and study the qualitative robustness of the optimal solution.

Moreover, a differential terror queue game is presented, wherein terrorists seek to determine optimal attack rates over time, while simultaneously the government develops optimal counterterror staffing levels. The number of successful and interdicted terror attacks is determined via an underlying dynamic terror queue model. Different information structures and commitment abilities derive from different assumptions regarding what the players in the game can and cannot deduce about the underlying model. We compare the dynamic game models to each other as well as to the optimal control model.

# Lehre von Theorie und Praxis der Mathematischen Optimierung mit modernen Methoden und Inhalten

Fabian Friese, André Schnabel  
Institut für Produktionswirtschaft  
Leibniz Universität Hannover  
{fabian.friese, andre.schnabel}@prod.uni-hannover.de

Am Institut für Produktionswirtschaft der Leibniz Universität Hannover werden den Studierenden der Studiengänge Wirtschaftswissenschaften und Wirtschaftsingenieurwesen die theoretischen Grundlagen des Operations Research (OR) und Operations Management vermittelt. Bei der Vermittlung der genannten Inhalte werden moderne, teils multimediale Lehrmethoden wie „umgedrehter“ Unterricht (inverted classroom), kurze themenspezifische YouTube-Videos, randomisierte Online-Übungsaufgaben, digitale Zusatzmaterialien und Veranstaltungsaufzeichnungen eingesetzt. Besonders fortgeschritten ist dieses Vorhaben bereits in der Grundlagenvorlesung „Operations Management“. Unterstützt wird diese Lehrveranstaltung durch ein speziell hierfür entwickeltes neues Lehrbuch von Stefan Helber, welches bereits mit dem VHB-Lehrbuchpreis ausgezeichnet worden ist.

Weiterhin wird das Know-how zur praxisnahen Nutzung von OR-Methoden vermittelt. Dies umfasst zum einen den Umgang mit dem Modellierungssystem GAMS zur Implementierung und Lösung betriebswirtschaftlicher Optimierungsprobleme. Hier erhalten Studierende bereits in der Grundlagenvorlesung „Operations Management“ die Möglichkeit, durch die Bearbeitung freiwilliger zusätzlicher Aufgaben grundlegende Funktionen kennenzulernen. Im Vertiefungsstudium befasst sich eine gesamte Lehrveranstaltung mit dem fortgeschrittenen Umgang mit GAMS. Darüber hinaus werden Lehrveranstaltungen zur Entwicklung von Heuristiken für kombinatorische Optimierungsprobleme sowie den Entwurf und die Implementierung von Web-Anwendungen, welche einem möglichen Endanwender ohne Kenntnisse in mathematischer Optimierung eine einfache Nutzung von Optimierungsverfahren zum Lösen konkreter Problemstellungen ermöglichen, angeboten.



# Queueing Theory in Practice at Semiconductor Manufacturing

Hermann Gold  
Infineon Technologies AG  
Wernerwerkstr. 2, 93049 Regensburg, Germany  
e-mail: [hermann.gold@infineon.com](mailto:hermann.gold@infineon.com)

Semiconductor manufacturing networks seen as queueing networks are known to be of highly difficult type. They are not amenable to queueing analysis based on one single comprehensive model capturing all their aspects. In this talk we present some queueing systems arising out of semiconductor manufacturing planning and control problems and demonstrate their usefulness and applicability. Manufacturing equipment can be divided into three main queueing station categories, namely single servers, batch servers and servers with internal flow, the first two being standard and as such established in Kendall's notation of queues. For batch servers we show how the theoretical result saying that any non-anticipative batching policy is of threshold type is put into practice. Exemplarily for single servers, we give an insight how routing optimization is done via fluid queue modelling. Routing is an essential problem, since a solid concept of traffic planning already applied in the planning and continuous adaption of capacity according to market demands is of great economic advantage. As the dynamic state development of a semiconductor fab is always prone to slow motions of operating points it is hard to convey the idealistic results from optimization into scheduling practice. Still queueing theory provides basic mechanisms to account for the sharpest optimization results to be put into the daily practice with its slower time scale. With regard to the aspect of global dispatching in a semiconductor fab we highlight the learnings from priority queueing network models for the related strategies.

# A Pilgrim Scheduling Approach to Increase Public Safety During Hajj

Knut Haase  
University of Hamburg  
Moorweidenstr. 18, 20148 Hamburg, Germany  
e-mail: [knut.haase@uni-hamburg.de](mailto:knut.haase@uni-hamburg.de)

The Hajj - the great pilgrimage to Makkah, Saudi Arabia - is one of the five pillars of the Islamic religion. With more than three million pilgrims performing Hajj rituals, it is also one of the largest pedestrian problems in the world. Until 2006, severe crowd disasters have repeatedly overshadowed the pilgrimage. Ramy al Jamarat the stoning of the devil ritual is known to be particularly crowded. In the aftermath of the Hajj in 2006, several measures were implemented to improve safety and to avoid crowd disasters. One particular measure is the development of a time schedule for the pilgrims to perform the stoning ritual. A model and a solution approach to the Pilgrim Scheduling Problem is represented. The model minimizes the deviation of the scheduled stoning time from the preferred stoning time, while taking into account infrastructure capacities to avoid critical densities of pilgrims. At the same time pilgrims are assigned to routes leading to the ritual site and back to the camp site. The routes enforce a rigor one-way flow in the surrounding area of the ritual site. The Pilgrim Scheduling Problem is solved by an intelligible x-and-optimize heuristic. The schedule is evaluated by a mesoscopic pedestrian simulation and discussed with local authorities. Critical feedback is then incorporated into the final schedules. The approach was an integral part of the planning process for Hajj in the years 2007-2014, 2016 and 2017, and no crowd disaster happened during this time. We illustrate our work with computational results and validation data for the Hajj in 2016.

