PROCESS FLOW ANALYSIS AND ACTIVITIES SCHEDULING AT BOMBARDIER PAINTING WORKSHOP

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BOMBARDIER

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BOMBARDIER TRANSPORTATION

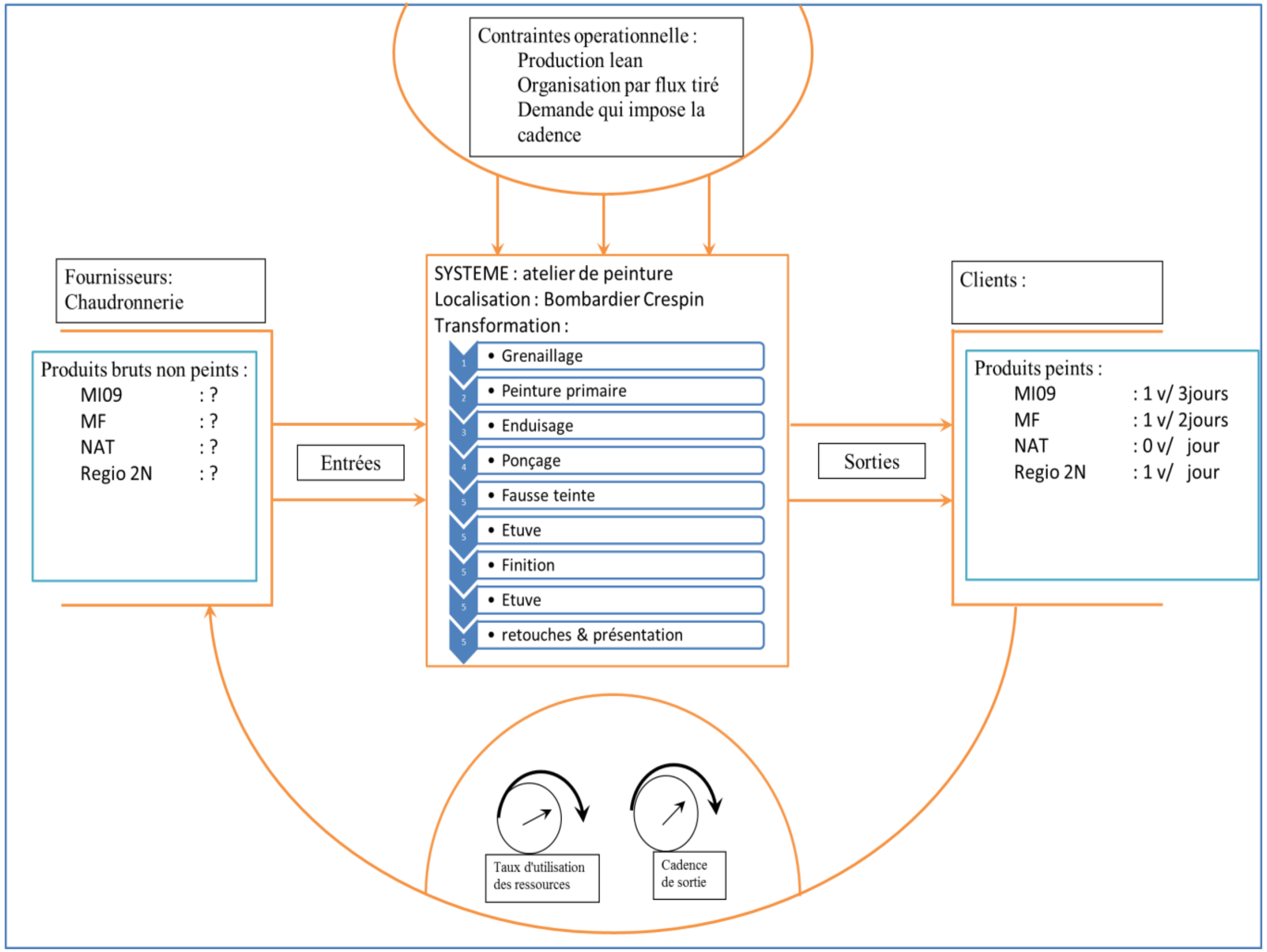
Outlines

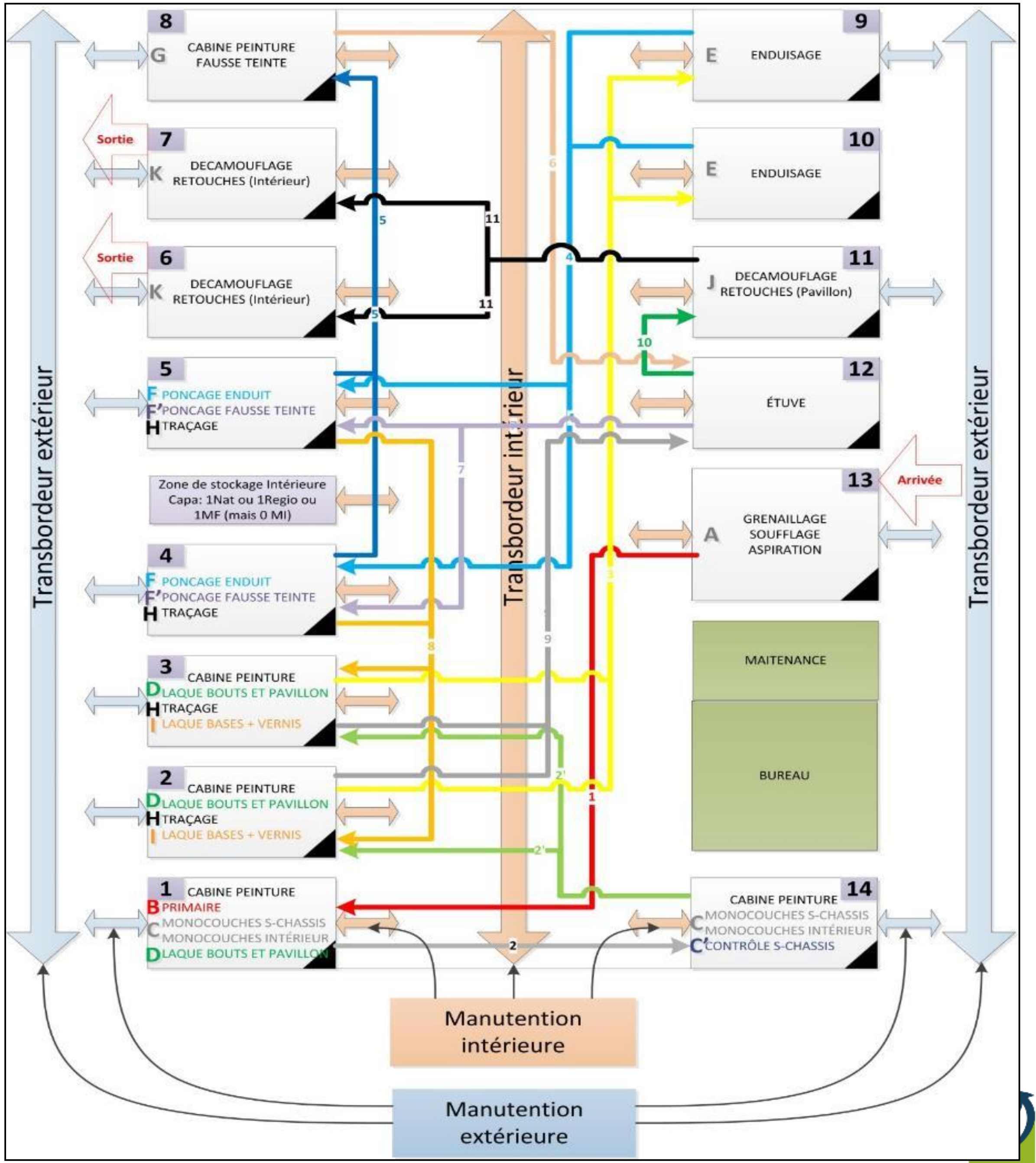
- Introduction – Context
- Methodological and scientific approaches
  - Process mapping
  - Problem definition
  - Simulation Modeling with ARENA
  - Simulation-based optimization through OptQuest
- Results
- Conclusion

Introduction - Context

- Request made by Bombardier-Crespin painting workshop.
- We aim to contribute to the bridging between university and industry.
- The Bombardier team objective:
  - Implement a lean strategy;
  - Meet the impose "Takt-time";
  - Increase the throughput;
  - Improve the planning (scheduling) without changing the actual shop configuration.
