Integrated Corridor Management

Phase 1 – Concept Development and Foundational Research

Technical Memorandum

Task 5.5 – Identification of Analysis Needs

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16. Abstract

Task 5 – Identify Corridor Types, Operational Approaches and Strategies, and Analysis Tools – is part of the overall foundational research to further the understanding of various aspects of Integrated Corridor Management (ICM) and to identify integration issues needed to evaluate the feasibility of the ICM initiative. The focus of Task 5.5 and the purpose of this document (TM 5.5) is to identify current modeling tools and analysis capabilities that support the evaluation of various corridors "types" and ICM operational strategies , and to conduct a gap analysis to determine what tool modifications or new developments are needed to provide the analysis capabilities necessary to fully support ICM operational strategy analysis and evaluation.

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Integrated Corridor Management (ICM)
Tech Memo 5.5 – Identification of Analysis Needs

Task Objective

Task 5 – Identify Corridor Types, Operational Approaches and Strategies, and Analysis Tools – is part of the overall foundational research to further the understanding of various aspects of Integrated Corridor Management (ICM) and to identify integration issues needed to evaluate the feasibility of the ICM initiative. The focus of Task 5.5 and the purpose of this document (TM 5.5) is to identify current modeling tools and analysis capabilities that support the evaluation of various corridors "types" and ICM operational strategies,[1] and to conduct a gap analysis to determine what tool modifications or new developments are needed to provide the analysis capabilities necessary to fully support ICM operational strategy analysis and evaluation.

Research Methodology

In order to meet the objectives of Task 5.5, the research team utilized the following methodology.

- Literature Review - A literature review was conducted, focusing primarily on (1) transportation analysis tool gap studies conducted in the past with respect to the use of traffic simulation models in the evaluation of ITS implementation and (2) research efforts dedicated to the use of simulation models for the evaluation of transit systems.
- Identification of Analysis Tools - The research team identified currently existing analysis tools that are best suited for modeling ICM. This was based on experience, published studies, and user documentation provided with the analysis tools.
- Tool Capability Assessment (Gap Analysis) - After the tools were identified, the research team analyzed each tool in terms of its capability to support ICM modeling in the following dimensions:
    - Network elements and junctions (as identified in TM 5.1-3)
    - ICM operational scenarios (as identified in TM 5.1-3)
    - ICM approaches and strategies (as identified in TM 5.1-3)
    - ICM performance measures (as identified in TM 3.4)

  This led to the identification of capabilities not currently available in existing analysis tools, but necessary for ICM evaluation purposes. These "gaps" in capability were then summarized for each dimension.
- Non-Tool Specific Issues - Effective modeling of ICM requires special attention to a number of key issues that are not specific to any one analysis tool. In this task, the research team addressed the issues of dynamic origin-destination (OD) tables, behavior modeling, and calibration and validation of models.

[1] Corridor Types and ICM Operational Strategies are discussed and described in Tech Memo 5.1-3.

- Develop Recommendations for Filling Gaps - To complete the effort, the research team proposes recommendations for FHWA to consider for filling the gaps identified in the analysis.

Literature Review

The literature review presents (1) a summary of transportation analysis tool gap studies conducted in the past with respect to the use of traffic simulation models in the evaluation of ITS implementations and (2) research efforts dedicated to the use of simulation models for the evaluation of transit systems.

The literature review revealed that the majority of studies have been related to finding gaps in traffic simulation models for ITS applications (Boxill and Yu, 2000; Vasudevan et al., 2001; Miller and Balke, 2003). In addition, the next generation simulation (NGSIM) project evaluated several selected core algorithms available within microscopic simulation modeling tools. These include (1) driving operation models (e.g., car following, gap acceptance, queue discharge, etc.), (2) tactical route execution models (e.g., lane changing, merging, passing and overtaking, etc.) and (3) strategic en-route choice models (e.g., route modification, parking choice and search models) (Cambridge Systematics, 2003). Thus, these studies do not fully address gaps related to ICM analysis.

