DALHOUSIE UNIVERSITY
FACULTY OF ENGINEERING

Ahmad M. Hadi, Hazem Ibrahim,
Pradeep Raj Nagaraj, Youssef Khattab

Canadian Blood Services — BLOOD, PLASMA, STEM CELLS, ORGANS & TISSUES

Department of Industrial Engineering

Allocation and Distribution of Collection Equipment for CBS

Problem Definition

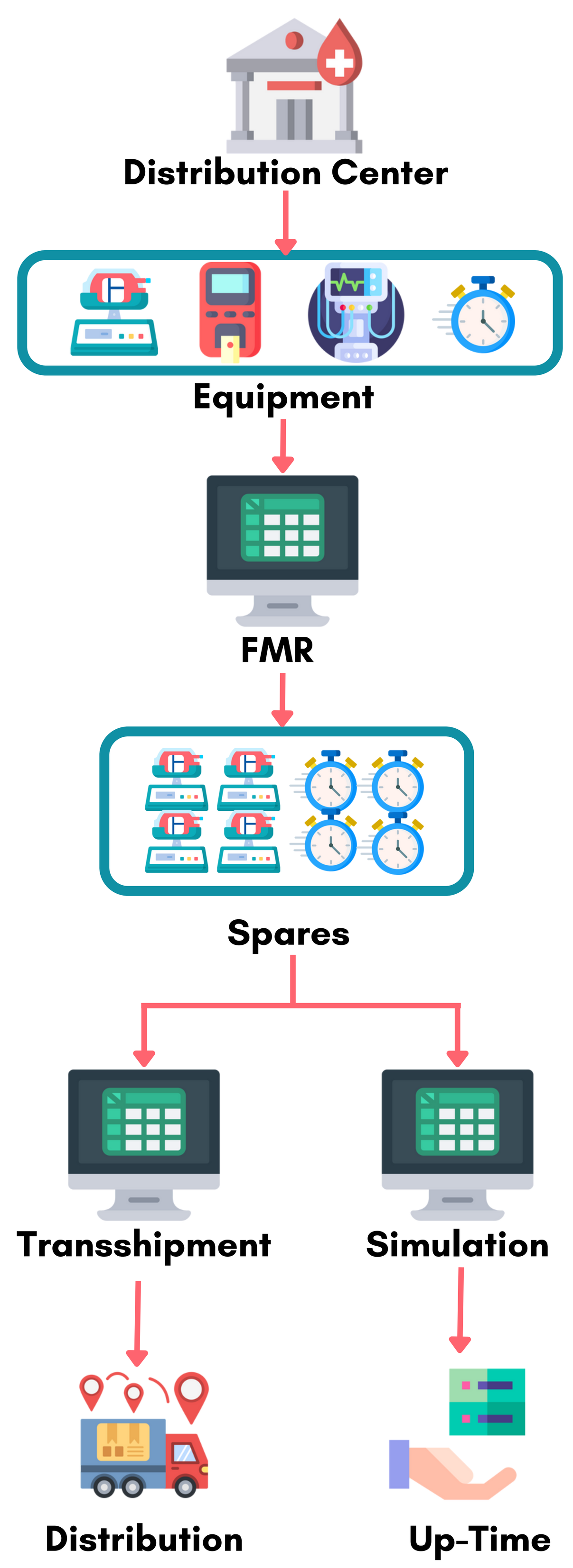
- **Canadian Blood Services (CBS)** manages the national supply of blood products across all provinces and territories, excluding Quebec.
- To maintain the desired blood collection target for each site. CBS currently stores an excess fleet of equipment spares to avoid any interruptions.
- Canadian Blood Services intent is to determine the optimal number of equipment that should be allocated, to maintain their operations and blood collection target without causing any disruptions.

