Modeling a tool for planning a new CSSD

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Introduction

Context

Consolidation of all the sterilization process of 3 hospitals in

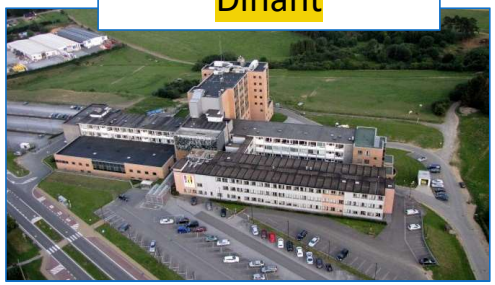
♦ CARE-NAM ♦

CHU UCL NAMUR

Sainte-Elisabeth

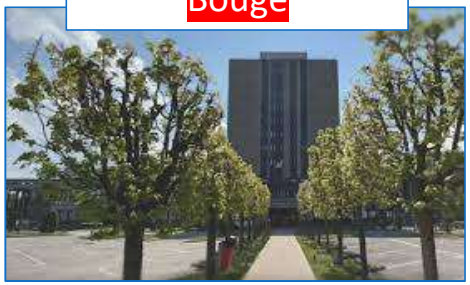
CHU UCL NAMUR

Dinant

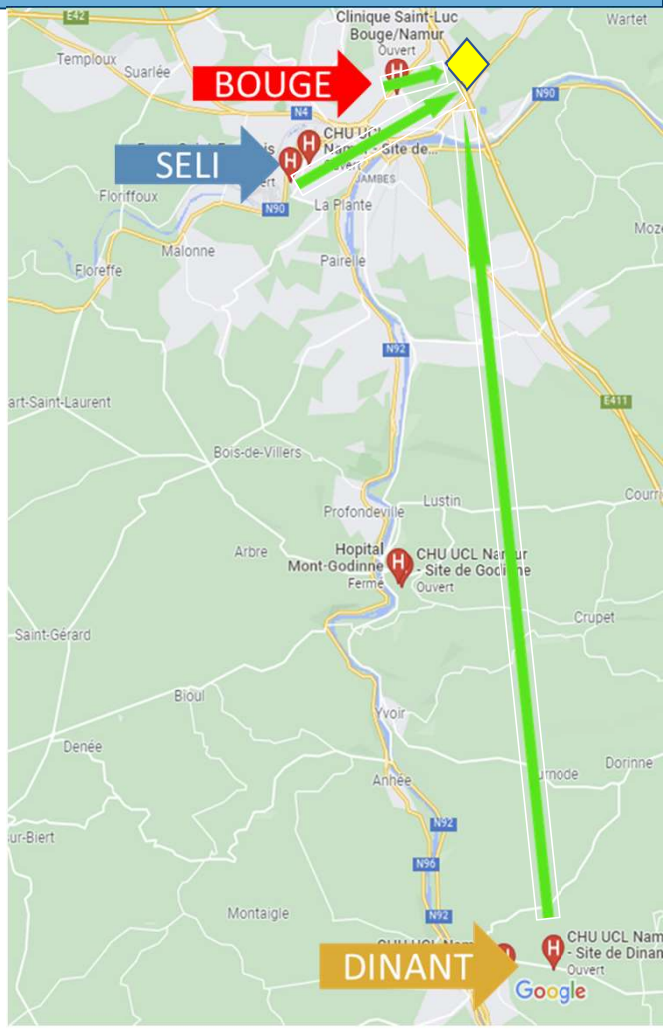


Clinique Saint-Luc Bouge

Bouge



CARE-NAM



Context

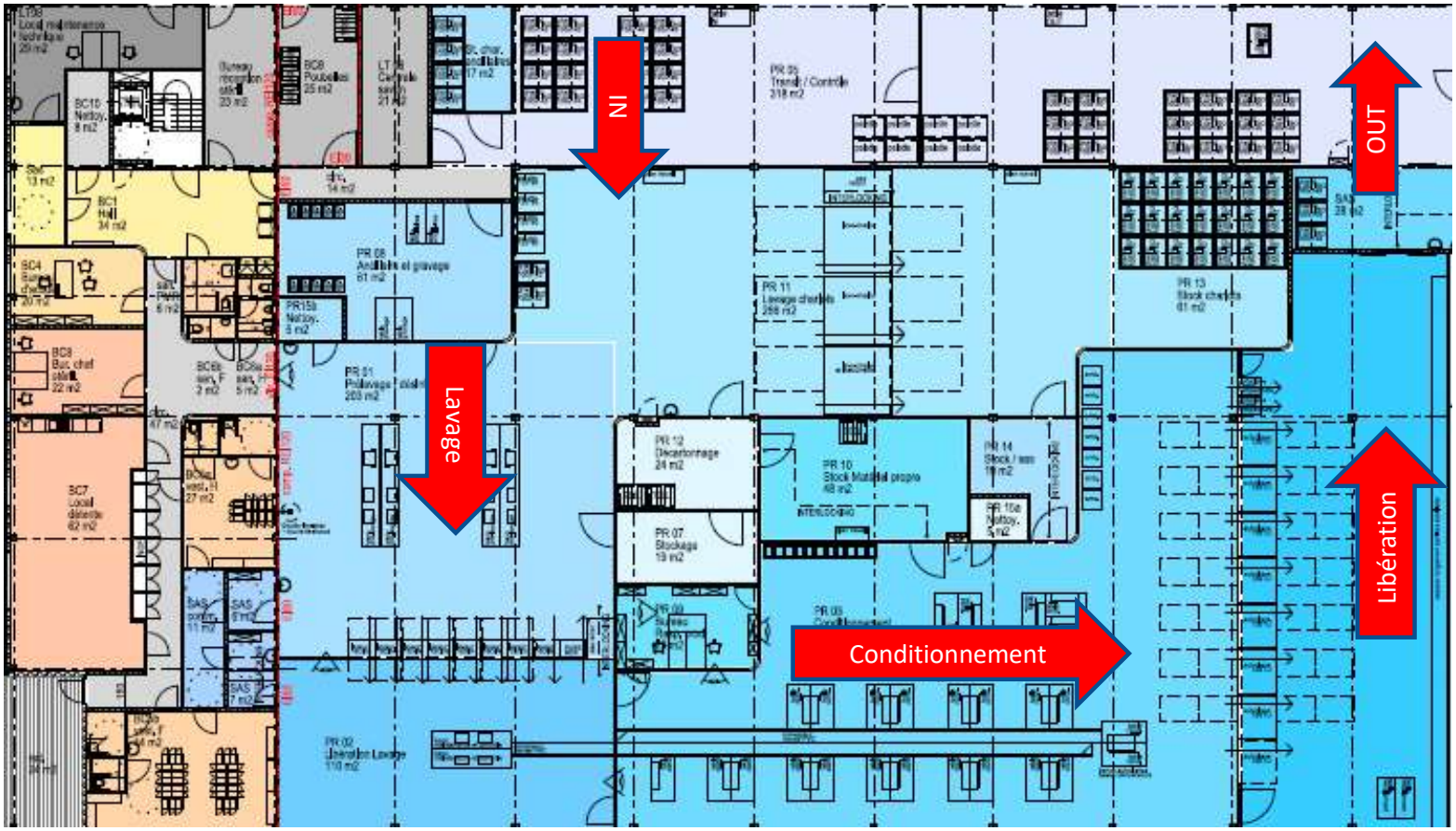

NORTH SEA
NETHERLANDS
Knokke
Oostende
Brugge
Antwerp
Sint-Niklaas
Gent
Flanders
Mechelen
Hasselt
Maas
GERMANY
Leie
Schelde
Aalst
Leuven
Kortrijk
BRUSSELS
Braine-l'Alleud
Liège
BELGIUM
Mons
La Louvière
Charleroi
Namur
Meuse
Malmedy
Wallonia
Ardennes
Bastogne
FRANCE
LUXEMBOURG
Arlon
LUXEMBOURG

Some key figures

- More than 40,000 surgical instruments in circulation
- More than 4,000 referenced sets
- More than 30,000 surgeries/year
- More than 110,000 DINs sterilized/year
- €16,000,000 construction and equipment budget…
