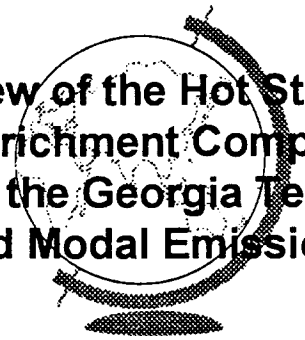
7TH CRC ON-ROAD VEHICLE EMISSIONS WORKSHOP
San Diego, California
April 9-11, 1997

MOTOR VEHICLE ACTIVITY AND EMISSIONS ALGORITHMS IN THE GEORGIA TECH GIS-BASED MODAL EMISSIONS MODEL

Randall Guensler, William Bachman, Simon Washington, Michael O. Rodgers, and Michael D. Meyer

School of Civil & Environmental Engineering, Georgia Institute of Technology, Atlanta, GA 30332-0355; e-mail: randall.guensler@ce.gatech.edu

This paper describes the emissions modeling features now online in Phase II of the Georgia Tech Research Partnership's GIS-based modal emissions model. In terms of vehicle activity, the regional travel demand model has been incorporated and new algorithms for predicting speed/acceleration profiles have been introduced. Links to the advanced traffic management system are being finalized so that real-time activity data can also be employed. Subfleet tracking and characterization routines (for spatial and temporal fleet distribution) are detailed. The model tracks emissions separately for engine start and non-engine start activity, and each of these are split into high-emitter and normal emitter groupings. Non-start activity is further subdivided into enrichment and non-enrichment operations. The algorithms used to provide enrichment activity (power demand model) and high emitter profiles (based upon RSD studies) are highlighted. Finally, the new tree-based regression analyses used to develop appropriate emission rate algorithms for incremental engine starts and non-enrichment activity are discussed.



Overview of the Hot Stabilized and Enrichment Components of the Georgia Tech GIS-Based Modal Emissions Model

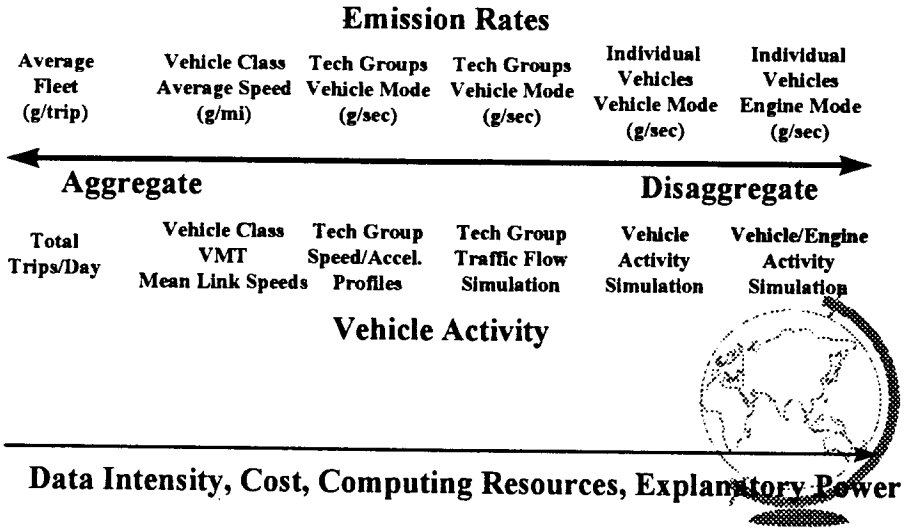
Seventh CRC On-Road Vehicle Emissions Workshop
April 1997

Randall Guensler, William Bachman, Simon Washington
Michael O. Rodgers, Michael D. Meyer
Georgia Institute of Technology
Atlanta, GA

