Smarter Work Zones / SHRP2 Demonstration Workshop- Tennessee Project Coordination Using WISE

Presentation by

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THE UNIVERSITY OF MEMPHIS

Outline

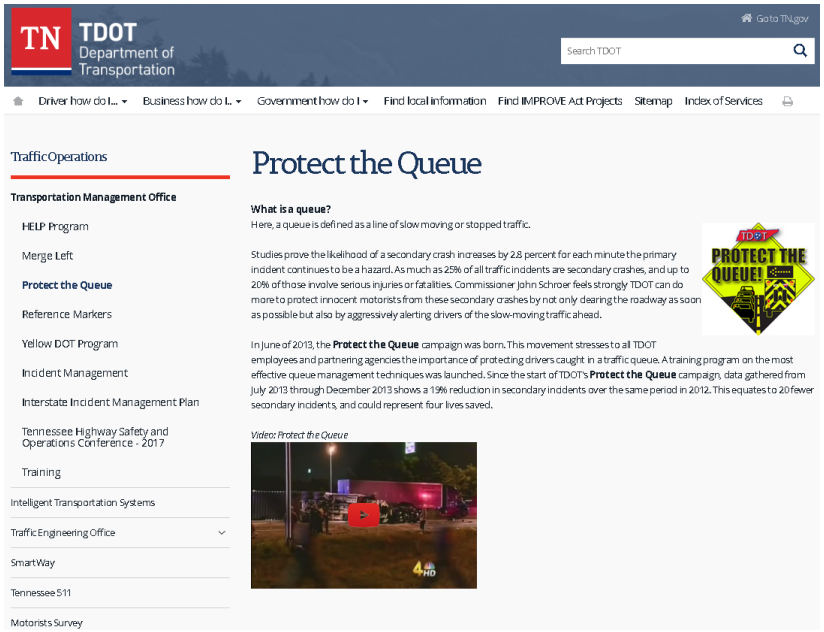
- Motivation
- Unfolding WISE-TN Pilot View
- Data Collection
- Proof-of concept runs
- Challenges and Path Forward

Motivation

Existing processes, challenges, and WISE pilot

Motivation (1)-Existing processes

- Work zone sequencing is a complex process
- Current work zone planning and operation enhancement programs
  - Lane closure decision support system
  - Protect the queue program



Motivation (2)- Challenges

- Need in Tennessee for coordinating work zone (WZ) projects
  - Type: construction, maintenance, utility, etc.
- TDOT selected EDC-3 Smarter Work Zones as a initiative to help stimulate and support the improvement of work zone planning.
- Coordination between state versus local work zones
    - Large versus small work zones
    - Spatial context
    - Facility types
    - Budget
    - Duration
- In TN
  - Approximately 500 WZ/ year on interstate/state routes
  - Highest type of WZ are construction

Motivation (3)-Vision

- Significant projects which are anticipated to cause sustained work zone impacts
- Currently revising the TDOT Work Zone Safety Mobility Manual and reformatting the Transportation Management Plan Process (TMPs)
- Optimal multiple project coordination he reduce work zone related crashes
- Obtain three pillars of benefit
  - Social
  - Economic
  - Environmental

