Saint-Gobain
Challenge ROADEF/EURO
2018-2019

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Datalab, Saint-Gobain Recherche

Outline

1. Introduction

2. Context

3. Problem description

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SAINT-GOBAIN

Key figures

2016 net sales

€39.1 BN

More than 170,000 employees and 100+ nationalities represented

Present in 67 countries

More than 80% of sales are made in the habitat markets: construction, renovation, infrastructures and civil engineering

SAINT-GOBAIN

Around 4,100 sales outlets

Created more than 350 years ago

One of the top 100 industrial groups in the world with around 950 production sites

SAINT-GOBAIN

Saint-Gobain Recherche

One of the top **100** global innovators

8 cross-business R&D centers

3,700 people

More than **380** patents in 2016

Around **100** development units

Academic and start-up partnerships

1 out of 4 products sold today by Saint-Gobain did not exist 5 years ago

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Datalab

- ≈ 20 engineers divided in 3 teams
- Mission : Bring value to all Saint-Gobain businesses through the use of data science and digital skills
- Scope : Sales, Marketing, Supply-chain, Production, R&D, Building science
- Core competencies : Optimization, Data science, Virtual reality, Coding

Outline

Saint-Gobain Glass Industry

- **Manufacture and sale of flat glass, processing and distribution of glass solutions** for the construction, automotive and transportation industries
- **Specific organization and salesforce** for each market segment
- **Solutions** to the challenges of environmental protection, aesthetic design, comfort, ergonomics and safety
- **Products and services** tailored to the specifics of each local market and customer services that make the most of the opportunities provided by digital technology

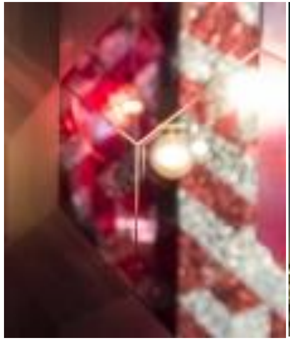
Approx. **300 MANUFACTURING FACILITIES**

#1 in Europe
#2 worldwide

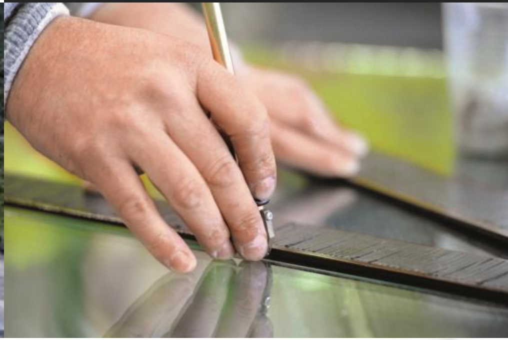
Over
33,000 EMPLOYEES

Sales and manufacturing operations in **42 COUNTRIES**

Sales **€5.4bn**





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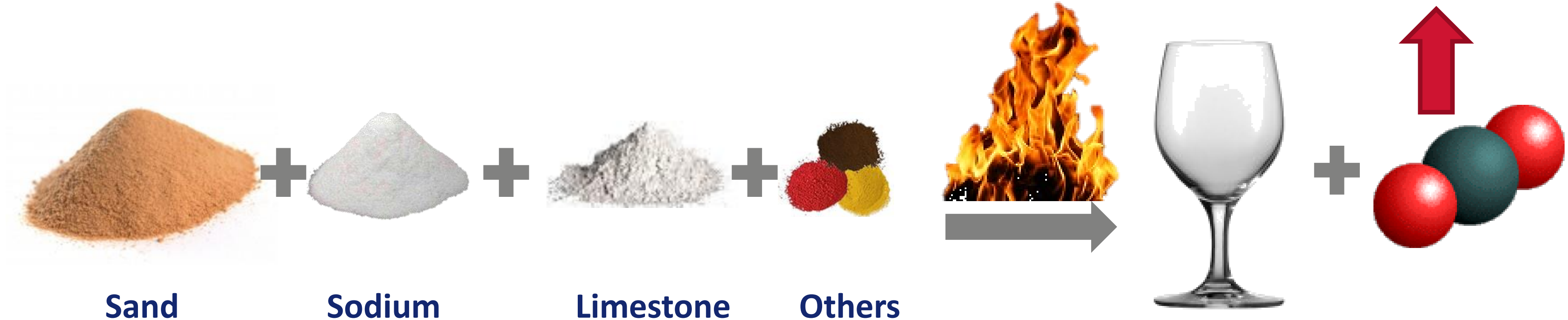
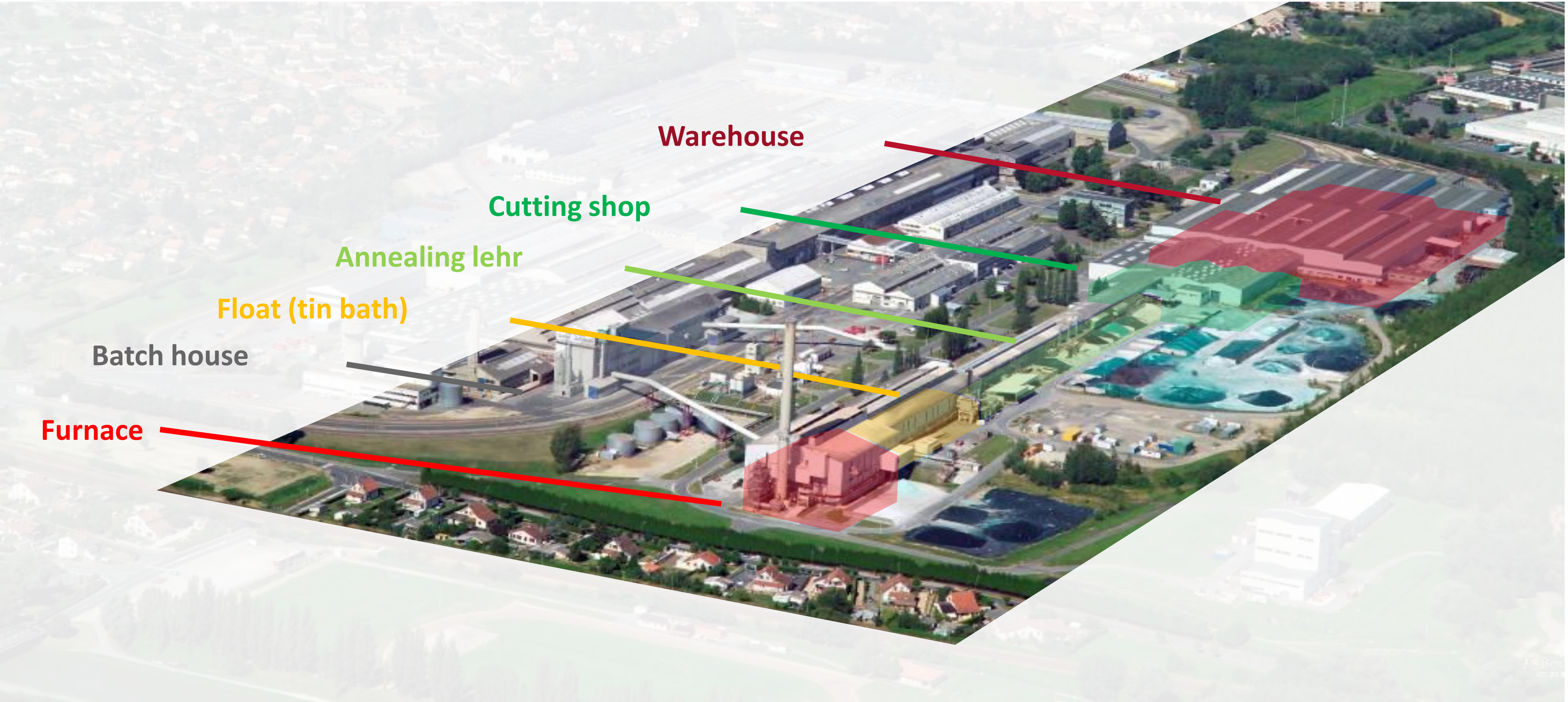
How to make glass ?



