

**orbit** | # 38



## ORbit

medlemsblad for Dansk Selskab  
for Operationsanalyse og Svenska  
Operationsanalys- föreningen

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## Editor



Hello readers!

I am writing this editorial letter from the room where, in about 1 hour, the DORS yearly conference AOO 2022 will start. The excitement for the talks was so high that I accidentally booked a train ticket that arrived 2 hours before the conference starts, so now I might as well use the

time productively.

As you could see from the cover, this issue has a focus on what is happening in Ukraine, and we have a special collection of texts curated by Jakob Krarup that highlight how the OR community around the world has reacted to the invasion of Ukraine. We live troubled times, and many of us thought that it was highly unlikely that a war would hit Europe again, so here's to hoping that it will finish soon!

Besides that, we have two other contributions that make up the magazine, but article submission has in general been low - hence the delay in getting this issue out (again). I would like to encourage our readers to make a contribution to the next issue, and mark on your calendars the deadline: October 10th 2022. We have however decided that we will no longer delay ORbit issues if there are not enough articles. From now on, we will skip the issue when we are in that situation, and articles already submitted will be published on the next issue.

On April 22nd we held our General Assembly at DTU and we said goodbye to two members of the board: Beizhen Jia and Julia Pahl (the former Editor of ORbit) both stepped out of the board, and we sincerely thank them for the hard work these past years. We welcomed Stephen Hall back into the board and were also joined by new member Alexandru Serbanescu. Among other things, it was voted an increase in the membership costs for DORS, partially motivated by the shipping costs of sending ORbit to our readers (which until now was sent through the universities, since our past Editors were all working at a University).

I hope you enjoy this issue in this great Spring weather, and see you again after the summer!

Best, João Fonseca (Editor)

## Aktuelt om DORS

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## Svenska Operationsanalysföreningen



Nu möter vi våren igen, och den här gången känns det faktiskt som att vi kanske äntligen har sluppit ifrån den värsta fasen av COVID-pandemin. När jag tittar tillbaka på mina Orbit-texter de senaste åren har de pendlat mellan hopp och förtvivlan, men nu känns det ändå som att förhoppningen på en långvarigt normaliserad situation är starkare än någonsin sedan pandemins början. Tyvärr har ju dessvärre oron kring pandemin ersatts av oro för global destabilisering och krig, vilket ju inte är särskilt mycket bättre.

Den 13 mars höll SOAF sitt årsmöte, som efter bakslaget med ökar smittspridning i början av året beslutades blir virtuell även den här gången. Som vanligt inleddes årsmötet med utdelning av SOAFs exjobbpris, som den här gången tilldelades Emil Lindh och Kim Olsson för deras examensarbete med titeln "Scheduling of an underground mine by combining logic-based Benders decomposition and a constructive heuristic". Juryns motivering löd.

*Emil och Kim har tagit fram en automatiserad metod för planering av hur gruvsdrift kan bedrivas på ett resurseffektivt sätt. I samarbete med Boliden har de tagit fram en matematisk modell för schemaläggning av aktiviteter och maskiner i underjordsgruvor. Deras arbete visar på god förmåga att modellera ett komplext system och använda avancerade matematiska optimeringsmetoder speciellt anpassade för detta viktiga industriella problem. Noterbart är hur de har använt en djupare förståelse av det underliggande problemet för att kombinera logikbaserad Bendersdekomposition, constraint programming och en konstruktiv heuristik som påvisats att kunna lösa storskaliga testfall tillhandhållna av Boliden med Nils-Hassan Quttineh som examinator och Elina Rönnberg som handledare, båda vid Linköpings Universitet.*

Handledare för examensarbetet var Elina Rönnberg och examinator var Nils-Hassan Quttineh, båda vid Linköpings Universitet.

Den ökade smittspridningen i början av året ledde även till att SOAFs styrelse valde att återigen skjuta på Svenska Operationsanalyskonferens, SOAK, som var planerad att anordnas i mars. SOAK är nu istället planerad att anordnas den 24-25 oktober 2022 på Scandic Hotel Järva Krog, Stockholm. Vi hälsar alla operationsanalysintresserade välkomna!

Mattias Grönkvist, Ordförande, SOAF

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## Aktuellt om SOAF

Individuellt medlemskap: avgiften är 160 kr/år

### Företagsmedlemskap:

Avgiften för företaget/institutionen beror på antalet OR-intressenter enligt följande tariff:

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# Tales of an aggressor, sanctions, history, and prominent personalities

by Jakob Krarup *et al.*

## Background

The Russian President Vladimir Putin visited the Winter Olympic Games in Beijing to give Xi Jinping, President of the People's Republic of China, personal, visible support. Xi asked Putin to delay starting the war in Ukraine until 20 February 2022, the end of the Winter Olympics, which he did. In the early morning of February 24th, Vladimir Putin, in his own words, *gave permission* to let his army launch the invasion of Ukraine.

The LSS therefore calls the world's scientists to work together and focus to bring the war in Ukraine to the end immediately and:

- use your institutional and personal contacts with scientists working in the aggressor's country to provide them with objective information and to search for ways to end the war in Europe immediately. No scientific institution or scientist should be involved in crimes against humanity and peace. It is a sacred duty of scientists not to cooperate with the structures that planned and launched military campaigns. Scientists are to contribute actively to the restraint of the regime that started the war in Europe. The responsible persons have to be taken to responsibility for the bloody military campaign;
- provide full support to fellow Ukrainian scientists in this tragic situation, helping them to withstand the damage caused by the aggressor's actions;
- stop the flow of scientific knowledge, state-of-the-art technology and innovations that can be applied to military infrastructure and operations to the aggressor state until the end of the war in Ukraine and the withdrawal of aggressor troops from Ukraine's territory.

## Lithuanian Scientific Society (LSS) and Lithuanian OR Society (LitORS)

On the same day, the following appeal was circulated by Professor Dalius Serafinas, Chairman of the Lithuanian Scientific Society (LSS):

TO THE WORLD SCIENTISTS | TO THE ORGANIZATIONS AND PEOPLE WHO SUPPORT WORLD PEACE AND DEMOCRACY | TO WORLD LEADERS (Resolution by the Lithuanian Scientific Society, Vilnius, 2022-02-24)

The Lithuanian Scientific Society (LSS) considers Russia's military actions launched today in the European sovereign democratic state of Ukraine to be a crime against humanity. It is obvious, sad and unjustifiable that scientific knowledge and the latest technologies are being used in this case to conquer other nations and kill people. Peace in Europe that lasted for eight decades, has been disrupted by military campaigns of Putin's regime today in early morning February 24th, 2022. Putin's regime has invaded the lives of peaceful people, while at the same time threatening the world not even to try stopping the war crimes it has begun, by openly threatening to use nuclear weapons as well.

LSS addresses the world leaders to:

- immediately review and suspend all economic projects with Russia that could be used to support the power of the Putin's regime;
- use all possible political, economic and other powers to stop the war in Ukraine.

The LSS states that Putin's unstoppable regime will not only continue its military actions against Ukraine, but may extend it to other European countries. We therefore call on all the people of the democratic world to contribute to the support of the Ukrainian people, realizing that Ukraine defends democratic values and its sovereignty, and also protects us all from aggression.

*Dalius Serafinas, Chairman of the Lithuanian Scientific Society*



Leonidas Sakalauskas, President of the Lithuanian OR Society (LitORS), who kindly obtained permission from Professor Serafinas to reprint the LSS resolution in **Orbit** 38 and added the following: "LitORS supports the resolution of the Lithuanian Scientific Society and calls upon all the people of the democratic world to contribute to the help of the Ukrainian people, realizing that Ukraine defends democratic values and its sovereignty, and also protects us all from aggression."

izing that Ukraine defends democratic values and its sovereignty, and also protects us all from aggression."

## Danish OR Society (DORS)



Five days after, on March 1st, Dario Pacino, President of the Danish OR Society (DORS), voiced his opinion in a letter to EURO:

Dear EURO Executive Committee,

In light of the recent illegitimate Russian invasion of Ukraine, many sports and cultural foundations have either been boycotting or excluding

Russia from different events. The Danish OR Society (DORS) feels that the time has come for the scientific community to let its voices be heard. We recognise that this is a complex discussion and that we cannot hold our dear Russian colleagues accountable for the actions of their government. However, being silent would be the same as giving our consent.

We propose the following, non-mutually exclusive, lines of action:

1. Exclude (temporary) the Russian Federation from being a member of the EURO.
2. Do not allow Russian participation at the EURO conference at ESPOO.
3. Produce a public statement that condemns the Russian invasion.

The exclusion of the Russian Federation is possible according to section 2.5 of the EURO Statutes: "The Executive Committee can propose the expulsion of a member society but only after the member concerned has had the opportunity to present their case to the

Executive Committee. Exclusion must be decided by the Council by a majority of two thirds of the votes of the full members present or represented."

DORS would see positively on any action taken by EURO but hopes that EURO will consider all of the above.

Best regards,

*Dario Pacino, President of DORS, 01/03/2022*

## THE TIMES OF ISRAEL, March 5th, 2022

7,000 Russian scientists 'Strongly protest' Ukraine war in open letter to Putin. Signatories who call Russia 'a rogue state' risk a fine or jail time as Kremlin cracks down on any opposition.

Kharkov, on March 3rd, 2022. (Sergey Bobok/AFP): MOSCOW — Nearly 7,000 Russian scientists, mathematicians, and academics had as of Thursday signed an open letter addressed to Russian President Vladimir Putin "strongly" protesting against his war in Ukraine.

The massive global backlash to Moscow's invasion a week ago has already affected a range of scientific initiatives, including the International Space Station and a planned Russian-European mission to land a rover on Mars.

"We, Russian scientists and science journalists, strongly protest against the military invasion of Ukraine launched by Russian armed forces," the open letter published Tuesday on the [trv-science.ru](http://trv-science.ru) news website said.

The more than 6,900 signatories could be risking a fine or jail time after Russian authorities adopted legislation in recent years allowing them to target citizens criticizing the government. And the Russian parliament took up another bill this week that would toughen punishment for criticizing the war in Ukraine.