Objectives

Provide CBS with set of tools to make decisions on:

- Required number of spares for each type of equipment
- Provide optimal uptime for a given service level
- Optimizing the distribution of excess and required equipment

Approach



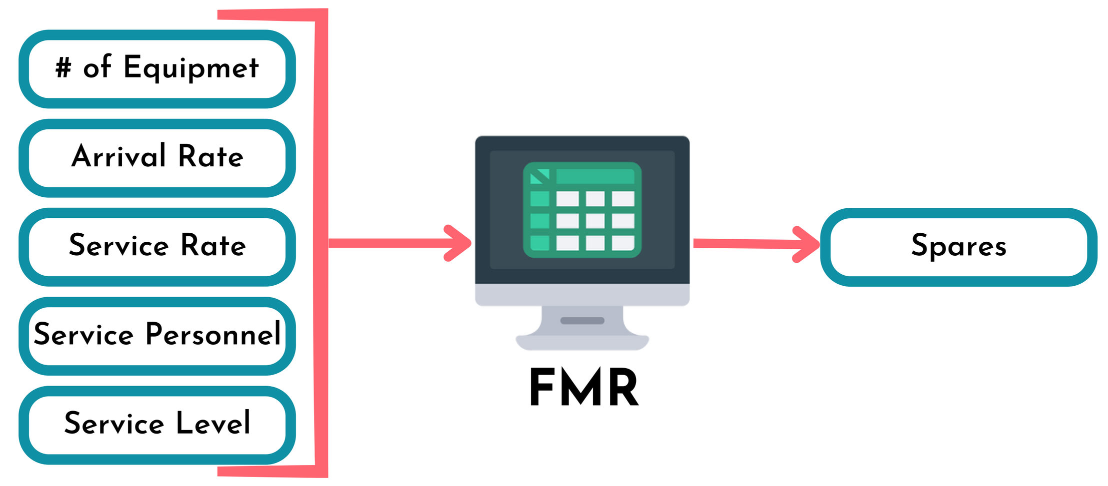
Details of Design

Model 1: Identifying the Spares

Why?

We chose finite machine repair (MMSN) because it considers failure rate, service rate, and service level to determine the optimal number of spares required, which ensures efficient use of resources and minimizes downtime for the equipment type.

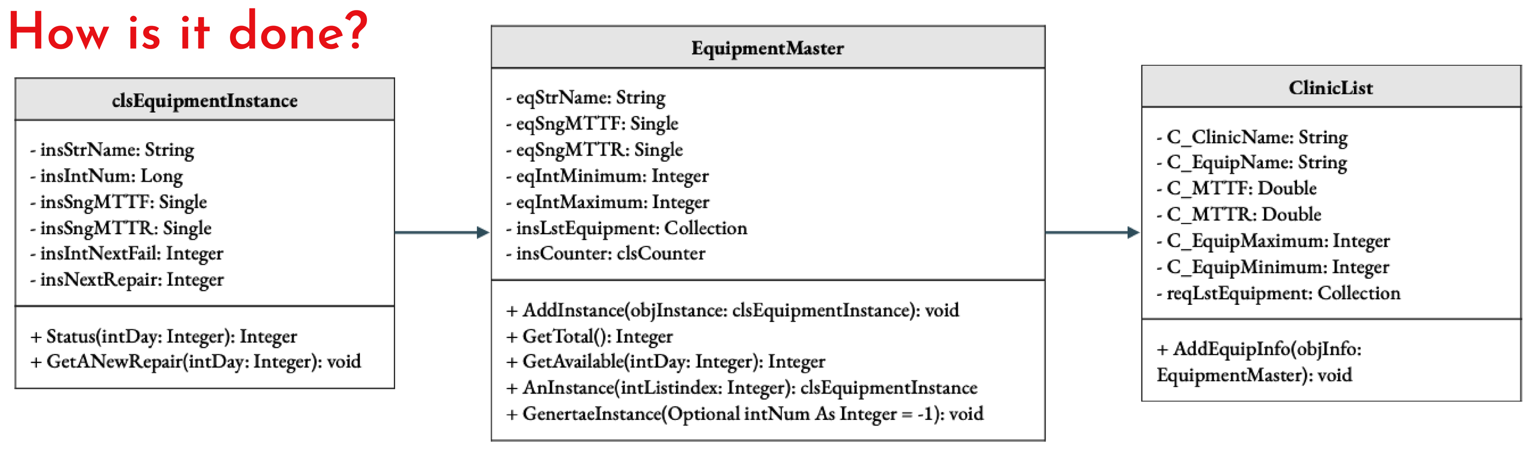
Inputs and Outputs :



Model 2: Determining the Uptime

Purpose: Is to validate the numbers obtained from model 1 and simulate the equipment behaviour to obtain overall uptime of a clinic.