Motivation (4)- Interest in WISE Pilot

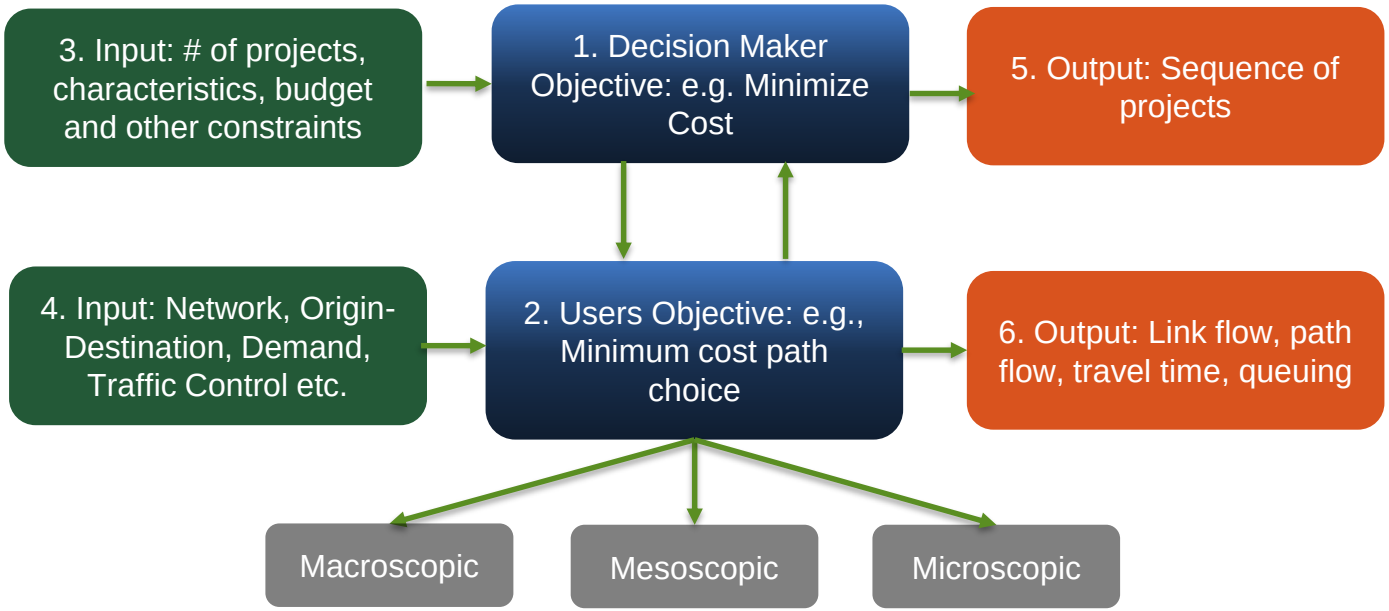
- Pilot activities in WISE
  - Sequencing using network design principles
  - Diversion using DTA
  - Use of both planning and operational features of WISE
  - Value in practice
  - Efficiency, robustness, and effectiveness

