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International Federation of Operational Research Societies

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Editorial

Promoting OR

Sue Merchant, IFORS VP at large

At EURO this summer I was struck by the enthusiasm, amongst developing country delegates in particular, for undertaking the type of practical OR which makes a real difference in industry, commerce and government. However the enthusiasts reported a problem which many of us have faced over the years – how to get business and government to recognise that OR makes a difference and hence recruit OR people. Indeed John Ranyard and Robert Fildes' recent international study, with responses from 28 countries, confirmed that the lack of client awareness and understanding was a continuing and widespread problem. They stress the importance of practitioner communities and OR societies in helping to drive awareness of OR in countries across the world.



▲ Glasgow City Council does its part in promoting OR: Elise and Sue at the Glasgow's St. George Square decked with EURO banners.

Various methods have been tried over the years to demonstrate how powerful OR is: for example, INFORMS' major campaign 'The Science of Better' was initiated a few years ago and the UK also adopted this approach, producing masses of promotional material, a DVD of OR activity in successful companies (which is available from the UK ORS) and setting up websites 'Science of Better.co.uk' and 'LearnaboutOR.co.uk' to help spread the word. More recently the UK has initiated a glossy magazine 'Impact', crammed with short readable articles aimed at clients, which we hope will make a difference. ORS members work hard annually to entice practitioners to conferences with 'Making an Impact', sessions that include networking events, practitioner case studies, academic/practitioner discussions and much more. I'm sure there must also have been many other campaigns elsewhere in the world. Still, we struggle, not helped by: the changing terminology for what OR people do (everything from Insight Analyst to Business Analyst and Management Scientist); the fact that practitioner departments don't find it 'client-friendly' to use the label 'OR'; and the threats arising from the emergence of Analytics/Big data.

Universities continue to play a big role in selling what OR can do by forging relationships with business and offering cheap or free summer projects by MSc students which often lead to longer term collaborations. The UK OR Society has more recently started to raise awareness through its 'pro bono' (free) OR scheme to charities: 'word of mouth' publicity for OR via delighted charity leaders has been one outcome which we hope will spread outside charities to the wider business world via charity trustees who are often from the business community. Another success has been the UK Government OR service (GORS) where enthusiastic individuals have spent years building up groups of respected OR consultants, resulting in the wide use of OR in government. Most recently, there has been a move in the UK (and I'm sure elsewhere) to try to tweet about successful projects as often as possible and thus spread good news in a modern way!

It occurs to me that if all countries with good ideas for, and articles about promoting OR could notify IFORS about them we could set up a section of the website listing them all (maybe called **Promote OR!**) so that any country needing new ideas could access it for helpful tips. Ideally, the site could have useful information in several languages and if word about it could be spread by tweeting, so much the better! Readers' feedback on this suggestion would be appreciated – please keep your ideas coming! 🌐

Reproduction of materials printed here is welcome. We do request that the source, IFORS News, be acknowledged.

Of Contributions and Transitions

This issue is longer than usual – so much has happened since the last quarter, highlighted by two regional conferences in 2015 – the EURO in Glasgow and the APORS in Sarawak.

IFORS President Maculan and I were present in both, and saw the energy and the enthusiasm that OR professionals put into their work and their research, and how serious they are about having fun too! All through the news about conferences happening all over (Italy, Greece, China, Iran, Malaysia, Scotland), notice how opportunities for networking and getting to know one another and their work are deliberately and consistently provided. This is the main reason why IFORS has continued to support the training of early-stage researchers, as can be seen from the report filed by the IFORS scholar to the summer school.

IFORS is also pleased to announce that work is ongoing not only for IFORS 2017 in Quebec, but also for IFORS 2020. Soon, members will get to select the venue of this IFORS Triennial. IFORS is also proud of the gains made by its journal, the International Transactions in Operational Research (ITOR).

It is with sadness, though that IFORS remembers those who have departed, leaving an indelible mark on IFORS and the people who make it up. In this issue, we present our tribute to: Heiner Muller Merbach, past IFORS President and Editorial Adviser of IFORS News; John Nash, IFORS Distinguished Lecturer; and Philippe Van Asbroeck, EURO Secretary.

Their contributions and those of others who have gone ahead inspire and enable us to go on with our work. One just needs to read about the impact that OR has made on manufacturing (see Impact and Tutorial), on development (see ORD section), on rail operations (Book Review) and even on dogs (Pro Bono)!

Surprisingly, a lot of such work has been happening in the community of our newest IFORS member, the Norwegian Operations Research Society. Welcome to IFORS! 🌍



▲ Elise with (l to r): Nelson Maculan, Ilias Mamat and Lai Soon Lee at the APORS Opening Session

EURO 2015: Scottish Kilts and Research Clans with Impact

David Pisinger <pisinger@man.dtu.dk>

EURO 2015 took place in Glasgow - where prominent conference banners flew all around the city center at George Square. This was a warm welcome from the city council, with the weather turning out to be better than expected. The organizers prepared for rain all four days, but it turned out that umbrellas were only needed on the first day.

Almost 2,200 delegates participated in the conference, and with almost 2,000 presentations, there were plenty of choices for nearly every research area (or perhaps research clan - since we are in Scotland). Having longer abstracts than at previous conferences helped the speakers give a better presentation of their talk, and hopefully made it easier for the delegates to choose the right sessions to attend.

The excellent, sold-out plenary talks were given by Terry Rockafellar, Sir Alan Wilson and Grazia Speranza, covering topics of risk in stochastic programming, cities in 2065 and trends in transportation planning. Professor Rockafellar was the designated IFORS Distinguished Lecturer for the conference. The plenary talks were supplemented by 11 insightful keynote and tutorial talks, one of which was given by incoming IFORS President, Mike Trick. The talks took place in the beautiful Barony Hall - a former Gothic church having a unique atmosphere, beautiful stained glass windows and spectacular architecture.

The organizers, in collaboration with the UK OR Society, arranged a large number of "Making an impact" activities where researchers and industry could meet and exchange ideas and knowledge. These activities mainly took place in the brand-new Technology and Innovation Center, and many delegates used the opportunity to drop in for one or more

sessions.

Social events at the EURO conference included an evening at the historic Merchant Square. Several of the restaurants served Haggis, a savoury pudding containing sheep's pluck (heart, liver and lungs); minced with onion, oatmeal, suet, and spices. The pudding is traditionally encased in the animal's stomach. Supplemented by a sufficient amount of beer, it actually tastes surprisingly good.

A traditional part of the EURO conferences is to honor brilliant research and hard commitment. The EURO gold medal was given to Alexander Schrijver while the EURO Distinguished Service Medal Award went to Bernard Roy. It was also time to remember Philippe Van Asbroeck who passed away last year after many years of committed work for EURO.

The conference was concluded in the best possible Scottish way - with folk dance and live music in the Barony Hall. Those delegates who had the luck to participate had a marvelous evening and sore feet next day. 🌍



▲ Program Chair, David Pisinger welcomes participants in his kilt.

OR People Make EURO: Glasgow Hosts 27th EURO Conference

Laura Lotero <laura.lotero@upb.edu.co>, Ozan Kocadagli <ozan.kocadagli@msgsu.edu.tr>

Gerhard-Wilhelm Weber <gweber@metu.edu.tr>

Glasgow hosted around 2000 Operational Research academics, researchers, practitioners and enthusiasts from around the world during the 27th European Conference on Operational Research (EURO 2015 <http://www.euro2015.org/>) held at the University of Strathclyde from July 12 to 15. *With Making an Impact* as a major theme, various innovations to past conferences were introduced, through the commitment and efforts of Organizing Committee co-chairs *Valerie Belton* and *Tim Bedford* as well as Program Committee Chair, *David Pisinger* along with their respective teams. EURO 2015 was co-organized by EURO (The Association of European Operational Research Societies <https://www.euro-online.org/>) and The OR Society of the United Kingdom (<http://www.theorsociety.com/>).

Strathclyde University – a leader in building translational research centers that are linking industry and academic research, 2012 University of the Year and 2013 Entrepreneurial University of the Year – was a fitting venue, with its Technology and Innovation Centre (TIC) hosting its first major conference.



▲ Merchant Square with food and music galore during the informal evening.



Keynote and tutorial speakers gave excellent talks about trends in diverse areas as follows: Automatic Algorithm Configuration (*Thomas Stuetzle*), Business Analytics (*Michael Trick*), Regional Innovation Ecosystems (*Markku Markkula*), The Relationship Between OR and the Government (*Tony O'Connor*), Criterion Space Search Methods (*Martin Savelsbergh*), Modern Supply Chain Planning (*Stefan Nickel*), Evacuation Planning Models (*Horst Hamacher*), Healthcare System Optimization (*Eva K. Lee*), Behavioural Operational Research (*Raimo P. Hämmäläinen*), OR and Bioinformatics (*Jacek Blazewicz*) and OR Education (*Ariela Sofer*).



▲ Glasgow City Chambers offered an elegant welcome to the delegates.

The conference program included inspiring and internationally known plenary speakers in Operational Research. IFORS Distinguished Lecturer *Ralph Tyrrell Rockafellar* talked about risk and reliability in stochastic optimization. *Sir Alan Wilson*, gave an overview of the challenges in solving long term complex problems in cities. *Maria Grazia Speranza* gave an exhaustive presentation which traces transportation and logistics from the very beginning to the present and trends for the future. All the plenary talks were given before a full house in a converted church, the elegant Barony Great Hall.



An innovative feature of the conference was the series of participative activities related to “Making an Impact”, aimed at making the practice of OR in the real world more effective. Some of the activities included workshops, seminars and tutorials dedicated to the practice of OR, case studies in OR and analytics, activities bridging the academic-practitioner divide by means of posters, discussions and round-tables, speed networking, and mentoring clinics featuring one-on-one sessions with experienced practitioners. Along this line, the European Excellence in Practice Award (EEPA) was given to *Jesse O’Hanley* (University of Kent, UK) for his work on “Optimizing River Connectivity Restoration”.

These scientific events were interspersed with many social activities, which included the: Welcome Reception, Informal Social Evening, Conference Dinner and Farewell Get Together. The Welcome Reception took place in two separate locations: The City Chambers - one of the city’s most important and prestigious buildings - and the TIC (Technology and Innovation Centre). The Informal Social Evening was held at the Merchant Square, a perfect venue to unwind and relax with good food and lively music. The farewell get together had many participants try their skill at traditional Scottish dancing.



▲ Barony Hall was the venue for the plenary and invited sessions.

Feedback from participants includes the following from Ozan from Turkey. To him, EURO 2015 was a successful conference in terms of impact of sessions, invited speakers and social activities made unforgettable by the friendly and helpful staff and the charming Glasgow setting. He had the opportunity to listen to presentations in Operations Research, Multi-Objective Optimization and Artificial Intelligence, chair a session on Fuzzy Systems I and give a talk on “Time Series Forecasting using Full Bayesian Approach of Artificial Neural Networks” as well as support a co-author, Derya Soydaner in the presentation “A Hybrid Artificial Neural Network Approach Based Information Criteria for Credit Scoring”. For Ozan, it was a full experience, which was intellectually and socially rewarding.

