ODOT Network Calculators

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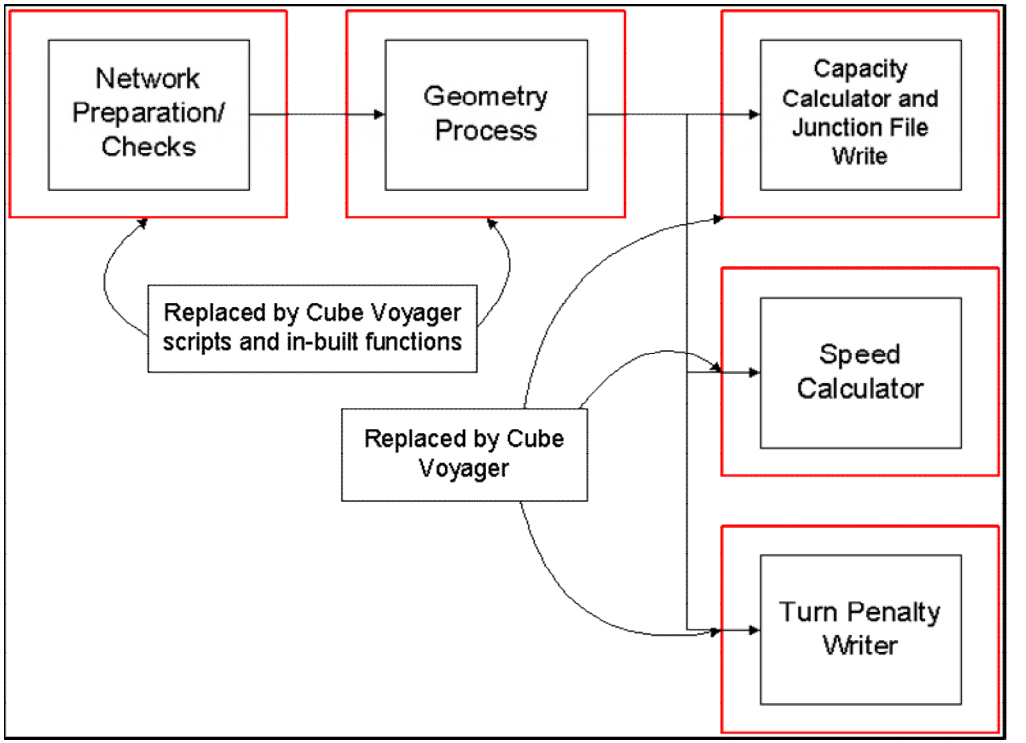
Project Motivation

- Replace existing Ohio Department of Transportation (ODOT) user programs in FORTRAN with Cube Voyager Applications
- Enhance Cube software to address network geometries
- Enhance the ODOT user programs with new HCM 2010 methodologies and other studies undertaken by ODOT



ODOT User Programs

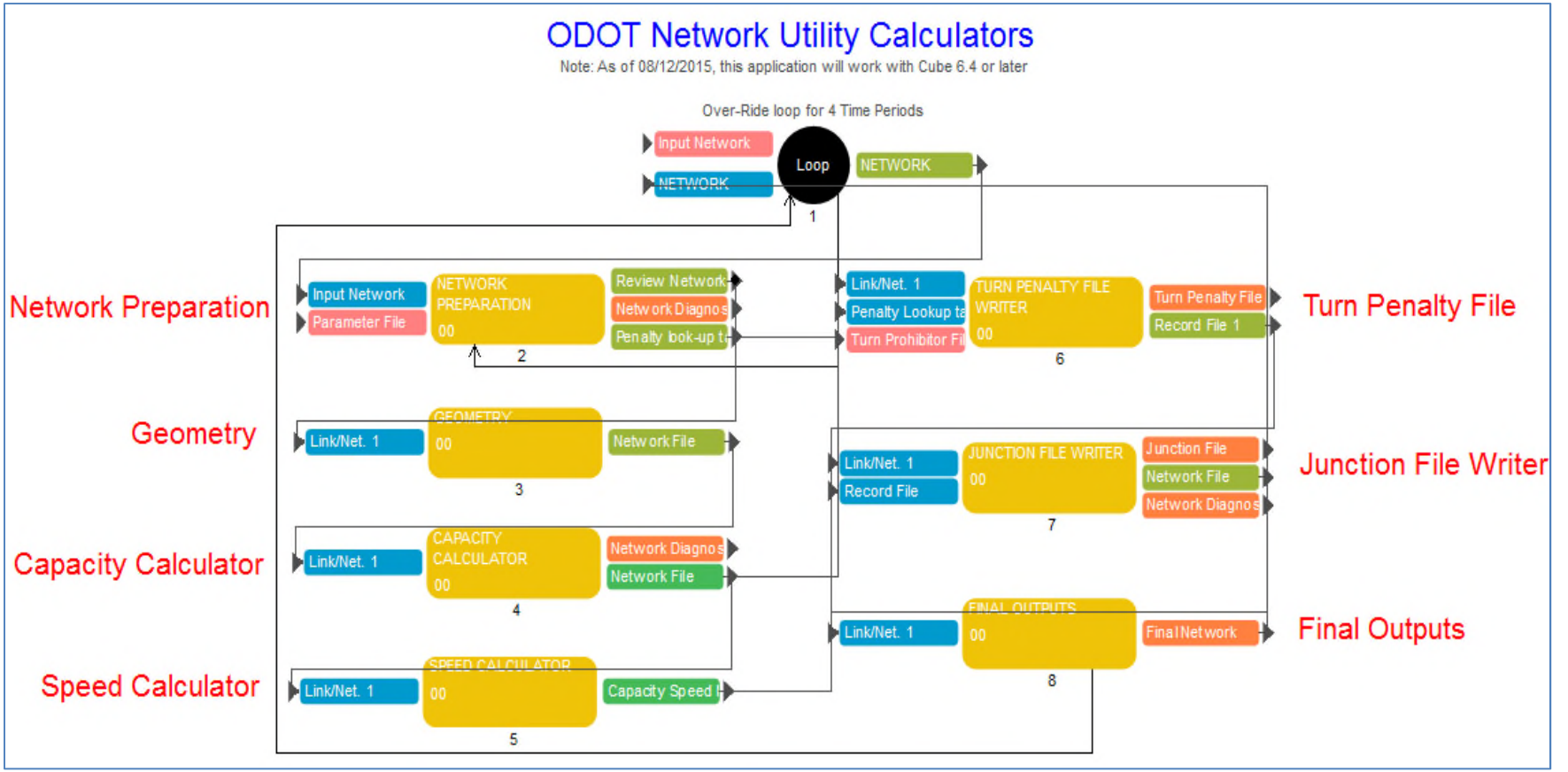
- Capacity Calculators
  - Compute capacities for freeways, rural highways, multi-lane highways, urban streets
- Speed Calculators
  - Compute total speeds and running speeds for links between two intersections
- Turn Penalty File
  - Write turn penalty file
- Junction Files
  - Write the junction file for use in Intersection Analysis