Sand	Sodium carbonate	Limestone	Others	Glass	CO_2
SiO_2	Na_2CO_3	$CaCO_3$			
700 kg	250 kg	200 kg	50 kg	1000 kg	200 kg

$$SiO_2 + \text{Carbonates} + \varepsilon \rightarrow \text{Silicate} + CO_2$$

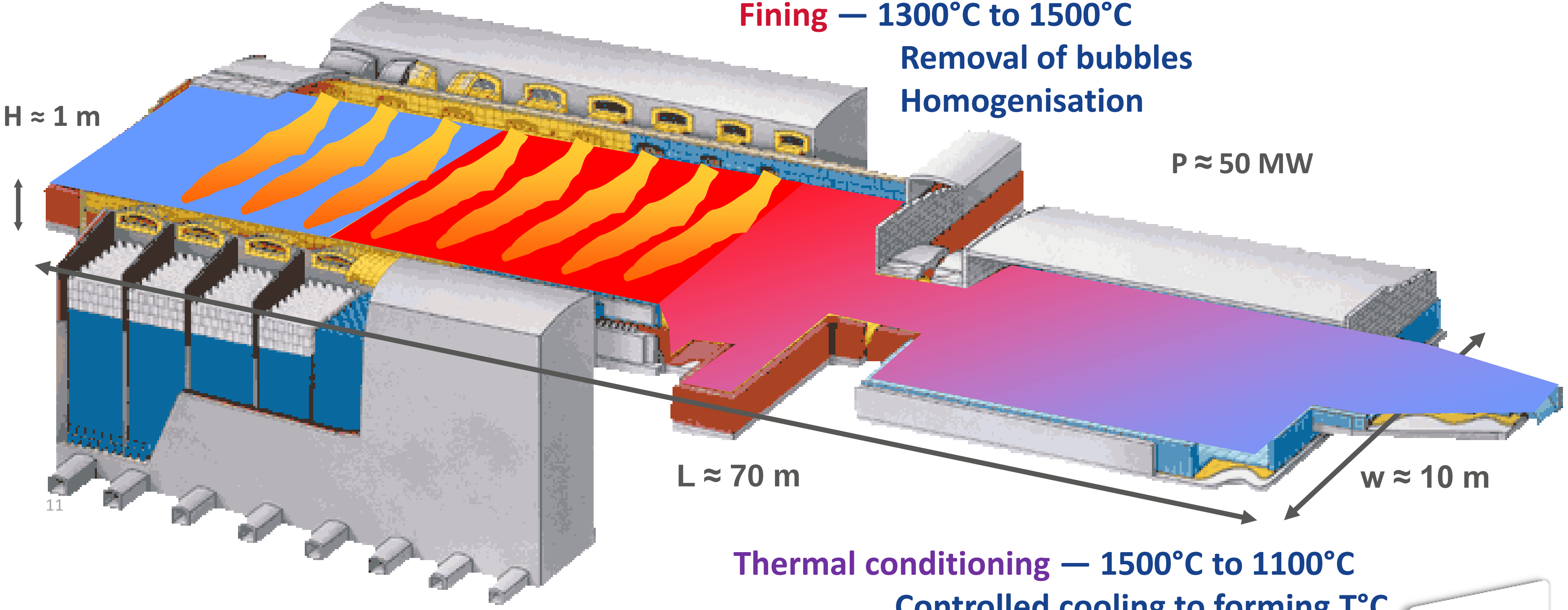
How to make glass ?



How to make glass ?

Melting — 800°C to 1300°C
Raw materials → inhomog. liquid
Various chemical reactions

Fining — 1300°C to 1500°C
Removal of bubbles
Homogenisation



Thermal conditioning — 1500°C to 1100°C
Controlled cooling to forming T°C

How to form glass ?

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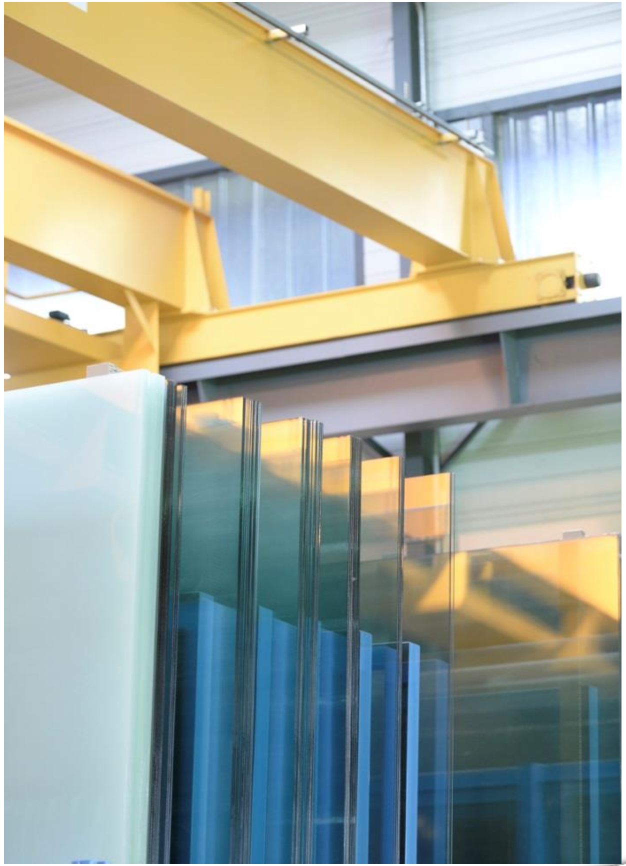
How to form glass ?