On the other hand, participant Laura from Colombia welcomed the opportunity to meet old and new friends from around the world. She presented her work in progress at the "Optimization for Sustainable Development" stream and co-chaired a session in the "OR for Development and Developing Countries" stream. The presentations in both sessions were interdisciplinary with different approaches from the broad spectrum of OR practice. For her, "OR for Development and Developing Countries" stream provided the perfect space for academics and practitioners to share experiences on making an impact in their developing contexts with OR tools.

In this regard, she invites readers to take a look and share their work related to OR for development and developing countries in the IFORS DC Resources (http://ifors.org/developing_countries/) and to be involved with the EWG-ORD Workshop prior to the EURO 2016 Conference in Poznan, made significant by the 10th anniversary celebration of the EWG ORD.

As announced during the Closing Session of the Conference, preparations are already in full swing for two main highlights of international OR: *EURO 2016* (<http://www.euro2016.poznan.pl/>) and *IFORS 2017* (<http://ifors2017.ca/>)

In summary, everyone who took part in EURO 2015 received and made an impact on the theoretical and practical sides of OR. Despite the rather changeable, yet always authentic and charming Scottish weather, the organizers made their best effort and succeeded in providing a warm and bright atmosphere for sharing expertise and experiences. EURO 2015 not only became a "conference of quantity" – with its nearly 2,400 abstract submissions, but also a "conference of quality" – where innovative ideas in organization, program and social events – were put to work. Thus, it can be said that the ubiquitous host city branding campaign, People make Glasgow (choose one or all: real, smart, home, creative, bright, better) maybe extended to what many in the 2015 EURO conference felt: OR People Make EURO (choose one or all: effective, dynamic, responsive, fun!) 🌍

Environment Takes Center Stage at APORS 2015

Lai-Soon LEE <lls@upm.edu.my>

The 10th Triennial Conference of the Association of Asia-Pacific Operational Research Societies (APORS2015) took place last August 2 to 6 at the Imperial Hotel in the city of Kuching, Sarawak in Malaysia with the theme *OR and the Environment*.

During the Opening Ceremonies, IFORS President Nelson Maculan congratulated the organizers and highlighted the relevance of the conference theme, adding that he was impressed with the use of recycled conference materials to produce the Programme Book, notepads, pens and other materials. Other IFORS personalities present were: NORAM Vice President Michel Gendreau, Past President Elise del Rosario, and Past APORS Vice President Tatsuo Oyama.

The conference consisted of 76 technical talks spanning the many disciplines of OR with an application towards the concerns of the environment. Delivering the keynote address on *OR and Corporate Environment Management* was IFORS Tutorial Lecturer Peter Letmathe from the RWTH Aachen University, Germany. There were 4 plenary talks, bringing together a unique combination of academic and industrial expertise of leading researchers in OR. The first was presented by Stefan Pickl from Universität der Bundeswehr München, Germany on *Intelligent Energy Networks and Security Structures (INESS) - Strategic Management, Process Optimization and Visualization of Critical Events within International Resource Conflicts*. Eric Sandosham of the Red & White Consulting Partners LLP, Singapore gave a variety of applications in his discussion on *Defining the OR Opportunity in Consumer Banking*. The third plenary talk by Murali Sambasivan from



▲ Warming up for the APORS Council meeting: (standing, l to r): Lai Soon Lee-Malaysia, Govinda Tamang-Nepal, Degang Liu-China, Aldy Gunawan-Singapore, Chang Won Lee-Korea, Francis Miranda-Philippines, (seated, l to r): Sunity Shrestha Hada-Nepal, Elise del Rosario-IFORS, Ilias Mamat-APORS, Nelson Maculan-IFORS, Tatsuo

Taylor's University, Malaysia dealt with *OR and Sustainable Supply Chain Management*, followed by Graham Kendall from the University of Nottingham Malaysia Campus, who discussed *Good Laboratory Practice for Operations Research*. The wide range of topics covered in the plenary sessions was reflected in the papers presented by most of the 100 delegates from 21 countries.

The choice of the conference site, Sarawak - home to some of the world's most pristine rainforests – was appropriate for the conference theme, as was the choice of the social activities. Conference Chair Lai Soon Lee meticulously arranged a visit to the Sarawak Cultural Village located in the middle of a rainforest as well as a tree planting activity on the last day.

The excursion, held on the afternoon of the second day, culminated with the conference dinner. At the Village, delegates experienced the cultures of the seven local ethnic tribes by visiting a re-creation of their dwellings. This tour was followed by an afternoon tea served with local desserts. At this time, delegates got to take a peek at the preparations for the renowned Rainforest World Music Festival which was scheduled that week. The ensuing conference dinner offered a unique combination of local dishes and a presentation of tribal dances. There were games, where everyone had fun. On the last day, participants planted 150 trees, a contribution to the city's effort to preserve its environment and heritage.



▲ ITL Peter Letmathe gives plenary talk on Opening Day.

The APORS Council Meeting was also held, where preparations for the APORS 2018 in Nepal was discussed. Ilias Mamat was elected IFORS Vice President for APORS for the term 2016-2018.

Delegates were very pleased, particularly with the eco-friendly efforts, friendliness and hospitality of the organisers.

Conference sponsors and supporters were: the Nottingham University Business School Malaysia (of the University of Nottingham Malaysia Campus) and Malaysian Communication and Multimedia Commission, the International Federation of Operational Research Societies (IFORS), the Sarawak Convention Bureau, the Ministry of Tourism Sarawak and the Malaysia Convention and Exhibition Bureau. 🌐

OR for Development Section

ICORD 2015

EXTENDED DEADLINE!

INTERNATIONAL CONFERENCE ON OR FOR DEVELOPMENT,

DECEMBER 3-4, 2015 @ PALM VILLAGE HOTEL, USWETAKEIYAVA, NORTH OF COLOMBO, SRI LANKA



The International Conference on Operational Research for Development 2015 (ICORD 2015) will be held from 3 to 4 in December this year at the Palm Village Hotel, Uswetakeiyava (North of Colombo) Sri Lanka in collaboration with the Department of Mathematics, Faculty of Engineering, University of Moratuwa.

Conference Theme

Theme of conference is **OR: Enabling Development through Good Governance**. History is replete with examples of how good governance has paved the way to development. A recent example is Singapore, where the leadership of Lee Kuan Yew has transformed a third world country mired in poverty to a prosperous global financial hub.

Literature shows that OR applications have not only enhanced the profitability of companies but have enabled governments to create effective and efficient public institutions that respond to people's needs, thus accelerating the development process to enhance the standard of living. These have called on OR approaches that optimize the use of scarce resources as well as facilitate the implementation of social and economic initiatives in the developing world. This conference aims to focus on work that will enable good governance towards the objective of development, especially in developing countries.

Call for Papers

Operations Researchers who are working in the area of OR for Development are invited to submit their work.

Extended abstracts (no less than 1,500 words) will be accepted, though full papers (needed for a meaningful review) are preferred. Please submit to Arabinda Tripathy <tripathy44@rediffmail.com>.

Participants who have participated in previous ICORDs and who have brought their work forward are encouraged to attend to report on developments on their previously presented work.

Speakers

Ali Emrouznejad

Professor and Chair in Business Analytics
Aston Business School
Aston University
Birmingham, UK

Kirit Shantil Parikh

- Former Member, Planning Commission, Government of India
Chairman, Integrated Research and Action for Development (IRADe), New Delhi
- Former (Founder) Director (Vice Chancellor), Indira Gandhi Institute of Development Research (IGIDR), Mumbai
- Honoured with Padma Bushan by the President of India in March 2009.
- Fellow, National Academy of Sciences, India.

Important Dates

- Deadline for extended abstract submission – September 15, 2015
- Notification of Acceptance – September 20, 2015
- Deadline for registration for inclusion in the program – November 5, 2015

Organizing Committee

OVERALL CHAIR - Arabinda Tripathy

INTERNATIONAL ADVISORY COMMITTEE

Sue Merchant, IFORS Vice President
Elise del Rosario, Past President, IFORS
Gerhard Wilhelm Weber, Institute of Applied Mathematics, METU, Ankara, Turkey,
Hans Ittmann - Operational Research Society of South Africa
Sunity Shrestha Hada- Operational Research Society of Nepal

LOCAL ORGANIZING COMMITTEE

Prof. T S G Peiris (Chairman) University of Moratuwa
John NLC Fernando, Arbitrator/Consultant/Lecturer, IBM QCC
Prof. H S Chandana Perera (SLIIT, SL)

TECHNICAL COMMITTEE

Prof. W B Daudasekara (University of Peradeniya, SL)
Dr (Mrs) R A R Prabodini (University of Wayaba)
Dr. D M Samarathunga (University of Ruhuna, SL)
Mr. T M J A Cooray (University of Moratuwa, SL)

Fees

Local Participants: Rs 7,000
Participants from SAARC countries: USD 75
Others: USD 125 🌐

A Perfect Setting for a Workshop on Uplifting Living Conditions

Andres Felipe Osorio Muriel <Aafo1e13@soton.ac.uk>

The Euro Working Group in OR for Development (EWG-ORD) and IFORS organized a workshop entitled "OR for development: Uplifting living conditions" on July 8 and 9 as part of the 27th European Conference on Operational Research (EURO 2015). The workshop was held at the Graham Hills Building of the University of Strathclyde in the beautiful city of Glasgow, Scotland.

But Glasgow was not always beautiful - the 1970s and early 1980s were dark periods in the history of Glasgow, as urban decay set in, caused by mass unemployment. The city has since then enjoyed an economic and cultural renaissance. The city was therefore a perfect setting for discussing the role that OR can play in uplifting living conditions all over the world. The papers and talks presented showed how OR has helped and could potentially help in urban development, health, peacekeeping policies, and in manufacturing in developing countries.

The conference gathered delegates from 12 countries, including Chile, Ukraine, Colombia, US, India, Philippines, UK, Turkey, Russia, Nigeria, Brazil and Tunisia. The schedule of the workshop offered an interesting combination of technical workshops and presentations of research and applied works carried out in developing countries. The format of the conference allowed the presenters to have reactors assigned previously which generated a deeper analysis and discussions of the papers presented.

The event started with a very friendly dinner at Carluccio's restaurant on the night of July 7. The dinner was the perfect occasion for most of the delegates to get to know one another and share research work experiences. This helped everyone prepare for the next day's sessions.

The first day began with the registration and opening remarks from the chair of the event, *Elise del Rosario*. Following the introductory part, the keynote speech entitled "Operational



▲ Participants on the morning of the first day. Not in photo are others who joined later.

Research and Development; 'Real World' Insights from Health O.R" was presented by *Geoff Royston*. During the same day, there were presentations and a workshop entitled "Multicriteria Mapping Tools", which was carried out by researchers from the University of Sussex.

The schedule of the second day was also a combination of presentations, plenaries and a workshop. *Sue Merchant* shared her OR experiences with the police force in her talk on "A Life in Crime" and *Honora Smith* on "Healthcare Development: A Case Study of Location of HIV/AIDS Laboratories in South Africa". The hands-on workshop run by Simul8 was aimed at introducing Discrete Event Simulation through the use of the Simul8 software.

