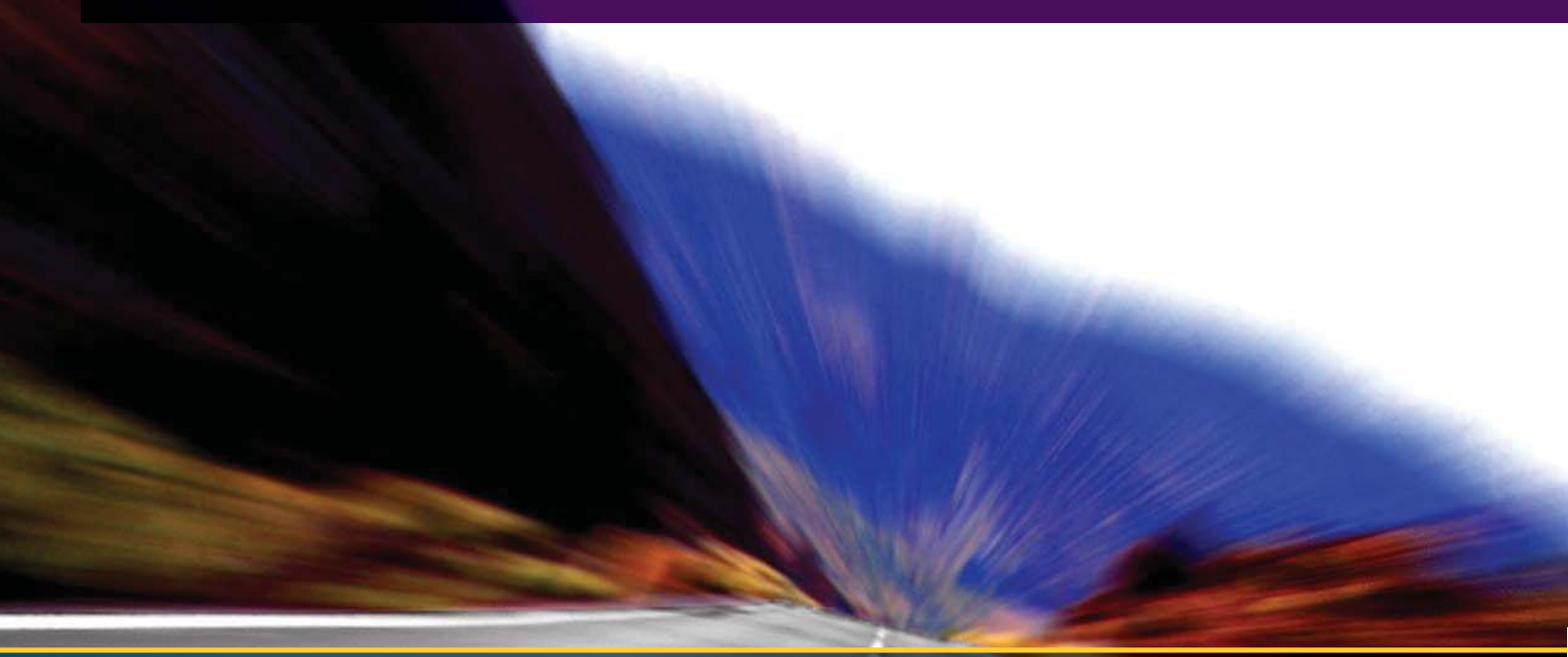
Applying Analysis Tools in Planning for Operations

Case Study #2 – Incorporating Highway Capacity Manual Procedures into Long-Range Transportation Planning

U.S. Department of Transportation
Federal Highway Administration



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16. Abstract

More and more, transportation system operators are seeing the benefits of strengthening links between planning and operations. A critical element in improving transportation decision-making and the effectiveness of transportation systems related to operations and planning is through the use of analysis tools and methods. This brochure is one in a series of five intended to improve the way existing analysis tools are used to advance operational strategies in the planning process. The specific objective of developing this informational brochure series was to provide reference and resource materials that will help planners and operations professionals to use existing transportation planning and operations analysis tools and methods in a more systematic way to better analyze, evaluate, and report the benefits of needed investments in transportation operations. This particular case study focused using Highway Capacity Manual (HCM) procedures in long-range transportation planning for arterial signalization strategies. To better estimate link capacity, this case study developed an automated methodology to 1) transfer demand volumes from a regional model to software implementing the HCM Urban Streets procedure, 2) combine the volumes with known traffic signal timings to calculate a link-specific capacity, and 3) transfer that capacity back to the regional model for the next iteration. In addition, operational treatments that can influence capacity can be accounted for in the HCM-implementing software, thus allowing the effects of these treatments to be reflected in the regional model output.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	$candela/m^2$	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	$candela/m^2$	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

Applying Analysis Tools in Planning for Operations

Case Study #2 – Incorporating Highway Capacity Manual Procedures into Long-Range Transportation Planning

More and more, transportation system operators are seeing the benefits of strengthening links between planning and operations. A critical element in improving transportation decision-making and the effectiveness of transportation systems related to operations and planning is through the use of analysis tools and methods. This brochure is one in a series of five intended to improve the way existing analysis tools are used to advance operational strategies in the planning process. The specific objective of developing this informational brochure series was to provide reference and resource materials that will help planners and operations professionals to use existing transportation planning and operations analysis tools and methods in a more systematic way to better analyze, evaluate, and report the benefits of needed investments in transportation operations.

The series of brochures includes an overview brochure and four case studies that provide practitioners with information on the feasibility of these practices and guidance on how they might implement similar processes in their own regions. The particular case studies were developed to illuminate how existing tools for operations could be utilized in innovative ways or combined with the capabilities of other tools to support operations planning.[1] The types of tools considered when selecting the case studies included:

- Sketch planning tools;
- Travel demand forecasting models;
- Deterministic models;
- Traffic signal optimization tools;
- Simulation tools;
- Archived operations data;
- Operations-oriented performance measures/metrics; and
- Combinations of these tools and methods.