"Humanist values are the foundation on which science is built. The many years spent strengthening Russia's reputation as a leading centre of mathematics have been completely scuppered" the letter said.

The letter pointed out that the International Congress of Mathematicians, which Russia had been scheduled to host in July, has been cancelled due to the invasion. It also called Russia "the military aggressor and, accordingly, a rogue state."

## Background, continued

On March 10th, the deadline for submission of papers to **Orbit** 38, João Fonseca, the Editor-in-Chief, notified

me of lack of material for the coming issue. Having spent more than forty years with both IFORS and EURO and enjoyed the privilege of being an emeritus since 2006 without any pressing commitments, I started collecting material for **ORbit** 38. The result is the contents of this document.

As regards sanctions, prompted by the invasion of Ukraine, institutions like IFORS and EURO play a dominant role in the sequel. Whereas second or third generation of OR people may well be familiar with what both IFORS and EURO are offering today, only few know much about their foundations up to about 60 years ago. History-less people are poor! To this end, an account on how it started is provided in the next two sections, both excerpted from S. Fores, J. Krarup, "On the origins of OR and its institutions", Invited Review, **CEJOR** 21.2 (2013) 265-275.

## The birth of IFORS, the International Federation of OR Societies



As any other emerging field, OR found relatively early a need for establishing its own institutions. Thus, the Operational Research Club (United Kingdom) was inaugurated in April 1948 with an initial membership of 50. Similar clubs or societies were brought about in United States, France, and Germany and the UK OR Club was renamed Operational Research Society (ORS) in 1953. By 1955 interest in OR had spread to most western countries. The First International Conference on OR (Oxford, England, 1957) assembled over 200 participants from 21 countries. This event is recognised as a truly exceptional milestone in the history of OR. The Proceedings Volume contains a section entitled "Progress in OR" in which the state-of-affairs in 18 countries is accounted for.

In January 1959 the professional cooperation between national OR societies was formalised with the formation of IFORS, the International Federation of OR Societies. Within two years of the formation of IFORS, the three founding members, United States (ORSA), United Kingdom (ORS), and France (SOFRO), had been joined by a further seven national societies. Currently, 48 active member societies make up the IFORS family. Two of the early main activities of IFORS were

the organisation of the triennial conferences and the publication of the journal *International Abstracts in Operations Research*, first published in 1961. Such instruments facilitated better communication internationally for academics and practitioners interested in OR. Today the national member societies represent some 30,000 individual members. Their membership ranges from around 10,000 (INFORMS, USA) to about 3,000 (UK and Japan) to those with less than 50 (Belarus, Lithuania, Slovakia). *End of excerpt.*

In the intervening years since 2013 when these lines were written, the IFORS family has been extended by the national OR societies of Nigeria, Columbia, and Russia.

## The birth of EURO, the Association of European OR Societies within IFORS

By the 1970s, 13 of the 27 members of IFORS were European national OR societies but communication between them and other European OR researchers was difficult. Some national societies did (and do still) cooperate on an ad-hoc basis but not to an extent to satisfy the general need for 'something' between IFORS and the national societies. As will be accounted for in the sequel, this 'something' led to a subdivision of IFORS into five so-called Regional Groupings, among which is EURO.

### 1975 – The birth of EURO

At the end of EURO I, a draft of the agreement was signed by the Representatives of ten European OR Societies:

**Belgium, Denmark, Finland, Germany, Great Britain, Greece, Ireland, Netherlands, Sweden, Switzerland**



**EURO**  
The Association of European  
Operational Research Societies

At the IFORS conference in Dublin in 1972, the participating presidents of the European OR societies met and agreed that more could be done to improve communication and cooperation on a European level. In particular it was observed during this conference that the triennial IFORS conference would not be held in Europe again until nine years after. Two further meetings of European national societies were held and,

in May 1974, it was agreed to: "... formalize and institutionalize increased European cooperation ... and to assemble operational researchers from all Western European countries for the First European Conference on Operational Research".

EURO I was opened on the morning of 27 January 1975 at the Sheraton Hotel in Brussels. "At the very festive and impressive Final Session the draft of the agreement was signed by the Representatives of ten European OR Societies (Belgium, Denmark, Finland, Germany, Great Britain, Greece, Ireland, Netherlands, Sweden, Switzerland)". "On 8 March 1976, the Honorary Secretary announced: 'I hereby declare that EURO, The Association of European Operational Societies within IFORS, is now formally constituted with effect from 5 March 1976 and the draft statutes circulated on 29 June 1975 are effective'".

The sanctions proposed by IFORS, EURO, and the national OR Societies in Croatia, Denmark, Slovenia, and Switzerland in a series of Statements will be presented in the next sections.



## Janny Leung, President of IFORS: IFORS Statement on Ukraine

At the IFORS Administrative Committee (AC) meeting on 9th March 2022, it was decided to issue the following statement: "The International Federation of Operational Research Societies (IFORS) Administrative Committee declares its denunciation of the military action on Ukraine by Russia in disregard of territorial integrity and in violation of international law. We join institutions across the world in calling for a cessation of hostilities and for a peaceful resolution of the conflict.

We send our thoughts of care and hope to our colleagues, their families and all whose lives are disrupted by this crisis."

The AC also decided to exclude any member of Russian organisation/society from any IFORS event and not to hold any IFORS event in Russia, as long as the military action continues.

The declaration and decisions were disseminated to all Presidents and Board Representatives of all Member Societies of IFORS.

## Marc Sevaux, President of EURO 2021-2022: EURO statement on Ukraine



The Association of European Operational Research Societies (EURO) Executive Committee and its Council stand in solidarity with the people of Ukraine and support the democratically elected Government of Ukraine and their territorial sovereignty. We join institutions and leaders from across Europe in condemning in the strongest terms the unjustified attack by Russia on Ukraine and the violation of

international law. While we watch in horror at this disregard for democracy and humanity, we hope for a swift and peaceful resolution. Our thoughts and hopes are with everybody affected by the crisis, in particular with our colleagues and their families.

## Mario Jadrić, President of Croatian OR Society (CRORS): Statement on Ukraine



The membership of Croatian Operational Research Society (CRORS) voted on 3 March at the General Council to support the initiative of DORS.

By a majority of votes, the membership agreed with its contents in all 3 lines of action: a) Exclude (temporary) the Russian Federation from being a member of the EURO; b) Do

not allow Russian participation in the EURO conference at ESPOO; and c) Produce a public statement that condemns the Russian invasion.

I believe in the success of the initiative and hope that the war will end soon.

## Dario Pacino, President of DORS: Statement on Ukraine

The Danish OR Society supports the EURO statement of solidarity with the Ukrainian people.

DORS is not a politically active association. Nevertheless, we cannot ignore the current situation in Ukraine and silently accept the Russian invasion.

As further action to the statement from EURO, we would like to encourage all DORS members to boycott conference presentations from researchers associated with Russian and Belarussian institutions and organisations. We also ask you to refrain from attending events and meetings hosted in Russia or Belarus.

Our hearts are with the Ukrainian, Russian and Belarussian people, all of whom are victims of the aggressive actions of the Russian government.

## Lidija Zadnik Stirn, President of Slovenian Society INFORMATIKA – Section for OR (SSI-SOR)



I condemn that one country grants itself the right to shape the borders of another sovereign country. I therefore condemn Russia's political leaders, headed by Vladimir Putin, being responsible for the ongoing military operations and escalation of violence in Ukraine, and feel deeply concerned for the disastrous impact on the community, the immense casualties,

the harm, and pain caused to innocent civilians, as well as the significant destruction of the country itself.

Like other member societies of IFORS and EURO, SSI-SOR is a framework for OR scientists. Science has proven to act as a platform for dialogue even in times of war and is therefore a resource on which to build to avoid further loss of life and disruption, including scientific research and infrastructures. In principle,

we should then be fully committed to upholding scientific dialogue and collaboration and to support the organizations and scientists affected by conflicts and war.

At the beginning of March 2022, members of SSI-SOR were informed about various sanctions proposed in statements from both IFORS, EURO, and well as a series of national societies. Being aware of the fact that some of these proposals are more extensive than others, parts of the IFORS statement read as follows: "At the IFORS Administrative Committee meeting on 9th March 2022, it was decided to exclude any member of Russian organization/society from any IFORS event and not to hold any IFORS event in Russia, as long as the military action continues." The conclusion of SSI-SOR is that we agree with the IFORS statement.

In closing, I declare my solidarity with all colleagues and people that are affected by the current war and plead for peace. I hope soon to witness the end of further escalation of violence, and for the social, political, and economical recovery of the victims of this conflict. May my colleagues/friends and their families in Ukraine not only survive but remain uninjured, safe, and healthy.

## Bernard Ries, Representative, Swiss OR Society (SVOR/ASRO): Statement on Ukraine

Dear members,

Please find below a statement of EURO concerning the situation in Ukraine; the board of SVOR/ASRO fully supports this statement.

Note: The EURO statement referred to is not shown here but can be found among the statements already included, see above.



**To editors of OR journals published outside Russia:** until Putin terminates his invasion of Ukraine, will you accept papers authored by Russian OR scientists? A single answer was received from Ulrike Leopold-Wildburger, Editor-in-Chief of Central European Journal of Operations Research: **no, definitely not.**





Ulrike Leopold-Wildburger, Editor-in-Chief of **CEJOR**.

Project	What	Direct
Fight	Where	Might
Institutional	Who	Individual
Legislate	Which Way	Facilitate
Make	Whether	Take
Should	Whither	Would
Pragmatic	When	Opportunistic
Blame	Why	Gain
Protect	What	Connect
Right	Where	Bright
Societal	Who	Political
Emancipate	Which Way	Negotiate
Give	Whether	Bring
Good	Whither	Could
Optimistic	When	Idealistic
Shame	Why	Pain

Next to the series of statements, also other both timely and pertinent contributions to **ORbit** 38 have been received. Among them is:

## Cathal MacSwiney Brugha, President of the Analytics Society of Ireland

### Driven to Protect Society – A Dual Approach to Governance



One of the tools of decision-making is a set of eight questions: What, Where, Who, Which Way, Whether, Whither, When and Why.