The workshop was an excellent opportunity to meet participants with similar interests and discuss how to approach issues in countries with similar problems. The effort must continue in order to promote operational research methodologies around the world, including of course developing countries where conditions and resources make the environment very challenging. This event helped delegates realize the power of OR methodologies to uplift living conditions! 🌍

Mexico Sets Stage for ICORD 2016

EURWG-ORD **IFORS** **ITAM**
International Federation of Operational Research Societies
INSTITUTO TECNOLÓGICO AUTÓNOMO DE MÉXICO

David Muñoz, along with Adrian Ramirez announced that the International Conference on Operational Research for Development 2016 (ICORD 2016) would take place at the Instituto Tecnológico Autónomo de México on June 9-10, 2016.

ICORD aims to bring together researchers from around the world to present and discuss models and methods to overcome issues existing in developing countries. A particular interest for attendants of this meeting focuses on the information and comments a researcher may receive in order to achieve publication of his/her research in a prestigious, indexed journal. Further information on ICORD 2016 is available at <http://ifors.org/icord2016/>.

Traditionally a part of its ongoing commitment to OR in developing countries, IFORS is joined by the EURO Working Group in OR for Development and the Instituto Tecnológico Autónomo de México in sponsoring this event. Together with Sue Merchant (IFORS VP) and Elise del Rosario, the local organizers are calling on the OR community to help promote this conference. Potential candidates may ask for information on limited financial help to attend the conference after acceptance of his/her article for presentation at ICORD 2016. For further information, please contact David Fernando Muñoz Negron <davidm@itam.mx> and Adrian Ramirez Nafarrate <adrian.ramirez@itam.mx> 🌍



Obituary

Heiner Müller-Merbach

Past IFORS President

28 June 1936 – 30 May 2015

by Jakob Krarup <krarup@di.ku.dk>, Helle Welling <helle.welling@mail.dk>
(this is an excerpt of the full article that appears in the IFORS website,
<http://ifors.org/web/obituary/>)

Around December 2013, Professor Heiner Müller-Merbach broke an arm and six ribs when he fell on his porch. Around 1 May 2015, he fell again, and problems with his breathing began. After an operation, his condition worsened, and in a week, his heart stopped beating.

Knowing that Heiner vigorously opposed the thought of being in a nursing home, it was a gift of grace to 'shuffle off this mortal coil' in the way it happened. Possessing both a warm heart and a brilliant mind to the end, he enjoyed a rich life without suffering the horrors of old age.

He had an outstanding academic career, as can be found in *Lebenslauf*, his 1-page CV in German. He achieved the rank of full professor, and later as of emeritus. In *The life of an emeritus!*, circulated to his friends in January 2009, Heiner said: Isn't it good to have a few modest plans? I like them, each single one with full enthusiasm. That is my only problem, and I start every day with an internal dispute about the priorities. That keeps me going. But I must always think of the Amish wisdom: "The hurrier I go, the behinder I get".

Colleague and friend (Jakob Krarup)

My very first meeting with Heiner and several other notables within mathematical programming dates back to "Large-scale resource allocation", a NATO-sponsored conference held in Elsinore, Denmark, in 1971. George B. Dantzig and Richard W. Cottle were in charge of the scientific programme while all local matters were delegated to me.

A lasting friendship evolved along the way and extended soon to encompass all members of my family. In particular, we learnt to appreciate his truly outspoken sense of humour! I also remember an incident when prior to our departure on separate flights for Europe from the IFORS 1999 in Beijing, Heiner asked me for a brain teaser to play with *en route* to Frankfurt. I gave him this: "Does there exist a number $x = 11111 \dots$ of ones only having 1999 among its divisors?" Upon his return, he said, "Your puzzle was quite tricky but it appears that any prime n (save for $n=2$ and 5) is a divisor of $11111 \dots$, and the number of ones equals the period length of $1/n$ ".

Operational research, managerial problems, the intractable integers, and numbers in general: we were never short of subjects in discussions related to our main field. But also a wide variety of other aspects of the humanities occupied Heiner's mind. Thus, the visible result of his deep interest in philosophy was the appearance in 1991 of *Philosophie-Splitter für das Management*. "Why 'für das Management'?", I asked. Heiner replied, "This is meant to be an appetizer for potential buyers who normally associate my name with management. Thus, increased sales are hoped for".

IFORS (Helle Welling)

Heiner's son, Dr. Jens Müller-Merbach, told us that Heiner had already started making plans for his 80th birthday in 2016. Here is what I would have told Heiner:

I cannot talk about your profound O.R. knowledge and

insight, your fascination with numbers and your great mathematical skills, but I can talk as one who has worked with you throughout your involvement with IFORS. In 1972, you were the Program Committee Chair of the IFORS Conference in Dublin, where I learned a lot about the structure of the Programme for a Triennial Conference. In 1974, you became a member of the IFORS Publications Committee, followed by your appointment as IFORS VP 1974-1977, as Organising Committee member for the IFORS 1981 in Hamburg, as President 1983-1986, and, subsequently, as Immediate Past President.

We also worked closely together in connection with the UNESCO-funded FIACC – the Five International Associations Coordinating Committee – where IFORS was a member, along with IFAC, IFIP, IMEKO and IMACS. Representatives from each Federation met once a year somewhere in Europe to coordinate their various events. You chaired FIACC in 1985-1987.

In all these years, you have always been thoughtful, even when I retired from the IFORS Secretariat. There was always a postcard for me every time you participated in an IFORS or EURO event. They were postcards with notes for me from IFORS friends attending the event!

You are a true gentleman and a sincere friend, who is held in high esteem by your IFORS colleagues for all your contributions. IFORS Member Societies remember your many 'Letters from the President' – your monthly communication to the OR world – which at that time was distributed together with the IFORS Bulletin. The first presidential letter appeared in January 1983. By issuing "No. 2" only a month later, there was pressure to produce the next ones – which you did, issuing 34 more letters.

On the occasion of your 50th birthday in 1986, the editors of *European Journal of Operational Research* (EJOR) agreed to publish all 36 letters in a single paper. Let me repeat this same message I wrote for the Editorial: '*Apart from giving his time and his professional and diplomatic talents, I venture to say that Heiner has also lent his heart to the tasks he has been asked to do for IFORS. Heiner and I have worked together in many IFORS situations ranging as they do from the location of a Triennial Conference to the mixing of a German punch bowl during an Administrative Committee gathering at his house in Darmstadt. I have watched how Heiner always attacks the problems with thoughtfulness, with tenacity of purpose and sincerity. I think that the latter is Heiner's secret – and his strength.*' 🌍

Acknowledgments

Thanks are due to Dr. Jens Müller-Merbach who in a mail reported on his father's last days, and to Heiner's secretary, Ms. Dagmar Schwarzer, who provided us with the link to the family.

Reference

J. Krarup, J. Lesourne, and H.R. Welling, "Editorial to 'Letters from the IFORS President'", EJOR 25 (1986) 421-422.



Obituary

John Forbes Nash Jr.

Mathematician

13 June 1928 - 23 May 2015

John Little* <jlittle@mit.edu>

"This man is a genius." Professor Richard Duffin of Carnegie Institute of Technology wrote a single sentence reference, recommending John Nash for the doctoral program in mathematics at Princeton in 1948. Nash graduated in 1950 and took a job in the mathematics department at MIT in 1951. From his thesis he published two papers: (1) "Equilibrium Points in n -Person Games" (1950), *Proc. Nat. Acad. Sci.* (The total text in what turned out to be a Nobel Prize paper was 317 words); (2) "Non-Cooperative Games" (1951), *Annals of Mathematics*. The latter developed Nash's results further and contrasted them with Von Neumann and Morgenstern's famous book, *Theory of Games and Economic Behavior* (1944), which Nash described as about "cooperative games" and his own work about "non-cooperative games," noting that the former are zero-sum whereas the latter need not be.

Nash's initial paper proved that, a finite non-cooperative game always has at least one equilibrium point, today called a Nash equilibrium. This has the property that no player can obtain a better payoff by changing her/his strategy, if the other players do not change theirs.

The important new field of non-cooperative games was born. It is a better model of many real world situations than a zero-sum assumption can produce. It is in common use today to analyze business, economic, and political phenomena.

In 1978 INFORMS honored Nash. INFORMS awarded the John von Neumann Theory Prize to John Nash and Carlton Lemke for their contribution to the theory of games. The theory of games was von Neumann's most distinctive contribution to the field of OR/MS. It seems fitting that the von Neumann Prize should be shared by Nash and Lemke, who were major contributors to the theory of non-cooperative games, the principal extension of von Neumann's original idea. Furthermore, the prevailing trend among mathematicians has been to search for "elementary" (i.e., algebraic) proofs in new results. This tended to treat all game theory as a branch of the theory of linear inequalities. Nash, however, had introduced a different approach with his idea of non-cooperative n -person games and his general existence theorem.

Nash's equilibrium proofs, however, were non-constructive and for many years it seemed that the nonlinearity of the problem would prevent the actual numerical solution of any but the simplest non-cooperative games. The breakthrough came in 1964 with an ingenious method for solving finite, two person games. Carlton Lemke and J. T. Howson devised it. It provided a path-following algorithm that was both a constructive existence proof and a practical means of calculation. Lemke took the lead in exploiting its many applications. The game theory aspect was strengthened because the path-following methodology is a way of finding and calculating Nash equilibria.

In 1994 the Nobel Prize in Economic Sciences was shared by John C. Harsanyi, John F. Nash Jr, and Reinhard Selten "for their pioneering analysis of equilibria in the theory of non-cooperative games." Nash's contributions were: "to introduce the distinction between cooperative games, in which binding

agreements are not feasible and to develop an equilibrium concept for non-cooperative games that is now called Nash equilibrium." Harsanyi and Selten each founded new subfields with new literatures and applications but they both trace their ancestry to Nash's first existence theorem.

Other important Nash research includes two path breaking papers in 1954 and 1956. They prove that "every Riemannian manifold can be isometrically embedded into some Euclidean space." These provided the basis of much subsequent mathematics. Later, after bouts with mental illness from which he gradually recovered, Nash did important work in partial differential equations.

In 1957 Nash married an MIT physics student from El Salvador, Alicia Lopez-Harrison de Larde'. However, in 1959 he was stricken by mental illness, diagnosed as paranoid schizophrenia. Alicia had him admitted to McLean hospital near Boston. He continued to have delusions that took him in and out of mental hospitals near Princeton until 1970. He was largely supported mentally and financially by the mathematics community and by Alicia Nash through her professional income.

*On a personal note, I was a doctoral student in physics at MIT from 1950 through 1954, overlapping Nash's first few years at MIT. In the late stages of my PhD thesis, I informally audited a course in real analysis for a few weeks. It happened to be taught by Nash. People ask me what he was like. I found him to be competent but not especially inspiring. As I remember, he seemed somewhat abstracted, as if focused on something else. The only idiosyncrasy I recall is that, if Nash were near the window, he would occasionally absent-mindedly fiddle with the venetian blind cord, while he answered questions. Although I did not know it at the time, in this period, he was working on two brilliant papers that were published in 1954 and 1956.

In 1998 Sylvia Nasar completed an extensive (461 pages) biography of Nash titled "A Beautiful Mind –The life of mathematical genius and Nobel Laureate John Nash." It was nominated for a Pulitzer Prize. Subsequently it was made into a movie "A Beautiful Mind." The picture received four Academy Awards, including best picture.