Network Utility Calculators (1/2)

Multiple Applications in Cube Voyager were created to replicate ODOT's FORTRAN programs:

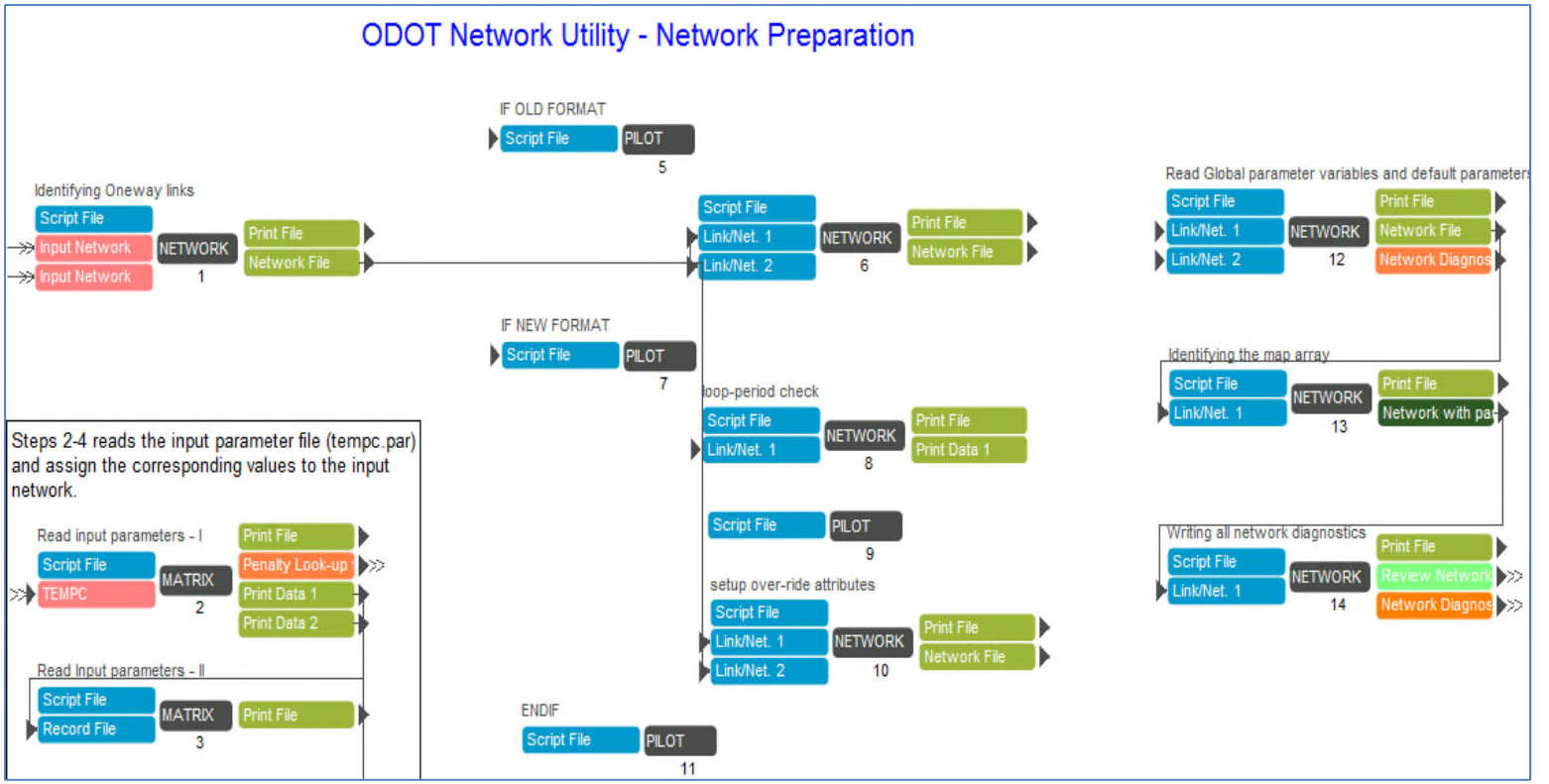
- Network Preparation
- Geometry
- Capacity Calculator
- Speed Calculator
- Turn Penalty File Writer
- Junction File Writer
- Final Outputs
- An external loop to process the data for different time periods

Network Utility Calculators (2/2)



Network Preparation (1/2)

– *Process to perform network diagnostics as pre-processing step*



Network Preparation (2/2)


