

Exhibit A
Project Scope of Work and Budget

Introduction

The following scope of work is presented as the proposed work plan for the TRM Service Bureau and Model Team for the budget year July 1, 2012 – June 30, 2013. The primary efforts outlined in this scope are intended to focus the efforts of the Service Bureau and Model Team on continuing development of a v6 model for the Triangle region with various enhancements. During this budget year work will begin on investigations for developing a future v7 model. Refer to Appendix A for an overall vision for v6 and v7 models.

Several assumptions are made within the context of this scope.

1. Each signatory agency's one half FTE contribution may include staff time from people other than their TRM Team member, but the TRM Team member will play a key role and other staff must be adequately trained to meet the needs of the TRM Team.
2. All TRM staff representing the signatory agencies will, as needed, work on site at ITRE, including any third person who is providing services in the name of a signatory agency. This enables the Team to work together on issues that require the input of multiple team members and reduces the tendency for team members to be reassigned to other tasks in their home offices.
3. The TRM Program Manager will assign tasks with associated deliverables and target dates. TRM Team members will agree to take responsibility for specific tasks and will be held accountable for completion of those tasks. The responsible team member (stakeholder and TRM Service Bureau) will be responsible for **monthly** reporting on progress via an email attachment including 1) status, 2) changes in anticipated completion dates, 3) reasons for change, and 4) hours spent on model development work for the month reported.
4. Signatory agencies will commit one half FTE per agency to the completion of the list of tasks outlined in this work plan. The TRM Program Manager will assume responsibility for providing adequate work to meet this obligation by specifying the task description, deliverables, and person hours required. This information will be provided at least quarterly and will be sufficient to fully incorporate the one half FTE required of each agency.
5. All intermediate and final products of this work program belong to the four stakeholders (NCDOT, CAMPO, DCHC, and Triangle Transit) and these will be delivered to the stakeholders in a form and via media acceptable to each stakeholder at the end of the contract year or before. The products include: model files including input files; scripts and program source code; all technical memoranda; estimation data file inputs and outputs; technical reports and user guides.

Note on model version names: the following version names will be used in this scope of work consistent with model team recommendations (for detailed TRM name history, please refer to Appendix B "TRM History" section).

- **TRM v5:** Based on structure of v4-2008 with revisions to model specifications and using 2006 household survey and 2006 on board transit survey data for estimating model components with an expanded study area [v5 TAZ system]. The enhancements requested by the stakeholders have been included. (see Appendix B "TRM History" for detailed list of enhancements) This version will be used for the Alternatives Analysis and Air Quality Conformity Analysis for the 2040 Long Range Transportation Plans.
- **TRM v6:** Updated and enhanced trip based model enhancing the v5 model. TRM v6 will be delivered in December, 2014 and will be used for the Alternatives

Analysis and Air Quality Conformity Analysis for the 2045 Long Transportation Plan.

- **TRM v7:** New tour based or activity based model designed to address policy testing needs not sufficiently addressed by TRM v6. TRM v7 will be delivered in December, 2018 and will be used for the Alternatives Analysis and Air Quality Conformity Analysis for the 2050 Long Range Transportation Plan.

Overall Work Program Summary Task Table (including stakeholder work hours)

Task Number	Task Title	Task Hours	% of Total
1.1	Advice on parking behavior data collection	112	1.2%
2.1	Maintain & update highway & transit networks, SE data	160	1.7%
2.2	Modify Net Manager to work with v6 networks	224	2.3%
2.3	Script & input file modifications	40	0.4%
2.4	Develop highway network procedures	528	5.5%
2.5	Transit Networks	160	1.7%
2.6	Zonal data and models	1,008	10.5%
2.7	Develop an improved parking constraint model	272	2.8%
3.1	Estimation and/or calibration of trip production models	520	5.4%
4.1	Peak spreading models	480	5.0%
4.2	Prepare time of day factors	136	1.4%
5.1	Develop improved destination choice model	1,186	12.4%
8.1	Develop improved commercial vehicle model	816	8.5%
8.2	University student model	1,040	10.9%
8.3	Land use models	136	1.4%
9.1	Investigate improving highway assignment	120	1.3%
10.1	Assist with LRTP model application	160	1.7%
10.2	Assistance with TRM model application	160	1.7%
10.3	Action items	621	6.5%
11	Oversight, reporting and training	1,816	17.7%
	Total	9,575	100%

1 Data collection

1.1 *Advice on parking behavior data collection management*

Once the model framework and specification designs for the parking models are approved by the stakeholders, parking related behavior data needs to be collected for later use in developing the models.

Deliverables:

A. By survey consulting firm:

- 1) Survey designs (sample plan, instrument etc.)
- 2) Pilot survey report on details and issues
- 3) Full survey report (usual survey contents)
- 4) Complete final cleaned/Geo-coded full survey and pilot survey data, fully expanded/weighted, ready to use; with complete data dictionary
- 5) Working data used (including but not limited to recruitment data, expansion/weighting source data and working files)
- 6) Training session to stakeholders

B. By TRM team:

Technical memoranda on

- 1) Pilot survey procedure/instrument and data QA/QC issues and suggested resolution
- 2) Pilot survey data analysis result
- 3) Full survey data QAQC issues and resolutions

Est. start date: 1/11/2013

Est. end date: 6/26/2013

1.1	Parking behavior data collection management	14
a)	Estimate parking data collection cost for stakeholders' approval	2
b)	Design and review data collection procedure	1
c)	Design and review sample plan	1
d)	Design and review survey instruments	2
e)	Review preliminary design for stakeholders approval	1
f)	Advice for management of pilot data collection [including but not limited to signing contract, overseeing survey consulting firm process, communication, issue resolving, budget/time control]	1
g)	QAQC and analyze pilot data; provide feedback to survey consultant	2
h)	Advice for management of full data collection [including but not limited to overseeing survey consulting firm process, communication, issue resolving, budget/time control; final training]	2
i)	QAQC full survey data; provide feedback to survey consultant	2

** Note: This effort estimate assumes a one for one matching effort will be provided by the stakeholder that contracts for survey data collection*

2 Model inputs

2.1 Maintain and update networks, and zonal data

Maintain and update highway and transit networks, and zonal data whenever new data (such as school enrollment or zonal path density and average block size) are available, new attributes (such as on-street parking, truck prohibited links and lanes indicator) are needed in the model, new projects are completed, or errors are discovered. The 2040 LRTP projects coded in TRMv5 true universe line layer need to be transferred to TRMv6. The SE data might need to be updated after CommunityViz is implemented.

Deliverable:

Revised highway and transit network and socio-economic data

Est. start date: 8/15/2012

Est. end date: 10/18/2012

ID	Task Description	Person Days
2.1	Maintain and update highway and transit network, and socio-economic data	20
a)	Maintain and update highway and transit network, and socio-economic data	10
b)	Maintain and update socio-economic data	10

2.2 Modify Net Manager to work with v6 model networks

- a) Edit Net Manager script to work with v6 highway and transit networks
- b) Fix a couple of bugs that have been found with transit network creation
- c) Test modified script and revise it until it works as expected.
- d) Prepare revised documentation

Deliverable:

Revised Net Manager script ready for use preparing v6 scenario networks and revised documentation.

Est. start date: 7/2/2012

Est. end date: 8/9/2012

ID	Task Description	Person Days
2.2	Modify Net Manager to work with v6 model networks	28
a)	Edit Net Manager script to work with v6 highway and transit networks	10
b)	Fix a couple of bugs that have been found with transit network creation	10
c)	Test modified script and revise it until it works as expected	5
d)	Prepare revised documentation	3

2.3 Zone geography

Objectives:

To make script and inputs work with new TAZ geography for TRM v6

Previous work:

TAZ geography was updated by the MPO partners during FY 2012. This included modifications to the highway network to make it consistent with the updated TAZ geography.

2.3.1 Script and input file modifications

The model script will be modified as needed for using the updated TAZ geography. Transit network files will be modified to work with the updated TAZ geography including any needed changes to park and ride lot inputs and auto intercept lots. As part of this work the auto intercept lot list will be converted to an input file (they are now hard coded in the program executable) for mode choice.

Deliverables:

Updated model script, mode choice program file, modified model input files, and technical memorandum

Est. start date: 7/2/2012

Est. end date: 7/9/2012

ID	Task Description	Person Days
2.3.1	Script and input file modifications for TAZ geography update	5
a)	Update model script for updated TAZ geography	1
b)	Update transit network inputs including park and ride lot inputs	1
c)	Modify mode choice program to read a list of auto intercept lot from a file	2
d)	Prepare a technical memorandum documenting all changes made	1

2.4 Develop highway network procedures

2.4.1 Update of volume delay function

The TRMv5 used conical volume delay functions with four different parameters (2, 4, 6, 8) for four groups of facilities. The facility types, free-flow speeds and capacities are updated in TRMv6, and it is a good time to review the volume delay functions and make changes when necessary.