Several recent studies have used traffic simulation models in the analysis of various transit system operational strategies. Cortes et al. (2005) modeled Bus Rapid Transit and studied a Large Scale Real-Time Routed Transit Design. PARAMICS with an application programming interface (API) was used to simulate various transit operations including vehicle stoppage at pick-ups, delivery, transfer points, and passenger boarding/alighting during transit usage. Kim et al. (2005a) proposed a transit signal priority algorithm that uses weighted least square regression modeling to estimate bus stop dwell time and associated bus prediction time using the VISSIM simulation model. PARAMICS was also used for the evaluation of transit signal priorities (Abhullai et al., 2002, Kim et al., 2005b). Ding et al. (2000) used CORSIM to simulate realistic bus operations for New Jersey Bus Route 39, and Khna et al. (2000) also used CORSIM for modeling a bus location system. In addition, Chien et al. (2000) enhanced CORSIM to allow it to simulate bus operations on transit routes. It is clear that various transit systems were evaluated using various microscopic simulation models. However, at least in literature, simulation models were rarely used in the evaluation of ICM strategies.

Identification of Analysis Tools

Given that a large number of ICM Approaches and Strategies require traffic management/control, the research team concluded that, at a minimum, a potential ICM analysis tool must allow for modeling operational strategies. Because of this, transportation planning models (such as EMME/2, TP+, TRANSIMS, etc.) were not considered as viable ICM analysis tools since their simulation fidelity is incapable of modeling operational level strategies.

Therefore, the analysis focused on traffic simulation tools that are widely used in both research and practice. The modeling tools considered in this effort are as follows:

- DynaMIT-R (Version “unknown,” User’s Guide v. 1.0, August 2004)
- DYNASMART-P (Version 0.930.7B, User’s Guide V. 2.0, February 2003)
- VISSIM (Version 4.10, User Manual, March 2005)

- CORSIM (Part of TSIS 5.1, User's Guide and Reference Manual, February 2003)
- PARAMICS (Version 5.1, Modeler User Guide, May 2005)
- AIMSUN-NG (Version 5.0, User's Manual, November 2005)

Note that the Analysis, Modeling and Simulation Focus Group also identified the tool, Trans Modeler, as having potential to support ICM analysis. It was not included in this analysis, but may need to be reviewed for future ICM efforts.

Tool Capability Assessment

The assessment relied on user documentation, published research efforts, professional experience and the results of a focus group discussion on Analysis, Modeling, and Simulation (AMS) activities in support of ICM. Note that in many cases the user documentation does not provide sufficient information to make a definite judgment concerning the tool's capabilities. Therefore, this report should be considered a draft that will be refined during subsequent phases of the ICM initiative.

Before presenting the results in each of the dimensions, it is important to address the role of application programming interfaces (APIs) in modern analysis tools. In very simple terms, an API is any language and format used by one program to help it communicate with another program. Thus, when an analysis tools provides an API, it provides a language and format that a modeler can use to create another program to extend the tool's "out-of-the-box" functionality. For example, in user documentation, PARAMICS states that the API can be used to allow users to "augment the core PARAMICS simulation with new functions, driver behaviors and practical features. At the same time researchers can opt to override or replace core logic of the PARAMICS simulation with their own behavioral models."

Therefore, APIs provide modelers with the capabilities to create scenarios (for example, particular ICM strategies) that could not be modeled with the "out-of-the-box" analysis tool. They have already been used extensively to model specialized situations. For example, researchers at the Institute of Transportation Studies at the University of California, Irvine have used the API to create extensions to PARAMICS to provide the following capabilities:

- Path-based Routing for ATIS Evaluation
- Adaptive Signal Control
- Time-based Ramp Metering
- Paratransit Routing

As a result of APIs, it is feasible to model aspects of ICM by creating external programs to interact with the simulation models. These aspects, however, could not be evaluated using the tool without the custom program. Given this situation, the research team categorized the capability of each tool in each ICM dimension in one of the following 6 classes:

- **FA+**: Fully available with required temporal and/or spatial resolutions. The standard tool has the capability to model this dimension to the desired temporal and spatial resolution.
- **FA–**: Fully available with approximate temporal and/or spatial resolutions. The standard tool has the capability to model this dimension – however, the temporal and/or spatial resolution that is desired for ICM analysis is not supported.

- **PA**: Partially available by tweaking model parameters. The standard tool has the capability to model this ICM dimension. However, it requires considerable attention to parameter setting.
- **FEA**: Feasible using existing APIs. External programs (APIs) currently exist that provide the capability to model the ICM dimension. Note that DYNASMART-P and DynaMIT-R do not provide APIs, therefore this category is not applicable for these models.
- **FCA**: Feasible with customized APIs. A custom external program (API) could be written to provide the capability to model the ICM dimension. However, such an external program does not currently exist. Note that DYNASMART-P and DynaMIT-R do not provide APIs, therefore this category is not applicable for these models.
- **NF**: Not feasible. The tool cannot model this ICM dimension – either in its standard form or by using the API to create a custom external program.

