CT-RAMP Family of Activity-Based Models

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Main Features of CT-RAMP

The paper describes the structure and implementation aspects of 7 different regional Activity-Based Models (ABMs) that belong to the same family in terms of conceptual design and also share the same software platform. This family of models is called **C**oordinated **T**ravel and **R**egional **A**ctivity **M**odeling **P**latform (**CT-RAMP**). This stresses the unique feature of this family of models compared to ABMs developed elsewhere in practice that is an explicit modeling of intra-household interactions across a wide range of activity and travel dimensions. Modeling intra-household interactions explicitly allows for a greater behavioral realism in forecasting practically all policies since in reality, person responses in terms of changing trip frequencies, destinations, time of day, or mode are subject to many constraints stemming from participation in joint activities and various other schedule synchronization and coordination mechanisms within the household. This feature is especially beneficial for modeling policies targeting joint travel (like HOV/HOT lanes).

The following main sub-models and associated travel choices are included in the basic CT-RAMP structure:

1. **Population synthesis**. This procedure creates a list of households with all household and person attributes based on the input (controlled) variables defined for each TAZ.

2. **Long-term choices.** These choices include usual workplace for each worker and usual school location for each student as well as household car ownership choice.

3. **Coordinated Daily Activity-Travel Pattern (DAP).** This set of sub-models generates travel tours for all household members. This component of CT-RAMP is distinctive in kind compared to the other ABMs since it includes multiple layers of intra-household interactions. The following main sub-models are included in this set: 1) Coordinated DAP type for all household members, 2) Frequency of work and school tours for each worker and student, 3) Household frequency and person participation in joint travel for shared non-work activities, 4) Household frequency of maintenance tasks and their allocation to household members, and 5) Frequency of individual discretionary tours for each person.

4. **Tour-level choices.** These sub-models include choices of the tour primary destination, time-of-day, tour mode combination, as well as frequency and location of intermediate stops.

5. **Trip-level choices.** These sub-models include choices of trip mode conditional upon the tour mode combination, parking location for auto trips, parking location for park-and-ride and kiss-and-ride trips (station choice), as well as trip departure time choice within the tour time window.

In the CT-RAMP model chain, the sub-models 3-5 are closely interlinked through time-space constraints and multiple feedbacks.

Current Members of the CT-RAMP Family

The first ABM of the CT-RAMP family was developed for the Mid-Ohio Regional Planning Commission (MORPC) located in Columbus, OH, in 2004. The second application of CT-RAMP, for the Lake Tahoe Area, NV, was completed in 2006 where the Columbus core model structure was adapted for the Tahoe Regional Planning Agency (TRPA). The Lake Tahoe ABM included special components to account for a significant seasonal population and external traffic that were implemented in an aggregate fashion.

The third and forth ABMs of the CT-RAMP family have been developed in parallel for the Atlanta Regional Commission (ARC) and San-Francisco Bay Area Metropolitan Transportation Commission (MTC). These ABMs were completed in 2009 and are currently being tested by the agencies. The Atlanta and Bay Area Models have included following refinements to the original structure of the Columbus/Lake Tahoe model:

- Inclusion of **long-term choices** of usual workplace for each worker and usual school location for each student prior to the car ownership model and subsequent chain of travel choices. In the Columbus/Lake Tahoe model, these choices were not modeled explicitly. They were “blended” with the non-usual locations in the destination choice model for work and school purposes.

- **Simultaneous choice of DAP type for all household members** accounting for interactions between them. This model replaced the sequential DAP applied in the Columbus/Lake Tahoe model. This enhancement significantly improves the model system integrity and eliminates the need in arbitrary putting household members in a predetermined sequence.

- Consideration of **multiple intermediate stops** on each half-tour (up to 3-4 depending on the tour purpose). In the Columbus/Lake Tahoe model, only one major stop was modeled on each half-tour in addition to the primary tour destination.

- Adding details to the **model segmentation** with respect to person types and travel purposes as well as for tour-level and trip-level mode choice. In particular, in the Columbus/Lake Tahoe model, the trip-level mode choice was implemented as a rule-based algorithm due to a very low share of transit based on a single mode – bus. In the Atlanta and Bay Area models, a **trip-level choice** model was introduced and both tour-level and trip-level mode choices were significantly extended to account for the multi-modal regional transit.

- Implementation of distributed values of time in the Bay Area ABM based on SP survey work performed for SFCTA in conjunction with the San Francisco Mobility Study.

Three new members of the family were added in the period 2008-2009. They include the San Diego, CA, ABM being developed for the San Diego Association of Governments (SANDAG); the Phoenix, AZ, ABM being developed for the Maricopa Association of Governments (MAG); and the Jerusalem, Israel, ABM being developed for the Jerusalem Transportation Master Plan Team (JTMT).

