# MDVRP

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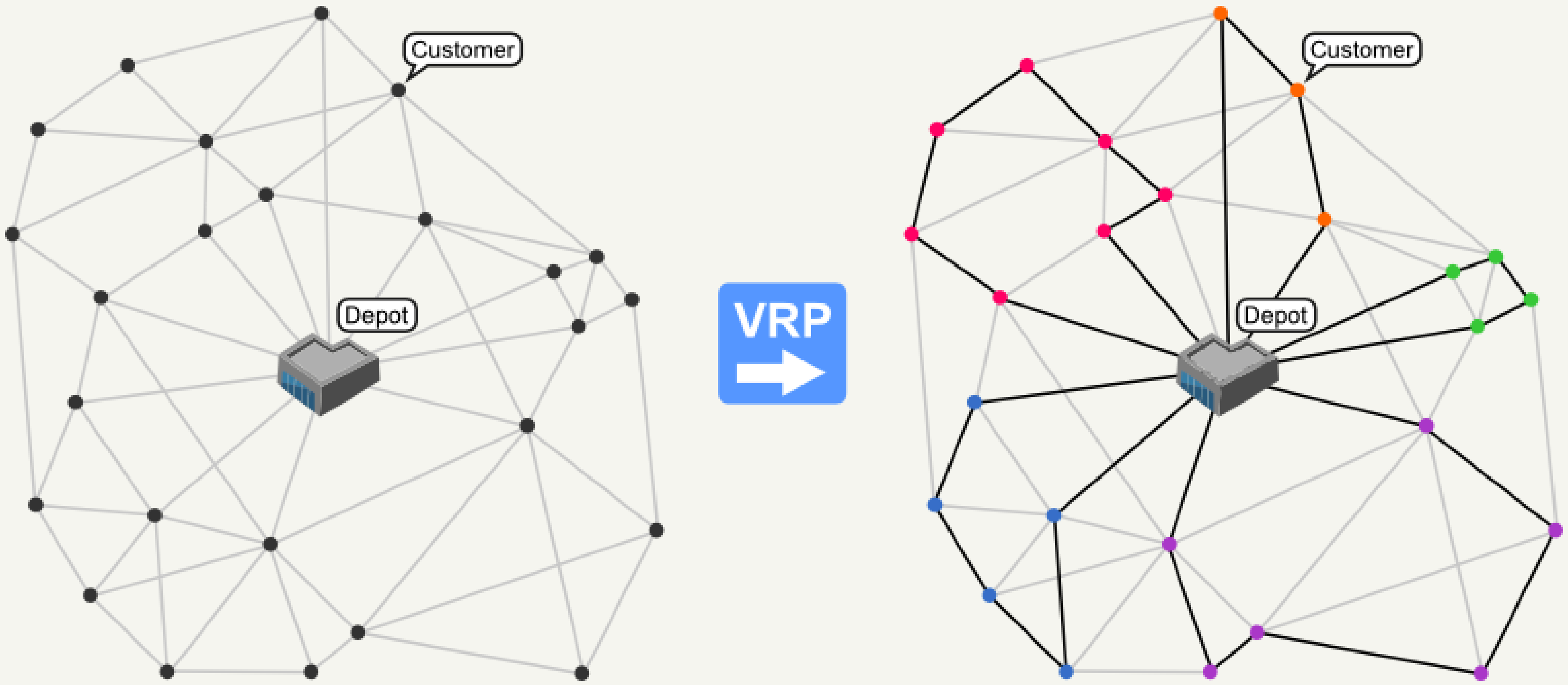
magalu

# VEHICLE ROUTING PROBLEM

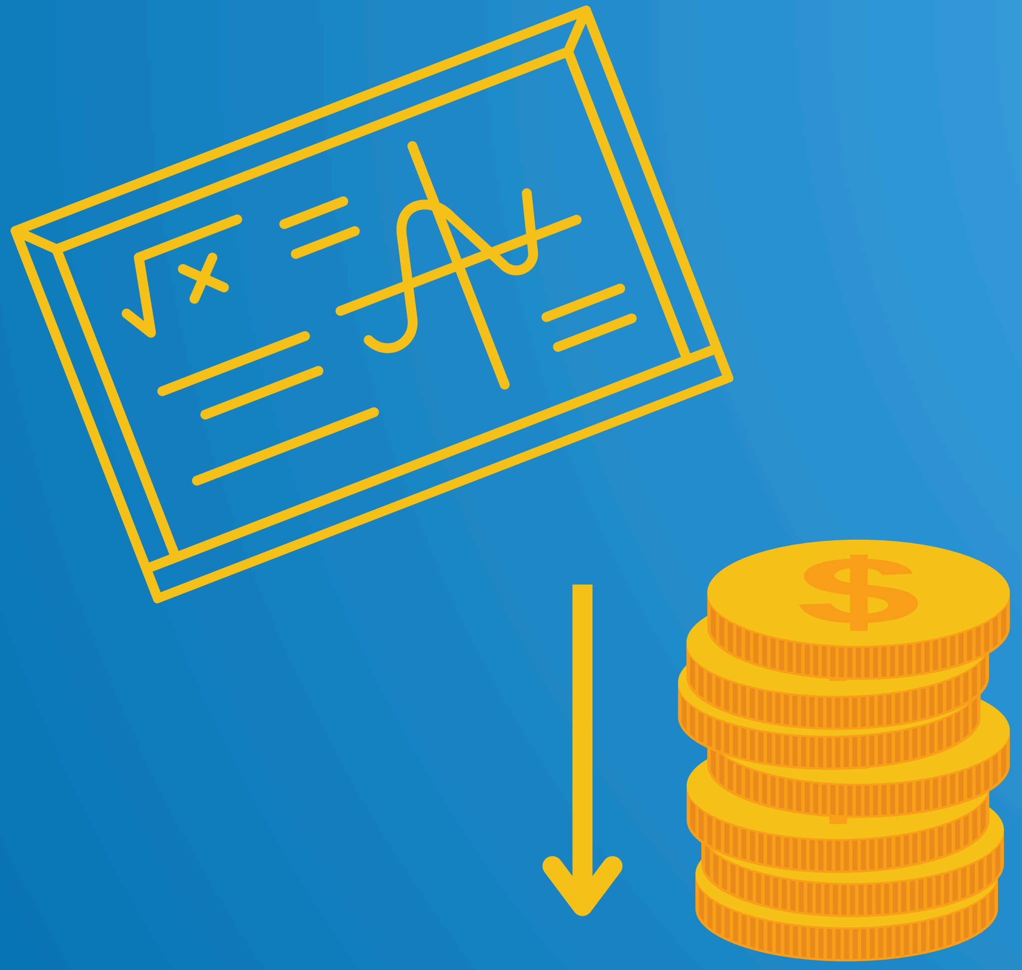
## COMBINATORIAL OPTIMIZATION



# VEHICLE ROUTING WITH MULTIPLE DEPOTS

- MAGAZINE LUIZA
- MULTIPLE DEPOTS
- SEARCH FOR DELIVERY ROUTES
- CUT COSTS
- INCREASE PRODUCTIVITY


# MATHEMATICAL MODELING



## OBJECTIVE FUNCTION:

$$\min Z = \sum_{i=1}^{N+M} \sum_{j=1}^{N+M} c_{ij} x_{ij}$$

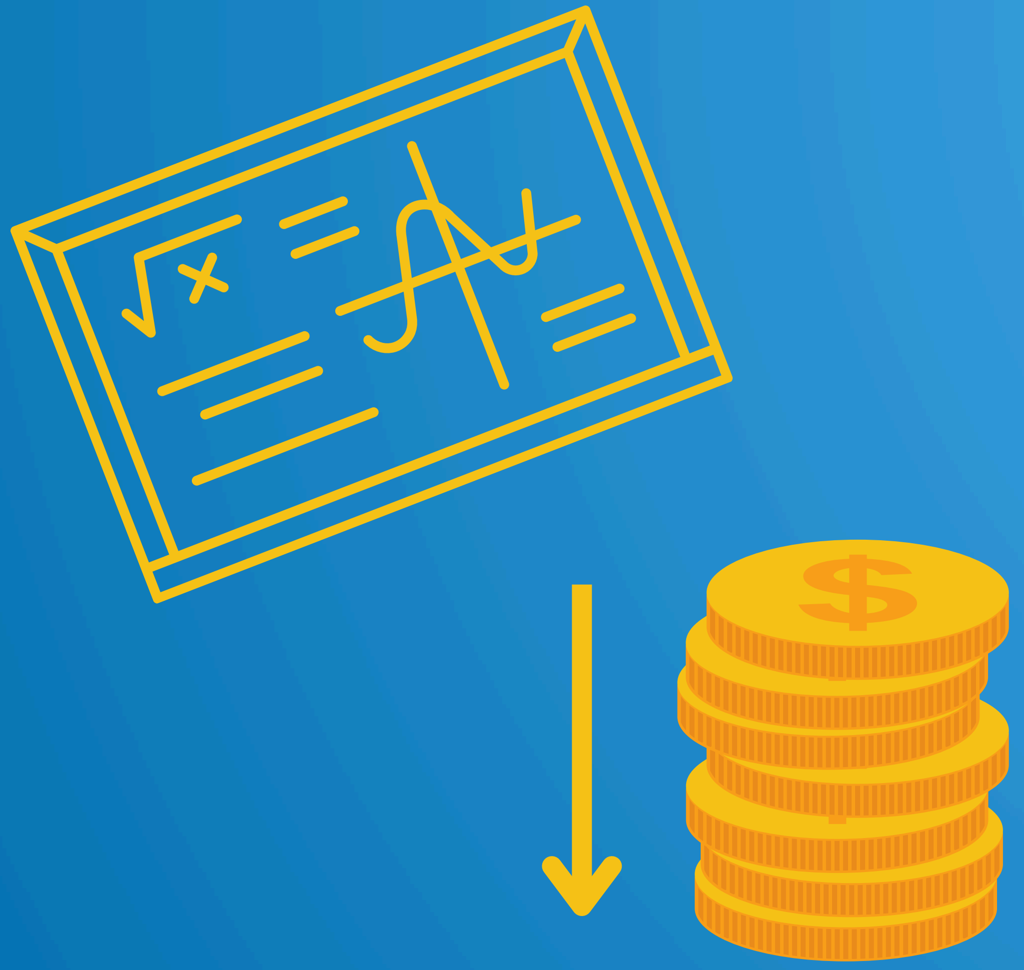
**Cij: TRAVEL DISTANCE FROM CITY i TO CITY j**