How is it done?



Model 3: Optimizing the Distribution

Linear Programming Model

Goal : Minimize the cost of shipping equipment type k from region i to j

Constraint 1 : The number of equipment shipped from region i to j can not exceed the amount of inventory available in region i.

Constraint 2 : Ensures that a fixed cost is incurred whenever equipment type k is shipped from region i to j.

$$MIN: Z = \sum D(i,j,k) * \sum X(i,j,k) + \sum Y(i,k) * F(i,k)$$

$C(i,j,k)$: *Cost of shipping equipment type k from region i to j*

$X(i,j,k)$: *Number of spare parts of equipment type k shipped from region I to j*

$$Y(i,k) \begin{cases} 1 \text{ if equipment is shipped from region } i \text{ to } j \\ 0 \text{ otherwise} \end{cases}$$

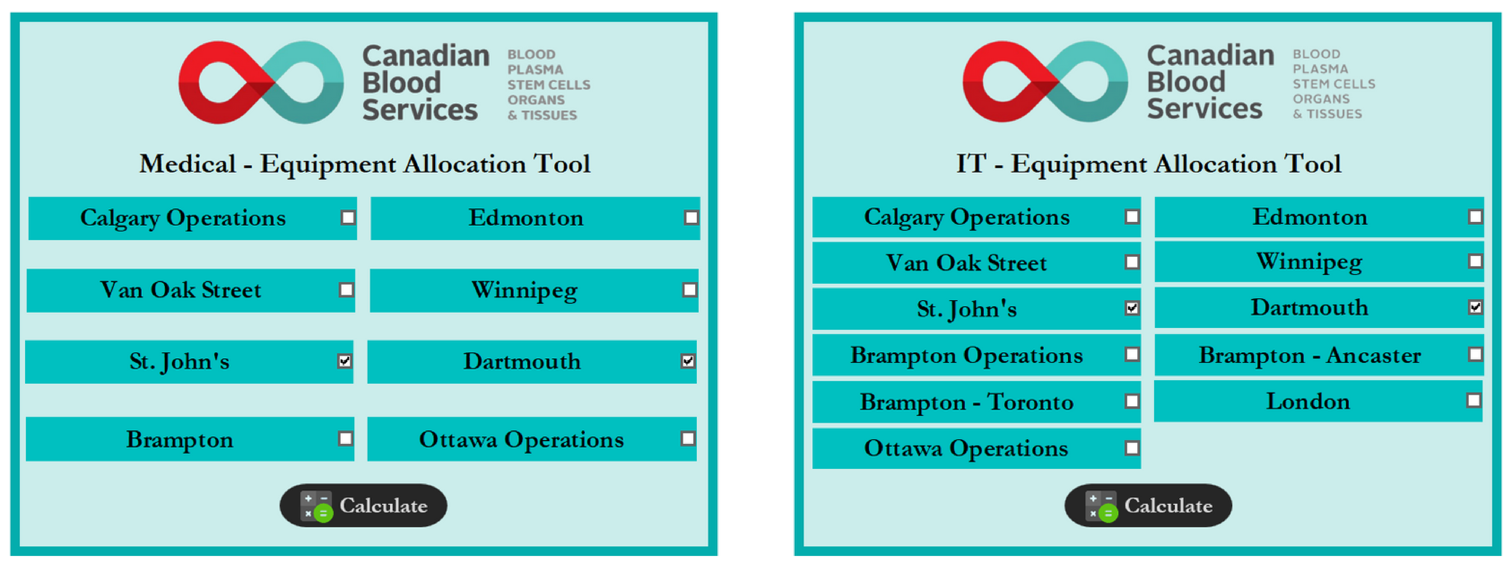
Subject to:

$$-\sum X(i,j,k) + \sum X(j,i,k) \geq R(i,k) - E(i,k)$$

$$M * Y(i,k) \geq \sum X(i,j,k)$$

$E(i,k)$ – *Number of equipment type k available in region i*
$R(i,k)$ – *Number of equipment type k required in region i*