Enhancements Incorporated in the San Diego ABM

The San Diego ABM development started in late 2008 and currently Phase 1 (out of 4) has been completed that included a full model system specification document as well as a first set of estimated and implemented models. The following most important new features were incorporated:

- **Improvement of the structure and segmentation of long-term models through Integration with a Land-Use model (PECAS).** A significant effort was made to improve the models for workplace and school locations that represent the most important travel markets in the peak periods as well as serve as important determinants of the person and household behavior with respect to non-work travel. This ABM improvement was based on the inputs provided by PECAS for location of labor force and jobs by occupation. The developed choice models include size terms and impedance measures that address industry type, person occupation, income group, gender, full-time/part time status, etc.

- **Fine spatial resolution.** The SANDAG ABM is taking a full advantage of the developed socio-economic and land-use database (supported by PECAS for future years) as well as network procedures at a level of 22,000 Master Geography Reference Areas (MGRAs). All location choices of the SANDAG ABM are implemented at the MGRA level. Transit procedures and mode choice are among the primary beneficiaries of the fine level of spatial resolution.

- **Improved Coordinated DAP type model integrated with joint activity episodes.** In the previous CT-RAMP ABMs, joint travel was generated after the DAP type and work/school tour schedules were defined for each person. Person availability to participate in joint activity was conditional upon the residual time window overlap with the residual time windows of the other household members. There is strong statistical evidence, however, that in reality this logic might be reversed and people synchronize their schedules and create time window overlaps in view of *planned* joint activities. This enhancement resolves this issue and allows for a more realistic decision-making mechanism where an indication on a joint activity episode is modeled simultaneously with the choice of DAP type of each household member.

- **Improved ABM system integrity by inclusion of a wide set of accessibility measures** in upper-level models for car ownership, DAP choice and tour generation to ensure their sensitivity to improvements of transportation LOS as well as changes in the Land Use. The SANDAG ABM will be one of the few travel models that do not use "flat" are-type dummies (like CBD, urban, suburban, etc). Accessibility measures are created in order to reflect the opportunities to implement a travel tour for a certain purpose from a certain origin (residential or workplace). Accessibility measures play the role of simplified tour-level logsums used in upper-level models instead of full logsums (which is computationally infeasible to calculate over all modes, time-of-day periods, and destinations for each possible tour). There are more than 50 types of accessibility measures used in the SANDAG ABM. They are distinguished by the specification of the zonal attraction size variable, impedance function from, and time-of-day period used to generate LOS variables.

- **Population synthesizer that incorporates both household and person controls**. The current version of the population synthesizer can only handle controls on household distribution like number of households by size, income group, dwelling type, etc. However, there are certain demographic dimensions like population distribution by age brackets that can be better expressed through person-level controls. Modified population synthesis algorithm that can incorporate both types of controls simultaneously has been developed and it is planned for implementation at Phase 2.

Planned Advanced Features for the Phoenix ABM

The Phoenix ABM development started in mid 2009 and currently at Phase 1 (out of 4). Full model system specification document has been completed as well as a first set of estimated and implemented models is planned by mid 2010. The following most important new features are planned:

- **Explicit modeling of seasonality.** The Phoenix ABM will be one of the first travel models in practice that address seasonal fluctuations in travel demand rather than just an average weekday. The model system will have a switch that allows for implementation of a run specific to summer, winter, or fall-spring period. Travel in the Phoenix metropolitan area is somewhat more seasonal than other similarly-sized areas, due to the presence of special travel markets. The main special markets and corresponding implications for the model structure are summarized in the subsequent bullets.

- **Special sub-models for university-related travel.** Arizona State University (ASU) is the largest public higher-education learning center in the United States, with more than 62,000 students. ASU accounts for almost 2% of total regional population (students plus workers), and has significant local traffic effects, modal effects (particularly with respect to transit use by the student body for both school and non-school trips) and seasonal variation, with school in session from late August through mid-May. A key differentiating characteristic for modeling behavior of students would be whether the students live with parents. Students who live with parents are sufficiently modeled using existing home-interview survey data, which typically captures part-time and commute students. Students who live in shared non-family households and group quarters would be defined as a special segment. It is also important to model the proper residential location for university students, as a function of distance/accessibility to campus. The synthetic student population would be generated explicitly given distance from campus and presence of group quarters and other zonal characteristics, and tracked as ASU students in household/person databases. This residential allocation (synthetic generation) model would replace the usual school location choice model for ASU students.

