Consolidated Travel Model Software Platform Development and Enhancement

Technical Memorandum: TASK 1A
Comparison of CT-RAMP Activity-Based Models

FOR: Association of Metropolitan Planning Organization (AMPO)

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INTRODUCTION

This memorandum documents a comparison between the most recent versions of CT-RAMP Activity-Based Models of San Diego Association of Governments (SANDAG) and Atlanta Regional Commission (ARC). For the purpose of this project only the core models of the two MPOs have been reviewed, not including the add-on models for airports, visitors, border crossings, etc. It was the project advisory group's recommendation not to review the Metropolitan Transportation Commission's (MTC) current version of CT-RAMP (Travel Model One) as they are currently in the process of adopting SANDAG's version of the model (Travel Model Two).

TREATMENT OF SPACE

SANDAG **–** There are 4996 Transportation Analysis Zones (TAZ), and 23002 Master Geographic Reference Area (MRGA) zones in the most recent version of the model.

ARC – The current version of the model utilizes a newly developed 6000+ zone system, replacing the original 2027 zones and transit accessibility sub-zones.

TREATMENT OF TIME

Five time periods of Early, AM Peak, Midday, PM Peak, and Evening are used in both models. They are for the most part similar between the two, with slight differences in the begin and end times of a few time periods; highlighted cells in Table 1, below, denote the differences. SANDAG's model operates at a ½ hour temporal resolution. The ARC AB model system was recently updated to function at a temporal resolution of 30 minutes as well. These half-hour increments begin with 3 A.M. and end with 3 A.M. the next day. Temporal integrity is ensured so that no activities are scheduled with conflicting time windows, with the exception of short activities/tours that are completed within a half-hour increment. For example, a person may have a short tour that begins and ends within the 8:00am-8:30 am period, as well as a second longer tour that begins within this time period, but ends later in the day.

TABLE 1- Comparison of Time Periods

Period	Description	SANDAG Begin Time	SANDAG End Time	ARC Begin Time	ARC End Time
1	Early	3:00 A.M.	5:59 A.M.	3:00 A.M.	5:59 A.M.
2	A.M. Peak	6:00 A.M.	8:59 A.M.	6:00 A.M.	9:59 A.M.
3	Midday	9:00 A.M.	3:29 P.M.	10:00 A.M.	2:59 P.M.
4	P.M. Peak	3:30 P.M.	6:59 P.M.	3:00 P.M.	6:59 P.M.
5	Evening	7:00 P.M.	2:59 A.M.	7:00 P.M.	2:59 A.M.

DECISION MAKING UNITS

Decision-making units in both models are persons and households.

PERSON TYPES

Person types are defined the same between the two models. School status categories are also consistent between the two. Table 2 presents a comparison of Person Types as currently defined in both models.

TABLE 2- Comparison of Person Types

NUMBER	PERSON-TYPE	SANDAG AGE	ARC AGE	SANDAG WORK STATUS	ARC WORK STATUS	SCHOOL STATUS
1	Full-time worker	18+	18+	Full-time	Full-time	None
2	Part-time worker	18+	18+	Part-time	Part-time	None
3	College student	18+	18+	Any	Any	College +
4	Non-working adult	18 – 64	18 – 64	Unemployed	Unemployed	None
5	Non-working senior	65+	65+	Unemployed	Unemployed	None
6	Driving age student	16-17	16-17	Any	Any	Pre-college
7	Non-driving student	6 – 15	6– 16	None	None	Pre-college
8	Pre-school	0-5	0-5	None	None	None