The director of the film, Ron Howard, said, "[The movie] captures the spirit of [Nash's] journey, and I think that it is authentic in what it conveys to a large extent. Certain aspects of it are dealt with symbolically. How do you understand what goes on inside a person's mind when under stress, when mentally ill, when operating at the highest levels of achievement. The script tries to offer insight, but it's impossible to be entirely accurate."

Of his portrayal by an actor in the film, Nash said: "It's not me, but Russell Crowe plays the part well." 🌐



Obituary

Philippe Van Asbroek

Permanent Secretary of EURO

30 September 1931 - 28 July 2014

Martine Labbé* <mlabbe@ulb.ac.be>

Philippe was appointed permanent secretary of EURO in 1993, a post he held until 2012. He prepared all EURO official documents for executive committee meetings. The only permanent member of the executive committee, he provided the organization's institutional memory, and you might say, was the soul of EURO. He was also one of those who initiated the IT transformation of EURO and the construction of its website.

He graduated as an Engineer in 1956 from the Katholieke Universiteit Leuven and got a Master degree in Econometrics from the Université Libre de Bruxelles in the 60's. Philippe spent the first part of his professional career as an engineer at the Center for Nuclear Studies in Mol. In 1986, he decided to start a second career.

A fresh academic at the Université Libre de Bruxelles in the early 90's, I met Philippe as he helped organize the university research production. Later, I had the privilege to know him from the EURO side when I became president elect. I appreciated very much his efficient help and his wise and subtle advice.

Others in EURO had likewise good words for him. Maurice Shuttler appreciated that Philippe agreed to be the first 'manager' of the EURO Office and stayed long in the post. Maria Grazia Speranza recalls his many interests and the support he gave, his kindness, and his smile. Denis Bouyssou, secretary

of EURO from 1995 to 2003, says he introduced Philippe to the writings of Vasquez-Montalban and his famous main character Pepe Carvalho. Marino Widmer, EURO Treasurer, had frequent discussions with Philippe about comic strips.

On a personal side, I had many unforgettable moments and passionate discussions with him. We travelled together to attend EURO and IFORS conferences, which include Prague, Vilnius, Hawaii, Sandton, Edinburgh, Beijing, Lisbon, Bohn, Reykjavik, and Rhodes. For him, these were occasions to discover the region, its gastronomy, literature, and music.

Philippe was always eager to learn and be an active member of today's society, not to mention his passion for IT and informatics. An example of open-mindedness and wisdom, he could always be expected to ask insightful questions. It was exciting to discuss philosophy, education, and history with him. Lastly, he understood what was important in life - his family. He leaves his daughters Dominique and Isabelle, his son Benoit and his ten grandchildren.

By having contributed to the shaping of EURO, Philippe will always remain in the hearts of those who were or are involved in EURO. 🌍

*Based on the eulogy delivered by M. Labbé during the Opening Ceremonies of EURO 2015

Conferences

IFORS 2020 Hosting Bids Shortlisted



IFORS President Nelson Maculan is pleased to announce that after a careful evaluation of all proposals, the Administrative Committee has selected two outstanding bids to enter the final round of voting for hosting the 2020 IFORS Triennial Conference. Member societies will be asked to cast their votes starting October to select from the two candidate sites proposed by the following member societies:

- **Seoul**, by the Korean Operations Research and Management Science Society; and
- **Istanbul**, by The Operational Research Society of Turkey.

Both Seoul and Istanbul are very accessible from many major cities in the world.

Executive summaries of both proposals along with a ballot for each member society will be sent out by mail and posted in the IFORS website at <http://ifors.org/web/cast-your-vote/> before the end of October, 2015. Ballots may be mailed or cast on-line.

The IFORS2020 Host Society will be chosen by a simple majority on a three-month ballot. Relevant materials will be posted at the IFORS website during the voting period. 🌍



13th EUROPT: Auld Reekie Blows Optimizers Away

Tomas Bajbar <bajbar@kit.edu>, **Gerhard-Wilhelm Weber** <gweber@metu.edu.tr>, **Ozan Kocadagli** <ozan.kocadagli@msgsu.edu.tr>

This year's workshop on Advances in Continuous Optimization (EUROPT 2015 <http://www.maths.ed.ac.uk/hall/EUROPT15/>) of EURO Working Group EUROPT (<http://europt.iam.metu.edu.tr/>) within The Association of European Operational Research Societies (EURO <https://www.euro-online.org/>) was held from July 8 to July 10, 2015 in Edinburgh, Scotland. It was hosted by one of the Europe's top research universities, University of Edinburgh.



▲ Playfair Library Hall, conference dinner venue

which counts as one of its visitors in 1726 Daniel Defoe, an English writer, mostly known for his famous novel Robinson Crusoe. The conference dinner took place in the beautiful, neoclassical, barrel-vaulted Playfair Library Hall in the University of Edinburgh's Old College, created by the great Scottish Architect William Henry Playfair.

The inspiring atmosphere certainly overwhelmed participants as knowledge and experience were

The annual workshop gathered some famous and leading researchers, specialists and young researchers in the fields of mathematical optimization in this charming city of Scotland. In the plenary talks, *Panos Pardalos*, the newly appointed EUROPT Fellow 2015 (Department of Industrial and Systems Engineering, University of Florida) in his plenary talk addressed the history of the development of nonconventional computer models, such as quantum or DNA computer architectures, as an attempt to solve some of the intractable optimization problems which are very difficult to solve. *Serge Gratton* (University of Toulouse) presented some of the recent computational results on multigrid approaches for large scale non-convex optimization problems, making some of the large scale real-world problems arising e.g., in physics or industry, efficiently solvable. *Lieven Vanderberghe*, (Electrical Engineering Department, University of California Los Angeles) spoke about chordal graphs and their applications in sparse semidefinite programming. *Sven Leyffer*, (Argonne National Laboratory) addressed the PDE-constrained mixed integer programming problems, which arise in various engineering applications, discussed the existing approaches to solve these problems and pointed out some of their emerging applications.

shared during the plenary talks and parallel sessions. The social activities provided many networking opportunities in terms of starting projects and discussing future works in the authentic and charming Scottish ambiance .

Programme Committee Chair *Jacek Gondzio* (Edinburgh University) and Organizing Committee Chair. *Julian Hall* (Edinburgh University) put in all their efforts in making the Workshop the great success that it was.

EUROPT 2015 was held in the collaboration with the EURO 2015 (27th European Conference on Operational Research, Glasgow. Ever since its founding in 2000, the EURO working group EUROPT has been a strong contributor to the international OR community through EURO, which in turn, has fully supported its activities.

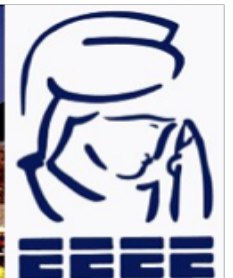
The conference took place at the George Square, not far away from the Royal Mile - a collection of four ancient streets that formed the main boulevard of the medieval Edinburgh. The welcome reception took place in the Fellows Library of the Royal College of Surgeons of Edinburgh, also known as "Surgeon's Hall";

Affectionately called *Auld Reekie* for *Old Smoky*, Edinburgh was a smoke covered Old Town which has since been transformed to the historical and cultural centre of Scotland. Its remarkable medieval districts and Georgian architecture sites are vivid remnants of the with glorious bygone days of the British Empire. Entering the city centre via Princess Street with a tram from the Edinburgh airport, the Edinburgh Castle - a historical architectural monument standing upon a granite core of an extinct volcano, overseeing the whole city, gives a visitor just a small foretaste of what the rest of the city has to offer. It is no wonder then that the EUROPT participants were more than inspired! 🌍



Chania Beacon Beckons OR Community

Evangelos Grigoroudis <vangelis@ergasya.tuc.gr>



The 4th International Symposium and 26th National Conference on Operational Research of the Hellenic Operational Research Society (HELORS) laid out a warm welcome to delegates last June 4 to 6 in Chania, Crete. Chania's lighthouse is among the 21 most famous in the world, and in much the same way that lighthouses enabled seamen to locate land, the conference aimed to gather together the OR community and provide direction by disseminating recent scientific advances in operational research

and management science (OR/MS) and promoting international co-operation among researchers and practitioners working on OR/MS.

Evangelos Grigoroudis and Michael Doumpos, from the School of Production Engineering and Management of the Technical University of Crete, Greece chaired the conference.



▲ The board of HELORS and the organizers join awardee Samouilidis (6th from left) during the opening session.

The scientific program of the Conference included 85 presentations by Greek and foreign researchers. The covered topics included all recent advances in operational research, including new methodological developments as well as applications and case studies in a wide range of fields, such as energy and the environment, management, logistics and supply chains, finance, transportation, public services and healthcare.

Invited plenary talks were given by Emmanuel Thanassoulis (Aston University, UK) and Athanasios Migdalas (Aristotle University of Thessaloniki, Greece).

During the opening session of the Conference, Emmanuel Samouilidis, Emeritus Professor at the National Technical University of Athens was bestowed the national award on operational research by HELORS for his contributions to the local and international development of operational research.

The proceedings of the Conference are available in electronic form (ISBN: 978-618-80361-4-7) through the website of the Conference: <http://www.helors2015.tuc.gr>.

Selected papers will be published after the review process in a special issue of the International Journal of Decision Support Systems, as well as in an edited volume that will be published by Springer in its book series Springer Proceedings in Business and Economics. 🌐



IFORS President Graces Industrial and Applied Mathematics Conference in Beijing

Degang Liu <dliu@amt.ac.cn>

IFORS President Nelson Maculan participated in a joint workshop with Chinese Academy of Sciences colleagues during the 8th International Congress in Industrial and Applied Mathematics (ICIAM) held from August 10 to 14, 2015 in Beijing. Held every four years, ICIAM hosted some 3,400 participants from over 70 countries at the China National Convention Center inside the Beijing Olympic Green. The Operations Research Society of China (ORSC) was one of the event sponsors.

China Vice-President Li Yuanchao opened the conference and congratulated the ICIAM Prize recipients. He was joined by ICIAM President Barbara Keyfitz and Congress director Guo Lei in welcoming the delegates.

With 31 invited and prize lectures, one public lecture, as well as 2900 contributed papers presented during plenary sessions, mini symposia, satellite and embedded meetings, this was the largest in ICIAM history in terms of number of papers and participants. ORSC helped organize streams on Optimization and Operations Research, Finance and Management Science, and Computational Science in Industry, among others.

This academic event was widely praised by delegates, even as local scientists cited its far-reaching impact on the development of Industrial and Applied Mathematics in China. Valencia, Spain was announced during the closing session as the site of the 9th ICIAM to be held in July 2019. 🌐



Iranian Society Hosts 8th International Conference

Nezam Mahdavi-Amiri <nezamm@sharif.ir>

The Eighth International Conference of Iranian Operations Research Society was held from May 21-22, 2015, at Ferdowsi University of Mashhad, Mashhad, Iran <http://or8.um.ac.ir>. Submitted papers (from Iran and other countries including Australia, China, Italy, Sweden and USA) numbered 350, of which 115 were accepted as oral presentations and 81 as posters. There were 600 registered participants. The invited speakers were: Tamás Terlaky (Lehigh University, USA), Baoding Liu (Tsinghua University, China), P. Serafini (University of Udine, Italy), Adil Bagirov (Federation University, Australia), Franco Giannessi (University of Pisa, Italy), N. Mahdavi-Amiri (Sharif University of Technology, Iran), M. Modarres Yazdi (Sharif University of Technology, Iran) and A. Seifi (Amir Kabir University, Iran). IORS also conducted workshops in Persian on three topics, each held for two hours. The invited speakers' presentation videos can be accessed at <http://or8.um.ac.ir/>.