Deliverable:

Updated volume delay function and documentation of findings and approach used

Est. start date: 7/2/2012

Est. end date: 7/10/2012

ID	Task Description	Person Days
2.4.1	Update of volume delay function	28
a)	Literature review	5
b)	Selection of volume delay function	5
c)	Data collection (such as from traffic.com)	5
d)	Validation of the selected volume delay functions	10
e)	Documentation	3

2.4.2 Collect and add link attributes for highway links

The new procedures for calculating link capacities and free flow speeds added link attributes for lane width and on-street parking. In order to use these attributes, link data needs to be collected for links in the highway network.

Deliverable:

TRM networks with updated link attributes and documentation of process used

Est. start date: 10/10/2012

Est. end date: 2/28/2012

ID	Task Description	Person Days
2.4.2	Collect and add link attributes for highway links	38
a)	Investigate sources for link attribute data	5
b)	Collect link attribute data using data sources identified in a) above	10
c)	Update link attributes in TRM highway network	20
d)	Document process for collecting and entering link attribute data	3

2.5 Transit networks

2.5.1 Develop improved transit model procedures

- a) Develop improved approach for calculating bus wait time
- b) Develop module to convert transit output from PA to OD format

Deliverable:

Script revised to calculate bus waiting time and to output transit trips in OD format and technical memorandum describing both enhancements.

Est. start date: 7/2/2012

Est. end date: 9/12/2012

ID	Task Description	Person Days
2.5.1	Develop improved transit model procedures	20
a)	Develop improved approach for calculating bus waiting time	10
b)	Develop module to convert transit output from PA to OD format	7
c)	Prepare technical memorandum	3

2.6 Zonal data & models

2.6.1 Population synthesizer

The current TRM includes a procedure that allocates population to households based on relationships in census data between zonal average household size and mean income and regional household size and mean income. This procedure creates a list of households by number of workers, non-working adults, and children by household size, income group, and auto ownership. It is proposed to add a population synthesis element to the TRM trip based model that can be used as part of a more advanced model.

Est. start date: 7/2/2012

Est. end date: 2/6/2013

2.6.1.1 Investigation of population synthesizers

An investigation of available population synthesizers will be conducted. Documentation and if available, program code will be collected for at least three population synthesizers. Documentation will be reviewed and summary of inputs required and outputs produced will be prepared. If available, information about application use of the population synthesizer will be reported. A brief technical memorandum will be prepared summarizing the investigation findings to provide a basis for the Model Team to recommend a population synthesizer. The Model Team will review the findings and provide a recommendation for a population synthesizer to incorporate in the TRM.

A brief investigation will also be conducted into population dynamics procedures that might be used to age the population over the forecast period. These procedures are designed to account for the life cycle phases that people go through as they get older. The investigation will find out the procedures that have been developed so far for application and will include the modules of UrbanSim that have been developed for this purpose. A brief technical memorandum will be prepared to report the results of the literature review and any information found about the use of

the procedures in application.

Deliverable:

Technical memorandum with findings from investigation

ID	Task Description	Person Days
2.6.1.1	Investigation of population synthesizers	18
a)	Obtain example population synthesizer documentation & program code	8
b)	Obtain information on population dynamics approaches	5
c)	Model team review	2
d)	Prepare technical memorandum documenting findings	3

2.6.1.2 Estimation of population synthesizer

Depending on the population synthesizer chosen for the model, data will gathered in the case of census data, and the Triangle household travel behavior survey will be prepared for use in model estimation. Targets for household and population controls will be prepared most likely from census data. Population synthesizer models will be estimated using appropriate data; perhaps household survey data.

Deliverable:

Documentation of process used for estimation

ID	Task Description	Person Days
2.6.1.2	Estimation of population synthesizer	14
a)	Prepare census data for model estimation	4
b)	Develop targets for household & population controls	4
c)	Estimate population synthesizer models	4
d)	Prepare documentation of estimation	2

2.6.1.3 Develop model application procedures

Model application modules will be prepared to apply the population synthesizer within the TRM. Depending on the population synthesizer selected, this may require the modification of the

model script, modification of the trip generation program, or modification of the population synthesizer program.

Deliverable:

Documentation of all code written

ID	Task Description	Person Days
2.6.1.3	Develop model application procedures	11
a)	Write program code or edit existing program	8
b)	Debug program code	1
c)	Test application	1
d)	Prepare program description	1

2.6.1.4 Population synthesizer calibration

The population synthesizer will be applied with appropriate inputs (perhaps travel survey data) and the model outputs will be compared to targets for the control totals. The model will be adjusted until control totals are matched satisfactorily.

Deliverables:

Report summarizing calibration work including development of targets and final model performance

ID	Task Description	Person Days
2.6.1.4	Population synthesizer calibration	6
a)	Prepare population synthesizer calibration inputs	1
b)	Prepare calibration targets	1
c)	Apply population synthesizer and adjust to meet targets	3
d)	Prepare calibration summary report	1

2.6.1.5 Population synthesizer validation

After calibrating the model, the model will be applied with 2010 TRM population inputs, and the output will be compared to census data for the study area. Adjustments will be made as

necessary to match household and population controls for the study area, though population controls may not be matched exactly.

Deliverables:

Documentation for developing validation data and model performance

ID	Task Description	Person Days
2.6.1.5	Population synthesizer validation	6
a)	Prepare TRM inputs for application in population synthesizer	1
b)	Prepare validation targets	1
c)	Apply population synthesizer with TRM inputs and adjust to meet targets	3
d)	Prepare validation summary report	1

2.6.2 Employment synthesizer

Employment by appropriate employment category is an important way to match workers in households with their place of employment. It is suggested to investigate whether it is possible to use available data (InfoUSA or other) to synthesize workers by employment type. The objective for developing an employment synthesizer is to develop an approach using available information to simplify the task to develop forecasts of employment by type. This task supports task 5.1 to develop an improved destination choice model as well as all model components that use employment data.

Est. start date: 7/2/2012

Est. end date: 1/14/2013

2.6.2.1 Investigation of employment synthesis

A review will be undertaken of techniques that have been used to estimate workers by employment type. A technical memorandum will be prepared to enable the Model Team to make a recommendation regarding whether to develop an employment synthesizer for the v6 model.

Deliverables:

Technical memorandum summarizing findings of investigation

ID	Task Description	Person Days
2.6.2.1	Investigation of employment synthesis	13
a)	Review employment synthesis techniques	10
b)	Document findings and make recommendation	3

2.6.2.2 Estimation of employment synthesizer

Appropriate data sources will be prepared for use in model estimation. Targets for worker controls will be prepared perhaps from census data. Employment synthesizer models will be estimated using appropriate data; perhaps household survey data combined with InfoUSA and Community Viz data and any other available data sources.

Deliverables:

Technical memorandum documenting estimation of employment synthesizer

ID	Task Description	Person Days
2.6.2.2	Estimation of employment synthesizer	20
a)	Prepare data for synthesizer estimation	3
b)	Analyze relationships between elements of available data sets	10
c)	Estimate employment synthesizer	5
d)	Prepare documentation for analysis & employment synthesizer estimation	2

2.6.2.3 Develop model application procedures

Model application modules will be prepared to apply the employment synthesizer within the TRM. This may require the modification of the model script, modification of the trip generation program, modification of the population synthesizer program, and any model components that use employment information.

Deliverables:

Documentation for all program code written

ID	Task Description	Person Days
2.6.2.3	Develop model application procedures	12
a)	Write program code	7
b)	Debug program code	3
c)	Test application & prepare documentation	2

2.6.2.4 Employment synthesizer calibration

The employment synthesizer will be applied with appropriate inputs (perhaps travel survey data) and the model outputs will be compared to targets for the control totals. The model will be adjusted until control totals are matched satisfactorily.

Deliverables:

Report summarizing calibration work including development of targets and final model performance

ID	Task Description	Person Days
2.6.2.4	Employment synthesizer calibration	9
a)	Prepare employment synthesizer calibration inputs	3
b)	Apply employment synthesizer and adjust to meet targets	5
c)	Prepare report	1

2.6.2.5 Employment synthesizer validation

After calibrating the employment synthesizer, the employment synthesizer will be applied with 2010 TRM population inputs, and the output will be compared to census data or other appropriate source for employment data for the study area. Adjustments will be made as necessary to match household and population controls for the study area.

Deliverables:

Documentation for developing validation data and model performance

ID	Task Description	Person Days
2.6.2.5	Employment synthesizer validation	7
a)	Prepare TRM inputs for application in employment synthesizer	1
b)	Apply employment synthesizer with TRM inputs and adjust to meet targets	5
c)	Prepare documentation for validation and model performance	1

2.6.2.6 Employment synthesizer documentation

Documentation for the employment synthesizer will be prepared.

Deliverables:

Documentation for employment synthesizer component including model performance

ID	Task Description	Person Days
2.6.2.6	Employment synthesizer documentation	2
a)	Prepare employment synthesizer documentation & distribute for comments	1
b)	Revise documentation in response to comments	1

2.6.3 Long-term decision models

It is possible to distinguish between decisions people make at long intervals (new home location, new employment location, school location, auto purchase), and decisions that are made at short intervals or even every day (shopping, recreation). Models of the decisions made at long intervals are developed early in model development, so later models can be conditional on the long interval decisions. The auto ownership model is proposed to be prepared first.

