GraphES-Planning

Graph Excel Studies for Transportation-Planning

GraphES-Introduction-Ankara Network-Formulation Cheat Sheet-Examples-Comparison with PTV Visum

This program has been developed in Microsoft Excel & VBA to solve transportation planning and graph problems with visual inputs and outputs. All codes are open source. Any user can utilize this program in various ways:

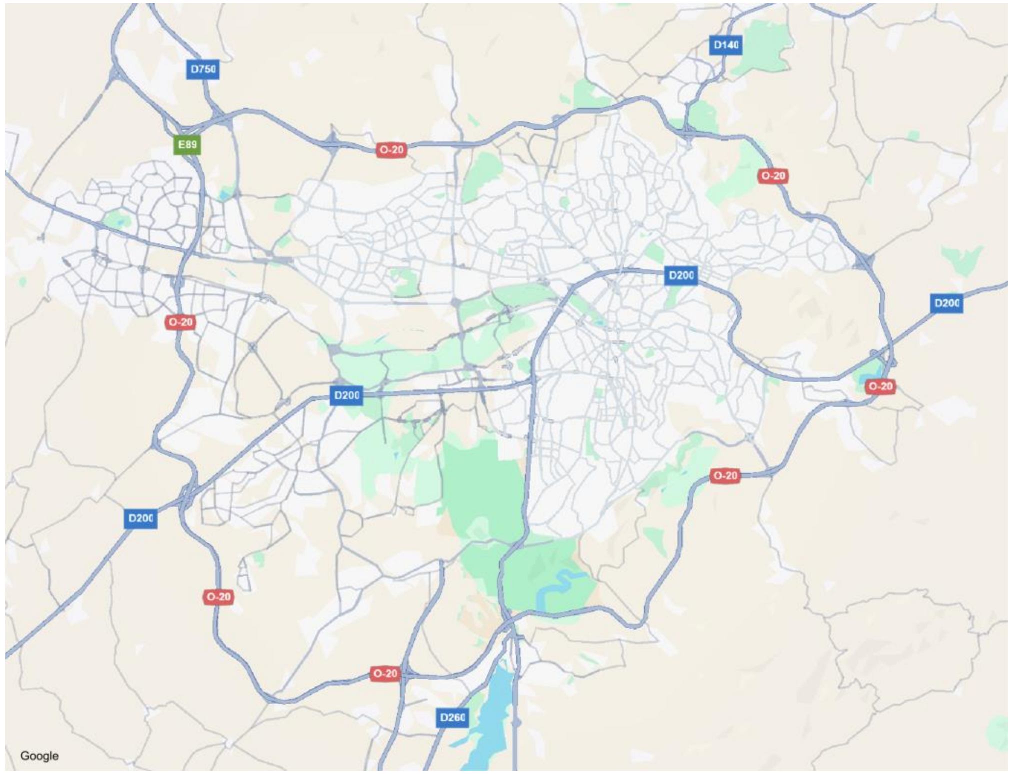
- Design of Intelligent Transportation Algorithms,
- Educational purposes for Transportation & Traffic Engineering,
- Graph Theory applications,
- Modeling exercises: Trip Distribution, Shortest Path, Traffic Assignment etc.
- Mathematical Optimisation & Artificial Intelligence practices...

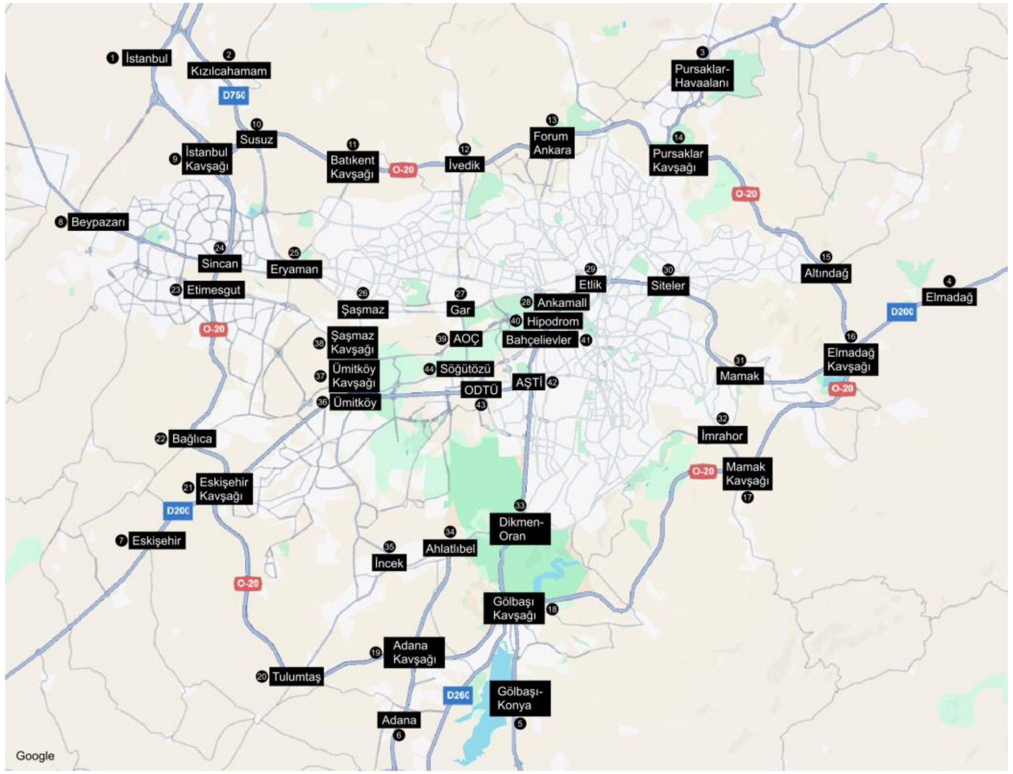
By default, the program includes a network of the city of Ankara, Türkiye, which has been simplified and adapted specifically for this program. "Ankara Test Network" consists of 12 Zones, 44 Nodes and 132 Links. If desired, different networks such as Nguyen-Dupuis, Sioux-Falls can be integrated into the program. The number of network components can be increased or decreased...