- More than 5,000 m² of surface to be built…
- Over €6,000,000/year estimated operating budget…
- More than 30 FTEs currently occupied in the sterilizations of the 3 hospitals involved...

A brand new building

A brand new building



A sustainable and ecological concept

- Cogeneration;
- Photovoltaic panels;
- Underground parking to limit the footprint of the project (equipped with electric charging stations);
- Rainwater harvesting system;
- Building designed with a very efficient insulating envelope which allows it to obtain a very low

Modeling & Sizing

The partners

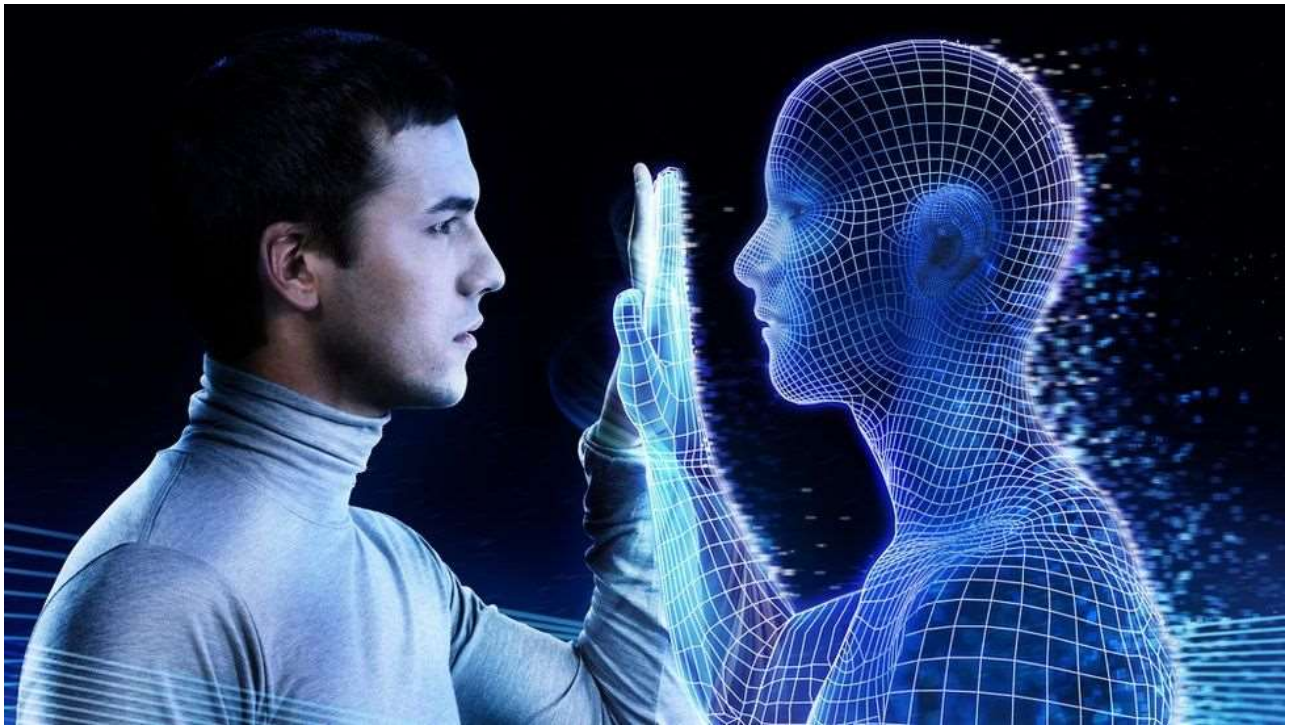
CETIC – Center of Excellence in Information and Communication Technologies

digital wallonia .be

- Created in 2001 on the initiative of 3 Universities
- Location : Charleroi Aeropole - Belgium
- Goal : Leveraging advanced technologies to serve companies
- Certification : ISO & Accredited Research Center
- International Development : European Research Area (ERA)

www.cetic.be

Why a digital twin?



