To: William A Davidson

From: Matthew Martimo

Date: 10/14/2011

Subject: AUTOCON DEVELOPMENT – Transit Model Update

The AUTOCON methodology for developing drive access links for the transit networks, as provided in the source code from Dave Schmitt, has been incorporated into the PT GENERATE methodology of automated connector generation process within the Voyager PT module. By using the new keywords in the PT GENERATE control statement, the following functionalities are realized:

1. Generates PNR and KNR drive-access connectors, where the mode number for PNR, KNR and auto access can be specified by the user with keywords.

2. Allows skipping generation of connectors for certain user defined zones.

3. Allows overriding specific connections, either by deleting or replacing them.

4. Calculates weighted costs for the connectors. This weighting takes into account:

   - Value of time

   - Inflation on various cost components (transit, parking etc.)

   - Out-of-vehicle time versus transit-in-vehicle time ratio

   - Drive access time versus transit-in-vehicle time ratio

   - Auto occupancy for PNR and KNR

5. Penalizes drive times that are outside defined distances from the stations.

6. Connectors are checked for "relevancy" (i.e. It will not generate a connector to a station farther away but in the same general direction of a closer station).

7. Connectors are checked for "backtracking" (i.e. When a station is on the other side of the CBD or a station is in the opposite direction of the CBD).

8. Eliminates connections to stations if the CBD is closer and the station does not have a premium service.

9. If the second shortest connector is ignored because it is in the same general direction of the first shortest connector and CHECKRELEVANCE is True, the program considers additional connectors farther away for other "relevance" connectors.

10. More connectors are considered to identify reasonable connectors if the top two connectors are over the backtracking limit. The maximum connectors to consider and generate can be set by the user using two parameters.

11. Stations with no PT service are ignored instead of being lumped together in one set.

MEMORANDUM

This update is provided in the Cube Voyager 6.x series of software.

The documentation updates of input/output data specification and addition keywords needed to control the process are detailed below. The names enclosed in () are names used in the existing AutoCon program to specify the same parameter.

DATA INPUT

NETWORK
Input by PT **NETI** Keyword. The program will automatically read the X, Y coordinates from the network.

As requested by FDOT, the program will also **read the station information directly from the network**. The station information should be presented by various fields as below:
- STANUM :   Station number, must be unique
- STAZ: Station zone number
- MAXD: Maximum distance * 100 for each station
- SPACE: Number of parking space
- STACOST_AM: Station parking cost (AM)
- STACOST_MD: Station parking cost (MD)
- STAW_PNR: Station terminal time (PNR)
- STAW_KNR: Station terminal time (KNR)
- TSTYPE: Station type
- STA_NAME: Station name
- N: Station node number (Same as network node #)

PT Line Data
Input by PT FILEI **LINEI** keyword

Skim Matrix
Input by PT FILEI **MATI** keyword

Override Data
Input by PT FILEI **NTLEGI** keyword. A new keyword **XTRAAUTONTLEGI** (see detailed definition in late section) in PT GENERATE is used to indicate the NTLEGI number

DATA OUTPUT

Generated NT Connectors
Output by PT FILEO **NTLEGO** keyword, where PNR, KNR, and drive access results are distinguished by respective mode number specified by user

Generation Report
Output by **PRINT PRINTO** keyword. A new keyword **GENREPORT** (see detailed definition in late section) in PT GENERATE is used to indicate the PRINTO number

| Connector List Report | Output by **PRINT PRINTO** keyword. A new keyword **CONNREPORT** (see detailed definition in late section) in PT GENERATE is used to indicate the PRINTO number |

Please note that any printing from the script to that PRINTO file will intermix with the printing from the enhanced AutoCon process so user should not use the AutoCon PRINTO file for other printing purposes.