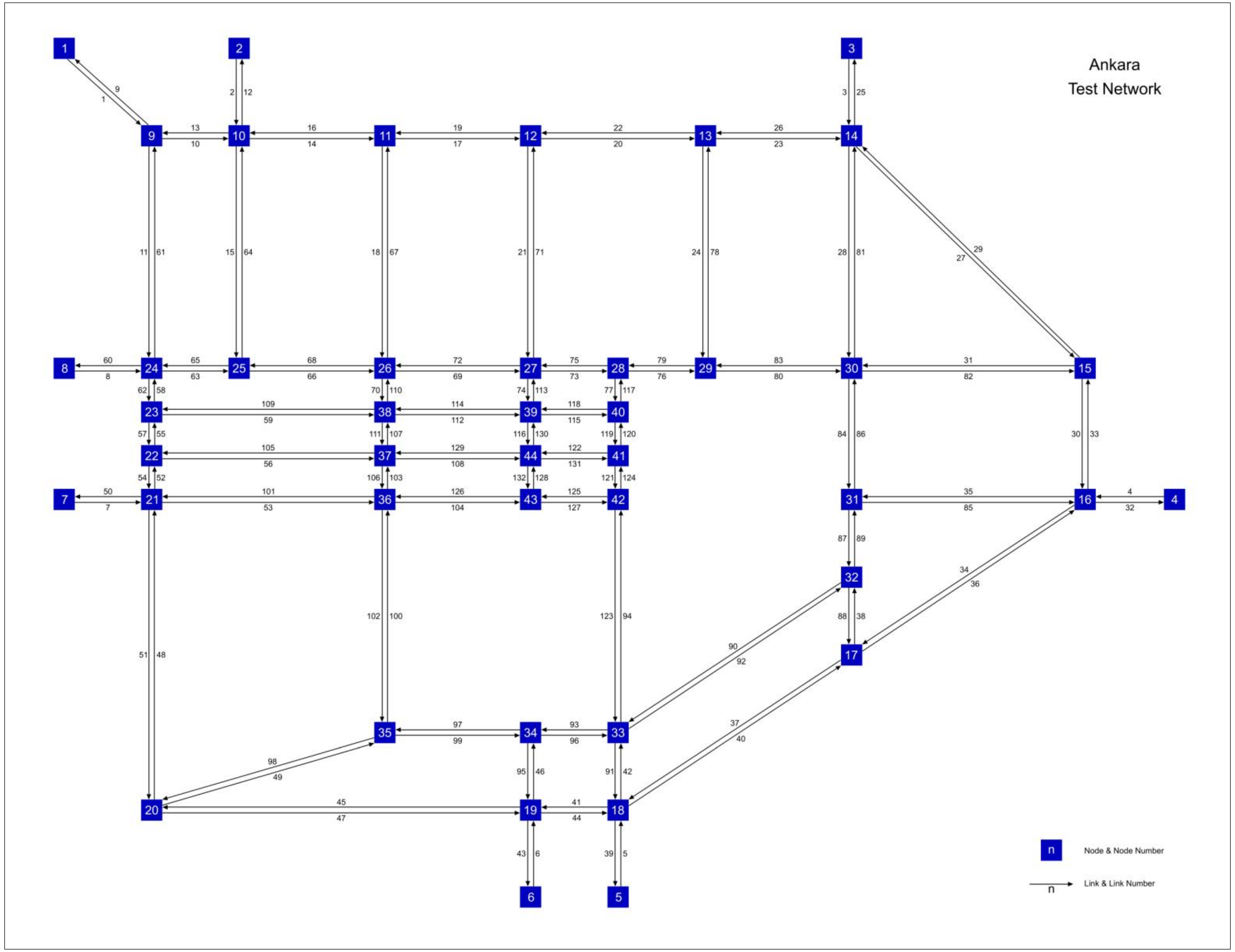
All code in the program was written manually (two modules were adapted from a specific source. Relevant references are given). Thus, it is also aimed to feed the artificial intelligence tools that are frequently used today from the codes written. GraphES Logo, on the other hand, was produced using ChatGPT.

The models used in the program (as well as the introductory models for transport planning) are given in the «GraphES Formulation Cheat Sheet».

Ankara, the capital of Türkiye, is a metropolitan city with a population of approximately 6 million. Several main arteries connect east-west and north-south directions in the city. There are two ring roads surrounding them. These ring roads are connected to motorways and national roads to accommodate trips outside Ankara. Considering the mentioned features, Ankara's transport network is a highly efficient and multidimensional network for transport planners and traffic engineers. Consequently, a test network project has been developed in order to utilise this network in various studies. In the “Ankara Transportation Test Network” project, the major intersections and arteries of the city were simplified with a geometric drawing, the length information of the links was obtained from Google, free flow travel times were calculated with the average free flow speed logic and thus a test network was formed.







Link information, types, capacities, free flow travel times can be found in the ‘Ankara Test Network Parameters’ excel file.

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GraphES-Planning V.1.0.0 contains introductory stages to transport planning. Consequently, the methods employed include both traditional and fundamental formulae and algorithms. However, it is planned to include advanced formulations, python infrastructure and a graphical user interface in future versions of the application.

Trip Production & Attraction

-Multi Parameter Linear Regression-

$$y_i = x_{0i} + \beta_1 x_{1i} + \beta_2 x_{2i} + \cdots + \beta_n x_{ni}$$

i= Zone Index

n= Variable Index

β_n = Coefficient of Variable n

y_i= Trip Production & Attraction of Zone i

x_{ni} = Variable n (Population, Labor Force etc.) of Zone i

Trip Distribution

-Gravity Model-

$$T_{ij} = A_i * B_j * O_i * D_j * f(c_{ij})$$

$$A_i = \frac{1}{\sum_j B_j * D_j * f(c_{ij})}$$

$$B_j = \frac{1}{\sum_i A_i * O_i * f(c_{ij})}$$

$$f_{Combined}(c_{ij}) = c_{ij}^{\alpha} * e^{-\beta * c_{ij}}$$

i= Origin Zone Index

j= Destination Zone Index

T_{ij}= Total Trips Between Origin i and Destination j

O_i= Total Trip Production by Zone i

D_j= Total Trip Attraction to Zone j

A_i= Balancing Factor Assuring $\sum_j T_{ij} = O_i$

B_j= Balancing Factor Assuring $\sum_i T_{ij} = D_j$

$f(c_{ij})$= Deterrence Function Between Zones i and j

e= Mathematical Constant (2.71828)

α, β= Coefficient

Modal Split (Mode Choice)