▲ Participants take time out for a group picture.

The society also published in this period, the Iranian Journal of Operations Research, Volume 5, Number 1, with 7 original articles (<http://www.iors.ir/journal>). 🌐

Joint ORSC/EURO Conference Paves Way for East-West OR Collaboration



Milagros Baldemor <milagros_baldemor@yahoo.com.ph>
Degang Liu <dliu@amt.ac.cn>
Gerhard-Wilhelm Weber <gweber@metu.edu.tr>

The first *Joint ORSC/EURO International Conference on Continuous Optimization* was held at Shanghai University, China, from May 10 to 22 (<http://orsc-euro2015.csp.escience.cn>). The Operations Research Society of China (ORSC <http://www.orsc.org.cn/>) President Xiaodong

Hu, and the Association of European Operational Research Societies (EURO <https://www.euro-online.org/>) Past President *Gerhard Wäscher* were on hand to oversee the conference.

The program was highlighted by the plenary talks of four well-known experts in the field of continuous optimization, as follows: *Yaroslav Sergeyev* (University of Calabria, Italy) on *Lipschitz Global Optimization*; *Dongdong Ge* (Shanghai University of Finance and Economics, China) on *The Complexity and Algorithms of Regularized Least Square Problem*; *Yaxiang Yuan* (Chinese Academy of Sciences, China) on *Recent Advances in Trust Region Algorithms*; and *Vladimir Shikhman* (Catholic University of Louvain, Belgium) on *the Algorithmic Models of Market Equilibrium*.

Of the abstracts received by the program committee, only 86 were accepted for presentation. Four parallel tracks featured the final papers covering such topics as: subspace global and control, stochastic, conic and tensor, non-linear and multi-objective optimization and their applications in the fields of: finance, economics and science, mathematics, programming, advertising, budgeting, productivity, hospital capacity management, marine fishery industry, water quality management, marketing, data envelopment analysis, location routing, information system for operational state estimation in complex machines, health care management, robust simulation of stochastic systems, fingerprint recognition, petrochemical industry, optical tenement application for alleviating traffic jams, aeronautics, hybrid energy, and procurement planning.

Of the 220 delegates, 60 were from Europe, USA and other Asian countries. Every one of them benefited from the informative and interesting lectures and presentations. A welcome reception took



▲ Participants gather for the traditional group picture.

place on the evening of the first day at the Lehu Hotel Chinese Restaurant where research scientists and optimization experts took time to get to know one another. The riverboat tour and dinner was a special treat, complete with the impressively lit night sights of

Shanghai. The iconic Bund and Pudong's Skyline witnessed old friendships deepen and new ones made, very valuable for scientific collaboration and future service to the OR community.

Yanquin Bai and *Gerhard-Wilhelm Weber*, co-chairs of the Organizing Committee with Program Committee co-chairs *Yuhong Dai* (President of the Mathematical Programming Subsociety of ORSC) and *Julius Zilinskas* (Chair of EURO Working Group on Continuous Optimization, EUROPT), expressed their deep gratitude to the participants and to the organizers for the success of the conference. Participants, in turn, were very impressed with the hospitality of the local organizing and service team as well as the conducive and world-class facilities of the conference venue. The positive experience left the participants looking forward to future conferences, such as the *EURO 2015* and *2016*, and *EUROPT 2016*, in Glasgow and Poznan and Warsaw, respectively. A second *Joint ORSC/EURO Conference* is planned in two years.

The idea of the joint event between EURO and ORSC was first proposed by then EURO President G. Wäscher in September 2013. After several discussions with ORSC and EURO leaderships regarding the theme, concept, and organization, plans were finalized during the IFORS Barcelona in July 2014. This was followed up with Wäscher's Beijing visit in November 2014. The detailed preparation resulted in the realization of the first joint EURO/ORSC international conference, a promising platform in the promotion of academic communication and cooperation not only between Chinese and European researchers and practitioners in the field of continuous optimization, but also among other interested international academicians and researchers. 🌐

ECCO28: Bellowing Brilliance at the Foot of Mount Etna

Silvano Martello <silvano.martello@unibo.it>

ECCO, the European Chapter on Combinatorial Optimization, held its annual spring meeting at the foot of Mount Etna, Catania in Sicily on May 28-30, 2015. The ECCO XXVIII attracted 90 participants and featured 75 presentations at the conference venue, the Department of Economics and Business of the University of Catania, in the Palazzo delle Scienze building.

Delivering well-received plenary lectures were: Jack Edmonds on *Existential Polytime and Polyhedral Combinatorics*; Tamás Kis on *Machine Scheduling with Non-Renewable Resources*; Erwin Pesch on *Optimization Problems in Intermodal Transport*; and Roman Słowiński on *Preference-Driven Evolutionary Multiobjective Combinatorial Optimization With Choquet Integral Preference Model*. The Program and Organizing Committees were chaired by Salvatore Greco and Benedetto Matarazzo.



▲ (l to r): Salvatore, Paolo, Van Dat, Jack, Benedetto take time for a picture during the conference.

The social activities included an excursion to Taormina, where the participants visited the ancient Greek theater and then enjoyed the banquet held in a typical fish restaurant. The next ECCO conference, organized by Tamás Kis, will take place in beautiful Budapest, from May 26 to May 28, 2016. ECCO is a EURO Working Group created in 1987 and today counts over 1,300 members. Chaired by Silvano Martello, the group includes in its Advisory Board: Jacek Błazewicz, Van-Dat Cung, Alain Hertz, and Paolo Toth.

Its latest conferences were held in Capri, Bonn, Lugano, Molde, Beirut, Minsk, Porto, Cyprus, Dubrovnik, Jerusalem, Malaga, Amsterdam, Antalya, Paris, and Munich. In this same period, thirteen special issues dedicated to the ECCO conferences

have appeared: eight in the European Journal of Operational Research and one each in: Computational Optimization and Applications, Journal of Scheduling, Annals of Operations Research, Optimization, and Discrete Applied Mathematics (in print). Another special issue of Discrete Applied Mathematics, edited by Bo Chen, Peter Gritzmam and Silvano Martello, is set to appear in 2016.

Submissions are currently encouraged for a special issue of the EURO Journal on Computational Optimization dedicated to the Catania conference and open to all ECCO members. (Submit online at <https://www.editorialmanager.com/ejco/> by selecting, as Article Type, \SI: Computational Advances in CO"). Deadline for submission is December 15, 2015. 🌐

An Unforgettable ESI Experience in Hungary

Roohollah Abbasi Shureshjani <roohollah31@gmail.com>

Organized every year in one of the European countries, the European Summer Institute (ESI) was held in Szeged, Hungary from June 15 to 26, 2015. The theme of ESI XXXII was *Online Optimization* <http://eswi.uszeged.hu/> and the venue was the University of Szeged at the Faculty of Education. Twenty early stage researchers (PhD students and those who had less than two years research experience post PhD) from the EURO member societies were invited to participate.

By the agreement between EURO and IFORS, one participant could be sponsored by IFORS from a non-EURO member society and I was very lucky to be given this opportunity. I presented my paper on *Solving Generalized Fuzzy Data Envelopment Analysis Model: A Parametric Approach*. Every participant was given 30 minutes for the paper presentation and allotted 10 minutes for the question and answer period.

Listening to the works of colleagues was enriching. Equally enlightening were the various topics covered in the mini courses given by the invited speakers, which included: Sandor Fekete who spoke on *Online Navigation*; Joan Boyar on *Advice Complexity, Relative Worst Order Analysis*; Jiri Sgall on *Randomization in Online Scheduling*; Gerhard Woeginger on *Covering Problems*; Gabor Galambos on *Online Bin Packing*; Leah Epstein on *Online Problems with Rejection*; Piotr Krysta on *Algorithmic Mechanism*



▲ The experts of tomorrow are born here!

Design; and Csanad Imreh on *Online Clustering Problems*. These talks covered a wide range of topics and were new to most participants. Therefore, the relaxed and friendly atmosphere encouraged by the speakers facilitated the learning and exchange.

The high quality technical presentations were

complemented by the social events, which included a visit to the Museum of Informatics, which has an extensive collection of over 12000 objects tracing the history of computing. The Opusztaszer National Heritage Park enabled the participants to be acquainted with the history, culture and life-style of the Hungarian people. Other places visited were the Aqua polis of Szeged and the Natural Museum of the Faculty of Education. The tours included a boat excursion on the Tisza River and a Szeged city tour.

Some of the papers presented will be published in a special issue of an OR publication. The experience had been one of learning more in my field, knowing other cultures and peoples, and networking with colleagues from other countries. I had been presented with an invaluable experience and my heartfelt gratitude goes to IFORS for this rare opportunity. Special thanks are due to the ESI organizing committee, and to Prof. Csanad Imreh, Chair of the ESI XXXII, for their efforts in bringing about an activity that all the participants will find hard to forget! 🌐

Publications Improved Impact Factor for ITOR Released

Celso Ribeiro announced during the **International Transactions in Operational Research** (ITOR) Editorial Board meeting held July 13 at the EURO 2015 in Glasgow that ITOR's impact factor has improved considerably, from 0.481 in 2013 to 0.977 in 2014. This puts ITOR at 49th out of 81 titles in the ISI's Operations Research and Management Science category, and 113th out of 185 titles in the general Management category.

It will be recalled that ITOR was accepted into the Social Sciences Citation Index (SSCI), Current Contents: Social and Behavioural Science, and the Science Citation Index Expanded (SCIE), Current Contents: Engineering, Computing and Technology only last 2011. The journal Impact Factor provides a quantitative index for journal evaluation. The impact factor is a measure of the frequency with which the "average article" in a journal has been cited in the two years following its publication.



▲ ITOR Editorial Board present at the meeting were (l to r, seated): Dominique de Werra, Peter Bell, Michel Gendreau, José Fernando Gonçalves, Kathryn Stecke; (l to r, standing) IFORS President Nelson Maculan, Sonia Cafieri, Rudolf Vetschera, Editor Celso Ribeiro, Elise del Rosario, Janny Leung, Theo Stewart, and Jan Weglarz

ITOR receives submissions from more than 80 countries, showing that ITO is truly a well established international journal. The Editor cited the quick refereeing times which average less than 4 months. He mentioned other statistics such as the acceptance ratio of papers at 21%. The publication is on the uptrend, with the record number of 50 papers published and 1,064 pages printed in 2014. The journal has also experienced a substantial increase in the number of paper submissions from 68 in 2007, to 361 in 2014 and to about 600 (estimated) in 2015. This puts a pressure on the editorial board.