Est. start date: 7/10/2012

Est. end date: 7/23/2012

2.6.3.1 Auto ownership model

Auto ownership plays a role in travel choices throughout the TRM. An important difference between aggregate trip based models and activity-based models is that in trip based models the auto ownership model usually comes before trip generation, whereas with activity-based models it usually comes after the models of usual workplace, and school locations. This reflects that if the work location is farther away, a household is more likely to purchase more cars (both for the worker(s) and for other non-worker(s)). For the approach to add new components to the trip based model, it may make sense to develop an auto ownership model before trip generation,

but it is very likely that it will be re-estimated for a later tour or activity-based model.

2.6.3.1.1 Investigation

Work on the auto ownership model will begin with a review of approaches that have been used by other metropolitan areas. Criteria to select an appropriate auto ownership model for the TRM will be developed and a technical memorandum will be prepared to enable the Model Team to make a recommendation of the model form to develop for application in the TRM.

Deliverable:

Technical memorandum

ID	Task Description	Person Days
2.6.3.1.1	Investigation	10
a)	Review auto ownership modeling approaches	5
b)	Document findings in draft technical memorandum	3
c)	Revise technical memorandum	2

2.7 Develop an improved parking constraint model

Purpose: Improve parking constraint model to better address regional policy issues with sub-area analysis within a PASA.

Objective: Design improved parking cost and capacity constraint model specifications; design parking data collection plan and instrument, collect, process and analyze data; and develop and implement improved parking constraint models in TRM v6.

Previous work:

The TRM v5 parking cost and capacity constraint models improved the model's responsiveness to policy control in terms of using parking pricing and parking capacity (parking spaces and/or space allocation among parking facility uses). It enables stakeholders to test policy scenarios using parking cost and/or capacity, e.g., for the purpose of encouraging mode change from driving alone to car pool, car pool to transit, or even making non-motorized trips. While parking capacity and cost are PASA-based, one can create a TAZ based cost scenario and test the cost variation and/or change by TAZ.

However, the TRM v5 models were developed based on limited data available at the time, i.e. limited observed traveler behavioral information. The TRM v5 parking models can only portray the aggregated parking behavior in response to a PASA-based aggregated parking cost. Further improvement could be to: 1) from the supply side to let the travelers choose among parking facilities (or TAZ) based on facility or TAZ based parking cost and capacity, and travel time/mode to the final destination TAZ; and 2) from the demand side to differentiate travelers facing different parking cost and/or capacity constraint (those with or without a reserved space, and those with or without a parking subsidy). The reason is that when facing a common parking cost and capacity, travelers would respond differently. Not portraying such behavioral details is

the weakness of the TRM v5 parking models.

The FY 2012 TRMSB staff review of best practice showed that the most common practice in the industry is to apply the posted parking rate as part of general cost in the mode choice process. Only a few regional models in the world have developed relatively sophisticated parking models estimating/forecasting parking price and/or spaces, and not all of them implemented parking capacity constraint explicitly. A few have a model with traveler parking subsidy choice or a model based on user side information such as actual out-of-pocket cost; very few have a model with traveler free reserved space choice, very few have a parking location choice model. All the variation of parking model approaches reflects each region's particular policy testing needs which may or may not be similar to those of the Triangle region.

Based on the Triangle Region's needs, cost effectiveness (in terms of effort needed), and current parking cost variation within each PASA, the TRM team has identified and recommended the most suitable approach, and provided for stakeholders' review. The TRM v6 parking model would focus on the following improvements:

- 1) traveler parking location choice in response to parking cost and/or parking capacity constraint, including modeling the parking capacity constraint by using a continuous "dynamic" shadow price function based on the percent use of parking capacity for a purpose in a PASA. As demand exceeds capacity for a PASA, the higher the shadow price (instead of the TRM v5 step function) – which is analogous to the concept of volume delay function in highway assignment.
- 2) Travelers' parking behavior subject to actual out-of-pocket cost, e.g., differentiate travelers with and without parking subsidy
- 3) travelers' parking behavior subject to actual effective parking space, e.g., differentiate travelers with and without a reserved space

However, the recommended improvement cannot be developed without further data collection on detailed travelers' parking behavior for both revealed and stated preferences. In FY 2012 TRMSB staff reviewed and evaluated other regions' approach with respect to parking behavior data collection, this helped us to catch up on current trends and learn from the best up-to-date practice. Reviewing others' data collection practice will help us budget our desired parking behavior data collection effort.

Effort estimated for the sub-tasks are based on the assumption that all three of the proposed parking choice models would be developed, while time needed for each model is given separately.

FY 2013 main tasks:

- 1) Design TRM v.6 improved parking cost and capacity constraint model specifications. This would be reviewed and approved by stakeholders.
- 2) Design parking behavior data collection plan. Data collection cost will be estimated and provided to stakeholders.
- 3) Collect data. A survey consultant will be hired by a stakeholder partner to conduct the survey, while TRM SB will provide advice, including pilot and final survey data QA/QC.
- 4) Process and analyze data for model development use
- 5) Develop improved parking models [estimation, calibration and validation]
- 6) Implement improved parking models in TRM v6 model stream (updating TransCAD script, Fortran program and so on)
- 7) Document the TRM v6 improved parking model development

2.7.1 Design TRM v6 parking constraint models specifications

The key tasks are: a) design parking improvement framework; b) design each parking constraint sub-model structure specification; c) design sub-model function specification used by each sub-model; d) identify input data (if not already in use in TRM v5); and e) prepare documentation.

Deliverables:

Technical memoranda on TRM v6 parking model design specifications for stakeholders review and approval.

Est. start date: 9/24/2012

Est. end date: 1/8/2013

ID	Task Description	Person Days
2.7.1	Design TRM v6 improved parking constraint model specifications	34
a)	Design parking improvement framework	5
b)	1) Parking location choice model (PLCM) model structure specification	5
	2) PLCM: design function specification	10
	3) PLCM: identify input data (if not already in use in TRM v5)	1
	4) PLCM: documentation	2
c)	1) Parking reserved space choice model (PRSCM) design model structure specification	1
	2) PRSCM: design function specification	3
	3) PRSCM: identify input data	1
	4) PRSCM: documentation	1
d)	1) Parking monetary subsidy choice model (PMSCM) design model structure specification	1
	2) PMSCM: design function specification	3
	3) PMSCM: identify input data	1
	4) PMSCM: documentation	1
e)	Provide preliminary design specification for stakeholder review/approval	2

3 Trip generation

3.1 *Re-estimation and/or re-calibration of trip production models*

In TRMv6, some important input files will be improved (such as SE data, TAZ system and networks), the SE Models will be updated, and the observed data set (2006 Household Survey) will be re-weighted/re-expanded based on the 2010 census. Therefore, efforts are needed to check if the trip production models in TRMv5 still work well in TRMv6, and if estimation and calibration will be necessary.

- a) Adjust the trip generation script to fit the TRMv6 TAZ system.
- b) Evaluate initial TRM v.6 trip production model result to determine if re-estimation/calibration is needed. If the model performs satisfactorily, no further work on trip production models may be needed.

This includes the following steps:

1. Develop observed 2010 observed person trip production target from re-expanded/weighted 2006HIS;
2. Run initial TRM v6 trip generation model
3. Assess initial trip production result by comparing the modeled to the target;
4. Determine if re-estimation and/or re-calibration is necessary for any of trip purpose and/or any person type.

Only when determined to be needed, the following steps will be carried out:

- c) Prepare the observed trip production targets from the re-expanded/re-weighted 2006 Household Survey and candidate explanatory variables
- d) Re-estimate and re-calibrate trip production models
- e) Document the work on re-estimation and/or calibration of Trip Production Models.

Deliverable:

New parameters for Trip Production Models, and technical memorandum on the re-estimation and/or calibration of Trip Production Models.

Est. start date: 2/7/2013

Est. end date: 5/8/2013

ID	Task Description	Person Days
3.1	Re-estimation and/or calibration of trip production models	65
a)	Adjust trip generation script to fit the v6 TAZ system	1
	Run initial TRM v.6 trip production model	1
	Evaluate initial trip production model vs. observed target Determine if any purpose/person type needs re-estimation/re-calibration	5
b)	Prepare observed trip production numbers and candidate explanatory variables	10
c)	Re-estimate/re-calibrate any trip production model (purpose-person type combination) as necessary	40
d)	Documentation	8

4 Time of day and peak spreading model

The current TRM v5 model uses fixed time-of-day factors to slice a daily trip matrix into multiple time periods of a day and estimates traffic conditions for each time period by assigning the sliced trip matrices onto the highway network. This is a typical time-of-day modeling approach widely used in the US. However, since time-of-day factors are most commonly specified as exogenous values derived from the household survey data or traffic count data, they are fixed and independent of congestion levels. Even when congestion gets more severe, the model still assumes the percentage of travelers that start their trips in the peak period will keep unchanged, which is not realistic and can over estimate traffic congestion for the peak period. It has been observed from travel surveys that the peak spreads when congestion gets more severe. A more sophisticated congestion-level-dependent time-of-day (or called peak spreading) modeling method should be employed in the TRM to better simulate traffic conditions.