-Multinomial Logit Model-

$$T_{ij}^m = \frac{e^{-U_{ij}^m}}{\sum_m e^{-U_{ij}^m}} * \sum_m T_{ij}^m$$

$$U_{ij}^m = a_1 * x_{1ij}^m + a_2 * x_{2ij}^m + \cdots + a_n * x_{nij}^m$$

i= Origin Zone Index

j= Destination Zone Index

m= Trip Mode

n= Variable Index

e= Mathematical Constant (2.71828)

a_n= Coefficient of Variable n

T_{ij}^m= Total Trips of Mode m Between Zones i and j

U_{ij}^m= Total Utility of Mode m Between Zones i and j

x_{nij}^m= Utility Variable n of Mode m Between Zones i and j

Assignment Matrice

-Linear Algebra-

$$T_{ij}^m = \frac{\sum_p T_{ij}^{m,p} * PHF_{ij} * PCU^m}{Occ^m}$$

i= Origin Zone Index

j= Destination Zone Index

p= Trip Purpose

m= Trip Mode

T_{ij}^m= Total Vehicle Trip (as Per Car Unit) of Mode m, Between Zones i and j

$T_{ij}^{m,p}$= Trips of Mode m and Purpose p, Between Zones i and j

PHF_{ij}= Peak Hour Factor Between Zones i and j

PCU^m= Passenger Car Equavalent (Per Car Unit) of Mode m

Occ^m= Occupancy of Mode m

Volume-Delay Relationship of Links

-BPR Function-

$$t_c = t_0 * \left(1 + \alpha * \left(\frac{V}{C}\right)^{\beta}\right)$$

t_c= Current (Updated) Travel Time

t_0= Free Flow Travel Time

V= Volume (veh/hr)

C= Capacity (veh/hr)

α, β= Coefficient

User Equilibrium Traffic Assignment

-Nonlinear Mathematical Optimization-

-Source for Notation: Mathew T. V., Rao K.V.K., 2007, Traffic Assignment, Introduction to Transportation Engineering, NPTEL May 7, 2007-

$$\text{Minimize } Z = \sum_a \int_0^{x_a} t_a(x_a)dx,$$

$$\text{Subject to } \sum_k f_k^{rs} = q_{rs} : \forall r, s$$

$$x_a = \sum_r \sum_s \sum_k \delta_{a,k}^{rs} f_k^{rs} : \forall a$$

$$f_k^{rs} \geq 0 : \forall k, r, s$$

$$x_a \geq 0 : a \in A$$

$$\delta_{a,k}^{r,s} = \begin{cases} 1 \text{ if link a belongs to path k,} \\ 0 \quad \text{otherwise} \end{cases}$$

k= Path

x_a= Equilibrium Flows in Link a

t_a= Travel Time on Link a

f_k^{rs}= Flow on Path k Connecting O-D Pair r-s

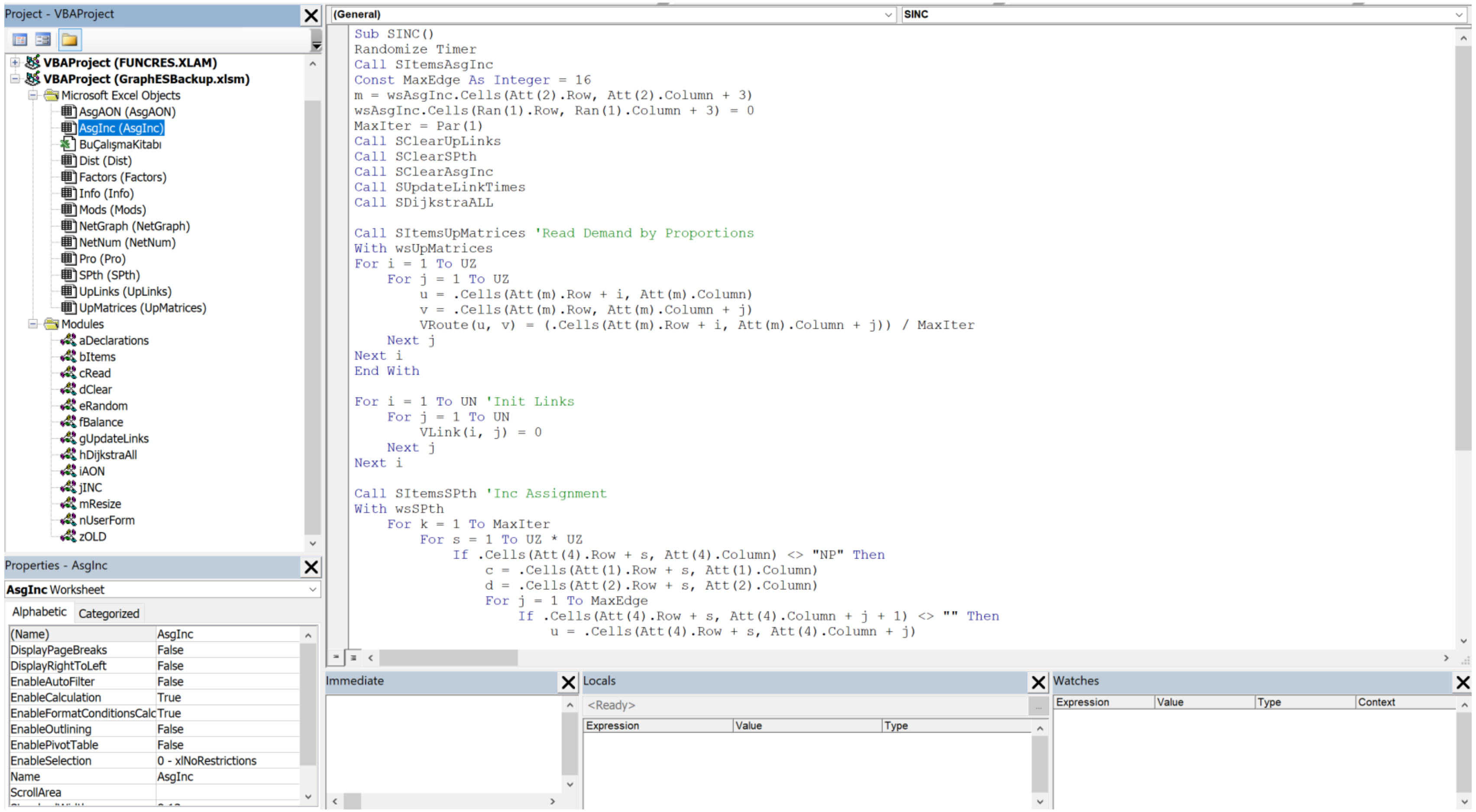
q_{rs}= Trip Rate Between r and s

$\delta_{a,k}^{rs}$= Definitional Constraint

GraphES-Planning V.1.0.0 contains 12 sheets. Their descriptions can be found below. Some sheets have sample figures in the following slides.