ACTIVITY TYPE

Activity types are similarly defined between the two models: Work, University, High School, Grade School, Escorting, Shopping, Other Maintenance, Social/Recreational, Eat Out, and Other Discretionary.
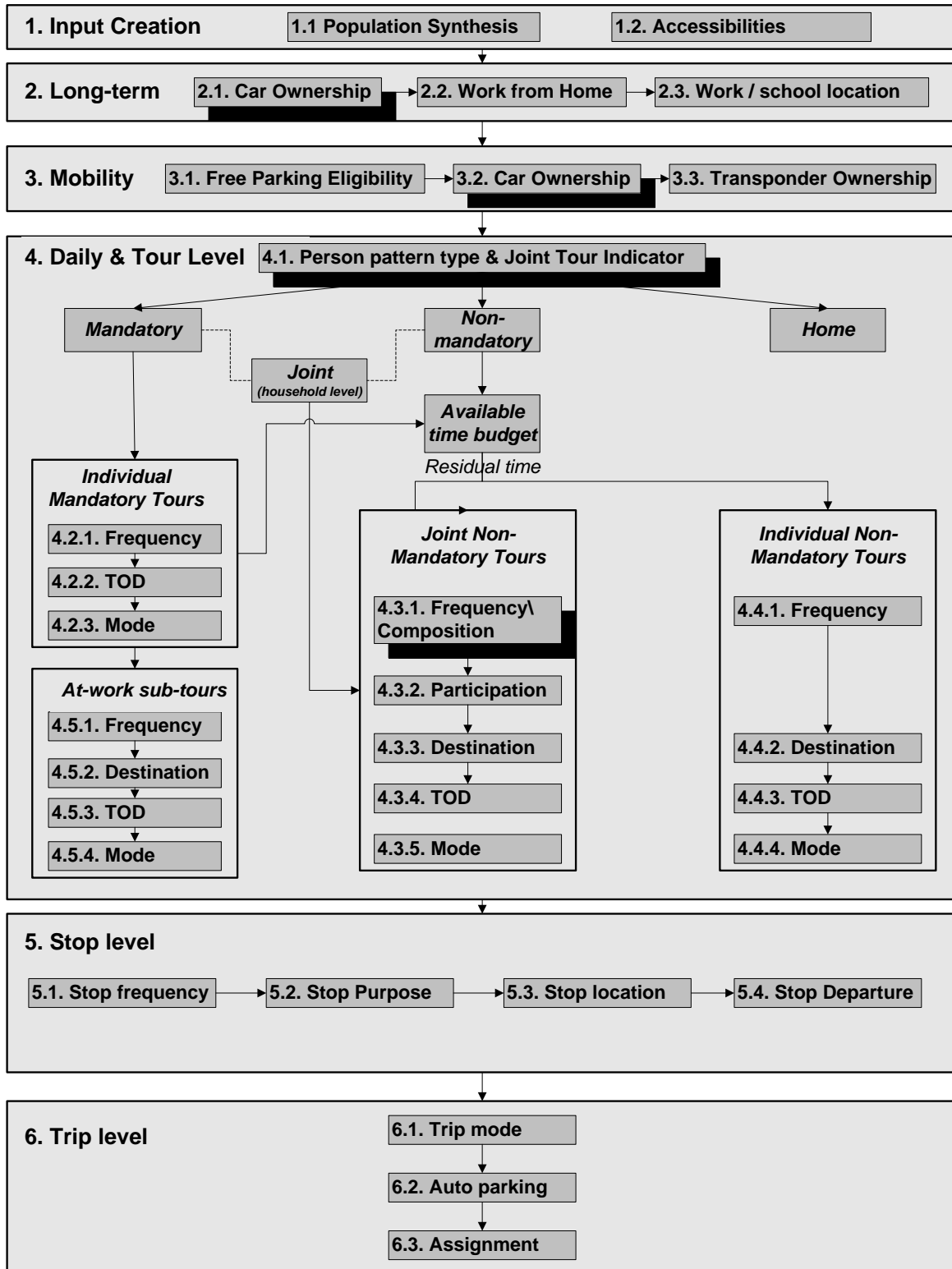
TRIP MODES

There are about half as many trip modes in ARC's version of CT-RAMP as there are in SANDAG's (15 vs. 26 modes), the difference being the disaggregation of transit line haul modes as well as availability of HOV and non-HOV paths for free shared ride alternatives in SANDAG's version of the model. Table 3, below, presents the modes used by each of the two models.