How to store glass ?

Cutting and storage



What happens to the glass next ?

1. The glass float is cut in jumbo’s of standard size (3m x 6m)
2. Jumbo’s are then stacked and sent to transformers
3. Transformers cut jumbo’s in smaller glass pieces.
4. Glass pieces are then sold to customers to match their needs (e.g. your home windows)

Production problems …

Defects arise on jumbo’s due to:

- The complicated glass metling process
- The moving of jumbo’s

Defects are of different types:

- Air bubbles trapped in the glass
- Cracks or impacts from moving
- Stone (not melted material)

Concerns

- Make our customers happy → Do not produce a glass piece having defects

- Remain competitive → Reduce glass loss

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Problem

Input : a set of jumbo’s with their defects and a set of glass pieces to cut

Objective : design a set of cutting patterns for the jumbo’s of minimal glass loss

Constraints :

- Cut all pieces ordered by a customer
- Each piece has to be defect free
- Respect cutting and organisatinnal constraints

➔ This problem is a two-dimensional bin-packing problem (a jumbo = a bin, a glass piece = an item)

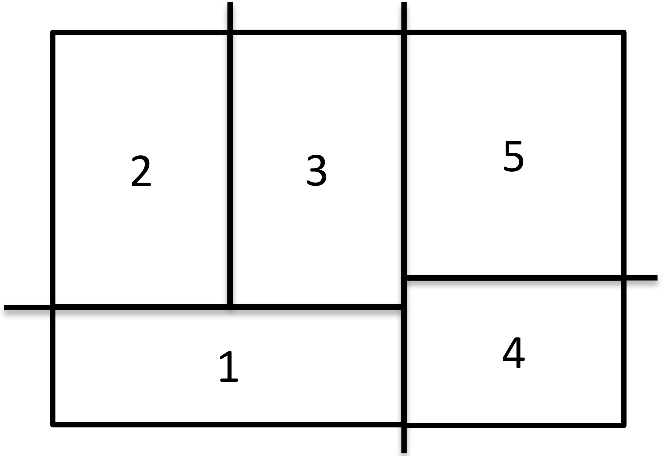
Constraints

Two sets of constraints :

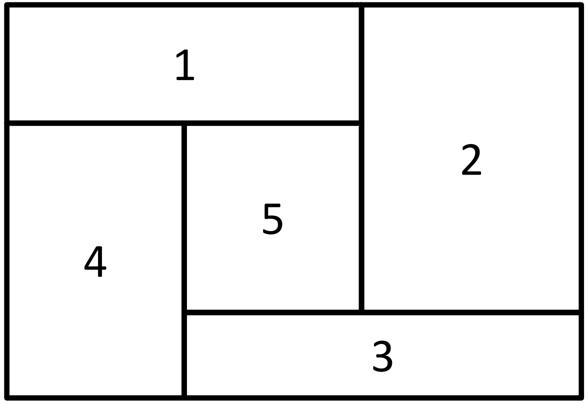
- Cutting , from technical limitation and glass property
- Organisationnal, from organisation in production units