Selection Panel



Results

Equipments	Number of equipments	Weighted Arrival Rate	Weighted Service Rate	Service Level
Shaker	68	0.006	0.438	0.95
Complabs	31	0.026	0.210	0.95
Carescape	31	0.009	0.306	0.95
Timer	101	0.006	0.508	0.95

Service Personnels: 3 — Re-Calculate

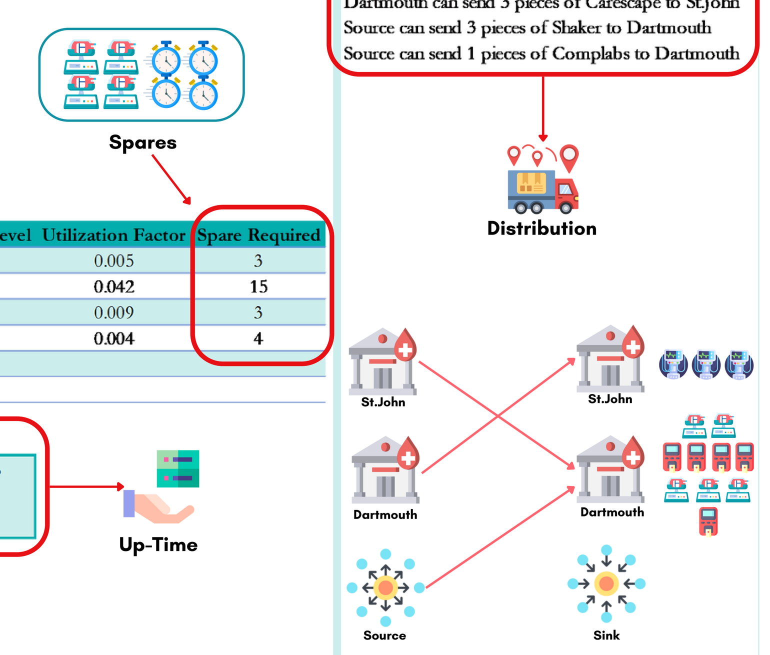
S.No	Date and Time	Equipment Name	Equipment in use	Number of servers	MTTF	Failure rate	Repair rate	Service Level	Utilization Factor	Spare Required
1	Apr 2,23 7:10 PM	Shaker	68	3	166.0	0.006	0.4375	0.95	0.005	3
2	Apr 2,23 7:10 PM	Complabs	31	3	38.2	0.026	0.209677419	0.95	0.042	15
3	Apr 2,23 7:10 PM	Carescape	31	3	114.8	0.009	0.306451613	0.95	0.009	3
4	Apr 2,23 7:10 PM	Timer	101	3	163.0	0.006	0.507920792	0.95	0.004	4

Locations: St.John, Dartmouth

Simulation Results:	
Average distribution center uptime:	95.4%
Avg.days the distribution center might not run at minimum capacity:	11.6
Standard Deviation:	5.6

Transshipment Results

- St.John can send 2 pieces of Shaker to Dartmouth
- St.John can send 4 pieces of Complabs to Dartmouth
- Dartmouth can send 3 pieces of Carescape to St.John
- Source can send 3 pieces of Shaker to Dartmouth
- Source can send 1 pieces of Complabs to Dartmouth



Final Thoughts

Impact

__Improved Methodology__

These set of tools provide CBS with a defined set of methods to make the required decisions, which leads to reduced randomness and promotes consistent decision-making.

__Major Cost-Benefits__

By re-defining the equipment fleet size, it will lead to reduction in annual maintenance cost and capital acquisition cost.

Recommendations

- Ensure **RAM database** for equipment tracking is being updated properly.
- Utilize the **"Bedding Model"** to find the required number of equipment.
- Use the provided tools when **acquiring new equipment**.

References

Hillier, F. S., & Lieberman, G. J. (2015). Introduction to operations research (10th ed., pp. 318-356). Mcgraw-Hill.

Hillier, F. S., & Lieberman, G. J. (2015). Introduction to operations research (10th ed., pp. 706-708). Mcgraw-Hill.

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