4.1 *Peak spreading model*

To employ a more sophisticated time-of-day modeling approach in the TRM v6, the following tasks will be carried out.

1) Literature Review. A preliminary review has found three promising innovative time-of-day modeling approaches that have been developed and employed by several other MPOs in the US. These include a link-based peak spreading approach developed for Phoenix, AZ and two trip-based approaches for Boston, MA and Washington, DC, respectively. These approaches will be examined thoroughly to identify their strengths and limitations. Findings will be documented.

2) Evaluation of Data Needs and Data Availability. Each of the approaches needs different types of data to develop the model. Data needs and local availability of the data will be assessed against each approach. In the case where required data is available, we may re-

estimate the model using our own data. If data is not available, the parameters developed by the aforementioned MPOs can be borrowed. Findings will be documented.

3) Proposing a Suitable Approach for the TRM. Based on the review and data assessment, one of the three approaches will be selected, with enhancements proposed where necessary and appropriate. However, it has to be recognized that, since none of these three approaches have been widely adopted in the US, not much information is available regarding their transferability and performance in different settings. Testing all the three approaches by implementing them in the TRM v6 model can be an option, if time allows and the implementation is not time consuming. In this case, selection criteria will need to be established first.

4) Model Estimation. Of the three approaches, one develops a share model using the household travel survey data. If this approach is chosen, model estimation for each trip purpose and both AM and PM peak periods using the Triangle region local data is expected.

5) Model Calibration. Regardless of which approach is chosen, hourly traffic count data will be used to calibrate the model parameters (if there is a share model), thresholds, and/or factors employed in the approach. The parameters, thresholds, and factors will be adjusted until model estimates agrees reasonably well with the count data.

6) Implementing the Model. A GISDK module will be developed and integrated with the main TRM script.

7) Investigating the Impact on Feedback Convergence. Since the Phoenix approach adjusts link volume and hence congested speeds directly and the Boston and Washington approaches make adjustments to trip matrices directly, all as an extra to the MSA process executed immediately after the highway assignment step, the impact of these peak spreading adjustments on the existing TRM feedback loop should be examined and any major changes should be investigated and explained.

8) Documentation of the Entire Module.

To carry out the above described tasks, significant time is needed; especially if it is decided to test all three approaches. Time available in FY 2012-13 is limited, so a two stage process is proposed with the first stage to be completed during FY 2013 and the second during FY 2014. The tasks and corresponding budget for the second stage will probably need to be revised based on the approach recommended during the first stage.

Est. start date: 10/29/2012

Est. end date: 6/5/2013

Stage	ID	Task Description	Person Days
	4.1	Peak spreading model	50/60*/91**
Stage 1	Subtotal		20
	1)	Literature Review	6
	2)	Evaluation of Data Needs and Data Availability	1
	3)	Proposing a Suitable Approach for the TRM	3
	4)	Script modifications if approach not requiring model estimation is chosen; otherwise prepare data for model estimation & estimate models	10
Stage 2	Subtotal		30/40*/71**
	5)	Modify GISDK script if approach requiring model estimation is chosen in stage 1	10*
	6)	Develop performance evaluation criteria	2
	7)	Develop GISDK performance evaluation module	8
	8)	Develop selection criteria if recommended to test all 3 approaches	1**
	9)	Test the three approaches & recommend the best based on selection criteria developed in number 8 above (script modifications need to be made for two additional approaches)	30**
	10)	Model calibration	10
	11)	Investigate the impact on convergence	5
	12)	Documentation of the Entire Module	5

Notes:

* Time required if the approach with model estimation is selected in Stage 1

** Time required for testing all three possible approaches

4.2 Prepare time of day factors

- a) Prepare the time of day factors from the re-expanded/weighted 2006 HH survey including preparing new time of day factors for the off-peak period to include new mid-day and night periods.

Est. start date: 5/9/2013

Est. end date: 6/3/2013

ID	Task Description	Person Days
4.2	Prepare time of day factors	17
a)	Prepare time of day factors from re-expanded/weighted 2006 HH survey including preparing new off peak factors for mid-day and night periods and peak factors and compare the new time-of-day factors vs. those used in TRM v5 documentation	16
b)	Document time of day factors	1

5 Trip distribution

5.1 *Develop improved destination choice model*

Objective:

The purpose of this task is to improve the TRM v5 destination choice model. The objective is for v6 to better model trip distribution for each trip purpose by household strata, by employee type by earnings, occupation and/or business type; focusing more on individual person types; to improve the accuracy of trip attraction allocation by purpose to appropriate destinations for each of the five household strata used in TRM. This task will include searching for and choosing an appropriate model specification.

FY 2013 main tasks:

- 1) Design improved destination choice model specification for stakeholders' review and approval.
- 2) Identify sources of model estimation data
- 3) Prepare model estimation file from re-expanded/weighted 2006 Household Travel Survey and other data sources (e.g., traffic skims)
- 4) Develop improved destination choice model (estimation, calibration and validation)
- 5) Script modifications to include destination choice model in TRM v6 model stream
- 6) Document the model development process

Final product will be a technical memorandum that documents the entire process above, model performance; and a completely updated ready-to-use destination choice model (including TransCAD scripts, Fortran programs, input data files and finalized parameters).

5.1.1 *Design TRM v6 destination choice model specifications*

Deliverables:

Technical memorandum on TRM v6 destination choice model design specifications

Est. start date: 7/2/2012

Est. end date: 7/25/2012

ID	Task Description	Person Days
5.1.1	Design TRM v.6 destination choice model specifications	17
a)	Design destination choice model specification	15
b)	Document design specification	2

5.1.2 Script modifications for application of destination choice in TRM v6

Deliverables:

- 1) Technical memorandum documenting all script and FORTRAN program modifications
- 2) Final model script and application program ready for application

Est. start date: 7/26/2012

Est. end date: 9/11/2012

ID	Task Description	Person Days
5.1.2	Script modifications for application of destination choice in TRM v6	33
a)	Design model application approach	5
b)	Modify model script and FORTRAN program: update TransCAD script/Fortran program (and control files), other needed input and parameter files	20
c)	Test and finalize parking cost model implementation	5
d)	Document all script and program modifications	3

5.1.3 Prepare v6 destination choice model estimation files

Est. start date: 9/12/2012

Est. end date: 10/19/2012

ID	Task Description	Person
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		Days
5.1.3	Prepare TRM v6 destination choice model estimation data files	13
a)	Identify destination choice model estimation data sources	1
b)	Adjust the initial destination choice model script to fit the TRMv6 TAZ system	1
c)	Prepare congested travel times in TRMv6 to create the skim files	1
d)	Prepare the model estimation files, which includes sampling 20 possible destination TAZs for each trip record in the 2006 Household Survey, and calculating all candidate explanatory variables for each possible destination TAZ	10

Tasks 5.1.4 through 5.1.7 listed below continue work started during FY 2012.

5.1.4 Estimate model using new specification

Est. start date: 10/22/2012

Est. end date: 11/16/2012

ID	Task Description	Person Days
5.1.4	Estimate TRM v6 destination choice model with new specification	20
a)	Estimate model	15
b)	Evaluate estimation performance (statistical tests) and select the best ones based on professional judgment	5

5.1.5 Calibrate model

Deliverables:

- 1) Technical memorandum documents estimation and calibration process, with statistical test results; and distribution results performance
- 2) Calibrated model (parameters, any input files)

Est. start date: 11/19/2012

Est. end date: 1/13/2013

ID	Task Description	Person Days
5.1.5	Calibrate TRM v6 destination choice model	35
a)	Identify and prepare calibration target data [mostly likely 2006HIS], including observed target trip tables, county level and district level flow	5
b)	Review model performance result vs. target [trip length/distance, county-to-county flow and district-to-district flow]	10
c)	Calibrate model specification (adjust parameters, and/or even function forms when necessary)	15
d)	Document estimation and calibration process	5

5.1.6 Validate model

Est. start date: 1/18/2012

Est. end date: 2/14/2013

ID	Task Description	Person Days
5.1.6	Validate TRM v6 destination choice model	19
a)	Identify validation data source [e.g., CTPP and other data sources]	1
b)	Prepare validation data [depends upon availability]	2
c)	Develop validation approach	1
d)	Validate model including: Duke University, Durham & Raleigh downtowns, RTP, NCSU, and UNC	10
e)	Document validation result	5

5.1.7 Final adjustment

Deliverables:

- 1) Technical memorandum summarizes validation process and results.