The ITO editorial board is currently composed of 58 editors from 23 countries. Those present at the Glasgow meeting commended the progress made by ITO and congratulated ITO editor Celso Ribeiro whose commitment, dedication, and strategies brought all the good news possible. 🌐

OR IMPACT

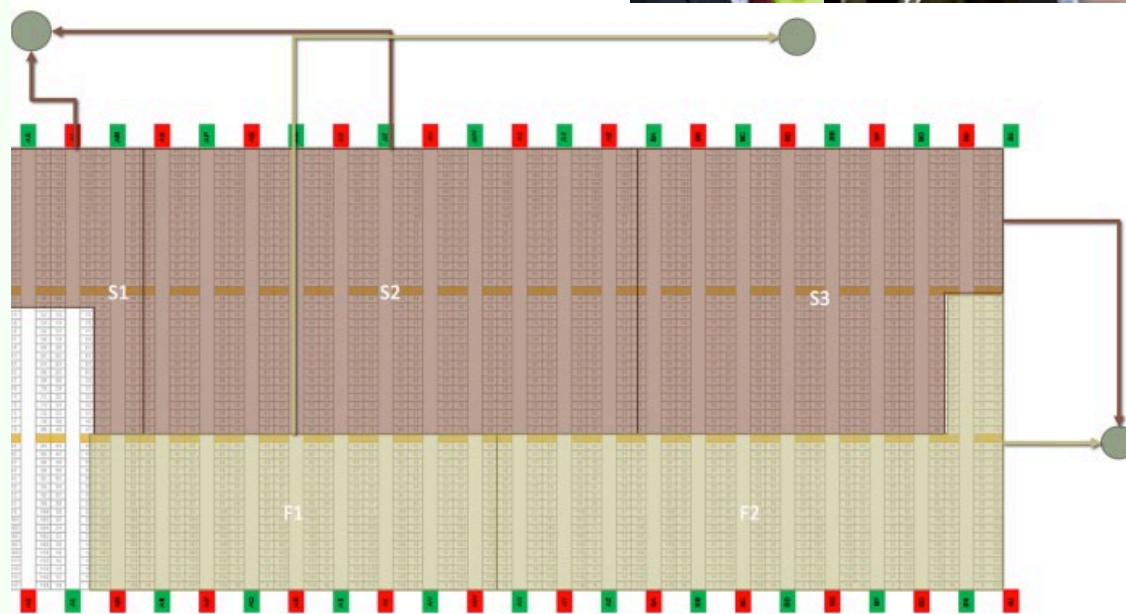
Articles demonstrating direct benefits from implementing OR studies

Section Editors: Sue Merchant <suemerchant@hotmail.com>, John Ranyard <jranyard@cix.co.uk>

Reducing Warehouse Picking Travel Times using OR

João Alves <jlalves@inesctec.pt>, Mário Amorim Lopes, Luís Guimarães and Bernardo Almada-Lobo, INESC TEC and Faculty of Engineering, University of Porto, Portugal

Distribution warehouses are a critical part of a seamless supply chain. Unautomated, labour-intensive warehouses contribute significantly to operating costs, thus presenting opportunities for efficiency gains. Of the operations typically performed at a distribution warehouse, manually picking items to fulfil orders is one of the costliest. In particular, travelling between picking positions is very time-consuming. Therefore,



▲ Fig 1 The Warehouse Layout (In each group of aisles the order picker can only move in one direction, from green to red and can cross groups of aisles using the path marked in yellow)

aisles that are one way only to prevent traffic jams (Figure 1). Each location of the PRS is five storeys high. Items stored at ground level are in picking positions and the remaining storeys serve as reserve positions to enable the picking level items to be replenished. Each product only has one picking position. Pickers use electric order picker vehicles and a voice picking system to assist them in their task. The warehouse has five distinct picking zones (Table 1).

minimizing travel times can help to bring costs down. This study enabled potential reductions of travel times of up to 26% and the consequential reduction in staff numbers.

The Client

The study was done for one of the distribution warehouses of a large, multinational specialized retailer. The warehouse stores and dispatches products from two main divisions: a Fashion Department (FD) and a Sports Department (SD). Both departments have clothing lines, but SD also deals with sports apparel and footwear, as well as large equipment. In total, over 7,000 products are active at any given moment. As expected, fashion items have a very short life cycle, ranging from one month to a year, while sports equipment and apparel typically have a longer life cycle. Combining both types of products is itself a challenge.

The warehouse has a Pallet Racking System (PRS) separated by

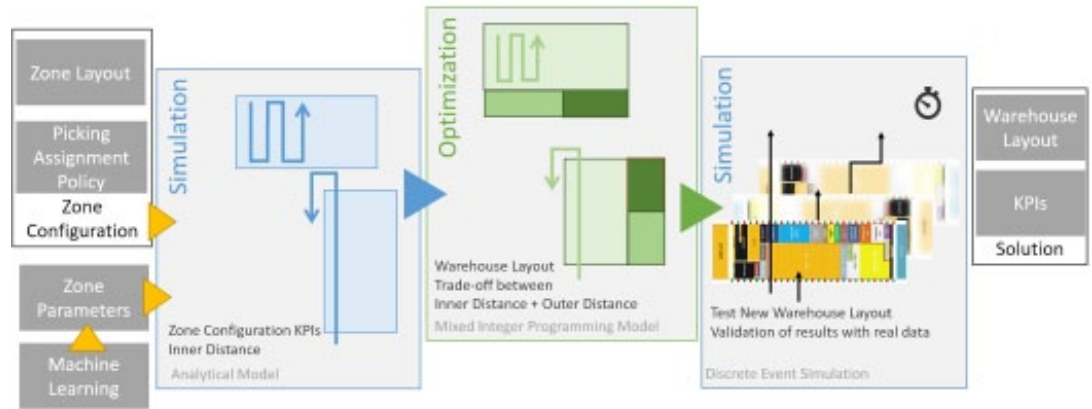
Table 1. Zone Description

Division	Zone	Product types
SD	S1	Sports energy drinks, consumables
SD	S2	Sports footwear
SD	S3	Sports clothing and equipment
FD	F1	Nursery
FD	F2	Clothing

A new product is automatically assigned to the first free location within its zone. This study puts in place a decision tool that locates a new product within the warehouse in a way that minimizes the picker's travel distance, and therefore, travel time.

Methodology

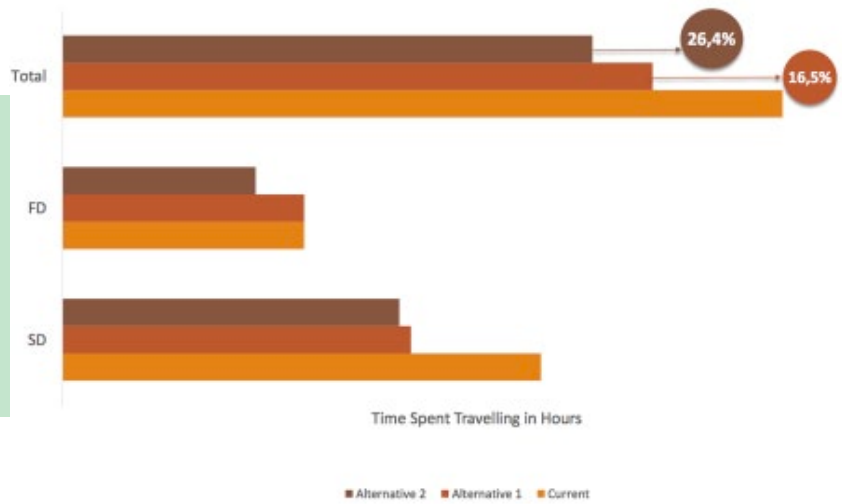
Improvements to the warehouse picking flow can be achieved at two levels: (i) within each zone, defining the picking location for each product through an optimized storage assignment policy; and (ii) at the layout level, defining the location for each zone within the warehouse. While the first level will have an impact on the distance travelled between picking positions (inner-distance), the second level will affect the distance travelled to the drop points



▲ Fig 2 The Simulation-Optimisation-Simulation (SOS) Methodology

Since most products have a very short life cycle with demand varying according to unstable fashion trends, the team used machine learning based on over two years of historical data, aggregated by typology (size, family, etc.), to estimate whether a product belonging to a particular category was likely to be frequently ordered or not.

(outer distance). For analysing improvements targeting both levels, a three-stage Simulation-Optimization-Simulation (SOS) methodology was devised. (Figure 2).



▲ Fig 3 The Predicted Reductions in Travelling Times from the Alternative Policies

The first stage consists of a novel probabilistic micro-simulation model for studying the picking performance inside the zone while considering different zone layouts and storage assignment policies. This yields average travel times for each setup (e.g., horizontal or vertical positioning, random storage assignments, etc.) and for varying order sizes. The second stage comprises a mixed integer programming optimization model that takes all the simulations obtained in the first stage for each of the five zones. It produces a macro layout that optimizes the overall warehouse flow considering the distance to the drop points and the total distance travelled inside the warehouse. The final stage is a full-blown discrete event simulation model that is used to

replicate the warehouse operations and test the optimized solutions under uncertainty.

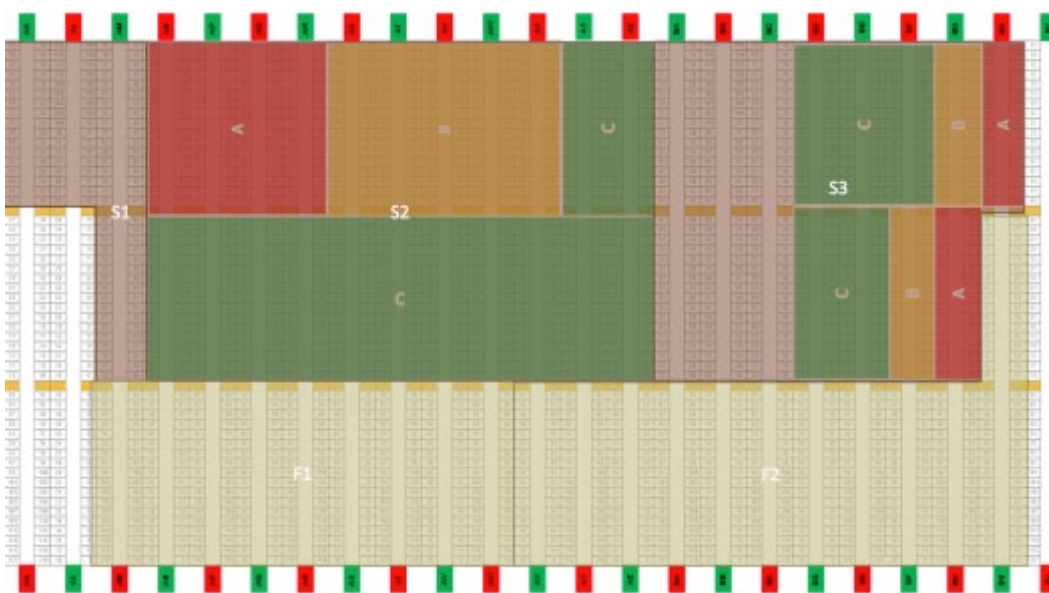
Following the promising results obtained in the first simulation stage, the researchers suggested a Cube per Order Index (COI) variation to the standard ABC policy for prioritising stock importance. COI is a measure that classifies products according to the frequency by which they are retrieved, as well as the number of storage locations they require. Since most products have a very short life cycle with demand varying according to unstable fashion trends, the team used machine learning based on over two years of historical data, aggregated by typology (size, family, etc.), to estimate whether a product belonging to a particular category was likely to be frequently ordered or not.

replicate the warehouse operations and test the optimized solutions under uncertainty.