- The Bombardier-Crespin painting workshop context:
  - The workshop is large;
  - The flow is complex;
  - The layout (not optimal) is fixed and imposed!

Introduction - Context





Introduction - Context

- Consequently, the problematic is:

  Handling the number of contracts to be processed, the scheduling, the throughput, the organization of the drawn flow and the management of the progress is quite complex and difficult to study manually.

- Bombardier expectations (questions to answer):
  - Do we have the capacity to meet the demand?
  - What is the throughput of the workshop?
  - Do we respect the "Takt-time"?
  - Is there a better sequence of products to be applied at the shop entrance to better use the resources and meet the demand?
  - What is the utilization rate?
  - What are the bottlenecks?

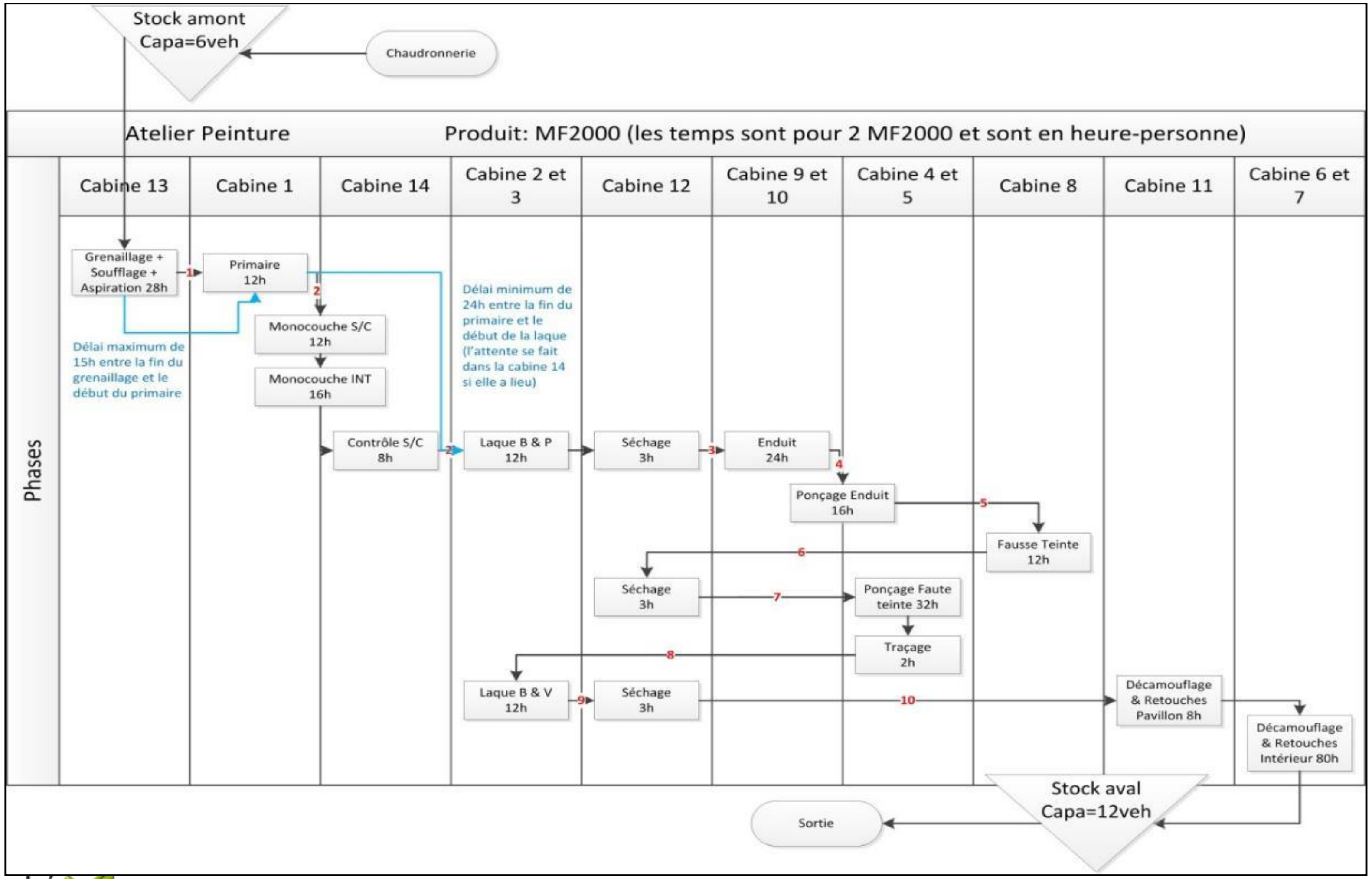
Methodological and scientific approaches