Est. start date: 2/15/2013

Est. end date: 2/28/2013

ID	Task Description	Person Days
5.1.7	Final adjustment	5

5.1.8 Documentation

Deliverables:

- 1) Technical memorandum on entire Task 1.8.2 TRM v6 destination choice model
- 2) Ready to use model components (TransCAD script, FORTRAN program, parameters, input files)

Est. start date: 3/1/2013

Est. end date: 3/18/2013

ID	Task Description	Person Days
5.1.8	Task 5.1.8 Final documentation for the TRM v6 destination choice model	6

6 Non-motorized

[Placeholder task for future work]

7 Mode choice

[Placeholder task for future work]

8 Special models

8.1 Develop an improved commercial vehicle model (CVM)

A preliminary commercial vehicle model (CVM) was developed during FY 2012 using traffic analysis zones (TAZs), highway network, and socioeconomic data in TRM v5 due to the postponed availability of v6 input data. The major tasks completed included:

- 1) re-weighting, re-expansion, and processing of the 2010 commercial vehicle survey data;
- 2) estimation of trip generation model for I-I trips using regression analysis technique;
- 3) estimation of destination choice model for I-I trips using discrete choice modeling technique;
- 4) development of a methodology to link the CVM with the NC Statewide Model to bring in statewide model estimates for better forecasting of IE, EI, and EE trips
- 5) development of GISDK script to implement trip generation model;

- 6) development of GISDK script to implement destination choice model;
- 7) development of GISDK script to implement the methodology to bring in statewide model estimates for IE, EI, and EE commercial vehicle trips;
- 8) development of GISDK script to implement truck-prohibited links and lanes for traffic assignment.
- 9) documentation of all the tasks # 1), 2), 3), and 4) above

In FY 2013, the preliminary commercial vehicle model developed in FY 2012 as described above will be brought into TRM v6. Since an improved TAZ system with newly estimated socioeconomic data and an updated highway network with a completely new speed and capacity estimation approach are to be used, the travel survey data and socioeconomic data used for model estimation will need to be re-prepared. The trip generation and distribution models estimated using the TRM v5 model data will have to be re-estimated. These models will also be calibrated using the v6 data. Due to the use of an improved, different TAZ system from the v5, interface between the TRM and the statewide model will need to be adjusted accordingly. In addition, calibration and validation of the full commercial vehicle model to align model outputs with observed traffic counts or VMT will be another major task. All the GISDK scripts will need to be adjusted accordingly, and all the documentations will be updated.

The following sub-sections detail the steps and related tasks required to complete the CVM and in particular to prepare it for use with v6 model inputs.

8.1.1 Model estimation and calibration with v6 input data

a) Trip generation model:

- 1) Re-form districts based on v6 TAZ system and associated SE data
- 2) Map survey trip ends to the improved TAZ system and the new districts and prepare model re-estimation input data
- 3) Re-estimate trip generation models by vehicle type and by trip purpose
- 4) Calibrate trip generation models to align model estimated trips with observed trips from the expanded 2010 CV survey
- 5) Update the GISDK macro to implement trip generation model in v6.

b) Trip distribution model:

- 1) Generate new highway travel time and travel distance skim matrices. To get reasonable congested travel times for the peak period, trip matrices from the v5 model will have to be adjusted and brought into v6 and assigned to the v6 highway network. Both AM peak and PM peak travel times are needed to distribute the trips by time of day.
- 2) Prepare new model estimation datasets
- 3) Re-estimate destination choice models based on new SE data and new skim data
- 4) Derive new trip length frequency distributions based on the improved TAZs and new highway travel times
- 5) Calibrate destination choice models to align model estimated average trip lengths with observed trip lengths
- 6) Update the GISDK macro to implement destination choice model in v6

Deliverables:

Updated technical memorandums documenting development/update of the models, calibration efforts made, and model performance.

Est. start date: 8/10/2012

Est. end date: 10/17/2012

ID	Task Description	Person Days
8.1.1	Model estimation and calibration with v6 Input data	48
8.1.1.a	Trip generation model	14
1)	Re-form districts	3
2)	Prepare model re-estimation input data (for 8 models)	2
3)	Re-estimate trip generation models (8 models)	4
4)	Calibrate trip generation models	4
5)	Update the GISDK macro	1
8.1.1.b	Trip distribution model	34
1)	Generate new highway travel time and distance skims	10
2)	Prepare new model estimation datasets (for up to 24 models, see below)	3
3)	Re-estimate destination choice models (up to 24 models, i.e. 3 times of day and 8 combinations of vehicle types and trip purposes)	12
4)	Derive new trip length frequency distributions (one for each model, up to 15 models)	2
5)	Calibrate destination choice models (up to 15 models)	5
6)	Update the GISDK macro	2

8.1.2 Interfacing with NC Statewide Model (for both CV and passenger models)

- a) Develop a correspondence between NCSTM and TRM zones and between NCSTM and TRM employment types.

Based on the preliminary analysis, it is apparent that the NCSTM created its zone structure for the Triangle Region based on the TRM v5 zones. Since the new v6 zones are a bit different from those in TRM v5, a more complicated correspondence table will need to be developed

between the NCSTM zones and the TRM v6 zones.

The correspondence table will contain estimated percentages to allocate population, households, and employment by type in each of the NCSTM zones to geographically overlaid TRM zones. Since NCSTM uses a different employment categorization scheme from the TRM, conciliation between the two schemes is anticipated using, for example, another correspondence table. This is especially true for commodity-based commercial vehicle trips estimated by the NCSTM.

b) Allocate internal trip ends to TRM internal zones.

With allocated socioeconomic data, it is anticipated that trip generation model coefficients will be needed to allocate from the NCSTM to the TRM the internal trip ends of I-E and E-I trips. Since NCSTM and TRM have different trip generation models and time of day definitions, reconciliation between the two models is anticipated in order for a successful integration. Comparison between model estimates using the two models along with some adjustments may be needed to find the best solution. CV trips and passenger trips may end up with using different methods, depending on the investigation. Further adjustments are anticipated in the model validation stage where modeled VMT or volumes are compared with observed VMT or counts in the region.

c) Allocate external trip ends to TRM external stations.

Allocating external trip ends (relative to the TRM model boundary) reasonably to TRM external stations is critical. However, unlike the TRM, many of the local roads and even some collectors not included in the NCSTM make this task a bit challenging. It is anticipated that a subarea analysis will need to be conducted in NCSTM to decide the pairs of ODs that have trips passing through each of the major road segments with TRM external stations located. After that, certain percentages of traffic will have to be assumed and allocated from the major road to the adjacent roads that are present in the TRM but not in NCSTM. Both I-E/E-I and E-E trips and both CV trips and passenger trips will need to be included in the analysis.

d) Factor NCSTM estimates to align estimated volumes with counts at external stations.

Truck trip ends (or called traffic volumes) at each TRM external station as estimated in the previous step will be compared with actual ground truck counts for the base year. One ratio will be developed and be applied as a factor to align the estimated volumes with the counts at each external station. A similar procedure will be done to adjust passenger vehicle volumes too based on the comparison of auto volumes and counts at the external stations.

e) Implement the interfacing approach in GISDK and integrate it with the other parts of the model.

Deliverables:

Updated technical memoranda documenting development/update of this interfacing model.

Est. start date: 10/18/2012

Est. end date: 11/30/2012

ID	Task Description	Person Days
8.1.2	Interfacing with NC Statewide Model (for both CV and passenger models)	30
a)	Develop a correspondence between NCSTM and TRM zones and between NCSTM and TRM employment types	6
b)	Allocate internal trip ends to TRM internal zones	8
c)	Allocate external trip ends to TRM external stations	7
d)	Factor NCSTM estimates to align estimated volumes with counts at external stations	3
e)	Implement the interfacing approach in GISDK and integrate it with the other parts of the model	6

8.1.3 Develop truck-prohibited link and lane function in v6

- a) Identify the truck-prohibited links and lanes in v6 highway network
- b) GISDK implementations will be developed. It is anticipated that script modifications will be made at many places in the v6 model because change of network is a fundamental change and impacts anywhere the network is used in the model, such as the steps of Create Network, Trip Distribution, and Highway Assignment. Full testing of the entire model is needed to make sure all the pieces impacted still work correctly.

Deliverable:

Technical memoranda documenting development of this function.

Est. start date: 12/3/2012

Est. end date: 1/2/2013

ID	Task Description	Person Days
8.1.3	Develop truck-prohibited link and lane function in v6	16
a)	Identify the truck-prohibited links and lanes in v6 network	1
b)	GISDK implementations and full test	15

8.1.4 Scope modifications for time of day traffic assignment

- a) Update the existing v5 model script to implement time-of-day CV traffic assignment in v6. If the v6 model is going to implement 4 time periods of day, additional scripting may be needed.

ID	Task Description	Person Days
8.1.4	Implement Time of Day Traffic Assignment	1
a)	Update related model script	1

8.1.5 Update overall model documentation for commercial vehicle model

- a) Model documentation prepared in FY 2012 based on the v5 data will be updated fully to reflect the modeling efforts made and results achieved using the v6 data.