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TABLE 3 – Comparison of Trip Modes

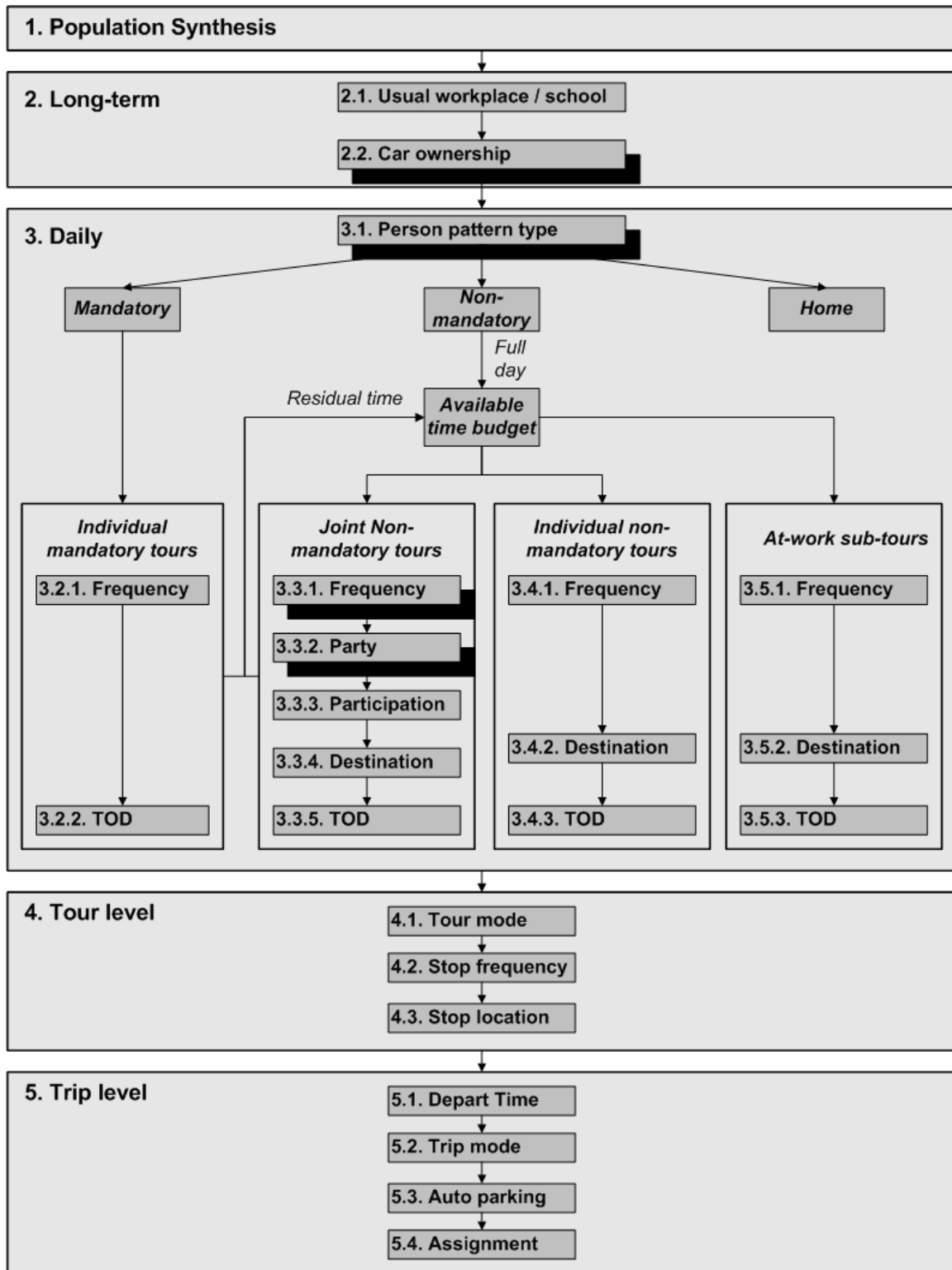| SANDAG	ARC
1. Auto SOV (Non-Toll)	1. Auto SOV (Free)
2. Auto SOV (Toll)	2. Auto SOV (Pay)
3. Auto 2 Person (Non-Toll, Non-HOV)	3. Auto 2 Person (Free)
4. Auto 2 Person (Non-Toll, HOV)	4. Auto 2 Person (Pay)
5. Auto 2 Person (Toll, HOV)	5. Auto 3+ Person (Free)
6. Auto 3+ Person (Non-Toll, Non-HOV)	6. Auto 3+ Person (Pay)
7. Auto 3+ Person (Non-Toll, HOV)	7. Walk –All Transit
8. Auto 3+ Person (Toll, HOV)	8. Walk – Premium Only
9. Walk-Local Bus	9. PNR–All Transit
10. Walk-Express Bus	10. PNR – Premium Only
11. Walk-Bus Rapid Transit	11. KNR–All Transit
12. Walk-Light Rail	12. KNR – Premium Only
13. Walk-Heavy Rail	13. Walk
14. PNR-Local Bus	14. Bike
15. PNR-Express Bus	15. School Bus
16. PNR-Bus Rapid Transit	
17. PNR-Light Rail	
18. PNR-Heavy Rail	
19. KNR-Local Bus	
20. KNR-Express Bus	
21. KNR-Bus Rapid Transit	
22. KNR-Light Rail	
23. KNR-Heavy Rail	
24. Walk	
25. Bike	
26. School Bus	