WISE Approach

Algorithms in WISE: planning and operation

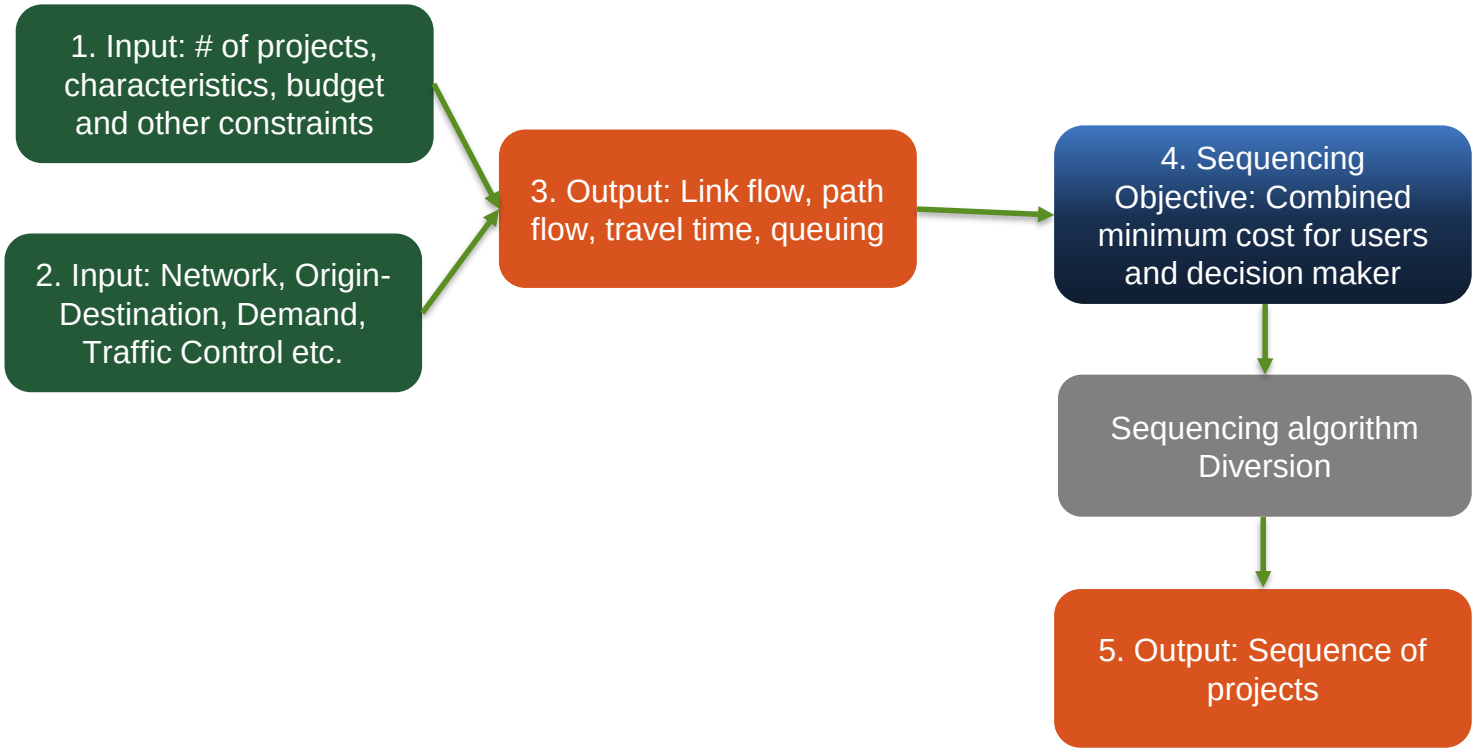
Network Design Problem

Time depended decision making



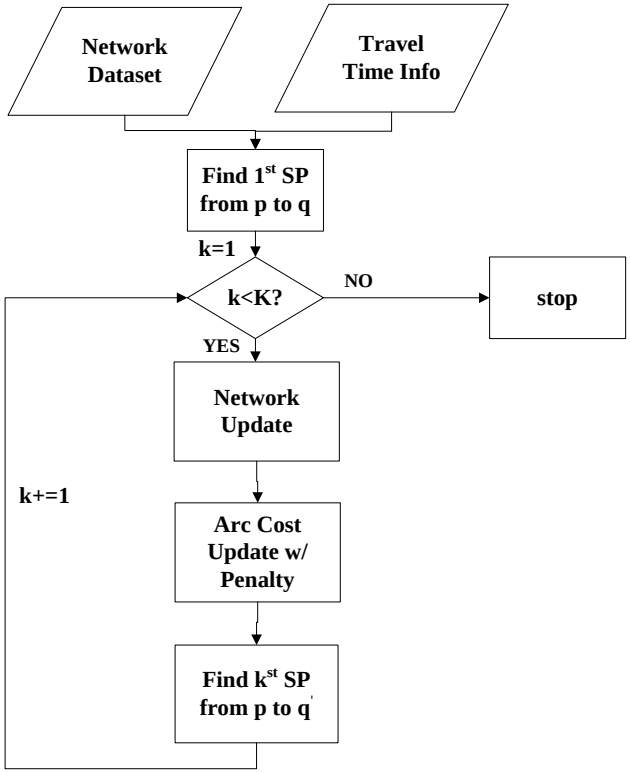
Network Design Problem

WISE Implementation



Sequencing Algorithm and Diversion

- WISE Scheduling Engine
  - Heuristic method, Tabu search to find optimal sequence of projects with defined starting month times, and construction mode (daytime, night time, or both)
- K-SP: Network Wide Travel Time
  - k-shortest path (k-SP) algorithm to find alternative paths where travel time is less than the path going through the work zone *(b)
  - Assign diverge traffic from the work zone path to K-SP by equilibrium method
  - Evaluate network-wide travel time accounting for traffic diversion



Sequencing Algorithm

- Step 1: Initialization

  Set each project an initial feasible schedule.

- Step 2: Neighborhood search

  For in each construction mode: daytime only, nighttime only, and both:

  For in each project:

  For in each month:

  If schedule project to start at month with a mode of is feasible:

  Do traffic diversion.