After assessing the capabilities of the analysis tools, gaps were identified based on trends in the capability ratings. Dimensions that were consistently rated as NF and PA were considered to represent gaps.

NETWORK ELEMENTS AND JUNCTIONS

To model an integrated corridor, the ability to “capture” the full range of networks and their respective characteristics is required; where the term “network” is used to denote a specific combination of facility and mode (e.g., arterials, freeways and transit networks.) Table 1 presents an assessment summary of the modeling network elements and junctions for ICM analyses.

Table 1. Assessment of Modeling Network Elements and Junctions

Network Type	Network Element	Simulation Modeling Tools					
		DynaMIT-R	DYNASMART-P	AIMSUN2	CORSIM	PARAMICS	VISSIM
Roadways	Arterials	FA+	FA+	FA+	FA+	FA+	FA+
	Freeways	FA+	FA+	FA+	FA+	FA+	FA+
	Pedestrian/Bicycle Path	NF	NF	FCA	FCA	FCA	FCA
Roadways with Restrictions	Work Zones	FA+	FA+	FA+	FA+	FA+	FA+
	Roadways under Bad Weather Conditions	FA–	FA–	FA–	FA–	FA–	FA–
	Lanes with Street Parking	PA	PA	FA–	FA–	FA–	FA–
	Mixed Lanes (with Pedestrian/Bicycle & Vehicle)	NF	NF	FCA	NF	FCA	FCA

Managed Roadway Lanes	Toll Roads	FA–	FA–	PA	PA	PA	PA
	Regular HOV	FA+	FA+	FA+	FA+	FA+	FA+
	Reversible HOV	FA–	FA–	FA–	FA–	FA–	FA–
	HOT lanes	FA–	FA+	FA+	FA–	FA+	FA+
	Reversible Lanes (e.g., Evacuation Purpose)	FA–	FA–	FA–	FA–	FA–	FA–
	Use of shoulders for Emergency Vehicle	NF	NF	FCA	FCA	FCA	FCA
	Exclusive Bus Lane	NF	NF	FA–	FCA	FA–	FA–
Transit Roadways and Facilities	Bus Transit	NF	NF	FA+	FA+	FA+	FA+
	Light Rail	NF	NF	FA+	NF	FA+	FA+
	Subways	NF	NF	FA+	FA+	FA+	FA+
	Commuter Rail (on exclusive ROW)	NF	NF	FA+	NF	FA+	FA+
	Heavy Rail (on exclusive ROW)	NF	NF	FA+	NF	FA+	FA+
	Transit Stations (e.g., bus stop, etc.)	FA–	NF	FA+	FA+	FA+	FA+
	Transit Center/Terminal/Port (physical center)	NF	NF	FCA	FCA	FCA	FCA
	Transit Center/Terminal/Port (for transfer purpose)	NF	NF	FCA	FCA	FCA	FCA
	Water Transportation Routes (e.g., ferry, barge)	NF	NF	FCA	FCA	FCA	FCA
Junctions	Park and Ride Lots (vehicle in & out)	NF	NF	FA–	PA	FA–	FA–
	Park and Ride Lots (modeling mode changes)	NF	NF	NF	NF	NF	NF
	Toll Booth (Physical)	PA	PA	FCA	FCA	FCA	FCA
	Toll Booth (EZ-Pass users & non-users)	NF	NF	FCA	FCA	FCA	FCA
	Ramps	FA+	FA+	FA+	FA+	FA+	FA+

FA+: Fully available with required temporal and/or spatial resolutions

FA–: Fully available with approximate temporal and/or spatial resolutions

PA: Partially available by tweaking model parameters

FEA: Feasible using existing APIs

FCA: Feasible with customized APIs

NF: Not feasible

SUMMARY OF GAPS

In general, the existing tools provide the capability to model the various network elements (with the exception of the rigorous modeling of toll roads). However, the analysis makes it clear that without the development of custom APIs, the tools are not currently well-suited to modeling junctions. This is particularly true when considering the need to model modal choice at junctions (see, for example, that none of the models can model mode changes at Park and Ride lots).