- Info: The page containing various explanations about the use of the application, formulation sheet, application vocabulary and database.
- NetNum: The page where the network components (link, node, zone...) are represented numerically.
- Pro: The page where the trip production-attractions are calculated.
- Dist: The page where the trip distribution is calculated.
- Mods: The page where the modal split is calculated.
- Factors: The page containing the parameters that will affect the reflection of the trips in the network (peak hour factor, occupancy...).
- UpMatrices: The page where the final (assignment) trip matrices are calculated on the basis of trip modes after all calculations.
- UpLinks: The page with link parameters and link travel times updated according to volume-delay relations.
- SPth: The page where the shortest paths, routes and their travel times are calculated.
- AsgAON: The page where all or nothing assignment is made.
- AsgInc: The page where incremental assignment is made.
- NetGraph: The page where network properties and assignment results can be viewed & analysed graphically.

Example Code



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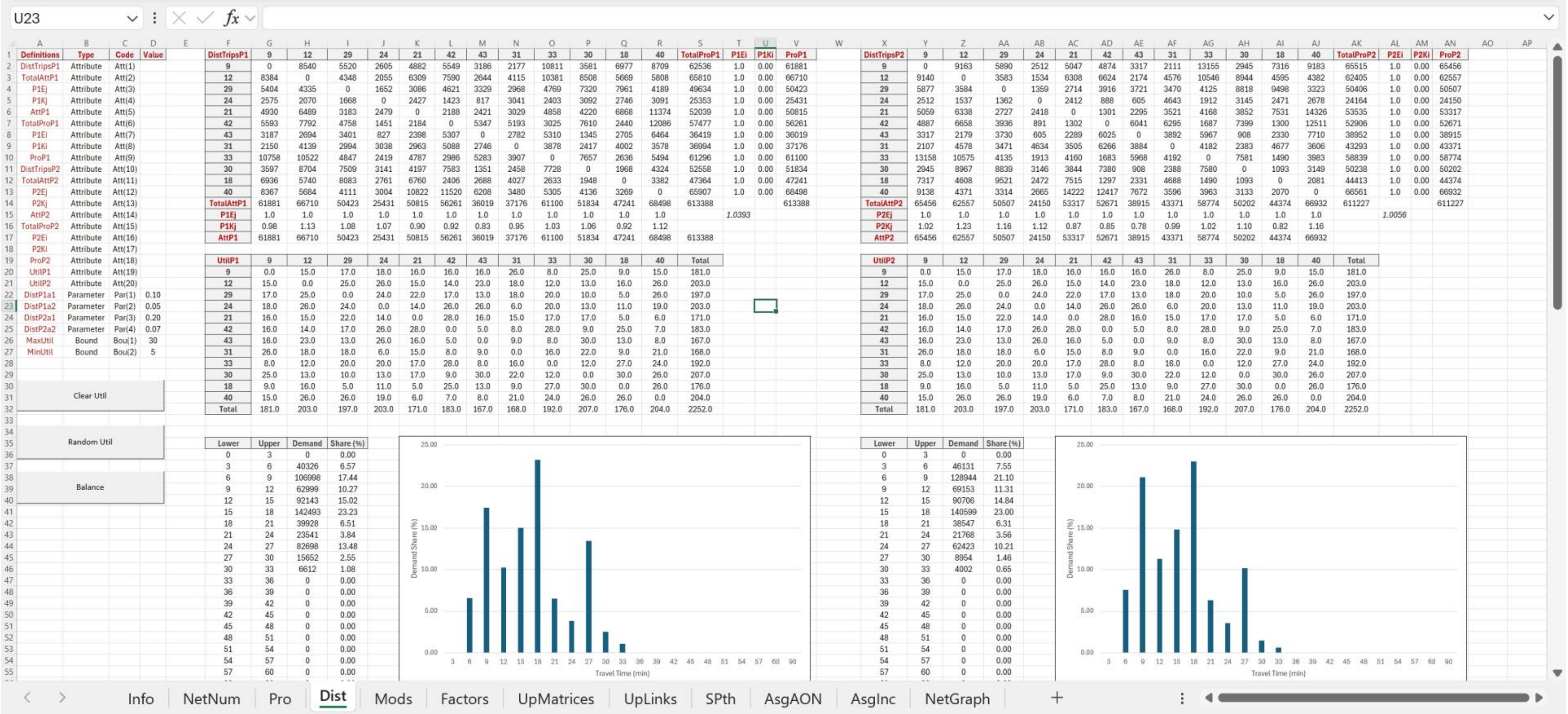
Trip Distribution & Matrix Balancing



Find Shortest Paths

Y19

Definitions	Type	Code	Value
FromZone	Attribute	Att(1)	
ToZone	Attribute	Att(2)	
CostMin	Attribute	Att(3)	
PathNodes	Attribute	Att(4)	
ZT	Attribute	Att(5)	

