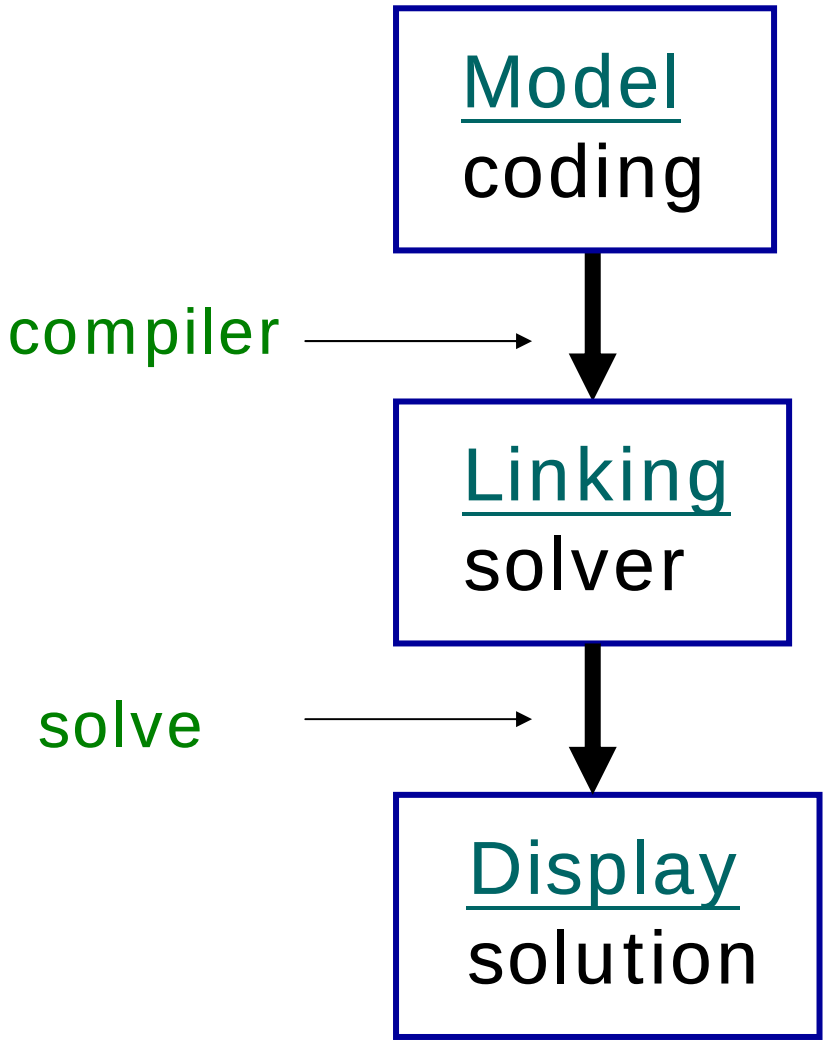
Introduction to GAMS

Ta-Hui Yang
Associate Professor
Department of Logistics Management
National Kaohsiung First Univ. of Sci. & Tech.

Outline

- What's GAMS
- Structure of a GAMS model
- Introduction of statements

What's GAMS
(General Algebraic Modeling System)



Structure

- **Sets**
  Declaration, Assignment of members
- **Data**
  (Parameters, Scalars, Tables)
- **Variables**
  Assignment of type
- **Equations**
  Declaration
  Definition
- **Model and Solve statements**
- **Display statement**

Remarks

- To Declare before using
- Typography appeals to the user
- Free of upper-and lowercase letters
- Using * to make some notes
- Declaration and Definition

Sets

```
Sets
i origin / Taipei, Kaohsiung , Beijing  /
j destination / Taipei, Kaohsiung , Beijing / ;
```

```
Set i  /1,2,3,...,18/
      j  /1,2,3,...,18/;
   =i  /1*18/
      j  /1*18/ ;
```

```
Set
      i  /1,2,3,...,18/
      Alias (i,j);
```

Parameters

```
Parameters
   f(*) facility fixed cost
   U(*) capacity upper bound;
   f(k)=420000000;
   U(k)=7000000;
   f(k) fixed cost of hub k in cases
          / Taipei 420000000, Kaohsiung 300000000
          , Beijing 500000000/
   U(k) capacity of hub k in cases
           / Taipei 7000000, Kaohsiung 6000000
            , Beijing 8000000/ ;
```

```
Parameter
   c(*,*) transportation cost;
   c(i,j) = ATK* length(i,j) ;
```

Scalar

Scalar

ATK Available Tonnage per Kilometer /8.77/ ;

Table

Table length(i,j) distance between origin i and destination j

	Taipei	Kaohsiung	Beijing
Taipei	0	1.7	1.8
Kaohsiung	1.7	0	2.5
Beijing	1.8	2.5	0;

	1	2	3
1	0	1.7	1.8
2	1.7	0	2.5
3	1.8	2.5	0;

Operators

Operator	Description
* *	exponentiation
*,/	multiplication and division
+,-	addition and subtraction
sum	Summation over controlling index
prod	Product
smin	Minimum
smax	Maximum

Functions

Function	Description
exp(x)	Exponential,
log(x)	Natural logarithm, loge(x)
abs(x)	Absolute Value of x, i.e. |x|
power(x,y)	Integer power. x^y
sqr(x)	Square of x.
sqrt(x)	Square root of x.
max(x,y,..)	Largest value among all arguments.
min(x,y,..)	Smallest value among all arguments
mod(x,y)	Remainder. x - y*trunc(x/y)

Variables

Variables

z total costs(transportation and fixed costs)

x(i,j) flow fraction for non-stop;

Positive Variable x ;

Variable Type	Allowed Range of Variable
Free (default)	$-\infty$ to $+\infty$
positive	0 to $+\infty$
negative	$-\infty$ to 0
binary	0 or 1
integer	0,1,…., 100 (default)

Equations

Equations

totalCost objective function

flowConservation(i,j) total flow fractions between OD should be equal to 1;

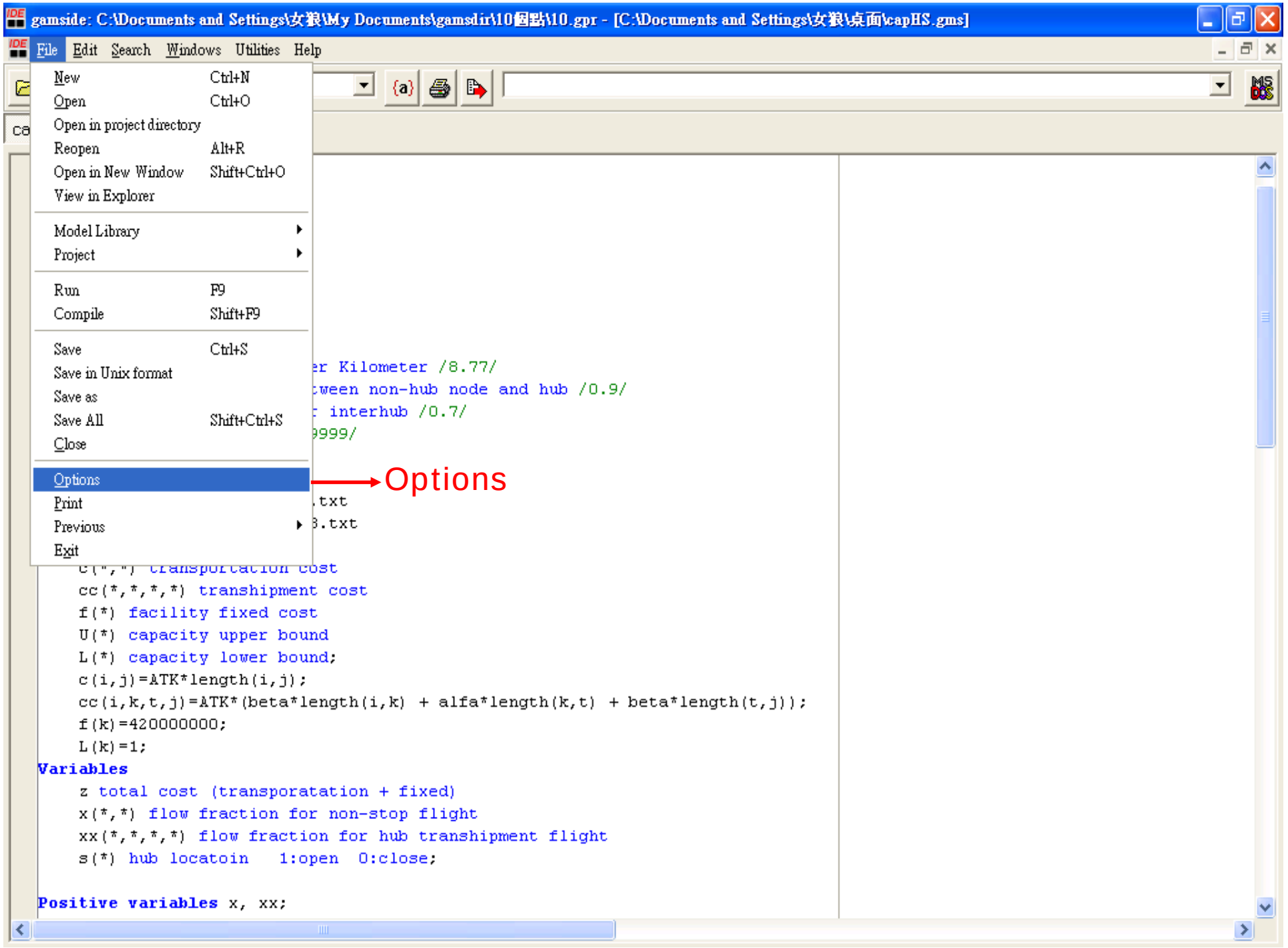
```
cost .. z =e= sum((i,j)$(ord(i) ne ord(j)),
d(i,j)*c(i,j)*x(i,j)) + sum((i,k,t,j)$(ord(i) ne ord(j)),
d(i,j)*cc(i,k,t,j)*xx(i,k,t,j)) + sum((k), f(k)*s(k));
flowConservation(i,j)$(ord(i) ne ord(j)).. x(i,j) +
sum((k,t), xx(i,k,t,j)) =e= 1; ;
```