As young people in Operations Research (OR), *What* we do is to help **Direct** resources, *Where* they **Might** maximise the profit for *Whom*: the **Individual**.

Years of experience with OR finds us spending more time interpreting the shadow costs, or dual

values. Later we find ourselves considering who is the ‘product owner’, and discovering that the business problem we were trying to solve was more about minimising loss to the community, the company, or society.

We should have been solving the ‘**Dual Problem**’.

We consider here three related and current challenges to how we approach urgent (when) and important (why) issues of governance: (1) Putin’s attack on the people of Ukraine, (2) do we as OR Societies expel the Russian OR Society? and (3) Europe’s dependence on Russian oil and gas.

The dual approach focuses on the societal.

1. Instead of encouraging the **Direct** response, that countries join NATO, we should be promoting non-military zones to **Protect** the people of Ukraine living in safety,
2. instead of OR Societies expelling the Russian OR Society, help **Protect** Ukraine OR People, and
3. **Protect** European people from their over-dependence on Russian oil and gas.

Both primal and dual governance approaches use political and institutional systems as mediators. The individual-driven approach takes resources, uses political means to bring resources to the people, then institutional means to make things of value, intending to give benefits to society.

The alternative society-driven governance starts with communities, such as the people of Europe, and our energy deficit, our reliance on imported energy. It next makes European institutional systems source and distribute energy adequately to satisfy European societal needs. It then uses political means to bring energy from sources to institutions, and onward to people. And finally, it uses individual points of sourcing energy, to get the process of energy supply started.

The current project is to distribute energy from the Atlantic across Europe. Its elements:

1. ‘Bobbing energy’: where Atlantic waves cause ships to bob up and down.
2. Atlantic wind is used to power jet engine wind turbines.
3. Both are incorporated on redundant / retired cruise passenger / container ships.
4. Both wave and wind energy are converted into Green Hydrogen.
5. Some of the Green Hydrogen is converted into electricity and brought into European grids.

6. A Western Europe Atlantic Offshore Logistics Transshipment Hub would take the surplus Green Hydrogen energy to Asia in the mainly empty container ships that transport Asian manufactured goods to Europe.
7. Green Hydrogen could power these container ships
8. Data Centres, the biggest growing user of energy, could be based in Ireland's western province of Connaught, where the soil is notably poor for agriculture
9. The reconditioning of ships for Green Energy production could be carried out in the currently little-used ship-building facilities of Belfast, Ireland

Institutions and politicians have vested interests in the old ways, and don't understand these opportunities. This not something that we would expect European bureaucrats, or Corporate Energy Companies, or even Political parties to initiate. It should come from the Community. We in the EURO OR community should drive this, and also resolve its technical challenges, because it is important (why) and urgent (when).

This idea will be presented at the forthcoming conference: EURO 2022, ESPOO, FINLAND, 3 – 6 JULY 2022, in session on Societal complexity and Governance, in the stream Ethics and OR.

Applying these ideas to the debate above about whether or not to exclude the Russian Operations Research Society from membership of our IFORS / EURO groups, the Analytics Society of Ireland proposed that IFORS / EURO adopt a Shame-Blame-Pain-Gain policy amongst Member Societies.

- **Shame:** IFORS / EURO condemns the the **Shameful** attack by the Russian Military on Ukrainian People
- **Blame:** IFORS / EURO **Blames** Vladimir Putin, for starting the war, not the Russian Operations Research Society
- **Pain:** To change the Russian and Chinese Governments' positions on the war, IFORS / EURO should spread awareness of the **Pain** the war is causing to the people of Ukraine.
- **Gain:** IFORS / EURO should promote a possible **Gain** from this war: a realisation that the only good weapon is a defensive weapon, not nuclear, biological, cluster, or rocket.

Do note (3) Protect European people from their over-dependence on Russian oil and gas. As of March 2022, one of the hottest issues debated among the member countries within the European Union is: stop import of oil and gas from Russia. Cathal Brugha must have been clairvoyant: the abstract of his talk at EURO 2022 was received on 16 February, **eight days before Putin invaded Ukraine!**

## EURO 1989, Belgrade, and EURO 1992, Espoo, Finland

It is not an objective for EURO to take political measures. But what happened at EURO 1992 held in Helsinki? Below is an account of the situation as I experienced it.

Excerpt from J. Krarup, "EURO – PER ASPERA AD ASTRA", **ORbit** 30 (2018) 13-19:

The six Warsaw Pact countries of Eastern Europe - Bulgaria, Czechoslovakia, Hungary, Poland, Romania, and The German Democratic Republic (GDR) – while nominally independent, were widely recognized by the international community as the Soviet satellite states. All had been occupied by the Soviet Red Army in 1945, had a Soviet style socialist regime imposed on them, and had very restricted freedom of action in either domestic or international affairs. GDR and Poland withdrew from the Pact in 1990. On 25 February 1991, the Pact was declared at an end at a meeting of defence and foreign ministers from the remaining member states. In the same year the Soviet Union itself was dissolved on 26 December.

Already as of 1990, this surprising development prompted several post-communistic countries to "knock on the door" to become admitted to IFORS and, if they succeeded, then to EURO. Accordingly, the report on "new members" in [J. Krarup, "EURO on the threshold to the nineties, President's Report 1989-1990] is unusually extensive and encompasses all the former satellite states. Talks were held, letters were exchanged, and obstetric aid was offered, notably to Hungary and Poland. Funnily enough, also the Icelandic OR Society (ICORS) managed to become member of EURO during that period. Apparently ICORS had believed it was a member already but had forgotten to submit an application for membership. Upon a reminder, this eventually was done on 4 April 1990.

It is not an objective of EURO to take political measures and no such measures were ever taken. It is not forbidden, however, to express concern for those of our colleagues who, in one way or another, are victims of political conflicts. Once a group of such victims, known as refusnik scientists, i.e., Jewish scientists who

had applied for and refused permission to leave the Soviet Union. Refusniks were normally demoted to low-level jobs or lost their scientific positions altogether. Some of them had their academic degrees removed retroactively; some were in labour camps or exile. In all cases they were cut off from normal interaction with other scientists.

Having participated in the International Moscow Refusnik Seminar in December 1988, held under abnormal conditions in private homes, I found it most appropriate at the Closing Session at EURO X (Belgrade, 1989) to choose the refusnik scientists as the subject of my address. Congratulatory notes were afterwards received from several EURO people whereas the Serbian chairman was really upset: “This was not the talk expected from the President of EURO”. Three years later, however, at EURO XII (Helsinki, 1992) the situation was reversed. Delegates from Serbia were banned from participating and I found it equally appropriate in my address to let the thoughts go to friends and colleagues in the different parts of former Yugoslavia. The congratulatory note was this time received from the former Serbian chair and we have been best friends ever since.

The former Serbian chair was Professor Radivoj Petrovic, to whom EURO owe a lot:

The EURO X conference (Belgrade, 1989) turned out to be a disaster. The 295 participants were almost invisible in the huge Sava Centre capable of accommodating 4,000 persons. The first accounts indicated that EURO might lose a substantial part of its net assets, and some felt that the mere existence of the Association was heavily threatened. Thanks to the admirable efforts of Professor Radivoj Petrovic, however, EURO managed eventually to become financially stable due to the generosity of Institut Mihajlo Pupin Beograd which contributed considerably more than planned.

Now, back to 1992: Delegates from Serbia were banned from participating ... . To be more precise, who were banned by whom and how was the ban communicated? Jaap Spronk succeeded me as President of EURO 1991-1992 but passed sadly away in 2021. Was the decision his or the EURO EC? Did the Serbian OR Society exist and was approached in 1992? Or was the ban passed to some individuals only? My rather extensive EURO files contain nothing. Jesper Larsen, the current Secretary of EURO, was consulted on 31 March but has found nothing to date in the EURO archives. It is strange that there is no evidence whatsoever, say, in terms of documents, to justify a serious decision without any precedent in the history of EURO.

The current INFORMS, The Institute for Operations Research and the Management Sciences, was established in 1995 with the merger of The Institute of Management Sciences (TIMS) and the Operations Research Society of America (ORSA). A few EURO conferences in the past (e.g. Lausanne 1973, Paris 1980)

as well as EURO 1992 were organised in cooperation with TIMS. In retrospect, it can safely be said that the cooperation was far from frictionless. Anyway, is it conceivable that TIMS had a finger in the pie when the Serbian delegates were discussed?

Among EURO’s current member societies is the Serbian OR Society, Drustvo Operacionih Istrazivaca, but it is nowhere told when it was founded and afterwards joined both IFORS and EURO. It adds to the mystery, that today’s IFORS website, among its National Societies has listed “Serbia, (YUORS)” but, as opposed to almost all other members of IFORS, is silent about when YUORS joined IFORS. “YU” must refer to the by now disintegrated Yugoslavia. It is unknown when YUORS was dissolved and replaced by today’s OR societies in the former Yugoslavia. Thus, it is also unknown whether any OR society was involved in the ban of the Serbian delegates from EURO 1992.

## Russian OR Societies

IFORS’ website, National Societies: Country – Russia, Title – RUORS, Year joined – 2016.

EURO’s website, Current Member Societies: Russian Federation, RuORS. <http://ruors.ru>. Online newsletter. Number of members: not mentioned.

RUORS website, visited on 5th April: The News listed span the period 19.01.21 – 21.09.21 and reduce to a series of announcements of various events. A sample is provided here:

- 21.09.2021 | 2021 call for the YoungWomen4OR: The period for the candidates’ application submission is from September 15th, 2021 to October 15th, 2021
- 21.09.2021 | V.L. Kreps Prize in Game Theory, Mathematical Economics and Related Disciplines (*translated from Russian*)
- 13.04.2021 | An EURO WISDOM Forum Bite-size Webinar: The Webinar will take place Friday 16th April 2021, 15.00-15.30 Central European Time.

Whereas all of the above is an account of the state-of-affairs as per 2002, the then Soviet Union OR Society was a member of IFORS from the early 1960s. What happened thereafter is considered in a letter from Helle Welling, IFORS Secretary 1976-1997, to Mary Magrogan, the current IFORS Secretary, who kindly sent me a copy on 3rd July 2014. Amongst others, Mary wrote: Below is an email from Helle in 2011 regarding Russia. I have searched the files that were sent to me from Canada when they were handling the Secretariat position and there are no files on Russia.