Which techniques for the digital twin?

digital twin

Simulator of the future sterilization process based on the history of existing processes

Queue issue
(reinforced by the mass arrival by truck in the new plant)

Modeling and simulation by discrete events

OscaR
OPERATIONAL RESEARCH IN SCALA

cetic
Your Connection to ICT Research

Data analysis

- Analysis of incoming sets
- Functional analysis
- Modeling of processing times
- Schedule analysis
- ...

Discrete event modeling and simulation?

Modeling the functioning of a system
as a sequence of events in time

For CARE NAM:

An event is the change of state of a set following an action.

This change of state makes the next action possible.

Ex: dirty set -> action: manual pre-wash -> set ready for washing machine

- based on the operational research library and its discrete event simulation module **OscaR.des**
- processing time unit: second

How to feed the simulator ?

INPUTs related to the activity

Source: Traceability of the passage of sets within the sterilization department

INPUTs related to the sets

Source: Description of the sets exported from the sterilization software
- Name
- Number of instruments
- Size: STU
- Low temperature or steam.

Digital twin simulator

Simulator VARIABLES

- Number of people/area
- Number of equipment/area
- Volume of equipment
- Time per step (machine/HR)
- Transportation (frequency, time, cost, CO2)

OUTCOME

Example of variables

	Acronyme	CareNam-Scenario-David	
1	Acronyme	CareNam-Scenario-David	
2	Jours Extras Horizon	2	
3	Nb Postes Lavage Manuel	4	
4	Nb Postes Reconditionnement	14	
5	Nb Postes Chargement	2	
6	Nb Laveurs	8	
7	Nb Autoclaves	5	2
8	Nb Ultrasons	4	
9	Temps Cycle Laveur	55	
10	Temps Cycle Autoclave	70	50
11	Temps Cycle Ultrasons	5	
12	Temps Emballage-Maintenance	3	
13	Temps Refroidissement	30	
14	Temps Chargement Camions	0,166666667	
15	Nb Packs Laveur	9	
16	Nb Packs Autoclave	12	9
17	Nb Packs Ultrasons	5	
18	Nb Individuels Pack	8	
19	Volume STU Charge Laveur	1,6	
20	Volume STU Charge Autoclave	4	0,49
21	Volume STU Charge Ultrasons	0,7	
22	Max Attente Laveurs	60	
23	Max Attente Autoclaves	60	30
24	Max Attente Ultrasons	15	

A scenario feeding table to modify parameters such as:

- Number of agents at different stations according to their schedule
- Adaptation of washing times, sterilization, transit, etc.
- Adaptation of the number of machines in the event of breakdown or maintenance

Example of variables

Day	Hours	Extrapay
Monday	1 a.m	1,35
Lu	2 a.m	1,35
Lu	2 a.m	1,35
Lu	3 a.m	1,35
Lu	4 a.m	1,35
Lu	5 a.m	1,35
Lu	6 a.m	1,1
Lu	7 a.m	1
Lu	8 a.m	1
Lu	9 a.m	1
Lu	10 a.m	1

Consommation	9,6	l/100km
Emission de CO2	263	g/km
Prix carburant	2	EUR/l

Introduction of economic parameters such as :

- The hourly cost of the staff according to their shift (night, day, weekend)
- The cost per kilometer of fuel consumption or depreciation of the transport vehicle. This cost can be replaced by the cost of renting the services of a transport company, accounted for by the kilometer driven.

Example of variables

Jour	Heure	Lavage manuel + Ultrason	Maintenance + Reconditio	Logistique	Total
Lu	0:00:00	0	0	0	0
Lu	1:00:00	0	0	0	0
Lu	2:00:00	0	0	0	0
Lu	3:00:00	0	0	0	0
Lu	4:00:00	0	0	0	0
Lu	5:00:00	0	0	0	0
Lu	6:00:00	0	0	0	0
Lu	7:00:00	1	0	0	1
Lu	8:00:00	1	1	0	2
Lu	9:00:00	1	1	1	3
Lu	10:00:00	2	2	1	5
Lu	11:00:00	2	2	1	5
Lu	12:00:00	2	8	1	11
Lu	13:00:00	2	8	1	11
Lu	14:00:00	2	8	1	11
Lu	15:00:00	2	8	1	11
Lu	16:00:00	2	10	1	13
Lu	17:00:00	2	10	1	13
Lu	18:00:00	2	10	1	13
Lu	19:00:00	2	8	1	11
Lu	20:00:00	2	8	1	11
Lu	21:00:00	1	8	1	10
Lu	22:00:00	1	7	1	9
Lu	23:00:00	1	3	1	5
Ma	0:00:00	0	2	1	3
Ma	1:00:00	0	2	1	3
Ma	2:00:00	0	2	1	3
Ma	3:00:00	0	2	1	3
Ma	4:00:00	0	1	1	2
Ma	5:00:00	0	1	1	2
Ma	6:00:00	1	1	1	3
Ma	7:00:00	1	0	0	1
Ma	8:00:00	1	1	0	2
Ma	9:00:00	1	1	1	3

3 work zones defined in the simulator:

- For each zone, the number of sterilization agents required to handle the medical devices is assigned per day and per hour.
- The simulator user can modify th number of sterilization agents to optimize the handling of the medical devices and adjust the resources to the inputs.