Design flow diagrams of both models are shown in Figures 1 and 2, below. Table 4 presents a summary comparison and a snapshot of differences and similarities of the various components of the two models. Numbers assigned to the table's cell entries correspond to the sub-models as shown on the design flow diagrams.

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FIGURE 1 – SANDAG Model Design

Source: SANDAG

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FIGURE 2 – ARC Model Design

Source: ARC

Table 4 – Comparison of Model Designs

MODEL	SANDAG	ARC
Auto Ownership	*2.1 & 3.2*- A two-level nested Logit model with 5 alternatives (0, 1, 2, 3, 4+ autos) and a two-tiered implementation process. A preliminary model generates household-level auto ownership for use in the Mandatory Activity Workplace/School Location Choice model. The A/O model is run a second time after and informed by the Workplace/School Location model generating final household-level auto ownership values.	*2.2*- MNL model with 4 alternatives (0,1, 2, 3+ autos). The Auto Ownership model is implemented only once after the Workplace/School Location model.
Work from Home	*2.2*- A binomial logit model determining the choice between working from home or outside of home; implemented prior to the Workplace/School Location Model.	*2.1*- Not a stand-alone model, presented as an alternative in the multinomial logit Mandatory Activities Workplace/School Location Choice Model.
Mandatory Activity (Work/School) Location Choice	*2.3*- MNL models (work, pre-school, grade school, high school, university) with sampled sets of alternative zones. Implemented as a two-stage iterative process where balancing factors (referred to as shadow prices) are used in matching workers to employment control totals.	*2.1*- MNL models (work, K-12, university). Similar to SANDAG's version of the model, except that the Work from Home choice is presented as an alternative in this model.
Employer Parking Provision	*3.1*- A three-prong MNL model predicting the choice of free on-site parking, parking reimbursement, and no parking provision.	Implemented along with the Parking Location Choice Model (see section 5.3)
Transponder Ownership	*3.3*- A Quasi-Binomial Logit model predicting households' ownership of toll transponder devices.	N/A