GENERATION PARAMETERS

| PNR | |?| | Flag indicating if turn on the enhanced AUTOCON process. |

Default is False.

| KNR | |?| | Flag indicating if turn on the additional Kiss and Ride generation for AUTOCON. |

Default is False.

| XTRAAUTONTLEGI | |I| | *Optional.* To specify the NTLEGI file number to use. The ACTION keyword in the NT records are used to control the action of the override data. |

Default is no override data.

| SKIPZONES | |S| | *Optional.* To specify the zones should not be considered in the AUTOCON process. |

Default is no Skip Zones.

| CONNREPORT | |I| | To specify the PRINTO number for connector list (ACONLIST) |

| GENREPORT | |I| | To specify the PRINTO number for AUTOCON report (AUTOCONRPT) |

| PERIOD | |I| | To indicate the AUTOCON process period. (PERIOD) |

- 0 - OFFPEAK period
- 1 - PEAK period

TIMEMAT	|NV|	Numerical expression used to get the time skim matrix (TIMEMAT)
DISTMAT	|NV|	Numerical expression used to get the distance skim matrix
INTERNALZONES	|S|	To specify the internal zones to process (ZONESI)
CBDZONE	|I|	To Specify the CBD area (CDBZONE)
DISTANCEFACTOR	|R|	To specify the factor to convert distance to coordinate (UNITS)
PREMIUMMODE	$|IVm|^1$	To indicate premium service by mode (PRFLAG]M]) • 0 - the mode is not premium • 1 - the mode is premium
MODEPRIORITY	$|IVm|^1$	To indicate priority by mode (PRIORITY]M]) Range from 1 to 999, default is 999
INFLTRANSITFARE	|R|	To specify inflation factor for transit fare (InflTransitFare)
INFLAOC	|R|	To specify inflation factor for auto operating cost (InflAOC)
INFLPARKINGCOST	|R|	To specify inflation factor for parking cost (InflParking Cost)
VOT	|RV|	To specify the value of time in $/hour (VOT). Different values could be set for different PERIOD.
OVTRATIO	|RV|	To specify the ratio of OVT/IVT mode choice coefficients (OVTRRATIO). Different values could be set for different PERIOD.
AATRATIO	|RV|	To specify the ratio of drive-access time to IVT mode choice coefficients (AATRATIO). Different values could be set for different PERIOD.

ORIGINTERMTIME |R| To specify the terminal time for origin (TERM).

DEFDRIVETIME |R| To specify default drive-access time used if time from matrix is zero (DEF).

CHECKRELEVANCE |?| Flag to indicate if check relevance of the connectors (NOPT).

CHECKBACKTRACT |?| Flag to indicate if check backtracking of the connectors (BACK).

MAXBACKDIST |R| To specify the maximum backtracking distance allowed (BACKD).

MAXBACKFACTOR |R| To specify the maximum backtracking factor allowed (BACKPC)

AUTOCCPNR |R| To specify the auto occupancy for PNR (AUTOCCPNR)

AUTOCCKNR |R| To specify the auto occupancy for KNR (AUTOCCKNR)

AOC |R| To specify the auto operating cost (AOC)

MAXCHECK |I| To specify the maximum connectors to consider

MAXCONN |I| To specify the maximum connectors to use

PNRMODE |I| To allow user specify the mode for PNR connectors

KNRMODE |I| To allow user specify the mode for KNR connectors

AUTOMODE |I| To allow user specify the mode for auto access connectors (for AUTODAT file)

AUTOMATCH |?| To indicate if use original AUTOCON logic or enhanced AUTOCON logic

                          Default is True

1. m indicates the maximum number of modes

ENHANCED AUTOCON LOGIC

The keyword AUTOMATCH indicates if the program uses the same logic as AUTOCON FORTRAN code or not.

