

LISCOS meeting 28 Mars 2003

PSA test cases :
Production Planning (PSA1)
Line Balancing (PSA3)

Marcel Beauseigneur
and Stéphane Noiré

Summary

- **Partnership**
- **Introduction to company**
- **Description and problematic**
- **Results**
- **Conclusion & perspectives**

PSA test cases

- PSA
- LORIA
- COSYTEC



Are partners to evaluate
CHIP, XPRESS and LISCOS' methodology
for the PSA test cases

Introduction to company

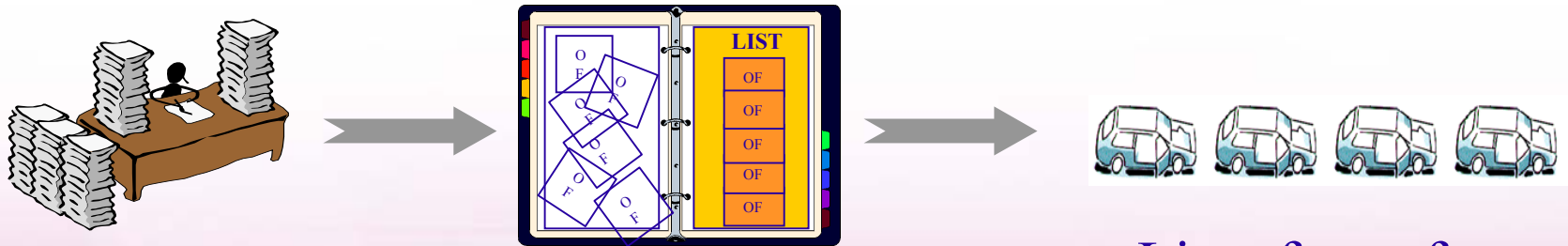


- **2nd car-maker in Europe**
- **More than 3.250.000 cars sold in 2002**
- **14 production centres over the world**
- **A huge diversity ex : 206 more than 12000 possibilities (due to options)**



PSA1 problem : car sequencing

- **Objective :**
 - Daily scheduling for a 5 days-car-production:
 - Computing car position per day and per line.
 - Respecting the production constraints.



Set of 5 days-
command

MIP and CP

List of cars for
each day and
each line

PSA1 : Context and Constraints

- **A plant is composed of 3 shops :**

- Body shop Non-succession Smoothing
- Paint shop Grouping Densification Non-succession
- Assembly shop Smoothing Non-succession