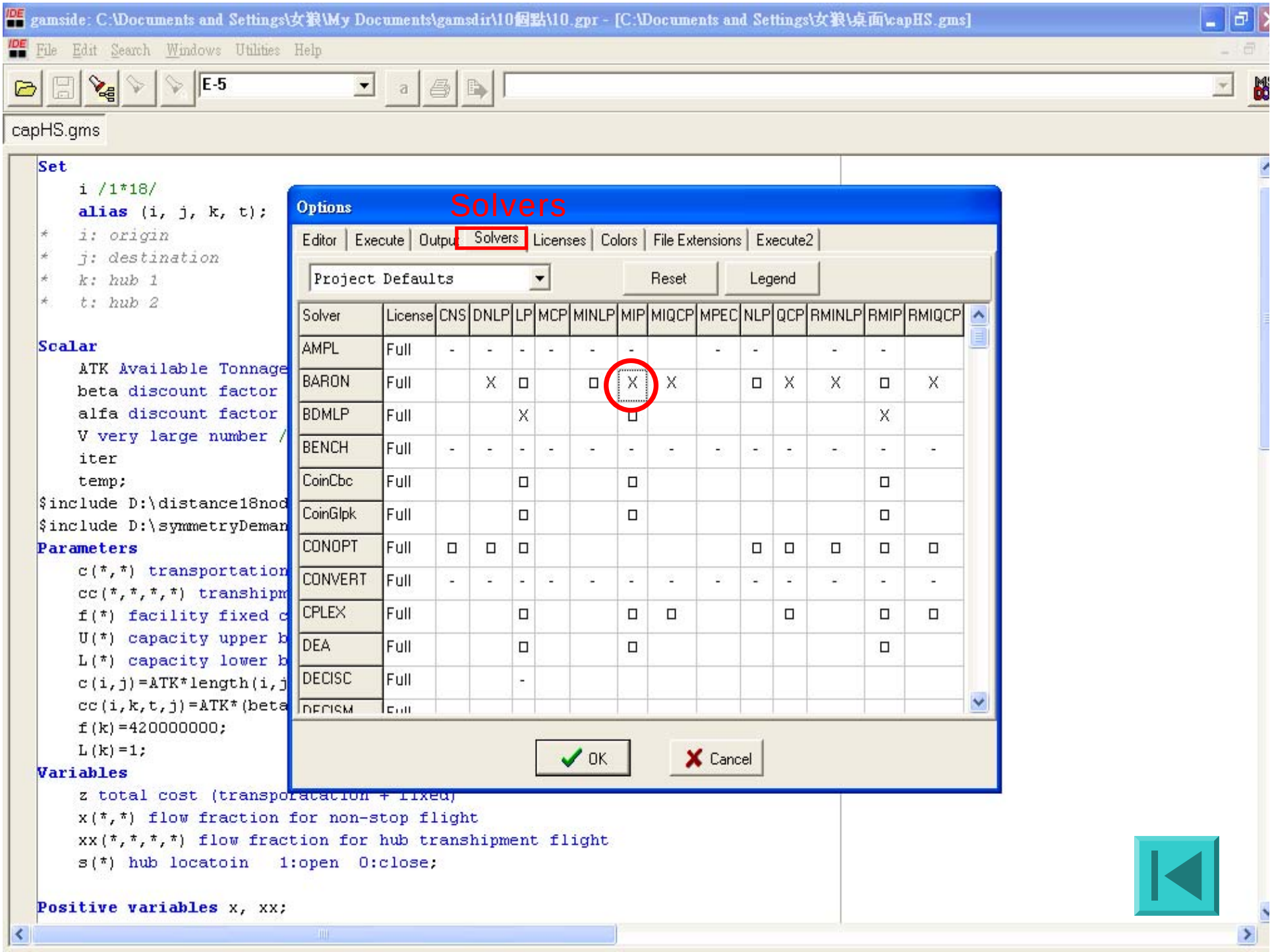
Equation type	Description
=e=	rhs equal lhs
=g=	lhs greater than or equal to rhs
=l=	lhs less than or equal to rhs

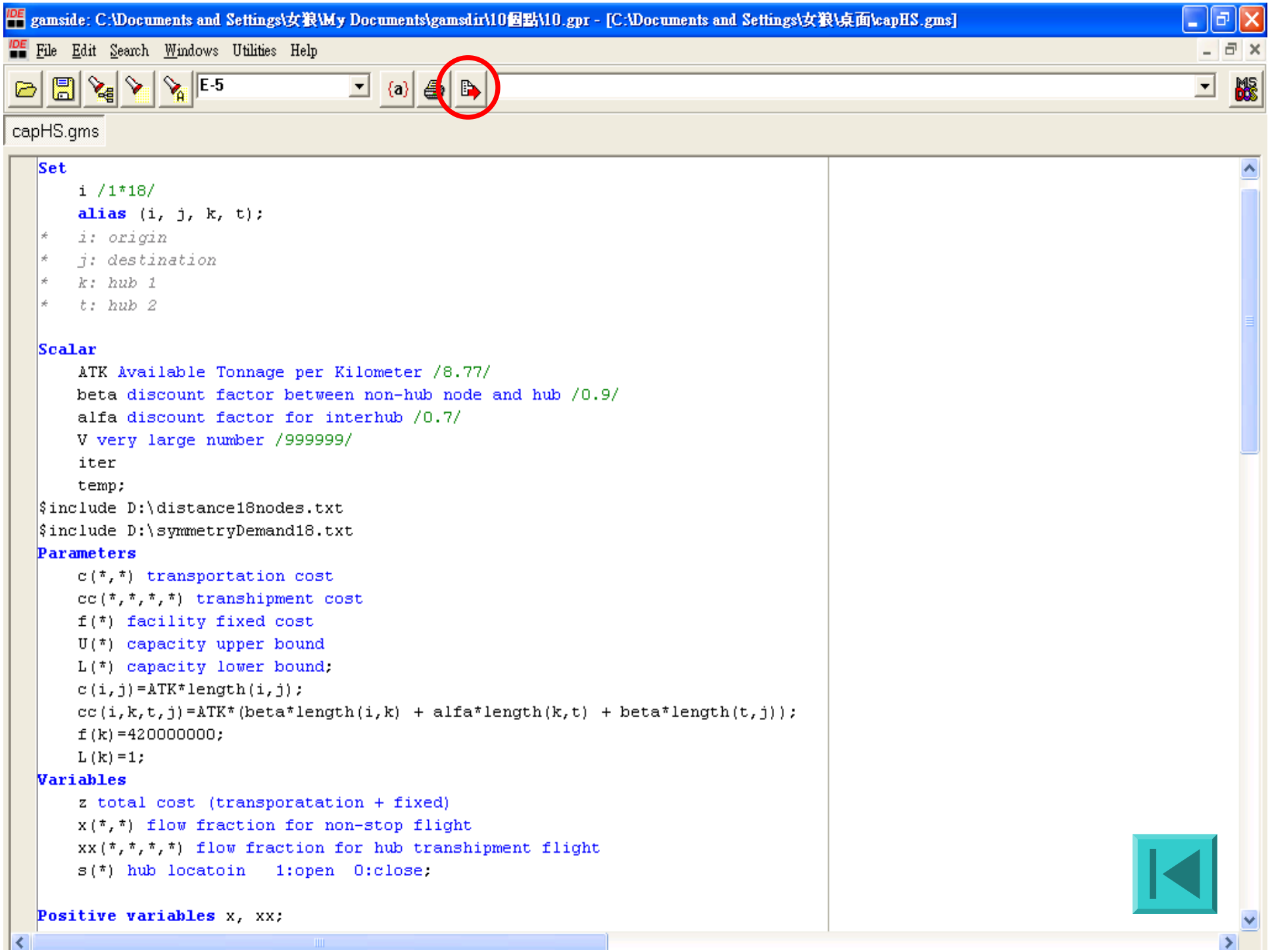
Model and Solve

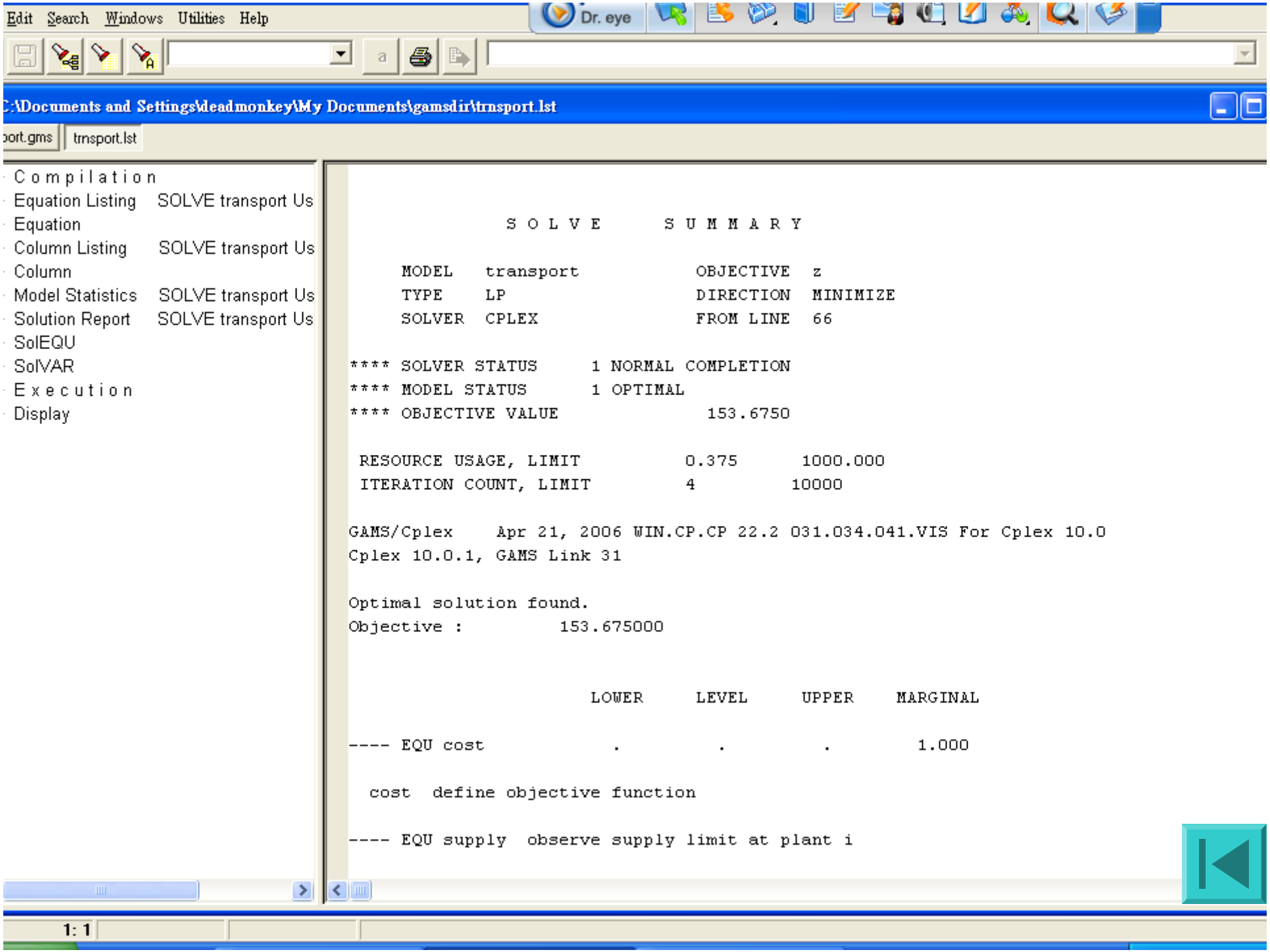
```
Model transport /all/ ;
Solve transport using mip minimizing z ;
Display x.l, z.l ;
```