Clear Routes

Find Paths

FromZone	ToZone	CostMin	PathNodes	e1	e2	e3	e4	e5	e6	e7	e8	e9	e10	e11	e12	e13	e14	e15	e16	e...
9	9	0.0	NP	NP																
9	12	15.9	9---10---11---12	9	10	11	12													
9	29	32.8	9---10---11---12---13---29	9	10	11	12	13	29											
9	24	12.3	9---24	9	24															
9	21	20.6	9---24---23---22---21	9	24	23	22	21												
9	42	43.9	9---24---23---22---21---36---43---42	9	24	23	22	21	36	43	42									
9	43	31.7	9---24---23---22---21---36---43	9	24	23	22	21	36	43										
9	31	35.8	9---10---11---12---13---14---15---16---31	9	10	11	12	13	14	15	16	31								
9	33	36.7	9---24---23---22---21---20---19---34---33	9	24	23	22	21	20	19	34	33								
9	30	33.0	9---10---11---12---13---14---30	9	10	11	12	13	14	30										
9	18	34.2	9---24---23---22---21---20---19---18	9	24	23	22	21	20	19	18									
9	40	31.4	9---10---25---26---27---28---40	9	10	25	26	27	28	40										
12	9	15.6	12---11---10---9	12	11	10	9													
12	12	0.0	NP	NP																
12	29	16.9	12---13---29	12	13	29														
12	24	22.3	12---11---26---38---23---24	12	11	26	38	23	24											
12	21	28.7	12---11---26---38---23---22---21	12	11	26	38	23	22	21										
12	42	39.1	12---27---39---44---41---42	12	27	39	44	41	42											
12	43	31.0	12---27---39---44---43	12	27	39	44	43												
12	31	19.8	12---13---14---15---16---31	12	13	14	15	16	31											
12	33	32.5	12---13---14---15---16---17---18---33	12	13	14	15	16	17	18	33									
12	30	17.1	12---13---14---30	12	13	14	30													
12	18	29.1	12---13---14---15---16---17---18	12	13	14	15	16	17	18										
12	40	22.8	12---27---28---40	12	27	28	40													
29	9	32.6	29---13---12---11---10---9	29	13	12	11	10	9											
29	12	16.9	29---13---12	29	13	12														
29	29	0.0	NP	NP																
29	24	30.3	29---28---27---26---38---23---24	29	28	27	26	38	23	24										
29	21	36.7	29---28---27---26---38---23---22---21	29	28	27	26	38	23	22	21									
29	42	41.1	29---28---27---39---44---41---42	29	28	27	39	44	41	42										
29	43	33.0	29---28---27---39---44---43	29	28	27	39	44	43											
29	31	27.7	29---13---14---15---16---31	29	13	14	15	16	31											
29	33	40.4	29---13---14---15---16---17---18---33	29	13	14	15	16	17	18	33									
29	30	19.3	29---30	29	30															
29	18	37.0	29---13---14---15---16---17---18	29	13	14	15	16	17	18										
29	40	14.0	29---28---40	29	28	40														
24	9	12.3	24---9	24	9															

ZT	9	12	29	24	21	42	43	31	33	30	18	40
9	0.0	15.9	32.8	12.3	20.6	43.9	31.7	35.8	36.7	33.0	34.2	31.4
12	15.6	0.0	16.9	22.3	28.7	39.1	31.0	19.8	32.5	17.1	29.1	22.8
29	32.6	16.9	0.0	30.3	36.7	41.1	33.0	27.7	40.4	19.3	37.0	14.0
24	12.3	22.4	30.5	0.0	8.3	31.5	19.4	36.5	24.4	39.5	21.9	21.3
21	20.6	28.9	36.9	8.3	0.0	23.3	11.1	28.3	16.1	36.4	13.6	27.7
42	43.9	40.0	42.2	31.6	23.3	0.0	12.2	40.2	22.2	48.3	25.6	30.5
43	31.6	31.5	33.7	19.4	11.1	12.1	0.0	37.0	19.0	45.2	22.4	22.6
31	35.5	19.9	27.8	36.5	28.2	40.3	37.0	0.0	18.0	12.0	14.6	41.7
33	36.7	32.5	40.4	24.4	16.1	22.3	19.0	18.0	0.0	26.2	3.4	37.7
30	32.8	17.2	19.7	39.5	36.4	48.5	45.2	12.1	26.2	0.0	22.8	33.7
18	34.2	29.1	37.0	21.9	13.6	25.7	22.4	14.6	3.4	22.8	0.0	41.1
40	31.1	22.7	14.0	20.7	27.1	28.8	21.6	41.7	36.9	33.3	40.3	0.0

Info | NetNum | Pro | Dist | Mods | Factors | UpMatrices | UpLinks | SPth | AsgAON | AsgInc | NetGraph

Incramental Assignment

C36

Definitions	Type	Code	Value
INC	Attribute	Att(1)	
INCMod	Attribute	Att(2)	1
Iter	Parameter	Par(1)	4
CurIter	Range	Ran(1)	4

Clear Assignment

Run Incramental Assignment

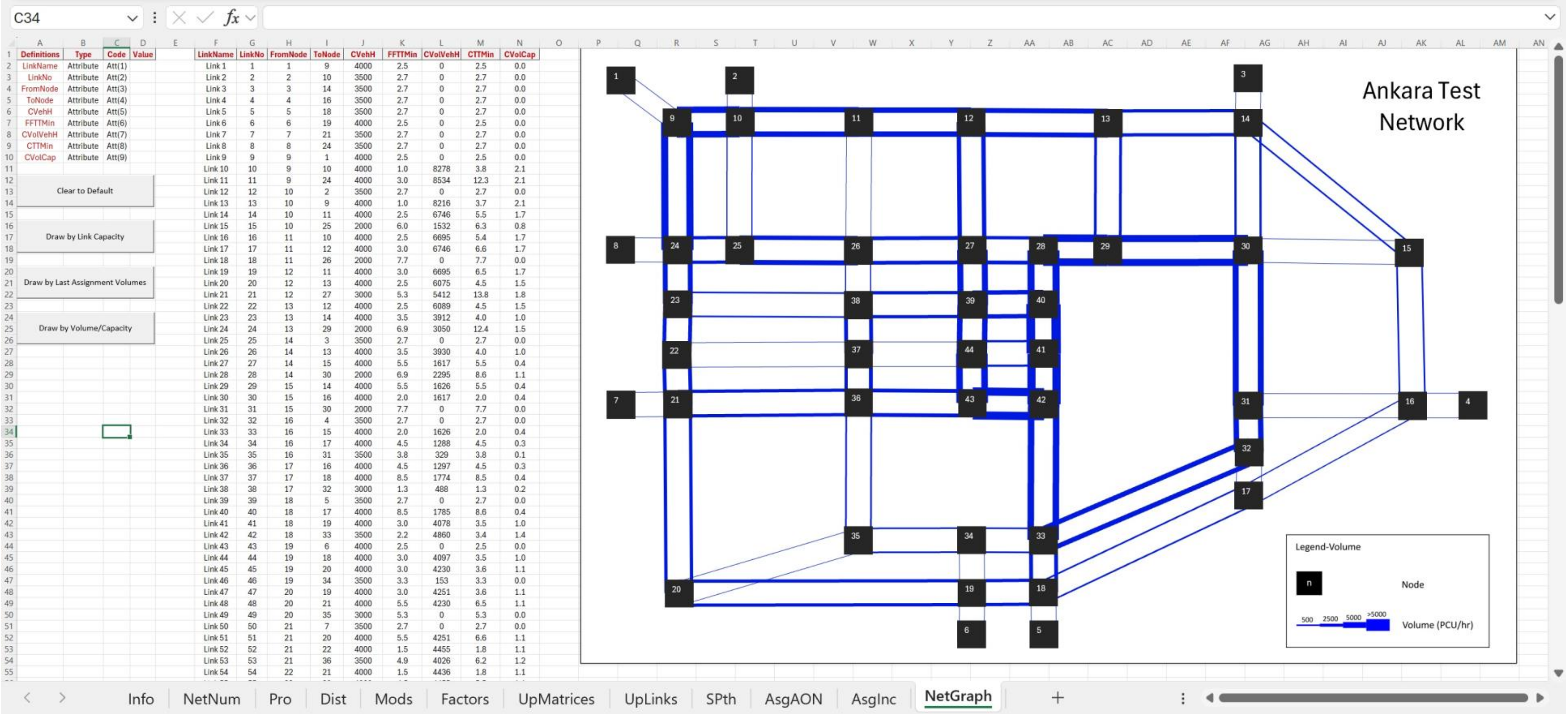
Note: Range item types generate their own value. It is automatic.