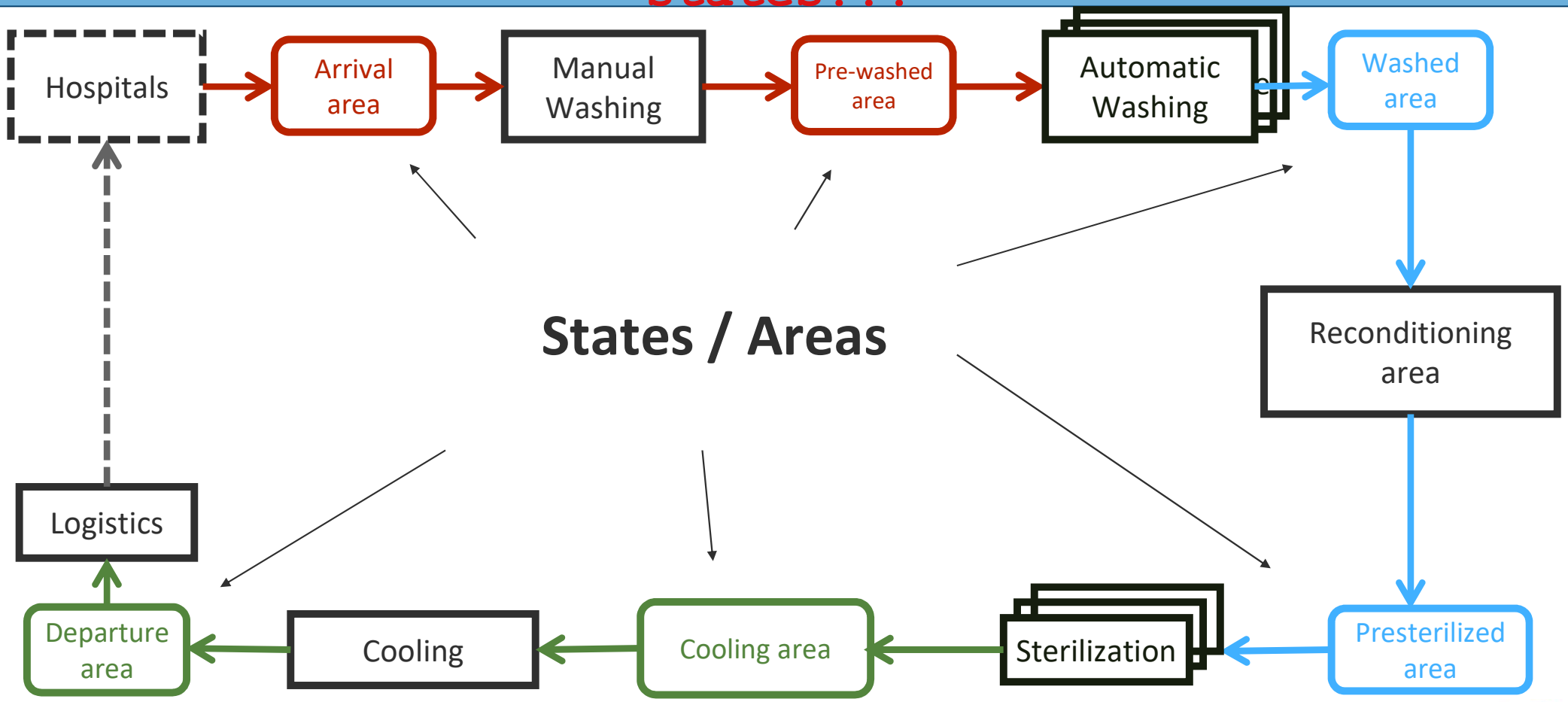
Inputs and variables

Depending on the site concerned:

- Input of the actual activity of the operating room theater
- Distances in kilometers
- Transport time + latency time
- Proposal of material pick-up times
- …

Start	End				
	1/24/22 6:00	2/6/22 23:32			
Files	**Site**	**DistanceSite (km)**	**LatenceLo**	**Lundi**	**Marc**
DINANT-01-10-2021-REP_SETCYCLES.csv	Dinant	36	45	06:00, 12:30, 16:00, 20:30	06:0
BOUGE-REP_SETCYCLES_202203080944_2021-22_sep.	Bouge	3	15	07:00, 10:30, 14:00, 18:30	07:0
SELI-01-10-2021-REP_SETCYCLES.csv	Seli	6,5	30	06:45, 11:15, 14:45, 19:15	06:4
# commentaires: par jour, introduire les heures d'enlèvements (ex: 06:00, 11:30, 15:30, 21:00) ou "direct" pour une extraction à flux tendu					

Simulation Model: Alternating states...



Simulation Model: Alternating states...