Mary Magrogan, Secretary of IFORS, and Sarah Fores, Manager of EURO.

Excerpt from Helle's mail: The Soviet Union withdrew from IFORS - mid 1970'ies. Reason: The then Soviet Union OR Society accused IFORS of 'turning political'. A well-known Russian mathematician, Dr. Lerner, wanted to leave the Soviet Union, he was not allowed to, and some US OR workers wanted IFORS to interfere. IFORS did not interfere, but, apparently, the Soviet Union OR workers did not approve of the interference by the US OR workers. The discussion about this all happened behind closed doors at the 1972 conference in Dublin - my first IFORS conference (not as IFORS secretary, but as Secretary to the then IFORS President, Arne Jensen). I recall the event vividly - it was rather dramatic. I kept the Soviet Union OR President/Rep./Secretary on the IFORS Bulletin mailing list and, as far as I recall, there were some 'feelers' from the Soviet Union later on about a renewed membership. But it never materialized. Strange, that Russia has never applied for membership - or did they?

Upon having covered sanctions and fragments of the OR history, the next sections will deal with portraits of two prominent personalities.

## Professor Janny Leung, President of IFORS 2022-2024

Presidents of IFORS serve for a 3-year period. On 1 January, Professor Janny Leung took office as President of IFORS for the three years, 2022-2024. Certainly, the incoming President is not a newcomer within the international OR community:



Janny Leung is the Master of Choi Kai Yau College and Professor at the State Key Lab of Internet of Things for Smart City at the University of Macau. She holds an S.B. degree in Applied Mathematics from Harvard University, an M.A. in Mathematics from Oxford University, and a Ph.D. in Operations Research from the Massachusetts Institute of Technology. Her main research interests are combinatorial optimization, transportation, and logistics. Her research has been well-supported by the Hong Kong Research Grants Council and the U.S. National Science Foundation. She has been plenary speaker at international conferences and serves on the editorial boards of several leading journals. She was the President of the Informs Forum on Women in OR/MS in 2001 and was elected a Fellow of Informs in 2020. She served as the Scientific Program Chair for the 19th Triennial IFORS Conference held in Melbourne in 2011 and was the IFORS Distinguished Lecturer at the Athens EURO conference in 2021.

## IFORS News, Vol. 17, March 2022: From the President

I am honoured to have been elected the 23rd President of IFORS. Together with the other members of the Administrative Committee for this 2022-2024 term, I look forward to serving IFORS in support of our member societies and the many initiatives to promote Operational Research around the world.

Like many of you, I discovered Operational Research in my undergraduate days. The models and methodologies of Operational Research include elegant mathematical theories, integrate knowledge from different disciplines, and are applied to decision-making in practice. Doing OR means working on problems that are intellectually stimulating and have practical impact – what's not to love about OR!

Operational Research was created out of necessity, where scientists of different disciplines – mathematics, physics, statistics, physiology — were brought together

to help develop solutions for the pressing problems arising in a war situation. Since then, the use of Operational Research has spread across almost all industries: production, transportation, communications, services, finance, etc. Throughout OR's development, a firm theoretical underpinning for its methods and effective applicability in their implementation have always been intertwined.

In the past two years, Covid-19 has disrupted all our lives, causing havoc to our health care systems, supply chains and economies. As with the early days of OR, multi-disciplinary and multi-locational teams of OR scientists have responded to the challenge, developing models and methods for forecasting and tracing the spread of the epidemic, for vaccine allocation and distribution, etc. — as part of the global effort to control the pandemic.

As Operational Researchers, I believe that we can play a critical role in developing solutions to the many complex global challenges that are facing the world today. As the global federation of OR societies, IFORS has the responsibility to promote the use of OR and the sharing of knowledge and best practices across the world. The Administrative Committee and I look forward to working with all of you in that effort.

May I wish you all the best for this the Year of the Tiger!

Janny Leung, IFORS President 2022-2024

## Helle Welling, IFORS Secretary 1976-1997

Excerpts from Graham K. Rand, "Forty years of IFORS", *Intl. Trans. in Op. Res.* 8 (2001) 611-633.



As the initial presidents of IFORS were originally called secretary, IFORS did not have at that time someone appointed to carry out the secretarial task. What seems to have happened in the early years is that the secretary of the Secretary carried out the secretarial duties on behalf of IFORS.

The first secretary in the current sense was Margaret Kinnaird, who formally took on this role in 1968, when Alec

Lee became President, though she had been carrying out IFORS' responsibilities for several years. Margaret had become secretary to the Operational Research Society in the UK in 1962, after being interviewed by Sir Charles Goodeve. She had retired from a job with

the Norwegian government some six months earlier, and so it was rather appropriate that she found herself attending her first IFORS conference in Oslo in 1963.

For most people currently involved with IFORS and for many operational researchers around the world, Helle Welling is its embodiment. She served as IFORS Secretary from 1976 until 1997. A moving farewell dinner was held in her honour near Brussels in July 1998, when several former Presidents paid tribute to her. But it was not quite the end of her involvement with IFORS, as she played a valuable role at the Triennial Conference in Beijing in August 1999.

Helle had first become involved in IFORS in 1970, when working for the then IFORS President-Elect, Arne Jensen from Denmark. It would appear that he assumed that Helle would know what IFORS was all about, but eventually he realized that this was not the case and suggested that she went to London to visit Margaret Kinnaird. Helle comments that "after half a day spent with Margaret, things started falling into place".

In 1972 Helle went with Arne Jensen to the IFORS Conference in Dublin. She recalls how she sat listening to the General Meeting of the Board of Representatives, with English being spoken in about 30 different accents. Helle asked Margaret how on earth she was able to minute all these statements/outbursts/questions. Margaret's answer was: "I write what they think they said". Helle says "later on, when I myself became in charge of the minutes of the General Meeting, I always had Margaret's words in the back of my mind".

In 1973 the IFORS President, Arne Jensen from Denmark, the then IFORS Treasurer, Roger Collcutt from the UK, Margaret, and Helle went to Japan to look at conference facilities for the 1975 Conference. They were entertained in the most magnificent way. Apparently, Margaret and Helle became so absorbed in the Japanese way of entertaining, that one night when they returned to the hotel, their heads filled with the day's discussions, they decided to have their own private tea ceremony. Helle recalls that 'there we were at 12 o'clock at night all dressed up in our version of the Japanese kimonos, trying to copy the Japanese way of relaxing. I am not sure we met all the requirements for a Japanese tea ceremony, but I do recall that we put the work behind us and had a good night's sleep, although disturbed by a minor earthquake'. Both Helle and Margaret have a number of anecdotes about their times in IFORS, nearly all of which seem to relate to the idiosyncrasies of nationalities and individuals and are therefore best omitted from this account. What is clear is that both much appreciated the enrichment of their lives through involvement in this international society.

The IFORS Statutes state: "The duties of the Secretary are to act as administrative servant of the Federation". Helle has been a marvellous servant to the

Federation. Perhaps 'mother' would have been a better word than 'servant', because she has said that "to function as the IFORS Secretary is in many ways like running a big family. To be in charge of the organisation of a General Meeting, a President's dinner, and to cooperate with various organizing committees of a Triennial Conference is like organising a big party at home". She went on to comment that "to me it was like having pen friends all over the world. I sat in the middle trying to meet demands from the member societies and from the IFORS officers, answering questions, organising, planning meetings, and solving problems. And - as in a real family - when you give, you receive. I will never cease to marvel how much you receive in return for trying to be there for the member societies and the IFORS officers".

*End of excerpt.*

### Helle Welling: some of Jakob Krarup's recollections



Helle was a young Miss Nørgaard when we met around 1970. By that time, we were both affiliated with IMSOR, the Institute for Mathematical Statistics and Operational Research, the Technical University of Denmark: Helle, as Arne Jensen's secretary, I as a member of the scientific staff. For many years, IFORS and EURO was our common passion. Being indeed familiar with how work was conducted

at EURO, IFORS was in the beginning kind of virgin territory to me. Helle's guidance through the wilderness during my three years as EURO's IFORS VP (1991-1993) was more than just valuable. A side effect was to be together with Helle at several of IFORS' triennial conferences all over the world.

A single person among our mutual collaborators deserves special mention, Heiner Müller-Merbach, President of IFORS 1983-86. As time passed by, and like Helle herself, Heiner mounted up to rank among the closest friends to both my wife and myself. Self-evidently, both Helle and Heiner were our guests at a long series of family events spanning several decades. Furthermore, two publications materialized. 'Letters from the President', Heiner's monthly communication to the OR world was originally distributed together with the IFORS Bulletin. The first presidential letter appeared in January 1983 and 35 more followed. On the occasion of Heiner's 50th birthday, the Editors of European Journal of Operational Research (**EJOR**) agreed to publish all 36 letters in a single paper. The result, guest-edited by J. Lesourne, President of IFORS 1986-88, Helle, and myself, appeared as Editorial to

"Letters from the IFORS President", **EJOR** 25 (1986) 421-422.

Helle's contribution adds to the present portrait of herself: "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".

Heiner's untimely death on 30 May 2015, caused by a fall, prompted Helle and me to write the obituary, "Heiner Müller-Merbach, Past IFORS President, 28 June 1936 - 30 May 2015", which appeared in **IFORS NEWS** 9,3 (2015) 7. (<http://ifors.org/newsletter/ifors-news-sept2015.pdf>)



**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/>)

The obituary is divided into two parts. Under the heading, IFORS (Helle Welling), Helle wrote as follows: "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.

*End of obituary.*

The 1999 IFORS Triennial Conference in Beijing was the last one I attended together with Helle. Upon her retirement in 1997, and, as Graham has noted above, a moving farewell dinner was held a year after in Brussels.

Attending yet another Triennial Conference? Helle strained at the leash when I suggested/bullied her to join me for IFORS 2014 in Barcelona. Eventually she

surrendered ... and, as was hoped for, became the focal figure at an evening event, where, once again, several former Presidents acknowledged her admirable work over a long span of time for IFORS.