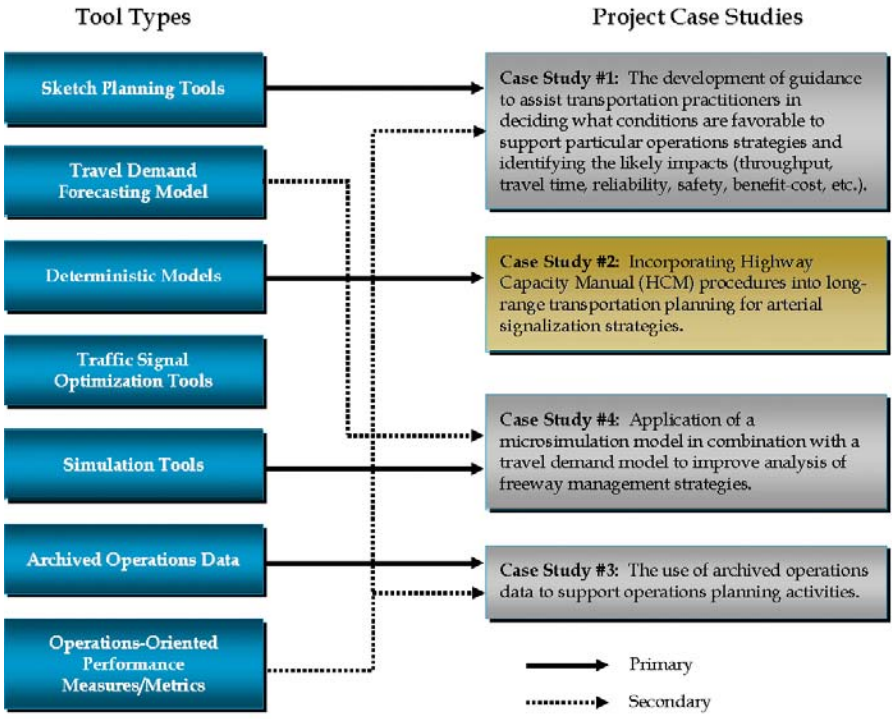
Additional information on these existing tool types is presented in the overview brochure to this series.

In selecting the case studies to highlight in this brochure series, a number of innovative analysis practices and tool applications were considered. Ultimately, four different case studies were selected from among many

1 The use of the term "Tools" in this context is meant not only to include physical software and devoted analytical applications, but is also intended to encompass more basic analysis methods and procedures as well.

worthy candidates. Each of these case studies represents an innovative use of one or more of the tool types listed above. Figure 1 presents the topics of the case studies and maps them to the related tool. Although individual case studies were not developed for each tool category, this should not be considered as a measure of indictment of the ability of any tool type to be used in innovative ways to support operations planning – there simply weren't project resources to identify and document all of the innovative practices being used. Likewise, the selection of a particular case study representing a specific tool should not be construed as the only manner in which to apply the particular tool. Instead, the case studies represent a sampling of the many innovative ways planners and operations personnel are applying these tools currently.

Figure 1. Analytical Methods/Tools and Related Case Studies Developed Under this Project



Case Study Introduction

Many mid- and long-range transportation planning efforts make use of regional transportation planning models to forecast future traffic volumes on roadways. The traditional four-step process is used to generate trips at origins, to distribute trips to destinations, to choose the mode used for each trip, and to assign trips along various alternative routes between origin and destination. This last step of the process, trip assignment, is the focus of this case study.

An iterative process is typically used for trip assignment, where all trips between an origin and destination are assigned to the shortest-time path under free-flow conditions. If too many trips are assigned to a given link in a network, congestion results, which results in a longer travel time. The new travel time is used as an input to the next model run and a number of similar iterations are run as the model tries to balance travel times along the various alternative routes.

The estimate of speed (and from speed, travel time) for a given network link is typically based on a function that relates speed to the link's volume-to-capacity ratio. The link capacity is usually related to the number of directional lanes on the link and the roadway's functional class, and a relatively small set of assumed capacities are built into the model. During the model calibration process, these capacities may be manually adjusted up or down in an effort to more closely match modeled traffic demands to existing conditions. However, it would be desirable to be able to more accurately specify roadway capacities within the model to begin with.

The roadway functional class is a surrogate for many of the operational factors that impact capacity. One of the most important of these factors for arterials is the amount of green time allocated to through movements at the signalized intersection at the end of the link. To better estimate link capacity, this case study developed an automated methodology to 1) transfer demand volumes from a regional model to software implementing the Highway Capacity Manual's (HCM) Urban Streets procedure, 2) combine the volumes with known traffic signal timings to calculate a link-specific capacity, and 3) transfer that capacity back to the regional model for the next iteration. In addition, operational treatments that can influence capacity can be accounted for in the HCM-implementing software, thus allowing the effects of these treatments to be reflected in the regional model output.

Case Study Background

The participating agency for this case study was the Wasatch Front Regional Council (WFRC), which is the metropolitan planning organization (MPO) for Davis, Morgan, Salt Lake, Tooele, and Weber Counties in Utah (i.e., the Salt Lake City–Ogden region). At the time of the case study, WFRC was in the process of updating its regional transportation plan. The agency's travel demand model includes major urban roadways within the WFRC region, as well as major urban roadways in Utah County (Provo) to the south.

Prior to the start of the case study, WFRC staff had developed a prototype spreadsheet implementing the HCM's Urban Streets methodology. To make the case study results more transferable to others, it was decided at the start of the case study to use the ARTPLAN software developed by the Florida DOT for capacity analysis, rather than the WFRC spreadsheet. This decision was made for several reasons, but primarily because:

- ARTPLAN is existing software that has been extensively tested;
- FDOT distributes the software freely, and makes instructions and training materials available to users;
- FDOT is committed to supporting the software in the future and incorporating future HCM changes; and
- ARTPLAN has a batch-processing function that can read external input files, perform calculations, and write the results to an output file.

Other HCM-implementing software is available on the market that may also be suitable for the type of work described in this case study; however, ARTPLAN is used in this document to illustrate the process, as potential users can readily obtain the software.

Required Data

Data from the Regional Model

WFRC exported a table from their model that described the characteristics of the roadway network's links. The following link attributes are required:

- Segment length;
- Number of directional through lanes;
- Afternoon peak hour volume (WFRC models a peak three-hour period, so the model's volumes needed to be converted to a peak one-hour volume for HCM analysis purposes);
- Average Annual Daily Traffic (AADT);
- An attribute defining whether a segment was part of a one-way or two-way street;
- An attribute defining the segment's direction (e.g., southbound); and
- Free-flow speed, defined as five miles per hour greater than the posted speed limit.

In addition, as discussed later, an attribute defining the segment's position within a given corridor may be needed.