# Modelling for Mathematical Optimization: Historical Notes and Current Trends

Susanne Heipcke  
FICO, Xpress Optimization  
Starley Way, Birmingham B37 7GN, UK  
e-mail: [susanneheipcke@fico.com](mailto:susanneheipcke@fico.com)

This talk reviews the development of modelling languages and tools for the formulation and solving of mathematical optimization problems since the 1980s when many of today's commercial tools were first published. With the advent of more powerful processors and highspeed network connectivity the general usage patterns of OR tools have evolved over time and user expectations on modelling software include an increasingly large range of functionality.

Optimization models are more and more frequently deployed as distributed, multi-user solutions within company networks or in cloud-based environments. We discuss the impact of these trends on modelling tools, including aspects such as data handling, support of concurrent and distributed computing, integration with analytic tools, and the role of visualization and user interaction including during the solving process.

# Optimizing yields in gemstone cutting - mathematics as a driver of process innovation

Karl-Heinz Kuefer, Jan Schwientek, Tobias Seidel  
Fraunhofer Institute for Industrial Mathematics  
Fraunhofer Platz 1, 67663, Kaiserslautern Germany  
e-mail: [karl-heinz.kuefer@itwm.fraunhofer.de](mailto:karl-heinz.kuefer@itwm.fraunhofer.de)

For centuries and nowadays, cutting and grinding of colored gemstones has been manual work of artists and craftsmen all over the world, while the treatment of glass is subject to evaluated industrial processes. Since about 14 years the department of optimization together with a worldwide operating German company has been developing an industrial process for the automatic processing of gemstones.

Semi-infinte optimization models have been proved powerful enough to cope with the practical needs of the gemstone branch. The talk will survey the developments of the last years and the new algorithms that came up in order to reach fast, reliable and convincing yields in gemstone cutting.

# 20 years of Mathematical Optimization in the Real World or how to Survive Industry Projects as a Mathematician

Thorsten Koch

Zuse Institute Berlin and Technische Universität Berlin

Takustr. 7, 14195 Berlin, Germany

e-mail: [koch@zib.de](mailto:koch@zib.de)

This talk aims at sharing the experience from 20 years of successfully employing integer programming in industry related projects with the audience. After numerous research-industry collaborations, we found that there are several reoccurring topics during these projects.

The problems encountered seem to be universally the same, as there are standard misunderstandings between the partners. We will try to draw some general conclusions, and use the projects of the author as examples to show some common pitfalls. We will talk about acquiring projects, getting them running and how to explain the results to practitioners. Furthermore, we will try to outline what is essential to make collaboration projects with industry worthwhile for both partners and what impact and repercussions they can have on a mathematical career.

Finally, we will give some notes on what are required skills we could teach to students who want to follow this path.

# Towards integrated planning in public transportation

Anita Schöbel  
University Göttingen  
Göttingen, Germany  
e-mail: [schoebel@math.uni-goettingen.de](mailto:schoebel@math.uni-goettingen.de)

Planning in public transportation consists of several planning stages which are algorithmically treated sequentially. This is the reason why planners perform better than algorithms on small instances: they use an integrated point of view when constructing customer-friendly and cost-efficient lines, timetables, and schedules.

In this talk we discuss the drawbacks of sequential planning in public transport and show approaches to be used for integrated optimization. We demonstrate a successful look-ahead heuristic which was able to outperform planners even on a well understood and easy example. We also sketch the so-called Eigenmodel as a general framework for designing integrated approaches.

# LITIC: From a model to a graphical end-user application

Robert Schwarz  
LITIC Software  
e-mail: [schwarz@litic.com](mailto:schwarz@litic.com)

LITIC offers an integrated software environment that allows the users to build graphical end-user applications quickly. All development steps from data input to web publishing are covered. Data can be analyzed with tables and charts and optimization problems formulated in a modeling language.

In this presentation we will demonstrate how to specify a model and make it available to end users through an interactive application.

# From Planning to Real Time: The Challenges of applying Optimization in Airline Operations

Andreas Söhlke  
Lufthansa Systems  
Salzufer 8, 10587 Berlin, Germany  
e-mail: [andreas.soehlke@lhsystems.com](mailto:andreas.soehlke@lhsystems.com)

Lufthansa Systems is specialized on software and consultancy services in the airline industry with 1900 employees worldwide and around 300 airlines among our customers.

Airlines use optimization to improve the quality and robustness of the crew pairings and rosters since years. Still, in each implementation of planning optimization at a new airline, there are interesting challenges to overcome. But even more challenging is to make real time optimization usable for the airlines. This presentation will show some of the challenges of applying optimization to crew planning and what obstacles are still to overcome to introduce decision support and optimization to recover from irregular operations.



# A Historic Voyage on Solving Optimization Problems with CPLEX

Roland Wunderling  
IBM  
Gottlieb-Remschmidt-Gasse 18, Graz, Austria  
e-mail: [roland.wunderling@at.ibm.com](mailto:roland.wunderling@at.ibm.com)

In a world with limited resources and dangerous environmental issues one thing is certain: This world needs Operation Research to do the most of the resources available with the lowest environmental impact. What better opportunity than the 100th Symposium of GOR to take a moment and look back at the growing success in helping to do just that via our ever improving ability of solving OR problems as exemplified by the development of CPLEX.