Note that , actually even we choose AUTOMATCH=1, the outputs from the PT program have already reflected enhancements as below comparing to the original AUTOCON FORTRAN program by fixed the following bugs and allow more control flexibilities. This should be counted when we considering the ENHANCEMENTS implemented in the PT program:

- In the PT program, the station information can be directly read from the network/GEO database input. This provides much better integration of the AUTOCON functionality with the Geo system, while the original AUTOCON can only get the input from the ASCII file

- In the initialization of the node array, the PT program completely initialized the array, while the original AUTOCON only initializes the first 400 nodes in the array. It means that the information of the nodes from pervious lines that have over 400 nodes will still be in the node array of AUTOCON and affects the computation thereafter.

  Note: This problem if not fixed, *will cause the NERPM model to generate incorrect connectors* because some PT lines have more than 400 nodes

- In the PT program, the RELEVENCE check really takes effect in PT program, which means the generated connectors will be different if using relevance check.

  However, in original AUTOCON program, the option NOPT doesn't work. *For CFRPM model, identical results are produced regardless NOPT parameter set to 0 or 1*.

- In the PT, *the mode number for PNR, KNR and auto access can be specified by the user* with keywords PNRMODE, KNRMODE and AUTOMODE, while the original AUTOCON program cannot.

- In the PT , *the stations with no PT service have been ignored* in the process, unlike being lumped together in one set in original AUTOCON. This improves the performance of the excution.

- In the PT, maximum number of connectors to consider and generate is set by keywords MAXCHECK and MAXCONN. It provides more flexibility for controlling the generation process.

- In the PT, the OVERRIDE process was controlled by the NTLEGI file specified by keyword XTRAAUTONTLEGI. This enables the users to utilize the PT ACTION controls under the NT keyword, where a NT leg can be added, deleted, conditionally replaced or unconditionally replaced, while the original AUTOCON cannot provide such powerful functionalities.

- In the PT computation of the station parking cost, the STAC formula was corrected to reflect the right inflation factor.
  - ☐ (in STAC(NN,2)=((STAC(NN,2)*INFL(1))/(DIR(2)*AO(1)))*VOT(PERIOD))

- In the PT computation using station terminal time, the STAW is corrected to be not period specific
  (in TT = (COND(L,NDD,5)/100.0*aatrat(PERIOD)) + (dd/100.0*AOC*INFL(2)
  *VOT(PERIOD))/AO(1)+STAC(K,PERIOD)+STAW(K,PERIOD) +   (TERM*OVTRAT(PERIOD)))

Once we set AUTOMATCH to 1, except all those already incorporated enhancements mentioned above, the following additionally enhancements are implemented for the improvement of the inside connector generation logic:

- After the connectors were generated during the process, they need to be checked for their relevance or back tracking.
  In the original AUTOCON program, the relevance check is performed for the first connector even if the first connector may be discarded later.
  To correct and enhance this logic, in the PT program, a pre-screen process is incorporated in the relevance check: if the corresponding station of the connector has no premium service, and it is too close to the CBD area, the connector will be skipped. In addition, if the unweighted drive access time or weighted travel time outside range is greater than the threshold, the connector will be skipped. This enhancement will improve the performance of the relevance check.

- During the checking of the generated connectors, the PT program monitors the number of checks and number of connectors for each route set (based on MMMLLL route signifier). Once the number of checks or number of connectors reach the maximum check or connector constrains, the program will done with the current route set and move to the next one.

- In addition, in the process of checking feasibility of the connectors (after the checking the first connector in the first step above), the enhanced logic in PT checks the relevance only for connectors which is not the first connector and also passed other tests, CBD closer, time over limit, etc.. The original AUTOCON program, however, only check CBD closer, time over limit test after the top 2 connectors are selected.

- After the relevance check, the program needs to do back track check before write out the NT connectors. In the original AUTOCON program, the CBD closer check and time limit check is placed after this backtrack check. In the enhanced logic in PT, these checks are integrated and moved to the pre-screen section for better performance.