Capacity

- **Computes the sequencing order of cars respecting:**

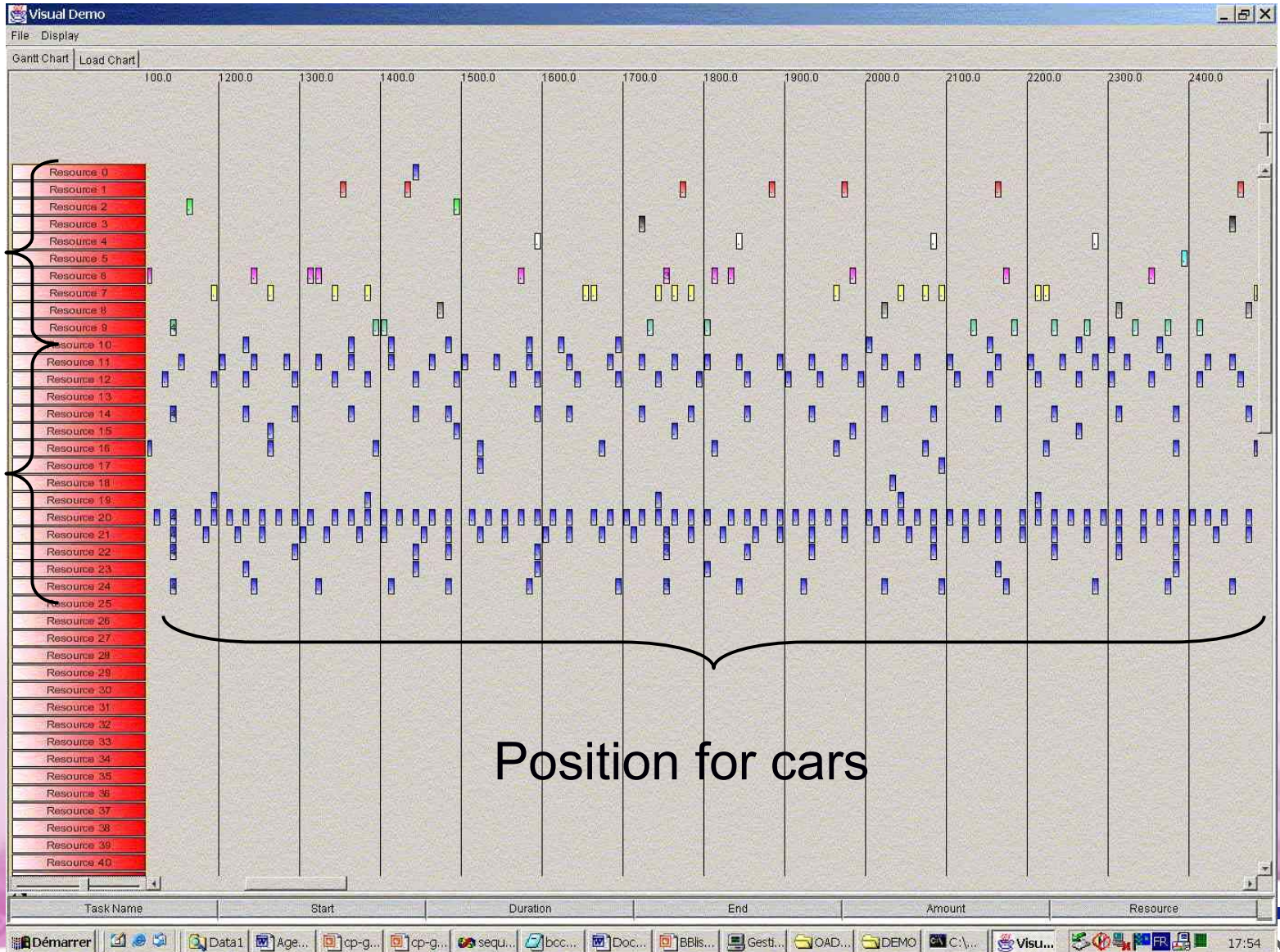
- hard constraints (ex : Capacity)
- Soft constraints (ex : Smoothing)

PSA1 : Modelling

- **2 sub problems :**
 - Computing the quantity for each day and each line
 - MIP model (LORIA):
 - Handles capacity constraints of resources
 - Handles due dates
 - Preserves the stability
 - Takes CP module into account (LISCOS hybrid added-value)
 - Scheduling per day and per line
 - CP model
 - Computes the positions of cars
 - Densification constraints
 - Smoothing constraints
 - Forbidden successions