  Compute the objective function (work zone cost)

  If it results in a reduced objective, schedule project starting from month with construction mode , update the corresponding solution;

  Add triple into Tabu list, and restrict this solution in the next few iterations (user defined).

  Otherwise: continue

- Step 3: Check stop criteria

  Stop if a predefined maximal iteration number is reached, or in continuous 5 iterations it does not find a solution with improved objective.

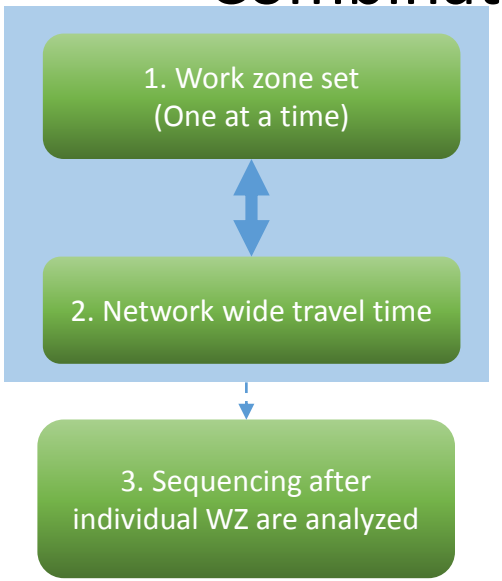
- Step 4: Return the solution with the minimum objective that has been found.

Complementary Comments (1)

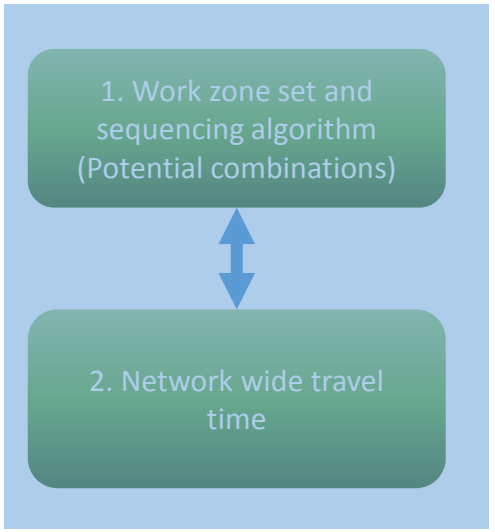
- Compare with other methods, such as (can be more than the list below)
  - Exact algorithms in cases of predetermined diversion strategies
  - Distributed Genetic Algorithm (GA)
  - Simulated annealing
  - Particle swarm optimization
  - Simulation based optimization
- Consideration of combinatorial projects in place?
  - Improve the method computing traffic diversion;
  - Improve K-SP;
- Automate scheduling and traffic impact assessing procedure, batch run DTA?

Complementary Comments (2)