Cutting constraints

- Only guillotine cuts are allowed



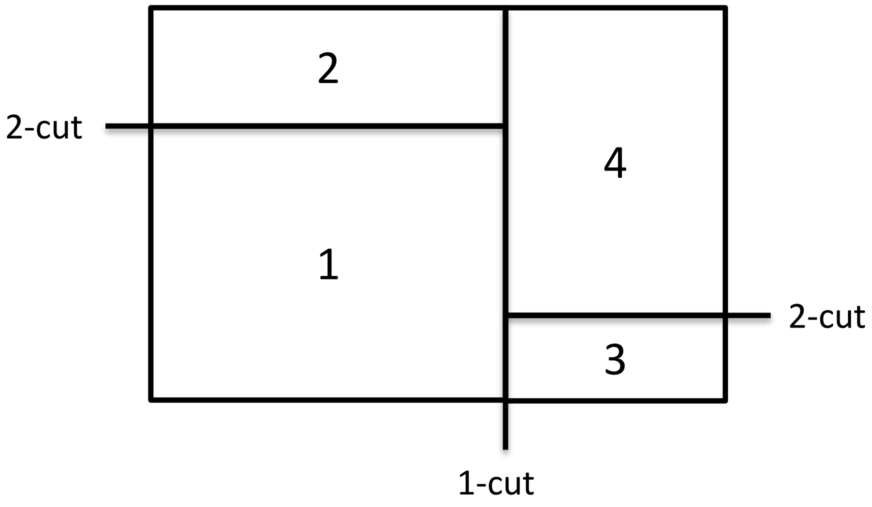
Guillotine



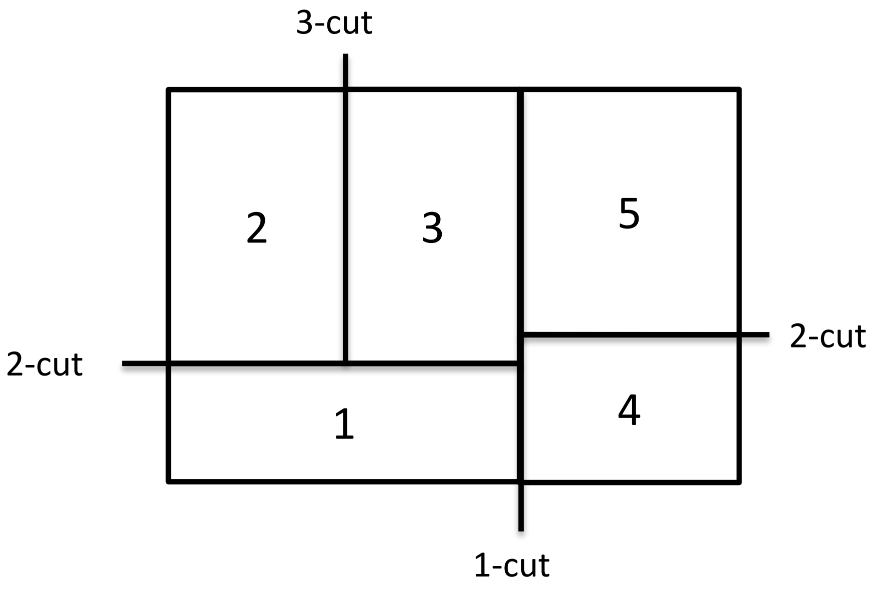
Non guillotine

Cutting constraints

- The number of cuts to obtain an item is at most 3



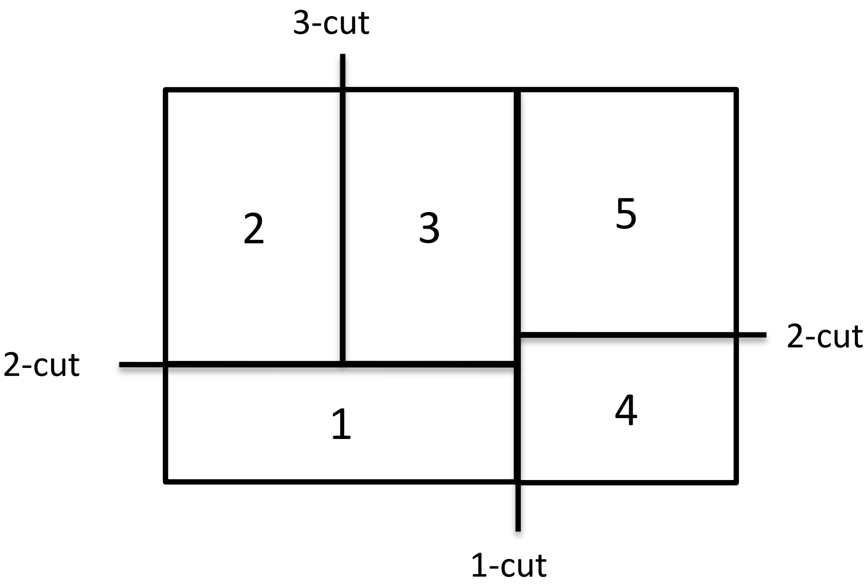
Allowed



Allowed

Cutting constraints

- Only one extra cut is allowed after a 3-cut to remove waste



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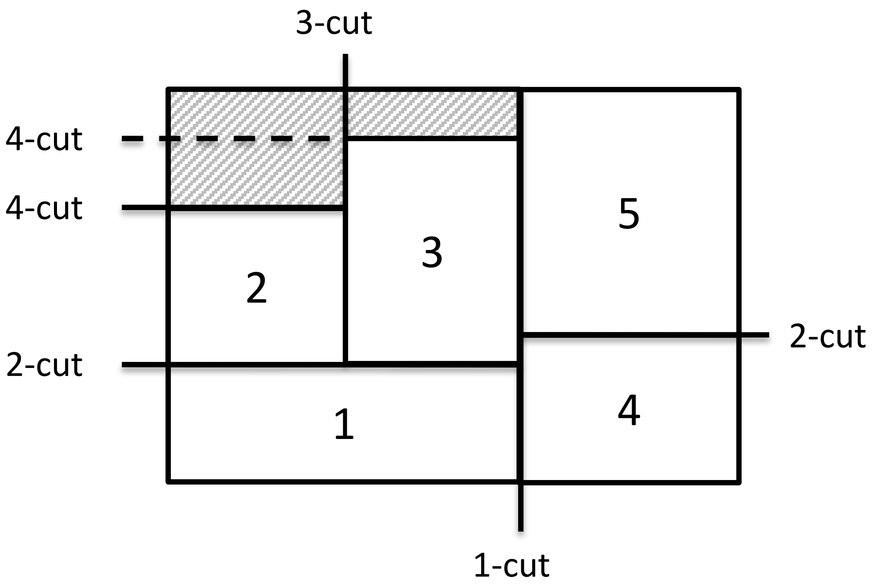

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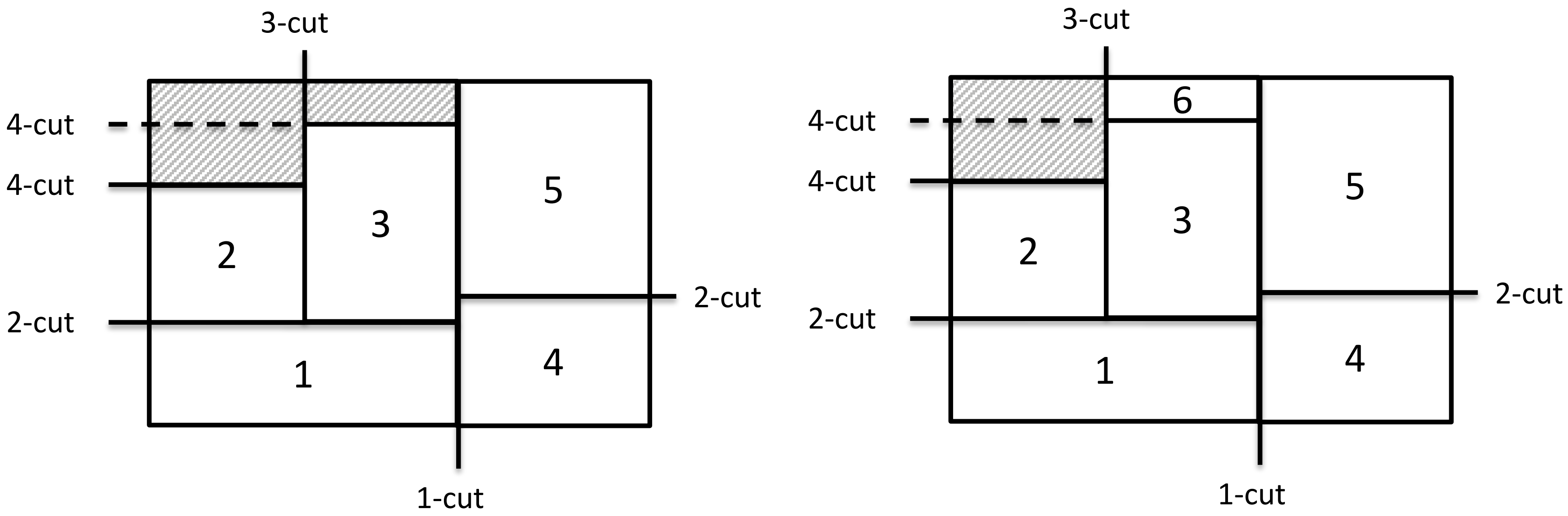