PSA1 : Results - Only Smoothing

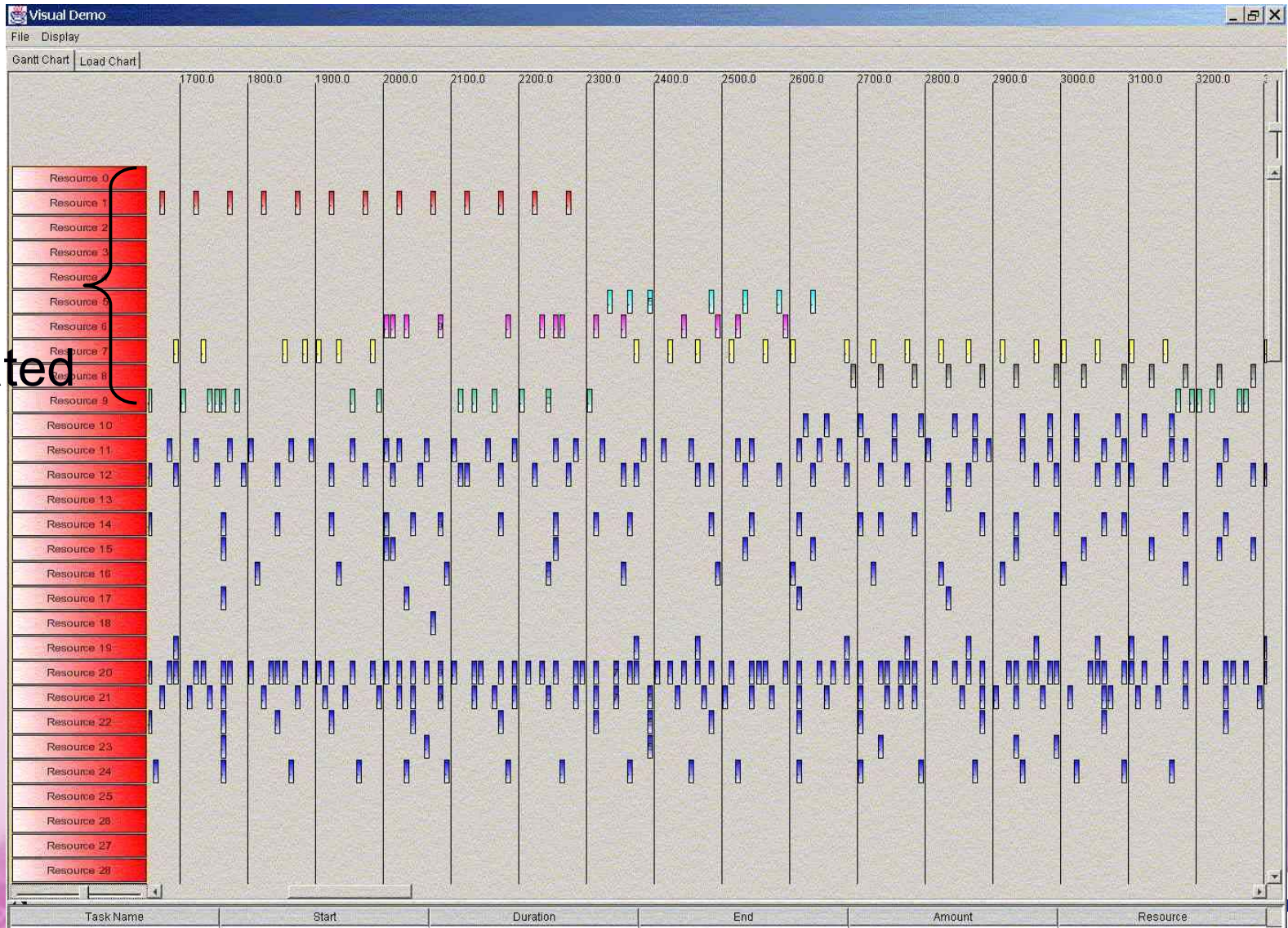
Rare and standard colour
Smoothed item



Position for cars

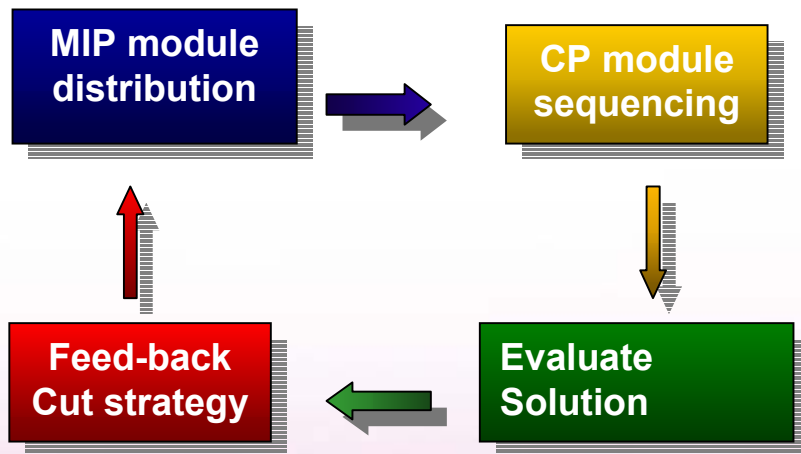
PSA1 : Results – Smoothing & densification

