Prof. Dr. Alexandre Dolgui

**Deputy Director for Research of the Henri Fayol Institute
and UMR CNRS 6158, LIMOS**

École des Mines de Saint-Étienne
(Saint-Étienne School of Mines)
France

dolgui@emse.fr

www.emse.fr/~dolgui

Alexandre Dolgui

Born in Borisov, Belarus, September 12th, 1961

Citizenship: French (2002) and Belarusian (by birth)

Current position:

Full Professor of Exceptional Class at the Ecole des Mines de St Etienne

Deputy Director for Research of Henri Fayol Institute (90 persons)

Deputy Director of CNRS Lab. LIMOS (~250 persons)

Previous professional experience in France

Ecole des Mines de St Etienne

2003 – 2011, Full Professor of 1st Class, Director of the Centre for Industrial Engineering & Computer Science as well as the Head of the Industrial Management Dept.

University of Technology of Troyes

2001 – 2003, Full Professor, Head of the Graduate Program in Production Management

1996 – 2001, Associate Professor of 2nd (tenure in June 1997), then 1st Class, Head of Graduate Program in Production Management

National Institute of Automation and Computer Sciences (INRIA)

1992 – 1996, Assistant Professor/Researcher

Education

Dr. Habil. in Industrial Engineering, University of Technology of Compiègne, France (2000)

Docent in Computational Methods & Programming, Ministry of Research & Education, Russia (1992)

Ph.D. in Engineering Cybernetics and Computer Aided Production Management, Academy of Sciences of Belarus, Institute of Engineering Cybernetics, Minsk, Belarus (1990)

Master of Science/Engineer in Computer Aided Production Management, Minsk Radio-engineering Institute, Belarus (1983)

30 years of teaching experience (design of production systems, planning and scheduling, inventory control)

Created and developed several engineer, master of science and PhD programs

16 PhD theses in France have been completed under my supervision (One of them was awarded as **the best PhD thesis** in Industrial Engineering in 2007)

Participated in about **140 defense committees** (in France, Spain, Belgium, Italy, China, Canada, Romania and Tunisia)

Procured funding for Research, PhD Programs, Scientific Conferences, etc. of well over **5,800,000** euros

5 books authored, **14** books edited, **28** chapters of books, **120** *papers in refereed international journals* (ISI Web of Science), **17** papers in refereed national journals, about **300** papers in conference proceedings, etc.

Several awards and international distinctions

Deputy Director,

## Henri Fayol Institute and UMR CNRS 6158, LIMOS

Saint-Etienne School of Mines (EMSE)

- Created by Royal decree on the 2nd of August 1816

- One of the oldest Schools of the group "Grandes Ecoles" (a sort of Ivy League), with Ecole Polytechnique, Ecole Centrale de Paris, etc.

Our School is often classed among the Top 10 Graduate Engineering Schools in France

The EMSE produces outstanding industrial managers

St-Etienne: pop. 400 000
56 km from Lyon

Ecole Nationale
Supérieure des Mines
SAINT-ETIENNE
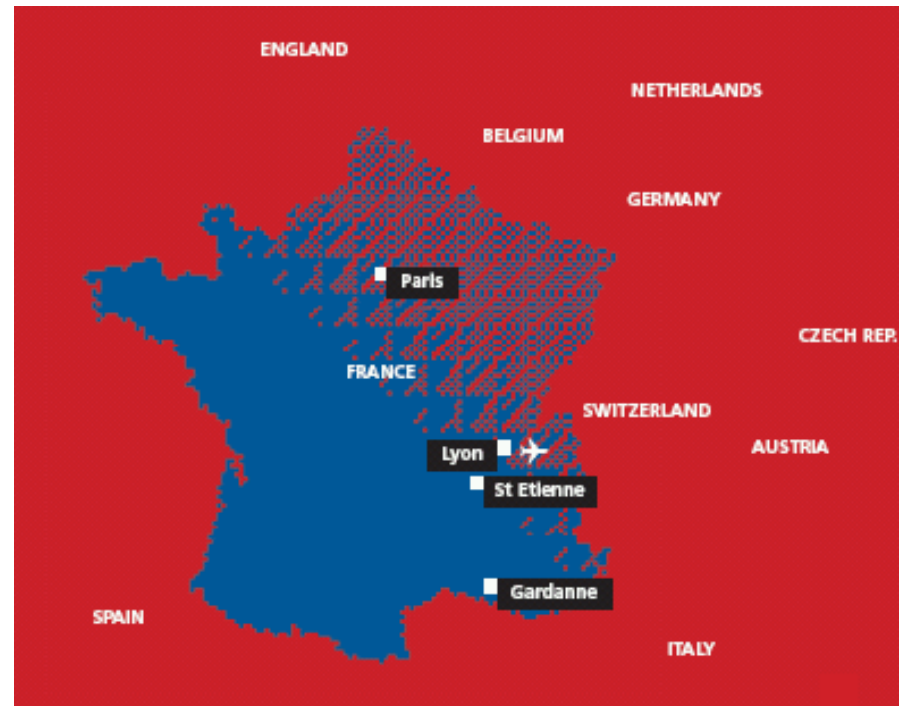
Saint-Etienne School of Mines (EMSE)

is structured around <u>five divisions</u>:

- **Henri Fayol Institute**
- Materials Science Centre
- Chemical Engineering Centre
- Microelectronics Centre
- Engineering and Health Centre

Just a couple who have made history from our School:

Benoît Fourneyron (1802-1867) - inventor of the hydraulic turbine
Henri Fayol (1841-1925) - known for his theory of management

The laying of the first French rail route (Saint-Etienne to Andrézieux) which opened in **1825** is also credited to the School
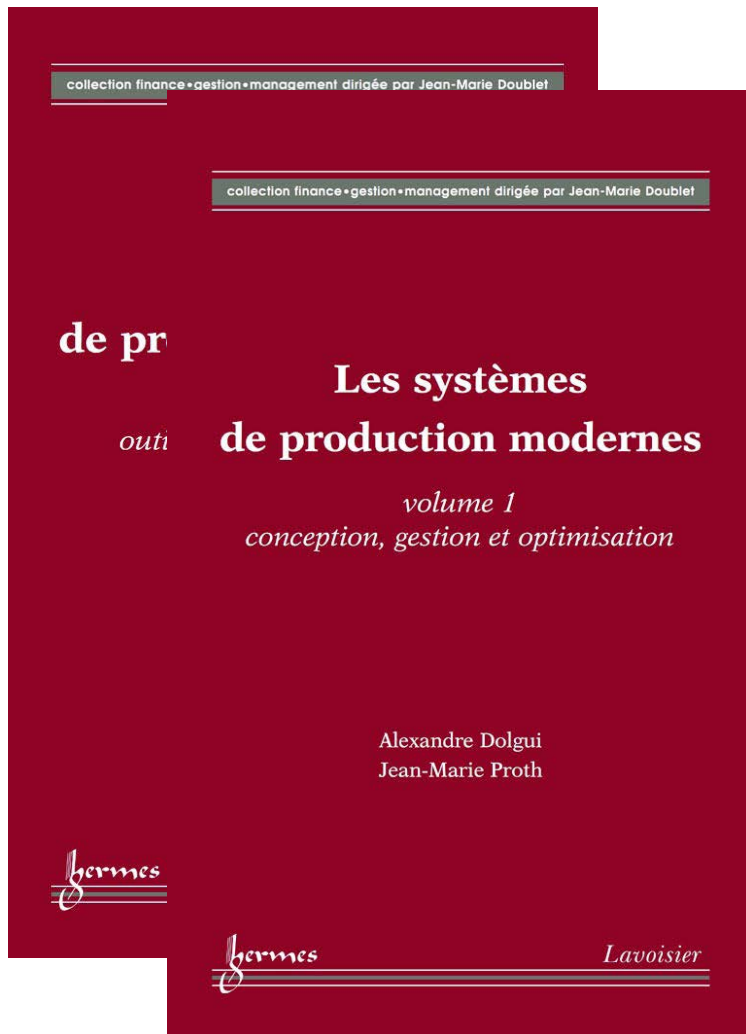
Henri Fayol Institute

The Institute was named after one of the fathers of modern management, **Henri Fayol** who graduated from our School in **1860**

Our institute deals with industrial management, systems engineering and information technology

Composed of four departments:

- **Decision in the Enterprise: Modeling and Optimization**

- Industrial and Environmental Management

- Distributed and Cooperative Multi-agent Systems

- Behavior Management and Social Sciences

collection finance•gestion•management dirigée par Jean-Marie Doublet

collection finance•gestion•management dirigée par Jean-Marie Doublet

de pr

outi

**Les systèmes
de production modernes**

*volume 1
conception, gestion et optimisation*

Alexandre Dolgui
Jean-Marie Proth

hermes

hermes   *Lavoisier*

A. Dolgui, J.M. Proth.
Les systèmes de production modernes,
Hermès Science/Lavoisier, 2006,
2 volumes (In French), 806 pages

Ecole Nationale
Supérieure des Mines
SAINT-ETIENNE
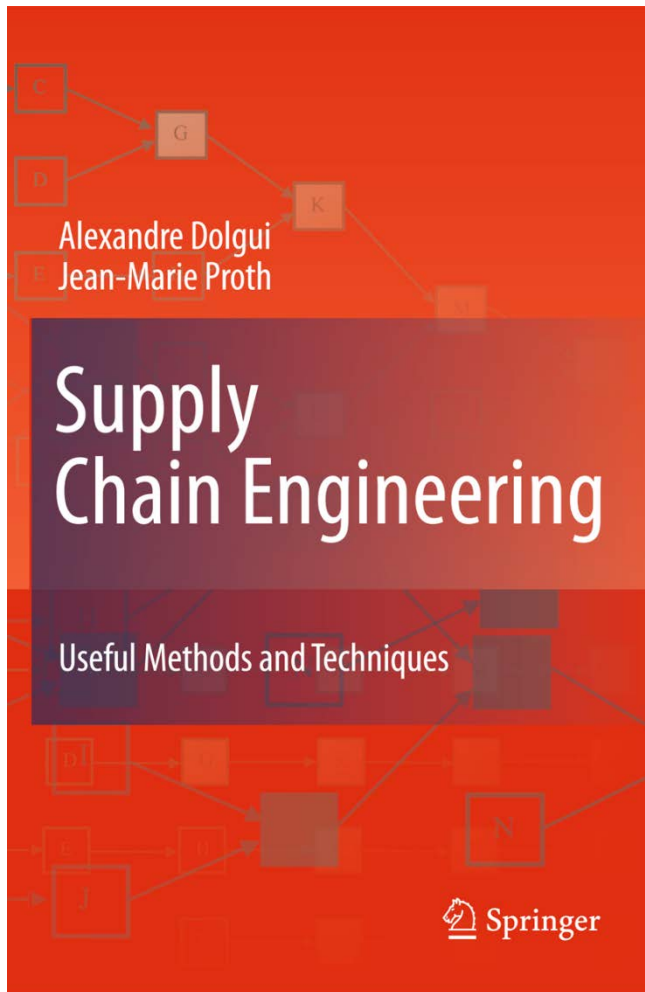
A. Dolgui, J.M. Proth.
Supply chain engineering: useful methods and techniques,
Springer, 2010, 542 pages

Ecole Nationale
Supérieure des Mines
SAINT-ETIENNE

# ASSEMBLY LINE BALANCING

Applications in machining environments
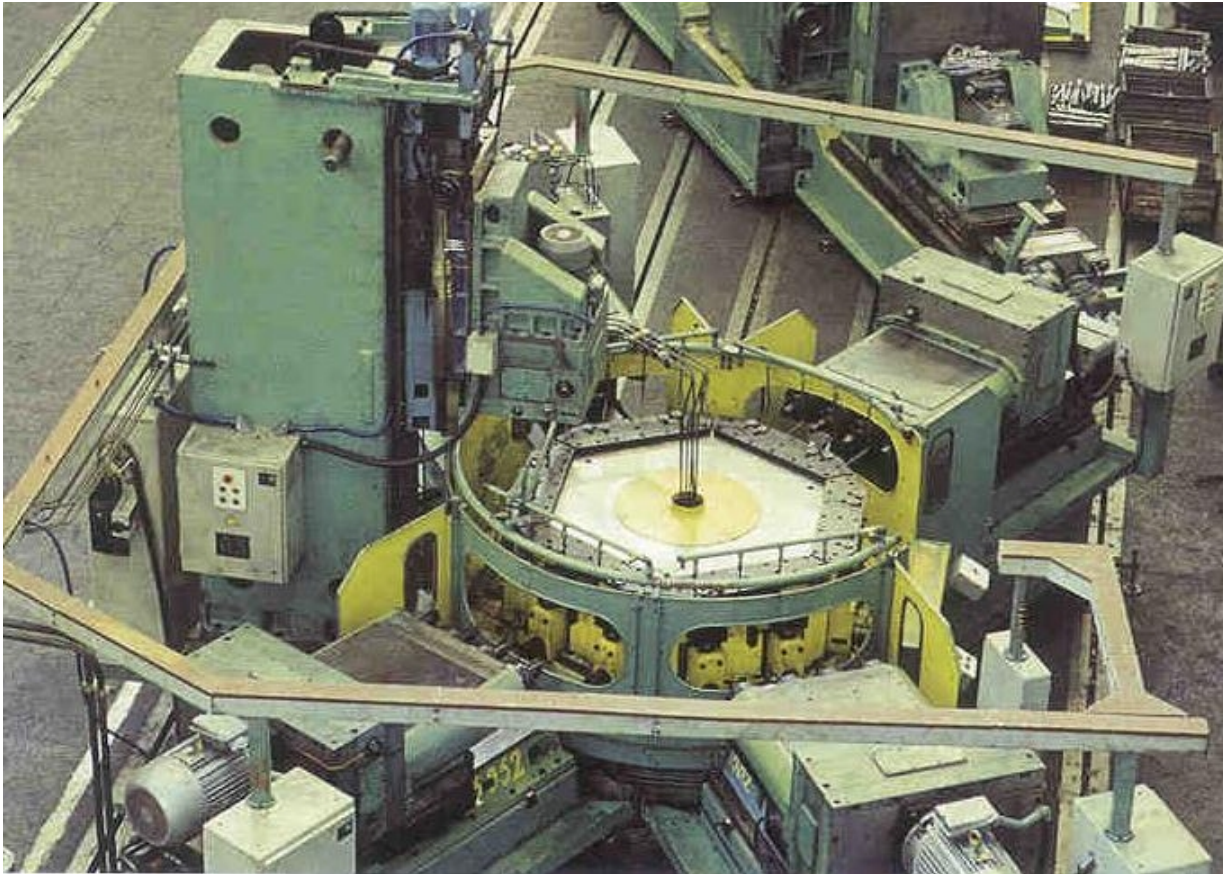
A. Dolgui, N. Guschinsky, G. Levin. **Graph approach for optimal design of transfer machine with rotary table**, *Int. J. of Production Research*, 47 (2), 2009, 321–341.

Ecole Nationale
Supérieure des Mines
SAINT-ETIENNE

Transfert linéaire
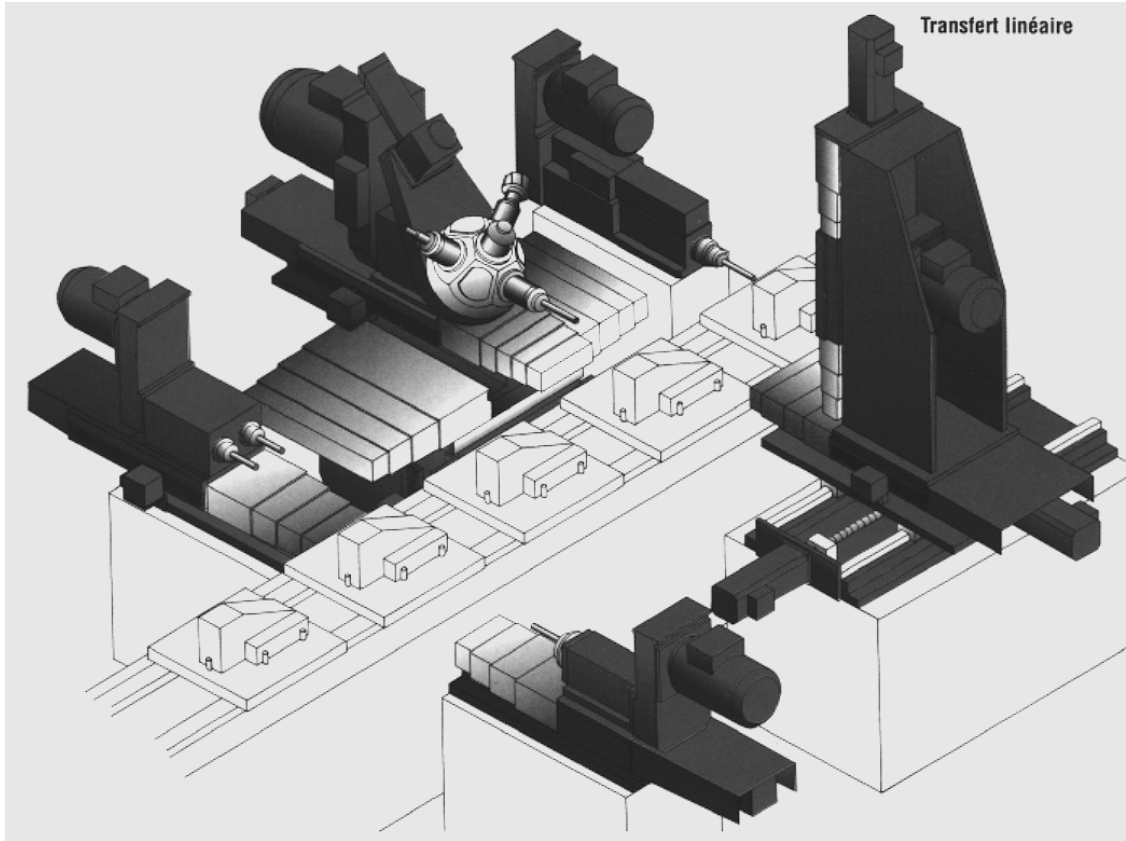
A. Dolgui, B. Finel, N. Guschinsky, G. Levin, F. Vernadat. **MIP Approach to Balancing Transfer Lines with Blocks of Parallel Operations**, *IIE Transactions*, 2006, 38, 869–882.