MODEL	SANDAG	ARC
Coordinated Daily Activity Pattern (CDAP)	*4.1*- MNL with 691 total available alternatives (depending on household size), predicts the daily activity pattern (DAP) for each household member, combination of 3 DAP types (mandatory, non-mandatory, at-home) for up to 5 household members with and without joint travel. The decision to make a joint tour is determined at the household level in CDAP model.	*3.1*- MNL with 363 available alternatives (depending on household size). Similar to SANDAG's except that joint travel is not considered explicitly by CDAP model.
Individual Mandatory Tour Frequency	*4.2.1*- MNL with 5 alternatives (1 work tour, 2+ work tours, 1 school tour, 2+ school tours, 1 work/1 school tour), determines the number and purpose of mandatory tours for those persons who chose mandatory DAP type in the CDAP model.	*3.2.1*- Similar in structure to SANDAG's model.
Individual Mandatory Tour Time of Day (TOD) Choice	*4.2.2*- Three MNL hybrid choice and duration models (work, university, school). Uses tour departure-from-home and arrival-back-home time combinations as alternatives. Utility structure based on "continuous shift" variables. A temporal resolution of one-half hour expressed in 820 half-hour departure/arrival time alternatives.	• *3.2.2*- Similar to SANDAG's model. ARC's model has a temporal resolution of a half-hour that is expressed in 1,176 30-minute departure/arrival time alternatives. Every possible combination of the 48 departure half-hours with the 48 arrival half-hours (where the arrival half-hour is the same or later than the departure hour) is an alternative. This gives 48 × (48-1)/2 + 48= 1,176 choice alternatives.
Joint Non-Mandatory Tours Frequency	*4.3.1*- Joint tour frequency and composition model. Predicts the frequency (1 or 2+) of joint tours by tour purpose for the entire household. The model also predicts party composition for each joint tour. MNL model with 105 alternatives (1 Tour segmented by 5 purposes and 3	*3.3.1*- Predicts the frequency (1 or 2+) of joint tours by tour purpose for the entire household. MNL model with 21 alternatives (No Tours, 1 Tour segmented by purpose, 2 tours segmented by purpose combination). ARC's joint tour party composition is modeled

| MODEL	SANDAG	ARC
	composition classes, 2 tours segmented by 5 purposes and 3 composition classes). Only those households, predicted to have a joint tour by CDAP are considered in this model.	separately.
Joint Non-Mandatory Tour Party Composition	*4.3.1-* Combined with the Tour Frequency model (above).	*3.3.2-* MNL, modeled for each joint tour, with 3 alternatives regarding the person types of those participating in joint tour: Adults-only, Children-only, Adults + Children.
Joint Non-Mandatory Tour Participation	*4.3.2-* Binomial logit, modeled for each person and each joint tour, with 2 alternatives regarding participation in the joint tour: Yes or No.	*3.3.3-* Similar to SANDAG's version of the CT-RAMP model.
Joint Non-Mandatory Tour Primary Destination Choice	*4.3.3-* MNL model determining the primary destination of the tour assigned to all participants, implemented at MGRA level with 30 sampled alternatives.	*3.3.4-* MNL model determining the primary destination of the tour assigned to all participants, implemented at sub-zone level.
Joint Non-Mandatory Tour TOD Choice	*4.3.4-* Same as the Individual Mandatory Tour TOD model. When applied to joint tours, the tour departure and arrival period combinations can only be those during which each tour participant is available to participate in the activity, after mandatory activities are all scheduled. Once the tour departure/arrival time combination is chosen, it is applied to all participants on the tour.	*3.3.5-* Similar in structure to SANDAG's version.
Individual Non-Mandatory Tours Frequency	*4.4.1-* MNL model with about 197 alternatives composed of 0-1+ or 2+ tours of each type of maintenance activity (escorting, shopping, maintenance, eating out, visiting and discretionary). Tours cover non-mandatory, household-generated activities carried out by an individual	*3.4.1-* MNL model with 89 alternatives, corresponding to most frequently observed combinations of number of individual maintenance and discretionary tours by purpose. The model generates non-mandatory, non-fully-joint tours at the

MODEL	SANDAG	ARC
	(based on his/her availability) on behalf of all the members of the household.	individual person level. This is a simplified version of SANDAG's model in which non-mandatory household maintenance tours are generated by households and assigned to individuals, similar to the model for fully joint tours.
Individual Non-Mandatory Tour Primary Destination Choice	*4.4.2*- Six MNL models by tour purpose (Escort, Shop, Other Maintenance, Eat Out, Visit, and Other Discretionary), determining the location of the tour primary destination. Applied at the MGRA level, with sampling of destination alternatives and off-peak mode choice logsums.	*3.4.2*- Similar in structure to SANDAG's version of the CT-RAMP model.
Individual Non-Mandatory Tour TOD	*4.4.3*- Tour departure-from-home and arrival-back-home time combinations as alternatives. Utility structure based on "continuous shift" variables. A temporal resolution of one-half hour that is expressed in 8861 half-hour departure/arrival time alternatives. Tour departure and arrival period combinations are limited to those available for each tour participant, after scheduling individual mandatory and joint tours.	*3.4.3*- Similar to SANDAG's model with 89 alternatives, corresponding to most frequently observed combinations of number of individual maintenance and discretionary tours by purpose.
At-Work Sub-Tour Frequency	*4.5.1*- MNL model with 7 alternatives (none, 1 eating-out sub-tour, 1 work, 1 maintenance sub-tour, 2 work sub-tours, 2 maintenance sub-tours, and one combination of eating out, work, and maintenance tours), applied to those who have at least one work tour. Sub-tours are mainly work-related or are for the purpose of eating out, but can also include person or household maintenance activities.	*3.5.1*- Similar to that of SANDAG's model, but with the following 6 alternatives: no sub-tours, 1 eating out, 1 work tour, 1 maintenance tour, 2 work sub-tours, 1 eating out + 1 work sub-tour.