Due to the context of the study and the complexity of flow, the methodology chosen is based on the observation of the existing and the simulation of the flow by the tool "ARENA" followed by an optimization in with the OptQuest solver.

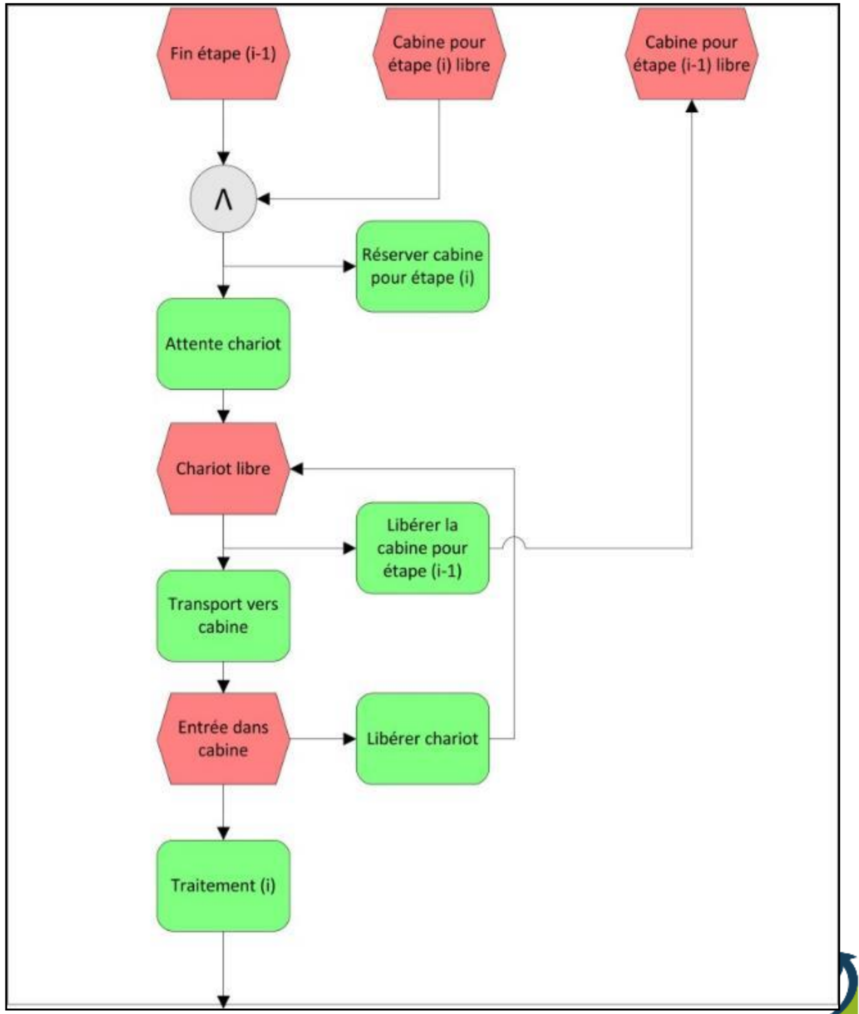
- The approach was as follows:
  - We start with a "GEMBA WALK";
  - Documentation and mapping of the processes;
  - Definition of the problem;
  - Overall evaluation of the process through the bottleneck concept;
  - Simulation modeling of the workshop;
  - Simulation based optimization through OptQuest.
  - The validation of the simulation is done on the workshop floor.

Methodological and scientific approaches

Process Mapping



Logic for vehicles' transition between cabins



Methodological and scientific approaches

The Problem definition:

Flow control in a Hybrid Flow Shop problem with side constraints

The objectives (in order):

- Meet the Takt-time (Satisfy the demand)
- Maximize the utilization of the workshop:
- Optimize the use of each resource;
- Allow continuous and uninterrupted flow;
- Avoid the process defusing.