- Features in the application
  - conduct data consistency/completeness checks, flag inconsistent or incomplete network coding
    - See next to see what conditions were flagged
  - handle how the period-over ride attributes are used and decide how many times the outer loop should run
  - write a network diagnostic summary file for the users' reference

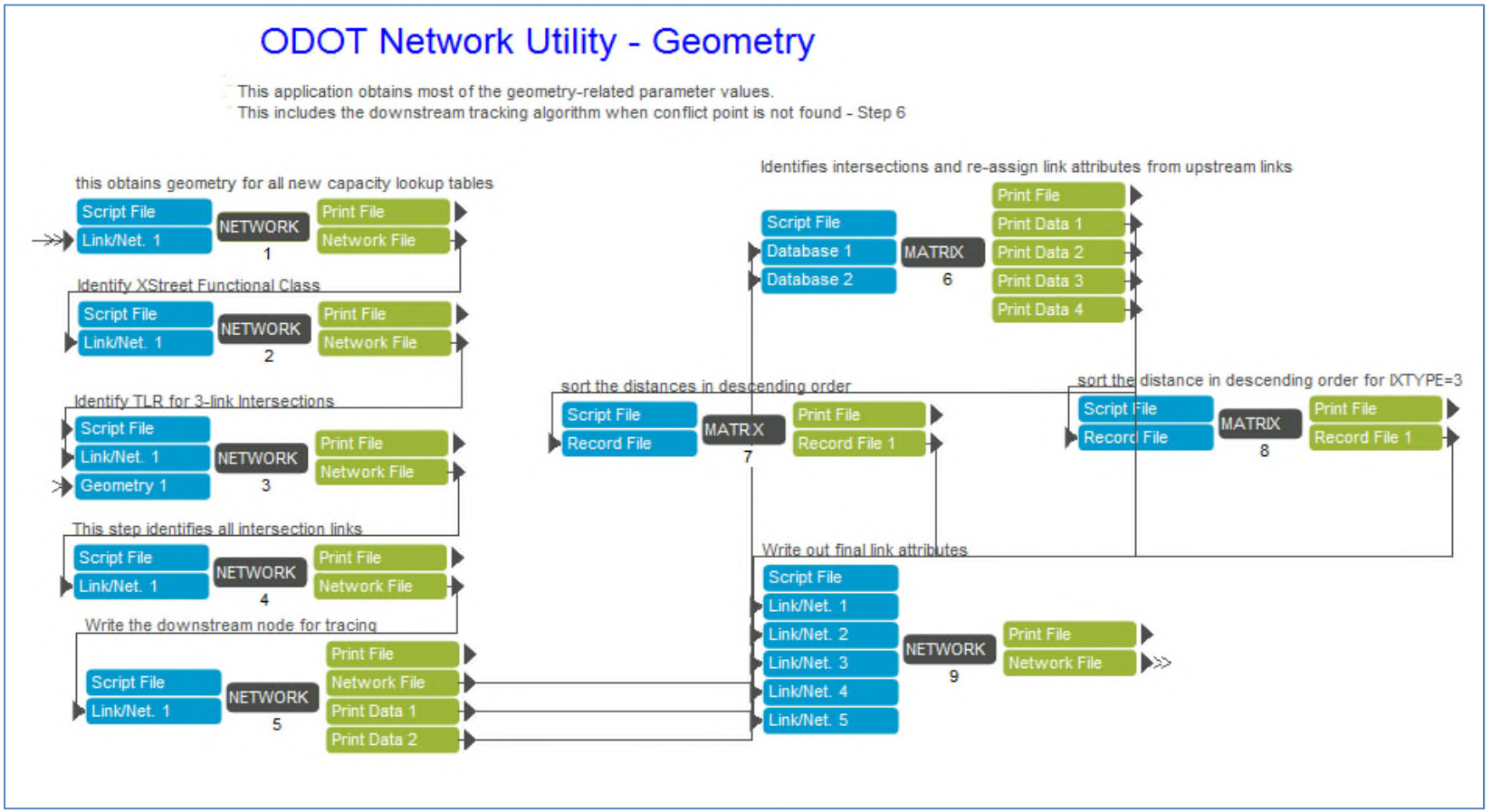
Network Preparation – Flag Criterions

Node	
WARNING	**Description**
1	Unused Nodes

Link	
WARNING	**Description**
2	Number of links are more than 4
3	Direction is wrong at node. Two-Way link connected to a One-Way link
4	Freeway Link only has 1 link
5	Distance coded for the link is zero
6	Lanes coded for the link is zero
7	Distance of subject link and opposite link are different (only for two-way links)
8	Zone connected directly to Freeway Link
9	Freeway link directly connected to an Arterial/Connector/Local
10	Dangling Link found at Node
11	Two-way link connected directly to centroid connector (XSt lane will be assumed as 1)
12	Inconsistent Intersection types - Roundabouts
13	Inconsistent Intersection types - Two-Way Stops
14	Inconsistent Intersection types - Signal Intersections
15	Link Width is Zero (0), Capacity will be assigned as 999999
16	Lane Widths less than 7 ft

Geometry (1/3)

– *Determine additional information on network attributes for adjoining links from subject link*



Geometry (2/3)