Results

Using this methodology, two alternative layouts to be used in the warehouse were presented. The results of each solution can be seen in Figure 3.

The first solution does not require changes to the current macro layout, only introducing the implementation of a COI-based ABC policy at the zone level, as shown in Figure 4. A saving in travelling costs of 16.5% can be achieved and the implementation costs are small.

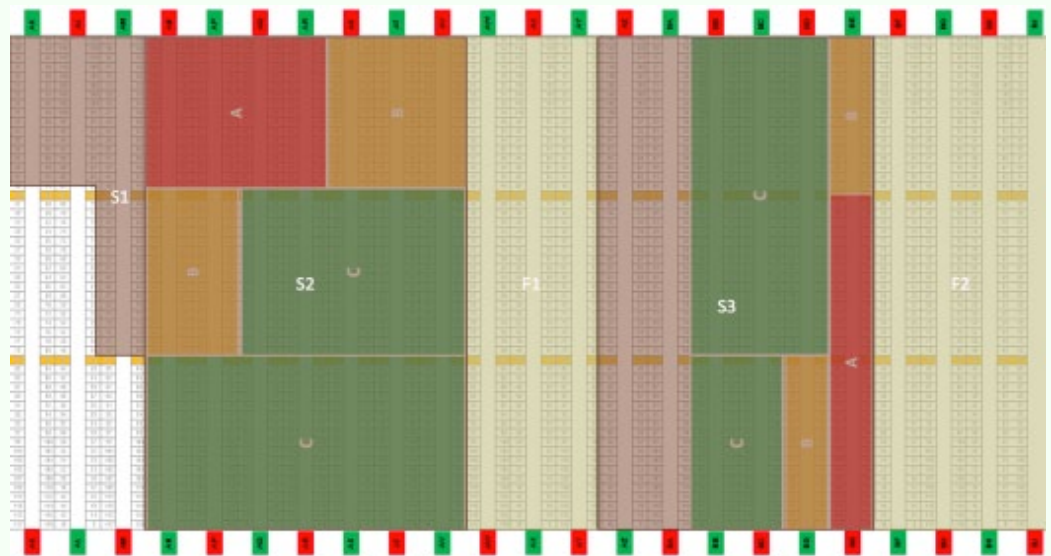


▲ Fig 4 Results from Optimising the Current Layout

The second solution presented to the warehouse managers was an optimized layout along with a COI-based ABC policy at the zone level. This achieves a better trade-off between the inner and outer distance travelled in the warehouse (a 26.4% reduction in travelling times), resulting in higher productivity gains. However, significant implementation costs would be incurred. The optimized layout can be seen in Figure 5.

In summary, apart from providing a tool to determine where new products are best located, the SOS methodology allows for a comprehensive study of the warehouse picking performance, as well as testing out new picking assignment policies.

Currently, the first solution is being implemented and tested



▲ Fig 5 Results from Optimising at the Zone Level

in the warehouse. The client comments: "The main objective of this endeavour was to reduce picking travel times and the results were so positive that we are currently implementing the proposed solution and validating the results." 🌐

Tutorial

Unsold Versus Unbought Commitment: Inventory Control and Procurement Contracts

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Procurement is fast becoming one of the more important strategic functions in the business world. Traditionally, its role is to ensure cost, quality and supply. Today, its role has expanded to include finding ways to gain competitive advantage for the firm. One of these ways is the design of contract terms between upstream suppliers and the downstream buyer, with the typical objective of achieving a good balance between supplier stability and buyer flexibility.

One of the more popular contract types is the Minimum Total Commitment (MTC) contract, which stipulates that for a fixed number of periods, the buyer is required to purchase a minimum total quantity. In exchange, the buyer gets better terms from the supplier such as discounted purchase cost or shorter lead time. For example, Stanley Black and Decker, a manufacturer of home improvement DIY tools, managed to negotiate a lead time reduction from four weeks to two weeks using an MTC contract with its supplier. This contract is also commonly used in other industries such as electronics (Dell), aviation (American Airlines), pharmaceuticals (Merck), and mining (Tally Metals). In fact, MTC contracts are so widespread that most Enterprise Resource Planning (ERP) software providers such as SAP have provisions for such MTC feature called master contract or blanket contract.

While the benefits of MTC contracts are clear, designing the terms of these contracts requires much data and analysis. For instance, the supplier must understand how the buyer will behave after a contract is signed and how he will choose among a menu of contracts that the supplier or its competitors may offer. Or the buyer, as in the case of Stanley Black and Decker, may propose contract terms or negotiate offered contracts in anticipation of future actions. This is where operations research, with its collection of tools such as optimization, stochastic modeling, dynamic programming and game theory, can contribute.



To analyze a given contract, we need to study how the buyer will behave throughout the contract duration. In inventory theory parlance, the buyer solves a periodic-review finite-horizon stochastic inventory problem. This is a classic problem that has already been studied as early as the 1950s. The most important contribution of operations research to classic inventory theory is proving that the optimal ordering policy is a base-stock policy when there is no fixed ordering cost and (s,S) policy when there is a fixed ordering cost. In the former case, at the beginning of each ordering period, the buyer orders enough to bring the inventory level up to a base-stock or order-up-to level. For example, if the base-stock is 100 and the inventory level is 25, the buyer orders $100 - 25 = 75$ units. In the latter case, a fixed ordering cost (e.g. administrative costs, handling, transportation) is incurred regardless of the order size. The buyer now has incentive to collect orders rather than place orders every period. The optimal policy is to place an order whenever inventory level is sufficiently low, that is lower than s . He then brings the inventory up to S , that is, order $S - x$ where x is the inventory level. If inventory is greater than s , he does nothing in that period.

This is an important result for at least two reasons. First, it is intuitive, hence easy to communicate to practitioners and easy to implement.

Second, the optimal policy is typically searched using dynamic programming. With knowledge of the structure of the optimal policy, the search reduces to finding the base-stock level or the values of s and S . This is a substantial reduction in the computational complexity of the problem.

The bad news is that the above result is for the case without MTC. The presence of MTC introduces a joint constraint across all periods involved. Dynamic programming can still handle this by introducing another state variable, which would naturally be the remaining commitment not yet bought from the supplier at the beginning of the period. However, the base-stock and (s,S) structures can no longer be established. For many years, this has been the prevailing thought in inventory literature.

Recently, we proposed a new way to study this problem by introducing the distinction between unbought commitment and unsold commitment. Unlike unbought commitment, unsold commitment includes both unbought commitment and the inventory at the buyer. The table below shows a three-period example. In each period, we tabulate demand, inventory, and these two types of commitments before ordering, after ordering the units in parentheses and after demand in parentheses occurs.

Interestingly, we find that by simply tracking unsold commitment instead of unbought commitment, the optimal policies once again become base-stock and (s,S). As one can see in the table above, while unbought commitment changes each time an order is placed, unsold commitment evolves independently of ordering decisions and depends only on cumulative demand.

We believe that our work can be a building block for operations research to solve larger supply chain procurement problems. For instance, while the supplier prefers minimum order quantity

Period	Cumulative Demand	Inventory Level	Unbought Commitment	Unsold Commitment
1 – before order	0	0	10	10
1 – after order (2)	0	2	8	10
1 – demand (1)	1	1	8	9
2 – before order	1	1	8	9
2 – after order (1)	1	2	7	9
2 – demand (3)	4	-1	7	6
3 – before order	4	-1	7	6
3 – after order (4)	4	3	3	6
3 – demand (2)	6	1	3	4

(MOQ) in each period and the buyer prefers MTC, we find that neither MTC nor MOQ is consistently better in terms of total supply chain performance. The preferred contract depends on factors such as commitment level, the supplier's unit production cost and order variability penalty. Another useful idea we found is to use multiple two-period contracts as a compromise between the extremes of MTC and MOQ where both parties sacrifice the least. There are more questions to ask and more problems to solve. This is just the tip of the iceberg! 🌍

This article is based on the following forthcoming article in POM: Q. Yuan, G.A. Chua, X. Liu, Y.F. Chen. (2015). Unsold versus Unbought Commitment: Minimum Total Commitment Contracts with Nonzero Setup Costs. *Production and Operations Management*, Forthcoming.

The Norwegian OR Society: New Member, Old Hand

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The Norwegian OR society has existed for a long time within IFORS, but in a rather peculiar way. This society had little or no contact with OR at all. At the same time, there was a large Norwegian OR community, very active internationally, even within EURO, but with no formal ties to EURO and IFORS, save for the fact that some of us were members of other national societies.

In early fall of 2013, I tried to solve this problem by bringing up, with all OR people I knew, the idea of establishing a genuine OR society. The idea caught on at the same time that the existing IFORS member society agreed to withdraw from IFORS. The coast was clear for us to organize, produce bylaws, call for elections, and apply for IFORS membership. The new NORS was accepted into IFORS last March 2015.

Understandably, we are very happy to finally find our place in the family of OR Societies not only to gain access to the resources of our bigger community but also to contribute and play an active role where needed. It is to be noted that even before its formal membership in IFORS, NORS participated in the 2012 EURO in Vilnius (two of us were on the Programme Committee, with Marielle Christiansen chairing), organized VeRoLog 2014 in Oslo (chaired by Geir Hasle); and is currently organizing EUROCOMB 2015 with The University of Bergen.

On the purely academic side, Norwegian OR is primarily found in Trondheim and Bergen, but is also developing in Molde. The founding fathers of OR in Trondheim and Bergen were Bjørn Nygreen and Sverre Storøy. The main institutions are The Norwegian University of Science and Technology, The Norwegian School of Economics, The University of Bergen and Molde University College. These four institutions - an engineering school, a business school, an informatics department and a school specialized in logistics - give OR a wide exposure in Norway.

The other flavor of OR in Norway is found in the applied research setting. A founder of applied OR in Norway was Ralph Lorentzen, who initiated early work in telecommunications. SINTEF and MARINTEK, based in Oslo, Trondheim and Bergen are the centers of applied research in a wide range of areas, to wit: transportation, logistics and shipping, fisheries, and energy systems (electricity, oil and gas, wind; planning, production and bidding).

In transportation and logistics are important applications in food processing, upstream petroleum logistics, distribution and routing. The academic institutions are likewise active in these areas, both in theory and practice.

The new OR society has around 80 members from across the country, covering universities, applied research institutions, government and industry. It is a tightly knit society with a lot of cooperation both on research and PhD education. We commonly co-supervise PhDs in other institutions, and we organize PhD courses at a national level, realizing that we are all too small to set up complete PhD course programs individually. By pooling our resources, we are able to focus on what we are good at, while accommodating a greater number of students. It is also worth noting that the Norwegian OR community is very open to a wide range of international cooperation in terms of research, PhD co-supervision and the delivery of PhD courses.