- Combinatorial work zone sequencing



Current, simplistic, and far from reality



Improved, relatively complex and realistic

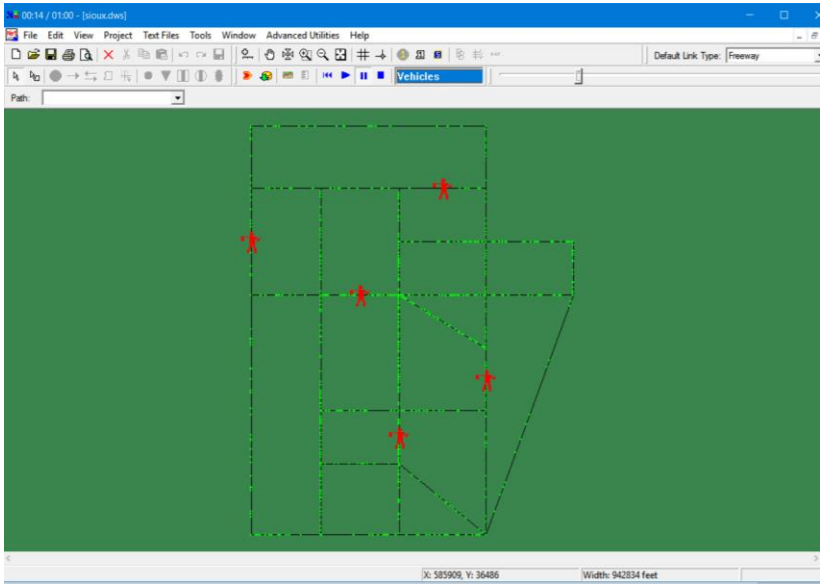
Software structure & design