Methodological and scientific approaches

The Problem constraints:

- The routing of each product constraints:
  - The routing is the same (flowshop), but
  - The duration of operations depend on the product,
  - Some parts of the routing are open.
- The resources' capacity constraints:
  - Number of available operators;
  - Cabins' capacity; It depends on the handled product;
  - One transfer table inside (two outside with reservation, no priority, limited access);
  - One TrackMobile.
- The resources' schedule constraints:
  - Operators schedule;
  - External transfer tables schedule;
- The Consumable resources constraints

Methodological and scientific approaches

The Problem constraints:

- The storage constraints:
  - 1 intermediate buffer (cabin) + 2 external storage zones (entrance & exit)
  - The cabin cold be used as a buffer but this penalize its availability.
- The set-up constraints
- The transitions constraints
- The cabins’ polyvalence constraints
  - Due to their equipment, cabins could handle different operations.
- The schedule rules (for the capacity change) constraints
  - Rules are preempt, wait or ignore
  - Their impact on operation execution
- The product mix constraints

Methodological and scientific approaches

The Problem constraints:

- Time constraints:
  - Working time: 5 days per week ? shift x 8 hours per day;
  - The maximum waiting time between operations (ex: shot blasting -> primer coat of paint);
  - The minimum delay between operations (ex: primer coat of paint -> the lacquer, sanding -> nest step);
- Specific constraints:
  - Products can not leave the workshop before the Coating step (so no external transfer before this stage);
  - The drying could be done outside the dedicated cabin but it will last at least twice the required time.

…

Methodological and scientific approaches

The preliminary evaluation of the process:

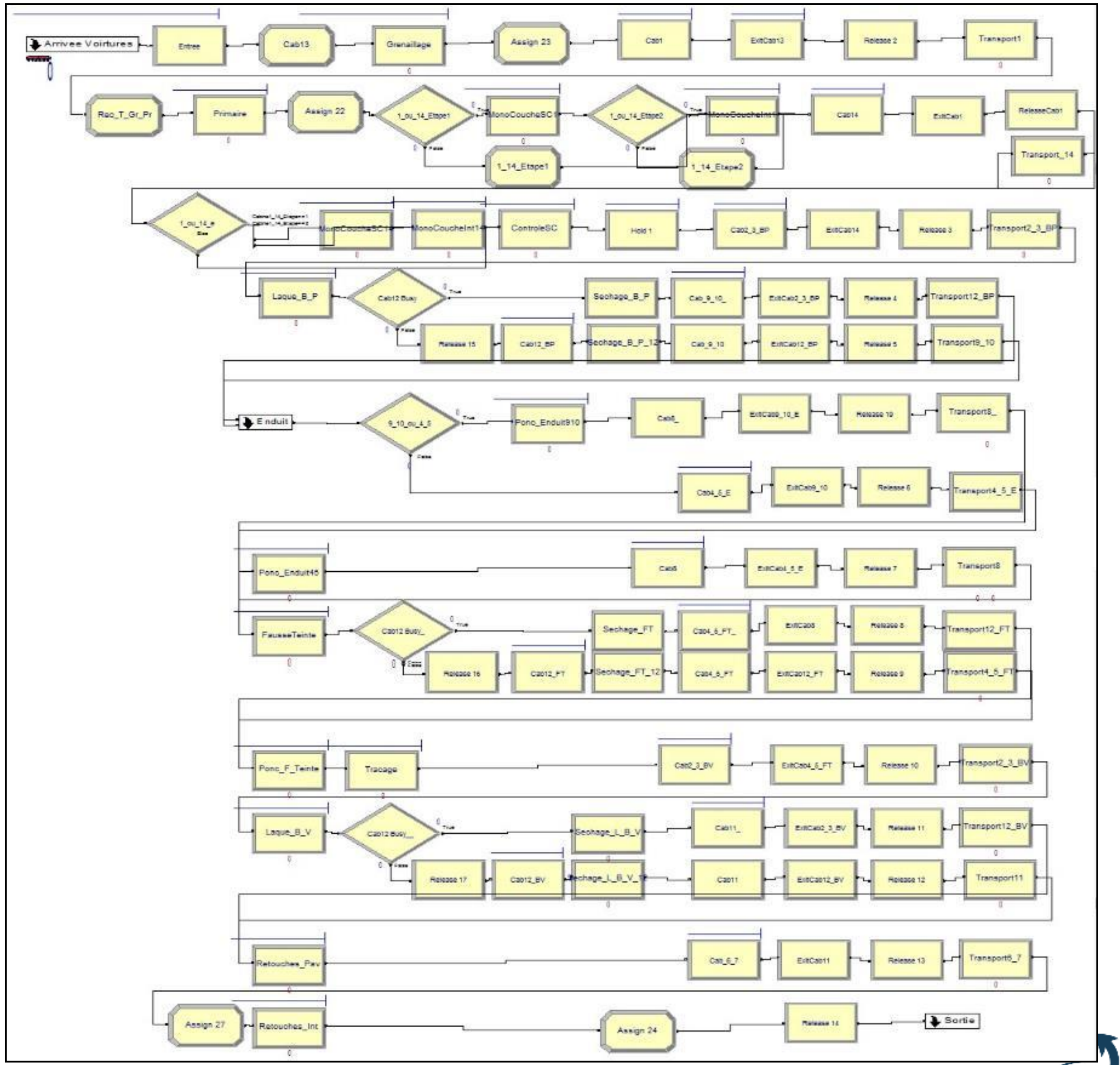
- We used the bottleneck concept
- We define the average product
- Then detect the bottleneck step
- Finally evaluate the process

- For a scenario with 2 shifts of 8 h:
  - Throughput = 31.44 v.e./ month < obj.
  - Cycle (v.e.) = 16.35 hours > Takt-time.
- For a scenario with 2 shifts of 8 h:
  - Throughput = 47.17 v.e./ month> obj.
  - Cycle (v.e.) = 10.90 hours <Takt-time.
- Conclusion:
  - With 2 teams per day, the Takt-time will not be respected.
  - However, with 3 teams per day, it is a priori achievable.