Helle turned 90 on 7 March 2022. She was indeed celebrated on the day before when about 55 family members and friends gathered for a festive brunch. “Sto lat” – hundred years, as the Poles like to close a birthday speech. May many good years still be granted to Helle! Nobody of those present objected to my idea of being together once again in 10 years from now.

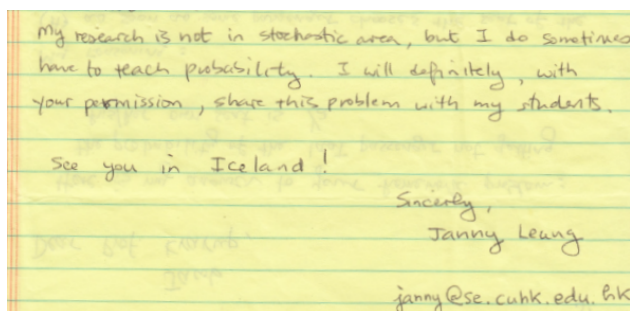
## IFORS 2005, Hawaii: a homework assignment

As it is a habit of mine at all conferences attended, my talk at IFORS 2005 was closed with a homework assignment (HWA) for the audience. The first one to come up with the correct answer would be awarded with a free drink.

HWA #1: “The 100th passenger”. There is an airplane with 100 seats and 100 passengers, each with a seat assignment. The first passenger to enter the plane loses his seat assignment and therefore picks a random seat. Any of the following passengers, entering one by one, takes his/her seat if available; if not, the passenger picks randomly an available seat.

When the 100th passenger enters the plane, there is one seat available. *Question*: what is the probability that it is his/her seat?

To give readers of **ORbit** 38 a possibility for solving the problem themselves, let **P** denote the correct probability asked for. Two attempts to solve the problem were presented. 1) from Janny Leung whose calculations correctly terminated with **P**. 2) About a month after Hawaii, three densely handwritten pages were received from an Australian professor. On the bottom of page three, he reached his conclusion: I *believe* that the probability is **P**.



My research is not in stochastic area, but I do sometimes have to teach probability. I will definitely, with your permission, share this problem with my students.

See you in Iceland!

Sincerely,  
Janny Leung  
janny@se.cuhk.edu.hk

Here is the last part of Janny’s solution. We failed to meet a year after at EURO 2006, held in Reykjavik.

So, as Janny pointed out in a recent mail (7 March 2022): “You still owe me a drink from many years ago!”

The originator of HWA #1 is Professor Dorit S. Hochbaum, University of California, Berkeley, who in 2004 was awarded an honorary degree at Copenhagen University, cf. J. Krarup, “Dorit S. Hochbaum, doctor honoris causa ved Københavns Universitet”, **ORbit** 7 (2004) 19-22.

**OR News** is the Newsletter for the German OR Society. Almost all issues include a homework assignment challenging the readers, and the solution is provided in a subsequent issue. Presented by Professor Heiner Müller-Merbach, a solution to HWA #1 can be found in **OR News** 41, 2010.

## IFORS 1990, Athens

It was unthinkable in 1990 to ban Russians from participating in any OR event, just the contrary. I met Sergei, a Russian OR scientist, at a conference in Hungary around 1988. Some articles and other writings were afterwards exchanged.

At the beginning of the 1990 IFORS conference in Athens, my wife and I were called from the hotel reception: there is somebody here who wants to see you. A minute after, Sergei entered our room: “Here I am – but I have no money!” Well, a Hungarian friend of mine, also attending the conference, owed me a favour. Though somewhat reluctantly, he agreed to share his double room with Sergei. The next step was to convince the organizers from IFORS that Sergei should be accepted as a regular participant without paying the registration fee.



Figure 3: Sizeable...!

Later, people with their prepaid tickets were queuing up for the banquet. A German colleague standing next to Sergei became aware of the situation and offered generously to pay for him.

On the day of our departure, there was a second call from the reception. Once again, Sergei came to our room: “Here is a small gift in return for what you have done for me!” The “small gift” appeared to be a sizeable Russian samovar, way beyond what we could carry on a flight back to Denmark. My Hungarian friend was then approached: “In appreciation of the nights spent at your room, Sergei has left a small gift for you”. “Good grief”, he replied, “I am travelling by train and already overloaded with luggage”.

Eventually, my wife got a bright idea: “Who was the German who paid for Sergei’s banquet?” The final fate of the samovar is unknown, but, unless other people were involved, the samovar can today most probably be found somewhere in Germany.



## Acknowledgments

Those interested in the history of OR should consult two papers, both authored by Graham K. Rand, “IFORS: the formative years”, *Intl. Trans. in Op. Res.* **7** (2000) 101-107, and “Forty years of IFORS”, *Intl. Trans. in Op. Res.* **8** (2001) 611-633. Delightful reading! Graham’s permission to reprint parts of the latter in the portrait of Helle Welling is hereby acknowledged with thanks.

Though not anticipated from the beginning, collecting material for **ORbit** 38 turned out to be a true con amore activity. An abundance of emails was circulated throughout March with up to forty recipients in one shot; in addition to those with whom I frequently am in contact, the happy side effect was renewed acquaintance with many from a remote past.

My most sincere thanks for all contributions to **ORbit** 38 in terms of texts, pictures, permissions to reuse fragments of articles published elsewhere, are due to Janny Leung, Marc Sevaux, Dalius Serafinas, Leonidas Sakalauskas, Dario Pacino, Lidija Zadnik Stirn, Mario Jadrić, Ulrike Leopold-Wildburger, Cathal Brugha, Bernard Ries, Sarah Fores, Helle Welling, Mary Magrogan, and Graham Rand. Without their kind support, this document would never have materialized.



Jakob Krarup Professor emeritus. Ph.D., D.Sc. & h.c., DIKU (Dept. of Computer Science, Copenhagen University). President of DORS 1977-79, of DAPS Society 1978-2018, and of EURO 1989-90. EURO Vice President of IFORS 1991-93. DORS Representative of EURO and IFORS 1977-79, 1983-2008. Honorary member of DORS (2016). [krarup@di.ku.dk](mailto:krarup@di.ku.dk)



# Modeling and optimization of capabilities for modular organizations under uncertainty

by Luis San Martin and Jorge Vera

Several organizations perform their tasks by combining different groups of people, equipment, etc., in such a way to reach a certain goal. These modules, which we call building blocks (BB) have certain capabilities and their combination provides an overall capability for the whole organization. How to combine these blocks optimally, considering various sources of uncertainty, is what we address in this work. We propose a binary optimization model to allocate those modules under an additive rule, i.e. all modules linearly contribute with a specific capability which is aggregated to build the global desired capability balance. Later, we reformulate the optimization model by employing a cardinality-constrained robust counterpart for the capability balance constraints. The results show that the effects of uncertainty can be controlled by the robust solution at optimality. Lastly, the model proved to be flexible when a more detailed solution was needed, providing useful information for the decision-making process.

## Introduction

The capability-based planning (CBP) process is a methodological framework to guide the strategic management process over a long-term horizon. The scope of this methodology is to provide capabilities to face a full-scale range of uncertain scenarios and threats under a set of constraints [1].

An essential element in the CBP process is the numerical estimation of the capability level that an organization possesses. This need is crucial for organizations in the national security and defense sector [2] [3], all of which require a particular level of capabilities to accomplish a mission [4]. Otherwise, a lack of capability might fail the organizational purpose to deliver value.

The capability-based approach is also applicable to contexts other than defense. Emergency, care, and first response units such as forest brigades, modular field hospitals, and firefighters are some examples [5] [6] that have taken experiences from the military field for setting their foundations.

Different approaches have been followed to employ

capabilities in the defense and military field. One of those approaches seeks to generate and optimize capabilities from an effects-based view. In this perspective, capabilities appear only once an organization executes actions according to its mission.

Several related works in [7] [8] [9] [10] [11] [12] have addressed the force design process using different optimization approaches and some of them have employed stochastic optimization techniques. However, capability allocation under modular structures that can be assembled within bigger ones has not been deeply developed. Moreover, apart from the stochastic optimization techniques that seek to deal with uncertainty, none of the previous works have explored robust optimization formulations as an alternative for uncertainty.

In the research presented in this article, we developed a proof of concept in the military field proposing an optimization model that assures a capability level based on an optimal allocation of minimal units (normally battalions) called building blocks (BBs) to larger units (Brigades - BRG).

Particularly, capabilities are assumed to be an attribute of BBs i.e., each BB contributes with a specific capability to the BRG that is assembling. Although BBs possess multiple capabilities, they also belong to a unique branch (infantry, artillery, etc.) so, there is a one-to-one relationship between the type of unit and its main capability under a functional-based approach. Figure 1 summarizes the concepts about that idea.

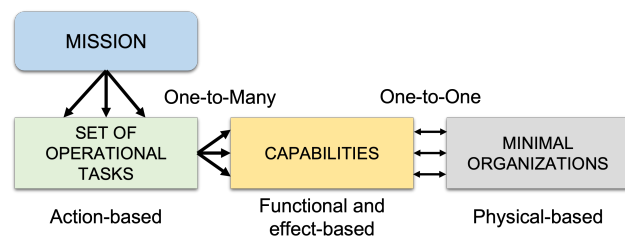


Figure 1: Operational perspective of capabilities and units relationship.

Besides, a robust reformulation integrates uncertainty to assess the organizational behavior under parameter variations. Later, the comparison between the nominal and robust formulations provides a judgment about tractability, operational performance, and the

price of robustness for the proposed force design.

## Capability allocation problem

The capability allocation approach presented in this paper corresponds to an adaptation of the two-echelon capacitated warehouse location model with transportation modes (*2E-CWLPwTr*).

The capability allocation model exploits the flexibility of the *2E-CWLPwTr* conception defining three entities: adversaries (ADV), battalions, also called building blocks (BBs), and own brigades (BRG). ADV units exist and impose a capability demand. The selection of the BRG candidates depends on the capability requirements (demand) that ADV units impose. BBs possess capabilities and are allocated within BRGs.