Allowed Forbidden

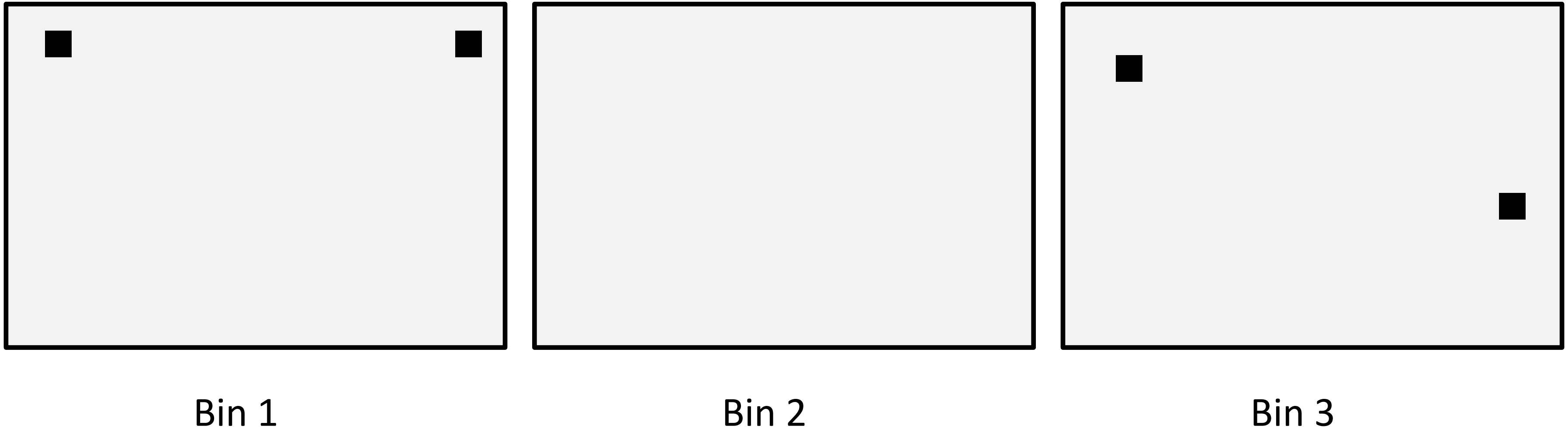
Cutting constraints

Extra cutting constraints :

- Limits on minimal and maximal cut lengths depending on cutting stages
- Limits on the minimum dimension of a waste
- Interdiction to cut through defects

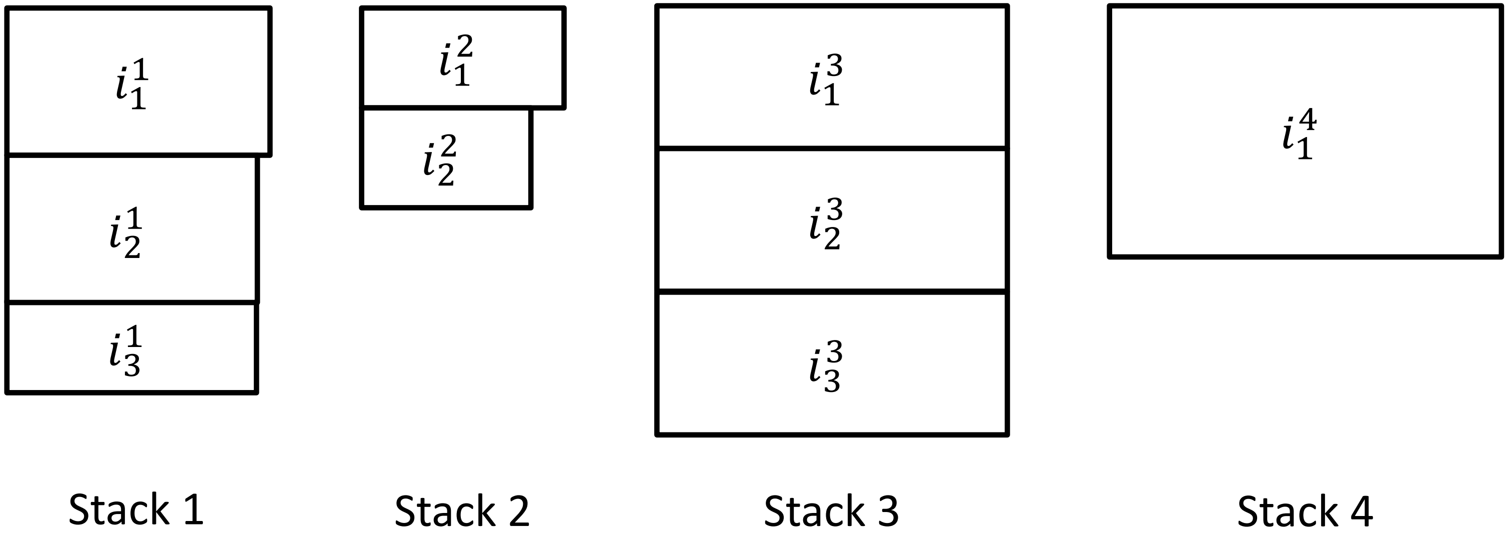
Organisationnal constraints

- Bins have the same size and may contain rectangular defects
- Bins are stacked and have to be considered as ordered when designing cutting patterns