MODEL	SANDAG	ARC
At-Work Sub-Tour Destination Choice	*4.5.2-* MNL model with 30 sampled alternatives applied at MGRA level. Only destinations within a reasonable time frame from the workplace location are chosen, such that the tour can be completed within the total available time window for the sub-tour.	*3.5.2-* Similar to SANDAG's version of the model.
At-Work Sub-Tour TOD	*4.5.3-* A hybrid choice and duration model similar to other TOD models. This MNL model with 861 alternatives comprised of combinations of tour departure and arrival half-an-hour periods determines the sub-tours departure from and arrival to the workplace simultaneously. The tour departure and arrival period combinations are restricted to only those available based on the time window of the parent work tour.	*3.5.3-* Similar to SANDAG's version, with 1,176 combinations of tour departure half-hour and arrival half-hour back at home.
Tour Mode Choice	*4.2.3, 4.3.5, 4.4.4, 4.5.4-* A three-level nested logit model with 26 available alternatives, assigns modes to the available tours. The mode of each tour is identified based on the combination of modes used for all trips on the tour, according to a set of pre-defined rules. There are 26 tour modes at the lowest level of the tour model. The second level has 9 aggregate tour modes (Drive-alone, Shared-Ride 2, Shared-Ride 3+, Walk, Bike, Walk-Transit, Park-and-Ride Transit, Kiss-and-Ride Transit, School Bus (only available for grade school and high school tour purposes). The tour mode choice model is	*4.1-* A three-tiered nested logit model with 12 alternative modes. ARC's ABM features three transit access modes: walk, park-and-ride, kiss-and-ride. Under each access mode are two line-haul mode options: "all-transit" and "premium-only transit". All-transit includes paths made only by local bus and paths made by express bus or rail, where a local bus transfer is required. Premium-only includes paths, which are only made by express bus or rail, and no local bus transfer is required. . The tour mode choice model is based on the round-trip level-of-service between the tour "anchor" location and the primary destination. The tour mode is chosen based on LOS