- **Sub-models for non-resident visitor travel.** Approximately 6% of homes in the Phoenix metropolitan region are owned by seasonal residents. In addition to that, the Phoenix region has many hotels, motels, and resorts, whose occupancy is also highly seasonal. Non-resident visitors are likely to have different travel patterns than residents, depending on whether they are seasonal residents, business travelers, or recreational travelers. In the Phoenix ABM, it is planned to account for non-residents explicitly in the population synthesis and subsequent chain of travel models.

- **Special Events integrated with the core travel model.** MAG is currently conducting a new comprehensive survey of special events by location. The challenge is to integrate Special Events with the core model in a disaggregate fashion to ensure that participation in a special event is organically incorporated in the individual DAP for both residents and non-resident visitors. Each special event is considered as a special activity with predetermined time schedule and expected patronage. The core ABM will select participants for special event activities prior to generation of DAP from the appropriate resident and visitor populations. The event participation sub-model will consider household and person characteristics (including probability of forming a party of several persons), location and travel accessibility of the event, as well as feasibility of participation in more than one event. For each participant, the model would then 'reserve' time window for the special event, and seek to generate and schedule other activities for the person conditional upon the event.

- **Incorporation of passenger trips to and from airport with and explicit modeling of choices of airport and ground access mode.** This model component becomes especially interesting in relevant in view of the expansion of the ABM modeling area to include the city of Tucson. There are three airports with commercial air service in the Phoenix-Tucson region: Phoenix Sky Harbor (the eight-largest airport in the United States), Phoenix-Mesa Gateway (a small airport), and Tucson International Airport. Phoenix Sky Harbor and Tucson International Airport compete for travel to and from the Tucson region. This will require special sub-models for generation of long-distance trips through airports and airport choice.

Planned Advanced Features for the Jerusalem ABM

The Jerusalem ABM development started in 2008 but the Phase 1 of the project was devoted to implementation of Household Travel Survey employing an innovative method of "prompted recall" with 100% of persons equipped with a GPS device (currently under way). Full model system specification document has been completed and a first set of estimated and implemented models is planned by end 2010. The following most important new features are planned:

- **Explicit modeling of individual mobility attributes**. Person and household mobility attributes relate to the medium-term choices that are conditional upon long-term choices (residential, workplace, and school location) but logically precede short-term travel choices related to a particular day, tour, or trip. In most of the previously developed ABMs, mobility attributes included car ownership only. In the Jerusalem ABM, this component is significantly expanded to include a wider range of interrelated person and household attributes: possession of a driver license, disability or limited mobility category, transit pass, transit ticket discounts and/or subsidy from the employer or school, employer provided transportation for commuting, employed provided or subsidized parking, school bus availability, holding a toll transponder, etc.

- **Intra-household car allocation**. The Jerusalem metropolitan region is characterized by a comparatively low car ownership compared to US with a large number of 0-car households and 1-car households with multiple workers. A large share of mode choice decisions is predetermined by the intra-household car allocation priorities. A special model that allocates household cars to individual tours and creates a logical linkage across mode choice decisions for tours overlapping in time has been developed.

- **Perceived highway time by congestion levels as a proxy for travel time reliability**. While transit time components like in-vehicle time, wait time, and walk time have long been modeled with highly differential weights, highway time has been always considered a generic in travel models regardless of the level of congestion. There is strong evidence that auto users also perceive travel time in a highly differential way where each minute spent in congested conditions is equal to almost 2 minutes of free-flow conditions. This weights accounts for negative psychological perception of congestion as well as for unpredictable travel time for a given trip. The Jerusalem Household Travel Survey has several SP extensions specifically devoted to measurement of impacts of travel time reliability on choices of route, mode, and time-of-day.

- **Parking Choice and Constrained Parking Equilibrium.** The CBD area of Jerusalem is characterized by a limited parking supply and several parking policies are currently being considered. ABM can explicitly incorporate parking behavior that makes the model sensitive to constraints and policies associated with parking. By virtue of individual microsimulation with an enhanced temporal resolution, the model can portray the dynamics of parking in each traffic zone during the day. The most important individual variables that relate to parking demand are tour destinations, arrival times, and planned activity durations (time for which the auto would occupy the parking space). Parking supply is estimated by free and paid parking capacity in each zone as well as parking rates including the daily rate (relevant for long parking) and hourly rate (relevant for short parking). The equilibrium mechanism is implemented by means of the parking choice model that is applied in combination with two functional models to estimate the associated parking search time and track the actual parking availability at any point of time during the day. With this model, a driver does not necessarily park in the destination zone but can choose to park in some other zone (where parking is more available or cheaper) and then walk to the final destination.