

**For orders on 14th June**

**For Objective 1 : Minimize the number of vehicles used**

xijv variables **3798**

siv variables **513**

lv variables **19**

Optimization solver GUROBI called

Status: Optimal

objective= 4.0

Time taken < 1min

### **Validation**

Post processing to get routes of each vehicle used

T3\_1 ['INV\_source\_00', 'INV\_14062024\_25', 'INV\_14062024\_21', 'INV\_14062024\_10',  
'INV\_14062024\_02', 'INV\_14062024\_06', 'INV\_14062024\_14', 'INV\_14062024\_17',  
'INV\_14062024\_07', 'INV\_sink\_00']

#### **Truck T3\_1**

Capacity **2800** total weights served **2753.88** total distance covered **444.86**

T3\_3 ['INV\_source\_00', 'INV\_14062024\_24', 'INV\_14062024\_20', 'INV\_14062024\_04',  
'INV\_14062024\_13', 'INV\_14062024\_15', 'INV\_14062024\_22', 'INV\_14062024\_11', 'INV\_14062024\_23', 'INV\_14062024\_12', 'INV\_sink\_00']

#### **Truck T3\_3**

Capacity **2800** total weights served **2769.6** total distance covered **332.07**

T3\_5 ['INV\_source\_00', 'INV\_14062024\_16', 'INV\_14062024\_03', 'INV\_sink\_00']

#### **Truck T3\_5**

Capacity **2800** total weights served **2484.0** total distance covered **193.37**

T7\_1 ['INV\_source\_00', 'INV\_14062024\_09', 'INV\_14062024\_01', 'INV\_14062024\_18',  
'INV\_14062024\_19', 'INV\_14062024\_05', 'INV\_14062024\_08', 'INV\_sink\_00']

#### **Truck T7\_1**

Capacity **7000** total weights served **6969.0** total distance covered **147.17000000000002**

Total Travel Distance of all trucks **1117.47**

### **Time Window validation**

T3\_1 [('INV\_source\_00', 480.0), ('INV\_14062024\_25', 557.0), ('INV\_14062024\_21', 631.0), ('INV\_14062024\_10', 846.0), ('INV\_14062024\_02', 1006.0), ('INV\_14062024\_06', 1027.0), ('INV\_14062024\_14', 1101.0), ('INV\_14062024\_17', 1178.0), ('INV\_14062024\_07', 1224.0), ('INV\_sink\_00', 1321.0)]

T3\_3 [('INV\_source\_00', 480.0), ('INV\_14062024\_24', 525.0), ('INV\_14062024\_20', 588.0), ('INV\_14062024\_04', 644.0), ('INV\_14062024\_13', 747.0), ('INV\_14062024\_15', 814.0), ('INV\_14062024\_22', 855.0), ('INV\_14062024\_11', 919.9999999999998), ('INV\_14062024\_23', 978.9999999999998), ('INV\_14062024\_12', 1044.9999999999998), ('INV\_sink\_00', 1117.0)]

T3\_5 [('INV\_source\_00', 480.0), ('INV\_14062024\_16', 595.0), ('INV\_14062024\_03', 1320.0), ('INV\_sink\_00', 1427.0)]

T7\_1 [('INV\_source\_00', 480.0), ('INV\_14062024\_09', 530.0), ('INV\_14062024\_01', 581.0), ('INV\_14062024\_18', 633.0), ('INV\_14062024\_19', 680.0), ('INV\_14062024\_05', 700.0), ('INV\_14062024\_08', 725.0), ('INV\_sink\_00', 802.0)]

## For Objective 2 : Minimize total travel distance

xijv variables **3798**

siv variables **513**

lv variables **19**

Optimization solver GUROBI called

Set parameter MIPFocus to value 2

Set parameter Cuts to value 3

Set parameter MIPGap to value 0.07

Gurobi status= 2

Status: Optimal

objective= 567.6100000000001

Time taken ~2hrs

## Validation

Post processing to get routes of each vehicle

T3\_1 ['INV\_source\_00', 'INV\_14062024\_10', 'INV\_14062024\_20', 'INV\_14062024\_09', 'INV\_14062024\_15', 'INV\_sink\_00']

### Truck T3\_1

Capacity **2800** total weights served **2718.0** total distance covered **211.97999999999999**

T3\_2 ['INV\_source\_00', 'INV\_14062024\_16', 'INV\_14062024\_13', 'INV\_14062024\_14', 'INV\_sink\_00']

Truck T3\_2

Capacity **2800** total weights served **2635.0** total distance covered **132.51999999999998**