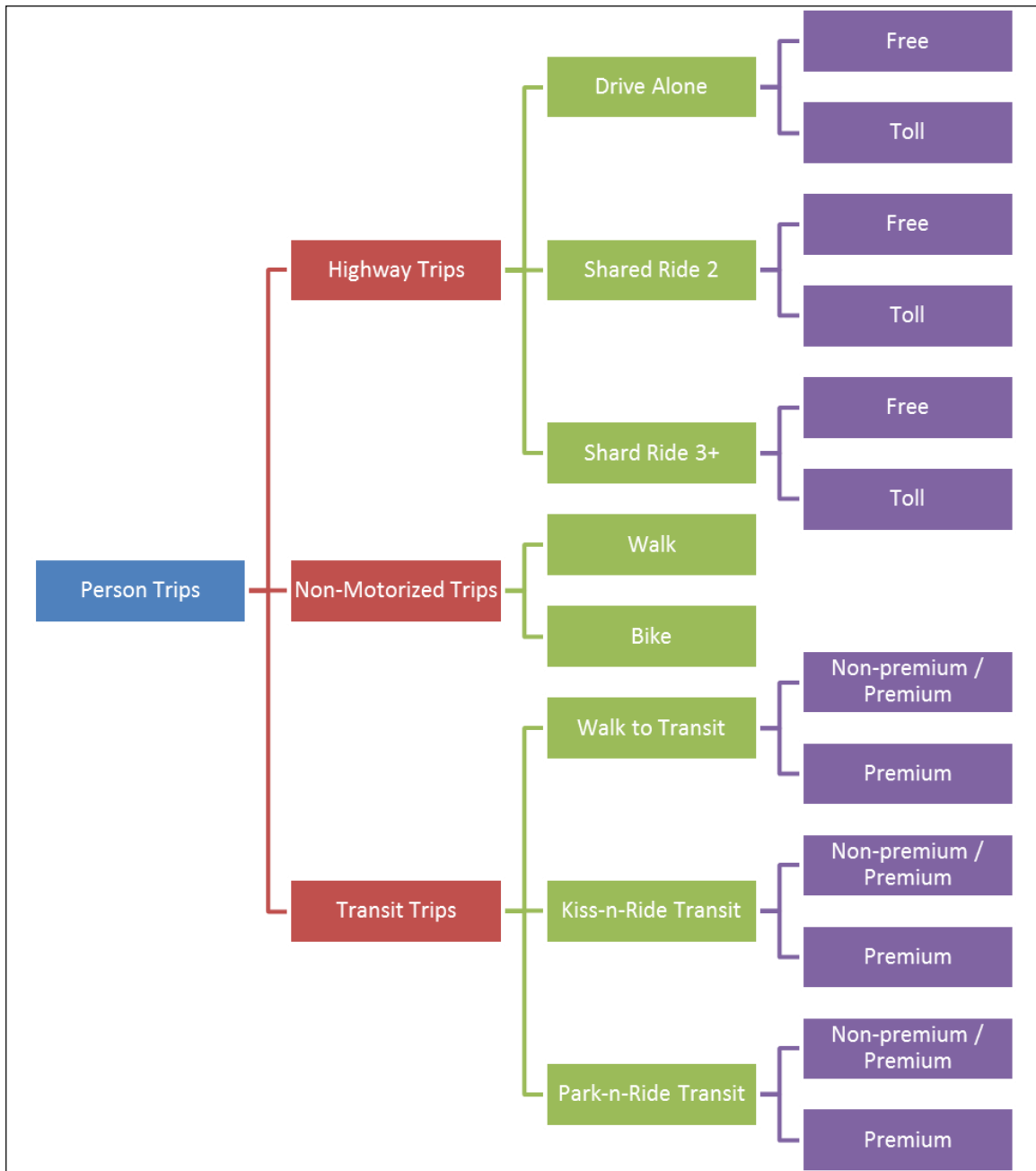| MODEL	SANDAG	ARC
	based on the round-trip (outbound and return) level-of-service (LOS) between the tour anchor location (home for home-based tours and work for at-work sub-tours) and the tour primary destination. The tour mode choice model assumes that the modes of the outbound and the return journeys are the same in the consideration of level-of-service information. Aggregate level tour modes act as constraints for trip level mode choice. They are also use in stop frequency and stop location models. The structure of the model is presented in Figure 3.	variables for both directions according to the outbound and return time periods. Similar to SANDAG's model, ARC's version of CT-RAMP also forces symmetry of tour modes on both inbound and outbound directions of a given tour. Aggregate level tour modes act as constraints for trip level mode choice. Figure 4 presents the structure of ARC's Tour Mode Choice Model
Intermediate Stop Frequency Model	*5.1*- Ten MNL models (9 by primary tour purpose: work, school, university, shopping, escorting, maintenance, discretionary, social/recreational, and eating; plus one for at-work sub-tours), determining the number of intermediate stops to and from the primary destination; 16 total alternatives.	*4.2*- Similar to SANDAG's model.
Intermediate Stop Purpose	*5.2*- Assigns a purpose to each intermediate stop based on a look up table of probabilities.	*4.2* - Similar to SANDAG's model.
Intermediate Stop Location	*5.3*- Predicts the location of stops along the tour (not including the primary destination stop). An MNL model implemented at MGRA level with sampled alternative MGRAs (subject to the availability of a positive size term).	*4.3*- Similar to SANDAG's model.