IIE Transactions Best Paper Award 2008

Ecole Nationale
Supérieure des Mines
SAINT-ETIENNE
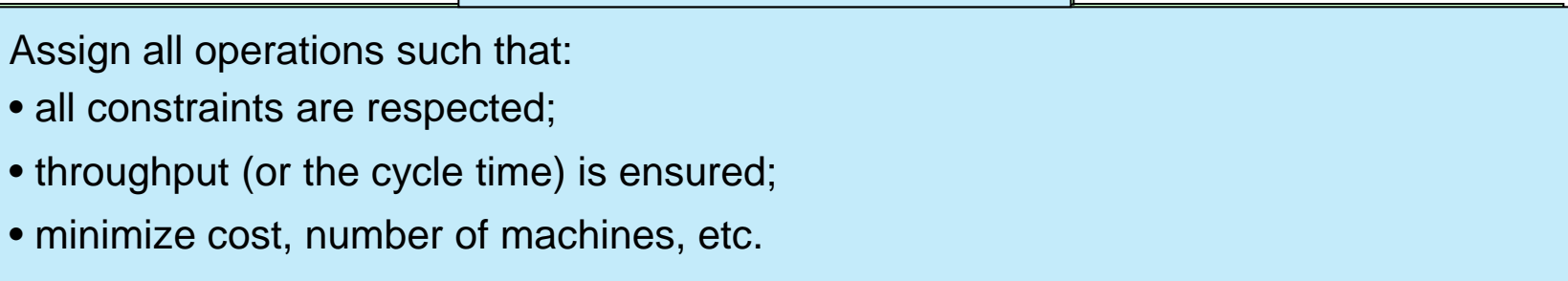
Reconfigurable lines composed of machining centers
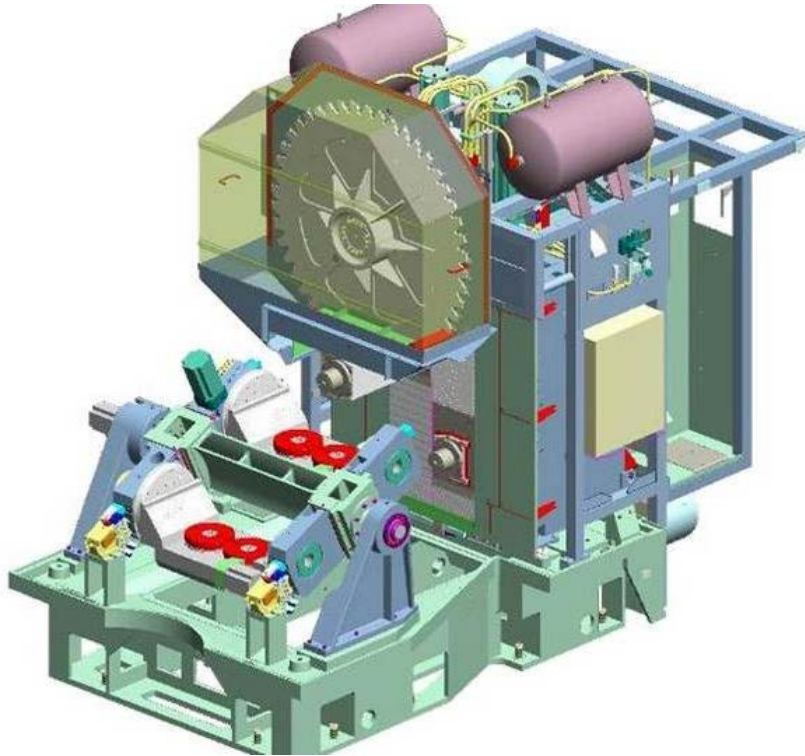
M. Essafi, X. Delorme, A. Dolgui.
A Reactive GRASP and Path Relinking for Balancing Reconfigurable Transfer Lines, *Int. J. of Production Research*, 2012

➢ Mono-spindle CNC machining centers

➢ Several identical machining centers at each station

➢ Setup times for tool replacement and/or displacement

Ecole Nationale
Supérieure des Mines
SAINT-ETIENNE

Decision-Aid Tool for Machining System Design
(based on line balancing techniques)

Design of a machining systems

```
New product  →  ┌─────────────────────┐        ⟷        ┌─────────────────────┐
                 │  Definition of      │                 │   Line balancing    │
                 │  operations         │                 └─────────────────────┘
                 │        ⇕            │                          ⇕
                 │  Process planning   │                 ┌─────────────────────┐
                 └─────────────────────┘                 │ Evaluation and      │
                                                          │ simulation          │
                                                          │        ⇕            │
                                                          │ Detailed design and │
                                                          │ implementation of   │
                                                          │ the system          │
                                                          └─────────────────────┘
```

Line balancing

Assign all operations such that:

• all constraints are respected;

• throughput (or the cycle time) is ensured;

• minimize cost, number of machines, etc.

Steps for decision making

Step 1. "Takt time" calculation and choice of layout type

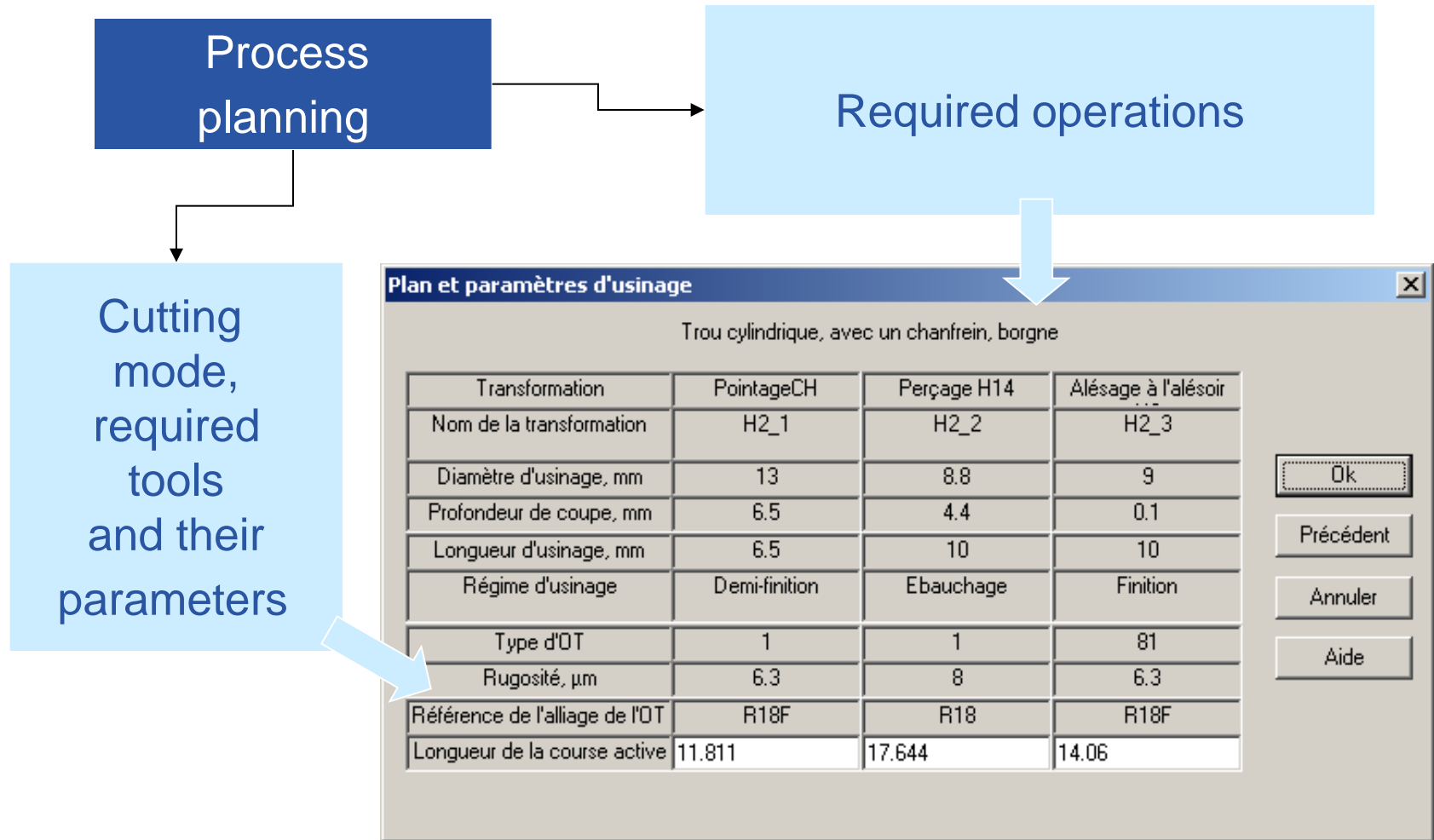Step 2. Part modeling: using standard features to define tasks