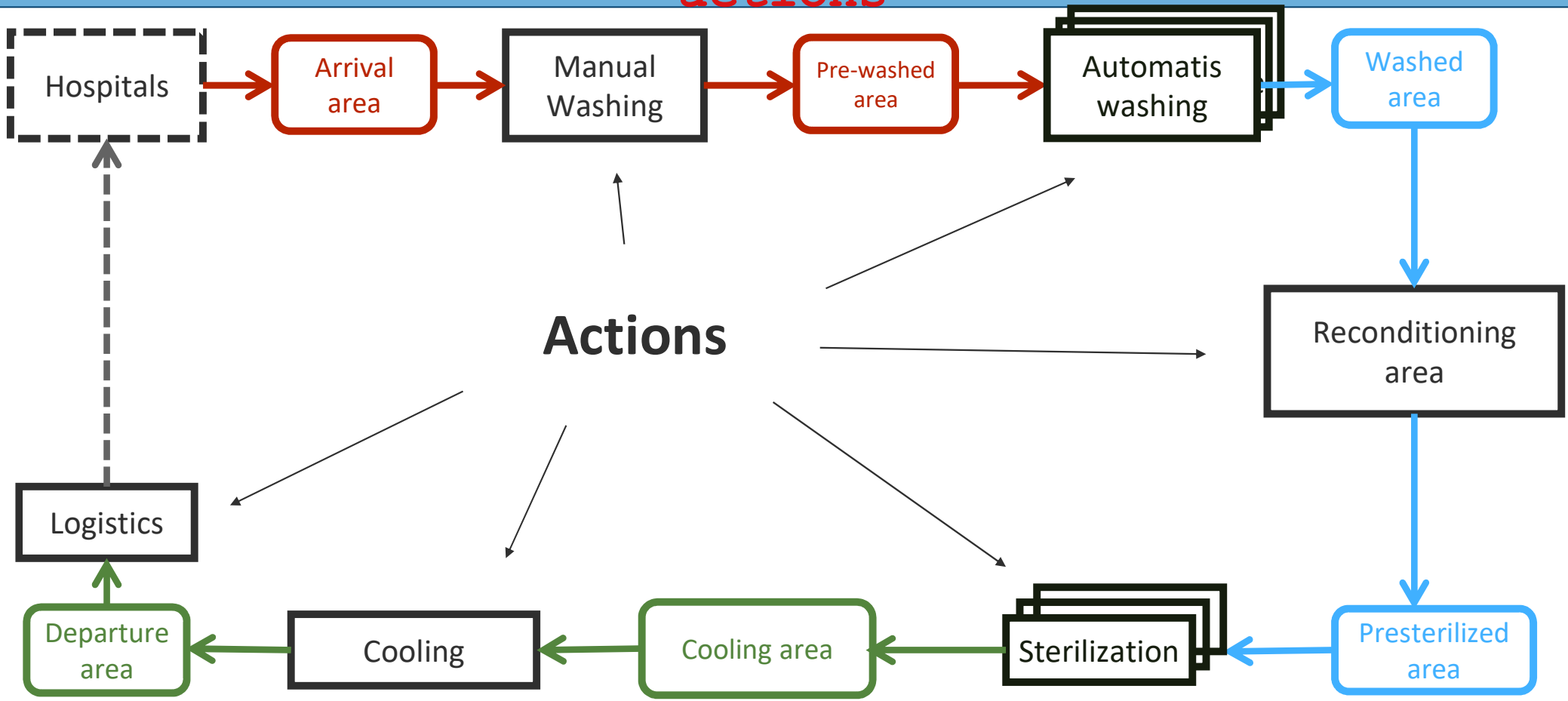
Arrival area

Presterilized area

Departure area

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	
1	Temps	Sets Arrivés Zone Arrivage	Sets Arrivés Zone Preultrasons	Sets Arrivés Zone Prelavage	Sets Arrivés Zone Reconditionnement	Sets Arrivés Zone Prestérilisation	Sets Arrivés Zone Refroidissement	Sets Arrivés Zone Chargement	Sets Arrivés Zone Départ	Nb Ultrasons Démarrés	Min Nb Ultrasons Occupés	Max Nb Ultrasons Occupés	Nb Laveurs Démarrés	Min Nb Laveurs Occupés	Max Nb Laveurs Occupés	Nb Autoclaves Démarrés	Min Nb Autoclaves Occupées	Max Nb Autoclaves Occupées	Nb Operateurs Zone Sale Disponibles	Charge Travail Zone Sale (%)	
76	Semaine 1, Jeudi 8h	30	30	34	0	0	0	0	0	6	0	3	2	0	2	0	0	0	1	41,65	5
77	Semaine 1, Jeudi 9h	0	0	0	26	9	0	0	0	0	0	0	1	0	2	0	0	0	1	0	0
78	Semaine 1, Jeudi 10h	0	0	0	20	8	0	0	0	0	0	0	0	0	1	0	0	0	1	0,8	0
79	Semaine 1, Jeudi 11h	26	21	22	0	16	0	0	0	6	0	4	2	0	2	0	0	0	2	18,3	1
80	Semaine 1, Jeudi 12h	146	31	20	17	15	0	0	0	2	0	1	1	0	2	1	0	1	2	25	1
81	Semaine 1, Jeudi 13h	0	107	130	9	23	43	0	0	6	0	2	3	1	4	1	0	1	2	63,3	1
82	Semaine 1, Jeudi 14h	29	29	29	119	50	0	43	43	3	0	1	1	0	3	0	1	1	2	30,8	3
83	Semaine 1, Jeudi 15h	48	46	48	47	94	24	24	24	9	0	3	3	1	3	1	0	1	2	37,5	5
84	Semaine 1, Jeudi 16h	171	92	79	40	61	109	0	0	6	0	1	3	1	3	1	1	2	2	75	3
85	Semaine 1, Jeudi 17h	32	83	104	115	51	72	109	109	6	0	1	3	2	5	1	1	2	2	60,8	7
86	Semaine 1, Jeudi 18h	0	12	20	75	95	41	72	72	3	0	3	1	1	3	1	1	2	2	7,5	1
87	Semaine 1, Jeudi 19h	60	18	15	20	66	69	41	41	3	0	3	1	0	1	1	1	2	2	25	8
88	Semaine 1, Jeudi 20h	211	65	60	26	10	94	69	69	9	0	2	4	1	4	1	1	2	2	65	2
89	Semaine 1, Jeudi 21h	0	135	139	64	55	10	104	104	9	0	2	5	2	5	2	0	2	2	100	4
90	Semaine 1, Jeudi 22h	22	46	70	132	76	78	47	47	4	0	1	2	2	5	1	1	2	1	85	1
91	Semaine 1, Jeudi 23h	0	0	9	50	72	64	31	31	1	0	1	1	1	2	1	1	2	1	0	0
92	Semaine 1, Vendredi 0h	0	0	0	22	23	0	64	64	0	0	0	1	0	1	0	1	1	1	0	0
93	Semaine 1, Vendredi 1h	0	0	0	9	23	84	84	84	0	0	0	0	0	1	0	0	1	0		
94	Semaine 1, Vendredi 2h	0	0	0	0	19	0	0	0	0	0	0	0	0	0	1	0	1	0		
95	Semaine 1, Vendredi 3h	0	0	0	0	16	63	0	0	0	0	0	0	0	0	0	0	1	0		
96	Semaine 1, Vendredi 4h	0	0	0	0	9	0	63	63	0	0	0	0	0	0	1	0	1	0		
97	Semaine 1, Vendredi 5h	0	0	0	0	0	5	0	0	0	0	0	0	0	0	1	1	2	0		
98	Semaine 1, Vendredi 6h	0	0	0	0	0	35	5	5	0	0	0	0	0	0	0	0	1	0	100	0
99	Semaine 1, Vendredi 7h	4	4	0	0	0	0	35	35	0	0	0	0	0	0	0	0	0	1	1,65	0
100	Semaine 1, Vendredi 8h	10	10	14	0	0	0	0	0	2	0	1	0	0	0	0	0	0	1	8,3	1