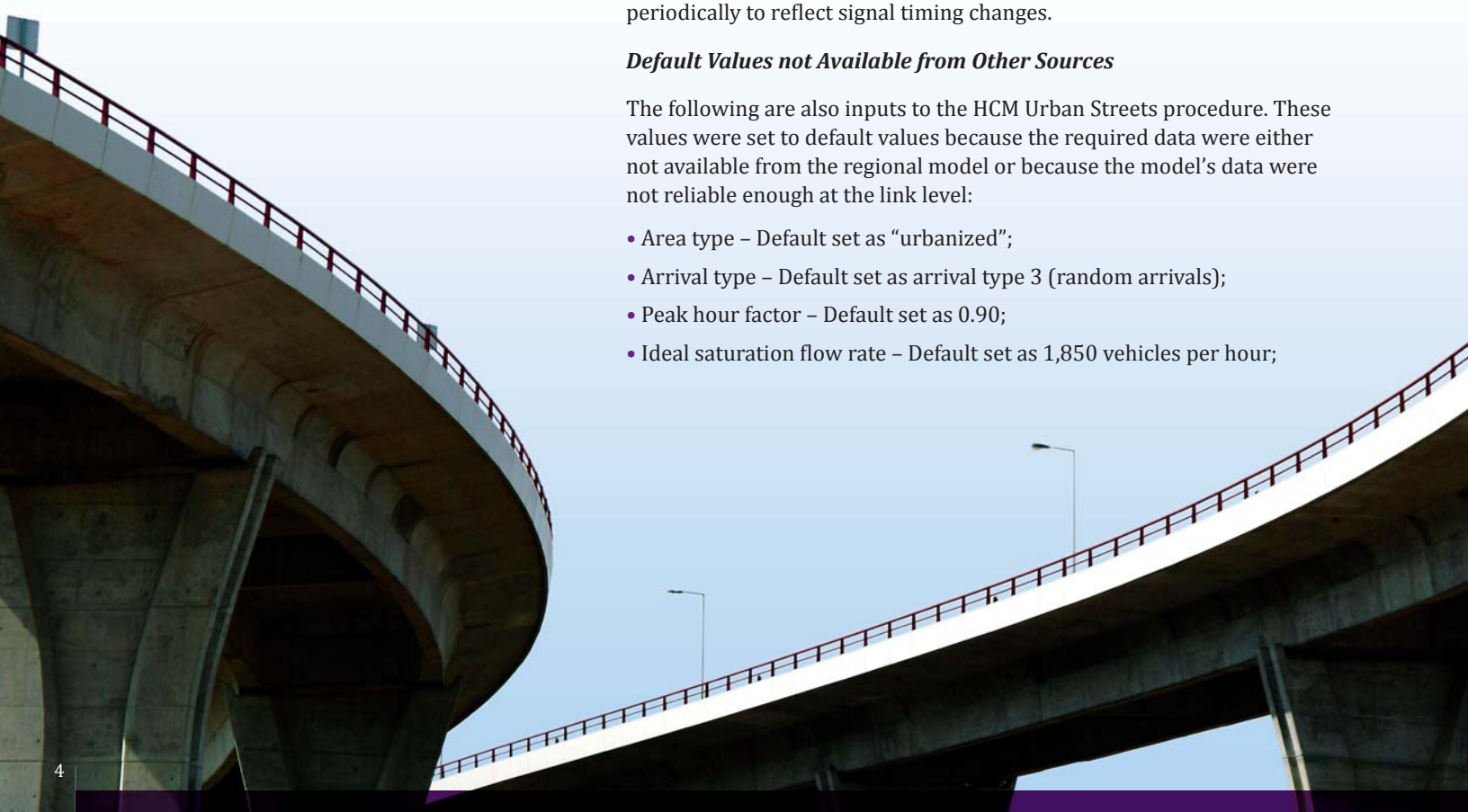
Data from Other Regional Sources

WFRC also provided a database of current intersection traffic signal locations that allowed the traffic signal data (cycle length, minimum arterial through-traffic green time, and control type) to be matched to a specific node (intersection). In addition, a database was provided that allowed the names of intersecting roadways to be matched to a specific node/intersection. Compiling such a database could take some time, depending on the number of agencies that operate traffic signals within a region, and whether the timing data comes from paper timing plans or is available electronically. The database would need to be updated periodically to reflect signal timing changes.

Default Values not Available from Other Sources

The following are also inputs to the HCM Urban Streets procedure. These values were set to default values because the required data were either not available from the regional model or because the model's data were not reliable enough at the link level:

- Area type – Default set as "urbanized";
- Arrival type – Default set as arrival type 3 (random arrivals);
- Peak hour factor – Default set as 0.90;
- Ideal saturation flow rate – Default set as 1,850 vehicles per hour;



• Proportion of turning traffic – Although node-specific turning movement volumes are available from regional models, they typically do not reflect reality; therefore, the HCM default of 12 percent was used; and

• Heavy vehicle percent – Default set as 3 percent.

Users are able to override default values on specific links within ARTPLAN (or other HCM-implementing software). However, a reasonable value needs to be provided as an initial input to the software. Other regions would use default values appropriate to conditions within their region.

Finally, ARTPLAN requires a few additional default values beyond the usual HCM defaults, either because FDOT has extended the HCM2000 procedure (e.g., impacts of medians on urban street capacity) or because certain inputs are needed for a successful file import to ARTPLAN even if the values are not needed for a particular analysis. These additional default values consist of the following:

• Median type – FDOT has extended the HCM2000 methodology by including median type as an additional factor; a default of "none" was used.

• K and D factors – Reasonable values are needed to ensure a successful file import, even though ARTPLAN ignores the values when peak-hour volumes are provided; a K factor (percent of daily traffic during the peak hour) of 10 percent was used, and a D factor (percent of traffic demand in the peak direction during the peak hour) of 75 percent.

• Multimodal data – FDOT has extended the HCM2000's urban streets methodology to provide level-of-service results for pedestrian and bicycle facilities and transit services provided along an urban street. Although not used in this case study, default values for these modal level-of-service procedures needed to be provided to ensure a successful file import.

Data Transfer from the Regional Model to ARTPLAN

The files output by the regional model were not in the same format used by input files for ARTPLAN. Therefore, it was necessary to convert WFRC's model data into the required format. ARTPLAN uses the Traffic Model Markup Language (TMML) format, which is an Extensible Markup Language (XML) description of data commonly used by traffic analysis software. TMML can be used to transfer data between software programs that support the XML format.