Step 3. Process planning, i.e. choice of a process plan (required operations, tools, technological constraints,…) by using an *expert system*

Step 4. **Synthesis of the manufacturing process using optimization models**: line balancing and equipment configuration taking into account cutting modes and parameters

Step 2: Part modeling to define tasks
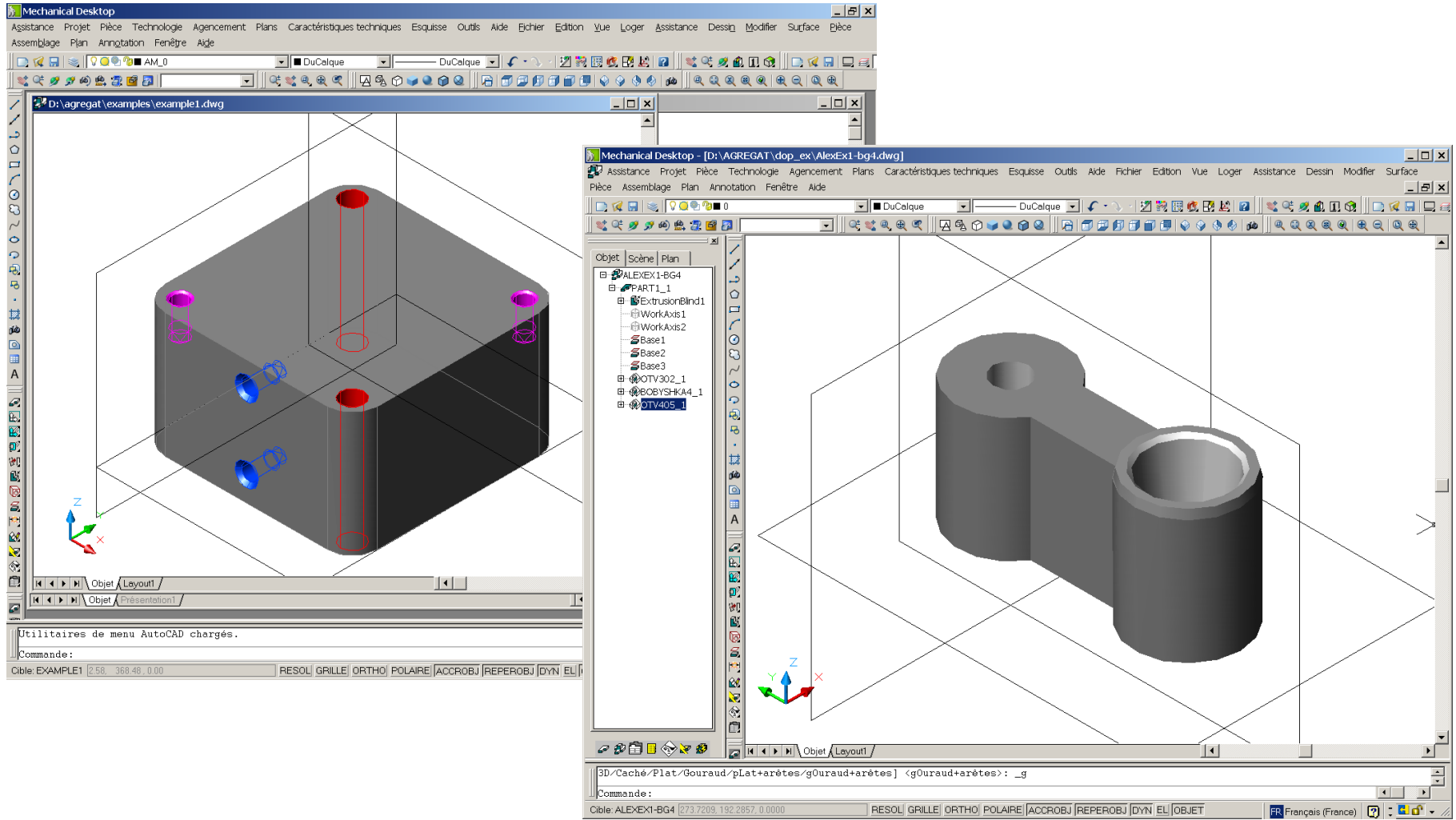
Step 3: Choice of a process plan (expert system)

Process planning

Required operations

Cutting mode, required tools and their parameters

Plan et paramètres d'usinage

Trou cylindrique, avec un chanfrein, borgne

Transformation	PointageCH	Perçage H14	Alésage à l'alésoir
Nom de la transformation	H2_1	H2_2	H2_3
Diamètre d'usinage, mm	13	8.8	9
Profondeur de coupe, mm	6.5	4.4	0.1
Longueur d'usinage, mm	6.5	10	10
Régime d'usinage	Demi-finition	Ebauchage	Finition
Type d'OT	1	1	81
Rugosité, µm	6.3	8	6.3
Référence de l'alliage de l'OT	R18F	R18	R18F
Longueur de la course active	11.811	17.644	14.06