Simulation Model: ... and actions



Simulation Model: ... and actions

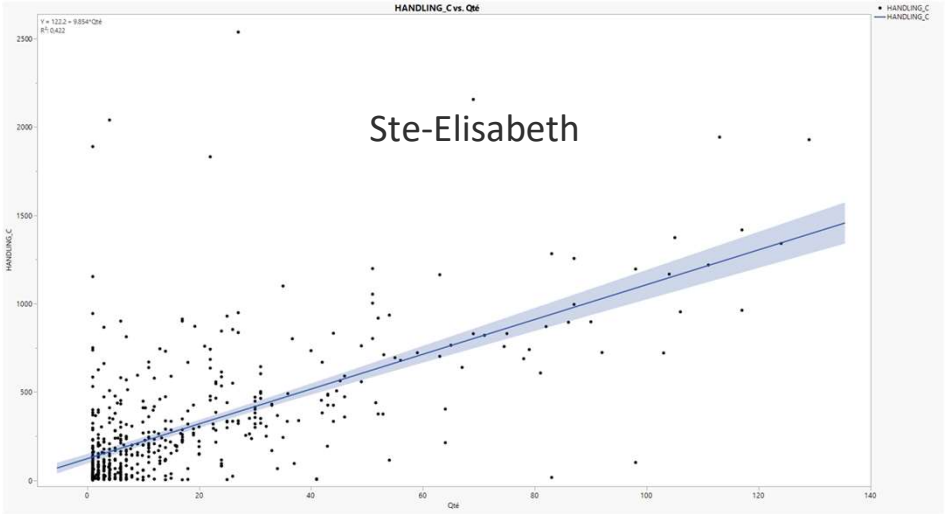
Automatis washing

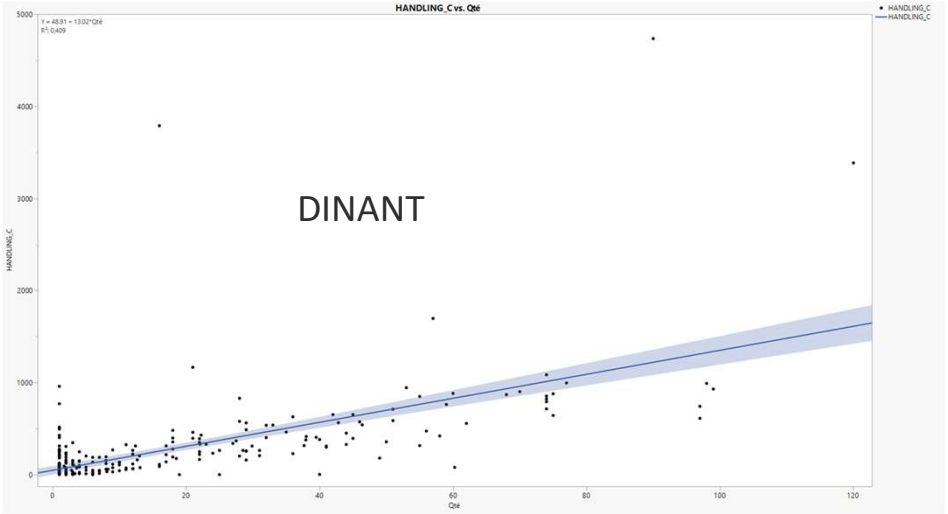
Reconditioning area

	Temps	Sets Arrivés Zone Départ	Nb Ultrasons Démarrés	Min Nb Ultrasons Occupés	Max Nb Ultrasons Occupés	Nb Laveurs Démarrés	Min Nb Laveurs Occupés	Max Nb Laveurs Occupés	Nb Autoclaves Démarrés	Min Nb Autoclaves Occupées	Max Nb Autoclaves Occupées	Nb Operateurs Zone Sale	Charge Travail Zone Sale	Temps Restant Zone Sale	Nb Operateurs Zone Propre	Charge Travail Zone Propre (%)	Temps Restant Zone Propre (h)	Nb Operateurs Logistique Disponibles	Charge Travail Zone Logistique (%)	Temps Restant Zone Logistique (h)
76	Semaine 1, Jeudi 8h	0	6	0	3	2	0	2	0	0	0	1	41,65	3 minutes	0	100	0 minute	0		
77	Semaine 1, Jeudi 9h	0	0	0	0	1	0	2	0	0	0	1	0	0 minute	1	95	2 heures	0	100	0 minute
78	Semaine 1, Jeudi 10h	0	0	0	0	0	0	1	0	0	0	1	0,8	0 minute	1	100	2 heures	1	0	0 minute
79	Semaine 1, Jeudi 11h	0	6	0	4	2	0	2	0	0	0	2	18,3	1 minute	2	100	57 minute	1	0	0 minute
80	Semaine 1, Jeudi 12h	0	2	0	1	1	0	2	1	0	1	2	25	12 minute	2	68,33333	13 minute	1	0	0 minute
81	Semaine 1, Jeudi 13h	0	6	0	2	3	1	4	1	0	1	2	63,3	12 minute	8	30,41666	1 minute	1	0	0 minute
82	Semaine 1, Jeudi 14h	43	3	0	1	1	0	3	0	1	1	2	30,8	3 minutes	8	83,95833	37 minute	1	11,65	1 minute
83	Semaine 1, Jeudi 15h	24	9	0	3	3	1	3	1	0	1	2	37,5	5 minutes	8	100	27 minute	1	6,65	1 minute
84	Semaine 1, Jeudi 16h	0	6	0	1	3	1	3	1	1	2	2	75	33 minute	8	91,08333	8 minutes	1	0	0 minute
85	Semaine 1, Jeudi 17h	109	6	0	1	3	2	5	1	1	2	2	60,8	7 minutes	10	61,83333	9 minutes	1	31,65	3 minutes
86	Semaine 1, Jeudi 18h	72	3	0	3	1	1	3	1	1	2	2	7,5	1 minute	10	100	26 minute	1	18,3	2 minutes
87	Semaine 1, Jeudi 19h	41	3	0	3	1	0	1	1	1	2	2	25	8 minutes	10	65,16666	10 minute	1	11,65	1 minute
88	Semaine 1, Jeudi 20h	69	9	0	2	4	1	4	1	1	2	2	65	24 minute	8	17,5	1 minute	1	18,3	2 minutes
89	Semaine 1, Jeudi 21h	104	9	0	2	5	2	5	2	0	2	2	100	42 minute	8	97,70833	8 minutes	1	30	3 minutes
90	Semaine 1, Jeudi 22h	47	4	0	1	2	2	5	1	1	2	1	85	15 minute	8	99,58333	37 minute	1	13,3	1 minute
91	Semaine 1, Jeudi 23h	31	1	0	1	1	1	2	1	1	2	1	0	0 minute	7	100	1 heure 5	1	8,3	1 minute
92	Semaine 1, Vendredi 0h	64	0	0	0	1	0	1	0	1	1	1	0	0 minute	3	100	2 heures	1	16,65	1 minute
93	Semaine 1, Vendredi 1h	84	0	0	0	0	0	1	0	0	1	0			2	100	2 heures	1	23,3	2 minutes
94	Semaine 1, Vendredi 2h	0	0	0	0	0	0	0	1	0	1	0			2	100	1 heure 5	1	0	0 minute
95	Semaine 1, Vendredi 3h	0	0	0	0	0	0	0	0	0	1	0			2	100	54 minute	1	0	0 minute
96	Semaine 1, Vendredi 4h	63	0	0	0	0	0	0	1	0	1	0			2	47,5	6 minutes	1	16,65	1 minute
97	Semaine 1, Vendredi 5h	0	0	0	0	0	0	0	1	1	2	0			1	0	0 minute	1	0	0 minute
98	Semaine 1, Vendredi 6h	5	0	0	0	0	0	0	0	0	0	1	0	100	0 minute	1	0	0 minute	1	1,65	0 minute
99	Semaine 1, Vendredi 7h	35	0	0	0	0	0	0	0	0	0	0	1	1,65	0 minute	1	0	0 minute	1	10,15	1 minute
100	Semaine 1, Vendredi 8h	0	2	0	1	0	0	0	0	0	0	1	8,3	1 minute	0	0	0 minute	0		