Colour concentrated



PSA1 : Results on hybridization

- **Hybridization as coupling between MIP and CP by**
 - Feeding back information after the CP module
 - To generate some cuts in the MIP part



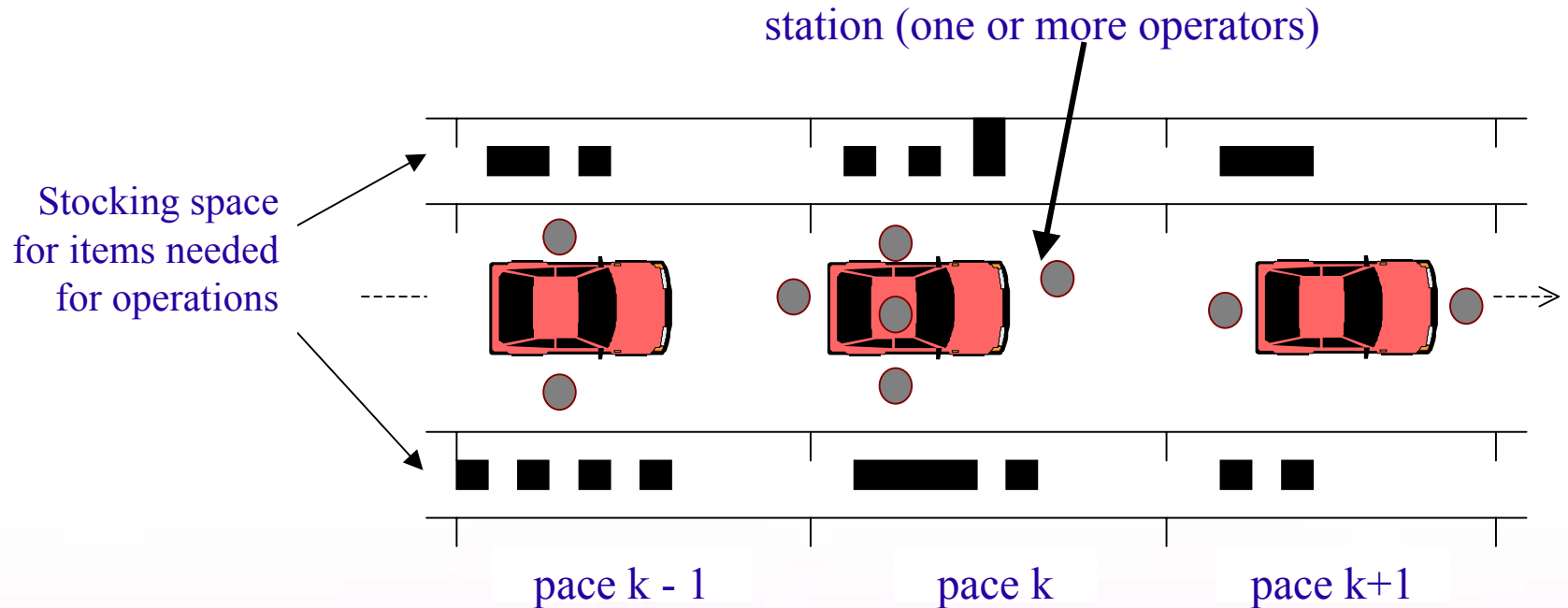
Data set	Number of iteration	Number of violation	Gain	Cost	Gain
RJ1L	1	3274		2392590	
RJ1L	5	3236	1,16%	2199260	8,08%
P18C	1	27		27000	
P18C	5	14	48,15%	14000	48,15%
G183J	1	845		2156800	
G183J	5	813	3,79%	2106800	2,32%
G183J	20	779	7,81%	2014600	6,59%