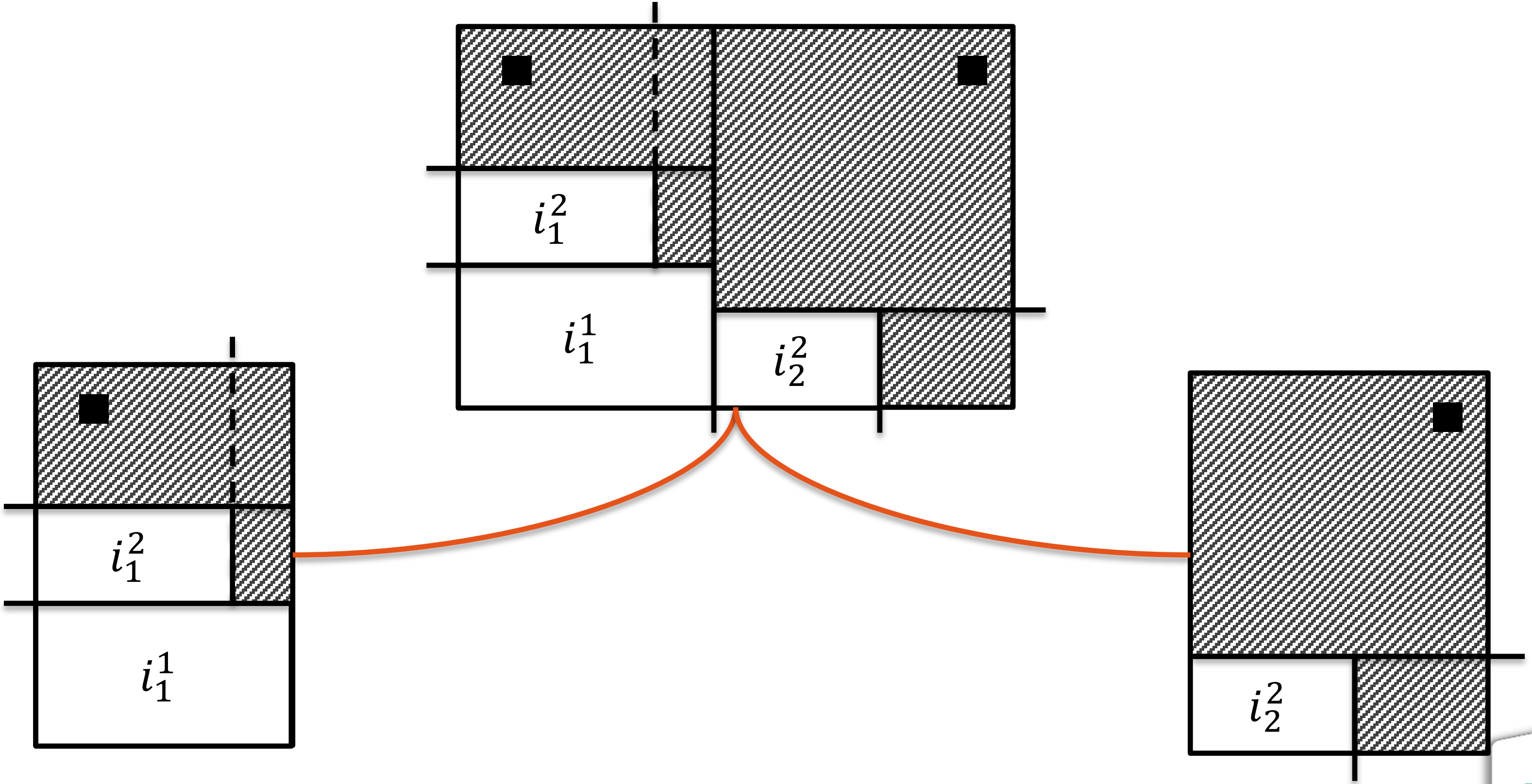
Organisationnal constraints

- After cutting, items are put on sillages and send to production units next
- They have to be cut in a given order (a stack) to respect production planning



Organisationnal constraints

- To ensure production planning, items are extracted in a left-bottom manner



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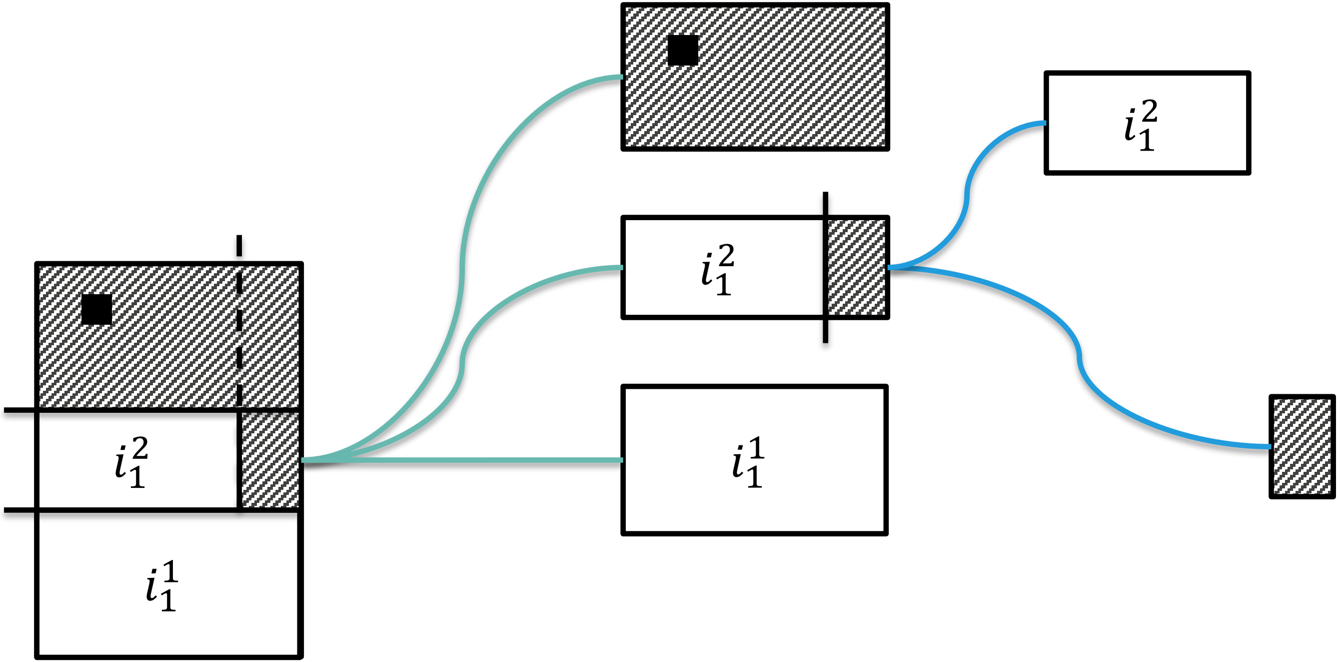