MODELING ICM OPERATIONAL SCENARIOS

Operational scenarios, for example unplanned and planned events, will impact the selection and effectiveness of potential ICM strategies. An effective traffic simulation modeling tool should be able to capture performance of various ICM strategies under a variety of operational scenarios. Modeling capabilities for several such corridor operational scenarios are summarized in Table 2.

Table 2: Assessment of ICM Operational Scenarios

Type of Event	Scenarios	Simulation Modeling Tools					
		DynaMIT-R	DYNASMART-P	AIMSUN2	CORSIM	PARAMICS	VISSIM
Unplanned Events	Recurring Congestion	FA+	FA+	FA+	FA+	FA+	FA+
	Roadway Incidents	FA+	FA+	FA+	FA+	FA+	FA+
	Transit Incidents	PA	PA	FCA	PA	FCA	FCA
	Bad Weather	FA+	FA+	FA+	FA+	FA+	FA+
	Unexpected Changes in Transit Schedule	PA	PA	FCA	PA	FCA	FCA
Planned Events	Evacuation	FA+	FA+	FA+	NF	FA+	FA+
	Roadway Incident (e.g., work zone, construction)	FA+	FA+	FA+	FA+	FA+	FA+
	Special Event	FA+	FA+	FA+	FA+	FA+	FA+
	Transit System Schedule Change	PA	PA	FCA	PA	FCA	FCA
Duration & Severity of Events	Location Specific (e.g., shoulder vs. main-lane)	FA–	FA–	FA+	FA+	FA+	FA+
	Impact of Emergency Vehicle Responses	FA–	FA–	FA–	FA–	FA–	FA–
	Dynamic (i.e., severity changes over time)	PA	PA	FA–	FA–	FA–	FA–
	Severity of Incidents/Events by Lanes	PA	PA	FA–	FA–	FA–	FA–

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SUMMARY OF GAPS

An examination of Table 2 reveals that there exist gaps in modeling transit-related operational scenarios. In most cases, planned or unplanned changes in transit schedules can be modeled to a limited extent through parameter adjustment, or through the development of new custom APIs. In addition, most of the tools are not currently able to model dynamic events or the impact of emergency vehicles to a desirable level of temporal and spatial accuracy.

MODELING ICM APPROACHES AND STRATEGIES

Numerous ICM operational approaches and strategies, as identified in Tech Memo 5.1-3, were considered for this analysis. The approaches include information sharing/distribution, improve operational efficiency at network junctions, accommodate / promote cross-network route & modal shifts, and manage capacity – demand relationship within the corridor (both short and long term strategies). The analysis tools' capabilities to model these approaches and strategies are summarized in Table 3.

Table 3. Assessment of ICM Approaches and Strategies

ICM Approach	ICM Strategy	Simulation Modeling Tools					
		DynaMIT-R	DYNASMART-P	AIMSUN2	CORSIM	PARAMICS	VISSIM
Information Sharing/ Distribution	Manual information sharing	FA+	FA+	FA+	FA+	FA+	FA+
	Automated information sharing (real-time data)	FA+	FA+	FA+	FA+	FA+	FA+
	Automated information sharing (real-time video)	PA	PA	PA	PA	PA	PA
	Information clearing-house/Information Exchange Network between corridor networks/agencies	PA	PA	PA	PA	PA	PA
	A corridor based advanced traveler information system (ATIS); including access by ISPs.	FA+	FA+	FEA	FCA	FEA	FEA