Ok
Précédent
Annuler
Aide

Constraints

Step 4: Line balancing and equipment selection

The designer checks and/or modifies the constraints and parameters

Optimisation

Optimal solutions that take into account all the given constraints

Final solution

The solutions are presented to the designer who then verifies it

Tête d'outils

Station de chargement   station de travail   station de déchargement
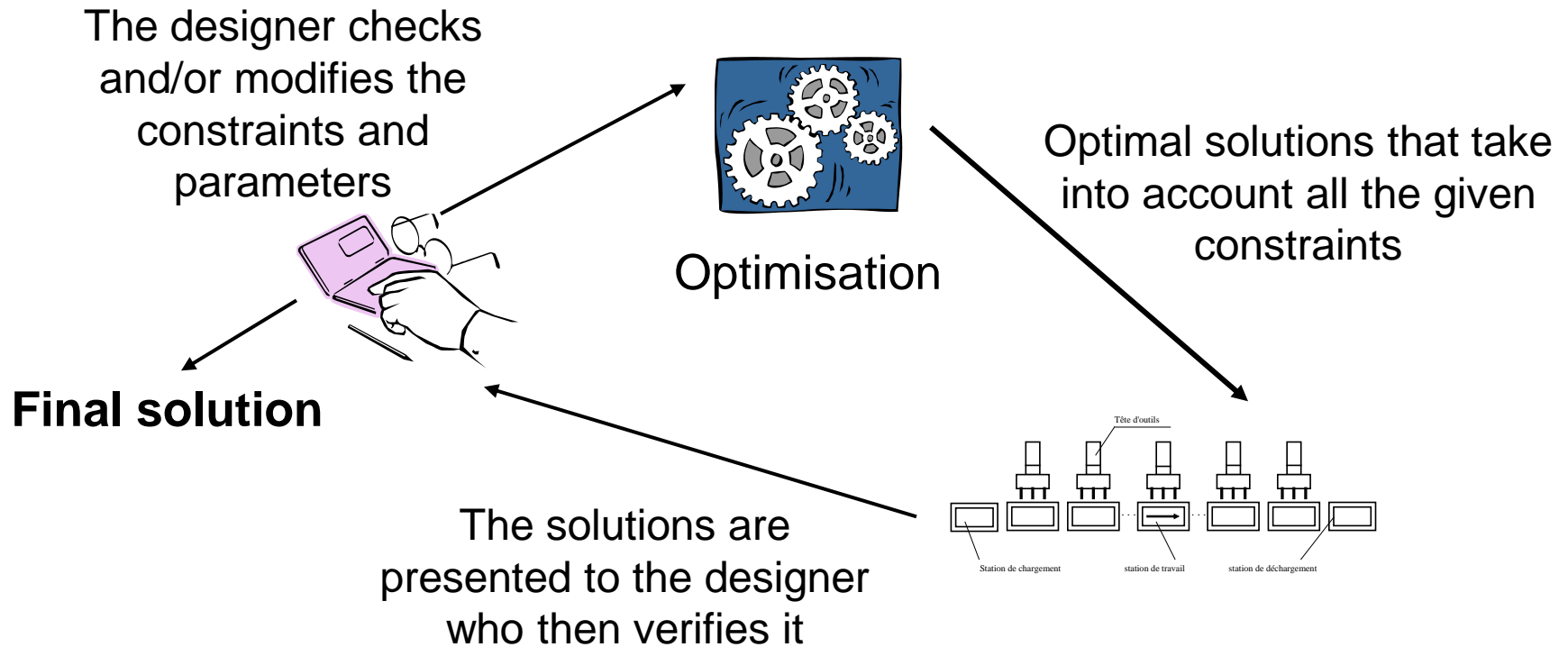
Mass production machines with multi-spindle heads

Multi-tool spindle heads

Reconfigurable multi-spindle head

All operations of the same spindle head are executed in parallel
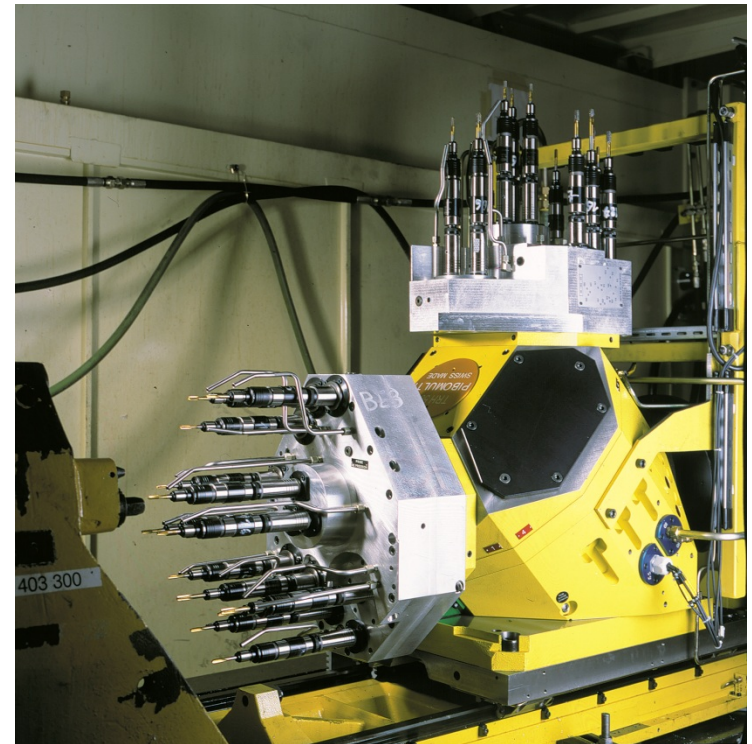
New problem: multi-spindle machining line balancing
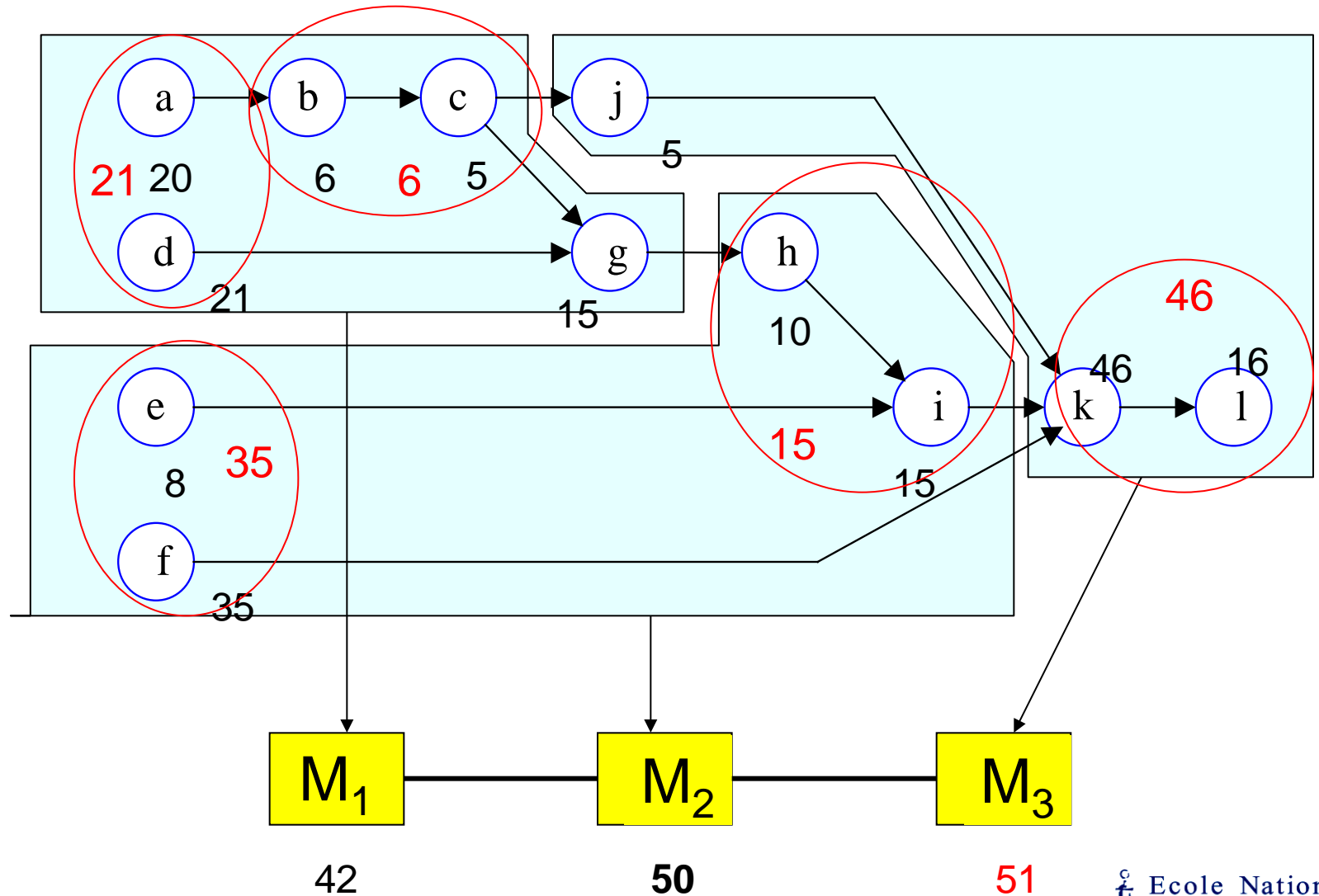
*Comparison with assembly line balancing (ALB)
and their generalizations*:

- Operation times are not known before optimization

- Assignment restrictions (constraints) are more complex

- Operations of the same spindle head are executed in parallel

- Line balancing simultaneously with equipment selection/design

MIP model (Cplex)

Analysis of constraints to reduce the number of binary decision variables

↓

Cplex solver for MIP model

Note that without this constraint analysis:
Only problems with maximum 40 tasks were optimally solved in 10 hours

Dolgui et al., MIP Approach to Balancing Transfer Lines with Blocks of Parallel Operations, *IIE Transactions* 38, 2006, 869–882