EXAMPLE

As shown in Appendix, the PT AUTOCON process that can be implemented using the latest PT version has been tested using the data provided from the NERPM (Northeast Regional Planning Model). The user can define the same parameter values along with the 'GENERATE' statement in the PT program as utilized in the original AUTOCON program. The Figure 1 shows an example defining the parameter settings that are converted from the original control file to the PT AUTOCON script. Note that the detail information for the sub-keywords can be referred in the previous sections of this documentation.
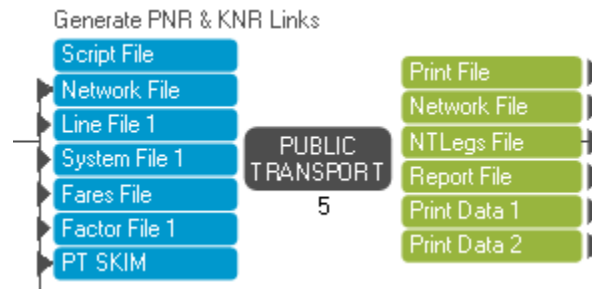
Figure 1. Examples of AUTOCON parameter settings

< Original AUTOCON control >

```
; Output
AUTOCONRPT              C:\Cube_PT_Updates_NERPM
PNRAUTOAM               C:\Cube_PT_Updates_NERPM
PNRAUTOMD               C:\Cube_PT_Updates_NERPM
KNRAUTOAM               C:\Cube_PT_Updates_NERPM
KNRAUTOMD               C:\Cube_PT_Updates_NERPM
; AutoCon Parameters
AUTOCONVERSION          2
ZONESI                  2494
CBDZONE                 730
TERM                    2.00
DEF                     2.00
NOPT                    1
BACK                    1
BACKD                   4.0
BACKPC                  0.30
UNITS                   5280
MAXMODE                 27
MODENUM (not used)       21 22 23 24 25 26 27
PREMIUMFLAG              0  1  0  1  1  1  1
MODEPRIORITY             7  5  7  2  1  4  3
VOTAM                   6.00
VOTMD                   3.00
OVTRATIOAM              2.00
OVTRATIOMD              2.00
AATRATIOAM              1.50
AATRATIOMD              1.50
AUTOCCPNR               1.2
AUTOCCKNR               1.2
AOC                     9.5
InflTransitFare         0.9487
InflAOC                 1
InflParkingCost         1.1976
AUTODATAM               C:\Cube_PT_Updates_NERPM
AUTODATMD               C:\Cube_PT_Updates_NERPM
ACONLISTAM              C:\Cube_PT_Updates_NERPM
ACONLISTMD              C:\Cube_PT_Updates_NERPM
```

< PT AUTOCON script >

```
PROCESS PHASE=DATAPREP
   ; GENERATE AUTO CONNECTORS FOR PNR AND KNR
   list='\nGenerate Zone Access/Egress Legs'
   GENERATE,
     PNR=T,
     KNR=T,
     PERIOD=1,
     PNRMODE=2,
     KNRMODE=3,
     INTERNALZONES=1-2494,
     CBDZONE=730,
     ORIGINTERMTIME=2.0,
     DEFDRIVETIME=2.0,
     CHECKRELEVANCE=1,
     CHECKBACKTRACK=1,
     MAXBACKDIST=4.0,
     MAXBACKFACTOR=0.30,
     DISTANCEFACTOR=5280,
     PREMIUMMODE=0,1,0,1,1,1,
     MODEPRIORITY=7,5,7,2,1,4,3,
     VOT=6,3,
     OVTRATIO=2,2,
     AATRATIO=1.5,1.5,
     AUTOCCPNR=1.2,
     AUTOCCKNR=1.2,
     AOC=9.5,
     INFLTRANSITFARE=0.9487,
     INFLAOC=1,
     INFLPARKINGCOST=1.1976,
     MAXCHECK = 2,
     MAXCONN = 2,
     CONNREPORT=1,
     GENREPORT=2,
     TIMEMAT=MI.1.4,
     DISTMAT=MI.1.2,
     AUTOMATCH=T      ; T=original logic, F=Enhanced logic
ENDPROCESS
```