Note: Please specify Iter Number. If you set a high value of iteration, graph can reach user equilibrium but run time will increase. Since this program visualize data at each iteration.

INC	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	8278	0	0	0	0	0	0	0	0	0	0	0	0	0	8534	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	8216	0	6746	0	0	0	0	0	0	0	0	0	0	0	0	0	1532	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	6695	0	6746	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	6695	0	6075	0	0	0	0	0	0	0	0	0	0	0	0	0	5412	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	6089	0	3912	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3050	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	3930	0	1617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2295	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	1626	0	1617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1626	0	1288	0	0	0	0	0	0	0	0	0	0	0	0	0	329	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1297	0	1774	0	0	0	0	0	0	0	0	0	0	0	0	0	488	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1785	0	4078	0	0	0	0	0	0	0	0	0	0	0	0	0	4860	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4097	0	4230	0	0	0	0	0	0	0	0	0	0	0	0	0	153	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4251	0	4230	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4251	0	4455	0	0	0	0	0	0	0	0	0	0	0	0	0	4026	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4436	0	4455	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4436	0	6144	0	0	0	0	0	0	0	0	0	0	0	0	0	1705	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	8524	0	0	0	0	0	0	0	0	0	0	0	0	0	6141	0	4167	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	1521	0	0	0	0	0	0	0	0	0	0	0	0	0	4151	0	5699	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5671	0	4729	0	0	0	0	0	0	0	0	0	0	971	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	5418	0	0	0	0	0	0	0	0	0	0	0	0	0	4700	0	4333	0	0	0	0	0	0	0	0	0	0	7334	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4287	0	9632	0	0	0	0	0	0	0	0	0	0	8602	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	3046	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9619	0	8833	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	2305	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8884	0	7650	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	329	0	0	0	0	0	0	0	0	0	0	0	0	0	7640	0	6597	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	486	0	0	0	0	0	0	0	0	0	0	0	0	0	6610	0	6110	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4840	0	0	0	0	0	0	0	0	0	0	0	0	0	6121	0	1894	0	0	0	0	0	0	0	8006	0	0
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	152	0	0	0	0	0	0	0	0	0	0	0	0	0	1891	0	1742	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1737	0	1742	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3965	0	0	0	0	0	0	0	0	0	0	0	0	0	1737	0	4365	0	0	0	0	0	4759	0
37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4315	0	4589	0	0	0	0	0	403
38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1688	0	0	971	0	0	0	0	0	0	0	0	0	0	4538	0	3916	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7357	0	0	0	0	0	0	0	0	0	0	3848	0	5548	0	0	0	6761
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8569	0	0	0	0	0	0	0	0	0	0	5433	0	11021	0	0	0
41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11196	0	9917	0	2590
42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7995	0	0	0	0	0	0	0	10070	0	10055	0
43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4743	0	0	0	0	0	10025	0	8362
44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	405	0	6831	0	2612	0	8267	0

Info | NetNum | Pro | Dist | Mods | Factors | UpMatrices | UpLinks | SPth | AsgAON | AsgInc | NetGraph

Graphical Results

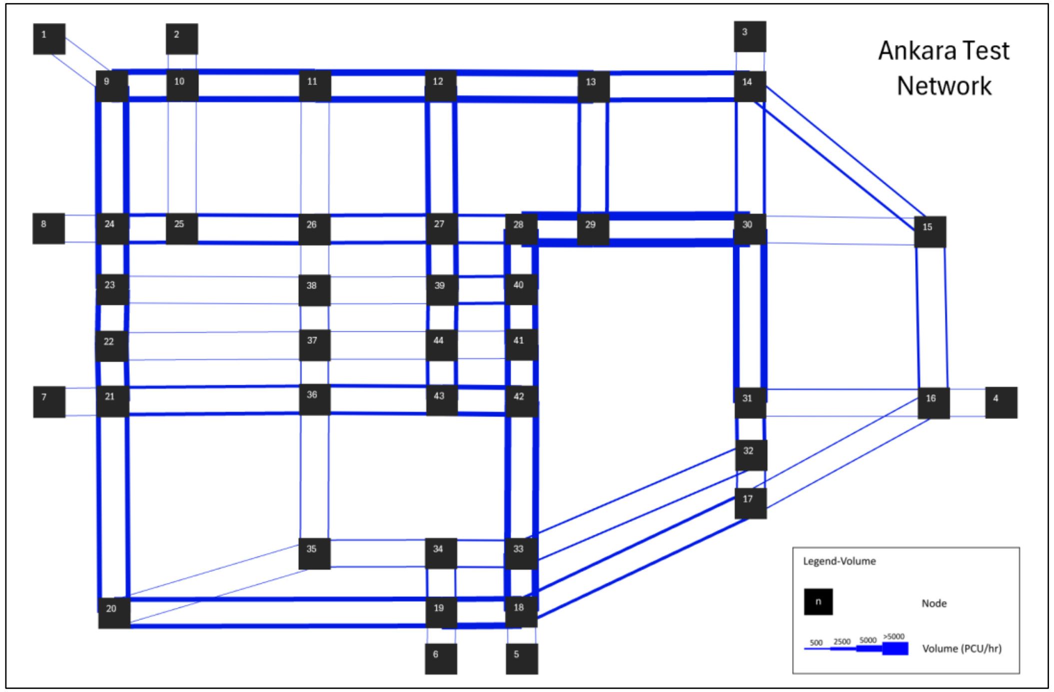


Definitions	Type	Code	Value
LinkName	Attribute	Att(1)	
LinkNo	Attribute	Att(2)	
FromNode	Attribute	Att(3)	
ToNode	Attribute	Att(4)	
CVehH	Attribute	Att(5)	
FFTTMin	Attribute	Att(6)	
CVolVehH	Attribute	Att(7)	
CTTMin	Attribute	Att(8)	
CVolCap	Attribute	Att(9)	