T3\_3 ['INV\_source\_00', 'INV\_14062024\_17', 'INV\_14062024\_11', 'INV\_14062024\_21',  
'INV\_14062024\_12', 'INV\_14062024\_06', 'INV\_14062024\_02', 'INV\_14062024\_04',  
'INV\_14062024\_07', 'INV\_14062024\_25', 'INV\_14062024\_22', 'INV\_14062024\_23', 'INV\_sink\_00']

Truck T3\_3

Capacity **2800** total weights served **2784.48** total distance covered **131.73999999999998**

T7\_2 ['INV\_source\_00', 'INV\_14062024\_03', 'INV\_14062024\_08', 'INV\_14062024\_01',  
'INV\_14062024\_05', 'INV\_14062024\_19', 'INV\_14062024\_24', 'INV\_14062024\_18', 'INV\_sink\_00']

Truck T7\_2

Capacity **7000** total weights served **6839.0** total distance covered **91.37**

Total Travel Distance of all trucks **567.60999999999999**

### **Time Window validation**

T3\_1 [('INV\_source\_00', 480.0), ('INV\_14062024\_10', 639.0), ('INV\_14062024\_20', 722.0),  
( 'INV\_14062024\_09', 1293.0), ('INV\_14062024\_15', 1320.0), ('INV\_sink\_00', 1372.0)]

T3\_2 [('INV\_source\_00', 480.0), ('INV\_14062024\_16', 595.0), ('INV\_14062024\_13', 648.0),  
( 'INV\_14062024\_14', 1320.0), ('INV\_sink\_00', 1388.0)]

T3\_3 [('INV\_source\_00', 480.0), ('INV\_14062024\_17', 531.0), ('INV\_14062024\_11', 556.0),  
( 'INV\_14062024\_21', 600.0), ('INV\_14062024\_12', 620.0), ('INV\_14062024\_06', 677.0),  
( 'INV\_14062024\_02', 698.0), ('INV\_14062024\_04', 1206.0), ('INV\_14062024\_07', 1231.0),  
( 'INV\_14062024\_25', 1257.0), ('INV\_14062024\_22', 1278.0), ('INV\_14062024\_23', 1320.0),  
( 'INV\_sink\_00', 1372.0)]

T7\_2 [('INV\_source\_00', 480.0), ('INV\_14062024\_03', 557.0), ('INV\_14062024\_08', 580.0),  
( 'INV\_14062024\_01', 602.0), ('INV\_14062024\_05', 628.0), ('INV\_14062024\_19', 1244.0),  
( 'INV\_14062024\_24', 1291.0), ('INV\_14062024\_18', 1320.0), ('INV\_sink\_00', 1366.0)]

### **For Objective 3 : Minimize total cost**

xijv variables **3798**

siv variables **513**

lv variables **19**

Optimization solver GUROBI called

Set parameter MIPFocus to value 1

Set parameter Cuts to value 3

Set parameter MIPGap to value 0.02

objective= 40119.199999999999

Time taken ~6 mins

Validation

Post processing to get routes of each vehicle

T3\_3 ['INV\_source\_00', 'INV\_14062024\_16', 'INV\_14062024\_14', 'INV\_14062024\_13', 'INV\_sink\_00']

Truck T3\_3

Capacity **2800** total weights served **2635.0** total distance covered **132.51999999999998**

T3\_4 ['INV\_source\_00', 'INV\_14062024\_18', 'INV\_14062024\_10', 'INV\_14062024\_20', 'INV\_14062024\_19', 'INV\_14062024\_22', 'INV\_14062024\_15', 'INV\_14062024\_23', 'INV\_sink\_00']

Truck T3\_4

Capacity **2800** total weights served **2756.0** total distance covered **211.01**

T3\_5 ['INV\_source\_00', 'INV\_14062024\_24', 'INV\_14062024\_25', 'INV\_14062024\_07', 'INV\_14062024\_06', 'INV\_14062024\_02', 'INV\_14062024\_12', 'INV\_14062024\_21', 'INV\_14062024\_11', 'INV\_14062024\_17', 'INV\_sink\_00']

Truck T3\_5

Capacity **2800** total weights served **2706.48** total distance covered **131.3**

T7\_2 ['INV\_source\_00', 'INV\_14062024\_05', 'INV\_14062024\_01', 'INV\_14062024\_04', 'INV\_14062024\_03', 'INV\_14062024\_08', 'INV\_14062024\_09', 'INV\_sink\_00']

Truck T7\_2

Capacity **7000** total weights served **6879.0** total distance covered **95.93**

Total Travel Distance of all trucks **570.76**

### Time Window validation

T3\_3 [('INV\_source\_00', 480.0), ('INV\_14062024\_16', 595.0), ('INV\_14062024\_14', 648.0), ('INV\_14062024\_13', 1320.0), ('INV\_sink\_00', 1388.0)]