Deliverable:

Commercial vehicle model documentation section of v6 model documentation

Est. start date: 1/3/2013

Est. end date: 1/11/2013

ID	Task Description	Person Days
8.1.5	Update model documentation	7
a)	Update model documentation	7

8.2 University Student Model

The TRMv5 included university students with other adults as workers and non-workers with and without autos. Trips from home to the three main campuses were modeled as a separate trip purpose (Home Based University or HBU). While this approach improved on earlier models, it left room for improvement, in particular for non-home based travel between Duke University east and west campuses and NCSU main and Centennial campuses. An improved university student model will be developed to better represent travel choices made by students.

8.2.1 Investigation of university student models

Up to three examples of university student models will be obtained and will be described. These will be compared with the TRM v5 model approach. Based on the examples and on analysis of the NCSU student survey data, an approach for a university student model will be proposed for Model Team consideration. It is expected that developing a student daily activity pattern model based on prior work will be considered.

8.2.2 Prepare available university student data for analysis

The NCSU student activity survey will be prepared for analysis including developing any needed derived variables, such as trip/activity purpose. Data preparation will include appending TRM v6 TAZ numbers to survey records for destination choice model estimation. Appropriate strata for students will be developed such as: on-campus residents and off-campus residents, under-

graduate and graduate/professional students as determined by analysis of the data. Other data needed will be collected as required (population of students at each campus in each category used in analysis for example).

8.2.3 Trip/activity generation model estimation

Models of trips or activities by students will be estimated for trip purposes and strata depending on the specification recommended in section **Error! Reference source not found.**

8.2.4 Destination choice model estimation

Destination choice models will be estimated for either trips or tours/stops depending on the specification recommended in section **Error! Reference source not found.**

8.2.5 Non-motorized model estimation

The current TRM v5 model includes a step to separate trips into non-motorized and motorized modes after destination choice. If this structure is recommended for the university student model, then non-motorized models will be estimated for trips or tours/stops on tours.

8.2.6 Prepare models for application

It is anticipated that the university student models will require new model scripts to be written. This is expected to be a substantial effort that will include the design of inputs and outputs, script flow, coding, and execution testing.

Deliverable:

University student model ready for application including documentation of all model development steps, data used and model performance.

Est. start date: 7/2/2012

Est. end date: 2/7/2013

ID	Task Description	Person Days
8.2	University student model	100
8.2.1	Investigation of university student models	10
8.2.2	Prepare available university student data for analysis	10
8.2.3	Trip/activity generation model estimation	20
8.2.4	Destination choice model estimation	10
8.2.5	Non-motorized model estimation	10
8.2.6	Prepare models for application	40

8.3 Land use models

Other regions have included the integration of a regional land use model with their advanced travel demand models. The Triangle region has experience with the UrbanSim land use model. It is suggested that the region consider whether to integrate a land use model with the TRM.

8.3.1 Investigation

An investigation will be conducted into land use models and the ways they have been used in other regions with a focus on tour-based models. As part of the investigation, a "summit" will be convened to share information and to prepare a recommendation regarding whether or not to pursue integrating a land use model with TRM v7. A technical memorandum will be prepared documenting the summit and the Model Team recommendation.

Deliverable:

Technical memorandum summarizing the investigation including results of the summit convened to consider land use modeling for the Triangle region.

Est. start date: 7/2/2012

Est. end date: 11/30/2012

ID	Task Description	Person Days
8.3.1	Investigation of land use models	17
a)	Obtain information on land use models in other regions	2
b)	Prepare resource document for land use model summit	3
c)	Prepare for and convene land use summit	9
d)	Prepare a technical memorandum documenting the summit and resulting recommendation	3

9 Trip assignment, calibration & validation

9.1 Investigate improving highway assignment

9.1.1 Dynamic traffic assignment

Dynamic traffic assignment is being considered for both pricing and safety planning applications, and tools are being developed that may be appropriate for application in the Triangle region. These include DTALite being developed under an FHWA research project, and the SHRP 2 C10 project combining an activity based model with Dynus T.

9.1.1.1 Investigation of dynamic traffic assignment

An investigation of dynamic traffic assignment tools will be performed. This will include a review

of available tools, and experience in other regions. A tool will be selected to test with Triangle region data and a test will be performed. Findings will be reported in a technical memorandum.

Deliverable:

Technical memorandum summarizing the investigation including results of the test of dynamic traffic assignment performed.

Est. start date: 2/28/2013

Est. end date: 3/21/2013

ID	Task Description	Person Days
9.1.1.1	Investigation of dynamic traffic assignment	15
a)	Literature review & collect information from other regions	5
b)	Set up test of dynamic traffic assignment	5
c)	Prepare a technical memorandum documenting literature review and results of tests	5

10 Technical Assistance

10.1 Assistance with model application for developing the 2040 Long Range Transportation Plan

Objective:

To enable the stakeholders to apply the model for developing their Long Range Transportation Plans.

Previous work:

Assistance was provided with modifying the TRM v5 model for including transit New Starts features.

The TRM Service Bureau and/or Model Team will provide assistance for the MPOs and NCDOT during development of the 2040 LRTPs. This will include assistance with setting up and running the TRM, interpreting results and debugging when problems are encountered.

10.2 Technical Assistance with TRM model application on as needed basis

Objective:

To enable stakeholders (including stakeholder contractors) to apply the model for project and system level analysis

Previous work:

Model files and assistance have been provided to stakeholders and their contractors

TRM Service Bureau staff will provide technical assistance for stakeholder partners on an as needed basis when they are applying the TRM. This will include providing model files and documentation to contractors working on the behalf of stakeholder partners. It will also include answering questions and providing assistance when problems arise.

10.3 Action items

Objective:

To address issues identified by stakeholders as Action Items.

Previous work:

None

From time to time the stakeholders may determine that there are work tasks not covered elsewhere in the work program that nonetheless must be done. During FY 2012 ten such action items were requested by stakeholders. The action item work program element sets aside time for conducting work on tasks as determined by the stakeholders. These tasks will result in a work product, such as a technical memorandum that will document the work done and the completion of the task. Unused time can be allocated to other work tasks after the end of the second quarter.

11 Oversight & reporting

Objective:

To enable efficient and effective team communication and project management.

Previous work:

During FY 2012 monthly team meetings and quarterly Executive Committee meetings were held.

This task includes necessary administrative tasks and meetings needed for project oversight and communication with stakeholders such as Executive Committee, Model Team, and internal TRM Service Bureau meetings. Periodically team members meet both internally and with stakeholders to review task progress and approaches, solve problems, and keep stakeholders informed of work taking place on the project. The project also requires developing an annual work program, task assignments, and monthly team reporting.

11.1 TRM Team Meetings

TRM Team Meetings will be held monthly on the 3rd Thursday of each month unless there are no items to discuss. Model Team members may convene a technical team meeting to review task approaches in detail and develop recommendations for tasks on an as needed basis

11.2 TRM Executive Committee Meetings

Executive Committee meetings will be held every other month on Tuesday afternoons, or as designated by executive committee members.

11.3 Quarterly Progress Reports and monthly status reports

Quarterly progress reports will be prepared in October, January, April, and July. Monthly status

reports will be prepared.

11.4 *Develop and maintain team collaboration web site*

A web site for team collaboration will be developed and maintained using Google Sites or similar approach. This will allow the team to share data, analysis, calendar, and documentation to improve collaboration and efficiency.

Appendix A

Vision for Developing the v6 and v7 Models

Policy Testing Needs Identified by Stakeholder Partners

Policy Testing Needs Identified by EC 10/20/2009	Part of Model?
1. Dynamic Tolls	Part of model
2. Greenhouse gas – land use change (Urban Sim)	Part of model
3. Peak spreading (a result)	Part of model
4. Parking constraint in CBD and elsewhere	Part of model
5. Environmental Justice (EJ) impacts (a result)	Analysis done outside model
6. Change mix of land uses within TAZs & consider design of land uses	Part of model
7. TDM policies	Analysis done outside model
8. ITS	Analysis done outside model
9. Making decisions on modal investments	Analysis done outside model

Suggested Elements of New Models or Work Programs

Suggested Elements (FY 2012 list)	In v6	In v7	Invest.	Notes
1. Improved Commercial Vehicle Model	X			DCHC #1
2. Improved Transit Assignment		X		DCHC #2
3a. Static Traffic Assignment Improvements	X		X	DCHC #3
3b. Dynamic Traffic Assignment		X		DCHC #3
4. Area Type Sub-model		X		DCHC #4
5. Population Synthesizer		X		DCHC #5

6. Trip Attraction and Destination Choice Sub-model	X			DCHC #6
7. University Student Trip Model		X		DCHC #7
8. Walk Access - Transit Link		X		DCHC #8
9. Employment Category and Special Trip Generators		X		DCHC #9
10. System Optimization	X			DCHC #10
11. Time of Day Model		X		DCHC #11
12. Parking Survey and/or Behavior Study		X	X	DCHC #12 Tri. Tran. req.
13a. Link Capacity Calculation			X	DCHC #13 CAMPO req.
13b. Intersection Delay			X	DCHC #13
14. HBW Journey or Tour Based Model		X		
15. Strategic data collection plan			X	MPO req.
16. TAZ review			X	

Suggested Elements (FY 2013 list)	In v6	In v7	Invest.	Notes
1. University student trip model	X			DCHC #1
2. Validation on person and CV trip rate	X			DCHC #2
3. Attraction share and destination choice improvement	X			DCHC #3
4. Mode choice estimation/calibration	X		X	DCHC #4
5. Transit model [updates]	X			DCHC #5
6. Time of day	X			DCHC #6
7. Disaggregated population synthesizer	X			DCHC #7
8. Auto ownership model	X			DCHC #8
9. Meso-scopic dynamic traffic assignment			X	DCHC #9

10. Action items				CAMPO
12. Parking Survey and/or Behavior Study	X			Tri. Tran.

V6 Model

The v6 model will be an aggregate trip based model based on the v5 model. It is expected the v6 model will be used for the 2045 LRTP development starting in 2015. The focus for this model will be on further enhancement of the aggregate trip based model.