Factors implemented in WISE

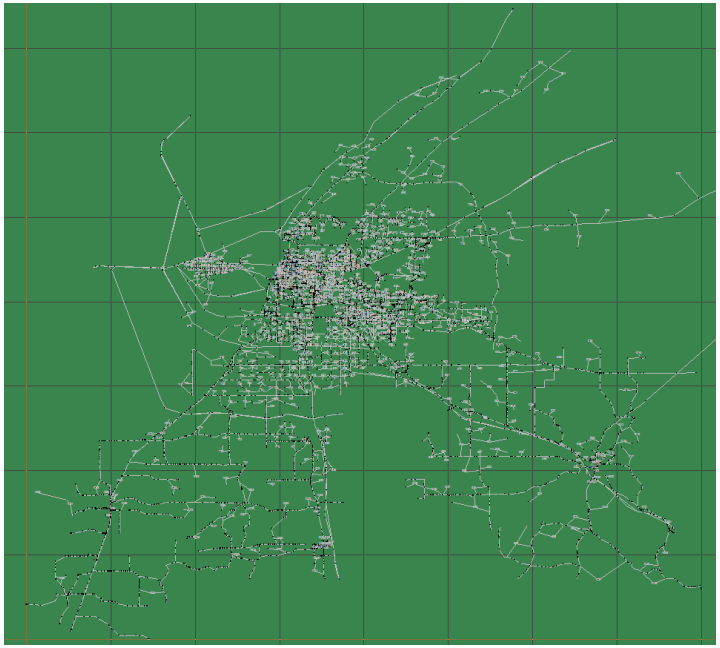
Complementary Comments

Our numerical experiments

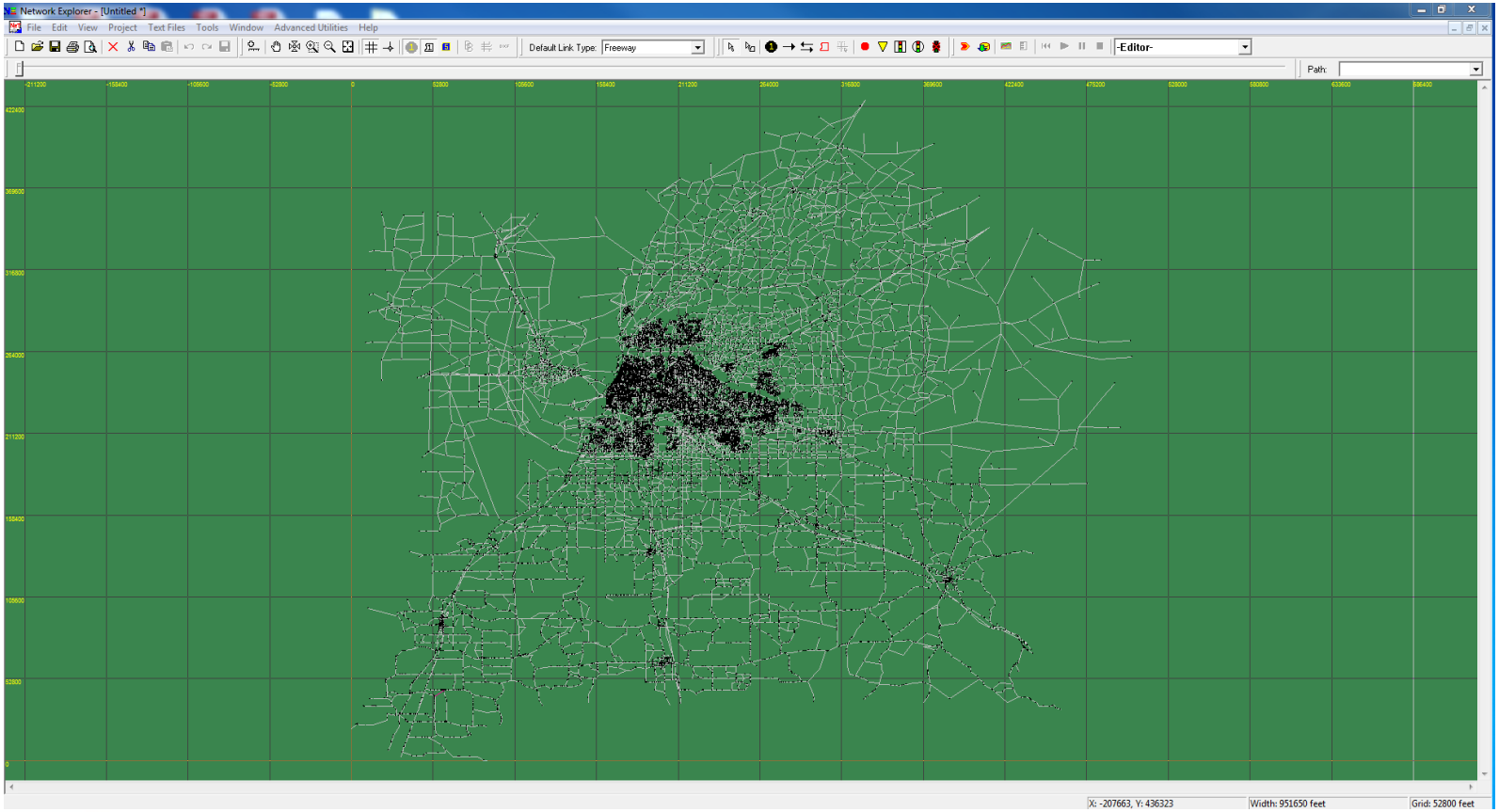
Siouxfall network (completed)