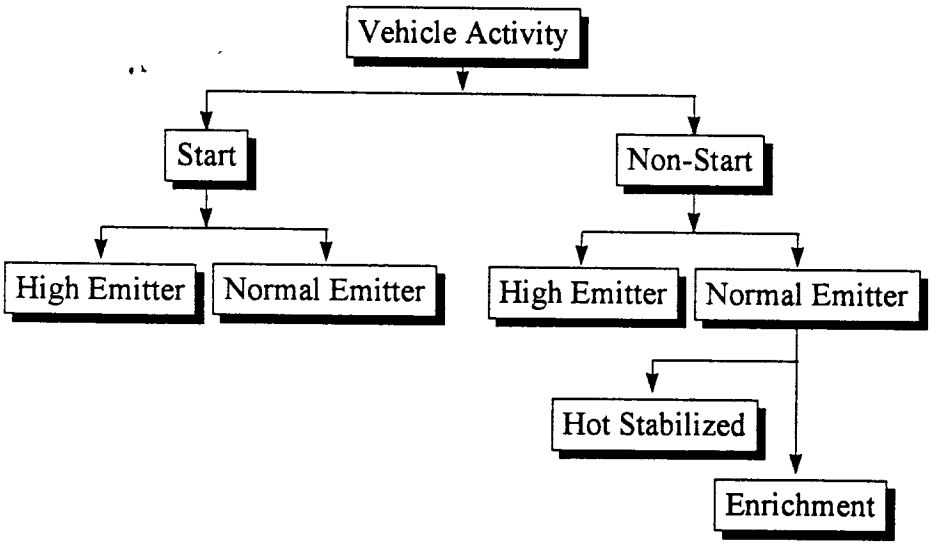
Research Goals

- Develop a new GIS-based research model
  - Improve spatial and temporal allocation
  - Improve high emitter characterization
  - Include modal emissions modeling approaches
- Don't worry about conforming with existing approaches
  - New technology groups
  - New emissions relationships
- Experiment with aggregation levels
  - How much disaggregation is too much
- Undertake extensive validation efforts

Emissions Modeling Spectrum



Exhaust Emissions Categories



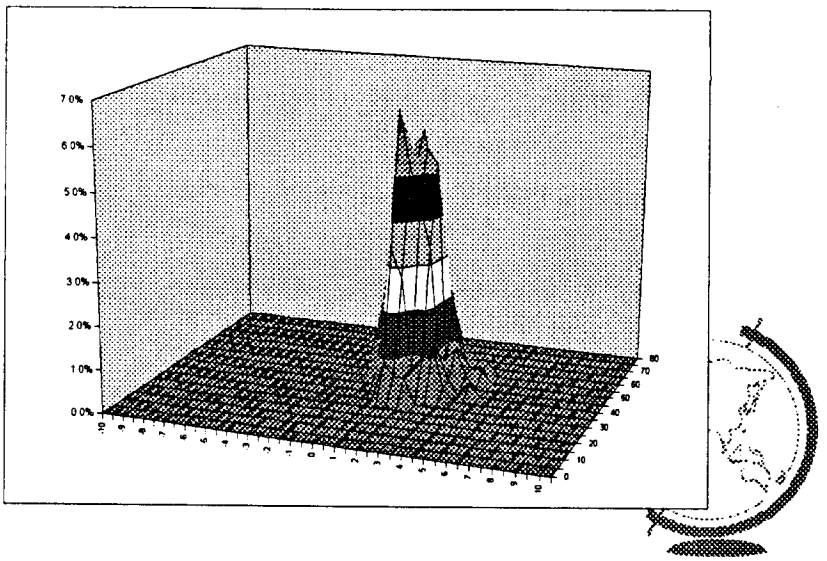
Activity Side of the GIS-Based Model

- Land use
- Demographic and socioeconomic data
- Infrastructure
- Subfleet characteristics
- Traffic volumes and trip ends
  - Improved travel demand model
  - Activity monitoring
- Speed/acceleration profiles
- Heavy-duty vehicle activity