Type	Description
LP	Linear programming
NLP	Nonlinear programming
MIP	Mixed integer programming
MINLP	Mixed integer nonlinear programming


gamside: C:\Documents and Settings\女狼\My Documents\gamsdir\10個點\10.gpr - [C:\Documents and Settings\女狼\桌面\capHS.gms]
File Edit Search Windows Utilities Help
New Ctrl+N
Open Ctrl+O
Open in project directory
Reopen Alt+R
Open in New Window Shift+Ctrl+O
View in Explorer
Model Library
Project
Run F9
Compile Shift+F9
Save Ctrl+S
Save in Unix format
Save as
Save All Shift+Ctrl+S
Close
Options
Print
Previous
Exit
Options
er Kilometer /8.77/
tween non-hub node and hub /0.9/
t interhub /0.7/
9999/
.txt
3.txt
cc(*,*,*,*) transhipment cost
f(*) facility fixed cost
U(*) capacity upper bound
L(*) capacity lower bound;
c(i,j)=ATK*length(i,j);
cc(i,k,t,j)=ATK*(beta*length(i,k) + alfa*length(k,t) + beta*length(t,j));
f(k)=420000000;
L(k)=1;
Variables
z total cost (transporatation + fixed)
x(*,*) flow fraction for non-stop flight
xx(*,*,*,*) flow fraction for hub transhipment flight
s(*) hub locatoin 1:open 0:close;
Positive variables x, xx;


gamside: C:\Documents and Settings\女猿\My Documents\gamsdir\10個點\10.gpr - [C:\Documents and Settings\女猿\桌面\capHS.gms]
File Edit Search Windows Utilities Help
E-5
capHS.gms
Set
i /1*18/
alias (i, j, k, t);
* i: origin
* j: destination
* k: hub 1
* t: hub 2
Scalar
ATK Available Tonnage
beta discount factor
alfa discount factor
V very large number /
iter
temp;
$include D:\distance18nod
$include D:\symmetryDeman
Parameters
c(*,*) transportation
cc(*,*,*,*) transhipm
f(*) facility fixed c
U(*) capacity upper b
L(*) capacity lower b
c(i,j)=ATK*length(i,j
cc(i,k,t,j)=ATK*(beta
f(k)=420000000;
L(k)=1;
Variables
z total cost (transportation + fixed)
x(*,*) flow fraction for non-stop flight
xx(*,*,*,*) flow fraction for hub transhipment flight
s(*) hub locatoin 1:open 0:close;
Positive variables x, xx;
Options
Solvers
Editor Execute Output Solvers Licenses Colors File Extensions Execute2
Project Defaults
Reset
Legend
Solver License CNS DNLP LP MCP MINLP MIP MIQCP MPEC NLP QCP RMINLP RMIP RMIQCP
AMPL Full - - - - - - - - - - - -
BARON Full X □ □ X X □ X X X □ X
BDMLP Full X □ X
BENCH Full - - - - - - - - - - - - -
CoinCbc Full □ □ □
CoinGlpk Full □ □ □
CONOPT Full □ □ □ □ □ □ □ □ □ □
CONVERT Full - - - - - - - - - - - - -
CPLEX Full □ □ □ □ □ □
DEA Full □ □ □
DECISC Full -
OK
Cancel

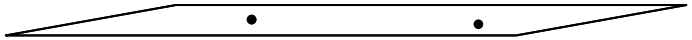

gamside: C:\Documents and Settings\女狼\My Documents\gamsdir\10個點\10.gpr - [C:\Documents and Settings\女狼\桌面\capHS.gms]
File Edit Search Windows Utilities Help
E-5
capHS.gms
Set
i /1*18/
alias (i, j, k, t);
* i: origin
* j: destination
* k: hub 1
* t: hub 2
Scalar
ATK Available Tonnage per Kilometer /8.77/
beta discount factor between non-hub node and hub /0.9/
alfa discount factor for interhub /0.7/
V very large number /999999/
iter
temp;
$include D:\distance18nodes.txt
$include D:\symmetryDemand18.txt
Parameters
c(*,*) transportation cost
cc(*,*,*,*) transhipment cost
f(*) facility fixed cost
U(*) capacity upper bound
L(*) capacity lower bound;
c(i,j)=ATK*length(i,j);
cc(i,k,t,j)=ATK*(beta*length(i,k) + alfa*length(k,t) + beta*length(t,j));
f(k)=420000000;
L(k)=1;
Variables
z total cost (transporatation + fixed)
x(*,*) flow fraction for non-stop flight
xx(*,*,*,*) flow fraction for hub transhipment flight
s(*) hub locatoin 1:open 0:close;
Positive variables x, xx;


Edit Search Windows Utilities Help
Dr. eye
C:\Documents and Settings\deadmonkey\My Documents\gamsdir\trnsport.lst
ort.gms
trnsport.lst
Compilation
Equation Listing SOLVE transport Us
Equation
Column Listing SOLVE transport Us
Column
Model Statistics SOLVE transport Us
Solution Report SOLVE transport Us
SolEQU
SolVAR
Execution
Display
S O L V E S U M M A R Y
MODEL transport OBJECTIVE z
TYPE LP DIRECTION MINIMIZE
SOLVER CPLEX FROM LINE 66
**** SOLVER STATUS 1 NORMAL COMPLETION
**** MODEL STATUS 1 OPTIMAL
**** OBJECTIVE VALUE 153.6750
RESOURCE USAGE, LIMIT 0.375 1000.000
ITERATION COUNT, LIMIT 4 10000
GAMS/Cplex Apr 21, 2006 WIN.CP.CP 22.2 031.034.041.VIS For Cplex 10.0
Cplex 10.0.1, GAMS Link 31
Optimal solution found.
Objective : 153.675000
LOWER LEVEL UPPER MARGINAL
---- EQU cost . . . 1.000
cost define objective function
---- EQU supply observe supply limit at plant i
1: 1

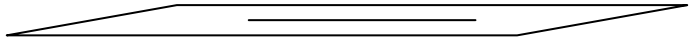
Introduction to TransCad

Structure

- Point Layer



- Line Layer



- Area Layer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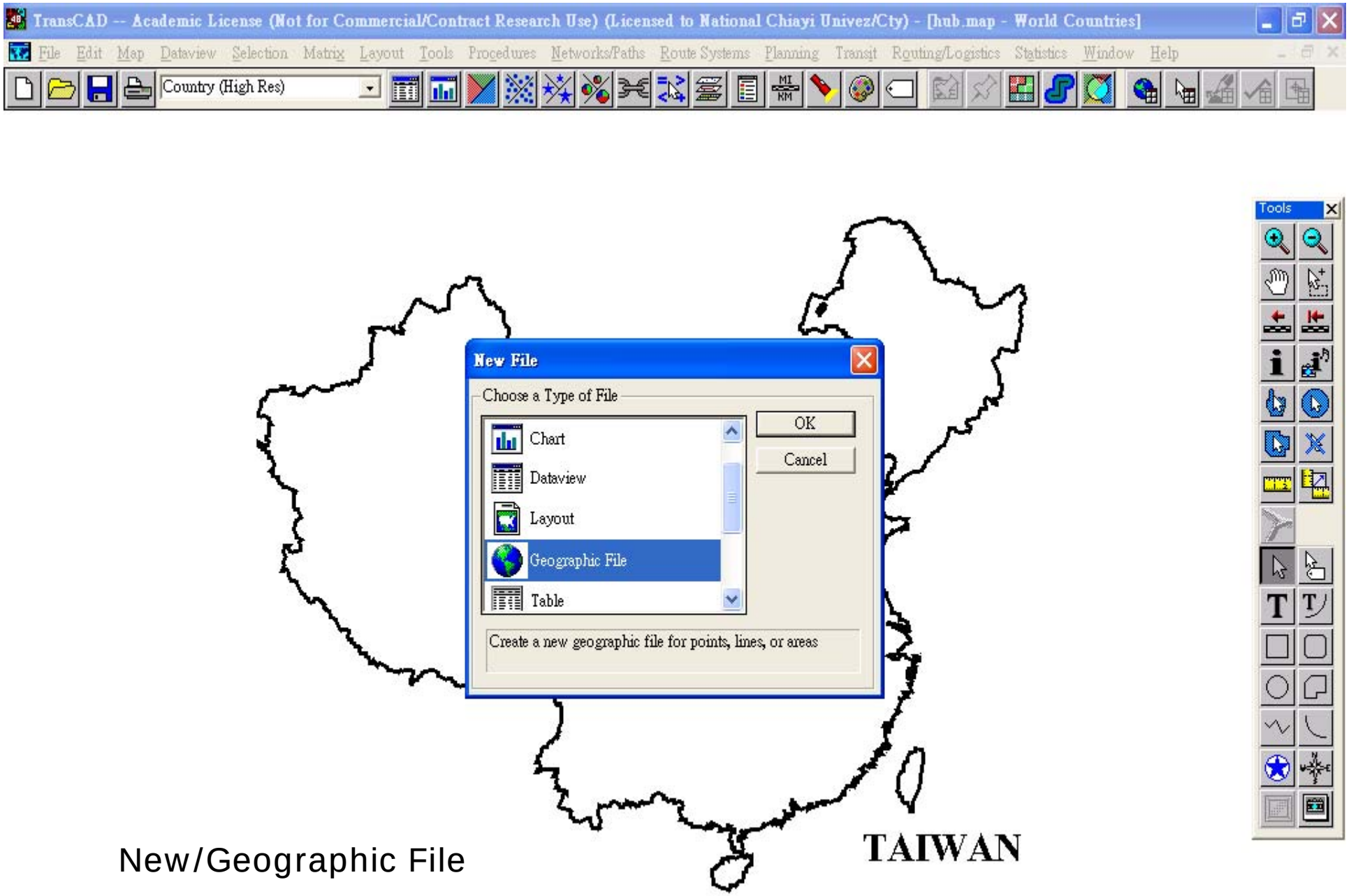
File Edit Map Dataview Selection Matrix Layout Tools Procedures Networks/Paths Route Systems Planning Transit Routing/Logistics Statistics Window Help
Country (High Res)
Tools
CHINA
TAIWAN