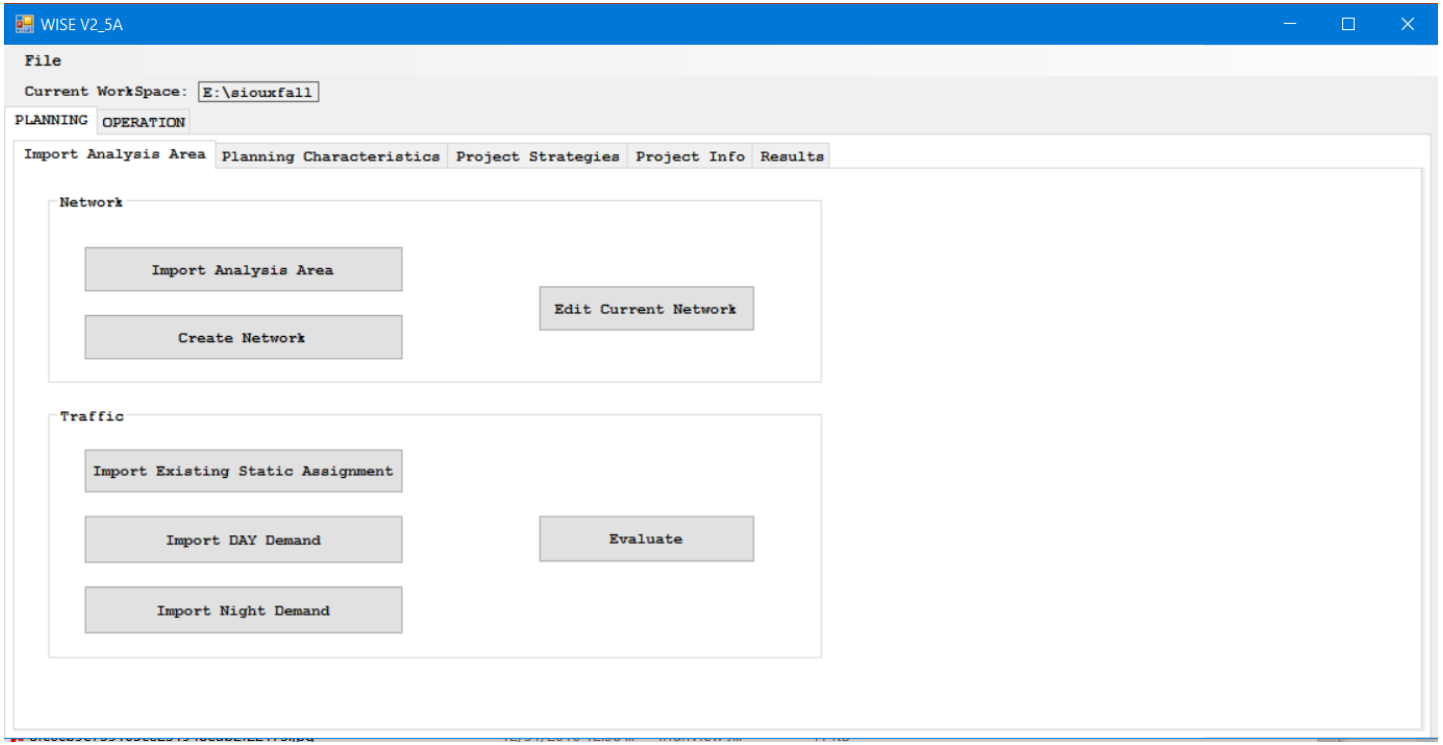
Memphis reduced network (Completed)