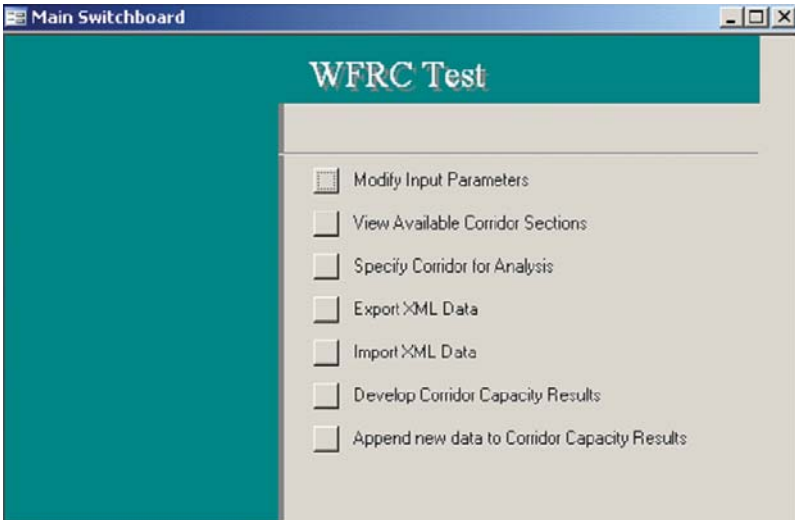
For this case study, both the data exported from the WFRC model and the traffic signal data were imported into a Microsoft Access database as separate tables. In the case study, only a single arterial street corridor was studied; a full-blown application could conceivably study the entire network. Additional tables were set up within the database to generate the default values not available from the WFRC data. Queries were written in Microsoft Access to join the data from the model and default tables and convert them into the proper format for ARTPLAN. Finally, a user interface (the "Data Conversion Switchboard") was developed to help automate the process.

A Microsoft Access file containing the default tables, queries, and Switchboard interface is available from http://www.plan4operations.dot.gov/casestudies/analysis.htm. (Note that no support is provided for this file.) Users in other regions would need to perform the following tasks to convert their data:

1. Match the fields exported from their regional model and the traffic signal database to the input fields required by ARTPLAN. For example, ARTPLAN uses "LinkLength" as the name of the field specifying the length of a link, while WFRC's model uses "Distance" as the corresponding field name. Microsoft Access needs to be told that the data for the "LinkLength" field in the output table will come from the "Distance" field in the input table. Users also need to perform any necessary unit conversions (for example, from feet into miles).

2. If ARTPLAN outputs other than capacity are desired (e.g., speed or level of service) for a corridor, users will need to provide a value in the "SectionS" field that indicates the sequencing of links that form the corridor. For a network-wide application, the only output possible from the process would be capacity and this step would be skipped.

3. Using the Switchboard (pictured below), identify which corridors have all of the data needed to perform a successful import, and then specify the particular corridor to be imported.



4. Use the Switchboard to export data in XML format. This generates eight files.

5. Use a utility program developed by FDOT to merge the eight files together and generate a single input file that can be opened by ARTPLAN.

The initial database setup covered by the first task in this process takes some time and requires careful attention, as any mistake made in incorrectly specifying fields will result in an output file that cannot be read by ARTPLAN. Detailed information on the process is provided at the end of this document.

Calculating Capacities and Testing Operational Scenarios Within ARTPLAN

Once the input file has been created, it can be opened within ARTPLAN, which will then calculate the capacities for individual segments. If a user desired, ARTPLAN could be used at this stage to test the capacity impacts of access management strategies (e.g., installing a raised median), physical improvements (e.g., exclusive turn lanes at intersections), or operational strategies (e.g., improvements to the traffic signal

progression). Once any desired changes were made, the user would then save the file, which would now be updated with each link's capacity.

There are two current limitations of the ARTPLAN software that analysts should be aware of. First, ARTPLAN limits input files to include a maximum of nine links. Thus, if capacities were desired for a longer corridor or for an entire region, the import-calculate-export process would need to be repeated multiple times. Second, ARTPLAN tests input values for reasonableness, so that reported performance measures will also be reasonable. While this is a understandable constraint to avoid reporting unrealistic speed estimates and levels of service, capacity estimates are independent of the demand volume, for a given average green time for the through movement at a traffic signal. Regional models, particularly during the iteration process, can produce traffic demand volumes that greatly exceed what a street segment could realistically carry. If the demand volume input for a link exceeds ARTPLAN's built-in threshold (>5,000 vehicles per hour), no capacity will be calculated, even though the capacity calculation would still be valid. A workaround for this issue would be to set the input volume to zero for each link (if only capacities are desired as an output), or to reduce very high input volumes to 5,000 vehicles per hour, if other performance measure outputs are desired from ARTPLAN to supplement the capacity estimate.

It should be noted that if some other operations software besides ARTPLAN had been used for the case study, it is likely that different, but just as potentially significant, issues would have arisen in developing a data conversion tool for that software.

Data Transfer from ARTPLAN to the Regional Model

The final step in the process is transferring the capacity results back to the regional model. The Switchboard can be used to import the ARTPLAN file back into Microsoft Access, extract the capacity results and match them back to the correct model link, and (if more than nine links are being evaluated) append the results to a master results file. The more-realistic capacities would then be available to the regional model to use.

One software limitation to be aware of is that ARTPLAN does not currently save a unique ID number for a given link. Therefore, the Switchboard matches capacities back to links using the link length field. If two links have an identical length, the wrong capacity may be matched to one of the links. A workaround for this issue is to add a small unique number to the link length (for example, the link ID number divided by 100,000, if lengths are calculated in miles).

Case Study Outcomes and Potential Benefits

This case study showed, at a proof-of-concept level, that it is possible to export data from a regional model to HCM-implementing software, calculate link-specific capacities based on a link's characteristics (particularly traffic signal timing), and import those capacities back into the regional model. There are two main benefits from doing so:

1. Link capacities used in the regional model would be significantly closer to their actual value, particularly on links that end at a signalized intersection with a major street, where the amount of available green time may be constrained. As a result, the model should produce more

accurate traffic forecasts. Although not tested as part of the case study, the use of more accurate capacities could also potentially reduce the time required to calibrate the model to reflect existing conditions.

2. Regional models are typically capable of modeling only the coarsest kinds of capacity improvements – such as adding a through lane. By using HCM methods as a preliminary step for generating link capacities, other kinds of treatments can also be tested, including operational, access management, and intersection-level turn-lane treatments, and those treatments can then potentially be included as projects within the transportation plans that the regional models support.

The table below compares the default arterial capacity to ARTPLAN's estimated capacity for the portion of State Street analyzed in the case study. The table also shows the revised capacity that would be obtained with a 5-mph higher speed limit and additional green time allocated to the corridor (at the expense of side-street movements). The table shows the WFRC model's default capacities overestimated the street's actual present-day capacity by up to 18 percent and illustrates the maximum degree to which capacity could potentially be improved without adding another through lane.