New/Geographic File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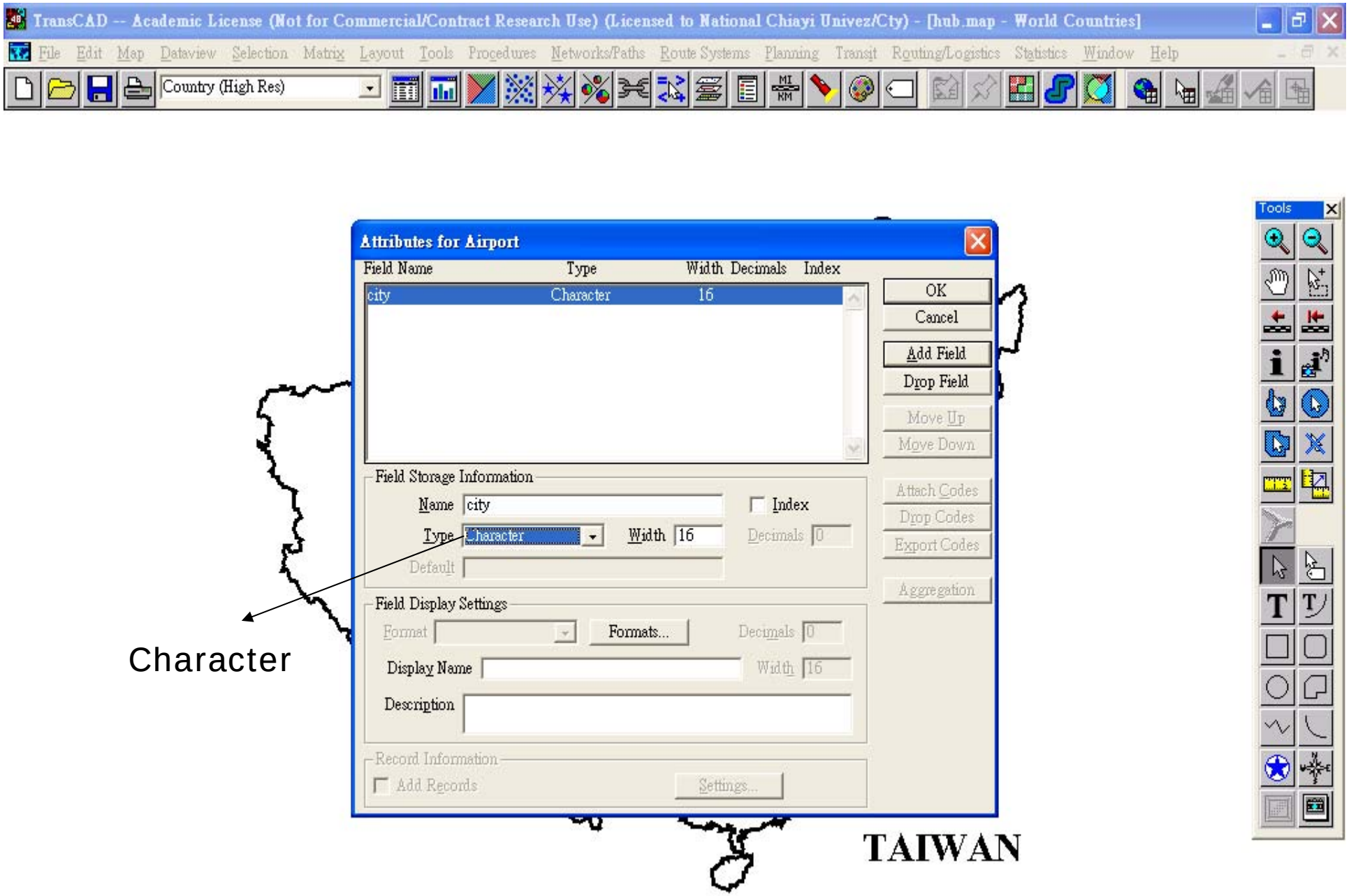
File Edit Map Dataview Selection Matrix Layout Tools Procedures Networks/Paths Route Systems Planning Transit Routing/Logistics Statistics Window Help
Country (High Res)
New Geographic File
Choose a Type of File
Point Geographic File
Line Geographic File
Area Geographic File
OK
Cancel
Layer Settings
Name Airport
Options
Add the layer to the current map window
Show the layer in a new map window
Endpoint Layer Settings
Tools
TAIWAN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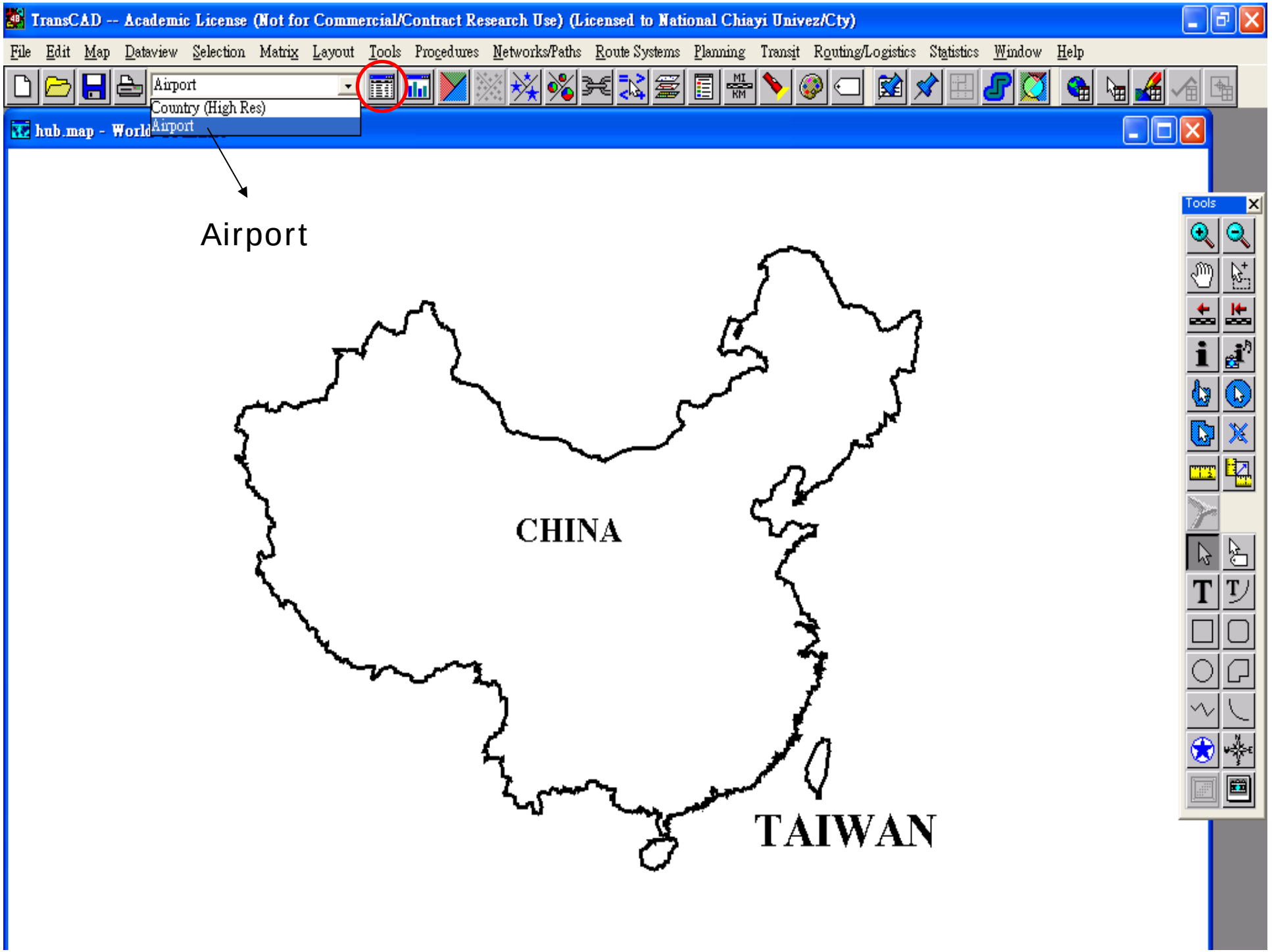
File Edit Map Dataview Selection Matrix Layout Tools Procedures Networks/Paths Route Systems Planning Transit Routing/Logistics Statistics Window Help
Country (High Res)
Attributes for Airport
Field Name Type Width Decimals Index
city Character 16
OK
Cancel
Add Field
Drop Field
Move Up
Move Down
Attach Codes
Drop Codes
Export Codes
Aggregation
Field Storage Information
Name city
Index
Type Character
Width 16
Decimals 0
Default
Field Display Settings
Format
Formats...
Decimals 0
Display Name
Width 16
Description
Record Information
Add Records
Settings...
Character
TAIWAN
Tools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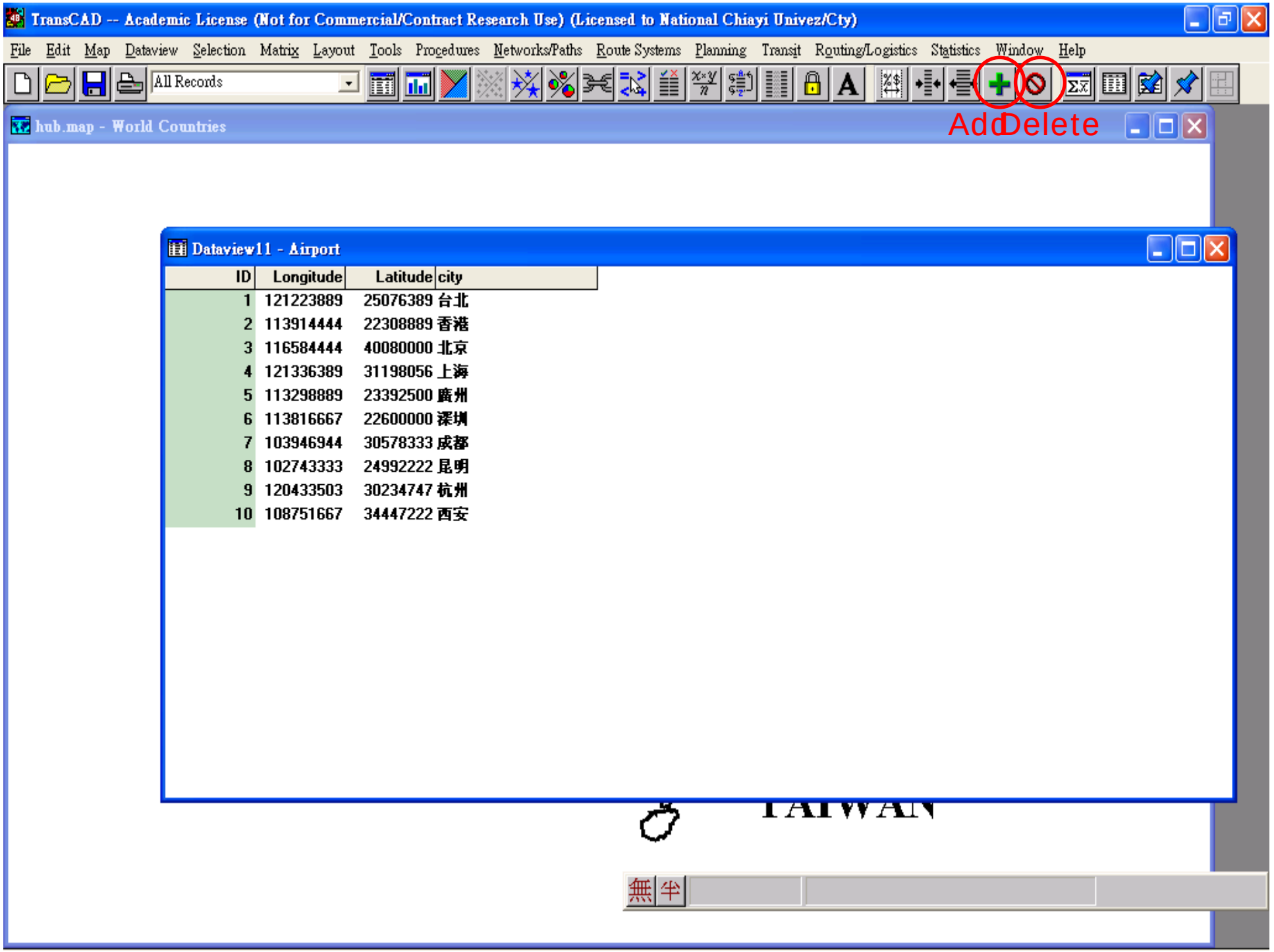
File Edit Map Dataview Selection Matrix Layout Tools Procedures Networks/Paths Route Systems Planning Transit Routing/Logistics Statistics Window Help