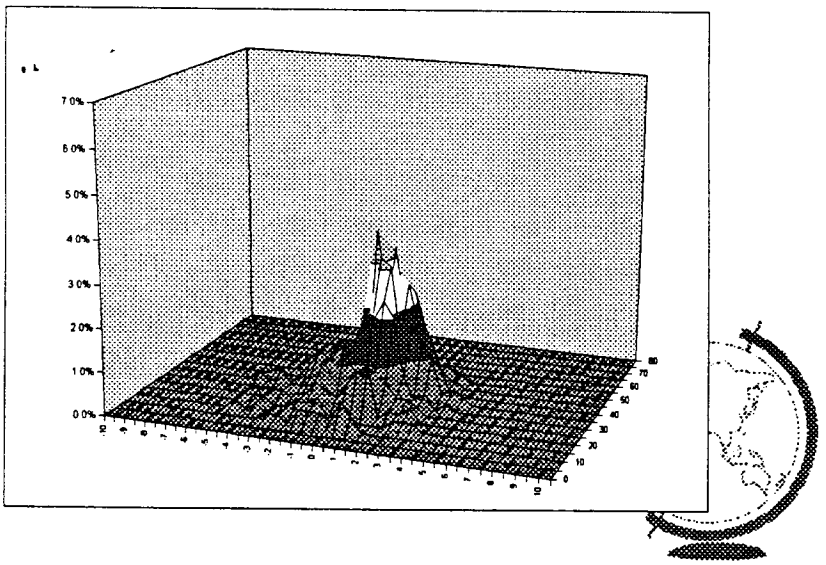
Speed/Acceleration Profiles

- Speed/acceleration profiles are used in two modal approaches in the GIS-based model
- Develop profiles for network links and mini-zones (space and time distribution matrices)
- Goal: derive profiles statistically, as a function of:
  - capacity, traffic volume, lane width, grade,
  - and other HCM parameters
- Sub-project: simulate speed/acceleration profiles (TRAF-NETSIM) and validate simulation algorithms

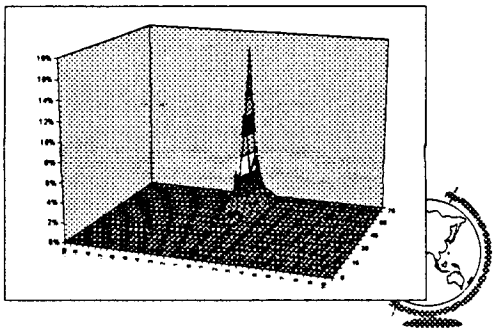
Bankhead Highway, On-Ramp to I-285 (Mainline Level of Service A)



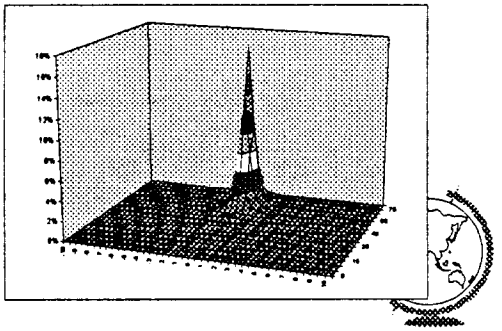
Bankhead Highway, On-Ramp to I-285 (Mainline Level of Service C to F)