	En-route traveler information devices (DMS, 511) owned by one network agency describing conditions on another network	FA+	FA+	FA+	FA+	FA+	FA+
	A common incident reporting system and asset management (GIS) system	NF	NF	NF	NF	NF	NF
	Shared control of "passive" ITS devices, such as CCTV (i.e., camera selection, pan /tilt/ zoom)	NF	NF	NF	NF	NF	NF
Improve operational Efficiency at Network Junctions	Signal priority for transit (e.g., extended green times to buses that are operating behind schedule	NF	PA	FEA	FEA	FEA	FEA
	Signal pre-emption / "best route" for emergency vehicles	NF	NF	FEA	FEA	FEA	FEA
	Multi-mode electronic payment	FA–	FA–	FA–	FA–	FA–	FA–
	Transit hub connection protection	NF	NF	FCA	FCA	FCA	FCA
	Multi-agency / multi-network incident response teams / service patrols and training exercises	NF	NF	NF	NF	NF	NF
	Coordinated operation between ramp meters and arterial traffic signals in close proximity	FA+	FA+	FA+	FA+	FA+	FA+
	Coordinated operation between arterial traffic signals and rail transit at–grade crossings	NF	NF	FCA	PA	FCA	FCA
Accommodate / Promote Cross Network Route & Mode Shifts	I. Passive Network Shifts ("Inform")						
	Modify arterial signal timing to accommodate traffic shifting from freeway	FA+	FA+	FA+	FA+	FA+	FA+
	Modify ramp metering rates to accommodate traffic, including buses, shifting from arterial	FA+	FA+	FA+	FA+	FA+	FA+
	Modify transit priority parameters	NF	NF	FEA	FEA	FEA	FEA
	II. Promote Network Shifts ("Instruct")						
	Promote route shifts between roadways via en-route traveler information devices (e.g., DMS, HAR, "511")	FA–	FA–	FA–	FA–	FA–	FA–
	Promote modal shifts from roadways to transit via en-route traveler information devices (e.g., DMS, HAR, "511")	NF	NF	NF	NF	NF	NF
	Promote shifts between transit facilities via en-route traveler information devices (e.g., station message signs and public announcements)	NF	NF	NF	NF	NF	NF
	Re-route buses around major incidents	NF	NF	FCA	PA	FCA	FCA
Manage Capacity – Demand Relationship Within Corridor – "Real-time" / Short-Term	I. Capacity Oriented						
	Lane use control (reversible lanes / contra-flow)	FA–	FA–	FA–	FA–	FA–	FA–
	Convert regular lanes to "transit-only" or "emergency-only"	PA	PA	FA–	FA–	FA–	FA–
	Add transit capacity by adjusting headways and number of vehicles	PA	PA	PA	PA	PA	PA
	Add transit capacity by adding temporary new service (e.g., express bus service, "bus bridge" around rail outage / incident)	PA	PA	PA	PA	PA	PA
	Add capacity at parking lots (temporary lots)	NF	NF	NF	NF	NF	NF
	Increase roadway capacity by opening HOV / HOT lanes / shoulders	FA–	FA–	FA–	FA–	FA–	FA–

	Modify HOV restrictions	FA–	FA–	FA–	FA–	FA–	FA–
	Restrict ramp access	PA	PA	PA	PA	PA	PA
	Convert regular lanes to “truck only”	NF	NF	FA+	PA	FA+	FA+
	Coordinate scheduled maintenance and construction activities	FA+	FA+	FA+	FA+	FA+	FA+
Manage Capacity – Demand Relationship Within Corridor – “Real-time” / Short-Term	II. Demand Oriented						
	Variable speed limits (based on TOD, construction, weather conditions)	PA	PA	FA–	FA–	FA–	FA–
	Modify toll / HOT pricing	FA–	FA–	FEA	FEA	FEA	FEA
	Modify transit fares to encourage ridership	PA	PA	FCA	FCA	FCA	FCA
	Modify parking fees	NF	NF	NF	NF	NF	NF
	Variable truck restrictions (lane, speed, route, time of day)	FA–	FA–	FA+	FCA	FA+	FA+
	Re-route thru-traffic (e.g., trucks) away from corridor (likely a regional issue)	FA–	FA–	FA–	FA–	FA–	FA–
Manage Capacity – Demand Relationship Within Corridor – “Real-time” / Long -Term	I. Capacity Oriented						
	Low cost infrastructure improvements to cross-network linkages and junctions	PA	PA	PA	PA	PA	PA
	Rail shared use	NF	NF	NF	NF	NF	NF
	II. Demand Oriented						
	Guidelines for work hours during emergencies / special events	NF	NF	NF	NF	NF	NF
	Peak spreading	FA+	FA+	FA+	FA+	FA+	FA+
	Ride-sharing programs	PA	PA	PA	PA	PA	PA

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FA–: Fully available with approximate temporal and/or spatial resolutions

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FEA: Feasible using existing APIs

FCA: Feasible with customized APIs

NF: Not feasible

SUMMARY OF GAPS

As seen in Table 3, the most significant gaps in analysis tools’ capabilities to support ICM evaluation are in assessing ICM approaches and strategies. The key gaps are summarized below:

Information Sharing/Distribution

- Automated information sharing (real-time video)
- Information clearinghouse/information exchange network between corridor networks/agencies
- Common incident reporting system and asset management (GIS) system
- Shared control of “passive” ITS devices, such as CCTV

Improve Operational Efficiency at Network Junctions

- Multi-agency/multi-network incident response teams / service patrols and training exercises

Accommodate / Promote Cross Network Route & Mode Shifts

- Promote modal shifts from roadways to transit via en-route traveler information devices
- Promote shifts between transit facilities via en-route traveler information devices

Manage Capacity-Demand Relationship Within Corridor – “Real-time” / Short-term

- Add transit capacity by adjusting headways and number of vehicles
- Add transit capacity by adding temporary new service
- Add capacity at parking lots
- Restrict ramp access
- Modify parking fees

Manage Capacity-Demand Relationship Within Corridor – “Real-time” / Long-term

- Low cost infrastructure improvements during emergencies / special events
- Rail shared use
- Guidelines for work hours during emergencies / special events
- Ride-sharing programs

MODELING ICM PERFORMANCE MEASURES

Technical Memorandum 3.4 (Institutional Strategies and Administration) discusses performance measurement in the context of ICM, and includes a list of potential “mode – independent” performance measures. Analysis tools should be able to produce corridor - wide performance measures under various ICM strategies. Several of the performance measures identified in Tech Memo 3.4 (and derivatives thereof) were considered in the analysis. The results are displayed in Table 4.

Table 4. Assessment of ICM Performance Measures

ICM Performance Measures	Type Definition	Simulation Model					
		DynaMIT-R	DYNASMART-P	AIMSUN2	CORSIM	PARAMICS	VISSIM
Travel time rate (minutes per mile)	Travel time (in minutes) / segment length (miles)	FA+	FA+	FA+	FA+	FA+	FA+
Delay rate (minutes per mile)	Actual travel rate – acceptable travel rate	FA+	FA+	FA+	FA+	FA+	FA+
Travel time index (TTI)	Comparing travel conditions in the peak period to free-flow conditions.	FA+	FA+	FA+	FA+	FA+	FA+
Delay per person (person-hours per year)	Expressed in person-hours per year	FA–	FA–	FA+	FA+	FA+	FA+
Travel Speed (minutes per mile)	Distance (miles) divided by time traveled	FA+	FA+	FA+	FA+	FA+	FA+
Total Segment Delay (minutes per mile)	[Actual travel time (min.) – acceptable travel time (min.)] x vehicle volume	FA+	FA+	FA+	FA+	FA+	FA+
Reliability Factor	Percentage of time that a person's travel time is no more than 10% higher than average	FA+	FA+	FA+	FA+	FA+	FA+

FA+: Fully available with required temporal and/or spatial resolutions

FA–: Fully available with approximate temporal and/or spatial resolutions

PA: Partially available by tweaking model parameters

FEA: Feasible using existing APIs

FCA: Feasible with customized APIs

NF: Not feasible

(Note – In addition to the potential corridor-wide performance measures listed above, these models area also capable of producing roadway – oriented measures, such as volume – capacity ratio, vehicle – miles traveled, queue lengths, and the number of stopped vehicles at a traffic control device)

SUMMARY OF GAPS

As seen in Table 4, the existing analysis tools meet the needs of several of the potential ICM performance measures. No gaps were identified for these particular measures. Other potential ICM performance measures – such as the number / percent of person-trips with travel times x % greater than the average travel, total emissions, and any additional corridor–wide measures identified during subsequent phases of the ICM initiative – will require further analysis vis-à-vis simulation and modeling tools.

Discussion of Non-Model Specific Issues

This section presents general issues related to the use of traffic simulation models in the evaluation of ICM strategies.

DYNAMIC ORIGIN DESTINATION (O-D) ESTIMATION

Most microscopic simulation models assume that dynamic origin destination (O-D) information is given, while DynaMIT and DYNASMART have the capability of estimating dynamic O-D matrices. The current practices in dynamic O-D estimation are based on either statistical or optimization methods to match observed link counts. One obvious gap is the use of link choice proportions, which is needed for efficiently obtaining estimated link counts at a given O-D. The link choice proportion is a result of traffic assignment indicating proportional usage of each OD pair by a number of predetermined paths used in the assignment, providing a quick and easy method to obtain link counts from any given OD matrices. Thus, during OD estimation, the link choice proportion generates link counts by applying it to OD matrix under consideration and determines the optimal OD that provides the best match with observed link counts. However, the problem is that the link choice proportion under newly estimated O-D could be different from the one used in the O-D estimation, resulting in often poor convergence. Furthermore, even though most of the O-D estimation methods require prior information (target O-D table) on the network, explicit means of collecting dynamic O-D information is yet to be standardized. Finally, several methods used to sample actual dynamic O-D estimation are difficult to evaluate because of lack of capability to sample actual dynamic O-D flows in the field.