Segment	WFRC Default Capacity	ARTPLAN Capacity	ARTPLAN Revised Capacity
First Avenue to Second Avenue	658	560	780
Second Avenue to South Temple	1,722	1,690	2,330
South Temple to 100 South	1,722	1,690	2,330
100 South to 200 South	1,722	1,690	2,330
200 South to 300 South	1,722	1,690	2,330
300 South to 400 South	1,722	1,690	2,330

Potential Challenges and Limitations for Application

A key ingredient to this process is obtaining traffic signal data. Depending on the number of traffic signals in the region, the number of different agencies owning traffic signals, and the format in which traffic signal timing plans are kept (electronic versus paper), assembling the traffic signal database could be a significant effort. The database would also need to be updated periodically. Trying out this process first on a selected corridor in a region, rather than trying to apply it to the entire region would allow a planning agency to realistically evaluate the amount of work required.

Matching the regional model's data fields to those used by ARTPLAN would be a one-time preparatory step that an agency would need to undertake; however, this is a straightforward process following the steps in this case study's appendix. One of the case study's data-gathering challenges was cleaning the data set of inconsistent street names. Over the years, as the WFRC travel model network evolved, inconsistencies in street names were introduced. For example, one facility in the network is identified variously as "1900 West," "1900 W," "Main St," "State St," and "SR 126," all of which are appropriate names for the facility, but which make it nearly impossible to select these segments by corridor using computer tools. WFRC staff invested time creating a more consistent street name field that proved very useful

when exporting the data to ARTPLAN. However, this street name update is only good until the next time that network revisions are made. Using GIS overlays could facilitate the task of keeping street names consistent, provided the GIS layer is accurate.

If arterial link volumes are anticipated to exceed 5,000 vehicles per hour, the input volumes will need to be set to zero (or some nominal value) in order for ARTPLAN to calculate link capacities. If other performance measure outputs, such as average travel speed or level of service, are desired from ARTPLAN, volumes greater than 5,000 vehicles per hour will need to be reduced to 5,000 vehicles per hour or less. As these volumes would still be significantly higher than an urban street's capacity, the other performance measures should still indicate poor performance, even with a lower demand volume.

ARTPLAN is currently only capable of analyzing nine links at a time. This limitation means that developing capacities for an entire network would require significant labor time to set up each nine-link analysis run and then compile the results together. More feasible at this point in time would be to analyze an arterial street corridor. As many corridors are longer than nine links, the import-calculate-export process would still probably need to be run several times and the results compiled to get results for the full corridor. If other output values besides capacity are required (e.g., speed or level of service), an additional necessary step would be to supply a field that indicates the sequencing of links along the corridor.

APPENDIX: Details on Applying the Case Study

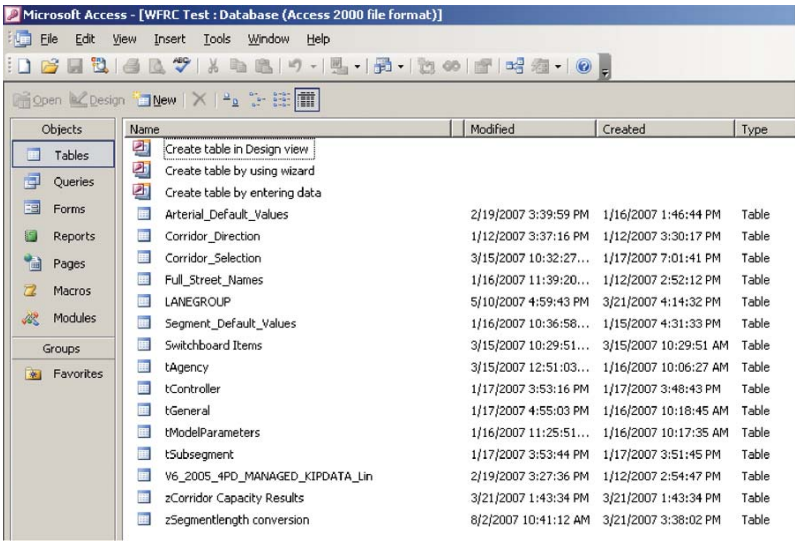
This appendix provides an overview of the Microsoft Access tables and queries and provides step-by-step guidance on using the switchboard.

Database Organization

The Microsoft Access database consists of a set of default tables, a planning model data table (WFRC's long-range transportation model data in this case), and queries that modify the model data into the format used by ARTPLAN. Users should examine the tables and queries closely to gain a better understanding of the extent and format of the data fields.

Tables Overview

The following screen capture shows the tables contained in the database.



Default Value Tables

The following tables contain the default values that ARTPLAN requires for a successful file import. Some of these values are used as inputs to ARTPLAN's operations analyses, while others are placeholders for the results of the analysis. Any of the default values contained in these tables can be user-adjusted within ARTPLAN for a specific link. If a default value applies to an entire corridor or network, it is easiest to supply it via these tables. Users should make sure that any values they supply conform to ARTPLAN's acceptable ranges of values for a particular variable; otherwise, the XML file will not successfully import into ARTPLAN. The allowed ranges of values are provided within the ARTPLAN user's manual, and the on-screen help for ARTPLAN, as well as at the bottom of the data entry window within ARTPLAN.

- tAgency – Information about the agency (agency name, city, and state);
- tController – Default table containing signal controller data;
- Arterial_Default_Values – Table containing default values for arterial links;
- tGeneral – Default table with administrative inputs such as analyst, date, etc.;
- tSubsegment – Default table containing multimodal default values;
- tModelParameters – Table containing ARTPLAN default period and analysis type data;
- Segment_Default_Values – Table containing default arterial segment values;
- Switchboard Items – Table generated by the Switchboard which contains a listing of the Switchboard items;
- Corridor_Direction – Table containing a code by direction, where 1 equals northbound, 2 equals eastbound, 3 equals southbound, and 4 equals westbound; and
- Corridor_Selection – Table where the roadway id, section id, and direction will be specified (via the Switchboard) for the corridor and links that will be analyzed.

Data Conversion Tables

The following tables are used by the ARTPLAN conversion routine, linking capacity results from ARTPLAN back to the Access database:

• zSegmentlength conversion – Table generated by the "zMk Segmentlength conversion" query, which is used to match the results in the ARTPLAN output file back to the model data. The ARTPLAN output file does not contain the section name or the names of intersecting roadways per segment. The segment length (in miles to five decimals) is the only unique property that allows the ARTPLAN results to be connected back to the corresponding segments within the Access database.