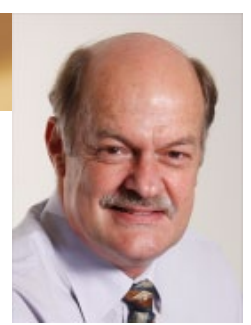
The board of the new NORS consists of: Stein W. Wallace, Norwegian School of Economics, Bergen; Geir Hasle, Sintef IKT, Oslo; Marielle Christiansen, Norwegian University of Science and Technology, Trondheim; Mario Guajardo, Norwegian School of Economics, Bergen; and Matthias Nowak, Marintek, Trondheim. 🌍



OR: On Track to Rail Improvements

Hans Ittmann <hittmann01@gmail.com>, University of Johannesburg

Handbook of Operations Research Applications at Railroads edited by Bruce W. Patty, 2015. Springer, US. pp. 278, ISBN: 978-1-4899-7570-6, US Dollars 129 (Hardcover) and ISBN: 978-1-4899-7571-3, US Dollars 99 (e-book).



The history of rail transport dates back to the time of the ancient Greeks. "Wagonways" were relatively common, especially for mining purposes in Europe during the 1500s through to the 1800s. Mechanised rail transport systems using steam locomotives first appeared in England during the late 1700s and early 1800s when the first public steam railway in the world started operating in 1825. Railroads played a critical role during the Industrial Revolution and have since remained the primary form of land transport across most of the world. Today, they are certainly the most cost effective means of transporting freight over long distances. While providing enormous opportunities for applying Operations Research, the area is full of challenges even in gaining an understanding of railroad terminology and concepts, and in dealing with operational complexities.

Initially working on airline problems, the editor found a striking difference in problem complexity, namely: connecting a railcar from an inbound train to an outbound train takes time and requires people, tracks and locomotives; on a specific railroad, one can only have "one-way traffic", i.e., a train cannot travel over another; where the same line is used for passenger and freight transport, passenger trains, in some cases, always get priority; it is possible to carry more passengers or freight with an additional engine; having to deal with axle load of a track, network electrification varying along older tracks, track capacity which can be increased by adding train passing sidings or "crossing loop lengths" and easing critical curves and gradients.

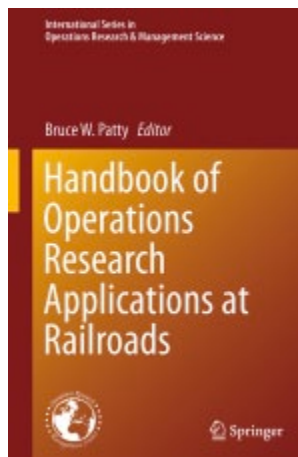
The aim of the handbook is clearly stated as "exposing the reader to the complete spectrum of the role Operations Research has played and can play in the improvement of freight railroads". Although all the material presented in the handbook originates from applications in Northern America, it is of universal interest. However, differences in terminology, operating rules and procedures are noted. The book explores how decisions are made at railroads with examples of mathematical programming formulations to address the complex problems and tools being used with the associated IT challenges. The emphasis is clearly on operational railroad aspects.

There are eleven chapters in the book, each addressing a clearly defined railroad topic. The authors of the various chapters are experts in their respective fields with extensive knowledge and understanding of the topics covered. Topics of the various chapters follow:

- **Train Scheduling** – covers the role of the train schedules, schedule data elements, design and real-time management. The critical concept of rail car *blocks* is explained in detail. A block is a grouping of rail cars that have disparate origins and destinations, transported by a train or multiple trains, as one grouping from a common assembly point to a common disassembly point where, in turn, cars can be broken up and where the process can be repeated till the railcar arrives at its final destination.
- **Locomotive Scheduling** – involves assigning a set of locomotives to each train so that the assignment satisfies hard and soft business constraints while minimizing total costs. The critical concept of *consist-busting* is explained. (A *consist* is a set of locomotives assigned to a train.)
- **Simulation of Line Road Operations** – devotes a lot of

analytic effort on these methodologies used extensively by line road operations and railroad planning departments to justify capital investments. Simulations are used to analyse whether the envisaged capacity (and capacity expansion) on a line can in fact be achieved. Here, the *meet-pass* planning process is critical. (a process where a set of trains, either following or opposing one another - a pass or a meet, respectively - will be routed to resolve any conflict in a network of more than one track.)

- **Car Scheduling/Trip Planning** – involves modelling that answers two main questions: In what block should a shipment be placed given its current location? What train should be used to advance the block to its destination?
- **Railway Blocking Process** – links with the chapter on train scheduling as it explains what is required to design a blocking plan. Two issues addressed are: What is the overall number of blocks that must be created at a location? Which traffic should be placed into each block?
- **Crew Scheduling** – minimizes operating costs while satisfying regulations and work rules that ensure quality of life for the crew.
- **Empty Railcar Distribution** – deals with the rail-owned empty railcar return to the shipper. This is called the empty railcar distribution problem. A whole range of considerations are given that contributes to problem complexity.
- **Network Analysis and Simulation** – considers a range of disparate changes effecting decisions using network analysis and simulation, deterministic simulations with fixed plans and no capacity constraints, capacitated simulations with dynamic plan elements, among others.
- **Simulation of Yard and Terminal Operations** – includes methodologies leading to: improved operations through training or improved processes; identification of capital investment requirements; evaluation of train schedule feasibility; and providing a replay capability within the simulation.
- **Operations Research in Rail Pricing and Revenue Management** – deals with improved revenue management since deregulation in the US through a whole range of analytical techniques.
- **Intermodal Rail** – considers the movement of containerized cargo using rail in combination with road/truck and ship. Intermodal rail is shown as a critical element in efforts to shift freight from road to rail. The chapter addresses aspects such as pricing, size of the container fleet, container assignment, etc. Clearly a whole multitude of issues are considered.



The *Handbook of Operations Research Applications at Railroads* succeeds in its objective of exposing the reader to the use and implementation of OR within railroads. Every topic is clearly outlined with an explanation of issues that need to be considered. Every model formulation with its constraints, objective function and solution approach is presented well. The book focusses largely on railroad operating applications and is an ideal resource for academics, experienced researchers, and consultants in the field. Aspects falling outside the operating environment such as railroad planning, freight demand modelling (mainly forecasting), prioritisation of investment decisions, are not covered. Even though railroad related terminology and concepts are explained in detail in all the chapters, those not familiar with the railroad environment will need to invest a lot of time in gaining the full value of the material covered in this book. 🌐

Multicriteria Mapping of Climate Engineering

Rob Bellamy <rob.bellamy@insis.oc.ac.uk>

The late sociologist Ulrich Beck famously observed that we have come to live in a society organised in response to risks. This 'risk society' is itself a product of modernisation and has brought with it a host of seemingly intractable problems; climate change, ozone depletion, nuclear waste, genetically modified crops, synthetic biology; to name but a few. Such issues quickly become polarized amongst stakeholders and established methods of risk assessment have proven unable to accommodate their divergent perspectives or handle the uncertainties.

It was with such pressing deficiencies in mind that Sussex University Professor Andy Stirling developed a new way for providing decision support on technoscientific risks: Multicriteria Mapping (MCM). Multi-criteria appraisal methods are not new to operational research, but unlike conventional methods, MCM pays exceptional attention to ambiguity and uncertainty. Particular attention is paid before the appraisal even begins: first and foremost to the diversity of its participating assessors. A wide range of institutional interests and perspectives are vital for identifying and evaluating key areas of ambiguity. Similarly, care is taken over the options themselves: those included for assessment should reflect the diversity of alternatives available to decision makers. Criteria with which to appraise those options can then be developed and weighted, before scoring the performance of the options against the criteria. Crucially, instead of providing a single, ostensibly certain value for option scores, MCM elicits two: an 'optimistic' score and a 'pessimistic' score to explicate uncertainty. Moreover, the scoring is not 'black-boxed' as is often the case in conventional appraisal processes: qualitative reasoning is carefully recorded to qualify its quantified counterpart. The result is a detailed 'map' of the issue, revealing the contours of contestation.

The method was recently employed in the appraisal of a new addition to the lengthening list of technoscientific hazards emerging in the risk society: deliberate, large-scale interventions in the Earth's climate system. Collectively known as 'climate engineering', these technology proposals would seek to address climate change through means other than reducing emissions (mitigation) or impacts (adaptation). Indeed, it is the apparent failure of international efforts to mitigate so far that has led some scientists to conclude that we might not be able to avoid dangerous climate change without (at least some) climate engineering. The disparate proposals broadly fall into two categories: carbon climate engineering proposals that would seek to remove the greenhouse gas carbon dioxide from the air; and solar climate engineering proposals that would seek to reflect a proportion of sunlight away from the Earth.

Appraisals of climate engineering began in earnest in 2009 after the Royal Society released its seminal review of the field. Yet, they have largely done so using the sorts of entrenched methods that have so often failed to provide decision makers with the plural and conditional results that are intrinsic to highly complex and uncertain risk issues. Expert opinions, cost-benefit analyses, conventional multi-criteria methods, climate modelling studies, survey questionnaires and other approaches have all neglected mitigation and adaptation alternatives. Involvement had been strictly limited to experts, leaving little room for wider stakeholder participation. Ultimately, through narrow framings the appraisals had begun 'closing down' on recommendations for particular climate engineering proposals, principally stratospheric aerosol injection, a controversial proposal for launching reflective sulphur particles into the stratosphere.

Having been successfully used to 'open up' the landscape of analogous technoscientific risks including genetically modified

crops, medical transplant technologies, and radioactive waste disposal, MCM was deployed in the context of climate engineering. This was done as part of a broader 'Deliberative Mapping' (DM) multi-criteria appraisal process which recruited not only diverse expert and stakeholder

participants from academia, civil society, government, and industry (specialists), but also ordinary members of the public (citizens). Situating climate engineering proposals within the broader context of alternative options for tackling climate change, the process involved two parallel strands of activity: one for specialists using computer-assisted MCM interviews, and one for members of the public using deliberative citizens' panels.

Compared with the previous assessments of climate engineering, the DM process massively expanded the diversity of perspectives, options, and criteria input to the decision context. 80 criteria were developed that spanned the natural, applied and social sciences, covering issues of efficacy, environment, feasibility, economics, politics, safety, society, ethics and co-benefits. From a process seeking to map pervasive ambiguities and uncertainties, you might expect findings that make more room for contestation rather than convergence. Yet, the results of the appraisal, now published in the journals *Public Understanding of Science* and *Global Environmental Change*, actually reveal a remarkable degree of convergence. A picture of option performance emerged in which climate engineering proposals were consistently outperformed by alternatives designed to reduce greenhouse gas emissions. This is a radically different finding to the other assessments that found climate engineering proposals, and in particular, stratospheric aerosol injection, to be preferable. Indeed, aerosol injection actually performed so poorly that it ranked alongside doing nothing to tackle climate change at all.

MCM has been widely used internationally, underpinning many influential published papers and reports. As part of a wider deliberative process, it has been mentioned in an editorial in *Nature*, favourably reviewed in a UK Government Manual and recommended in a number of major evaluations. It is available at <http://www.multicriteriamapping.com/> 

Dr. Rob Bellamy is a James Martin Fellow in the Institute for Science, Innovation and Society at the University of Oxford.

Further reading

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