Complementary, two stages configure the allocation procedure. The so-called rear stage represents the interaction between BBs and BRGs, and the front stage relates BRGs and ADVs. At the front stage, ADV capabilities set the demand for BRGs. Accordingly, at the rear stage, BRGs allocate BBs based on their particular necessity.

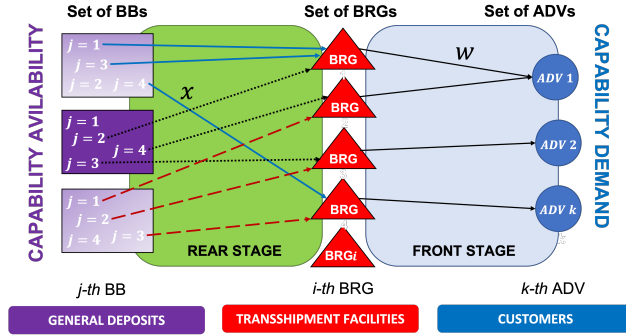


Figure 2: Conceptual framework of the capability allocation problem.

The relationship between the *2E-CWLPwTr* model and the proposed capability allocation problem is shown in figure 2. Concretely, variables  $x$  and  $w$  correspond to allocation decisions while variable  $y$  decides whether activating or not a BRG.

Therefore, the optimization model that formalizes the capability allocation problem is called *2i-BinQuad* model. The name emerges from the number of indices that the allocation variables possess (two), the nature of the decision variables (binary), and the non-linearity of the capability balance constraint (quadratic).

The *2i-BinQuad* is a binary optimization problem to solve the capability allocation problem under an additive rule. This rule means that the capability construction at the BRG level is performed under a linear relationship between the number of BBs allocated and their nominal capability.

Nevertheless, the method to compute capabilities is not the subject of this work, we comment with some brief ideas about it. As an ability, a capability can only be proved by action. Then, an approximation might be obtained by defining an index that reflects the capacity, readiness, and other non-physical elements such as technology level, morale, etc. The index is built by taking high-level technologies as a reference as well as the parametrization of the other elements. The index scores between 0 and 100, but eventually it could arise over 100 if there are higher-level technologies or new doctrine elements that let military forces get better operational performances on the battlefield.

The *2i-BinQuad* formulation works as a proof of concept to deal with the capability allocation necessity.

## 2i-BinQuad sets, parameters, decision variables

- $\mathcal{I}$  : is the set of the BRG candidates  $i$  to be selected.
- $\mathcal{J}$  : is the set of the BB candidates  $j$  to be selected. The subset  $\mathcal{J}_s$  groups the BBs for supporting activities and  $\mathcal{J}_m$  the maneuvering ones.
- $\mathcal{K}$  : is the set of the ADV units  $k$  that exist.
- $c_{ij}$  : is the cost to allocate the  $j$ -th BB to the  $i$ -th BRG.
- $f_i$  : is the aggregated cost to activate the  $i$ -th BRG.
- $d_k$  : is the estimated capability value for the  $k$ -th ADV.
- $\mu_j^k$  : is the estimated capability value for the  $j$ -th BB allocated to the  $k$ -th ADV.
- $\beta^{min}$  : is the minimum number of active BRG.
- $\beta^{max}$  : is the maximum number of active BRG.
- $b^{min}$  : is the minimum number of allocated BB within a BRG.
- $b^{max}$  : is the maximum number of allocated BB within a BRG.
- $h$  : is the proportionality factor that indicates the number of maneuver BBs that are supported by one combat service BB.

Table 1: Sets and parameters for *2i-BinQuad*

- $x_{ij}$  : 1, if the  $j$ -th BB is allocated to the  $i$ -th BRG; 0, otherwise.
- $y_i$  : 1, if the  $i$ -th BRG is active; 0, otherwise.
- $w_{ik}$  : 1, if the  $i$ -th BRG is allocated to the  $k$ -th ADV; 0, otherwise.

Table 2: Decision variables for *2i-BinQuad*

## 2i-BinQuad optimization model

$$\min_{x,y,w} \sum_{i \in \mathcal{I}, j \in \mathcal{J}} c_{ij} x_{ij} + \sum_{i \in \mathcal{I}} f_i y_i \quad (1a)$$

s.t.

$$\beta^{min} \leq \sum_{i \in \mathcal{I}} y_i \leq \beta^{max}, \quad (1b)$$

$$b^{min} y_i \leq \sum_{j \in \mathcal{J}} x_{ij} \leq b^{max} y_i, \quad \forall i \in \mathcal{I}, \quad (1c)$$

$$\sum_{i \in \mathcal{I}} x_{ij} \leq 1 \quad \forall j \in \mathcal{J}, \quad (1d)$$

$$\sum_{i \in \mathcal{I}} w_{ik} \geq 1 \quad \forall k \in \mathcal{K}, \quad (1e)$$

$$\sum_{k \in \mathcal{K}} w_{ik} \leq 1 \quad \forall i \in \mathcal{I}, \quad (1f)$$

$$x_{ij} \leq y_i \quad \forall i \in \mathcal{I}, j \in \mathcal{J}, \quad (1g)$$

$$w_{ik} \leq y_i \quad \forall i \in \mathcal{I}, k \in \mathcal{K}, \quad (1h)$$

$$\sum_{i \in \mathcal{I}, j \in \mathcal{J}} \mu_j^k x_{ij} w_{ik} \geq d_k \quad \forall k \in \mathcal{K}, \quad (1i)$$

$$x_{ij}, w_{ik}, y_i \in \{0, 1\}. \quad \forall i \in \mathcal{I}, j \in \mathcal{J}, k \in \mathcal{K} \quad (1j)$$

Objective function 1a minimizes the overall allocation and activation costs for the BB and BRG modules, respectively. Constraints 1b and 1c state the upper and lower bound for BRG openness and BB allocation, correspondingly. Constraints 1d ensure that each BB can be allocated at most once. Constraints 1e allow that at least one BRG must be allocated to an ADV. In constraints 1f each activated BRG can be allocated at most once to an ADV. For constraints 1g a BB is allocated to a BRG if and only if that BRG is active. Constraints 1h state that a BRG is only allocated to an ADV if that BRG is active. Constraints 1i indicate that there must exist a global capability balance. It means that the total allocated capabilities to deal with an ADV must be greater than or equal to the ADV capability. Constraints 1j define the binary decision variables for the problem.

This mathematical formulation corresponds to a mixed binary quadratically constrained optimization problem. Particularly, constraints 1i exhibit two interesting features. In the first place, the set  $\mathcal{K}$  includes all ADV entities and the set  $\mathcal{J}$  all BBs, then, all capabilities. It derives in that the global capability balance for each ADV is compulsory. However, it is challenging to be superior in all kinds of capabilities.

Next in order, the product of the binary variables  $x \cdot w$  increases the complexity of this formulation for the optimization process, even if it grants the capability balance for each ADV. Due to the quadratic nature of the capability constraint, this formulation is also known as *2i-BinQuad*.

Undoubtedly, constraints 1i are the base for the capability allocation process. Indeed, they are called the *capability balance* constraints because they establish the capability demand requirements that the planners must balance when the BRGs are structured.

In general, we can set whatever capability requirement during the force design process. However, the resources are restricted, and are not unusual that the decision-makers have to assume the existence of capability gaps. They are later managed by capability development programs as well as by risk assessments in case those gaps cannot be filled.

Lastly, the approximated nature of the capability parameter conducts the decision-maker to integrate the fact that uncertainty will be present within the design process. In that case, we have two choices: stochastic optimization and robust optimization frameworks.

In this first work, we will use the robust approach over our capability because we can have a rough knowledge of it. The ADV capabilities are assumed to be certain in the worst-case scenario due to the total ignorance about the ADV capability.

## Linearization and robust reformulation for the 2i-BinQuad model

The first step to pursuing a robust counterpart is the linearization of the capability balance constraints. We use the standard procedure to linearize the product of two binary variables by replacing the capability balance constraint 1i in three new constraints (*2i-BinLin*). Let us assume that  $b$  and  $B$  are two binary variables. The product of the variables  $bB$  can be replaced by the auxiliary decision variable  $z$  as follows:  $z \geq b + B - 1$ ,  $z \leq b$ ,  $z \leq B$ ,  $z \geq 0$ .

Moreover, in the *2i-BinLin* formulation for the capability allocation problem, uncertainty affects the parameter  $\mu_j^k$  in the capability balance constraints. In an attempt to deal with this behavior, we perform a robust reformulation of the capability balance constraints.

The final optimization model after the linearization and the robust counterpart inclusion using the cardinality-constrained approach [13] is the following:

$$\min \quad 1a \quad (2a)$$

s.t.

$$1b, 1c, 1d, 1e, 1f, 1g, 1h, 1j, \quad (2b)$$

$$\sum_{i \in \mathcal{I}, j \in \mathcal{J}} \mu_j^k z_{ij}^k - r^k \Gamma^k - \sum_{j \in \mathcal{J}_k} s_k^j \geq d^k \quad \forall k, \quad (2c)$$

$$r^k + s_k^j \geq \hat{\mu}_j^k t_{ij}^k \quad \forall i, j, k, \quad (2d)$$

$$-t_{ij}^k \leq z_{ij}^k \leq t_{ij}^k \quad \forall i, j, k, \quad (2e)$$

$$t_{ij}^k \geq 0 \quad \forall i, j, k, \quad (2f)$$

$$s_k^j \geq 0 \quad \forall j, k, \quad (2g)$$

$$r^k \geq 0 \quad \forall k, \quad (2h)$$

$$z_{ij}^k \geq x_{ij} + w_i^k - 1 \quad \forall i, j, k, \quad (2i)$$

$$z_{ij}^k \leq x_{ij} \quad \forall i, j, k, \quad (2j)$$

$$z_{ij}^k \leq w_i^k \quad \forall i, j, k, \quad (2k)$$

$$z_{ij}^k \geq 0 \quad \forall i, j, k \quad (2l)$$

In this formulation, all indices of the constraints and variables belong to the sets  $\forall i \in \mathcal{I}, j \in \mathcal{J}, k \in \mathcal{K}$ , except for constraints 2d and variable 2g which are defined on  $j \in \mathcal{J}_\mathcal{K}$ , where the set  $\mathcal{J}_\mathcal{K}$  states the elements possibly affected by uncertainty.