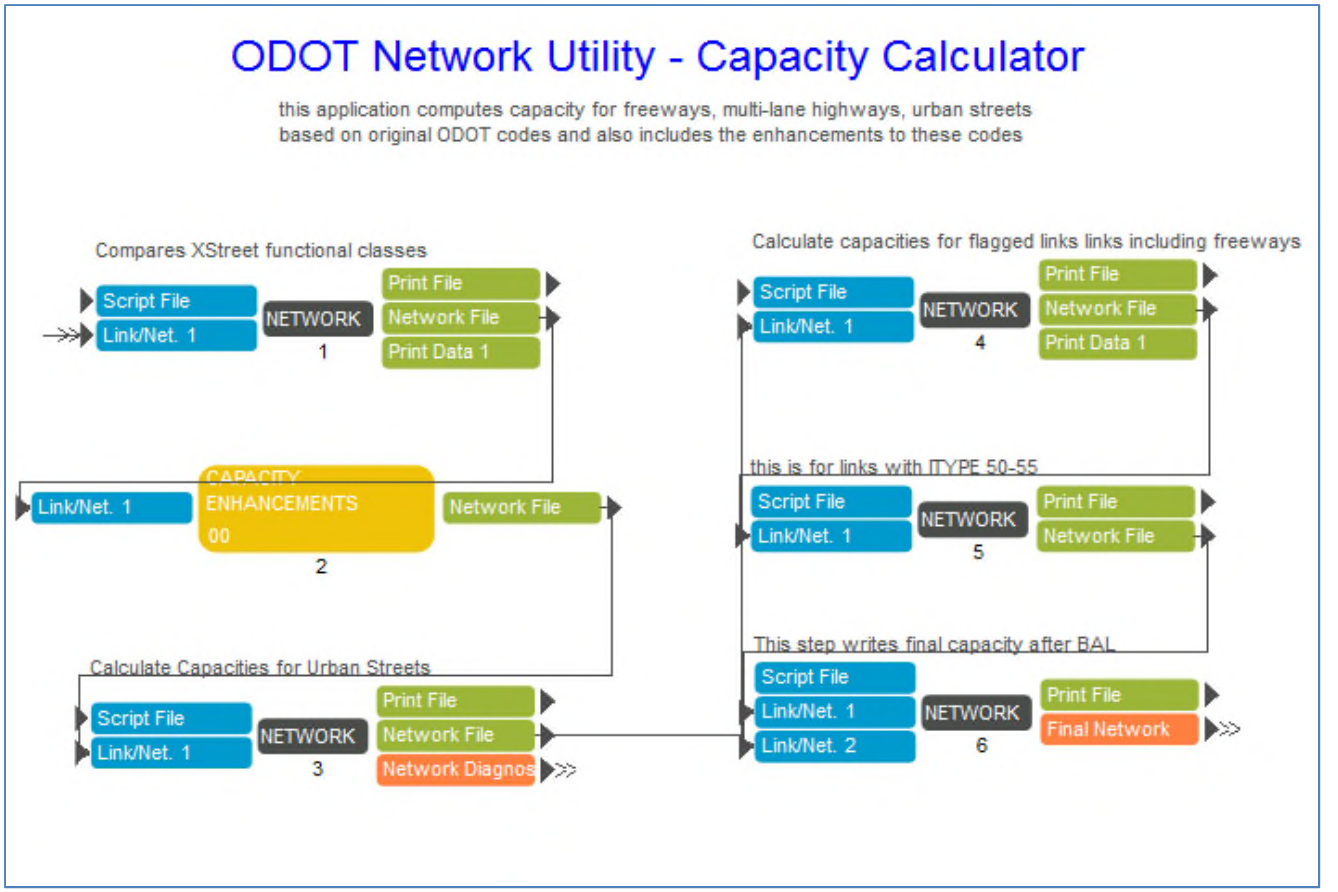
- Application Features
  - this step determines the geometry of subject link by accessing link attributes from adjoining links
  - step identifies the next intersection node (includes a tracing algorithm)
    - used to carry over the attributes of the intersection link to all upstream links, thus shape nodes or centroid connector nodes will generally not change capacity as software searches downstream for the intersection that controls capacity
  - computes true shape angles between links
    - Used to obtain turn movements – left/through/right

Geometry (3/3)


- Application Features (Cont'd)…
  - Used to identify the merging/diverging points for freeway merging analysis using HCM weaving section methodology
    - Capacity reduced on links between merge/diverge
    - Portion of reduction "spills-over" to upstream/downstream links
    - Accounts for apparent zero-distance (or very short) weaves due to loop ramp true shape
  - Obtains information on type of intersection, like two-way stops, four-way stops, roundabouts or a signal
  - Computes distance between two intersection nodes to calculate capacities
    - If distance is >2 mile, then uncontrolled, if <2 mile, controlled
    - Link approaching controlled intersection always controlled

Capacity Calculator (1/2)