## SUBJECT TO:

$$x_{ij} = 0 \; ou \; 1 \; para \; todo \; i, j$$

**BINARY VARIABLE**

# MATHEMATICAL MODELING



## SUBJECT TO:

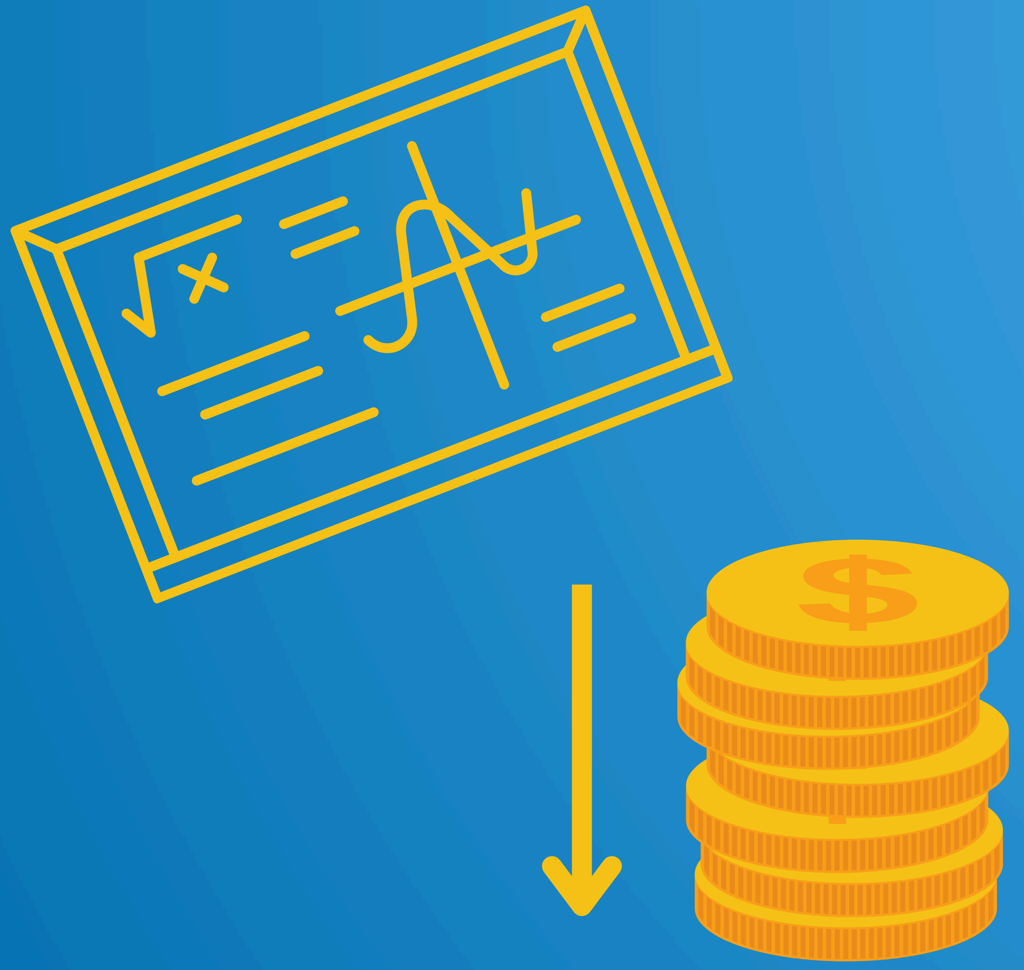
$$x_{ij} = 0\,,\ para\,todo\,i\ = j$$

$$x_{ij} = 0\,,$$
$$para\,i = N + 1,\ N + 2,\ ...,\ N + M$$
$$e\,j = N + 1,\ N + 2,\ ...,\ N + M$$

**CANNOT HAVE A CITY AS ORIGIN AND DESTINATION**

**CANNOT LEAVE ONE WAREHOUSE AND GO DIRECTLY TO THE OTHER**

# MATHEMATICAL MODELING



## SUBJECT TO:

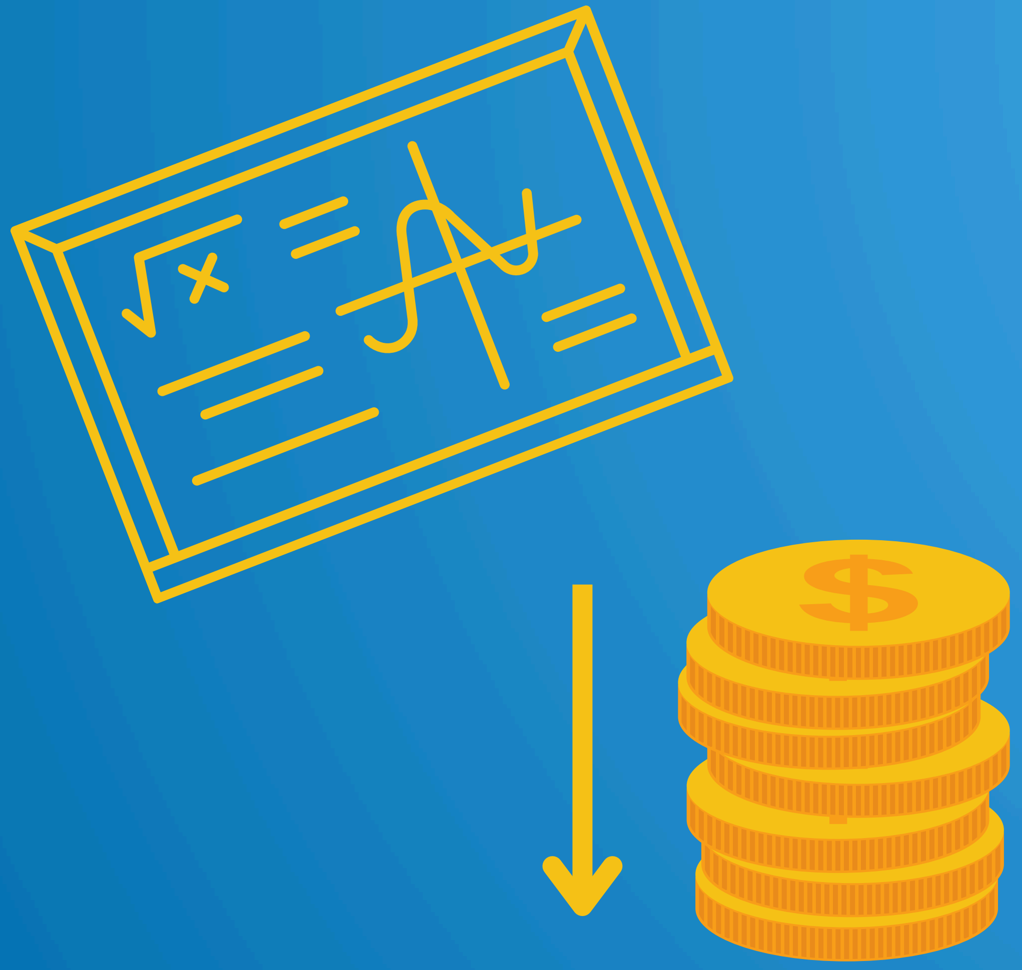
$$\sum_{i=1}^{N+M} x_{ij} = 1\, para\, j = 1, 2, ..., N$$