T3\_4 [('INV\_source\_00', 480.0), ('INV\_14062024\_18', 520.0), ('INV\_14062024\_10', 624.0), ('INV\_14062024\_20', 1045.0), ('INV\_14062024\_19', 1233.0), ('INV\_14062024\_22', 1258.0), ('INV\_14062024\_15', 1300.0), ('INV\_14062024\_23', 1320.0), ('INV\_sink\_00', 1372.0)]

T3\_5 [('INV\_source\_00', 480.0), ('INV\_14062024\_24', 525.0), ('INV\_14062024\_25', 560.0), ('INV\_14062024\_07', 614.0), ('INV\_14062024\_06', 640.0), ('INV\_14062024\_02', 661.0), ('INV\_14062024\_12', 735.0), ('INV\_14062024\_21', 755.0), ('INV\_14062024\_11', 808.0), ('INV\_14062024\_17', 833.0), ('INV\_sink\_00', 885.0)]

T7\_2 [('INV\_source\_00', 480.0), ('INV\_14062024\_05', 540.0), ('INV\_14062024\_01', 564.0), ('INV\_14062024\_04', 591.0), ('INV\_14062024\_03', 616.0), ('INV\_14062024\_08', 1278.0), ('INV\_14062024\_09', 1320.0), ('INV\_sink\_00', 1375.0)]

### Comparison of 3 objectives

Objective	No. Of Vehicles Used	Total Distance(Km)	Total Cost (Rs)	Time to solve(min)
Min No. Of Vehicles	4	1117.47	49208.31	<1
Min Total Distance	4	567.61	40083.89	1200
Min Total Cost	4	570.76	40119.19	6

From the above table it is better to implement objective 3 to minimize total cost as it takes less time to solve the problem.

### For Orders on 31st May

The model is infeasible and Irreducible Inconsistent Subsystem (IIS) is calculated and written into the .ils file available in the output folder.

An IIS is a subset of the constraints and variable bounds with the following properties:

- It is still infeasible, and
- If a single constraint or bound is removed, the subsystem becomes feasible.

One such IIS is calculated and it has following constraints and bounds causing infeasibility.

### **Constraints:**

exactlyOnce\_INV\_31052024\_05\_  
exactlyOnce\_INV\_31052024\_06\_  
exactlyOnce\_INV\_31052024\_07\_  
exactlyOnce\_INV\_31052024\_08\_  
exactlyOnce\_INV\_31052024\_15\_  
exactlyOnce\_INV\_31052024\_16\_

vehicleCap\_T3\_1\_  
vehicleCap\_T3\_2\_  
vehicleCap\_T3\_3\_  
vehicleCap\_T3\_4\_  
vehicleCap\_T3\_5\_  
vehicleCap\_T5\_1\_  
vehicleCap\_T7\_1\_  
vehicleCap\_T7\_2\_

### **Bounds**

Binaries

l#T3\_1, l#T3\_2, l#T3\_3, l#T3\_4, l#T3\_5, l#T5\_1, l#T7\_1, l#T7\_2

And x\_ijk variables corresponding to these vehicles.

If a single constraint or bound is removed, the subsystem becomes feasible.

There may be many such IIS for an infeasible model.

### **For Orders on 8th June**

The model is infeasible and Irreducible Inconsistent Subsystem (IIS) is calculated and written into the .ils file available in the output folder.

### **Constraints**

exactlyOnce\_INV\_08062024\_16\_  
exactlyOnce\_INV\_08062024\_18\_  
exactlyOnce\_INV\_08062024\_20\_

exactlyOnce\_INV\_08062024\_35\_  
exactlyOnce\_INV\_08062024\_36\_  
exactlyOnce\_INV\_08062024\_37\_

vehicleCap\_T3\_1\_  
vehicleCap\_T3\_2\_  
vehicleCap\_T3\_3\_  
vehicleCap\_T3\_4\_  
vehicleCap\_T3\_5\_  
vehicleCap\_T5\_1\_  
vehicleCap\_T7\_1\_  
vehicleCap\_T7\_2\_

### **Bounds**

Binaries

I#T3\_1, I#T3\_2, I#T3\_3, I#T3\_4, I#T3\_5, I#T5\_1, I#T7\_1, I#T7\_2  
And x<sub>ijk</sub> variables corresponding to these vehicles.

Solution same as 31st may.

### **For Orders on 12th June**

The model is infeasible.

IIS set has:

### **Constraints**

45 exactlyOnce constraints

5 vehicleCap constraints (for vehicles T3\_1 ....T3\_5)

### **Bounds**

Binaries

I#T3\_1 I#T3\_2 I#T3\_3 I#T3\_4 I#T3\_5

And x<sub>ijk</sub> variables correspond to the above vehicles.

To make the problem feasible in all three cases.

**Possible Option** : Increasing the capacity of vehicles so the bounds gets relaxed or removing some orders so no need to visit that order.