The capability deviation  $\hat{\mu}$  is treated as symmetric perturbation equal to  $\alpha \cdot \mu$ , where  $\alpha$  corresponds to the percentage of deviation from the nominal value  $\mu$ . Similarly,  $\Gamma$  is the number of parameters allowed to be affected by uncertainty in each constraint  $j \in \mathcal{J}$ .

## Analysis and discussion

The *2i-BinLinRob* formulation allocates BBs from an unique set  $\mathcal{J}$  that defines the capabilities through the vector  $d^k$ . In the mathematical model, we see that there is no differentiation among the several kinds of BBs that exist. In fact, we are only able to allocate one type of BB.

Although this situation is not an accurate representation of reality, it provides a valid lower bound for the capability allocation problem. Under these considerations, we assume that we are relaxing the necessity to allocate modules from different types.

Therefore, we could run  $|\mathcal{Q}|$  times this problem and get a valid upper bound for the allocation problem of different types of BBs supposing that  $\mathcal{Q}$  is the set that contains the types of BBs.

An alternative approach to deal with this situation is to divide the set  $\mathcal{J}$  into  $|\mathcal{Q}|$  subsets each one representing a particular type of BB. In this way, we can both individualize the types of BBs and allocate them according to the necessity and BRG design criteria.

## Experimentation, results and conclusions

### Experimentation

For the experimentation, we used two approaches to evaluate the model performance. First, we solved the initial *2i-BinQuad* formulation without uncertainty and the *2i-BinLinRob* model assuming BB uncertainty.

Concretely, for the *2i-BinLinRob* the deviation from the nominal of the BB capability  $\mu$  is symmetric and proportional to the parameter  $\alpha \in \{5\%, 10\%, 15\%, 20\%, 25\%, 30\%\}$ . Similarly,  $\Gamma$  represents the budget of uncertainty i.e.,

the number of parameters that we accept to be uncertain within each constraint. For this experimental instance, the set  $\mathcal{J}_\mathcal{K} = |\mathcal{J}|$ .

Later, we reformulated the set construction to include 12 different types of BBs and two types of BRGs.

We modeled and solved this model using Julia programming language v1.6.6 and JuMP v0.21.5 and the Gurobi v9.1 solver. All experimental instances were run on a MacBook Pro with 8 GB of memory and a processor Apple M1.

## Results

Table 3 presents the results of this initial evaluation. We see that as each instance increases the number of nonzero elements, the average time for the solution grows up. It happens because the linear reformulation increments the number of variables and constraints.

This situation does not allow the model to exploit the linear reformulation advantages. However, we expect that under instances of higher dimensions, the linearized model behaves better i.e., with lower resolution times than the quadratic one.

Performance Indicator	2i-BinQuad	2i-BinLin
Average time (s)	3.186	5.784
Continuous variables	0	1,872
Binary variables	498	498
Linear constraints	589	6,213
Quadratic constraints	4	--
Nonzero elements	2,455	17,431
Optimal value (M USD)	886	886

Table 3: Results for the nominal *2i-Bin* formulations

The solution presented in table 4 shows the activation of 4 BRGs each one containing 7 BBs. The BRG-to-ADV allocation was executed under a one-to-one scheme without the need for reinforcement from other BRGs. The BB allocation was materialized under a minimum cost criterion no matter the type of BB because it was not part of the requirements of the problem. In all cases, the model respected the capability allocation balance for the brigade capabilities (BCP) and adversary capabilities (ACP).

BRG	BCP	Battalions (BBs)	ADV	ACP
1	315	1/4/6/11/12/13/15	3	300
2	322	5/7/8/9/10/14/16	2	300
3	529	24/25/26/46/48/49/50	4	525
4	505	17/19/20/21/22/28/51	1	505

Table 4: Allocation and activation decisions for the *2i-Bin* nominal formulation

Figure 3 exhibits that the effect of uncertainty is notorious from  $\Gamma = 3$  for most of the parameter deviation

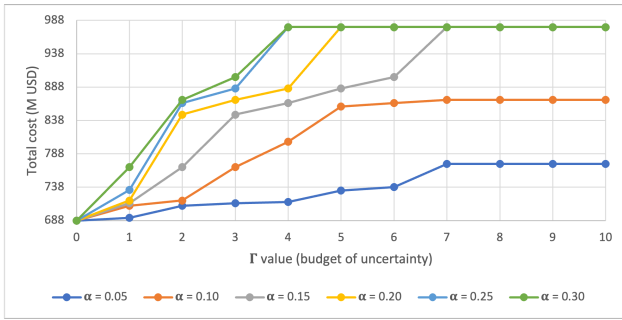


Figure 3: Robust capability allocation results

scenarios, especially when  $\alpha \geq 15\%$ . From  $\Gamma \geq 5$ , half of the scenarios reach the maximum level of protection and from  $\Gamma \geq 7$  all of them are in that condition.

On the other hand, we explored the chance to individualize each type of BBs (*2i-BinQuadSep*). Then, we split the set  $\mathcal{J}$  in 12 subsets, each one representing a particular type of BB. Additionally, we set BB lower and upper bounds requirements for the BRG composition in order to control the structure of those organizations. Table 5 shows the results of the same performance indicators previously used in table 3.

Performance Indicator	2i-BinQuadSep
Average time (s)	0.213
Continuous variables	0
Binary variables	498
Linear constraints	713
Quadratic constraints	24
Nonzero elements	3,011
Optimal value (M USD)	1,312

Table 5: Results for the nominal *2i-Bin* formulation with separated set  $\mathcal{J}$

Surprisingly, we got a better result in terms of the resolution time even if we had a higher number of constraints and nonzero elements. The main reason for that is because all constraints that involved a  $\forall j \in \mathcal{J}$  expression were now subdivided within 12 different types of subsets with fewer elements than the original one within the constraint.

BRG	BCP	Battalions (BBs)	ADV	ACP
1	501	1/6/15/18/30/46/56/63/74	2	300
2	312	12/13/38/51/61/69	3	300
3	463	2/3/17/29/39/45/58/68	1	505
4	451	14/16/28/31/43/44/62/70	1	505
6	529	21/26/41/52/57/66/72/78	4	525

Table 6: Allocation and activation decisions for the *2i-BinSep* nominal formulation

The result of this new formulation (table 6) includes

the activation of 5 BRGs all of them allocating between 6 and 9 BBs. ADV No. 1 allocates BRGs No.3 and 4 in a many-to-one BRG-to-ADV relationship. For ADV No.2, 3, and 4, there was a one-to-one allocation with BRG No.1, 2, and 6, respectively. It also maintained the capability balance requirement through the BRG-to-ADV allocations.

## Conclusions

In conclusion, we have seen that the robust reformulation of the capability allocation problem provides the necessary protection over uncertainty increasing the cost of the solution. A capability additive rule is a linear approach to constructing capabilities and constitutes an initial effort to characterize this process.

Moreover, we improved the initial formulation by splitting the set of BBs which led to identifying each type of entity according to its specialty. Similarly, this kind of analysis can provide the decision-makers with other information about structural issues in the design process, such as the necessity to convert a particular type of BB into another one.

Future lines of research are going to deepen into both the application of other robust and stochastic approaches and the implementation of a new rule of allocation based on nonlinear cross-effect relationships.

In the same order of ideas, we cannot discard the reformulation of the present optimization model in a version that includes a more detailed description of the decision variables. It will allow the decision-makers to generate options with a more realistic approach.

Complementary, the efforts must be also orientated to model and optimize the force management stage that is to say how the designed and implemented force is fed with resources to maintain the expected level of capabilities over time.

Finally, this capability design problem and the proposed approach can be applied to different contexts other than defense such as civilian emergencies, first response, and care organization, all of which provide services to society.

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# Using analytics and optimization at Portchain

by Alexander Krogsgaard, João Fonseca, Michael Lindahl, and Sebastian Christensen

The container shipping industry is the backbone and enabler of global trade, where 90% of all goods globally are transported through a container. At its core the industry is inefficient: 50% of all container vessels are delayed coming into port, and key planning processes are done manually on a global scale. This leads to high operational costs, lost revenue, and unnecessarily high greenhouse gas emissions. At Portchain, we work with our customers to reduce operational complexity and optimize planning through advanced analytics.

- A good customer service, where container vessels can berth when requested
- High robustness so delays don't occur if a vessel is delayed or a crane breaks down.

These decisions are hard to make, both because the data required to make these decisions is very fragmented and often inaccurate, but also because the complexity of the decisions makes it hard to strike the right balance between all the objectives. In Portchain, Operations Research and analytics all plays a role in all parts of the planning and execution process of the operations in a container terminal to support them in making the best decision based on the best available information. We support this in 3 steps:

1. Gather and predict demand from carriers
2. Optimize plan and execution
3. Follow up and identify opportunities for improvements

In the next sections we will go through each of them and provide more details about what they are and how we address them at Portchain.

## Container terminal operations

Every year 500,000 port calls are made all around the world. A port call is when a container vessel arrives at a terminal to discharge and load containers before it leaves to sail to the next terminal. Even though most container vessels sail on weekly schedules, every week looks different. Due to weather, volatility in demand, breakdowns, and other events, less than 50% of all container vessels arrive within 12 hours of their planned schedule.

This means that container terminals ongoingly have to adjust their plans to fit the change in the schedule. Since a terminal has a limited capacity, it is critical to ensure that the scarce resources are planned and utilized correctly. This leads to many decisions that need to be made:

- When do I have the capacity to berth this vessel?
- Where on the quay should I position this vessel?
- How many cranes should I allocate to each vessel?
- How much labor overtime should I book?

These decisions are re-evaluated multiple times per day and are critical to ensure that the container terminal operates profitably while attracting container volume from customers. They, therefore, need to ensure multiple factors in their decision-making:

- A low cost of operations
- High throughput of the terminal as much as possible during peak demand

## Gathering and predicting demand

Before you can start finding the best way to allocate your resources, you need to know the incoming demand to be served, since a key element to good decision-making is to ensure that it is based on good information.