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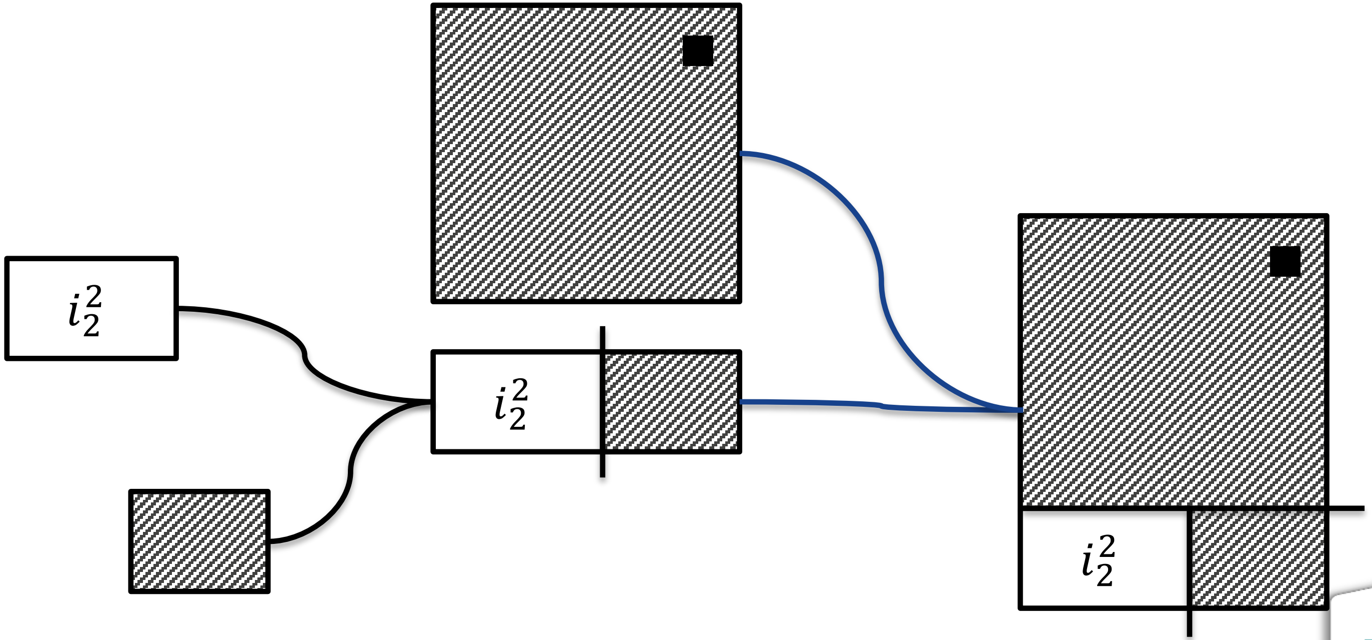
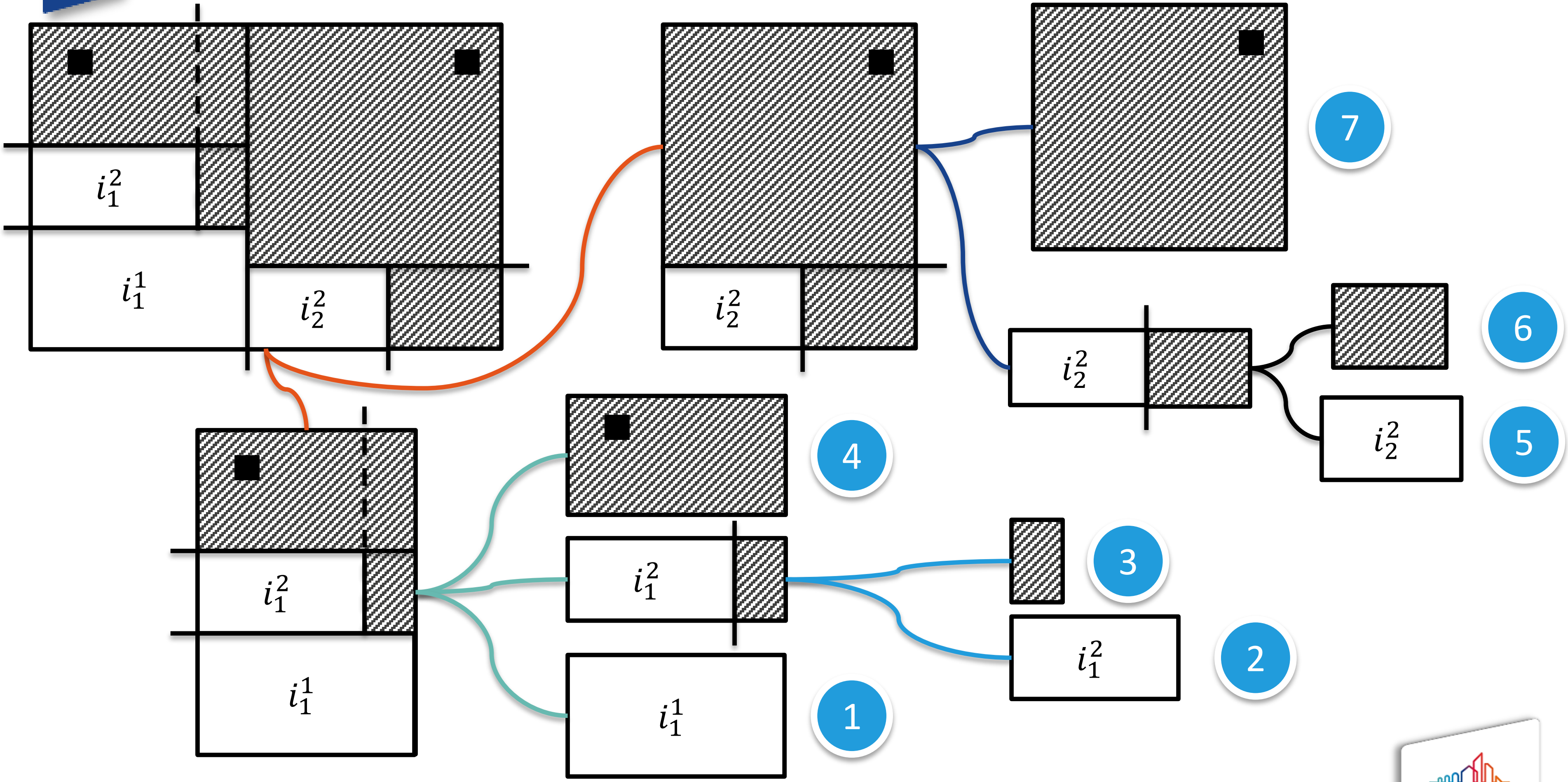


Organisationnal constraints



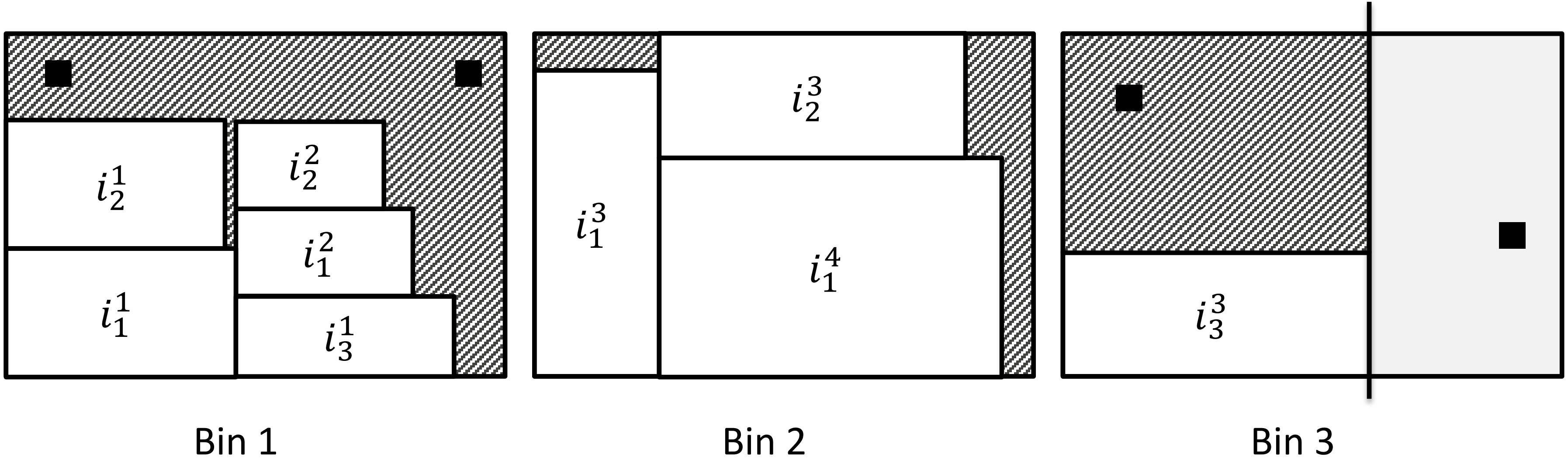
Problem

The problem to deal with is a two-dimensional bin-packing problem with :