$$\sum_{j=1}^{N+M} x_{ij} = 1\, para\, i = 1, 2, ..., N$$

**DESTINATION CITY IS VISITED ONLY ONCE**

**ALL CITIES MUST BE VISITED**

# MATHEMATICAL MODELING



## SUBJECT TO:

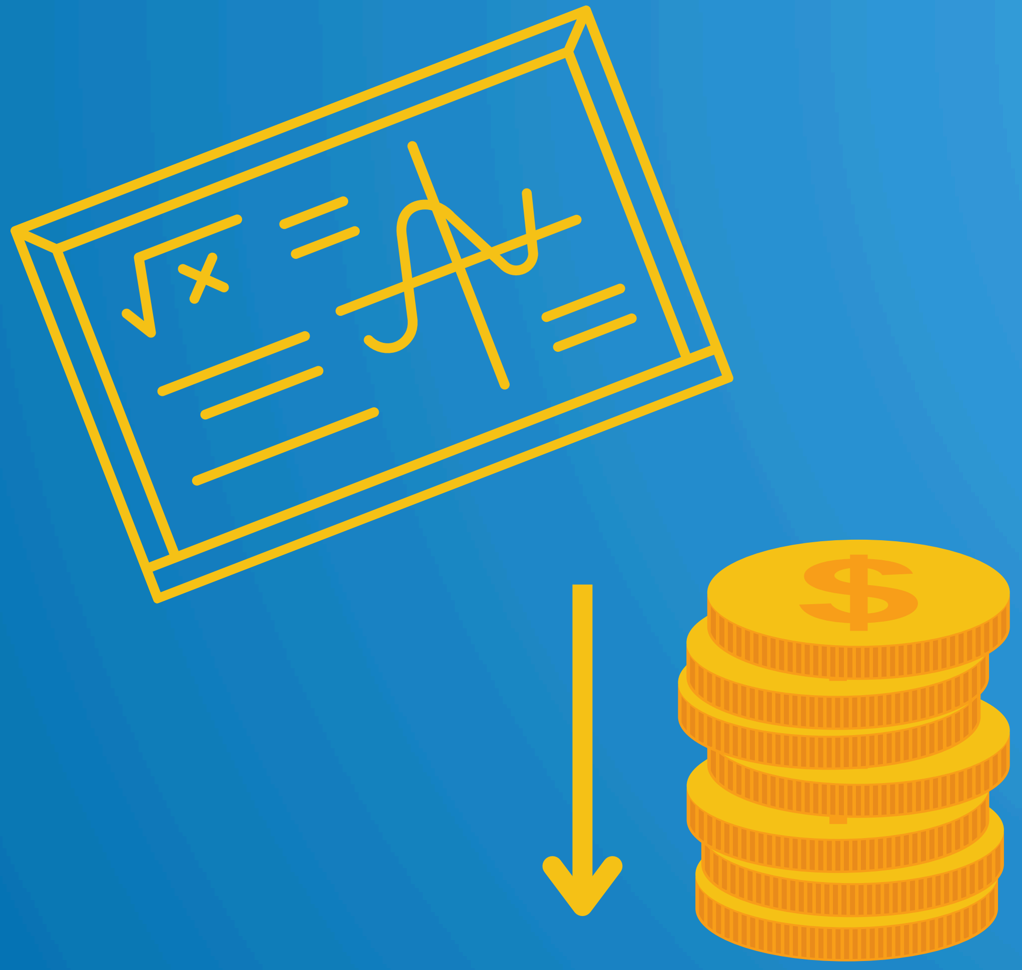
$$\sum_{i=N+1}^{N+M}\sum_{j=1}^{N+M} x_{ij} = V$$

$$\sum_{j=N+1}^{N+M}\sum_{i=1}^{N+M} x_{ij} = V$$

**ALL VEHICLES MUST BE USED**

**THE MODEL DISTRIBUTES VEHICLES**

# MATHEMATICAL MODELING



## SUBJECT TO:

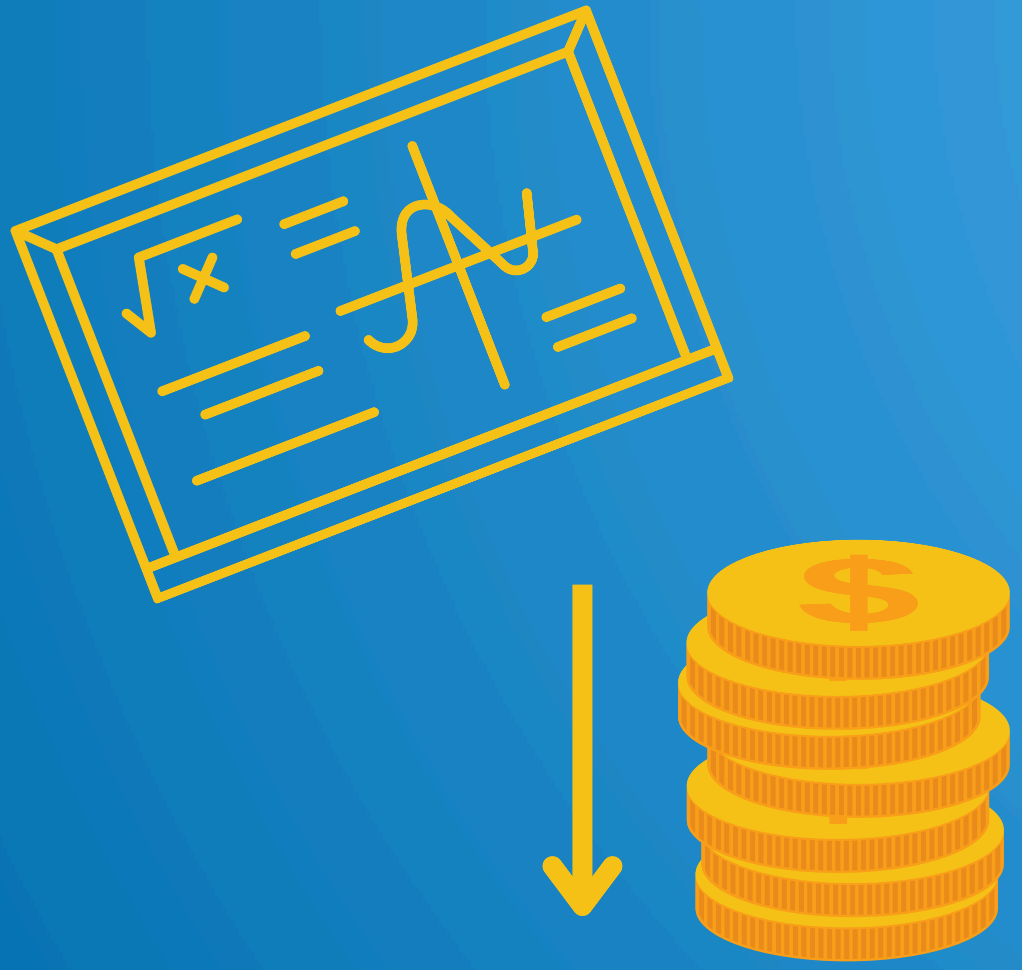
$$\sum_{j=1}^{N+M} x_{ij} = V_i \text{, } para\ i = N+1, N+2, \ldots, N+M$$

$$\sum_{i=1}^{N+M} x_{ij} = V_j \text{, } para\ j = N+1, N+2, \ldots, N+M$$

**ALL VEHICLES MUST BE USED**

**FIXED NUMBER OF VEHICLES PER DEPOT**

# MATHEMATICAL MODELING



## SUBJECT TO:

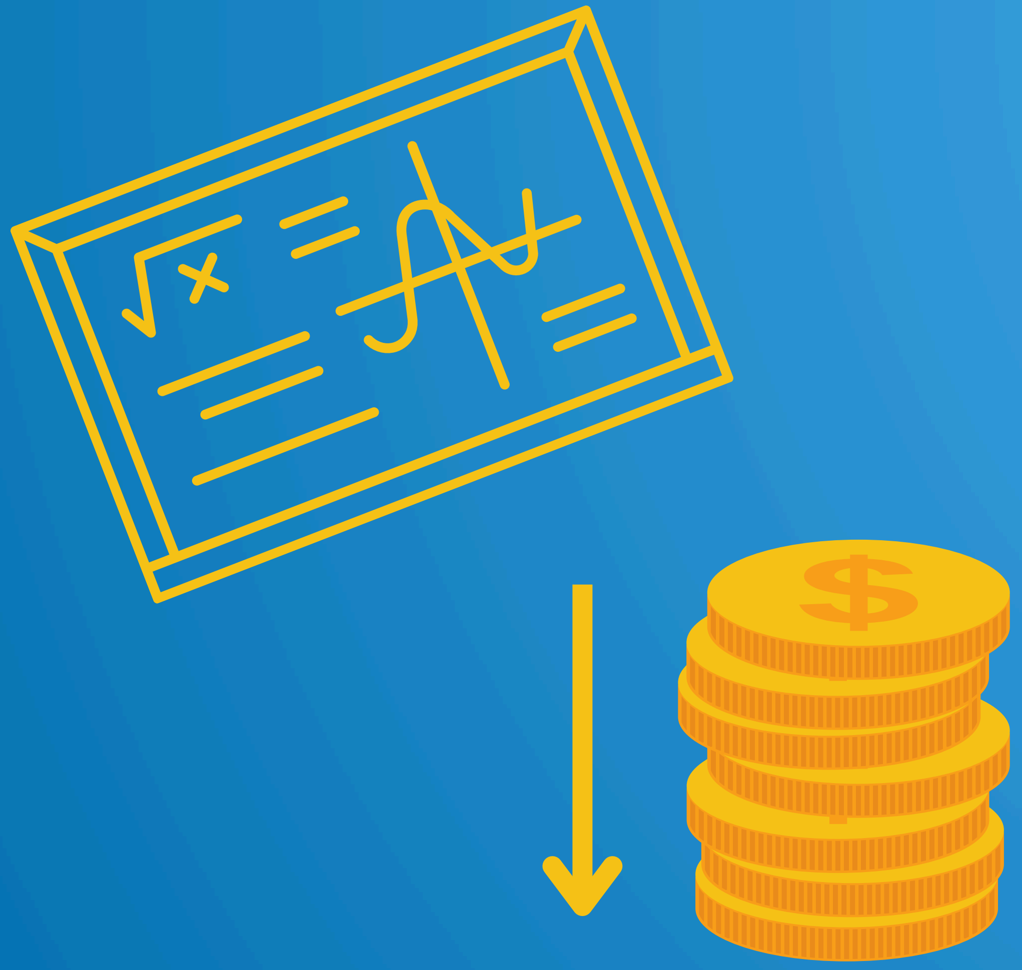
$$u_i - u_j + Px_{ij} \leq P - Q_i \; para \; 1 \leq i \neq j \leq N$$