BEHAVIOR ANALYSIS

Since ICM strategies will force travelers to make choices on route, mode, and departure time, it is critical to accurately calibrate behavioral models such that traveler's choice can be realistically modeled within the simulation modeling tool environment.

It is obvious from the previous section that choice behavior (e.g., route, mode, time, etc.) is a major modeling gap faced by simulation models. Even though various theoretically well-suited models are available, obtaining accurate parameters to "fit" such models is very challenging. One common practice is to conduct a survey and estimate choice parameters from users of the network. However, this approach will naturally be biased as it is based on stated preference rather than revealed preference. In addition, the preference would vary case by case including time of day, travel purpose, congestion level, perceived information, etc.

Furthermore, none of the existing simulation models have the capability of explicitly modeling elderly drivers, modeling of violators of various traffic operation strategies (e.g., violators at tollbooths), etc.

CALIBRATION AND VALIDATION

Calibration and validation is a key step to any simulation model-based evaluation. Much effort has been invested in this area of study and results show that evaluations performed under calibrated networks statistically are better than that from un-calibrated networks (Park and Qi, 2005). However, simulation model based analyses have been conducted often under default parameter values or best guessed values. This is mainly due to either difficulties in field data collection or lack of readily available procedures (or guidelines) to support simulation model calibration and validation. At times, simulation model results could result in unrealistic estimates of the impacts of new treatments if the simulation model is not properly calibrated and validated. It is noted that existing microscopic simulation modeling tools provide adequate access to simulation parameters for calibration and validation.

Recommendations: Proposed Approaches To Fill Gaps

Many specific modeling gaps have been identified in this task. In order to address these gaps and create the ability to effectively model ICM, it is recommended that FHWA support research and development in a number of critical areas. These are described below:

USE OF PERSON-BASED OD

In order to support mode choice/switch (e.g., car or transit, departure time, and route for a single home-to-work trip), it will be necessary to use *person-based Origin-Destination tables* instead of current vehicle demand-based OD tables. Once mode, departure time, and route choices are made by an individual traveler, that traveler's mode (either car or transit), departure time and route can be loaded into a microscopic simulation environment. It is noted that the mode switch can also occur while traveler is being simulated within the microscopic simulation environment. Thus, the mode choice/switch can happen at any given simulation time step as long as an alternative mode is available, which will make the mode choice a highly complicated search/optimization problem.

OPTIMIZATION FOR TRAVELER'S MODE, DEPARTURE TIME AND ROUTE CHOICES

An optimization algorithm is needed to determine an optimal mode choice (or choices with a combination of multiple modes), departure time, and route for travelers. None of simulation modeling tools considered in this task can optimize all these choice at a same time. TRANSIMS is one of the closest models that can consider a chain-based activity model for the optimization of multiple mode choices. Thus, it is recommended that the TRANSIMS logic may be used as an effective starting point.

ARCHIVING REVEALED TRAVELER'S BEHAVIOR CHOICES

In order to develop accurate behavior models and their associated parameters, it will be necessary to archive as much <u>field</u> behavior choice data as possible. The data should include various potential factors (socio-economic info. of traveler, time of day, travel purpose, congestion level, perceived information, etc.). How to obtain these data in the real world is a question that must be addressed.

SUPPORT DEVELOPMENT AND SHARING OF APIS

As seen in the gap analysis, the use of APIs will allow for modeling of a wide-range of ICM strategies. In many cases, the actual strategies will be tailored specifically for a region based on unique characteristics of the corridor. Thus, in many cases, “one size fits all” functionality added to core simulation models will not be useful. It is expected that the use of APIs to support specific simulation analyses will become more and more prevalent.

It is recommended that FHWA support the development of ICM related APIs and establish a clearinghouse for analysts and researchers to share APIs.

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