Fiscal Year	TRM v6 Enhancement	Notes
<p>Year 1</p> <p>July 1, 2011 - June 30, 2012</p>	<p>Develop new commercial vehicle model Optimize model run time performance Develop improved destination choice – attraction share model Develop improved parking constraint model TAZ modifications Modifications of SE data and SE models Develop improved transit network procedures Investigate and specify enhancements below: 1) definition of facility types 2) link capacity calculation 3) update link free flow speeds 4) intersection delay 5) develop GIS approach to changing future road characteristics 6) improve highway traffic assignment 7) employment categories and special generator definitions 8) investigate and implement improvements to area type calculations</p>	
<p>Year 2</p> <p>July 1, 2012 - June 30, 2013</p>	<p>Develop and implement enhancements below: 1) recommended highway traffic assignment method, 2) recommended changes to the trip attraction/destination choice sub model and 3) intersection delay & link capacity calculation implementation including data collection and input if recommended 4) improved parking constraint model specification and data collection .</p> <p>Depending on the nature of modifications needed, model components will be re-estimated using existing survey data.</p>	<p>[See detailed task list in the scope for more information on individual tasks]</p>
<p>Year 3</p> <p>July 1, 2013 - June 30, 2014</p> <p>Year 4</p> <p>July 1, 2014 - June 30, 2015</p>	<p>Depending on the nature of modifications needed, all remaining model components will be re-estimated using existing survey data.</p> <p>Model calibration and validation. All enhancements underway will be completed. Work tasks will include calibrating and validating model components and overall model performance.</p>	

V7 Model

The v7 model will be either a tour based or activity based model depending on stakeholder direction. It is expected the v7 model will be used for 2050 LRTP development starting in 2018. This will address policy testing needs that require consideration of how travelers change their daily schedules in response to policies intended to reduce peak congestion.

Fiscal Year	TRM v7 Enhancement	Notes
Year 1 July 1, 2011 - June 30, 2012	Stakeholders agree on concept for v7 1) Convene expert panel 2) Develop work plan for v7 model development	
Year 2 July 1, 2012 - June 30, 2013	Investigation/specification of model structure and components: 1) population synthesizer, 2) land use models.	[See detailed task list in the scope for more information on individual tasks]
Year 3 July 1, 2013 - June 30, 2014	Investigation/specification of model structure and components: 1) tour/activity scheduler, 2) router. Investigate/specify and develop data structures. Determine best data structures for storing, processing and updating model elements. Approaches will be sought that maximize analyst productivity and model runtime performance. Available data will be prepared in the chosen data structure.	
Year 4 July 1, 2014 - June 30, 2015	Modify programs as needed to implement the chosen model specification including: 1) population synthesizer, 2) tour/activity scheduler, 3) router. Model component programs may be borrowed and adapted for use in the Triangle region.	
Year 5 July 1, 2015 - June 30, 2016	Estimate models and implement. Recent survey data will be used to estimate model components specified during year one [population synthesizer, tour/activity scheduler, router].	

Fiscal Year	TRM v7 Enhancement	Notes
Year 6 July 1, 2016 - June 30, 2017	Model calibration and validation. Initial model will be applied and any problems will be noted and addressed. This process will be iterated until all problems discovered have been addressed. The model will then be validated to observed conditions.	

Conceptual Schedule for Model Development

Model Task	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
v6						
Investigate/specify enhancements	█					
Develop enhancements	█	█	█			
Calibration & validation				█		
v7						
Specify model components		█	█			
Specify data structures			█			
Modify programs			█	█		
Estimate models					█	
Calibration & validation						█

Appendix B

TRM History

Version - Release Year [Delivered Time]	Key Features Enhancements vs. Previous Version	Base Year	Use
v.1 - 2006 [Not to Stakeholder]	TTA New Start model converted to the TransCad platform with a 2002 base year as delivered by the contractor [Parsons Brinckerhoff] in Fall of 2006	2002	
v.2- 2006 [delivered 12/2006]	Revised and calibrated/validated to 2005 base year highway data only	2005	
v.3 - 2007 [β test version delivered 4/2007]	1. Updated mode choice ASC calibration using 2006 Household Interview Survey and 2006 Transit On Board Survey data 2. Repaired trip generation program and 3. Revised 2005 Socio Economic data provided by the MPOs.	2005	1) Transit Infrastructure Blueprint, 2) the Chapel Hill Long Range Transit Plan, 3) the Orange County Greenhouse Gas project and 4) the Deficiency and Needs Analysis for the 2035 Long Range Transportation Plans.
v.4 - 2008 [Delivered 1/2008; approved spring; adopted 8/2008]	Improved v3-2007 ready for application and including HOV/HOT and toll capabilities.	2005	1) Alternatives Analysis and 2) Air Quality Conformity Analysis for the 2035 Long Range Transportation Plans.

Version - Release Year [Delivered Time]	Key Features Enhancements vs. Previous Version	Base Year	Use
v.5 - 2011 Delivered 6/2011	<p>New:</p> <ol style="list-style-type: none"> 1. Parking capacity constraint 2. Airport trip making model 3. Bicycle and pedestrian travel submodels through trip distribution. 4. External station forecasts methodology. 5. Hourly capacity and traffic assignment 6. Use of Logsum in destination choice 7. Stratified utility coefficients by income in mode choice: 8. Summit analysis for FTA New Start analysis. [planned] 9. An off model GIS approach to forecast changes in road characteristics over time as rural areas become more urbanized [planned] 10. Travel by people from outside the region on transit. [planned] <p>Improved:</p> <ol style="list-style-type: none"> 1. Parking cost model improved; New: capacity constraint components added 2. Bus speed model: adjusted and validated vs. 2006 bus schedules. 3. Revise Federal Functional Class. Federal Functional Class has been updated in the 2010 v5 model to be consistent with NCDOT updates. [planned] <p>Investigated: Cost of Auto Travel [e.g. gas price component]</p>	2005	

Appendix C

TRM Calibration and Validation Statistics

Triangle Regional Model components will be calibrated and validated to the following targets. These tests based on local and national targets will be used to evaluate the quality of model components.

Calibration/validation Statistics

Model Inputs

Model demographic data inputs will be checked against benchmarks at a regional level for persons/household, employment/population ratio, and autos/household. Plots of persons per household and household income by zone (TAZ) will be compared to census values. A report will document all findings.

Model highway and transit networks will be checked for reasonableness and the results will be reported. Maps of various network characteristics (area types, lanes, speeds, counts, screenlines, and transit routes by company) will be plotted to aid in the checks and to document the process used. The transit on board survey data will be assigned by access mode to the transit network and comparisons of transfer rates and assignments by transit line and company will be made to determine if problems exist. The results will be reported.

Model output from the household and person model (workers, non-workers, and children), and by household strata will be compared to census and other data for the region and sub region levels as appropriate (county and district) depending on the availability of data. This comparison will be documented in a report.

Trip Generation

Work trips per worker match survey work trips per worker

Ratio of region wide trip productions to trip attractions by trip purpose +/- 10%

Summaries comparing observed and model estimated trips by trip purpose will be prepared

Daily trips by trip purpose will be compared to determine if proportions of daily travel by purpose match survey data and proportions from other areas (benchmarks)

Overall trip rates by trip purpose will be compared to those reported for other areas

Trip productions per household and per capita will be compared to standard reasonable ranges

Summary comparisons will be made at the region, county, and district levels

Work trip attractions will be compared to total employment, K-12 school trips will be compared to total school enrollments, and shopping trips will be compared to total retail employment

Trip Distribution

Percent Deviation of Average Trip Length (minutes) for all trip purposes +/- 5%

District to district comparisons will be made of observed and model estimated trips. Trip length frequency distributions by time and distance will be prepared by trip purpose by strata. Coincidence ratios will be prepared for the trip length frequency distributions with a target of >70% coincidence.

Percent intra zonal trips by purpose will be compared to benchmarks.

Mode Choice

All trip purposes will match observed mode shares for auto and transit modes (+/- 2%), though not for transit by access mode to avoid over calibrating

Summaries by trip purpose will be prepared comparing observed mode shares to model estimated mode shares. Work trip mode shares will be compared to census (CTPP) mode share data. District summaries will be prepared. Auto occupancies will be compared to survey auto occupancies. Mean transit trip lengths will be compared to observed and these will be expected to fall within +/- 5%. Parameters will be compared to acceptable ranges.