$$y_i - y_j + Lx_{ij} \leq L - 1 \; para \; 1 \leq i \neq j \leq N$$

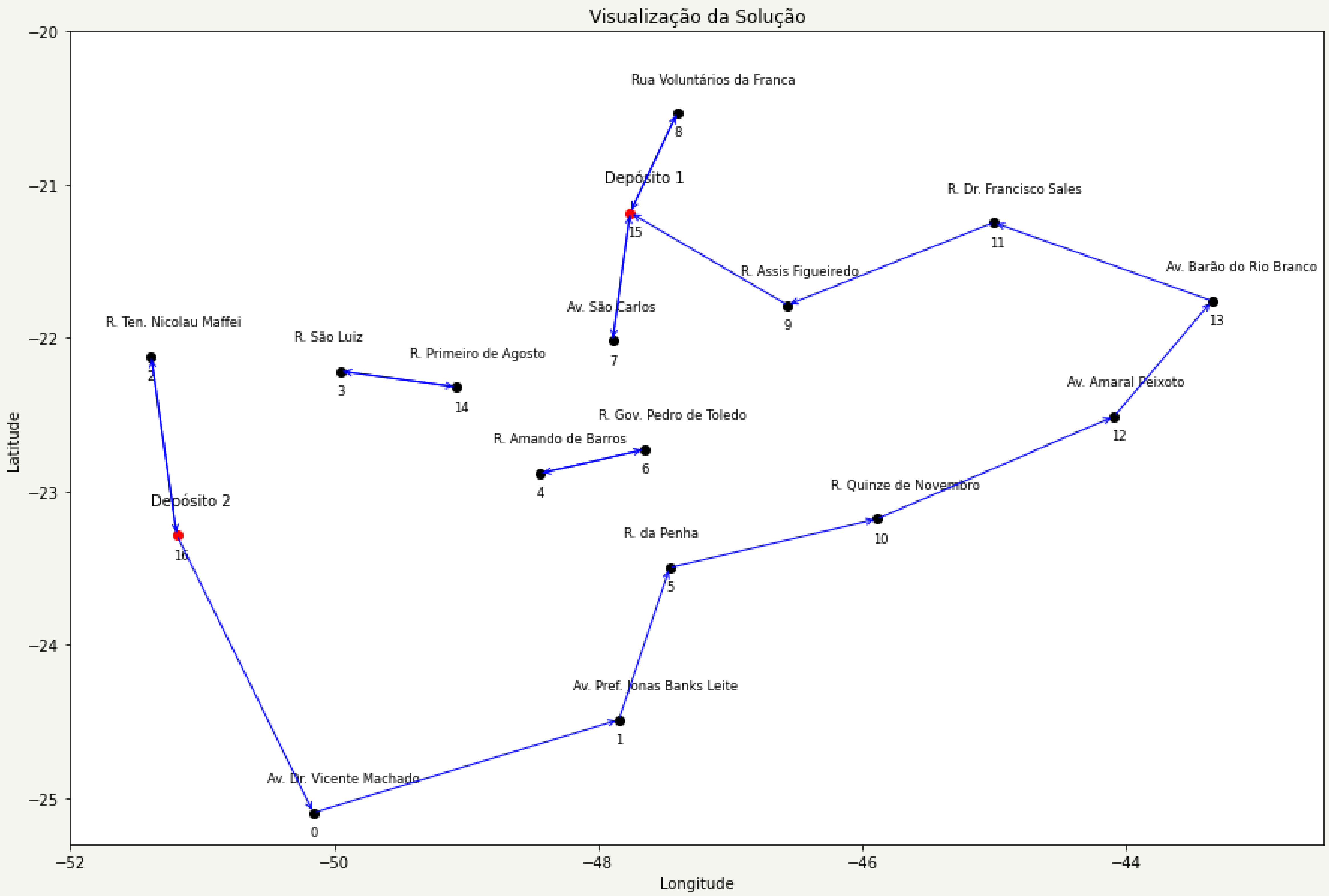
**CAPACITY RESTRICTION**

**RESTRICTION ON DELETING SUB-ROUTES**

# SOLUTION



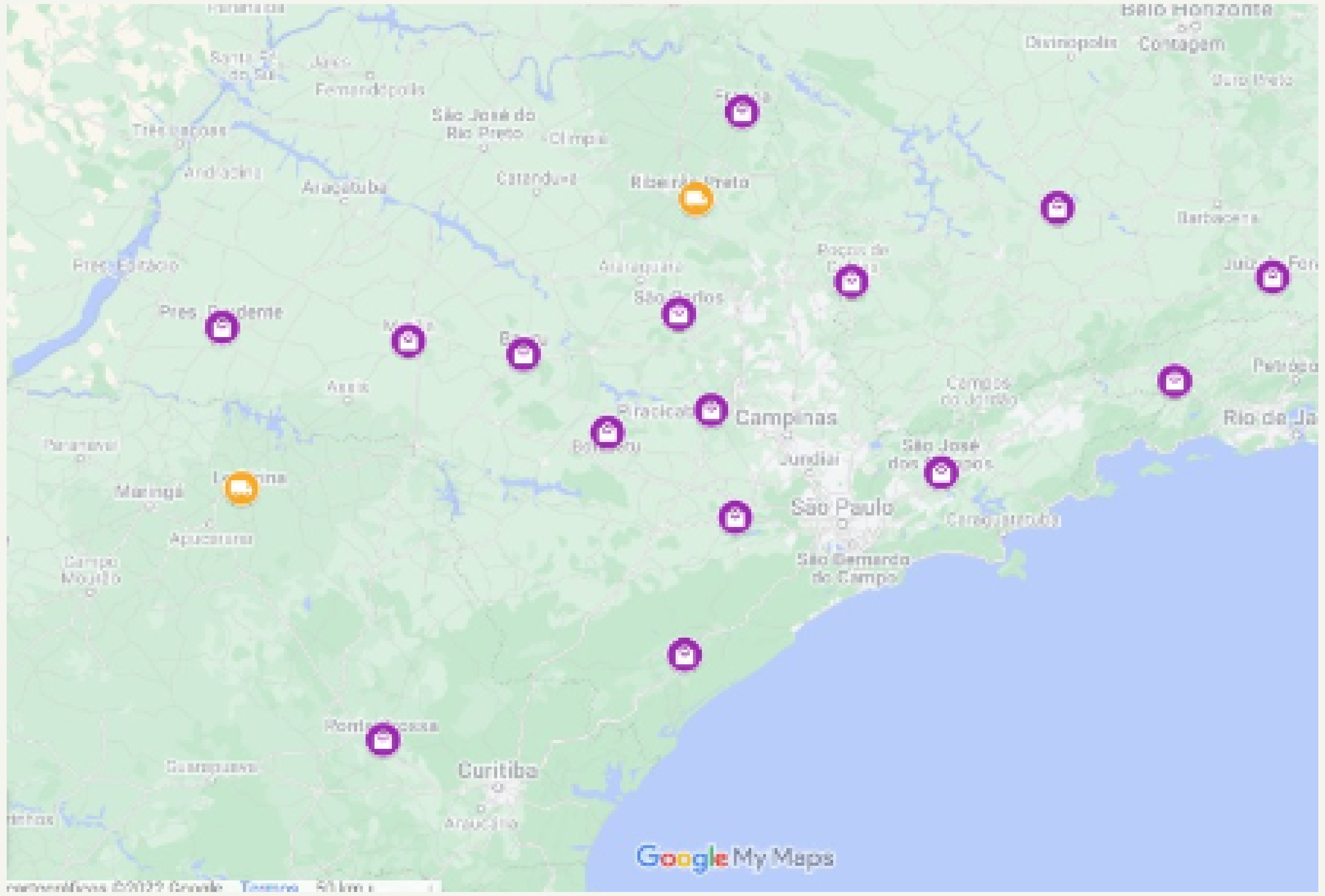
## EXAMPLE OF A SOLUTION WITHOUT BREAKING DISCONNECTED SUB-ROUTES

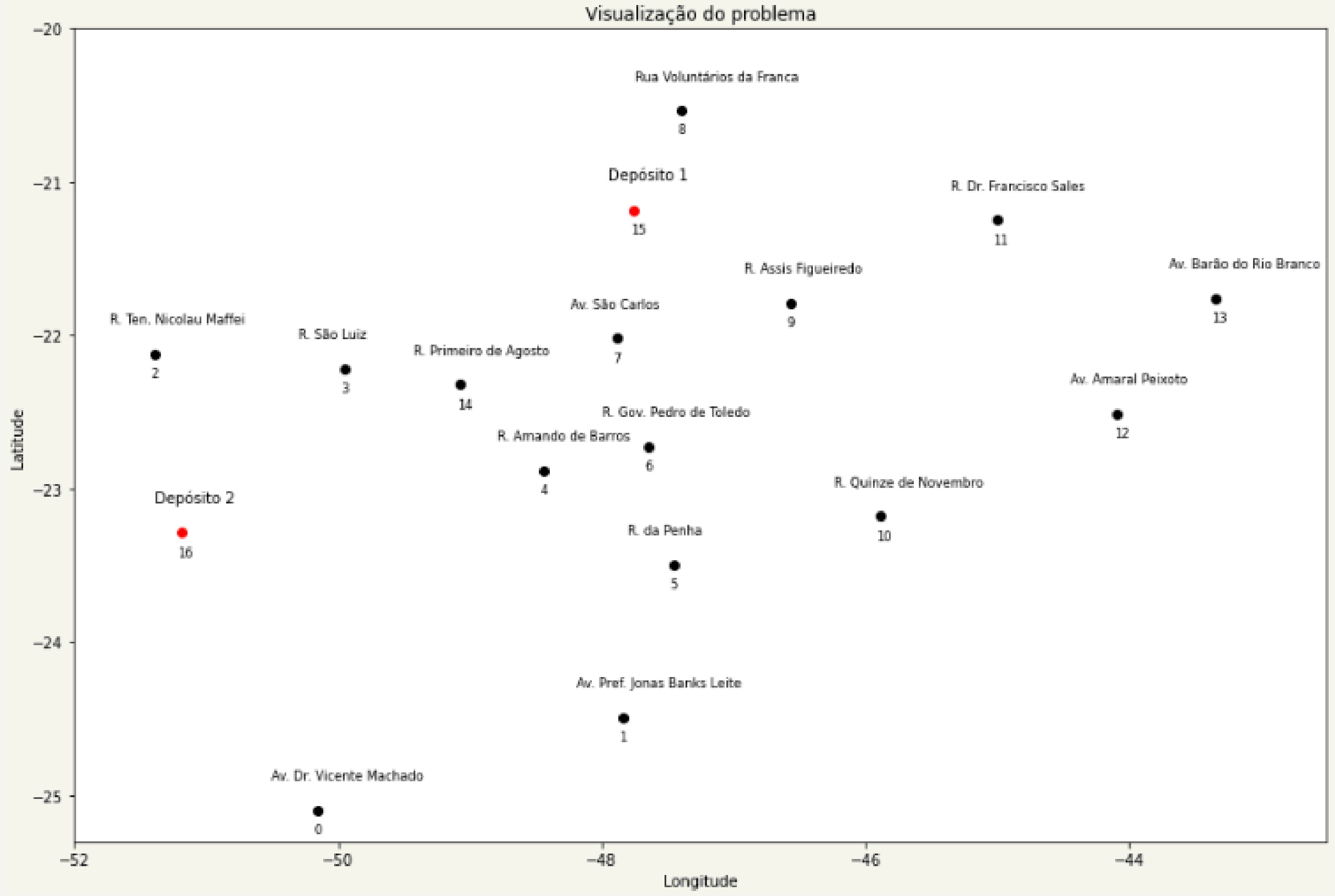


# COMPUTATIONAL EXPERIMENT

**CHOOSING THE LOCATION OF DISTRIBUTION CENTERS AND STORES:**

- **15 STORES AND 2 DISTRIBUTION CENTERS**
  - **SP, MG, PR and RJ**

# COMPUTATIONAL EXPERIMENT

# API

- CALCULATING THE DISTANCES BETWEEN:
  - STORES
  - DEPOTS
  - STORES AND DEPOTS
- GENERATE DISTANCE MATRIX

# DISTANCE MATRIX

# COMPUTATIONAL EXPERIMENT

## 1ST APPROACH::

VARY ONLY THE NUMBER OF VEHICLES

**WHAT ARE THE BENEFITS OF WORKING WITH A LARGER FLEET?**

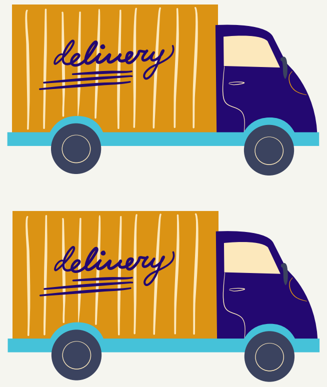
MOTORISTS

COMPANY

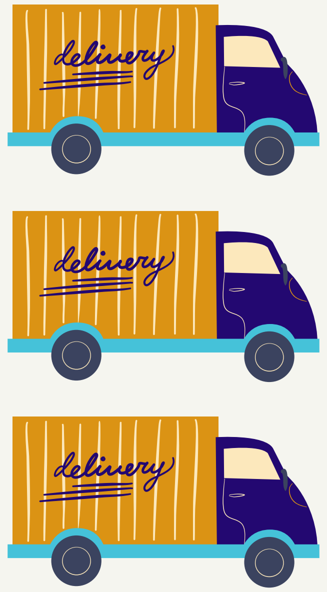
# COMPUTATIONAL EXPERIMENT

## CASES ANALYZED:

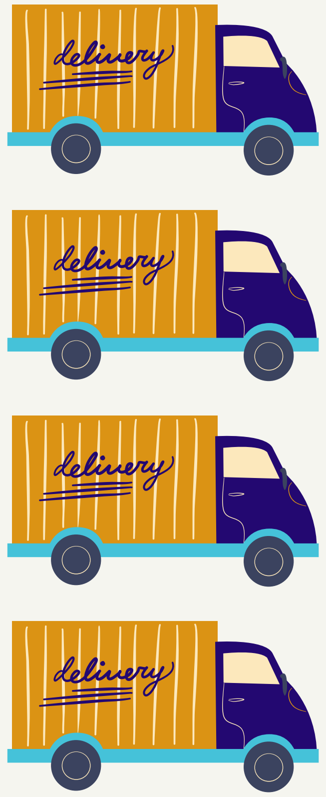
### 2 VEHICLES




### 3 VEHICLES




### 4 VEHICLES

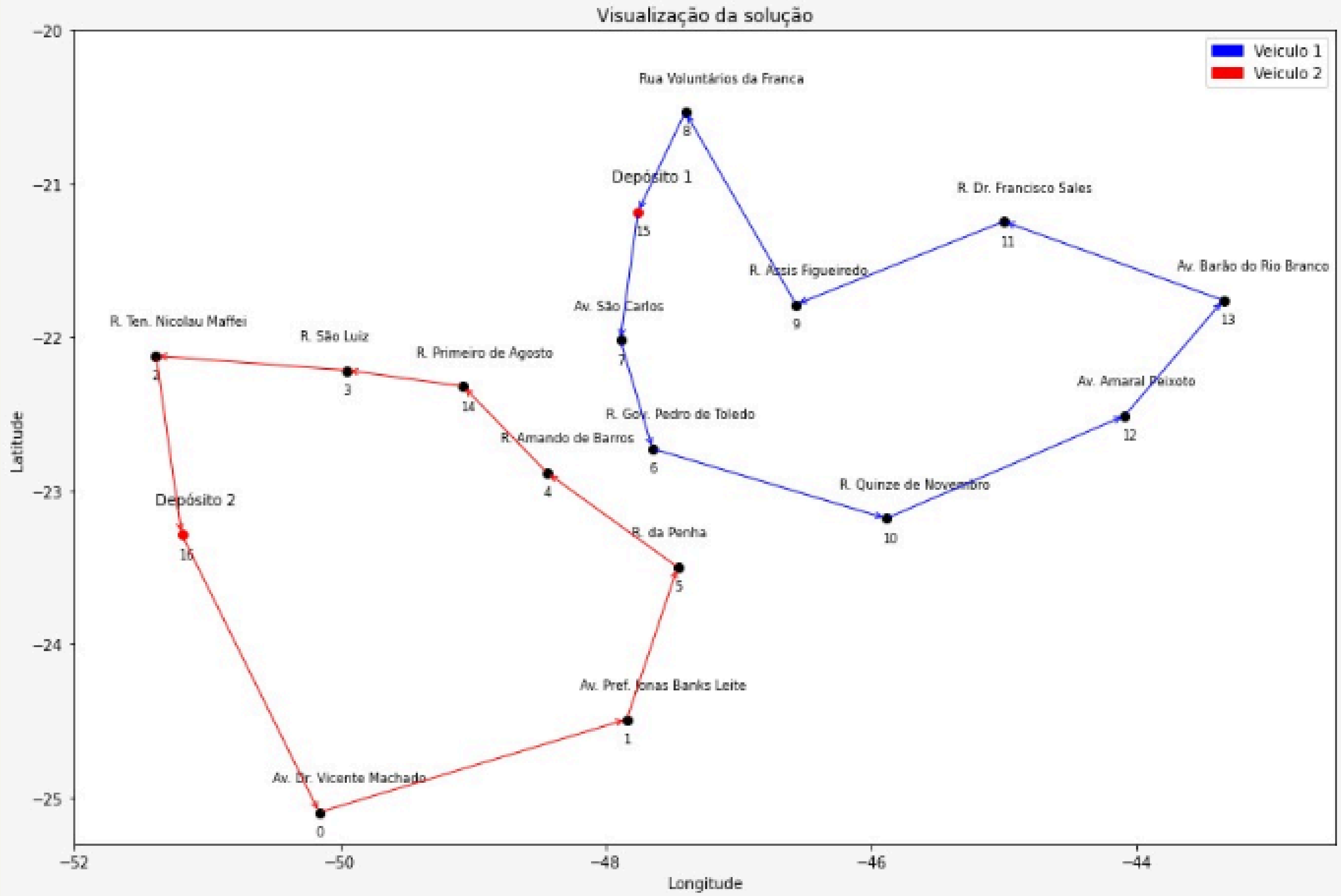