– *Process to calculate capacity values for network links*

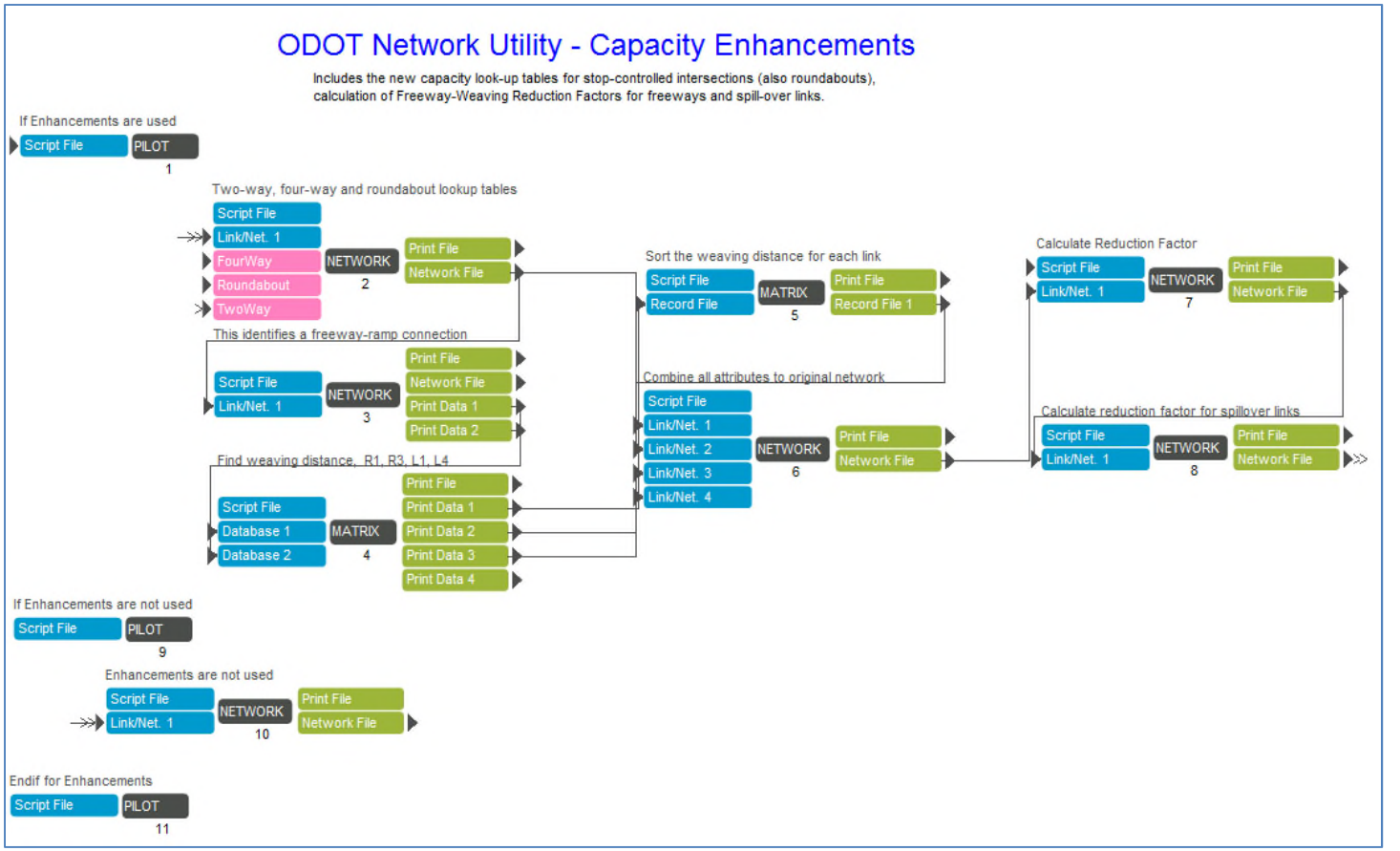


Capacity Calculator (2/2)


- Application Features
  - Computes capacities for freeway segments, multi-lane roads, rural highways, uninterrupted 2 lane facilities and interrupted urban segments using HCM (Highway Capacity Manual) 2010
    - All necessary information like number of lanes, facility type, area-type, coded in the network links
    - Additional information including left/through/right lanes, parking lanes and intersection control type will be used if coded
  - Cross-street attributes obtained from the Geometry step to identify different type of urban street capacity calculations

Capacity Enhancements (1/2)

– *Process to enhance capacity values based on freeway weaving, HCM 2010 methodologies*