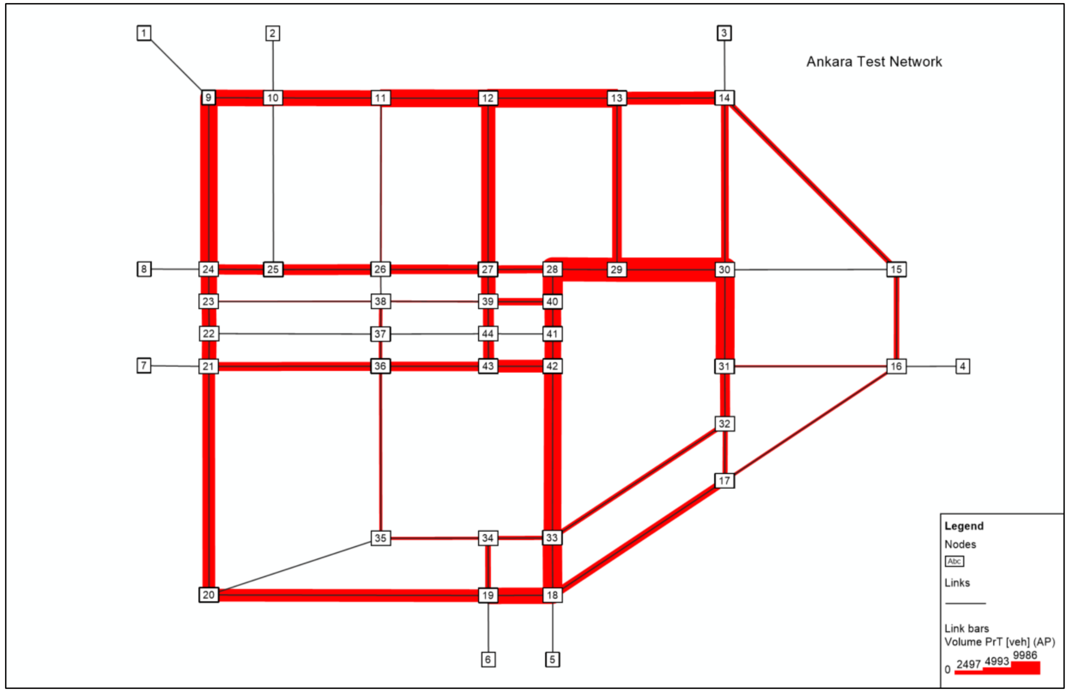
LinkName	LinkNo	FromNode	ToNode	CVehH	FFTTMin	CVolVehH	CTTMin	CVolCap
Link 1	1	1	9	4000	2.5	0	2.5	0.0
Link 2	2	2	10	3500	2.7	0	2.7	0.0
Link 3	3	3	14	3500	2.7	0	2.7	0.0
Link 4	4	4	16	3500	2.7	0	2.7	0.0
Link 5	5	5	18	3500	2.7	0	2.7	0.0
Link 6	6	6	19	4000	2.5	0	2.5	0.0
Link 7	7	7	21	3500	2.7	0	2.7	0.0
Link 8	8	8	24	3500	2.7	0	2.7	0.0
Link 9	9	9	1	4000	2.5	0	2.5	0.0
Link 10	10	9	10	4000	1.0	8278	3.8	2.1
Link 11	11	9	24	4000	3.0	8534	12.3	2.1
Link 12	12	10	2	3500	2.7	0	2.7	0.0
Link 13	13	10	9	4000	1.0	8216	3.7	2.1
Link 14	14	10	11	4000	2.5	6746	5.5	1.7
Link 15	15	10	25	2000	6.0	1532	6.3	0.8
Link 16	16	11	10	4000	2.5	6695	5.4	1.7
Link 17	17	11	12	4000	3.0	6746	6.6	1.7
Link 18	18	11	26	2000	7.7	0	7.7	0.0
Link 19	19	12	11	4000	3.0	6695	6.5	1.7
Link 20	20	12	13	4000	2.5	6075	4.5	1.5
Link 21	21	12	27	3000	5.3	5412	13.8	1.8
Link 22	22	13	12	4000	2.5	6089	4.5	1.5
Link 23	23	13	14	4000	3.5	3912	4.0	1.0
Link 24	24	13	29	2000	6.9	3050	12.4	1.5
Link 25	25	14	3	3500	2.7	0	2.7	0.0
Link 26	26	14	13	4000	3.5	3930	4.0	1.0
Link 27	27	14	15	4000	5.5	1617	5.5	0.4
Link 28	28	14	30	2000	6.9	2295	8.6	1.1
Link 29	29	15	14	4000	5.5	1626	5.5	0.4
Link 30	30	15	16	4000	2.0	1617	2.0	0.4
Link 31	31	15	30	2000	7.7	0	7.7	0.0
Link 32	32	16	4	3500	2.7	0	2.7	0.0
Link 33	33	16	15	4000	2.0	1626	2.0	0.4
Link 34	34	16	17	4000	4.5	1288	4.5	0.3
Link 35	35	16	31	3500	3.8	329	3.8	0.1
Link 36	36	17	16	4000	4.5	1297	4.5	0.3
Link 37	37	17	18	4000	8.5	1774	8.5	0.4
Link 38	38	17	32	3000	1.3	488	1.3	0.2
Link 39	39	18	5	3500	2.7	0	2.7	0.0
Link 40	40	18	17	4000	8.5	1785	8.6	0.4
Link 41	41	18	19	4000	3.0	4078	3.5	1.0
Link 42	42	18	33	3500	2.2	4860	3.4	1.4
Link 43	43	19	6	4000	2.5	0	2.5	0.0
Link 44	44	19	18	4000	3.0	4097	3.5	1.0
Link 45	45	19	20	4000	3.0	4230	3.6	1.1
Link 46	46	19	34	3500	3.3	153	3.3	0.0
Link 47	47	20	19	4000	3.0	4251	3.6	1.1
Link 48	48	20	21	4000	5.5	4230	6.5	1.1
Link 49	49	20	35	3000	5.3	0	5.3	0.0
Link 50	50	21	7	3500	2.7	0	2.7	0.0
Link 51	51	21	20	4000	5.5	4251	6.6	1.1
Link 52	52	21	22	4000	1.5	4455	1.8	1.1
Link 53	53	21	36	3500	4.9	4026	6.2	1.2
Link 54	54	22	21	4000	1.5	4436	1.8	1.1

GraphES-Introduction-Ankara Network-Formulation Cheat Sheet-Examples-Comparison with PTV Visum

GraphES-Incramental Assignment (10 Iteration)



PTV Visum-Incramental Assignment (10 Iteration)



GraphES-Introduction-Ankara Network-Formulation Cheat Sheet-Examples-Comparison with PTV Visum

The below table shows the assignment results of the same demand matrix in Ankara Network with GraphES-Planning V.1.0.0 Incramental Assignment (10 Iteration) and PTV Visum Incramental Assignment methods. In total, 30 of the 132 links with the highest volume are given in the table. Results show that both applications give the same output in the Incramental Assignment type. There is no difference in the link volumes obtained from incramental assignment between the two applications.