Battaïa and Dolgui. *Reduction approaches for a generalized line balancing problem,* Computers & Operations Research 39, 2012, 2337–2345

Dolgui et al. Enhanced mixed integer programming model for a transfer line design problem*, Computers & Industrial Engineering* 62, 2012, 570–578

Graph approach
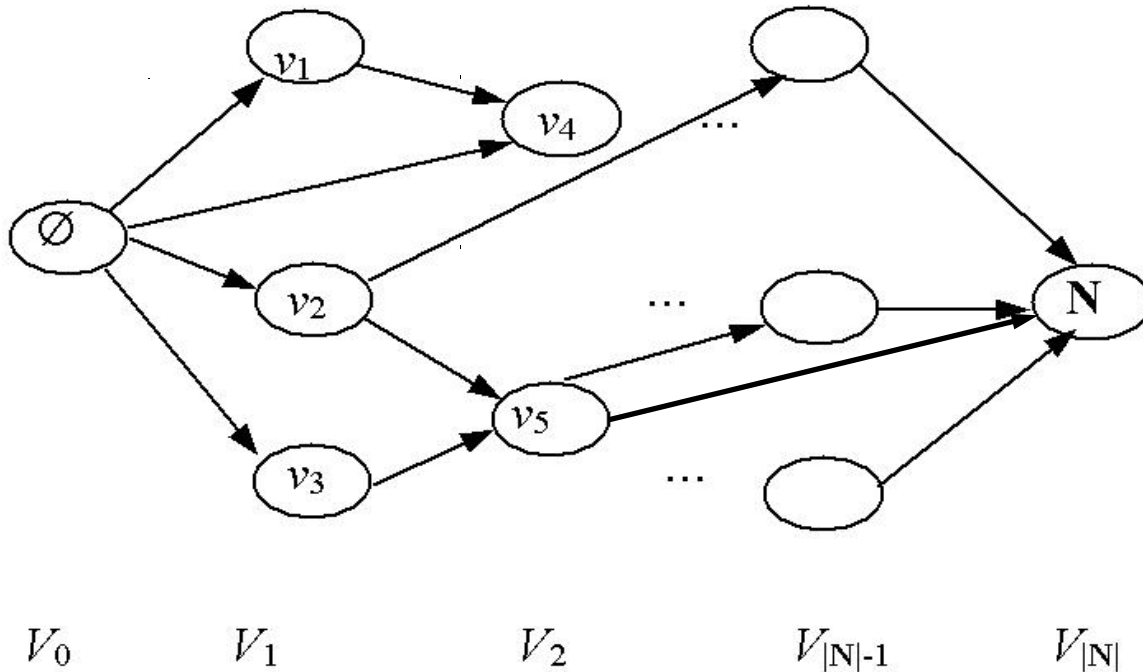
A. Dolgui, N. Guschinsky,
G. Levin, J.-M. Proth.
Optimisation of multi-position
machines and transfer lines,
Eur. J. of Operational Research
185, 2008, 1375–1389.

A. Dolgui, N. Guschinsky,
G. Levin. A Special Case of
Transfer Lines Balancing by
Graph Approach, Eur. J. of
Operational Research 168,
2006, 732–746.

Dominance properties to reduce the size of graph

Branch and Bound

- Enumerate solutions

- Evaluate Lower (LB) and Upper (UP) Bounds

    (a novel approach using set partitioning)

- Prune branches where LB<=UP

- Verify dominance properties: remove dominated nodes
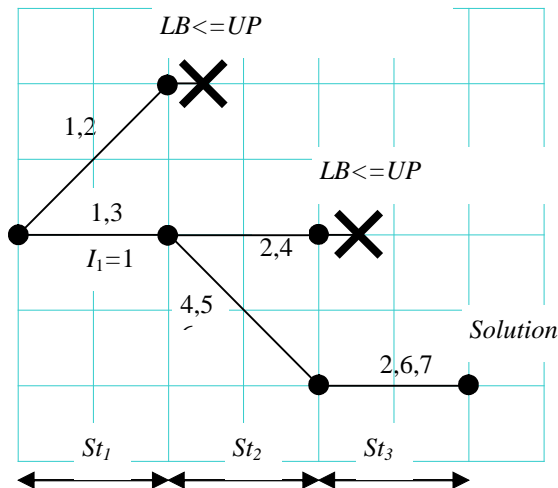
A. Dolgui and I. Ihnatsenka.
Branch and Bound Algorithm for a
Transfer Line Design Problem: Stations
with Sequentially Activated Multi-spindle
Heads, *Eur. J. of Operational Research*
197, 2009, 1119–1132

Heuristics

➤ **Random search** (COMSOAL like heuristics, Backtracking with learning, GRASP,…)

➤ **Decomposition**

a) Breakdown the initial problem into several sub-problems

　1. Based on precedence graph
　2. Based on a feasible solution

b) Solving sub-problems by an exact method

　1. Independent solving
　2. Aggregate solving

O. Guschinskaya, A. Dolgui, N. Guschinsky, G. Levin. A Heuristic Multi-Start Decomposition Approach for Optimal Design of Serial Machining Lines, *Eur. J. of Oper. Research* 189, 2008, 902–913.
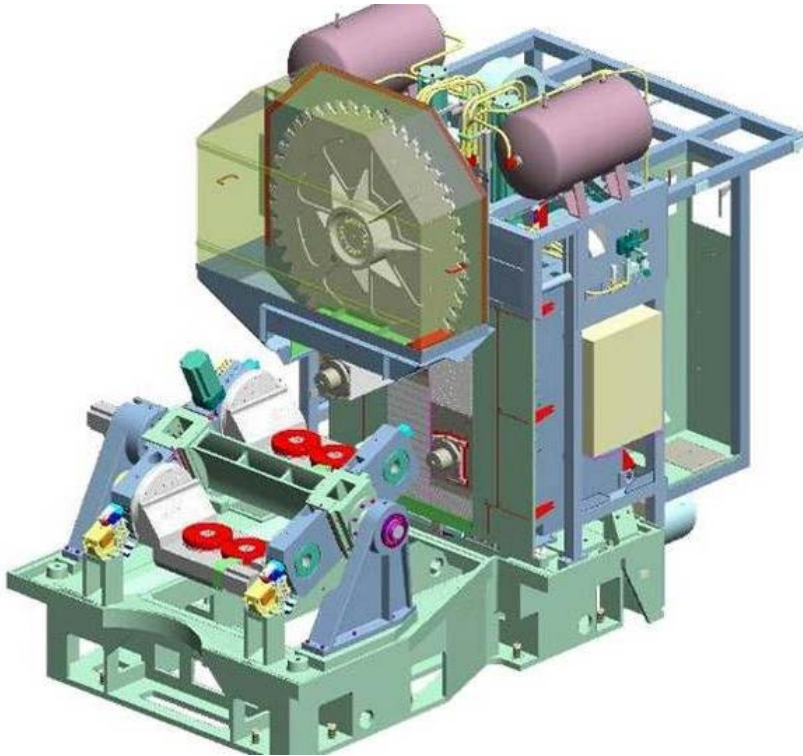
A. Dolgui, B. Finel, N. Guschinsky, G. Levin, F. Vernadat. A heuristic approach for transfer lines balancing. *J. of Intell. Manufact.* 16, 2005, 159–171.
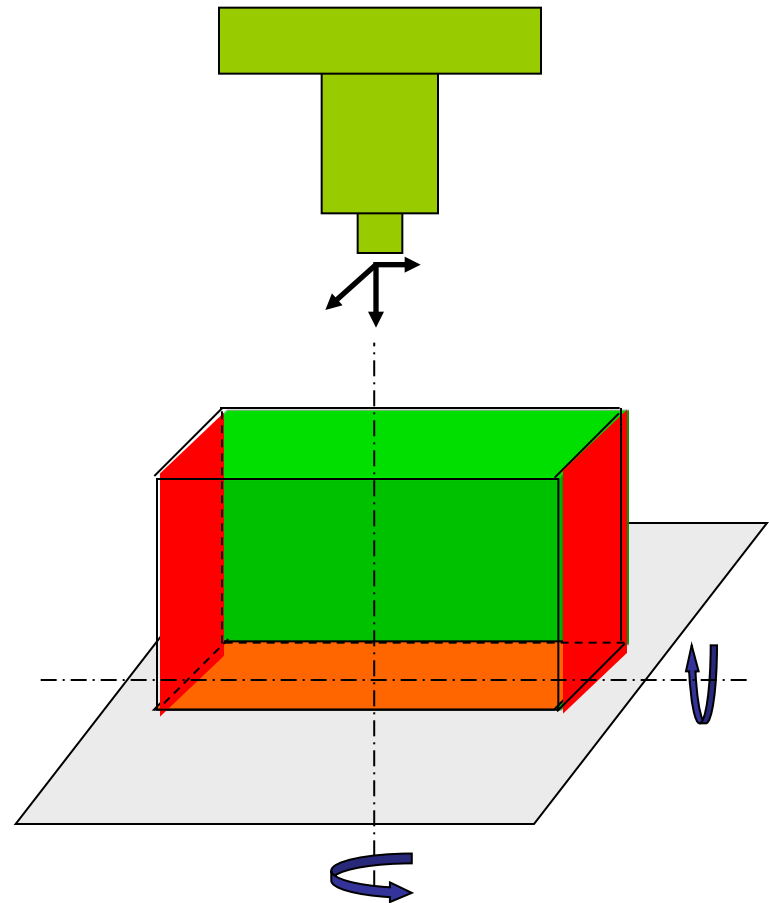
Comparison of the methods:

Problem size	Level of constraints	Best method
Small	**low**	**MIP**
	high	**Graph approach** or **Branch and Bound**
Medium	**high**	
	low	**GRASP**
Large	**high**	
	low	

Lines composed of machining centers

Accessibility constraints

4- and 5- axis centers

Additional setup times

$$t_{ij} = t_1 + t_2 + t_3$$
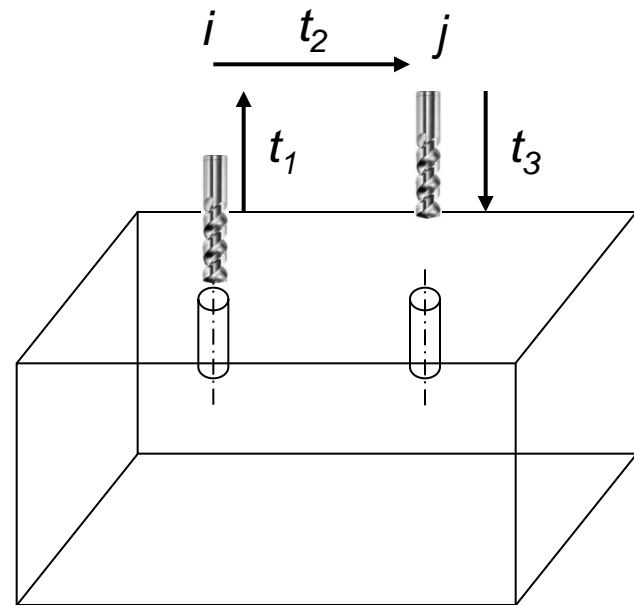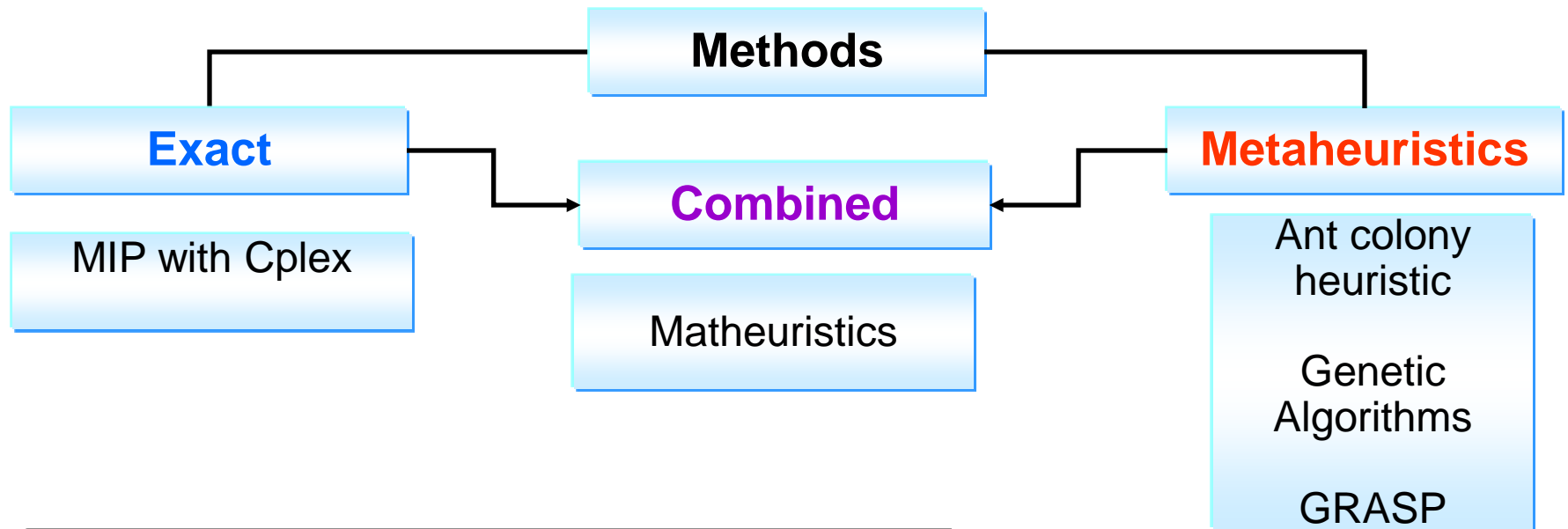
Tool change time

Methods

Exact

MIP with Cplex

Combined

Matheuristics

Metaheuristics

Ant colony
heuristic

Genetic
Algorithms

GRASP

M. Essafi, X. Delorme, A. Dolgui, and O. Guschinskaya. A MIP
Approach for Balancing Transfer Lines with Complex Industrial
Constraints, *Computers & Industrial Engineering* 58, 2010, 393–400

P. Borisovsky, X. Delorme, A. Dolgui. Genetic algorithm for balancing
reconfigurable machining lines, *Computers & Industrial Engineering*,
2013

Some our recent publications

O. Battaïa, A. Dolgui, N. Guschinsky, G. Levin. A decision support system for design of large series machining lines composed of stations with rotary or mobile table, *Robotics and Computer Integrated Manufacturing*, 28 (6), 2012, 672–680.

O. Battaïa, A. Dolgui. Reduction approaches for a generalized line balancing problem, *Computers and Operations Research*, 39(10), 2012, 2337–2345.

A. Dolgui, N. Guschinsky, G. Levin. Enhanced mixed integer programming model for a transfer line design problem, *Computers and Industrial Engineering*, 62(2), 2012, 570–578.

X. Delorme, A. Dolgui, M.Y. Kovalyov. Combinatorial design of a minimum cost transfer line, *Omega*, 40(1), 2012, 31–41.

M. Essafi, X. Delorme, A. Dolgui. Balancing lines with CNC machines: a multi-start Ant based heuristic, *CIRP Journal of Manufacturing Science and Technology*, 2, 2010, 176–182.

M. Essafi, X. Delorme, A. Dolgui, and O. Guschinskaya. A MIP Approach for Balancing Transfer Lines with Complex Industrial Constraints, *Computers and Industrial Engineering*, 58 (3), 2010, 393–400.

O. Guschinskaya, and A. Dolgui. Comparison of Exact and Heuristic Methods for a Transfer Line Balancing Problem, *International Journal of Production Economics*, 120 (2), 2009, 276–286.

A. Dolgui and I. Ihnatsenka. Branch and Bound Algorithm for a Transfer Line Design Problem: Stations with Sequentially Activated Multi-spindle Heads, *European Journal of Operational Research*, 197(3), 2009, 1119–1132.

X. Delorme, A. Dolgui, M. Essafi, L. Linxe and D. Poyard. Machining Lines Automation. in: *Springer Handbook of Automation*, S.Y. Nof (Ed.), Springer, 2009, 599–618.

Ecole Nationale
Supérieure des Mines
SAINT-ETIENNE

Editor-in-Chief of the International Journal of Production Research (IJPR)

appointed in March 2012

In 2012, IJPR celebrated its **50th volume anniversary**

(Volume 1 was published in 1961)

The past Editors-in-Chief of IJPR:

Norman Dudley, 1961 – 1981

Roy Sury, 1982 – 1997

John E. Middle, 1998 – 2011

They have accomplished a great deal and established a wonderful reputation for the journal:

- Many cutting edge scientific results were published in IJPR and rest in the annals of scientific research

- Significant advances published in IJPR were transferred from academia to industry and then to the rest of society

IJPR is a well established and respected journal in our domain

Indexed in ISI Science Citation Index® **(as well as in** British Library Inside; Cabell's Management Directory; Cambridge Scientific Abstracts; EBSCO Databases; Electronic Collections Online; Engineering Information Inc; INSEAD; INSPEC®; International Abstracts in Operations Research; ISI CompuMath Citation Index®; ISI Current Contents®: Engineering, Computing and Technology; New Jour; OCLC ArticleFirst; Recent Advances in Manufacturing Database (RAM); Scopus; Zentralblatt MATH/Mathematics Abstracts and Zetoc).