• zCorridor Capacity Results – Table generated by the "zMk Corridor Capacity Results" query, which summarizes the capacity results for the links analyzed in ARTPLAN.

• LANEGROUP – The ARTPLAN output file that is imported to Access. This table contains the capacity results from ARTPLAN.

Region-Specific Tables

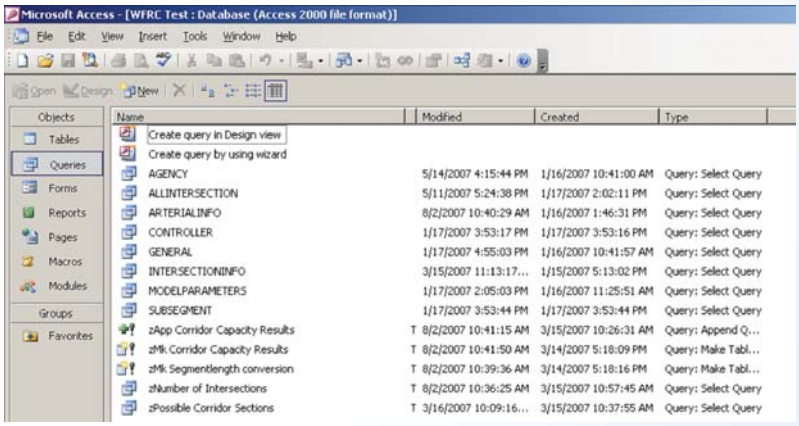
The following tables in the Microsoft Access template are specific to the WFRC's model data and would be replaced with equivalent tables from the local model:

• V6_2005_4PD_MANAGED_KIPDATA_Lin – WFRC's model extract.

• Full_Street_Names – Table containing the names of intersecting roadways in WFRC's database. This table is linked to the "V6_2005_4PD_MANAGED_KIPDATA_Lin" table in the query calculations.

Queries Overview

The following screen capture shows the queries contained in the Microsoft Access database. These queries either reference a default table or consolidate data from the default tables with the model data.



ARTPLAN Input Queries

The following queries is to join and structure the data from the model and default tables into the format used by ARTPLAN. The queries are exported as XML files that are subsequently consolidated into a single ARTPLAN input file. It is essential that the content and format of these queries not be changed in order for the ARTPLAN conversion routine to run successfully. The queries can be viewed in design view (right click on

the query name and select "Design View") to get a better understanding of how the tables join together, and to view the structure and format of the fields within the query.

• AGENCY – Query that will be exported as XML and contains the agency information from the table called "tAgency." There are no linked tables within this query, so any changes made in the table "tAgency" will automatically update in this query.

• ALLINTERSECTION – Query that will be exported as XML and contains controller, arterial, and volume data by segment. For the output file to generate properly, the following model data are required:

— *CrossStreetName* – In the WFRC database, this field was contained in the table "Full_Street_Names" and is linked to the "V6_2005_4PD_MANAGED_KIPDATA_Lin" table. This field contains the names of intersecting roadways, and should be provided within the main database. If the data are unavailable, it is suggested that the names of the intersecting roadway at the end of each link be added to the model data.

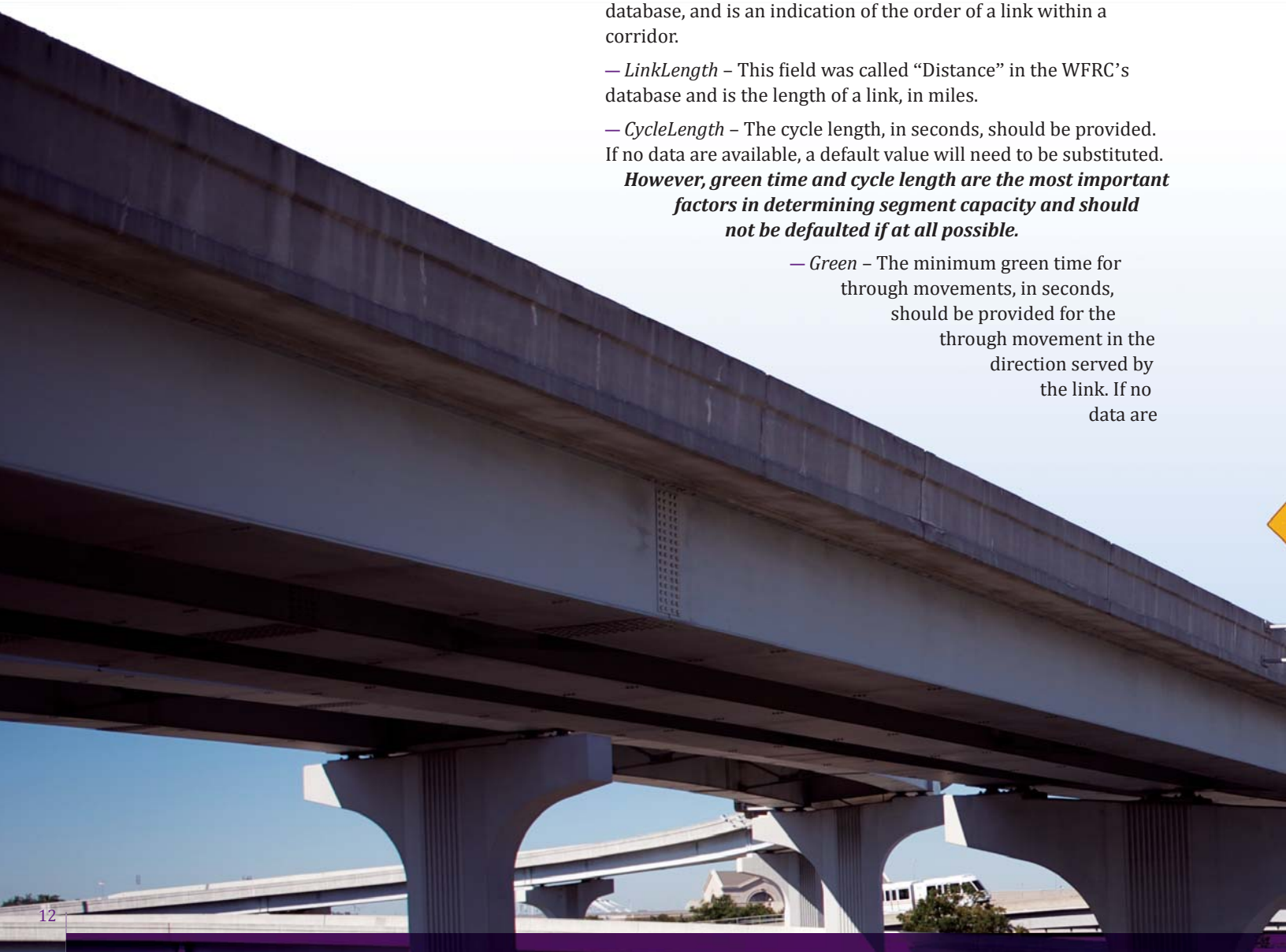
— *ControlMode* – If no data are provided this field, the query assumes the traffic signal at the end of the link is pre-timed. ARTPLAN can evaluate pre-timed, actuated, and semi-actuated signal control.