Airport
Country (High Res)
Airport
hub.map - World
Airport
Tools
CHINA
TAIWAN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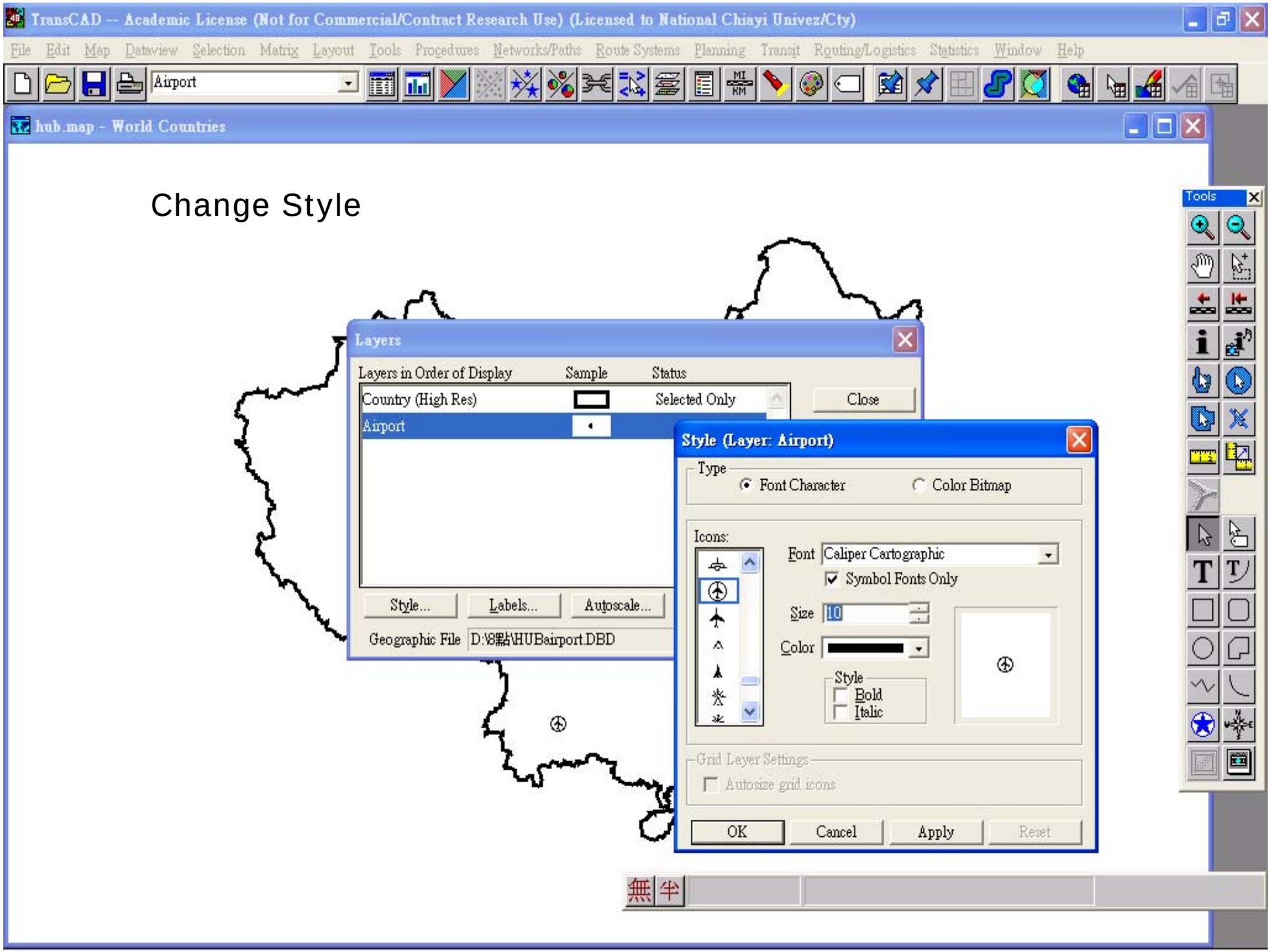
File Edit Map Dataview Selection Matrix Layout Tools Procedures Networks/Paths Route Systems Planning Transit Routing/Logistics Statistics Window Help
All Records
Add
Delete
hub.map - World Countries
Dataview11 - Airport
ID Longitude Latitude city
1 121223889 25076389 台北
2 113914444 22308889 香港
3 116584444 40080000 北京
4 121336389 31198056 上海
5 113298889 23392500 廣州
6 113816667 22600000 深圳
7 103946944 30578333 成都
8 102743333 24992222 昆明
9 120433503 30234747 杭州
10 108751667 34447222 西安
TAIWAN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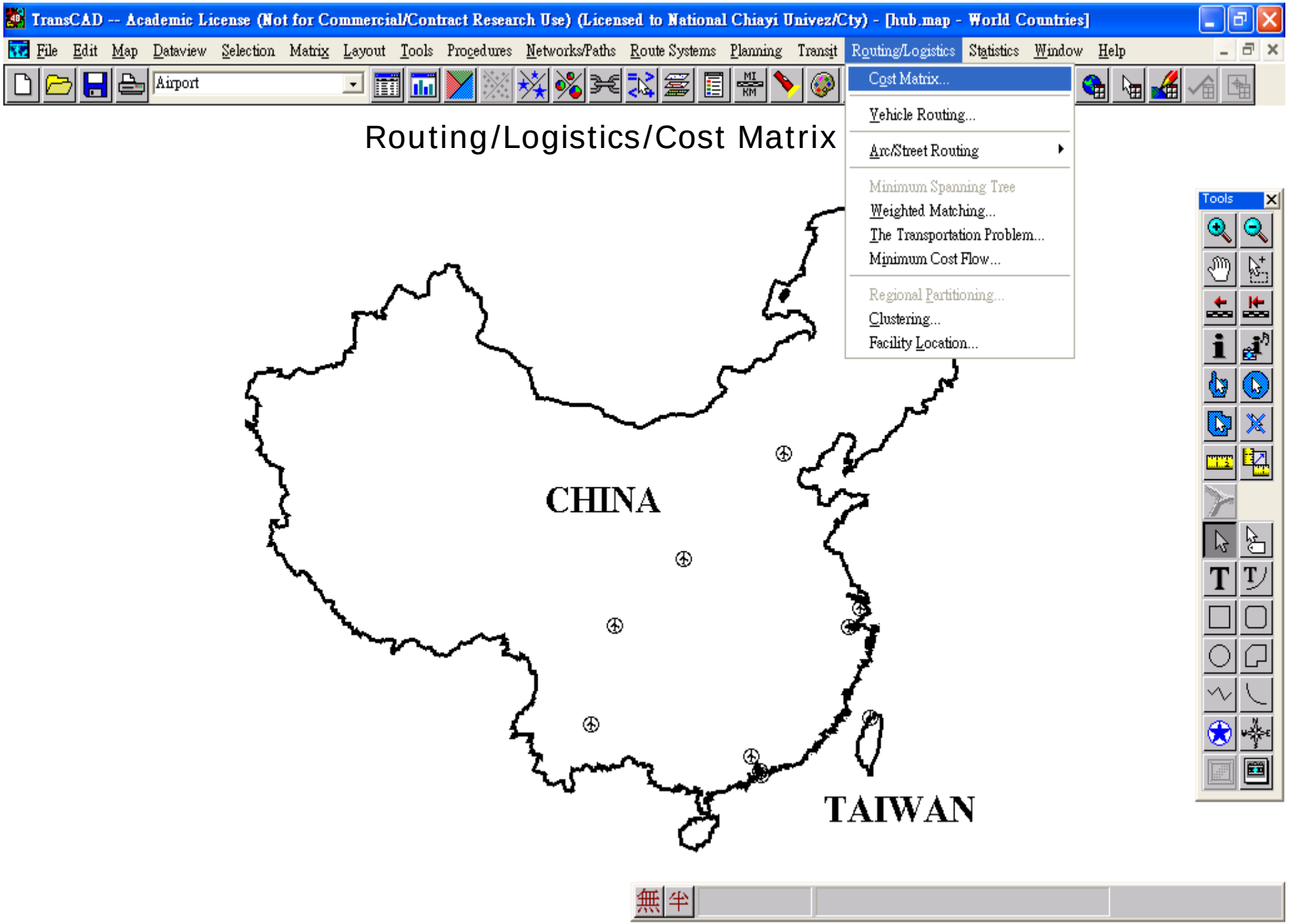
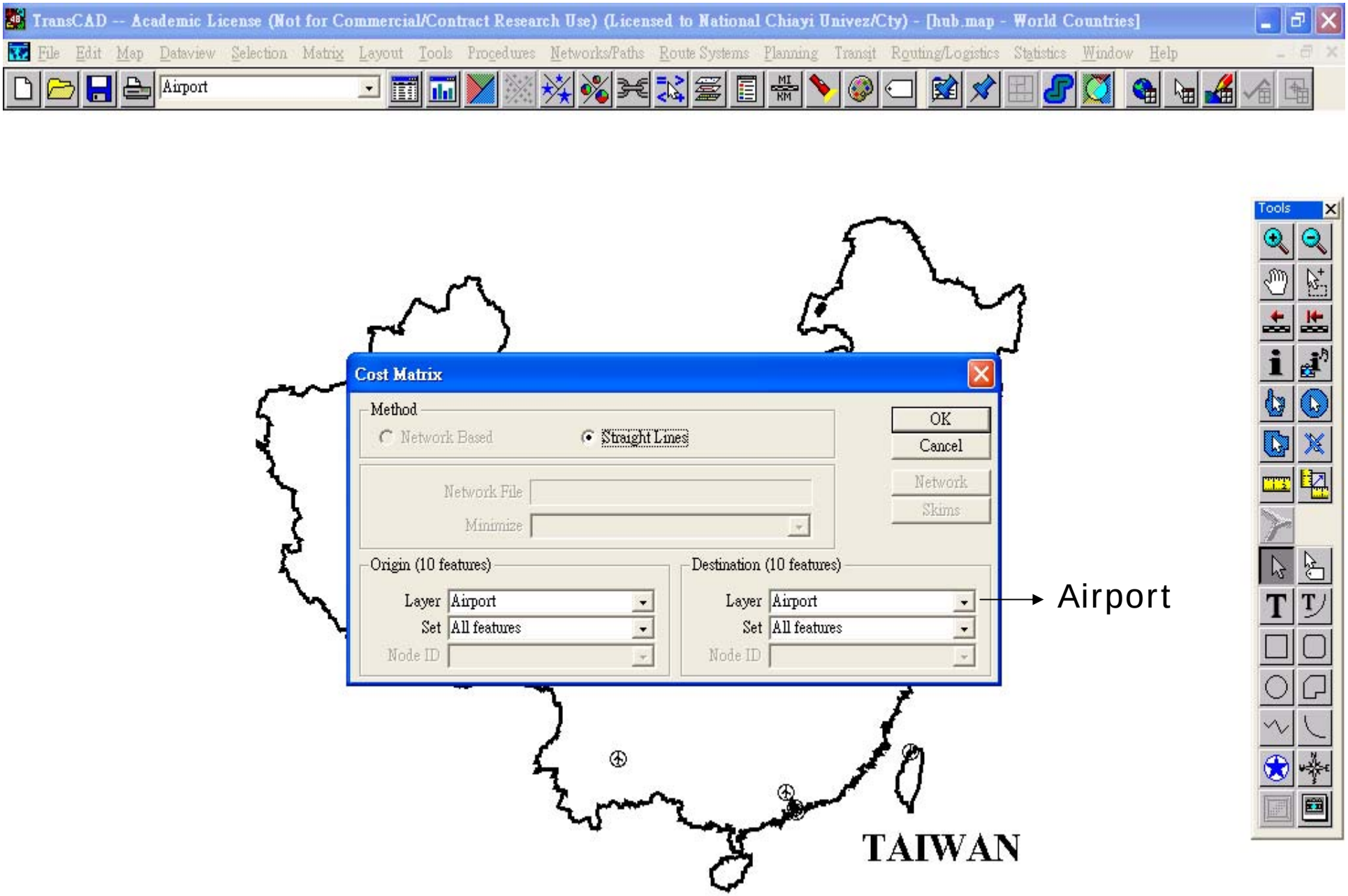
File Edit Map Dataview Selection Matrix Layout Tools Procedures Networks/Paths Route Systems Planning Transit Routing/Logistics Statistics Window Help
Airport
hub.map - World Countries
Change Style
Layers
Layers in Order of Display
Sample
Status
Country (High Res)
Selected Only
Airport
Close
Style...
Labels...
Autoscale...
Geographic File
D:\8點\HUBairport.DBD
Style (Layer: Airport)
Type
Font Character
Color Bitmap
Icons:
Font
Caliper Cartographic
Symbol Fonts Only
Size
10
Color
Style
Bold
Italic
Grid Layer Settings
Autosize grid icons
OK
Cancel
Apply
Reset
Tools