Methodological and scientific approaches

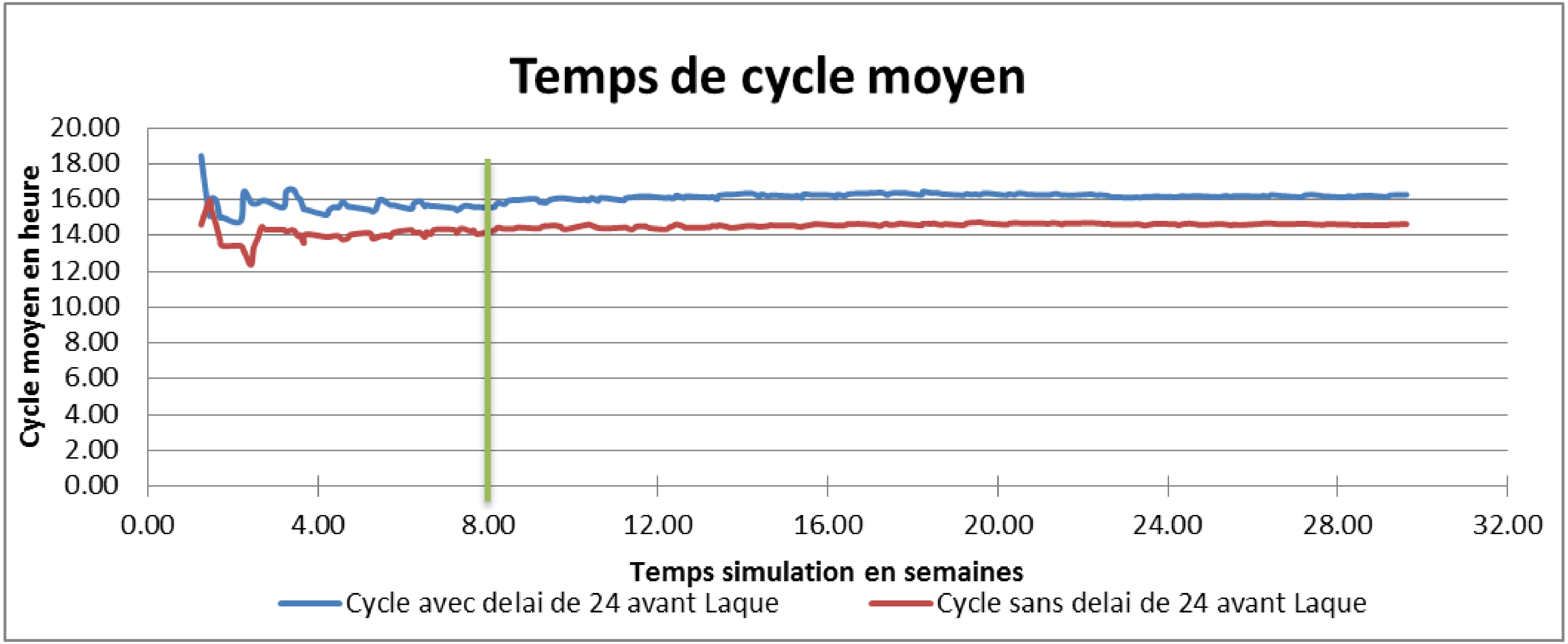
The simulation model:

- We used ARENA for modeling the work shop.
- The simulation validation is done with the Bombardier team.
- The simulation model is used:
  - To test scenarios and address the bombardier questions
  - To build a planning for a given working period,
  - To find the optimal entry sequence