# RESULTS

| NUMBER OF VEHICLES | OBJECTIVE FUNCTION (km) | DISTANCE PER VEHICLE (km) |
|---|---|---|
| 2 | 3190,070 | 1595,035 |
| 3 | 3223,344 | 1074,448 |
| 4 | 3386,440 | 846,610 |

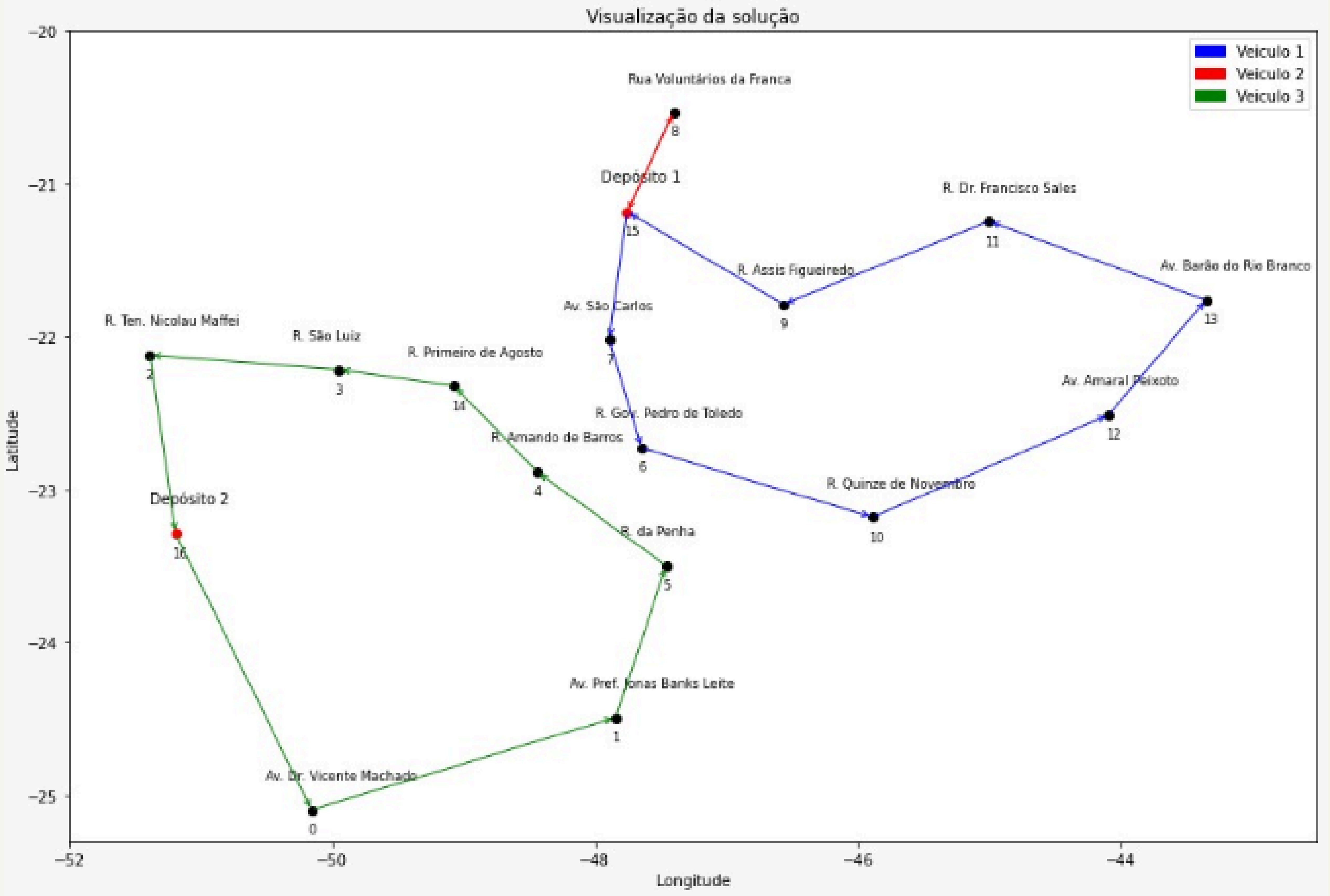
# OPTIMAL ROUTES

## 2 VEHICLES



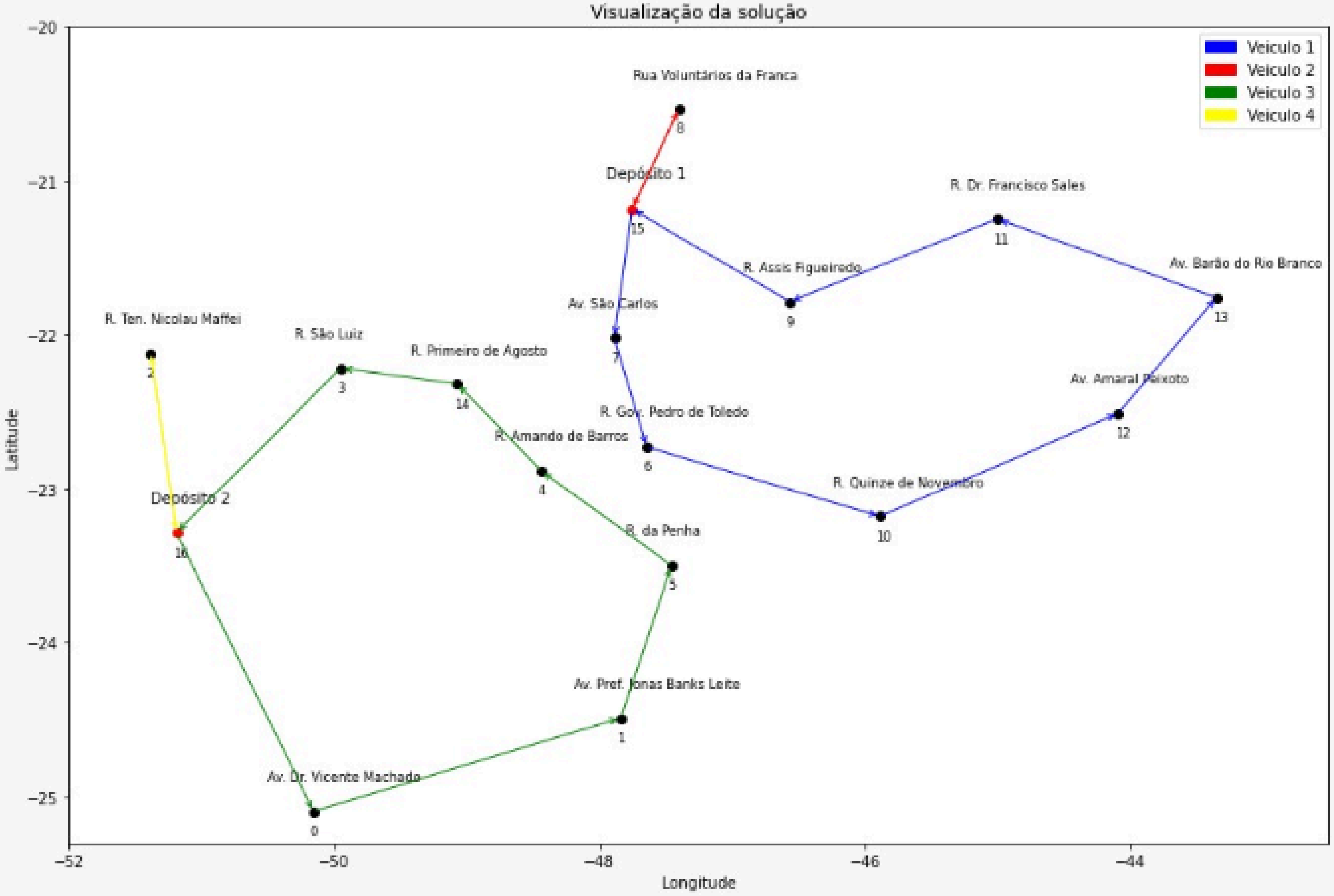
# OPTIMAL ROUTES

→ **3 VEHICLES**



# OPTIMAL ROUTES

## 4 VEHICLES



# COMPUTATIONAL EXPERIMENT

## 2ª ABORDAGEM:

- DIFERENTES NÚMEROS DE VEÍCULOS
- RESTRIÇÃO DE QUANTIDADE MÁXIMA (L) DE PONTOS QUE PODEM SER VISITADOS POR UM MESMO VEÍCULO