— *SectionS* – This field was called "Link_Order" in the WFRC's database, and is an indication of the order of a link within a corridor.

— *LinkLength* – This field was called "Distance" in the WFRC's database and is the length of a link, in miles.

— *CycleLength* – The cycle length, in seconds, should be provided. If no data are available, a default value will need to be substituted. ***However, green time and cycle length are the most important factors in determining segment capacity and should not be defaulted if at all possible.***

— *Green* – The minimum green time for through movements, in seconds, should be provided for the through movement in the direction served by the link. If no data are



available, a default value will need to be substituted. ***However, green time and cycle length are the most important factors in determining segment capacity and should not be defaulted if at all possible.***

— *GCRatio* – This field calculates the ratio of green time to cycle length by dividing the value of the "Green" field by the value of the "CycleLength" field.

— *FreeFlowSpeed* –The free-flow speed was called "SFF" in the WFRC's database. In ARTPLAN, the free-flow speed is assumed to be five miles per hour greater than the speed limit.

— *AADT* – This field was called "DY_VOL2WY" in the WFRC's database, and is the annual average daily traffic volume on the link.

— *DDHV* – This field is the daily design hour volume, and is an indication of the afternoon peak hour volume. It was called "PM_Vol" in the WFRC's database, and was a three-hour volume that was divided by three to obtain a single–hour volume. The formula used to generate the hourly volume should be changed if the local model data are for only a one- or two-hour peak period, or if the local agency has its own peak period–to–peak hour conversion factor.

— *RID* – This field is used to link the "Segment_Default_Values" table to the model data and should contain the value "1" in all of its records.

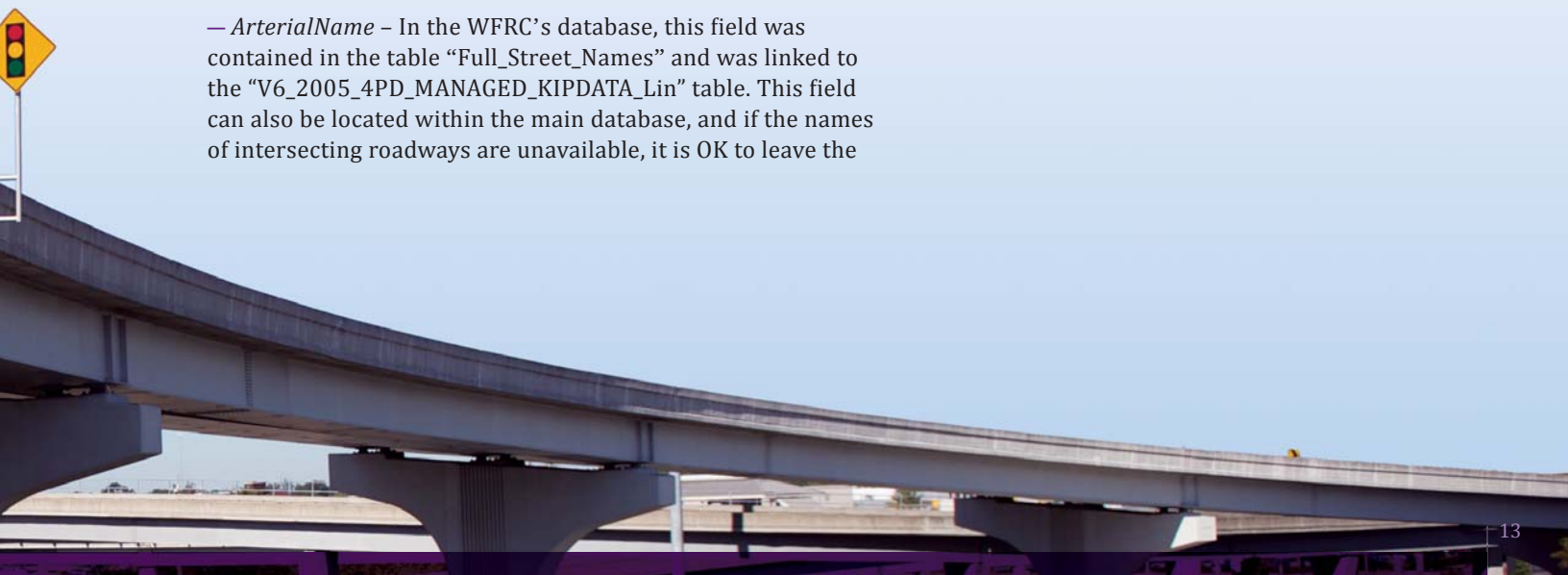
— *Roadway ID* – This field was called "NAME ID" in the WFRC database and is linked to the "Corridor Selection" table, where the corridor and link limits are set. This field provides a unique ID number for each roadway.

— *Section ID* – This field is linked to the "Corridor Selection" table, where the corridor and link limits are set. The field creates a unique ID number for up to nine links within a given corridor.

— *Direction* – Use 1 to indicate northbound, 2 for eastbound, 3 for southbound, and 4 for westbound. This field allows both directions of a roadway to be analyzed, but could be defaulted to 1 if only one direction needs to be analyzed. This field is linked to the "Corridor Selection" table, where the corridor and link limits are set.

• ARTERIALINFO – This query exports a variety of data pertaining to the link. For the output file to generate properly, all the following model data are required (fields noted above under ALLINTERSECTION are not repeated):

— *ArterialName* – In the WFRC's database, this field was contained in the table "Full_Street_Names" and was linked to the "V6_2005_4PD_MANAGED_KIPDATA_Lin" table. This field can also be located within the main database, and if the names of intersecting roadways are unavailable, it is OK to leave the



field's records blank; however the field should still be included in the query.

— *FwdDirection* – This field notes the direction being analyzed, and is extracted from the "Corridor Direction" table, which was linked to the model database field labeled "COR_NESW" in the WFRC database.