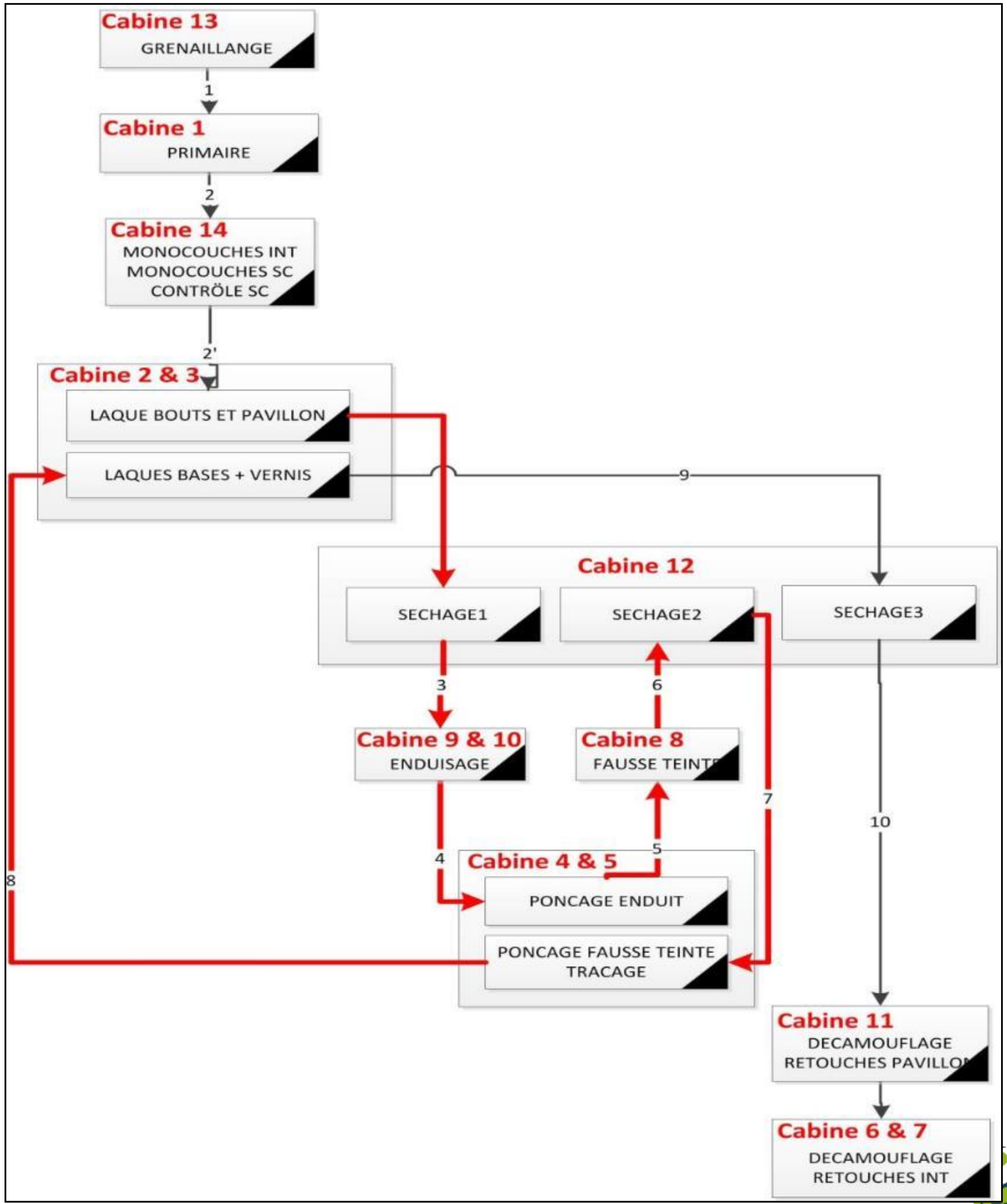
Results

- The Steady-state



Results

- From the simulation we depict some problems like the deadlock loops



Results

With the simulation

- We defined the rules to manage and establish a continues and pull flow.
- We answer the Bombardier questions:
  - Real capacity of the current system
  - Propose some improvement
  - Answer the takt-time

Results

With the simulation-based optimization

- We fined the right sequences: Those that respect the mix

Séquence	Les élements identifiés par leur codes (1 pour les MI09, 2 pour les paquets de 2 MF2000, 3 pour les NAT et 4 pour les Region2N.)																	
1	1	2	4	4	4	1	2	4	4	4	1	2	4	4	4	1	4	4	4
2	2	1	4	4	4	2	1	4	4	4	2	1	4	4	4	1	4	4	4
3	1	4	4	4	2	4	4	4	1	4	4	4	2	4	4	4	1	2	1
4	1	4	4	4	2	4	4	4	1	4	4	4	2	4	4	4	1	1	2
5	2	4	4	4	1	4	4	4	2	4	4	4	1	4	4	4	2	1	1
6	2	4	4	4	1	4	4	4	2	4	4	4	1	4	4	4	1	2	1
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10	2	4	4	1	4	4	2	4	4	1	4	4	2	4	4	1	4	4	1
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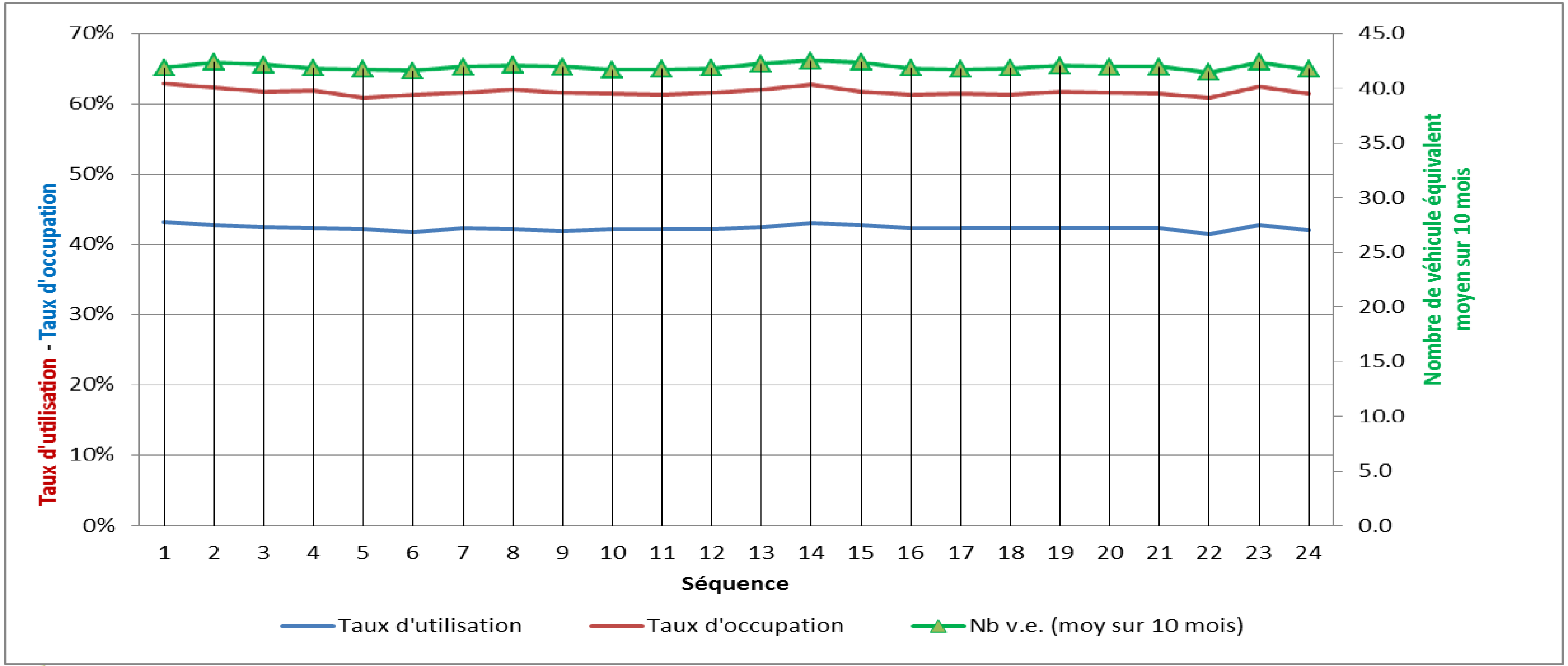
24	1	1	4	4	4	2	4	4	4	2	1	1	4	4	4	2	4	4	4

Results

With the simulation-based optimization

- We fined the right sequences: Those that respect the mix



Results

Performance of a given sequence.