Routing/Logistics/Cost Matrix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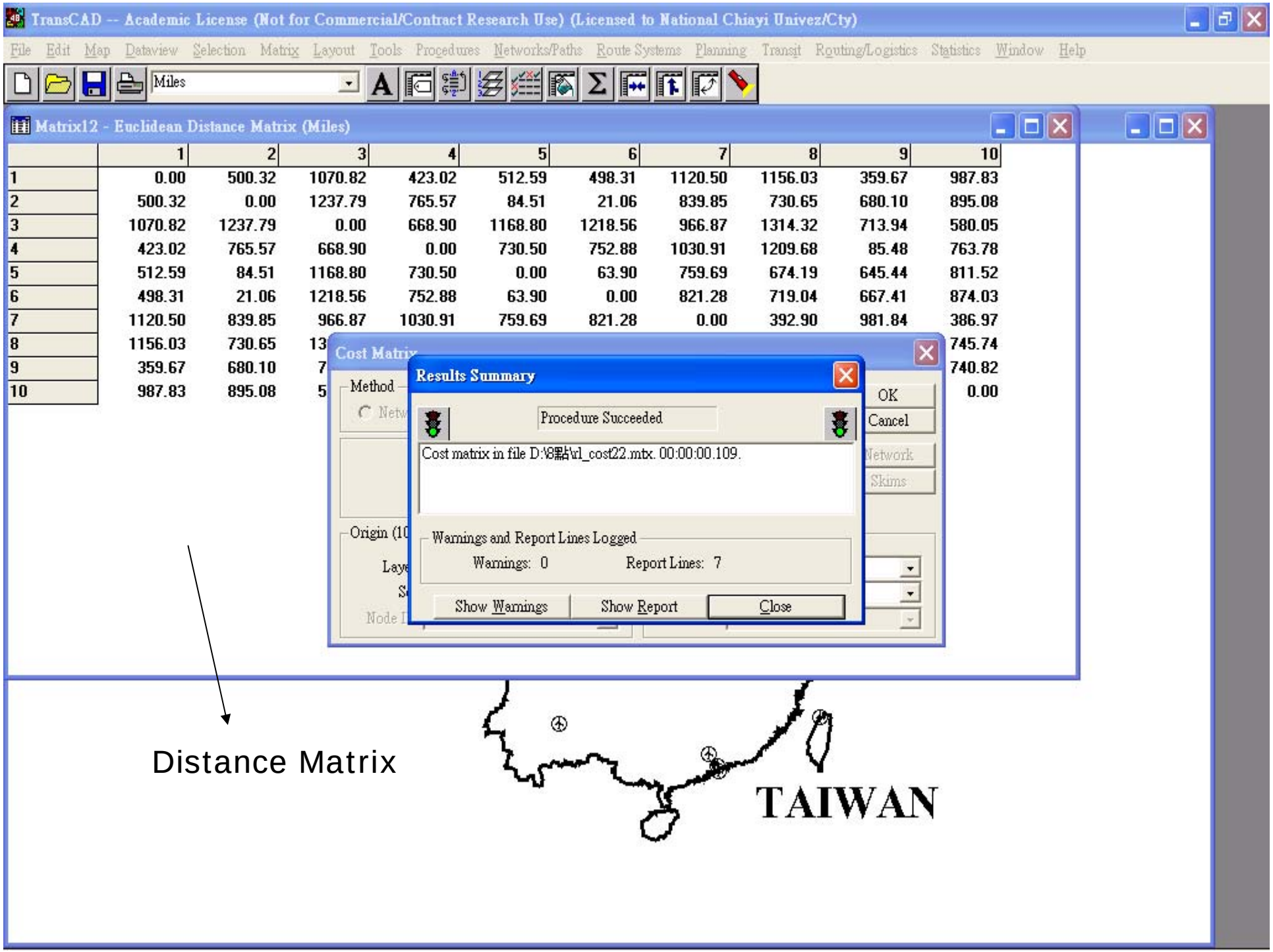
File Edit Map Dataview Selection Matrix Layout Tools Procedures Networks/Paths Route Systems Planning Transit Routing/Logistics Statistics Window Help
Airport
Cost Matrix
Method
Network Based
Straight Lines
OK
Cancel
Network
Skims
Network File
Minimize
Origin (10 features)
Layer Airport
Set All features
Node ID
Destination (10 features)
Layer Airport
Set All features
Node ID
Airport
Tools
TAIWAN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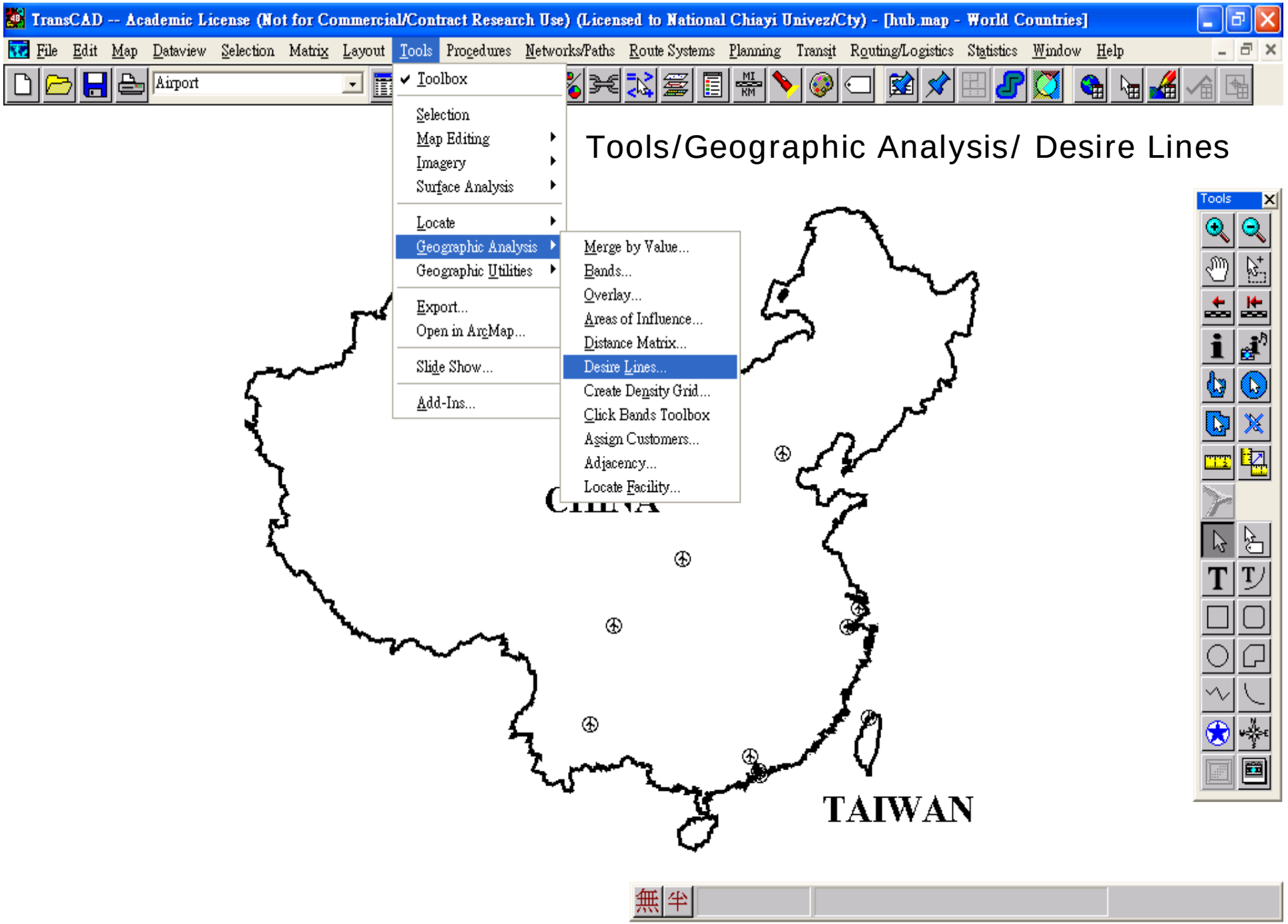
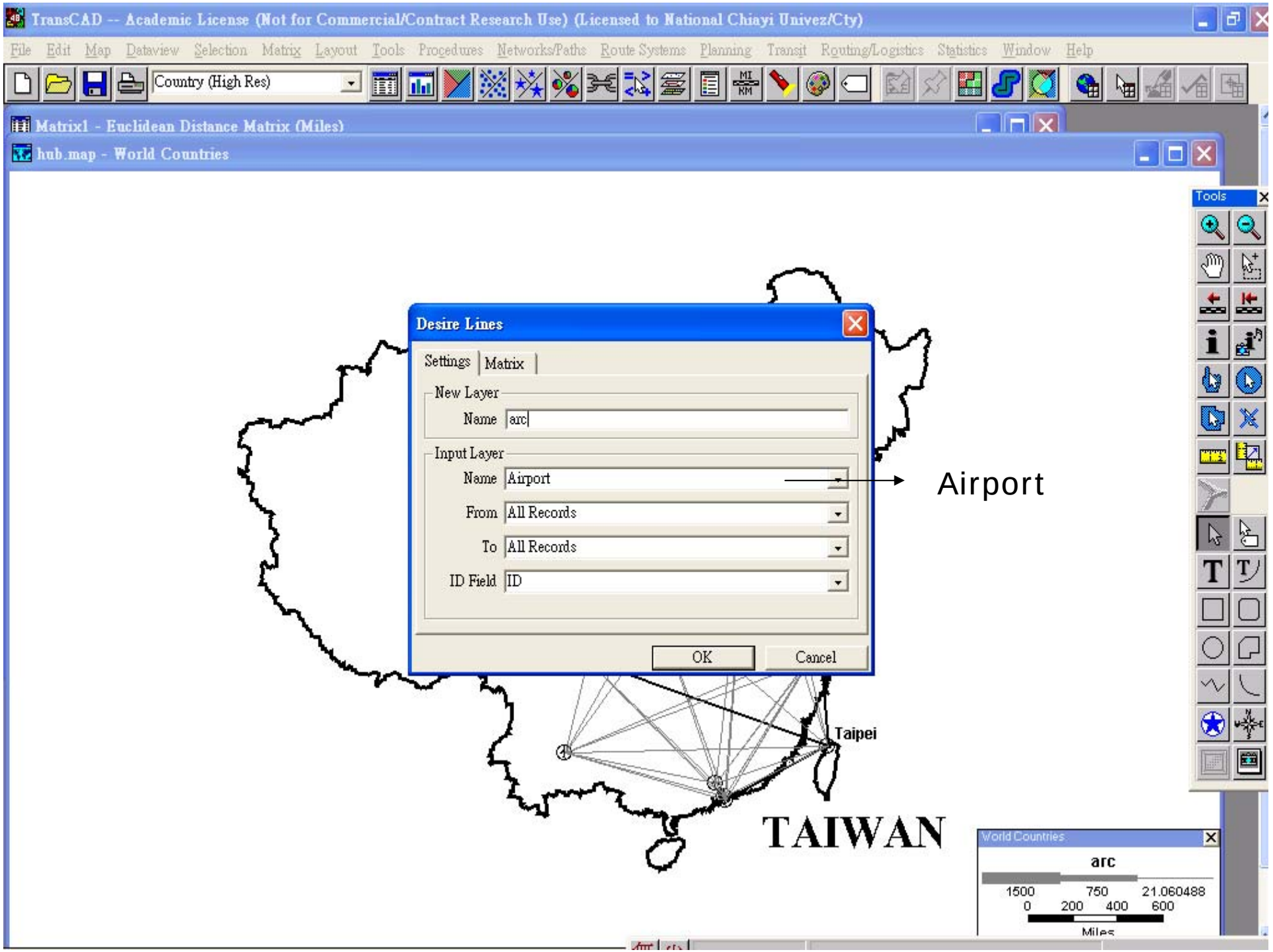
File Edit Map Dataview Selection Matrix Layout Tools Procedures Networks/Paths Route Systems Planning Transit Routing/Logistics Statistics Window Help
Miles
Matrix12 - Euclidean Distance Matrix (Miles)
1 2 3 4 5 6 7 8 9 10
1 0.00 500.32 1070.82 423.02 512.59 498.31 1120.50 1156.03 359.67 987.83
2 500.32 0.00 1237.79 765.57 84.51 21.06 839.85 730.65 680.10 895.08
3 1070.82 1237.79 0.00 668.90 1168.80 1218.56 966.87 1314.32 713.94 580.05
4 423.02 765.57 668.90 0.00 730.50 752.88 1030.91 1209.68 85.48 763.78
5 512.59 84.51 1168.80 730.50 0.00 63.90 759.69 674.19 645.44 811.52
6 498.31 21.06 1218.56 752.88 63.90 0.00 821.28 719.04 667.41 874.03
7 1120.50 839.85 966.87 1030.91 759.69 821.28 0.00 392.90 981.84 386.97
8 1156.03 730.65 13 745.74
9 359.67 680.10 7 740.82
10 987.83 895.08 5 0.00
Cost Matrix
Method
OK
Cancel
Network
Skims
Origin (10
Results Summary
Procedure Succeeded
Cost matrix in file D:\8點\rl_cost22.mtx. 00:00:00.109.
Warnings and Report Lines Logged
Warnings: 0
Report Lines: 7
Show Warnings
Show Report
Close
Distance Matrix
TAIWAN



