LP/MIP @ RENAULT SUPPLY CHAIN
Digital Transformation

Applied AI chapter
12 staff

- Product configuration
- Knowledge compilation
- Natural Language Processing
- Operations Research
  (5 staff + 2 interns)
RENAULT END TO END SUPPLY-CHAIN : KEY FIGURES

- **3,500** trucks or containers/day to supply our plants
- **200,000 m³** of transported parts/day
- **3,500** supplier sites
- **13** logistics platforms

- **40** Renault plants in **17** countries
- **7,500** model versions
- **300,000** parts references

- Around **2,000** trucks or boats per day to deliver our cars
- To over **5,000** destinations
- Over **200** ports used worldwide
OR tools in the supply chain

Suppliers

- Powertrain plants
  - Line re-supply
  - Production Planning
  - Job scheduling

- Car plants
  - Production Planning
  - Car sequencing / job scheduling
  - Generation of forecasted vehicles

- Dealerships
  - Sales & operations
  - Routes plants->dealerships

Sourcing suppliers (OASIS)

- Routes suppliers->plants

- Distribution schemas engineering

- Inventory of spare parts

- Truck loading and orders anticipation
  - Container loading

- Production Planning

- Kitting units layout
  - Line balancing body shop / paint shop / assembly line

- Inventory of spare parts
Whenever LP/MIP could be used, it was used!

Solvers: CPLEX since 1992, COIN/OR … but also CPO, LocalSolver
Planning tool in every RENAULT’s car factory worldwide
Mission : to optimize the daily production plan
Scope : total production of 2M vehicles in 2022
Car production planning

Horizon: D+6 to M+4
Day slots

Production plan

New orders

Constraints:
- Line specialization
- Suppliers capacities
- Plant capacities

Objectives:
- Maximize nb orders in the production plan
- Satisfy the customer wished delivery date
- Satisfy the plan stability
- Smoothing of complex vehicles / ....

Multi-objective optimization (LP), customized for each plant
Car sequencing (daily)

Production sequence

- Paint batches
  - Minimize solvent consumption due to paint color changes

- Spacing for the assembly shop: spacing ratios (ex: DD DD ¼)
  - To smooth complex vehicles
  - Not to overburden workstations
Engine/gearbox production planning (monthly)

Planning tool for engines, gearboxes, and all their components
Mission: to optimize the production plan for the next 18 months & solve capacity bottlenecks
Scope: 985 production lines worldwide

Production process of an engine

Production lines in Spain, France and Romania needed to produce car chassis

Multi-objective optimization (LP)
1. Demand satisfaction (goal programming)
2. Stock minimization
3. Transportation leadtime minimization
Sales & operations tools with LP/MIP

Detailed forecasts generation (monthly)
• Samples of fictive partial vehicles
• Product Mix objectives (versions, options)
  ✓ Quadratic MIP with barrier

Distribution of production capacities between countries (monthly)
• Invoice deadlines (June and Dec)
• Sales targets
• Transportation capacities
  ✓ Multi-objective optimization (LP and goal programming)

Production planning of show-room vehicles (on request)
• Production ramp-up
• Transportation capacities
• Countries demand (volume and timing)
  ✓ Multi-objective optimization (MIP)
Workforce scheduling in paint shop (on request)
Operators’ movements
## Holes Assignment to Operators

### Column Generation Method

<table>
<thead>
<tr>
<th>Column</th>
<th>Operator 1</th>
<th>Operator 2</th>
<th>Operator 3</th>
<th>Operator 4</th>
<th>Operator 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Time (cm²)</td>
<td>143.12</td>
<td>154.97</td>
<td>101.39</td>
<td>162.49</td>
<td>111.83</td>
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<tr>
<td>Total PFAA (cm²)</td>
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<td>40.50</td>
<td>36.00</td>
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<tr>
<td>Total O2 (cm²)</td>
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<td>28.09</td>
<td>28.00</td>
<td>26.00</td>
<td>20.00</td>
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<tr>
<td>OA Intensity (cm²)</td>
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<td>12.23</td>
<td>10.54</td>
<td>15.05</td>
<td>6.12</td>
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<tr>
<td>OA Extensity (cm²)</td>
<td>65.83</td>
<td>70.69</td>
<td>73.19</td>
<td>73.55</td>
<td>51.21</td>
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<tr>
<td>Np Buses</td>
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<tr>
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<tr>
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<td>(0.0,0.0)</td>
<td>(0.0,0.0)</td>
<td>(0.0,0.0)</td>
</tr>
<tr>
<td>Taux Engagement</td>
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<td>82.87</td>
<td>88.30</td>
<td>86.99</td>
<td>59.80</td>
</tr>
</tbody>
</table>

**Notes:**
- The table above details the assignment of different measures to operators.
- The column generation method is employed to optimize the assignment process.
Network design for inbound flows (on request)

Routes towards Douai’s plant (direct, milk-runs, x-dock)
Optimization methods

1. Clustering: Partition of suppliers into clusters,
2. Routing: Identification of Direct and Indirect flows (MIP per cluster, MIP master problem)
3. Scheduling: Routes Assignment to weekdays (MIP).
Trucks loading and orders anticipation (daily)

2D placement of items in the trucks with best fit heuristics

Build stacks and anticipate orders so as to maximize trucks filling rate
Construction heuristics + local search

3000 trucks / week – 7 weeks horizon / GCP

Visualization of trucks
Production volumes distribution
What-if scenario

Engine in shortage

Distribution of engine volumes between models?

Vehicle plants capacities

Engine/gearbox plants capacities

Optimization web service

Stock coverage

Sales forecasts and mix déformations authorized

Marginal profit per model

Volumes distribution which maximizes total profit

MIP optimization
- Min constraints
- Min/max satisfaction