**SOLUÇÕES ÓTIMAS MAIS FIÉIS À REALIDADE**

# COMPUTATIONAL EXPERIMENT

## CASES ANALYZED:

### 4 VEHICLES


L = 4

### 5 VEHICLES


L = 3

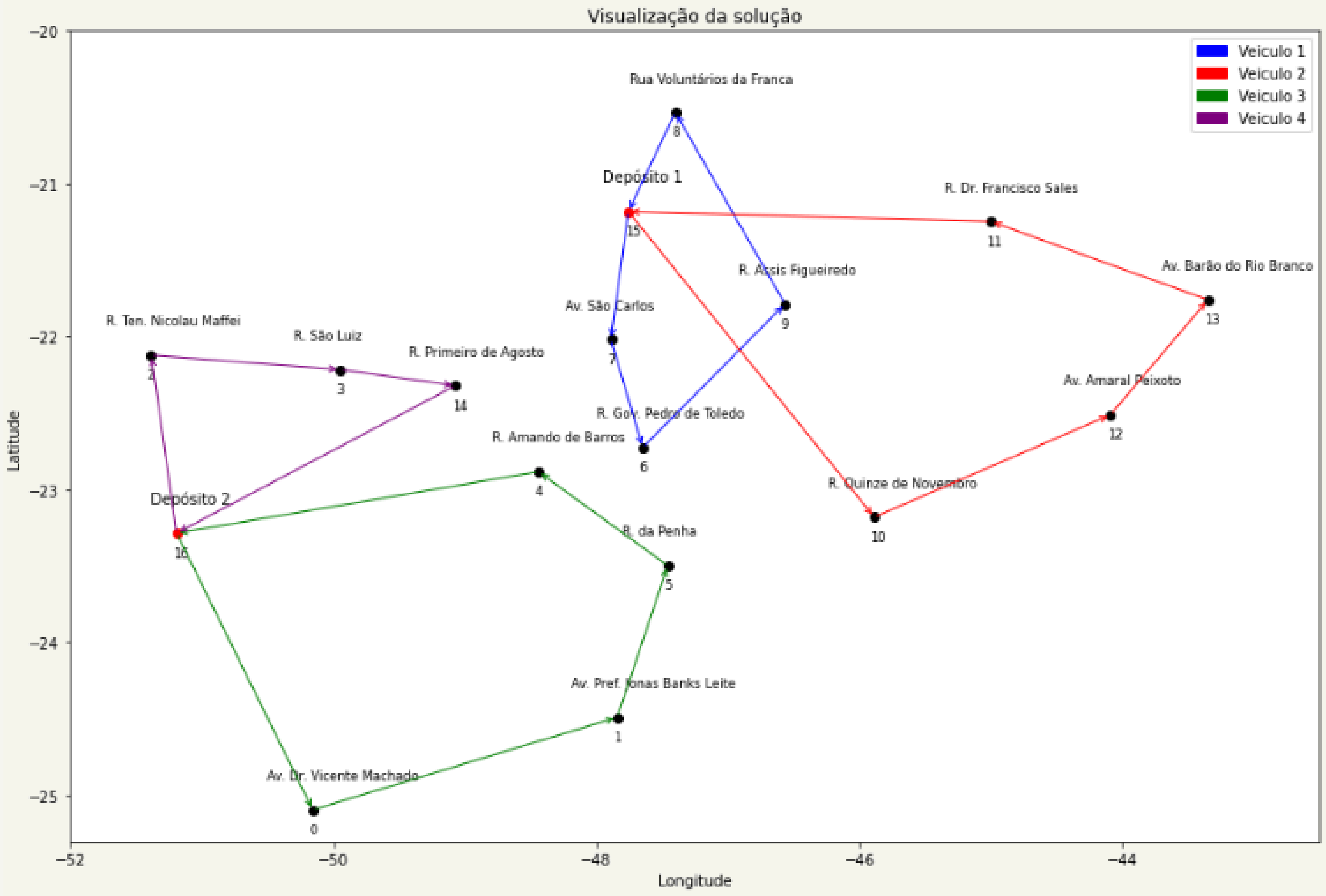
# RESULTS

| NUMBER OF VEHICLES | MAXIMUM POINTS PER VEHICLE (L) | OBJECTIVE FUNCTION (km) | DISTANCE PER VEHICLE (km) |
|---|---|---|---|
| 4 | 4 | 4249,801 | 1062,450 |
| 5 | 3 | 4592,503 | 918,501 |