Tools/Geographic Analysis/ Desire Lines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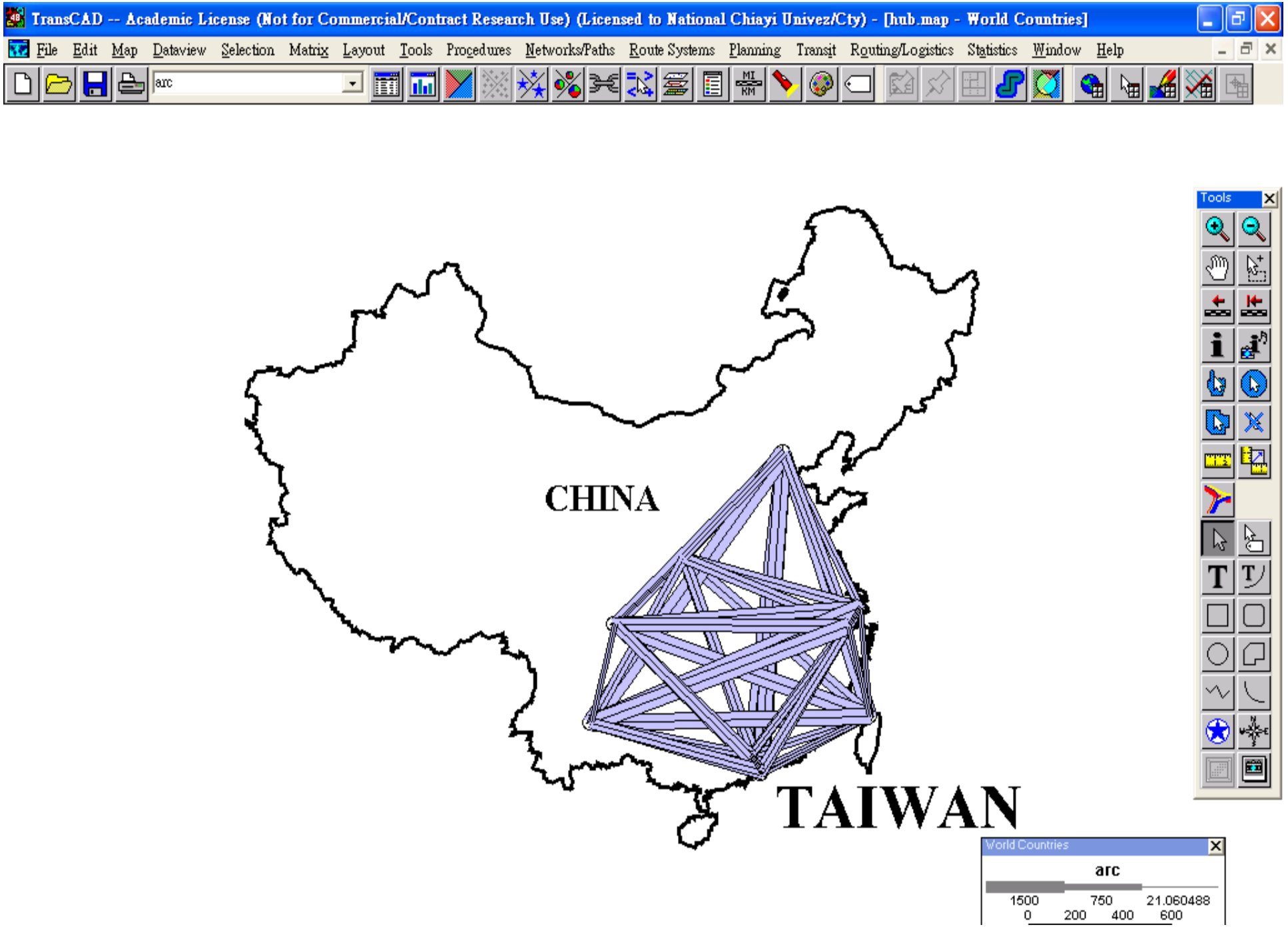
File Edit Map Dataview Selection Matrix Layout Tools Procedures Networks/Paths Route Systems Planning Transit Routing/Logistics Statistics Window Help
Country (High Res)
Matrix1 - Euclidean Distance Matrix (Miles)
hub.map - World Countries
Tools
Desire Lines
Settings
Matrix
New Layer
Name arc
Input Layer
Name Airport
From All Records
To All Records
ID Field ID
OK
Cancel
Airport
Taipei
TAIWAN
World Countries
arc
1500 750 21.060488
0 200 400 600
Miles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File Edit Map Dataview Selection Matrix Layout Tools Procedures Networks/Paths Route Systems Planning Transit Routing/Logistics Statistics Window Help
arc
Tools
CHINA
TAIWAN
World Countries
arc
1500 750 21.060488
0 200 400 600