Validation Statistics*

Vehicle Miles Traveled (VMT) by Federal Functional Class (based on links with counts)

Functional Class	Target % Deviation
Freeway	7%
Principal Arterial	10%
Minor Arterial	10%
Collector	15%
Local	15%
Total	5%

Screenline Comparison

Screenline Name	Target % Deviation
I-85	10%
I-40	10%
Wake/Durham County Line	10%

* All traffic counts used for validation will be factored in a consistent way

Cutline Comparison

Cutline Name	Target Deviation %
SW Durham	15%
Durham	15%
Johnston County	15%
Chatham County	15%
North Raleigh	15%
Eastern Wake	15%
US 1 South	15%
North Wake	15%
US 70	15%

* If unable to match this best practice target, then a secondary check will be performed based on the overall volume of the cutline

Percent Difference of Total Traffic Count Volume and Total Model Assigned Volumes by County and Area Type

Summary Level	% Difference Target (+/-)
<i>County</i>	
Durham	10%
Orange	10%
Wake	10%
Chatham	10%
Harnett	10%
Johnston	10%
Nash	10%
Franklin	10%

Granville	10%
Person	10%
<i>Area Type</i>	
Urban	10%
Suburban	10%
Rural	10%

Percent Difference of Model Estimated Daily Traffic Volumes by Federal Functional Class

Federal Functional Class	FHWA Target (+/-)	TRM Target (+/-)
Freeway	7%	5%
Principal Arterial	10%	8%
Minor Arterial	15%	10%
Collector	25%	15%
Local	25%	15%

Percent Difference of Model Estimated Daily Traffic Volumes by Volume Group

Volume Group	Target % Deviation
1 -1000	55%
1001 – 2500	50%
2501 – 5000	30%
5001 – 10000	25%
10001 – 25000	20%
25001 – 50000	15%
>= 50001	10%
Total	5%

R-Square for Region wide Estimated Volumes vs. Traffic Counts

Target $R^2 \geq 0.88$

Root Mean Square Error (RMSE) of Estimated Traffic Volumes

Target RMSE $\leq 35\%$

Evaluation of Peak Period Assignments for AM and PM Peak Periods

Screenline Comparison AM and PM Peak

Screenline Name	Target % Deviation
I-85	10%
I-40	10%
Wake/Durham County Line	10%

Cutline Comparison AM and PM Peak

Cutline Name	Target % Deviation
SW Durham	15%
Durham	15%
Johnston County	15%
Chatham County	15%
North Raleigh	15%
Eastern Wake	15%
US 1 South	15%
North Wake	15%
US 70	15%

* If unable to match this best practice target, then a secondary check will be performed based on the overall volume of the cutline

AM and PM Peak Period Percent Difference of Total Traffic Count Volume and Total Model Assigned Volumes by County and Area Type Based on Links with Hourly Traffic Counts

Summary Level	% Difference Target (+/-)
<i>County</i>	
Durham	10%
Orange	10%
Wake	10%
Chatham	10%
Harnett	10%
Johnston	10%
Nash	10%
Franklin	10%
Granville	10%
Person	10%
<i>Area Type</i>	
Urban	10%
Suburban	10%
Rural	10%

Overall average speeds will be reported for AM peak, PM peak and off peak periods.

Transit Ridership Assigned

Total transit riders target +/- 5%

Target for individual companies +/- 10%

Triangle Regional Model Service Bureau

Justification for Supplies and Materials

Plotter supplies are needed to support project plotting requirements.

Justification for Travel

Travel includes fees to cover project related training beneficial to the development of staff on the project.

Justification for Current Services

Current services covers the cost of long distance telephone communication.

Justification for Contracted Services

On-call technical assistance provides a way for the Service Bureau to obtain advice from technical experts in the field of travel forecasting. This enables the Service Bureau to learn how to appropriately implement new procedures consistent with national practice and experience.

Justification for Other Fixed Charges

The maintenance of TransCAD software requires a \$1000 per year maintenance fee.

**DCHC STAKEHOLDER BUDGET
TRIANGLE REGIONAL MODEL SERVICE BUREAU
BUDGET FOR YEAR 10: July 1, 2012 to June 30, 2013**

Budget Items	Description of Level of Effort	Budget FY 2012-13
Salaries and Wages (Personnel) *		
Director	25 % effort for 12 mo	\$ 23,205
Senior Research Associate	25 % effort for 12 mo	\$ 19,678
Senior Research Associate	25 % effort for 12 mo	\$ 19,496
Senior Research Associate	12.5 % effort for 12 mo	\$ 7,293
Graduate Intern	50 % /sem; 100 % summer	\$ -
SUBTOTAL PERSONNEL		\$ 69,672
Staff Benefits		
Staff (30%)		\$ 20,902
Graduate Intern1 (21%)		\$ -
SUBTOTAL STAFF BENEFITS		\$ 20,902
TOTAL PERSONNEL & BENEFITS		\$ 90,574
Supplies and Materials		
(Supplies, plotter paper, plotter ink)		\$ 250
		\$ -
Travel		
In State		\$ 138
Out of State		\$ -
Training		\$ 750
Current Services		
Communications (long distance)		\$ 37
Printing and Binding		\$ -
Contracted Services		
On-call technical assistance		\$ 6,250
Fixed Charges		
Rental of Equipment/State Vehicles		\$ 75
Other Fixed Charges (software maintenance fees, \$1,000/yr/key)		\$ 1,250
Student Aid / Tuition Remission		
In State		\$ -
Subcontract		
		\$ -
TOTAL OTHER DIRECT COSTS		\$ 8,750
Facilities & Administrative Costs		
20% of MTDC **		\$ 19,864
TOTAL BUDGET		\$ 119,188

* Uses a 3% growth factor/yr

** 20% based on one contract through the Master Agreement between NCSU-ITRE and NCDOT.

Exhibit A.1
Percentage of Effort Estimate by Task

Triangle Regional Model

LABOR		HOURS BY PERSONNEL AND TASK Triangle Regional Model Service Bureau - DCHC												
TRM Service Bureau staff assigned	Raw Direct Labor Hourly Rate	Estimated Level of Effort by Task											Total Hours	Total Cost
		1 Data collection	2 Model inputs	3 Trip generation	4 Type of day & peak spreading model	5 Trip distribution	6 Non-motorized	7 Mode choice	8 Special modes	9 Trip assignment, calibration & assignment	10 Technical assistance	11 Overlighting & timing		
Director	\$44.63	0	118.25	7.75	40.75	38.75	0	0	45.5	0	63	206	520	\$23,205
Senior Research Associate	\$37.84	33.5	103.75	1.25	0	244.75	0	0	2.5	0	62.25	72	620	\$19,678
Senior Research Associate	\$37.49	0	67	0	75.75	0	0	0	246.75	0	58.5	72	520	\$19,496
Senior Research Associate	\$28.05	0	38.625	40.75	0	0	0	0	113.5	0	31.125	35	260	\$7,283
NCDOT Staff														0
CAMPO Staff														0
DCHC Staff		0	311	0	252	0	0	0	260	0		107	930	
Total Hours TRM Service Bureau		33.5	327.625	49.75	116.5	283.5	0	0	408.25	0	214.875	388	1820	
Total Hours Stakeholder Staff		0	311	0	252	0	0	0	260	0	0	107	930	
Total Task Hours		33.5	638.625	49.75	368.5	283.5	0	0	668.25	0	214.875	493	2750	
Personnel cost by task		\$1,268	\$12,798	\$1,536	\$4,659	\$10,891	\$0	\$0	\$14,560	\$0	\$8,233	\$15,627		\$69,672
Fringe Benefits @ 30%		\$380	\$3,840	\$461	\$1,398	\$3,297	\$0	\$0	\$4,368	\$0	\$2,470	\$4,688		\$20,902
Total Labor with Fringe		\$1,648	\$16,638	\$1,997	\$6,057	\$14,288	\$0	\$0	\$18,928	\$0	\$10,703	\$20,315		\$90,574
REIMBURSEABLE EXPENSES														
Description													Total Cost	
Supplies and Materials (Photocopying, plotter paper, plotter ink)													\$250	
Travel														
In State													\$138	
Out of State													\$0	
Training													\$750	
Current Services														
Communications (long distance)													\$37	
Printing and Binding													\$0	
Contracted Services														
On-call technical assistance													\$6,250	
Fixed Charges														
Rental of Equipment/State														
Vehicles													\$75	
Other Fixed Charges (software maintenance fees, \$1,000/yr/key)													\$1,250	
Student Aid / Tuition Remission														
In State													\$0	
Total Reimbursable Expenses													\$8,750	
Subcontractors													\$0	
Facilities & Administrative Costs 20% of MTDC **													\$19,864	
Total Hours													1820	
Grand Total Labor													\$90,574	
Grand Total Subcontractors													\$0	
Grand Total Reimbursables													\$8,750	
Total Cost													\$119,188	