MODEL	SANDAG	ARC
Stop/Trip Departure Time	*5.4*- Assigns a departure time to each trip based on a look-up table of probabilities based on tour purpose, stop direction (inbound/outbound), tour departure time, and stop number.	*5.1*- ARC's newly developed *Stop Duration* MNL model allocates the total time on a tour into duration for each stop on the inbound and outbound legs of a tour.
Trip Mode Choice	*6.1*- Six MNL models (Work, University, K-12, Maintenance, Discretionary, and At-work sub-tours) with 26 alternative modes, determines the mode for each trip of a tour. Trip modes are constrained by the main tour mode. The correspondence between trips and tours are established through a set of hierarchical rules. Modal symmetry is not enforced at the trip level mode choice in the presence of unbalanced LOS conditions.	*5.2*- Eight MNL models (by purpose including one for at-work sub-tour) with 14 alternative modes. Otherwise, Similar to SANDAG's model.
Parking Location Choice	*6.2*- MNL models (work, and non-work) applied to trips destined to non-home zones with paid parking in order to increase the accuracy of AM and PM peak traffic assignment in the CBD.	*5.3*- Along with the Parking cost model (calculating average parking cost for each CBD zone), and the Free Parking Eligibility model (determining whether or not a worker has to pay for parking in CBD), the Parking Location Choice model determines the parking location zone for each CBD-bound trip. The model is of nested logit structure with an upper level binary choice between parking inside vs. outside the destination zone. At the lower level, the choice of parking zone is modeled for those who did not park in the destination zone.

FIGURE 3 – SANDAG Tour Mode Choice Model Structure
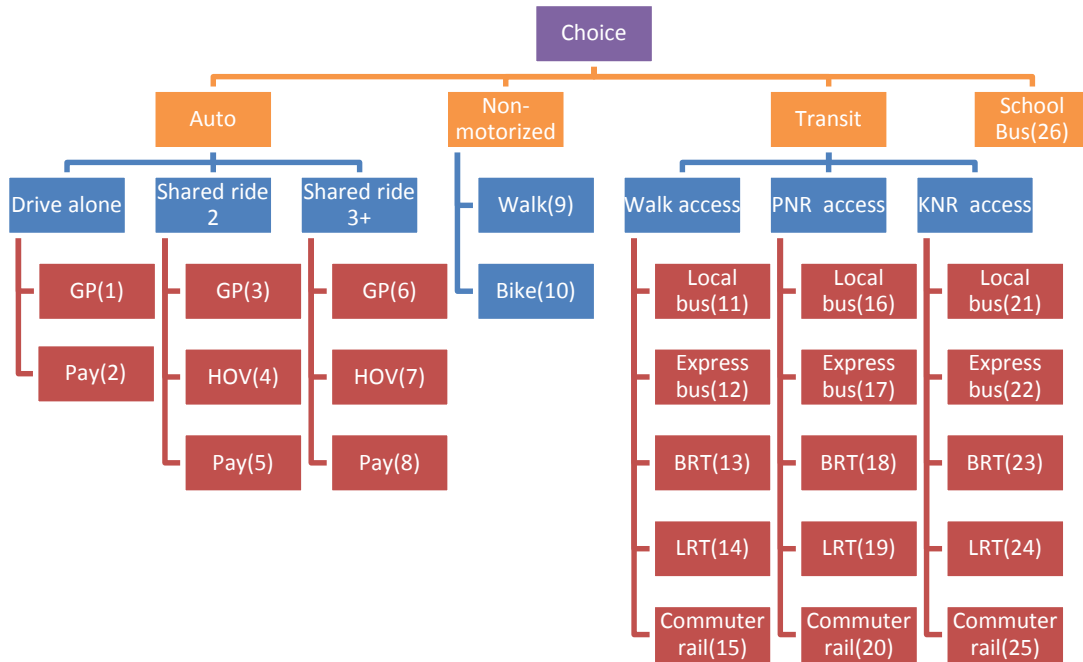
Source: SANDAG

FIGURE 4 – ARC Tour Mode Choice Model Structure

Source: ARC