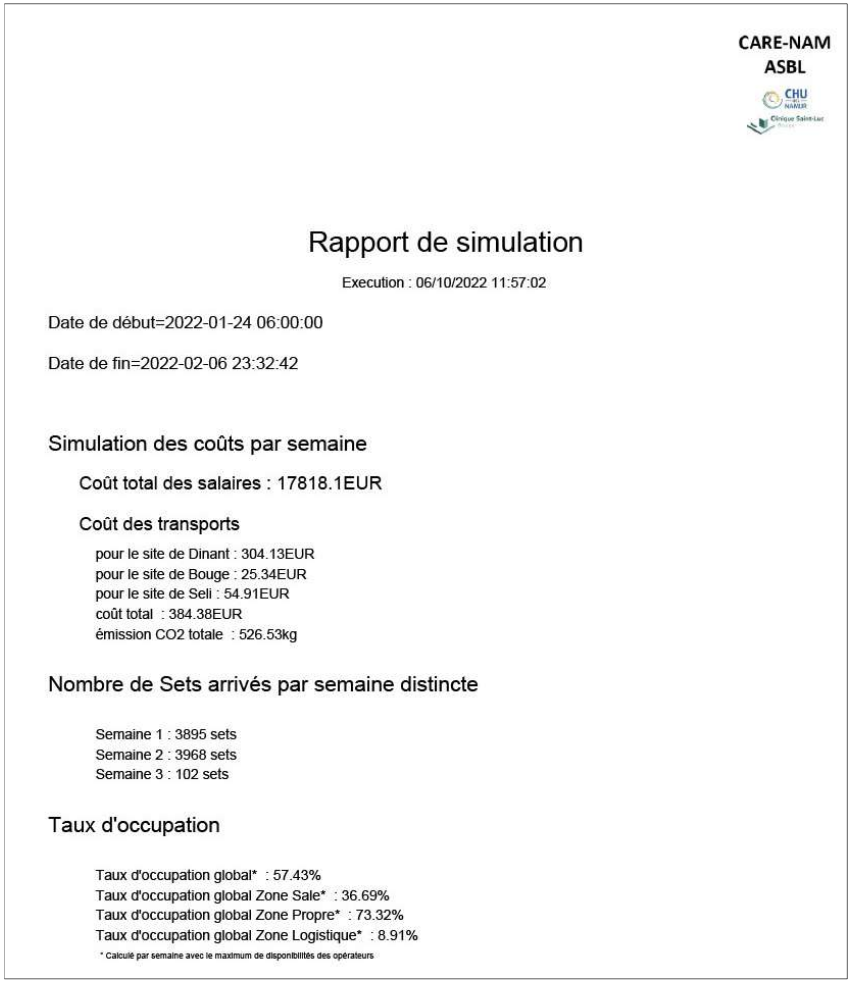
Some Results

Correlation between number of instruments and handling time





Some Results



CARE-NAM ASBL

CHU NAMUR

Clinique Saint-Luc

Rapport de simulation

Execution : 06/10/2022 11:57:02

Date de début=2022-01-24 06:00:00

Date de fin=2022-02-06 23:32:42

Simulation des coûts par semaine

Coût total des salaires : 17818.1EUR

Coût des transports

pour le site de Dinant : 304.13EUR
pour le site de Bouge : 25.34EUR
pour le site de Seli : 54.91EUR
coût total : 384.38EUR
émission CO2 totale : 526.53kg