- Defects on bins
- Order on bins
- Order on items
- Considering unrestricted 3-stage guillotine cutting patterns with trimming and item rotation

Problem

Find a set of cutting patterns ensuring all constraints and of minimal loss (dashed lines)



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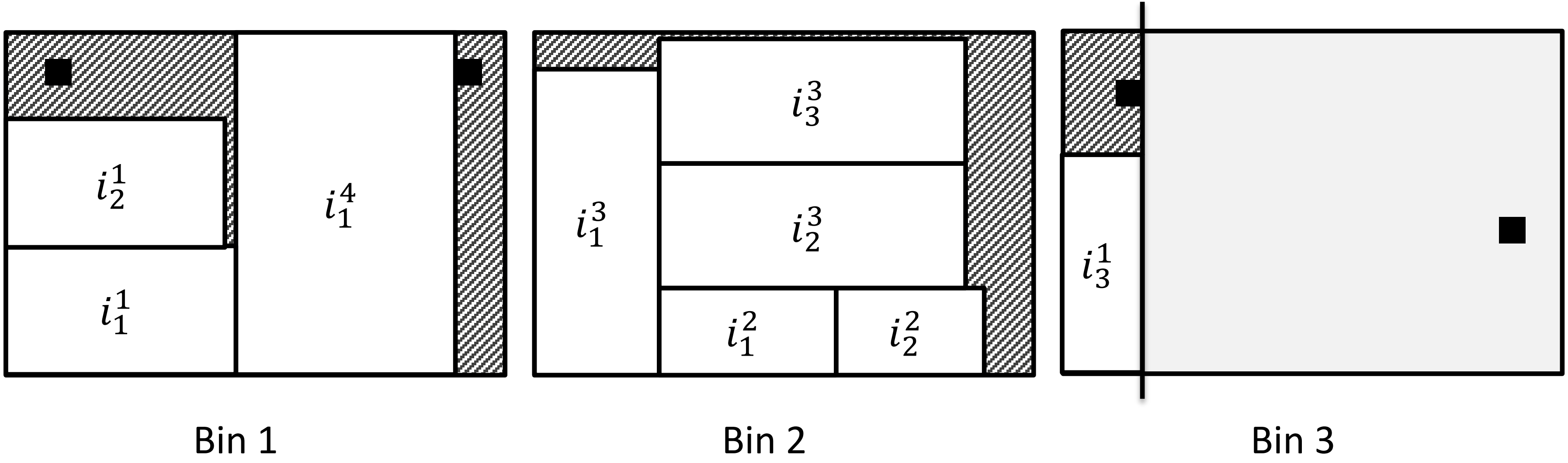

Problem size

A typical problem instance is composed of :

- A set of bins of size (3m x 6m) with defects (≈ 3 defects per bin)
- ≈ 300 items to cut and ≈ 22 item stacks

Challenge - Roadmap

- ~~ROADEF 2018 – Start qualification phase and sprint, release checker and dataset A~~
- ~~23th May 2018 – End of sprint~~
- ~~1st June 2018 – Announcement of sprint results~~
- EURO 2018 – Sprint awards
- 23th Sept. 2018 – End of qualification phase and release of Dataset B
- 23th Oct. 2018 – Start final phase for qualified teams
- 15th Jan. 2019 – End of final phase
- ROADEF 2019 – Results announcements and release of Dataset X
- March 2019 – Paper submission for scientific price
- EURO 2019 – Challenge awards

Challenge - Tools

Three datasets :

- A – 20 instances
- B – 15 instances
- X – 15 instances

Available tools :

- Checker
- Visualization

Challenge – Prices

- Sprint phase – 5000€
- Qualification phase – 5000€
- **Junior team final phase – 10000€**
- **Best team final phase – 10000€**
- **Open source price – 10000€**
- Scientific price – 5000€

45000 €

Challenge – Solution evaluation

Evaluation:

- Done on one of our machines
- For an instance, one run in 3 min. and one run in 1h.
- For an instance, value of a solution is: $\mathrm{V} = 0.1 \times V_3 + 0.9 \times V_{60}$

Free to use any solvers and/or programming languages

Challenge – Ranking function

- Ranking function:

1 – Get solution value for each instance and each team

2 – For a team, count the number of teams having a result strictly better than current team (n_{better})

3 – Give points to teams; compute score of each team as: $max\{0, R - n_{better}\}$

4 – Compute sum of score and select winner (max. total score)

Team/Ins.	Ins. 1	Ins. 2	Ins. 3
Team 1	20	25	26
Team 2	18	10	40
Team 3	15	16	17
Team 4	14	10	8
Team 5	22	21	19

n_{better}

Team/Ins.	Ins. 1	Ins. 2	Ins. 3
Team 1	3	4	3
Team 2	2	0	4
Team 3	1	2	1
Team 4	0	0	0
Team 5	4	3	2

$max\{0, R - n_{better}\}$ (R=5)

Team/Ins.	Ins. 1	Ins. 2	Ins. 3
Team 1	2	1	2
Team 2	3	5	1
Team 3	4	3	4
Team 4	5	5	5
Team 5	1	2	3

Winner

Team	Aver.
Team 1	5
Team 2	9
Team 3	11
Team 4	**15**
Team 5	6

Questions ?

challenge.roadef.org

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Intellectual property

- Participants have intellectual property on their computer programs developed during the challenge. Saint-Gobain Glass Industry and any third party may use information provided by the participants through technical reports, scientific papers and oral presentations, but cannot use a computer program without the agreement of the team who wrote this program.

- Participants to the challenge cannot claim to have a partnership or a contract with Saint-Gobain Glass Industry or any entities of the Saint-Gobain Group, even if they win the challenge. They can only claim to be participants (respectively qualified / winner) if it is the case.

- Saint-Gobain Glass Industry may (but has taken no engagement to) sign contracts with some participants after the challenge. Any such contract would be independent of the challenge.