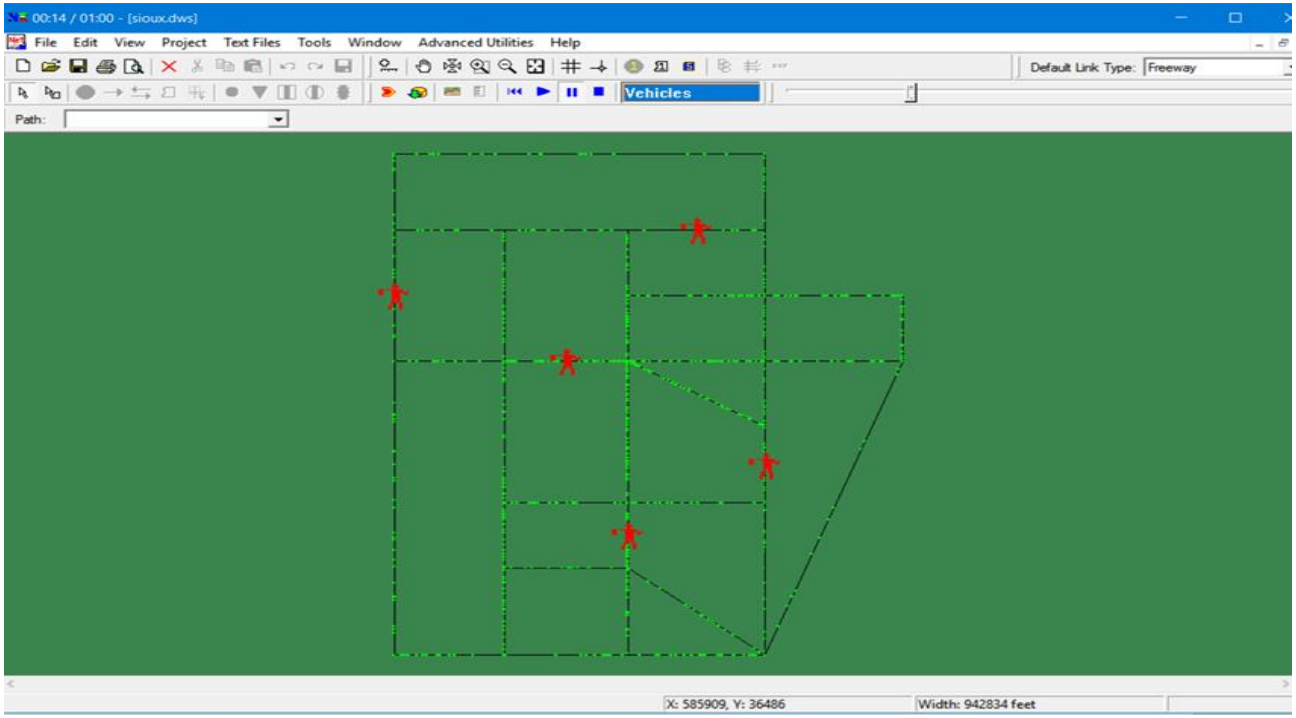
Memphis Full Network

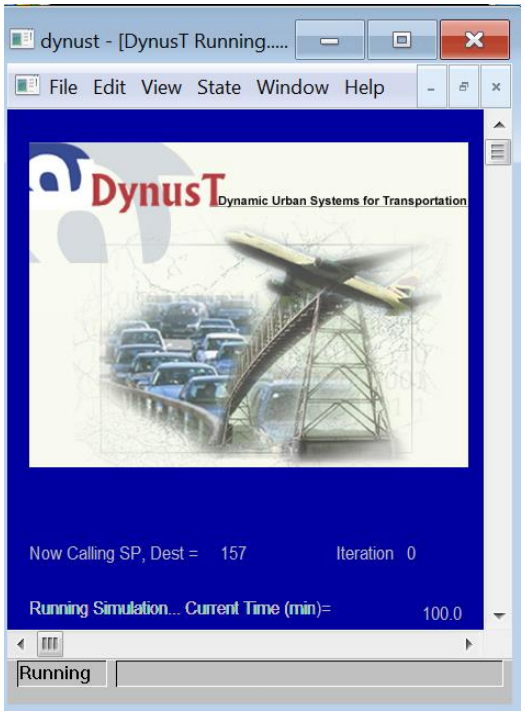


WISE Components: Basic GUI



WISE Components: Nexta/DynusT





Development environment

- Programming language:
  - C# for Interface of WISE
  - Python for modules including
    Demand Converter, Static Assignment, Scheduling Algorithm
  - C++ for NEXTA, traffic network editor and visualizer
  - Fortran for DynusT, dynamic traffic assignment engine

Complementary Comments

- Re-design structure, thinking from scratch
  - standalone to connect with other traffic assignment models

  or
  - a plugin component which can be loaded to other software
- Incorporate programming to one development environment
- Connect WISE with NexTA-DTALite or any one programing language environment

Engineering dimension

Factors implemented in WISE

Complementary Comments

Factors implemented in WISE

- Factors for work zone already considered in WISE
  - General construction cost
  - Daytime, nighttime, and both
  - Precedence sequence
  - Seasonal factor
  - Demand reduction factor

More factors to be taken into account

- Other construction cost components not defined as input in WISE
  - Labor
  - Materials tools
  - Schedule conflict
  - Accident factor and cost
- Traffic impacts at the project level not included in objective function
  - Queues at local project
  - Reduction of travel speed locally
  - Increase of traffic delays locally

WISE Software Review Summary

- Improvement in four dimensions
  - Inputs and output data flow in NexTA
    - Make it easier for practitioners
    - Importing features from existing DOT/MPO data formats
    - Standards for signal and control features
  - Improved processes
    - Engineering dimensions
  - Algorithms
    - Improved algorithms for both project sequencing, and traffic assignment
    - Consider combinatorial problems
    - Exact methods for sequencing rather than heuristics
    - Consider larger number of work zones
  - GUI
    - User friendly GUI for practitioners

Initial Recommendations

- enhance GUI
  - (*for wider use make it practitioner friendly*)
- data input/output
  - (*provide example data structure*)
- analyze larger number of WZ projects
  - (*test other sequencing algorithms*)
- capacity to analyze larger network
  - (*for planning enhance traffic assignment algorithm*)
- support other DTA platforms
  - (*direct WISE to other DTA platforms*)

Future considerations

- Data Preparation
  - Identify work zones to be analyzed
    - State, MPO and City (all have different databases!)
  - Sub-area selection if the network is bigger
  - Prepare standardized sdata
- WISE uses DynusT for DTA
  - Provide flexibility to include other software
- Significant effort needed mesoscopic model calibration
- Detail construction cost components not defined as input in WISE
  - Labor, materials, tools, schedule conflict, and other components

Acknowledgement

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Thank you and Questions

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