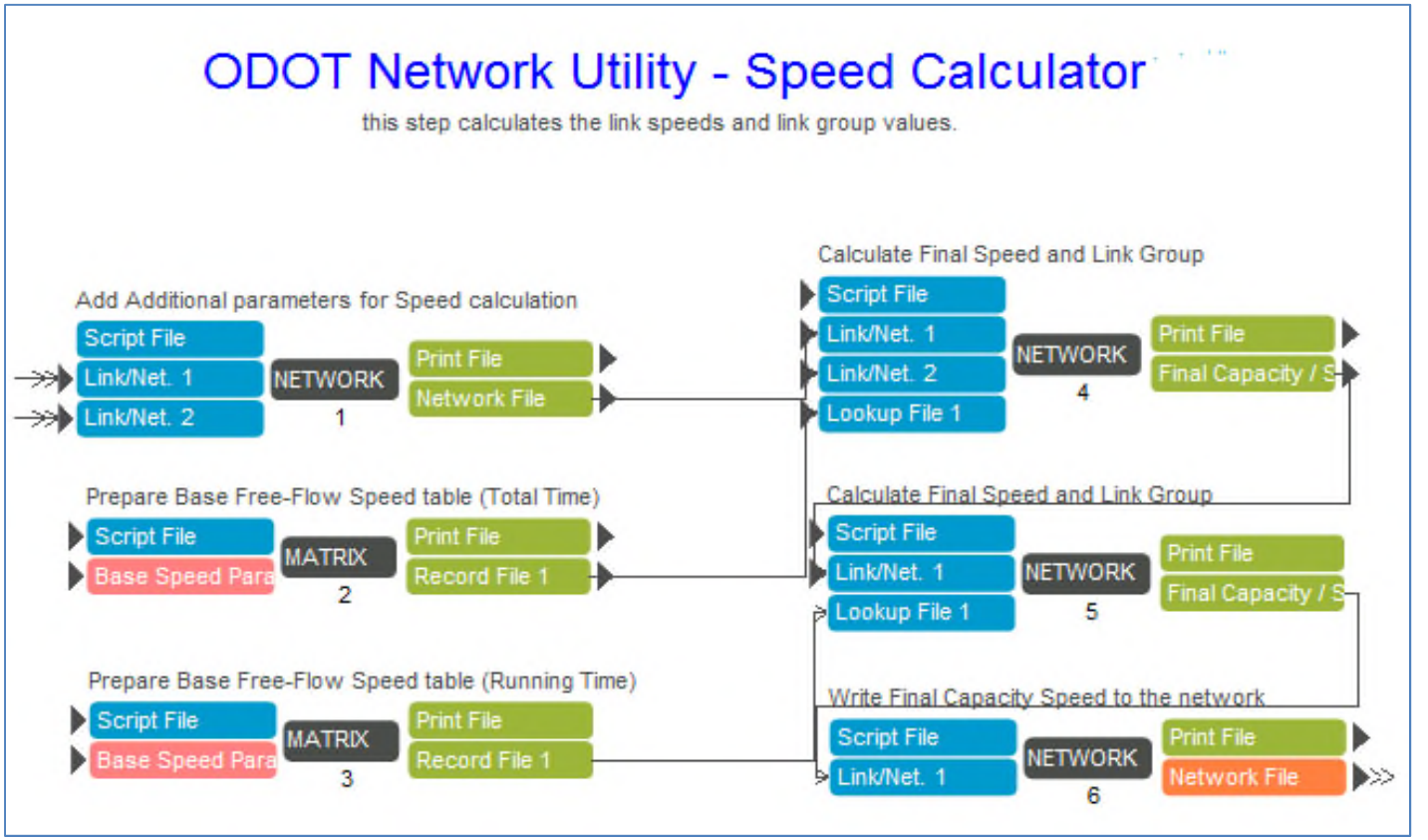


Capacity Enhancements (2/2)

- Application Features
  - modified equations for basic freeway segment capacity calculations, multi-lane and two lane highways
    - Inclusion of total ramp density
  - inclusion of freeway weaving analysis and corresponding reduction factors that reduces capacity due to weaving
    - For both freeways and ramps
  - enhanced capacity values for two-way stop, four-way stop and roundabouts
    - Capacities computed in a spreadsheet with all possible scenarios using HCM 2010 methodologies
    - Lookup table instead of direct computation following HCM for two reasons; the number of possible configurations is tractable and the computations are iterative (and thus time consuming) due to the approach interactions

Speed Calculator (1/2)

– *Process to compute free flow/running speeds on network links*

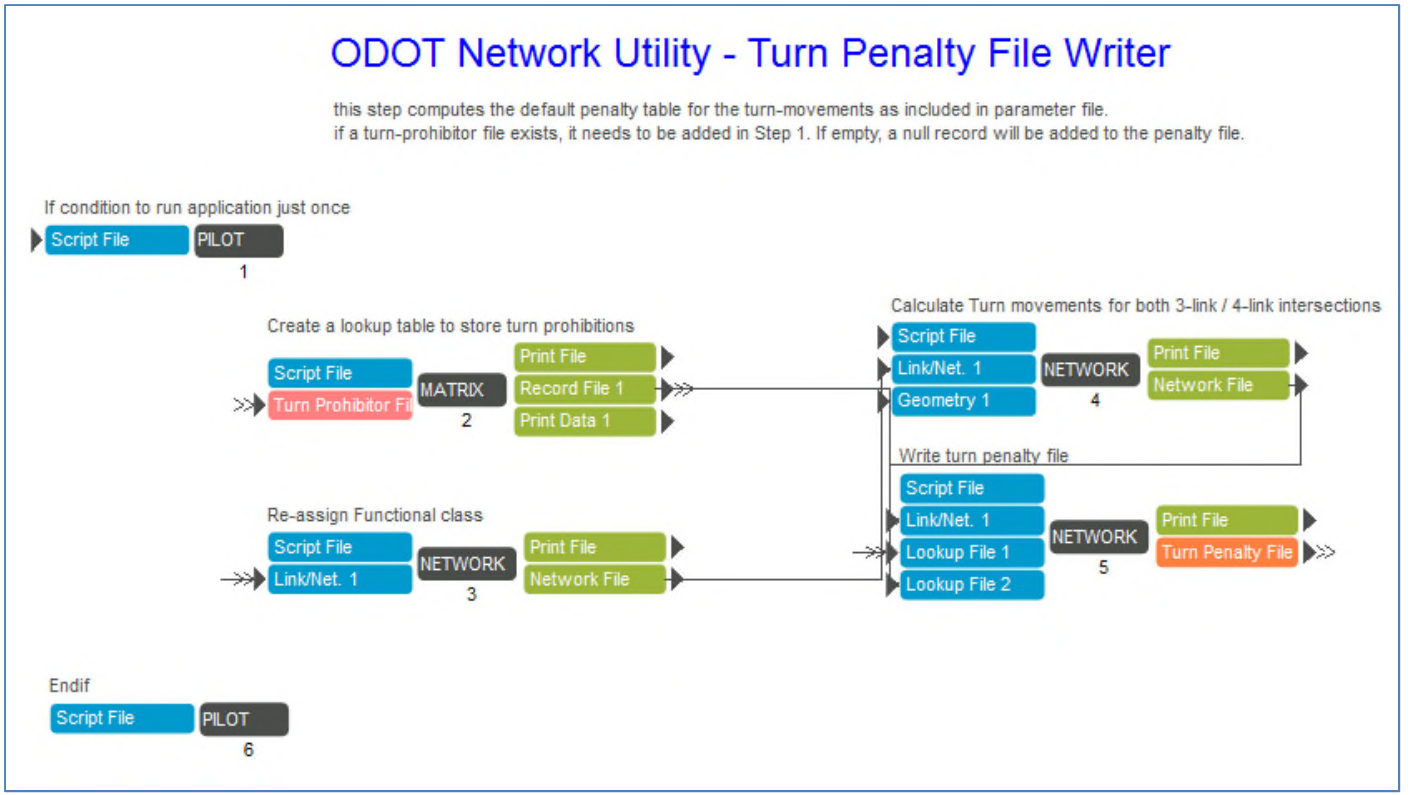


Speed Calculator (2/2)