- Improve quality of smoothing
- Increase calculate time

PSA1 : Conclusion and Perspectives

- **Share the know how of solving similar hard and large applications**
- **Hybrid approach (MIP + CP) :**
 - Promising approach for PSA applications
 - Problem decomposition to focus for each sub-problem on its specific constraints
 - Contradictory objectives
 - Investigation of a methodology for finding compromises during the search of a good solution
 - Relaxation techniques
 - Positive results:
 - Methodology
 - Mastering the hybrid technology
 - Modelling complex application

PSA 3 problem : Line Balancing



Objective :

- place new operations
- open only the necessary station
- smooth the task load
- move as few operations as possible

Constraints :

- ergonomics: pace & station (height, confinement)
- operator's task load
- Track side and equipment (fixed, air socket)
- precedence between operations

PSA 3 problem : Line Balancing

Present situation :

- compute the global task load
- manual shifting of operations
- a posteriori visualisation of load by station

LISCOS added values :

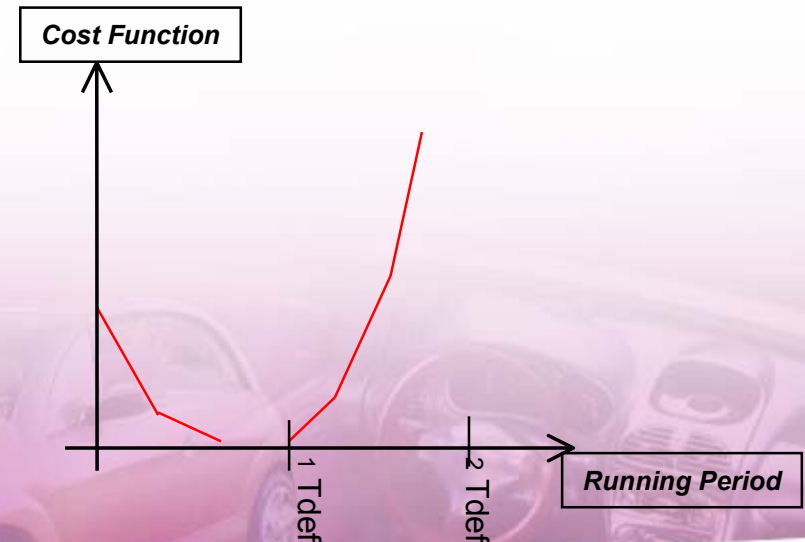
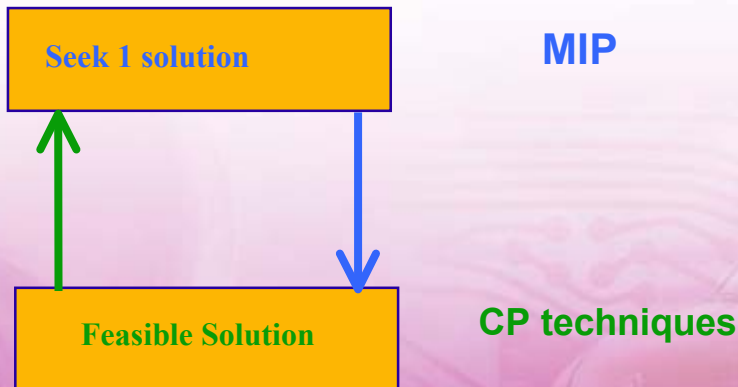
- Compute a solution
- Respect a part of the constraints
- Improve the quality of an existing solution

PSA3 : Modelling

- **Collaboration of two techniques**
 - Mixed Integer Programming (MIP)
 - Constraint Programming (CP)
- **Solving methods**
 - MIP : give a solution
 - CP : guarantee the precedence relations
- **Implemented Constraints**
- **Linked to car running period « Tdef »**
 - Link to the operator's assignment time
 - Precedence between operations
- **Ex: model of the objective function**