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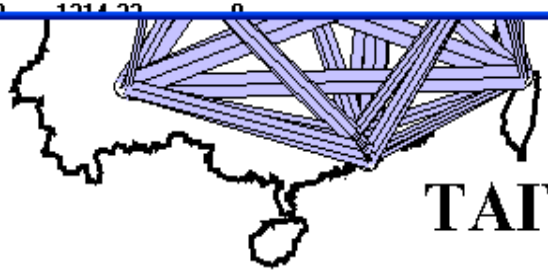
File Edit Map Dataview Selection Matrix Layout Tools Procedures Networks/Paths Route Systems Planning Transit Routing/Logistics Statistics Window Help

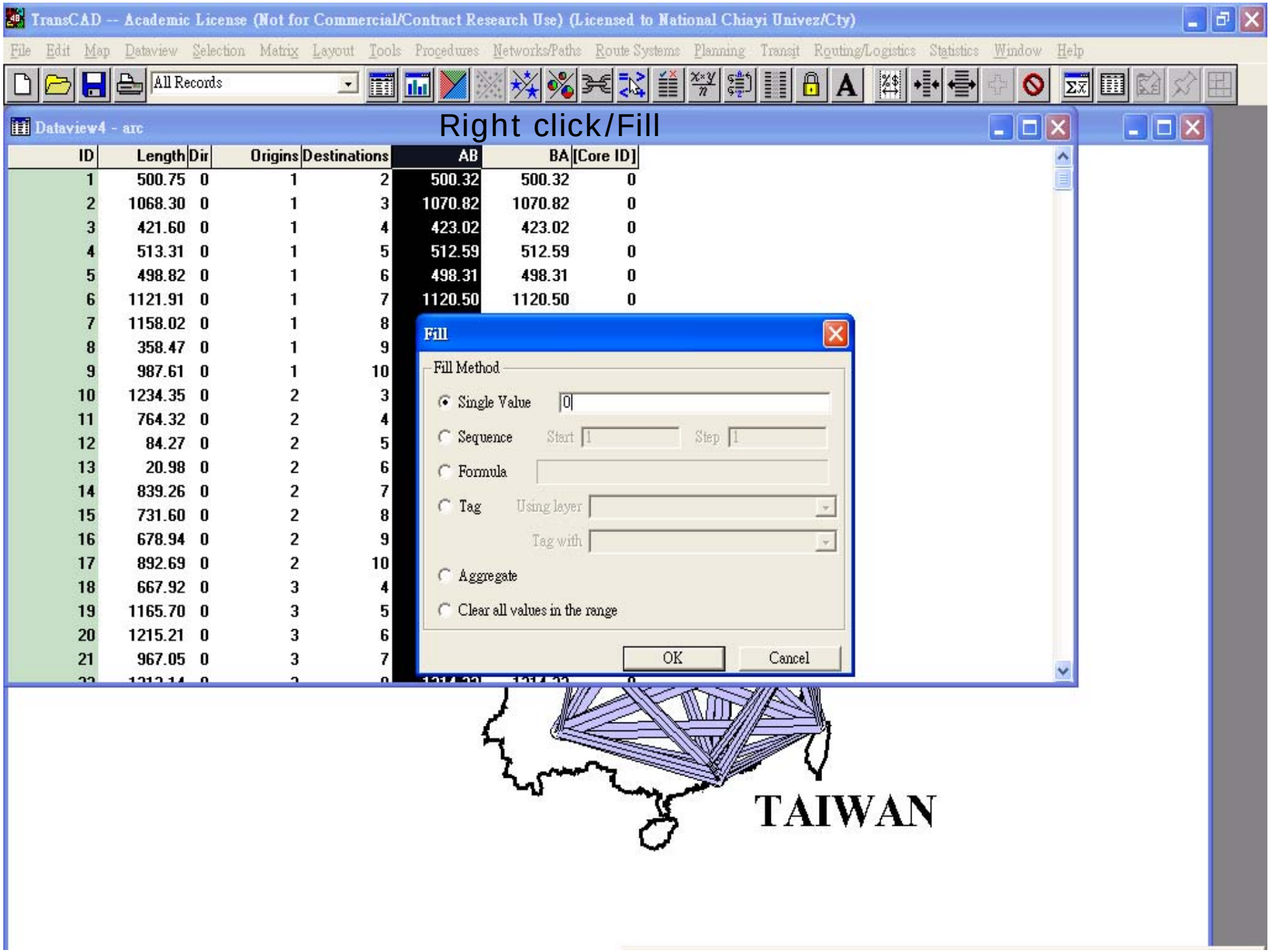
All Records

Dataview4 - arc

ID	Length	Dir	Origins	Destinations	AB	BA	[Core ID]
1	500.75	0	1	2	500.32	500.32	0
2	1068.30	0	1	3	1070.82	1070.82	0
3	421.60	0	1	4	423.02	423.02	0
4	513.31	0	1	5	512.59	512.59	0
5	498.82	0	1	6	498.31	498.31	0
6	1121.91	0	1	7	1120.50	1120.50	0
7	1158.02	0	1	8	1156.03	1156.03	0
8	358.47	0	1	9	359.67	359.67	0
9	987.61	0	1	10	987.83	987.83	0
10	1234.35	0	2	3	1237.79	1237.79	0
11	764.32	0	2	4	765.57	765.57	0
12	84.27	0	2	5	84.51	84.51	0
13	20.98	0	2	6	21.06	21.06	0
14	839.26	0	2	7	839.85	839.85	0
15	731.60	0	2	8	730.65	730.65	0
16	678.94	0	2	9	680.10	680.10	0
17	892.69	0	2	10	895.08	895.08	0
18	667.92	0	3	4	668.90	668.90	0
19	1165.70	0	3	5	1168.80	1168.80	0
20	1215.21	0	3	6	1218.56	1218.56	0
21	967.05	0	3	7	966.87	966.87	0



TAIWAN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File Edit Map Dataview Selection Matrix Layout Tools Procedures Networks/Paths Route Systems Planning Transit Routing/Logistics Statistics Window Help
All Records
Right click/Fill
Dataview4 - arc
ID Length Dir Origins Destinations AB BA [Core ID]
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5 498.82 0 1 6 498.31 498.31 0
6 1121.91 0 1 7 1120.50 1120.50 0
7 1158.02 0 1 8
8 358.47 0 1 9
9 987.61 0 1 10
10 1234.35 0 2 3
11 764.32 0 2 4
12 84.27 0 2 5
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14 839.26 0 2 7
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16 678.94 0 2 9
17 892.69 0 2 10
18 667.92 0 3 4
19 1165.70 0 3 5
20 1215.21 0 3 6
21 967.05 0 3 7
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Sequence Start 1 Step 1
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Tag Using layer
Tag with
Aggregate
Clear all values in the range
OK
Cancel
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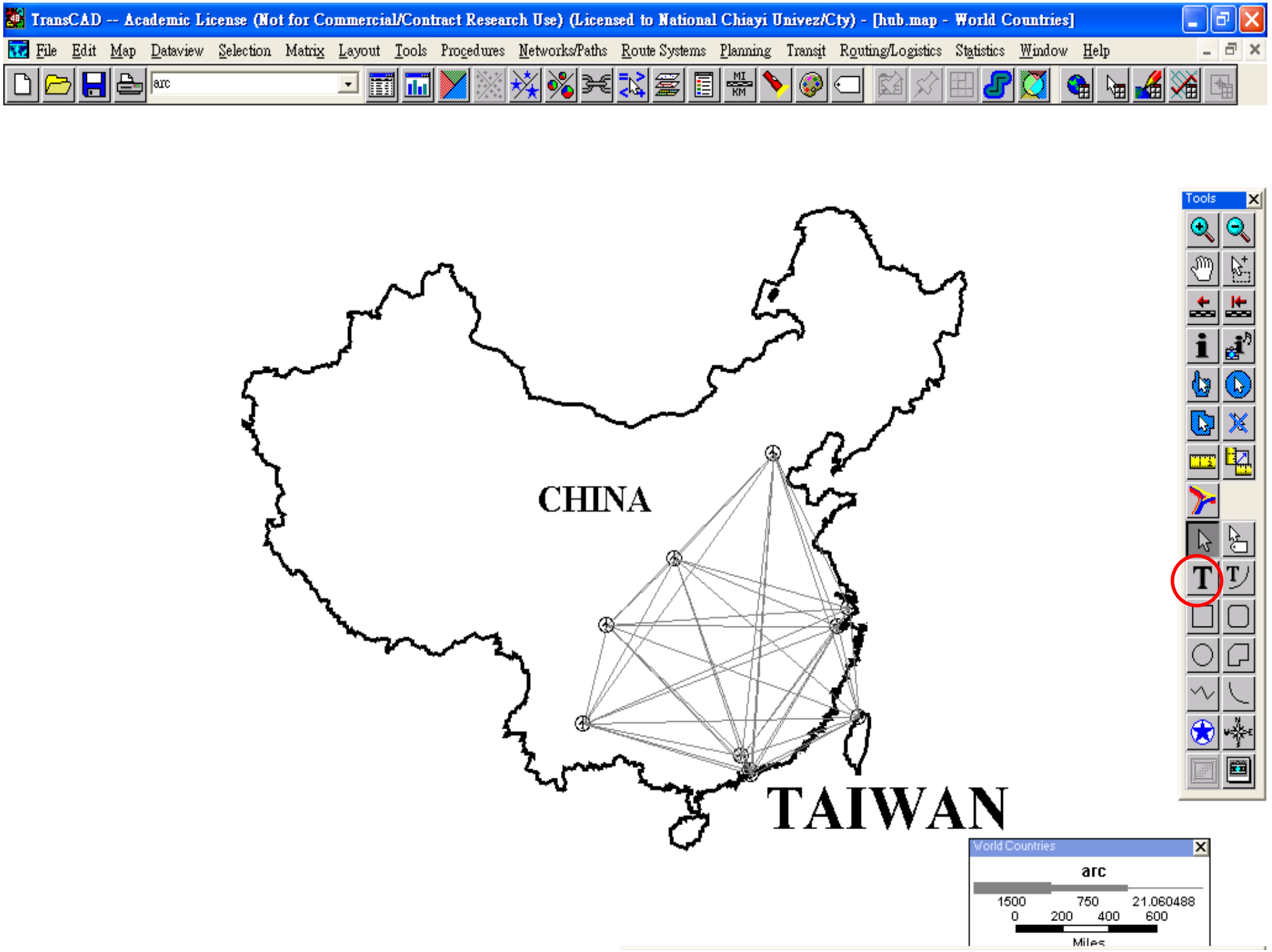
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World Countries
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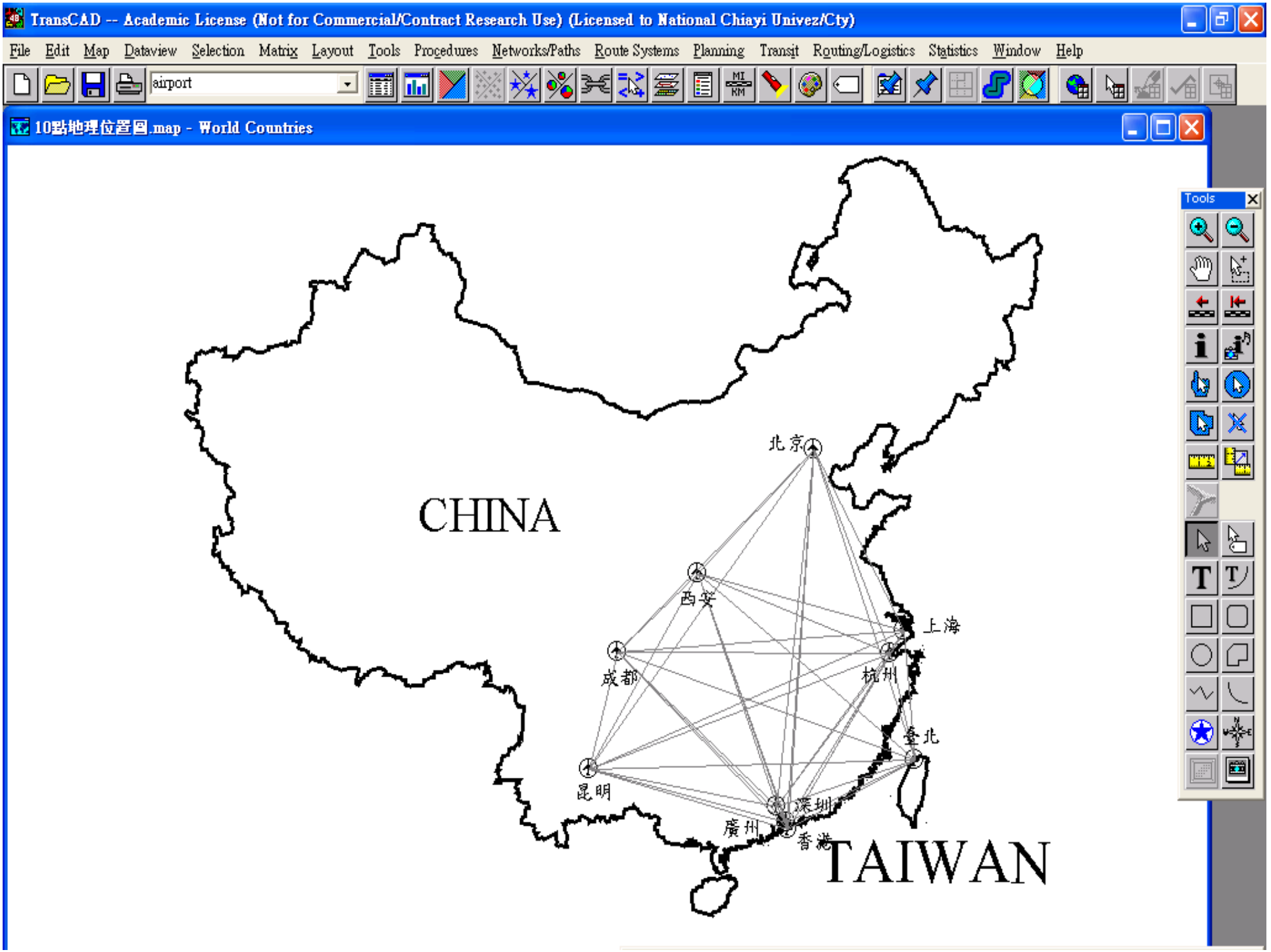
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THE END