# OPTIMAL ROUTES

L = 4

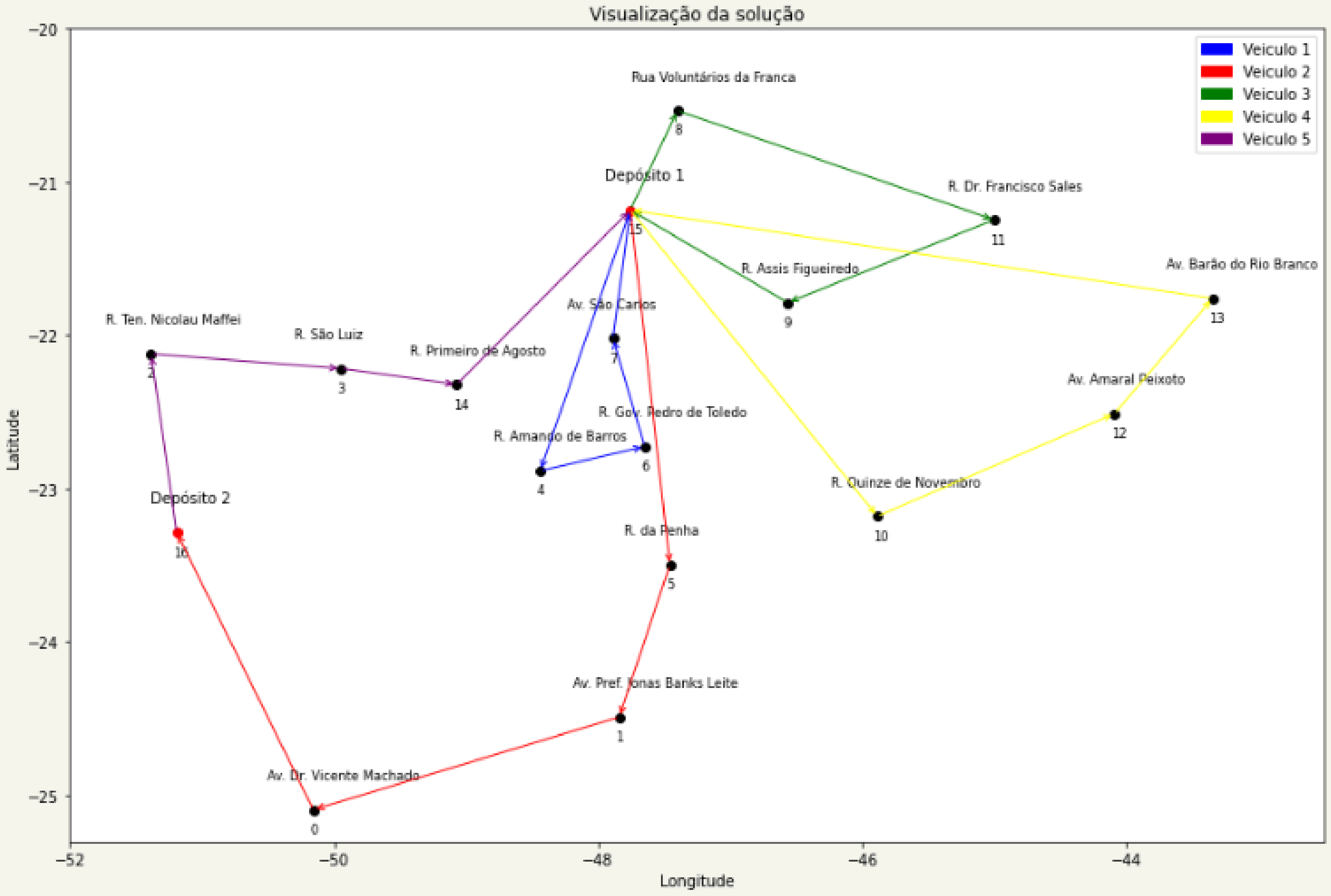
4 VEHICLES



# OPTIMAL ROUTES

L = 3

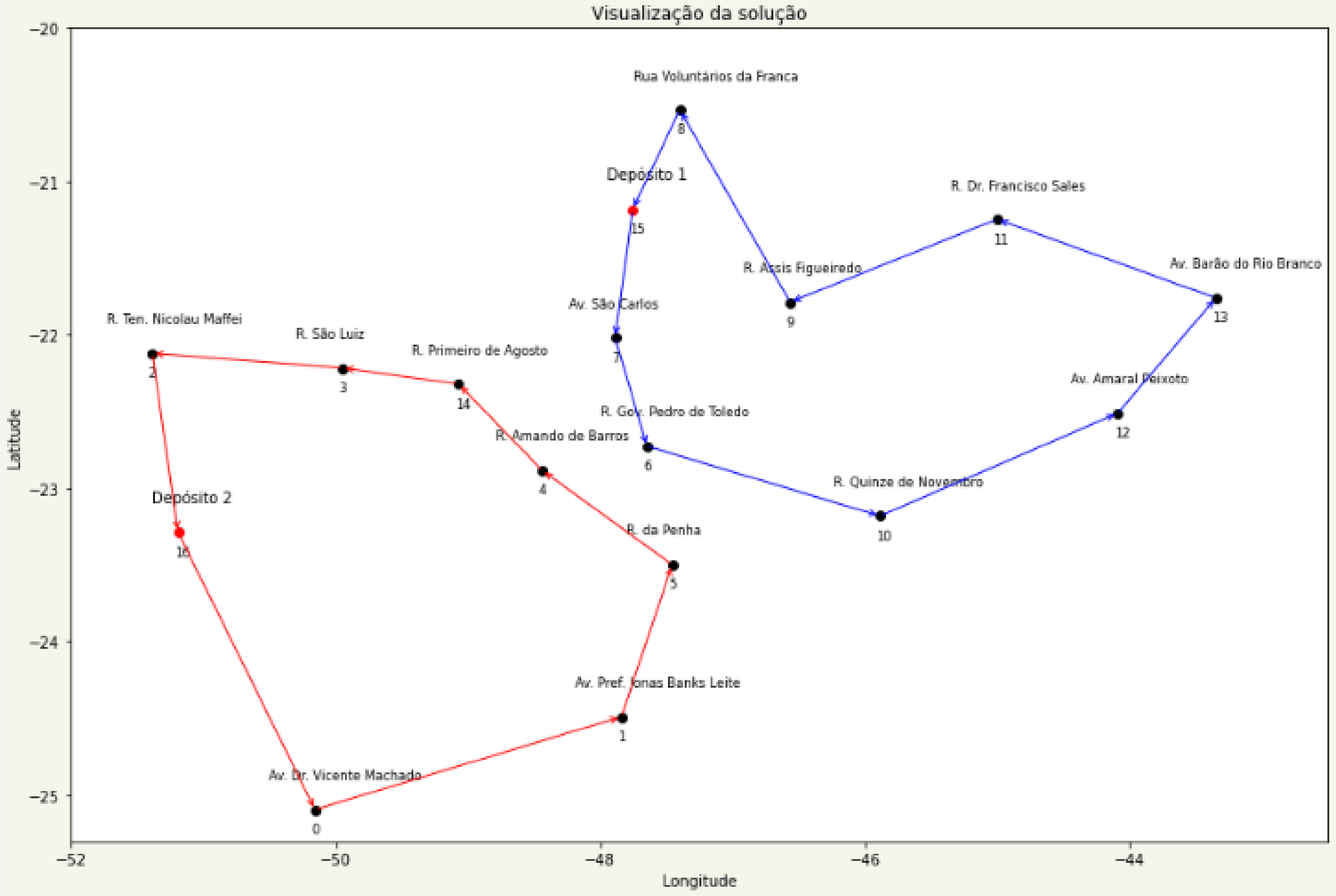
5 VEHICLES



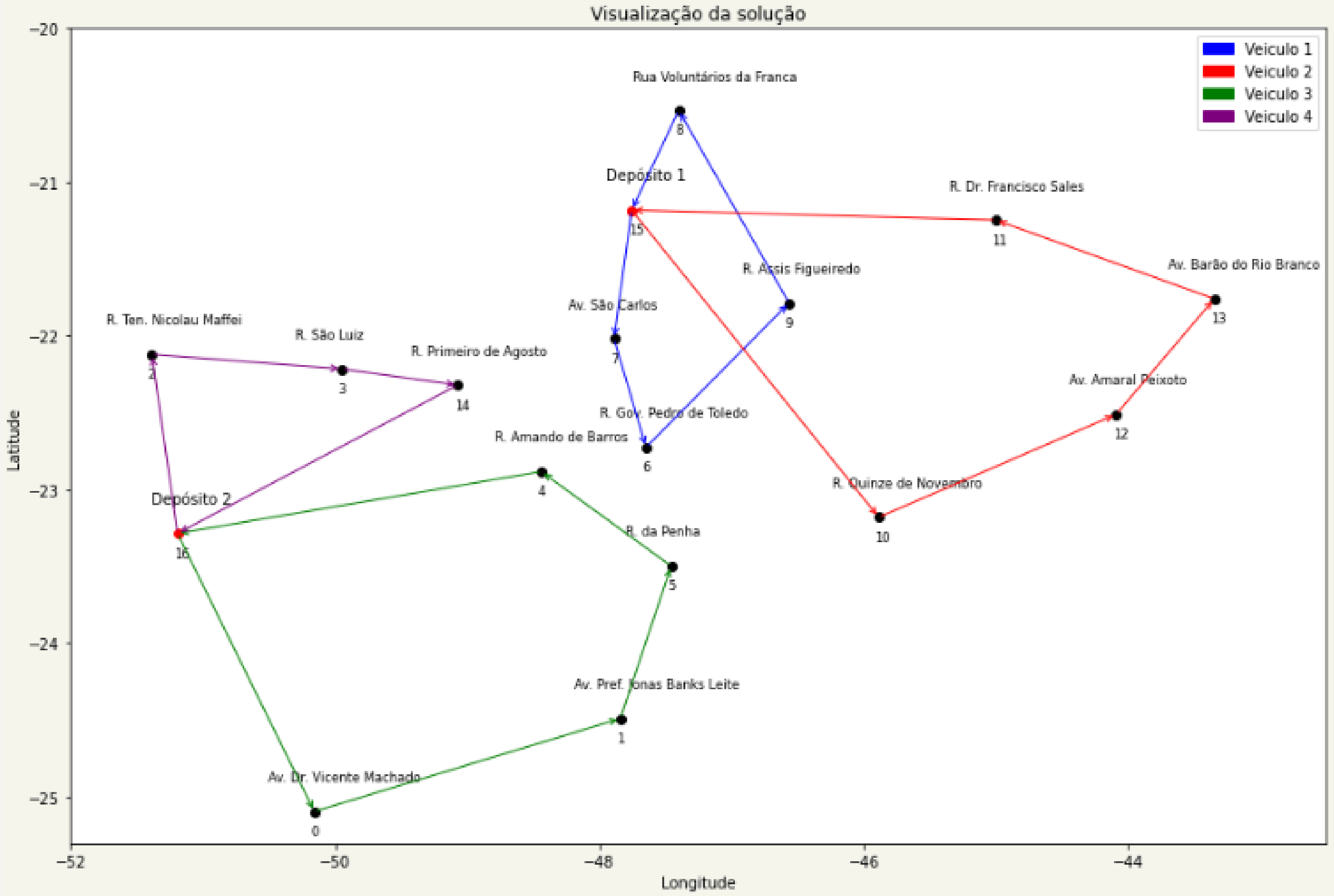
# ANALYSIS OF RESULTS

## THE 2 MOST INTERESTING APPLICATIONS ARE:

### 2 VEHICLES




### 4 VEHICLES
### L = 4



# RESULTS

| NUMBER OF VEHICLES | MAXIMUM POINTS PER VEHICLE (L) | OBJECTIVE FUNCTION (km) | DISTANCE PER VEHICLE (km) |
|---|---|---|---|
| 4 | 4 | 4249,801 | 1062,450 |
| 2 | - | 3190,070 | 1595,035 |

# CONCLUSIONS

- DELIVERY ROUTES THAT MINIMIZE THE DISTANCE TRAVELED

- THOROUGH ANALYSIS OF LOGISTICS CAN REDUCE COSTS
- INCREASED EFFICIENCY

- BUSINESS COMPETITIVENESS

# THANK YOU!

## QUESTIONS?