The user can create the Cube application including the PT program to perform the AUTOCON process as displayed in Figure 2. The input and output files can be defined using the interface tool by the Cube application manager. See the Cube manual for further information regarding managing the Cube application. The input files are set using the highway and transit networks, factor, fare, system, and PT skimming files. The user should create the separated PT programs for time periods such as peak and off-peak. The output files are defined by three files related to the

AUTOCON process in addition to one network file that includes highway network, transit network, and non-transit links. The report output file also provides the PT run information.

Figure 2. PT AUTOCON module


```
FILEI MATI[1] = "{SCENARIO_DIR}\RHSKIMS1_PT.MAT"
FILEI LINEI[1] = "{CATALOG_DIR}\Input_Data\TROUTE_05A.LIN"
FILEI NETI = "{SCENARIO_DIR}\PRELOAD_PT_PNR.NET"
FILEI FACTORI[1] = "{CATALOG_DIR}\Input_Data\PNRPrj.FAC"
FILEI FAREI = "{CATALOG_DIR}\Input_Data\TFARES_05A.FAR"
FILEI SYSTEMI = "{CATALOG_DIR}\Input_Data\SYSTEM.PTS"

FILEO NETO = "{SCENARIO_DIR}\PT_NTPNR_PK.NET"
FILEO NTLEGO = "{SCENARIO_DIR}\PT_PNR_PK.NTL"
FILEO REPORTO = "{SCENARIO_DIR}\PT_PNR_PK.RPT"
FILEO PRINTO[1] = "{SCENARIO_DIR}\PT_NTLEG2PK_A05.PRN"
FILEO PRINTO[2] = "{SCENARIO_DIR}\PT_AUTOCON.OUT"
```

As shown in Figure 3, The PT AUTOCON process generates three output files such as non-transit links, additional information for drive-access links, and reports. Unlike the original AUTOCON process, the PT AUTOCON process generates both the PNR (Park-and-Ride, MODE=2) links and KNR (Kiss-and-Ride, MODE=3) links into one output files.

Once the PT AUTOCON process is implemented, the user can utilize either the non-transit drive-access links (e.g. PNR or KNR links) or the output network to perform the transit skimming process and the transit assignment process. However, if the user wants to use only the PNR access links by excluding the KNR access links, it is suggested that the followed Matrix program can extract only the PNR links from the non-transit drive-access link file.

Figure 3. Examples of output files by PT AUTOCON process

< Non-transit links (e.g. 'PNRAUTOAM' & 'KNRAUTOAM' in original AUTOCON) >

```
;;<<PT>>;;
NT LEG=188-28469 MODE=2 COST=69.18 DIST=4.38 ONEWAY=T
NT LEG=188-28469 MODE=3 COST=66.18 DIST=4.38 ONEWAY=T
NT LEG=191-37148 MODE=2 COST=96.05 DIST=4.44 ONEWAY=T
NT LEG=191-37148 MODE=3 COST=93.05 DIST=4.44 ONEWAY=T
NT LEG=197-37148 MODE=2 COST=84.59 DIST=4.38 ONEWAY=T
NT LEG=197-37148 MODE=3 COST=81.59 DIST=4.38 ONEWAY=T
NT LEG=198-37148 MODE=2 COST=46.54 DIST=3.82 ONEWAY=T
NT LEG=198-37148 MODE=3 COST=43.54 DIST=3.82 ONEWAY=T
NT LEG=200-28469 MODE=2 COST=59.66 DIST=4.26 ONEWAY=T
NT LEG=200-28469 MODE=3 COST=56.66 DIST=4.26 ONEWAY=T
```