One of the first journals in this field, created 52 years ago

It was a pioneer in **manufacturing technologies, industrial engineering, product/process design and production management**.

The journal is a giant in our field. In the mind of many of our colleagues it is the reference for all of us.

To summarize, IJPR has been the **flagship of our profession for half a century**

In the first editorial, IJPR's founding Editor-in-Chief **Norman Dudley** wrote:

1916–2006

"Production is a meeting place of **many disciplines, for the planning, organizing and control of manufacturing industry** necessitate an understanding of the nature and interaction of the **technical, human and economic forces** which are the agents of production. If this understanding can be advanced by **bringing together** papers which would otherwise have been scattered throughout the literature of the **several contributing sciences**, the initiative of The *Institution of Production Engineers* in launching this International Research Journal will have been well justified."

Contributing sciences

Ergonomics

Mechanics

Manufacturing engineering

Industrial engineering

Operations Research

Automation and IT technologies

Computer science

Management science

Economics

etc.

Journal scope

IJPR traditionally publishes papers on

manufacturing technology and **production resources**,

problems of **analysis and control** that arise in combining these resources **within the design of production systems**,

production management strategies and **policies**

as well as **techniques developed in computer and mathematical sciences** used in the **design, measurement or operation of production systems and logistics**

Engineering and Management of Manufacturing Systems are still **crucial topics** today and major concerns of the journal

Other issues with key implications for the world economy, like **Global supply networks, Outsourcing, Pricing** are also widely discussed

Transportation and logistics, **Warehousing**, **Inventory control under uncertainties**, **RFID and other IT technologies**, **Mass customization**, **Holonic systems**, **Reconfigurable manufacturing systems**, **Product lifecycle management (PLM)**, **Cognitive and collaborative technologies** are some other examples

as well as applications of Production Research in service systems (**Call centers**, **Health care engineering**,…)

In 2012 (volume 50), we have published 492 papers in 24 issues

International Journal of Production Research

=

Scientific rigor

&

Practical relevance

Ecole Nationale
Supérieure des Mines
SAINT-ETIENNE

Timothy Fry, Joan Donohue et al.,

University of South Carolina, USA

have analysed 147 journals and 15 previous journal ranking studies published in literature, a DEA model was proposed

The final result, « Ranking of 32 OM journals …»,

place IJPR in **4th position (!)** after:

- Management Science

- Journal of Operations Management

- Operations Research

and Top 50 Countries Based on Ph.D. Granting Institution (1985-2010)

1. **USA, 5451 papers, 44.89%**

2. **UK, 1388 papers, 11.43%**

3. **India, 547 papers, 4.50%**

4. **Canada, 488 papers, 4.02%**

5. **Taiwan, 446 papers, 3.67%**

6. **China, 380 papers, 3.13%**

7. **Japan, 351 papers, 2.89%**

8. **France, 325 papers, 2.68%**

9. **Italy, 255 papers, 2.10%**

10. **Korea, 231 papers, 1.90%**

The same authors established the list of

Top 50 Institutions Based on *IJPR* Authors' Affiliations:

1. **Purdue**, 255 papers

2. **Penn State**, 246 papers

3. **National University of Singapore**, 201 papers

4. **Loughborough**, 193 papers

5. **Nanyang Technological University**, 193 papers

6. **Hong Kong**, 131 papers

7. **Arizona State**, 122 papers

8. **Shanghai Jiao Tong University**, 122 papers

9. **Korea Advanced Institute of Science and Technology,** 109 papers

10. **National Chiao Tung University,** 105 papers

Chair of IFAC technical committee,

Manufacturing Modeling for Management and Control

Manufacturing Modelling, Management and Control

Recent IFAC Conference in
Saint Petersburg, June 19-21, 2013

Site Web: **http://mim2013.org**
IPC chair: Alexandre Dolgui, France
IPC vice-chair: Agostino Villa, Italy
IPC vice-chair from industry: Oleg Gusikhin, Ford, USA

455 scientific participants from **54 countries**
(602 full papers submitted from 59 countries, 375 selected, 227 rejected)

INCOM 2015
Ottawa, Canada, May 11-13, 2015
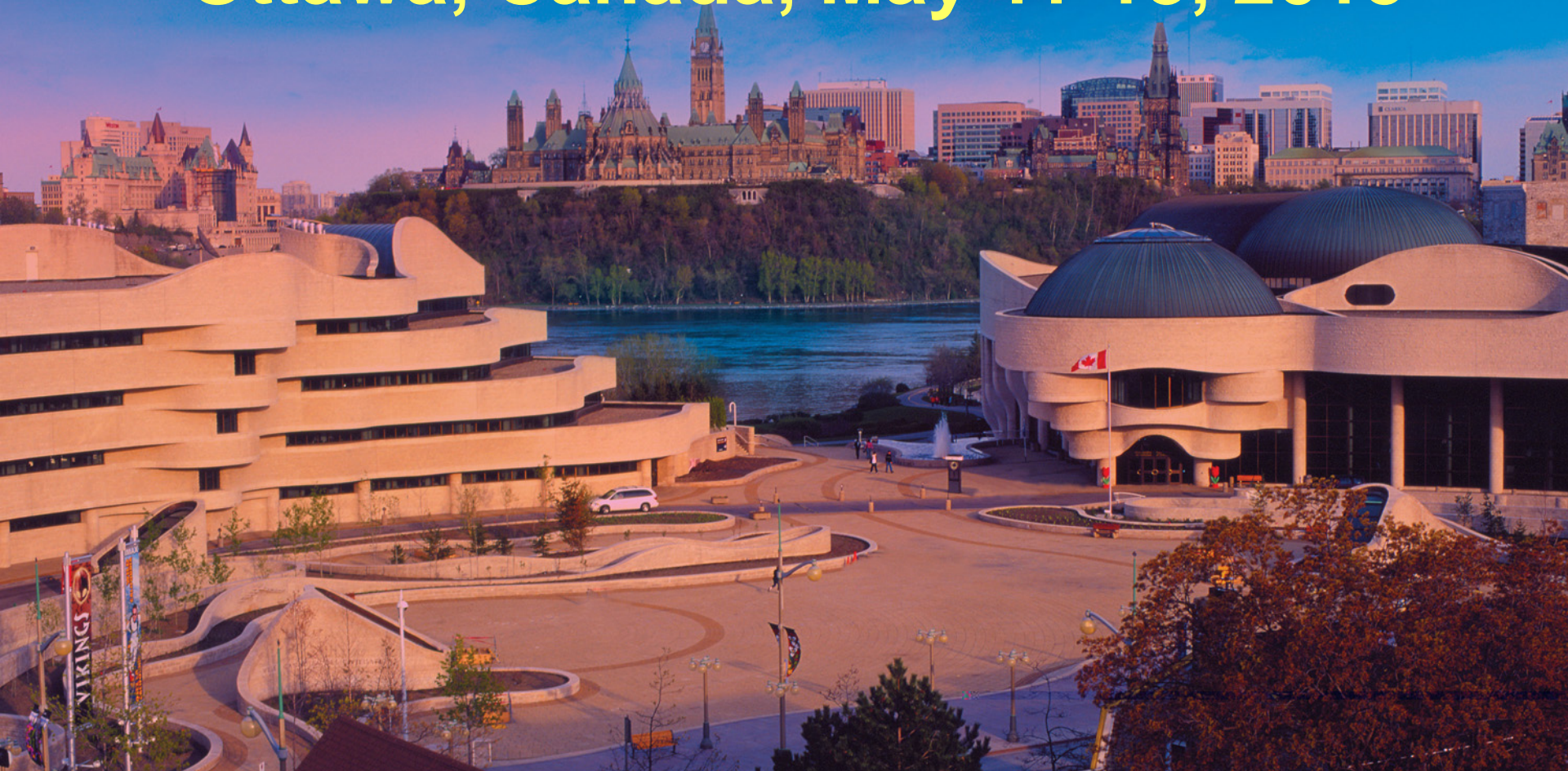
for more information see

www.emse.fr/~dolgui

Thank you very much for your attention