— *ArterialClass_HCM* – This field provides the HCM arterial class for the link, a number ranging from 1 to 4.

— *PostedSpeed* – This field could be extracted directly from the model database; otherwise, is assumed to be five miles per hour less than the "FreeFlowSpeed" field noted above.

— *NumberOfLanesBothDir* – This field gives the number of lanes in both directions on the street. WFRC's database provided a one-direction field in "LANES," which was multiplied by the "ONEWAY" field to determine the total two-way lanes.

• CONTROLLER – This query exports the default controller data. There are no linked tables within this query; therefore, any changes made in the table "tController" will automatically update in this query.

• GENERAL – This query exports the administrative data used by ARTPLAN, such as the analyst's name. There are no linked tables within this query, so any changes made in the table "tGeneral" will automatically update in this query.

• INTERSECTIONINFO – This query exports a listing of the intersecting roadways along a corridor.

• MODELPARAMETERS – This query exports ARTPLAN default period and analysis type data. There are no linked tables within this query, so any changes made in the table "tModelparameters" will automatically update in this query.

• SUBSEGMENT – This query exports multimodal default values used by ARTPLAN (and which are required for a successful file import to ARTPLAN, even if no multimodal analysis is intended). There are no linked tables within this query, so any changes made in the table "tSubsegment" will automatically update in this query.

"Make Table" Queries

The following queries create or populate tables that contain ARTPLAN's capacity results:

• zApp Corridor Capacity Results – Query that appends the corridor capacity results generated by ARTPLAN to the "zCorridor Capacity Results" table.

• zMk Corridor Capacity Results – Query that creates the "Corridor Capacity Results" table, which is a summary of the capacity results for the corridor.

• zMk Segmentlength conversion – Query that creates the "Segmentlength Conversion" table, which is used to associate segment data from the ARTPLAN output file with the model data in Microsoft Access.

Other Queries

• zNumber of Intersections – Query that calculates the number of intersections along a corridor, which is used by the XML export queries. The number of intersections must be less than 10 for the ARTPLAN conversion routine to run successfully.

• zPossible Corridor Sections – Query that lists the roadways and corridor sections that have sufficient data to be able to generate capacity results through ARTPLAN.

Editing the Queries

For the "ALLINTERSECTION" query, follow these steps to add the new dataset and to update the table links and data fields:

1. Open the query in design view, and add the new dataset to the list of tables. This can be done by right-clicking in the general area where the linked tables are shown and then choosing "Show Table." Browse to the new dataset and choose "Add."

2. Duplicate the links to the new dataset in a similar fashion as the links in place for the sample WFRC dataset.

3. Go through the list of fields at the bottom and change the references and calculations to reflect the new dataset.

Apply the same process for the "ARTERIALINFO" query.

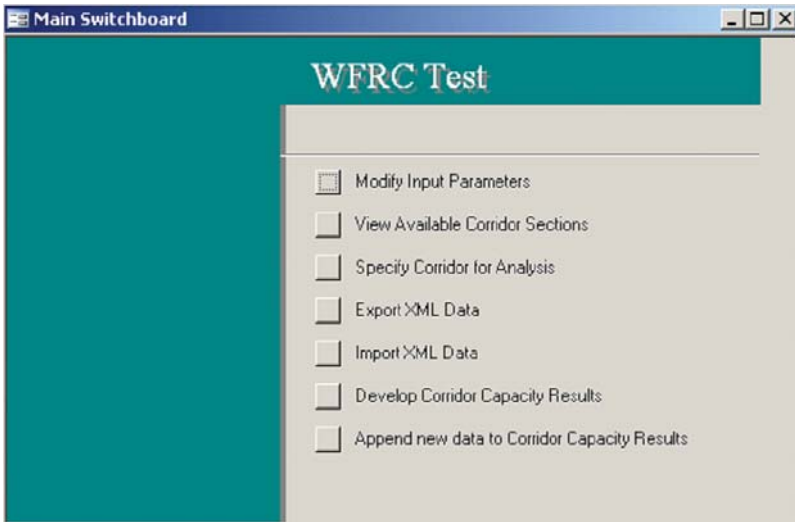
Using the Switchboard

The Microsoft Access database, although tailored to the WFRC's regional model) was developed in such a way that all of the tasks can be performed through the Switchboard interface. The Switchboard, shown below, automatically loads when the Microsoft Access database is opened and can also be accessed through the "Forms" menu in Access.

The following Switchboard options are available:

• Modify Input Parameters – This button opens the default tables used in ARTPLAN. It is not mandatory to specify anything here, since many of the default values will be overwritten by the link-specific data.

• View Available Corridor Sections – This button opens a table generated by the "zPossible Corridor Sections" query. This table shows which corridor sections have sufficient information for an ARTPLAN analysis. It is important to have a Roadway ID, Section ID, and direction (Cor_NESW) defined for each link. ARTPLAN is able to analyze up to nine links at once. Additional links can be analyzed separately and appended to the output file. This process is explained below.



• Specify Corridor for Analyses – This button opens the "Corridor_ Selection" table, where a corridor Roadway ID, Section ID, and direction (Cor_NESW) are defined. Only corridor sections that were shown in the previous step will work properly.

• Export XML Data – This button exports the corridor section data to a specified directory as eight XML-format files. The following is the procedure for working with the exported data:

— Run the "XMLdbMerge" utility program provided with ARTPLAN.

— In the "Display Files" window, browse to the exported XML data and select all eight files by holding down the shift key.

— Click the "Open Database XML files" button.

— Click the "Specify LOSPLAN XML file" button. When specifying the file name, make sure it starts with AP, for example "AP State Street." ARTPLAN only recognizes files that start with AP.

— Click "Create LOSPLAN file."

— Run the ARTPLAN application.

— In ARTPLAN, open the newly created file and click on the "LOS" button to calculate capacities and other performance measures. With the LOS screen open, select "Save As…" from the File menu. Specify an output name for the file. It is important to perform the "Save As…" command from the LOS screen, since different table formats (unusable for export back to Access) will be created if the file saved from another screen.

— Return to the Microsoft Access database and the Switchboard.

• Import XML Data – This button imports the results from the ARTPLAN output file into the Microsoft Access database.

• Develop Corridor Capacity Results – This button creates a table called "zCorridor Capacity Results," and opens the table showing the ARTPLAN capacity results.

• Append New Data to Corridor Capacity Results – This button is only used when additional sets of links were selected within Microsoft Access and analyzed in ARTPLAN. The button appends the most recent output table to a master table containing the earlier results.

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