Nombre de Sets arrivés par semaine distincte

Semaine 1 : 3895 sets
Semaine 2 : 3968 sets
Semaine 3 : 102 sets

Taux d'occupation

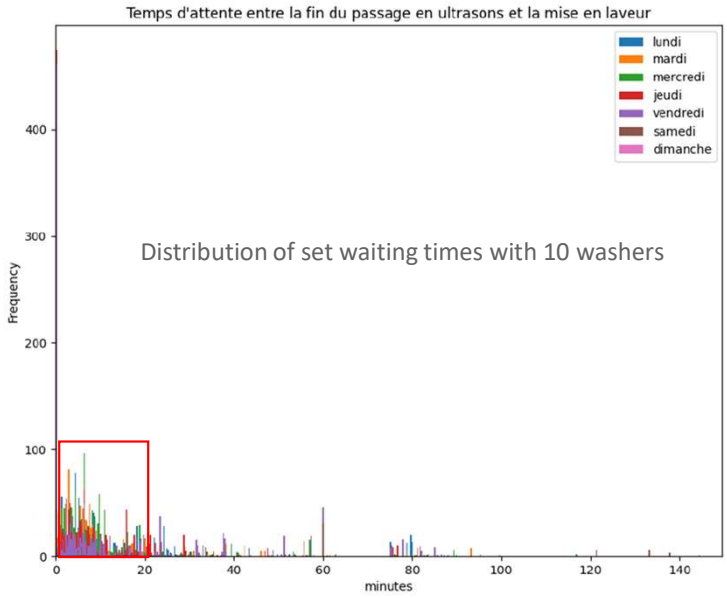
Taux d'occupation global* : 57.43%
Taux d'occupation global Zone Sale* : 36.69%
Taux d'occupation global Zone Propre* : 73.32%
Taux d'occupation global Zone Logistique* : 8.91%

* Calculé par semaine avec le maximum de disponibilités des opérateurs

The simulator issues a report with each new simulation and reports a number of standardized information:

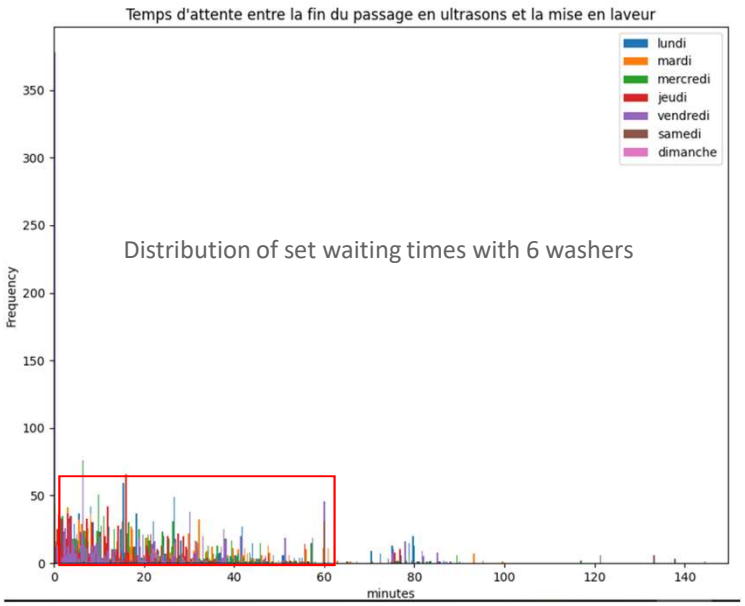
- Salary cost of the week or day concerned
- Cost of transportation
- Number of sets or compositions taken in charge
- Occupancy rate of the different work areas. Here, the packaging area is 73.32% occupied during this period. It is likely that this occupancy would have been higher with one less staff.

Some Results



A large number of sets with are processed without waiting time (>400)

For sets with waiting time, we notice that a majority of sets are sent before 20 minutes.



A significant amount of sets (350) are processed without waiting

For sets with a waiting time, there is a smoothing of the waiting times which ranges between 0 and 50 minutes.

Discussion

- Decision support. The decision makers remain in control of their destiny
- Simulations is effective and in progress: opening hours, staff schedules, transport schedules and frequencies, number of machines (washers, autoclaves, low temperature sterilizers, ultrasounds and washing benches, etc.)
- Importance of consolidated and harmonized databases (here between 3 hospitals that use the same sterilization and operating room theater management program (Ex: Aexis – www.aexis.com)). Numerous database corrections were necessary before injecting the data into the simulator because the habits and instructions during the creation of the databases were different between the 3 hospitals.
- The reading of the results is done by pre-defined time interval (from the minute to the full day, ideally by hour)
- User Interface is currently based on common tools for AI Engineers which requires a bit of learning for the uninitiated.
- The need to use the same OR/sterilization management program to capture all the data or the need to multiply the development of interfaces to retrieve data according to a pre-defined format in the simulator program. It is technically possible to make "connectors", a sort of automatic script that will repatriate new data to the right place

Perspectives

- The current solution is a cloud solution which makes it possible to work with several people, avoid local installation problems and quickly benefit from the latest updates
- Use of the model for tactical purposes (sizing when designing the service) and even operational purposes (Business intelligence BI).
- Possible interfacing with the programming tools used in the operating rooms theatre
- Help in analyzing the impact on the sterilization process of opening or closing rooms.
- Help in the decision to welcome new customers (tactical dimension).
- Continuous information on the expected workload based on the actual activity of the operating rooms and the allocation of human and material resources in sterilization through the development of Business Intelligence (BI) tools
- Anticipation of staffing needs during busy periods or, on the contrary, during vacations or following equipment shutdowns on the time of care

Conclusions

- Setting up digital twins is a real challenge, knowing that the results will always be imperfect, because not all scenarios can be imagined and not all data can be collected.
- The generic modeling of the sterilization process based on discrete events is now transposable to the new sterilization center for the 3 hospitals
- This digital twin makes it possible to plan the input load of the sterilization unit and to observe the response of its model.
- The simulations make it possible to carry out risk analyzes as well as to optimize the process according to well-defined criteria.
- The data generated by the simulations must be able to be compared with data obtained by the actual course of the process.
- In a later phase, we will be able to use this model for tactical and even operational purposes.

Thank you for your attention

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