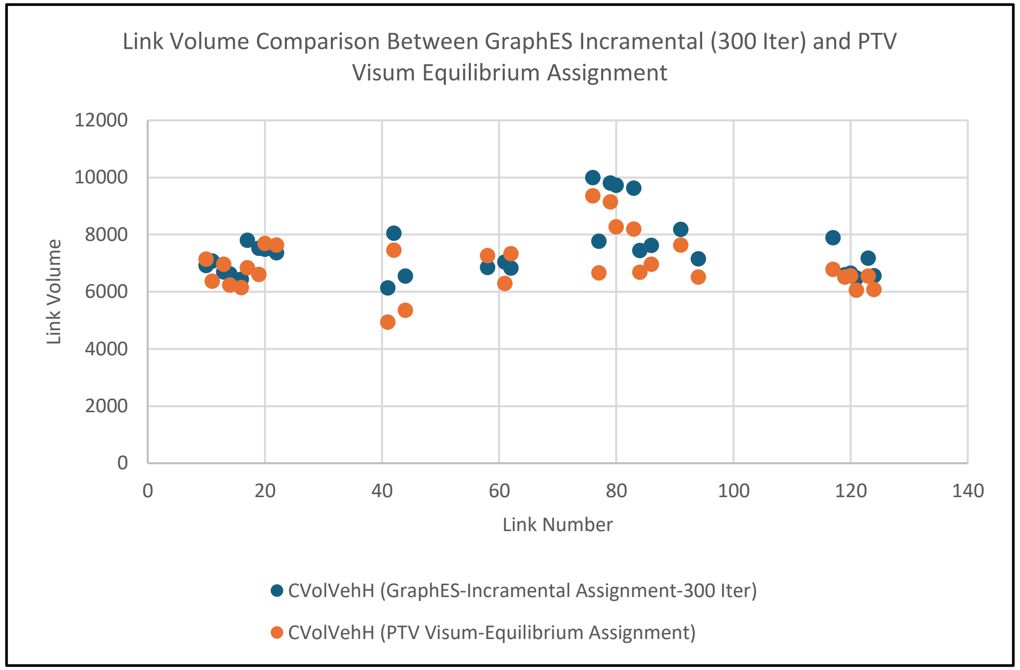
LinkNo	FromNode	ToNode	CVolVehH (GraphES-Incramental Assignment-10 Iter)	CVolVehH (PTV Visum-Incramental Assignment)	Difference (%)
80	29	30	9986	9986	0%
83	30	29	9946	9946	0%
76	28	29	9867	9867	0%
79	29	28	9851	9851	0%
117	40	28	8319	8319	0%
77	28	40	8182	8182	0%
91	33	18	8064	8064	0%
86	31	30	7989	7989	0%
42	18	33	7887	7887	0%
20	12	13	7789	7789	0%
84	30	31	7501	7501	0%
22	13	12	7483	7483	0%
17	11	12	7477	7477	0%
94	33	42	7274	7274	0%
123	42	33	7183	7183	0%
61	24	9	7175	7175	0%
11	9	24	7145	7145	0%
19	12	11	7126	7126	0%
44	19	18	7071	7071	0%
10	9	10	6894	6894	0%
120	41	40	6868	6868	0%
124	42	41	6868	6868	0%
119	40	41	6734	6734	0%
121	41	42	6734	6734	0%
58	23	24	6711	6711	0%
14	10	11	6634	6634	0%
62	24	23	6608	6608	0%
13	10	9	6606	6606	0%
16	11	10	6421	6421	0%
41	18	19	6353	6353	0%

Average Difference (%)	0%
Correlation Coefficient	1.00

GraphES-Introduction-Ankara Network-Formulation Cheat Sheet-Examples-Comparison with PTV Visum

In the table below, the assignment results of the same demand matrix in Ankara Network with GraphES-Planning V.1.0.0 Incramental Assignment (300 Iteration) and PTV Visum Equilibrium Assignment methods are given comparatively. In total, 30 of the 132 links with the highest volume are shown in the table. The results show that there is an average difference of approximately 9% between the two methods. Although GraphES incramental assignment gives approximate results compared to PTV Visum equilibrium assignment method, it results in higher link volumes. The correlation coefficient between the two methods is 0.86.

LinkNo	FromNode	ToNode	CVolVehH (GraphES-Incramental Assignment-300 Iter)	CVolVehH (PTV Visum-Equilibrium Assignment)	Difference (%)
80	29	30	9723	8277	15%
83	30	29	9633	8193	15%
76	28	29	10000	9361	6%
79	29	28	9804	9146	7%
117	40	28	7888	6789	14%
77	28	40	7770	6656	14%
91	33	18	8179	7639	7%
86	31	30	7621	6966	9%
42	18	33	8051	7453	7%
20	12	13	7488	7695	3%
84	30	31	7448	6683	10%
22	13	12	7365	7637	4%
17	11	12	7805	6844	12%
94	33	42	7155	6517	9%
123	42	33	7178	6551	9%
61	24	9	7041	6290	11%
11	9	24	7076	6367	10%
19	12	11	7525	6608	12%
44	19	18	6550	5352	18%
10	9	10	6920	7139	3%
120	41	40	6655	6560	1%
124	42	41	6561	6080	7%
119	40	41	6597	6515	1%
121	41	42	6486	6057	7%
58	23	24	6851	7268	6%
14	10	11	6627	6238	6%
62	24	23	6832	7332	7%
13	10	9	6698	6958	4%
16	11	10	6443	6149	5%
41	18	19	6133	4937	19%



Average Difference (%)	9%
Correlation Coefficient	0.86

GraphES-Planning

Graph Excel Studies for Transportation-Planning