- The exit sequence of the products

Mois	1	2	4	4	4	1	4	4	1	4	2	4	4	4	1	2	4	4	4	1	2	4	4	4	1	4	4	4	1	2	4	
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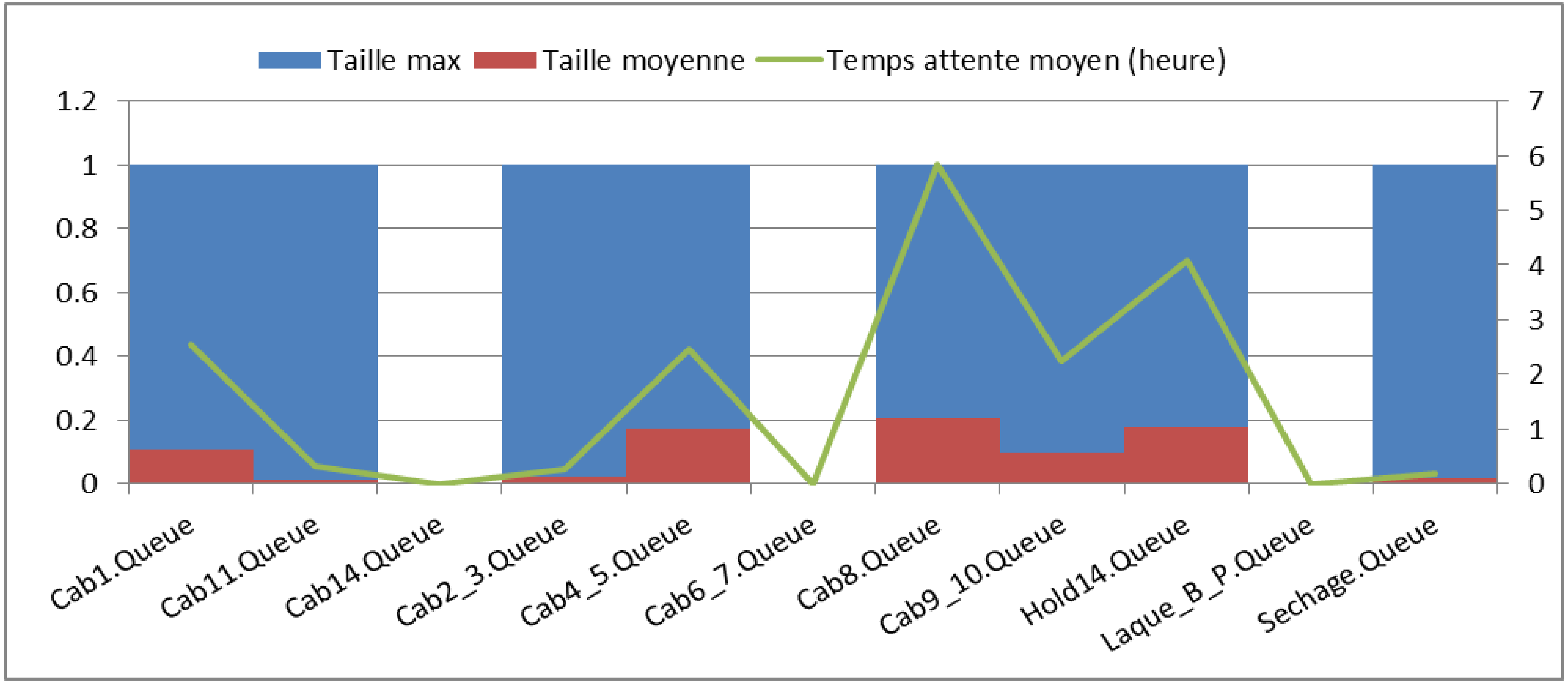
	15	4	1	2	4	4	4	1	4	4	4	1	2	4	4	4	1	2	4	4	4	1	2	4	4	4	1	4	4	4	1	

Results

Performance of a given sequence.