- Application Features
  - Update the base speeds on the basis of link attributes and cross street attributes to obtain the final total speeds (includes intersection delay) or running speeds (does not)
    - Base speeds provided by ODOT from extensive floating car studies
  - Enhancements – incorporated free flow speed adjustments from Chapter 17 of HCM 2010 that uses the area-type, distance between two consecutive signals *(from geometry step)*, and two-way-left-turn lane coding to incorporate mid-block delay
  - Compute Link Groups for each link for use in Highway Assignment

Turn Penalty File Writer (1/2)

– Process to generate turn penalty file

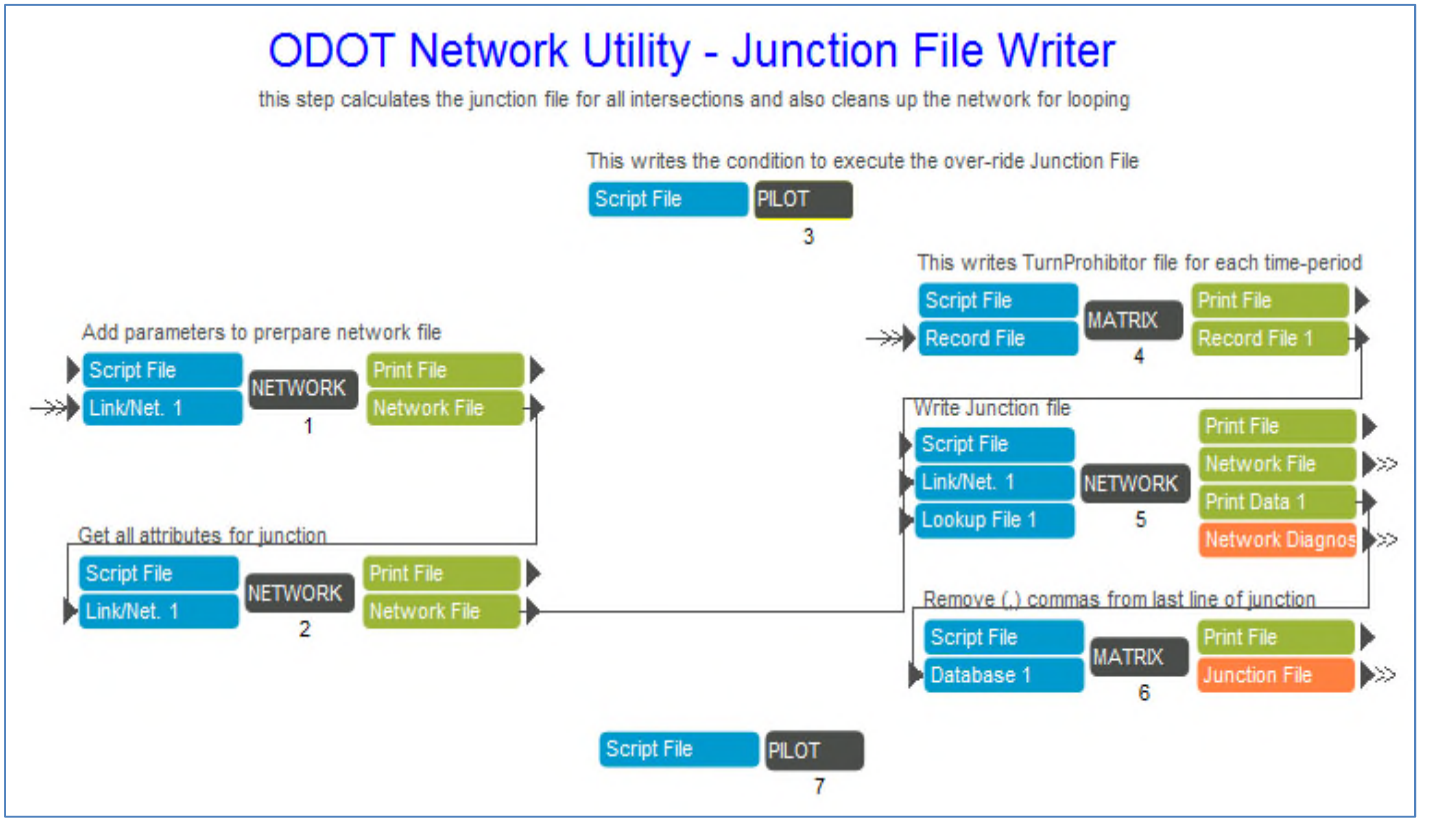


Turn Penalty File Writer (2/2)


- Application Features
  - Writes turn penalty files in Cube format (A-B-C-value-set)
    - append to any existing turn prohibitions that the user provide
    - use the geometry information to get all left-turn movements and give them user-specified penalty values
    - process can also apply turn penalties to through and right turn movements
    - applied by facility type to facility type category
    - ODOT only uses static turn penalties in the first global feedback iteration skims, junction based turn penalties used in assignment and subsequent skims

Junction File Writer (1/2)