< Additional information for drive-access links (e.g. 'ACONLISTAM' in original AUTOCON) >

```
188,  28469,    3.00,   4.38,   4.85,   2.22,   33.63,  38.47,  1.50,   57.70,  9.50,   41.62,
191,  37148,    3.00,   4.44,   5.63,   2.70,   50.72,  56.35,  1.50,   84.53,  9.50,   42.19,
197,  37148,    3.00,   4.38,   5.46,   2.51,   43.29,  48.75,  1.50,   73.12,  9.50,   41.62,
198,  37148,    3.00,   3.82,   5.90,   1.60,   17.78,  23.67,  1.50,   35.51,  9.50,   36.30,
200,  28469,    3.00,   4.26,   4.80,   2.01,   27.39,  32.19,  1.50,   48.28,  9.50,   40.48,
202,  37148,    3.00,   3.45,   5.10,   0.76,   5.50,   10.59,  1.50,   15.89,  9.50,   32.78,
227,  64893,    3.00,   3.38,   6.44,   0.81,   5.98,   12.42,  1.50,   18.63,  9.50,   32.12,
228,  64893,    3.00,   2.61,   3.93,   0.00,   0.00,   3.93,   1.50,   5.90,   9.50,   24.80,
229,  58551,    3.00,   3.40,   7.00,   0.93,   7.23,   14.22,  1.50,   21.34,  9.50,   32.31,
230,  58551,    3.00,   3.91,   6.92,   2.09,   29.71,  36.62,  1.50,   54.93,  9.50,   37.15,
233,  64893,    3.00,   1.59,   3.36,   0.00,   0.00,   3.36,   1.50,   5.04,   9.50,   15.11,
233,  65945,    3.00,   3.98,   5.31,   1.73,   20.43,  25.74,  1.50,   38.60,  9.50,   37.81,
234,  58551,    3.00,   2.50,   6.61,   0.00,   0.00,   6.61,   1.50,   9.92,   9.50,   23.75,
```

< AUTOCON reports (e.g. 'AUTOCONRPT' in original AUTOCON) >

```
NUMBER OF STATIONS:    32
STA     NODE    ZONE    MAXD    USE   RTE
  1,    19503, 2270,         300,    1,    210002
  2,    20242, 2203,         300,    1,    210045
  3,    23981, 2296,         300,    1,    210072
  4,    27395, 2224,         300,    1,    210056
  5,    28469,  841,         300,    1,    210067
 21,    35753,  677,         300,    0,         0
 22,    35792,  677,         300,    0,         0
  6,    37144,  738,         300,    0,         0
  7,    37148,  843,         300,    1,    210068
  8,    37203,  729,         300,    0,         0
  9,    37231,  719,         300,    0,         0
 26,    37705,  766,         300,    0,         0
 10,    38041,  665,         300,    0,         0
 24,    38942,  767,         300,    0,         0
 11,    40458,  482,         300,    1,    210003
 12,    46281, 2064,         300,    1,    210018
 13,    55419,  298,         300,    1,    210055
 14,    55718, 2065,         300,    1,    210058
 30,    58551, 1952,         300,    1,    210019
 15,    59392,  328,         300,    1,    210056
 16,    64141,  437,         300,    1,    210021
 29,    64893,  243,         300,    1,    210050
 17,    65945,  371,         300,    1,    210053
 18,    66285,  392,         300,    1,    210047
 19,    68036,  396,         300,    1,    210053
 31,    79001,  470,         300,    1,    210024
 28,    79003,  552,         300,    1,    210080
 20,    80001,  665,         300,    0,         0
 23,    80005,  677,         300,    0,         0
 27,    80006,  766,         300,    0,         0
 25,    80008,  767,         300,    0,         0
 32,    80025,  716,         300,    0,         0
  1,    4867.00000,   3.0000000000,   6570.00000,   4.0497226217
19503, 245909.9755098377
  1,    4525.00000,   3.0000000000,   6161.00000,   4.0846408840
```

MEMORANDUM

APPENDIX