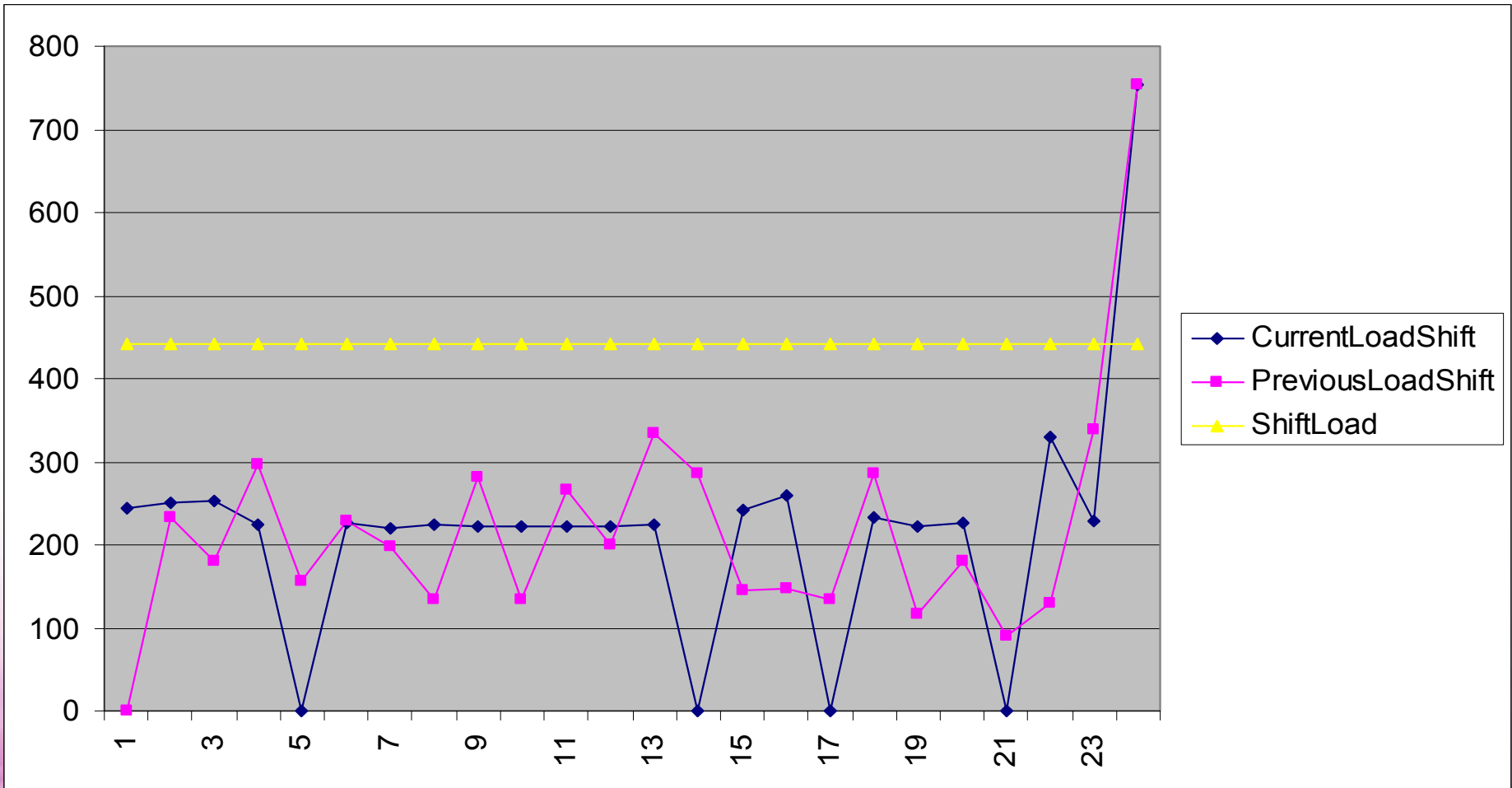
Model of the task load for a station / Tdef

Chaining MIP and CP



PSA 3 : Results

Example of load shifting over a typical day




PSA3 : Conclusions

- **Promising : main constraints well respected (smoothing, Tdef (assignment time))**
- **To be continued and be more precise taking into account :**
 - Track side clutter (containers' size)
 - Place of the station (all the operations made by the operator are in a same space = ergonomics)

Thank for your attention



 **DEMONSTRATEUR PLURIEL**