Three of the key factors to assess the incoming demand are to determine:

- How many containers should be discharged and loaded on each vessel
- How many vessels will arrive
- When will each vessel arrive

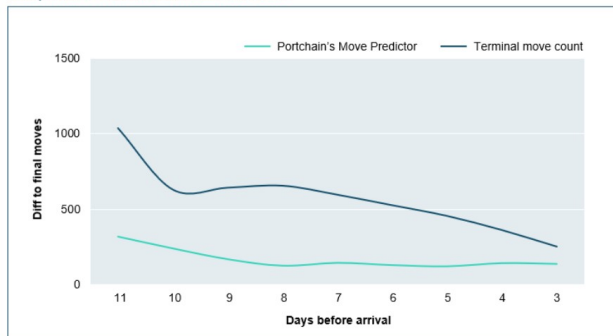
Before the vessel has physically arrived at the terminal these attributes have a big uncertainty as they are impacted by many factors. For example, the arrival time depends on when the vessel leaves the previous port and weather conditions on the sailing route. The number of containers also depends on bookings that



can be added and canceled shortly before the vessel's arrival.

One of our features to help terminals get better information is our move predictor. This estimates the number of container moves that can be expected on a port call well in advance of its arrival. This has improved volume forecasts among Portchain's customers, especially when the port calls are more than three days away from arrival. To predict the number of incoming moves, we train a machine learning model based on historical data combined with different attributes of the incoming vessel, such as the vessel's length and who is operating it.

Example: Move Predictor vs. terminal move count



## Planning and Optimization

Several resources take part in the planning process of a port call. First of all, the terminal quay has limited space, so we need to guarantee an arrival- and departure time that works together with the other vessels visiting the port. Not only that, but we also need to take into account that the section of the quay that we assign to each port call can be reached by enough available quay cranes, and that its location is as close as possible to the majority of containers to be loaded onto the vessel. Secondly, we need to plan enough human resources to maneuver both cranes and

straddle carriers that pick up containers to bring them to and from the vessel. Other factors that need to be taken into account in planning port calls are the impact of tides in the possible berthing times, physical safety buffer between port calls, crane maintenance, among others. Managing all these resources and input is a highly complex combinatorial problem, and Operations Research can help support the planner in making these decisions. At Portchain, we use Operations Research techniques to model and solve two different problems: Berth Optimization, and Crane Optimization.



**Berth Optimization** consists of determining arrival and departure times, and quay positions for each port call visiting the terminal in a given planning horizon. As input, each port call has a desired arrival and departure time, and a desired quay position, which can be determined by the location of containers in the terminal or other factors such as the characteristics of the quay cranes that can work at that position. We also know how much flexible labor is available to book and their associated costs, available cranes, and crane maintenance operations to take place. The main objective of the model is to find solutions where there are no berthing conflicts (port calls using the same location at the same time), minimizing the deviation from the desired arrival and departure times, and desired quay position. The problem is constrained by tides (influence on the possible arrival and departure times), berthing priorities between vessels (e.g. vessel A needs to berth before vessel B since there are containers to be transhipped from A to B), and crane and gang availability to ensure all required work is performed.

**Crane Optimization** assumes that both position and timings are fixed, and the decisions are which quay cranes to assign to each port call, and at what time. Each port call requires a total number of crane hours to perform all the container operations. There are several objectives considered, divided into three main groups: minimization of terminal costs, maximization of service level, and minimization of operational risk. The problem is constrained by the availability of gangs,



the availability of cranes, and other factors such as the maximum number of cranes that can operate simultaneously on each vessel based on how the vessel is stowed.

We encountered several challenges while modeling these problems. For example, labor considerations are tricky to consider since some terminals have highly complex cost structures and labor regulations. Furthermore, the cheapest plan is not always the best or the more robust one, so other factors need to be considered when choosing a plan. The physical layout of the terminal also presents its challenges, as cranes move on rails and have predefined ranges which constrain how they can be allocated to vessels. This also means that constraints to prevent solutions where cranes cross each other need to be included in the model. Also, some crane maintenance is planned, but crane breakdowns also occur, and when these happen the ranges of all other cranes are affected. To add a layer of complexity, some of the maintenance operations allow cranes to move, but others don't, so we also need to model them differently.

All our optimization models are lexicographical multi-objective mathematical problems, which we solve by addressing the different objectives in a hierarchical order. We always aim to provide the user with a solution in less than a minute, given the frequency of changes to the plan which means that the problem has to be solved multiple times each day. Due to that, we use math-heuristics to ensure that good solutions are found fast, limiting the solution space using a set of heuristics, and solve the resulting MIP models using Gurobi.



The shipping industry is quite conservative, so it is not always easy to introduce new technology into operations. These are highly complex problems where it is hard for a model to capture all the details that happen in reality. It is also challenging to build trust in a new system when some of the planners have been doing it differently for 30+ years. At Portchain, we strive to create an interactive human-machine interface,

which allows the user to control some of the parameters that go into the optimization models. For example, if a user inputs an infeasible instance, we have an interactive workflow where we suggest changes to the problem that the user can choose to accept to make the instance feasible. Another part is that we allow the user to only optimize parts of the plan so that the impact of the optimizer is more controlled and it is easier to verify the results.

## Monitoring and following up on operations

Modeling and structuring the data around the operations for terminals also allows us to monitor how the terminal is operating over time and how a plan evolves over time until it is executed. This is valuable for three reasons:

1. It allows the management in the terminal to monitor how much their resources are utilized over time to indicate if they are close to their maximum capacity or if they have room for more vessels.
2. It allows us to track and trend if our customers are improving how they plan. This is important to show the value generated by using our products and services, as well as support the ongoing change management process where we work closely with the terminal to identify how they can improve their planning processes.
3. Since there are so many changes happening ongoingly, it can be hard to understand why certain decisions were made. Knowing how the plan evolved and what happened in the past helps our users understand what decisions led to a specific outcome and, for example, improve how they determine their demand.



Some of the KPIs that we are monitoring is the utilization of critical resources such as cranes, labor, and the quay. Another focus is on how the terminal is performing towards its customers. For example, are they compliant with their agreements with the carriers, and how does the container volume develop over time.

Our users have access to a big variety of reports that each helps our customers identify issues and patterns in a specific part of the operation. This could, for example, be identifying a specific container service that always arrives late compared to the agreement that the terminal has with the carrier. Another example is that we are helping the planners understand when, during the week, they systematically have spare capacity to bring in more demand. It is very different how these reports are used, where some of them are sent around in the terminal every week, while others are used on a more *ad-hoc* basis.

Our analytics module is built separately from our planning application, only connecting to the same underlying data. The module is built with Tableau, which is a data visualization platform that we use to transform the data, but also to present data to the users giving them the possibility to filter and deep dive into the data to ensure they can answer their questions. This enables the analytics team to work independently from developers and to easily test out new reports and ideas with our users to quickly iterate and improve the module based on customer feedback.

## Quayside management system

Besides the analytical components of our application, there are many other features to support the end-to-end resource management in the terminal.

Our terminal application ingests data from multiple sources, and supports multiple people working on the same plan. Finally, we have a collaboration module that allows the planners to share their plan both internally within the terminal and externally with the customers so everyone always has the latest up-to-date information.

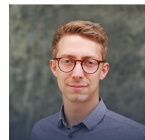
If you want to learn more about Portchain and our applications, please check out [www.portchain.com](http://www.portchain.com)



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# Calendar of Events

by EURO

## June 2022

- **7-9/6/2022** - IWOCA 2022, 33rd International Workshop on Combinatorial Algorithms, Trier, Germany
- **7-10/6/2022** - International Network Optimization Conference 2022 (INOC), Aachen, Germany
- **8-10/6/2022** - INFORMS TSL workshop, NHH Norwegian School of Economics, Bergen, Norway
- **13-15/6/2022** - VeRoLog 2022, Hamburg, Germany
- **13-22/6/2022** - EURO PhD School on Data Driven Decision Making and Optimization, Seville, Spain
- **16-17/6/2022** - Stockholm Optimization Days 2022, Stockholm, Sweden
- **19-25/6/2022** - TRISTAN XI - Eleventh Triennial Symposium on Transportation Analysis conference, Mauritius Island
- **21-22/6/2022** - 2nd EUROYoung Workshop, Porto, Portugal
- **27-29/6/2022** - Conference on Integer Programming and Combinatorial Optimization IPCO 2022, Eindhoven, The Netherlands

## July 2022

- **3-6/7/2022** - EURO 2022, Espoo, Finland
- **11-14/7/2022** - MIC 2022 - 14th Metaheuristics International Conference, Ortigia-Syracuse, Italy
- **17-24/7/2022** - EURO PhD School Reinforcement Learning Applied to Operations Research, Marienheide, Germany
- **18-29/7/2022** - EURO PhD School on MCDA/MCDM, Bilkent University, Ankara

## August 2022

- **1-5/8/2022** - Summer course at NHH: BEA522 Rural Logistics, NHH Norwegian School of Economics
- **24-26/8/2022** - IWLS 2022 (International Workshop on Lot Sizing), BI Norwegian Business School, Campus Oslo, Norway

- **30/8-2/9/2022** - ODS 2022 International Conference on Optimization and Decision Science, Firenze, Italy

## September 2022

- **6-9/9/2022** - OR 2022 - Annual Conference of the Operations Research Society of Germany, Karlsruhe, Germany
- **8-9/9/2022** - ATMOS 2022 - 22nd Symposium on Algorithmic Approaches for Transportation Modelling, Optimization, and Systems, Potsdam, Germany
- **10-14/9/2022** - PPSN 2022 Workshop on Data Science, Machine Learning and Optimization in Support of the Society of the Future (SSF), Dortmund, Germany

## October 2022

- **30/10-3/11/2022** - 15th International Conference on Advanced Systems in Public Transport (CASPT2022), Tel-Aviv, Israel

## 2023

- **10-14/7/2023** - IFORS 2023, Santiago, Chile
- **24-28/7/2023** - XVI International Conference on Stochastic Programming, California, USA

## 2024

- **30/6-4/7/2024** - EURO 2024, Copenhagen, Denmark