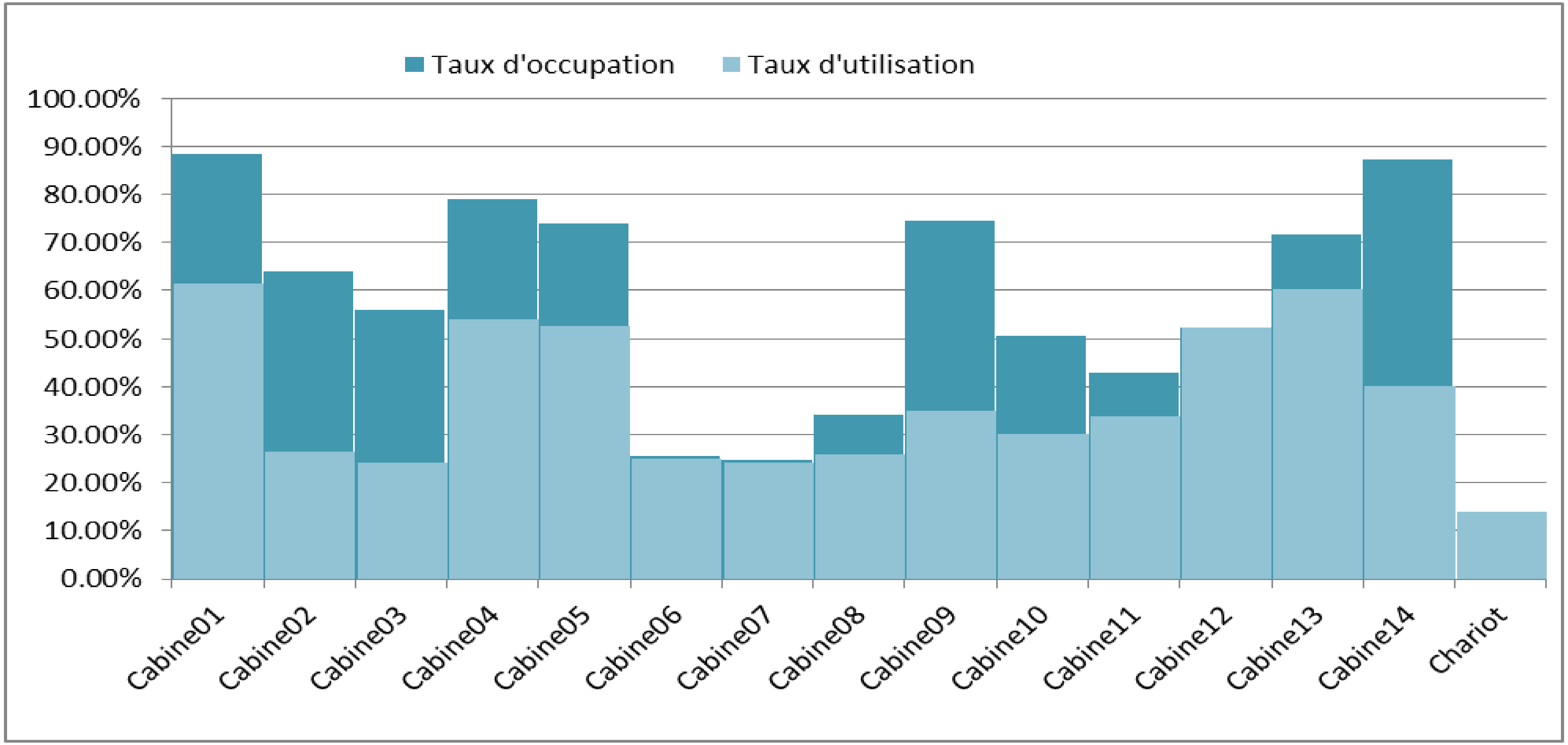
- The queue performances



Results

Performance of a given sequence.

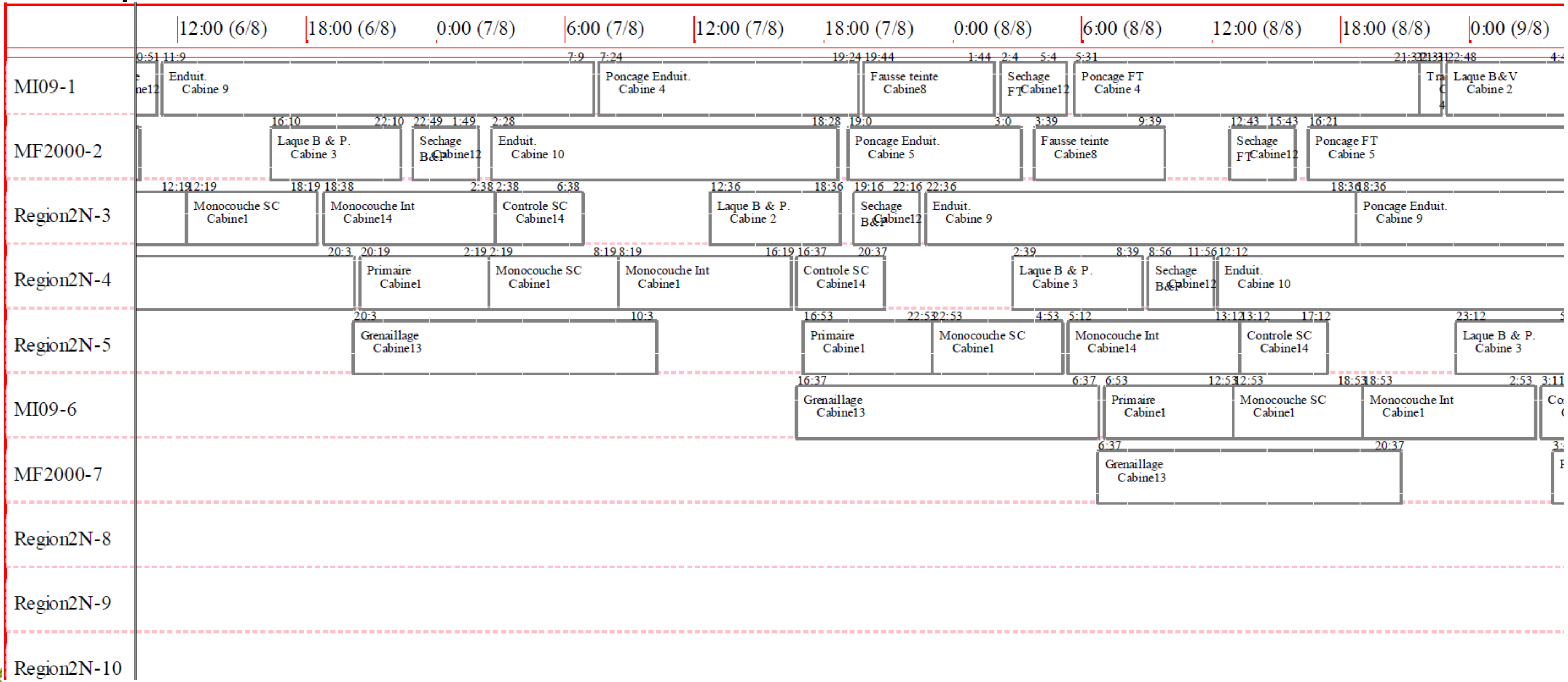
- The resources' utilization



Results

Performance of a given sequence.

- The production schedule



Conclusion

- We used Arena to simulate the painting Workshop and OptQuest to optimize the performance of our system.
- The simulation model helps us to study the process flow and address the client questions.
- OptQuest solver is also used to answer the scheduling question.
- We find the impact of the job sequence on the flow and the performance of the shop.

Acknowledgement

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