– *Process to generate junction file for junction modeling*

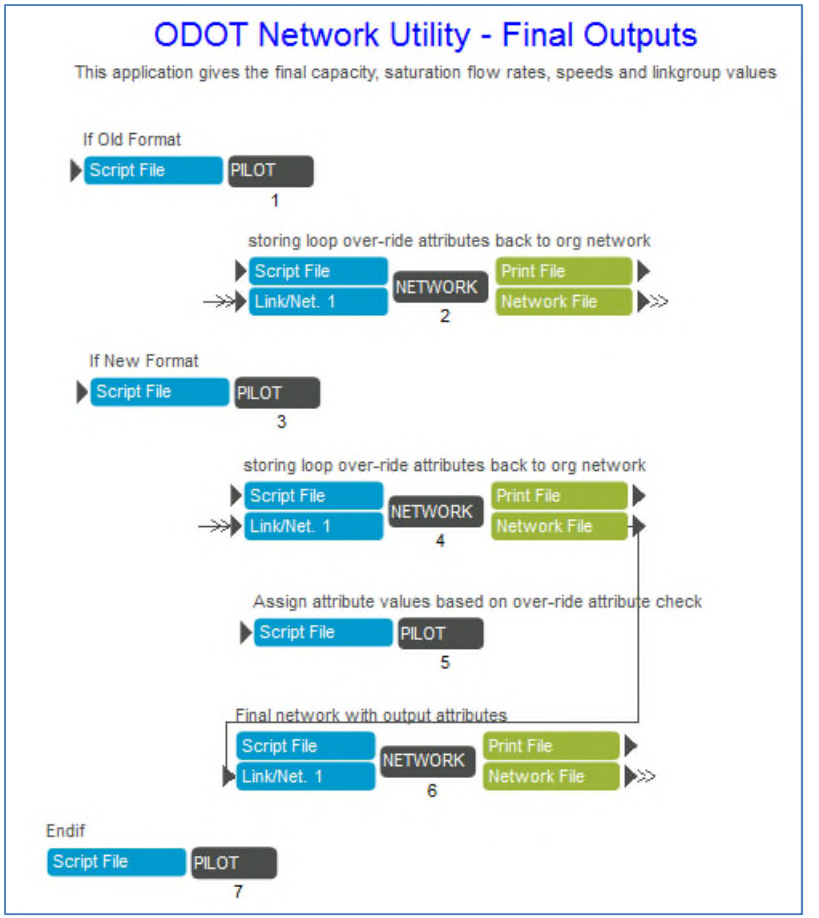


Junction File Writer (2/2)


- Application Features
  - writes Cube junction file for each controlled intersection node based on adjoining links information
  - use of turn prohibitions for banning movements
  - enhancements includes:
    - write out two-way stops, four-way stops, roundabout junctions in HCM 2010 format and methodology
    - introduction of new signal phases
      - split phasing based on link attributes
      - forced left-turn phases or prohibition of left-turn phases
    - write junction files for each time periods

Final Outputs (1/2)

– process to write out final outputs for all loops



Final Outputs (2/2)

- Application Features
  - Clean-up the network for the next loop and reset all temporary link attributes
  - Change attribute names for capacity, speeds, link group as per ODOT standards

Others

- An outer loop to handle how many times the application should run based on over-ride link attributes
  - Capacities, speeds, linkgroups are computed for all AM, MD, PM and MD time periods, ODOT network contains both default daily attribute fields and time period over-rides, if no over-rides coded for a give time period, its computation is skipped
- Flexible scenario manager to activate use of true-shapes in angle calculation
- Options to compute network utilities based on old methodology or new methodologies
- Option added to also use old (2000) format ODOT networks

Cube New Features

(As part of this project, included in Cube 6.4 or later)

Accessing Adjoining Link Attributes (1/2)

New Keywords added to NETWORK module in Cube Voyager

Both NODEMERGE/LINKMERGE	
_N.MaxConnect	Maximum number of connections for the whole network
NODEMERGE	
_N.Connections	Number of Connecting nodes to N
_N.Legs	Number of Legs at N
_N.Inbounds	Number of inbound links to N
_N.Outbounds	Number of outbound links to N
_NI.{name}[#]	Inbound link attributes, {name} is the attribute name, [#] is leg number
_NO.{name}[#]	Outbound link attributes, {name} is the attribute name, [#] is leg number
_NI._Angle[#]	Inbound link angles in degrees, # is the leg number
_NO._Angle[#]	Outbound link angles in degrees, # is the leg number

Accessing Adjoining Link Attributes (2/2)

New Keywords added to NETWORK module in Cube Voyager

LINKMERGE	
_A.Connections/_B.Connections	Number of connecting nodes to A/B
_A.Legs/_B.Legs	Number of Legs at A/B
_A.Inbounds/_B.Inbounds	Number of inbound links to A/B
_A.Outbounds/_B.Outbounds	Number of outbound links to A/B
_A.CurrentLeg/_B.CurrentLeg	The leg number of the current link
_AI.{name}[#]/_BI.{name}[#]	Inbound link attributes, {name} is name of attribute name, # is the leg number
_AO.{name}[#]/_BO.{name}[#]	Outbound link attributes, {name} is name of attribute name, # is the leg number
_L.Angle	Link angle for current link in degrees, 0 is north and counter-clockwise
_AI._Angle[#]/_BI._Angle[#]	Inbound link angles in degrees, # is the leg number
_AO._Angle[#]/_BO._Angle[#]	Outbound link angles in degrees, # is the leg number

HCM 2010 In Cube Junction Model

Roundabouts	
Uturns	Number of U-Turns per approach, 0
CirculatingLanes	Number of Circulating lanes per approach, 1
ByPassType	ByPass lane type per approach
	0 - none, 1-yielding, 2-nonyielding
CenterLanePercent	Utilization percentage per approach, 47% or 53%
CriticalGap	Critical Gap per approach, 3.0 to 6.0
FollowUpTime	Follow up time per approach, 2.0 to 5.0
All-Way Stop	
HeavyVehicles	Number of heavy vehicles per approach
Two-Way Stop	
SixLaneMajor	To specify the major roadway has six lanes
CriticalGap	3 values per movement - single stage/stage1/stage2
FollowUpTime	default added for six lane major roadways

Acknowledgments

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- Special thanks to Gregory Giaimo for all the ideas, suggestions, feedback and communications and to other ODOT staff

Questions?

Thank You!

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