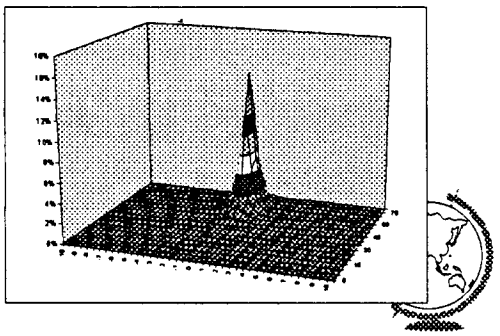
Freeway Automobiles
Level of Service A



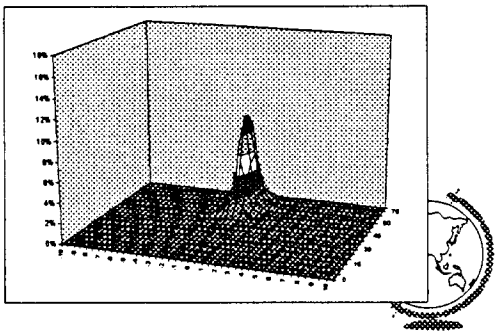
Freeway Automobiles
Level of Service B



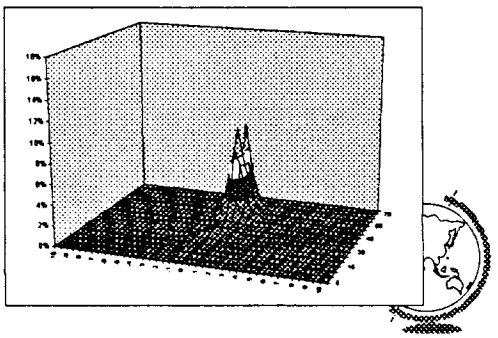
Freeway Automobiles
Level of Service C



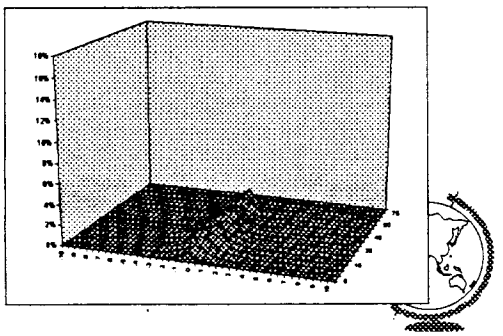
Freeway Automobiles
Level of Service D



Freeway Automobiles
Level of Service E

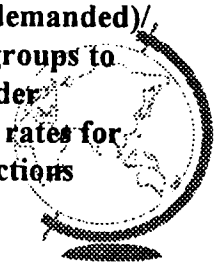


Freeway Automobiles
Level of Service F



Modeling Approaches Included for Hot Stabilized and Enrichment

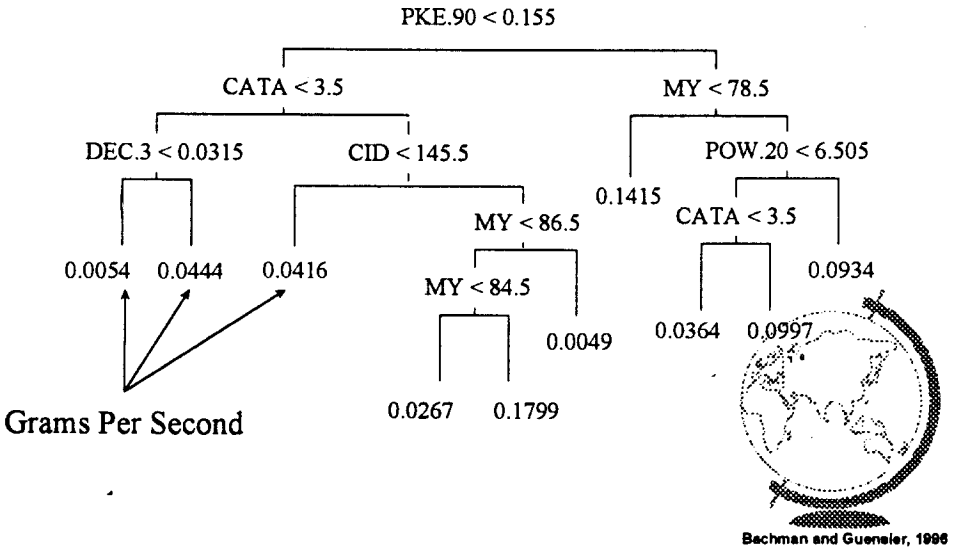
- Standard BEFs with speed correction factors
- Aggregate modal modeling approach
  - Uses existing cycle data and allow potential high power operations in a cycle to become statistical explanatory variables
- Power demand trigger modeling approach
  - Uses an enrichment trigger level (power-demanded)/(power-available) for vehicle technology groups to estimate fraction of vehicles operating under enrichment, then apply separate emission rates for hot stabilized and enrichment activity fractions



Aggregate Modal Model for Hot Stabilized and Enrichment (Version 2.01)

- 700+ vehicles, 4000+ vehicle tests on various test cycles
- High and normal emitters modeled separately
- Regression tree analysis yields FTP Bag 2 multipliers
- Emissions as a function of vehicle technology variables (my, engine size, curb weight, control system, fuel delivery, etc.) and modal operation variables (cycle fraction in designated conditions: cruise acceleration, idle, and power-surrogates)
- ~40 vehicle technology groups
- Modal enrichment is implicit and derived from the regression tree analysis (allows interactions) but limited to test cycle characteristics

Non-Start Regression Tree Analysis
Normal CO Emitters

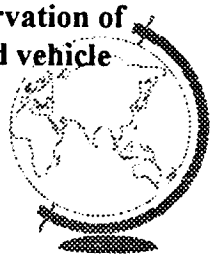


Aggregate Modal Model Implementation

- **Model subfleet composition (technology groups) on roadway links and mini-zones**
- **Speed/acceleration profiles establish local operating cycle characteristics**
- **Assume that subfleets operate across entire s/a profile (i.e., no shifting for sports cars)**
- **Regression tree results povide appropriate emissions rates for each technology group and link operating condition**

Power Demand Enrichment Module for Hot Stabilized and Enrichment (Version 2.02)

- Power demand model provides next refinement:
  - Demanded power (HP)/available power (BHP)
  - Power demand = f (inertial load, grade, wind resistance, and accessory load)
  - Power demand triggers per technology group
  - Tracking of required variables in GIS
- Trigger levels based upon RSD studies (observation of grade-induced enrichment) and instrumented vehicle data



Power Demand Implementation

- Demanded power by technology group:
  - Onroad subfleet characterization
  - Speed/acceleration profiles by link
  - Grade by link
  - Accessory assumptions
- Distributional matrices employed in the model
- Predict fraction of technology group expected to be in enrichment on a link and apply enrichment emissions rates to that fraction

Spring and Summer 1997

- Rerun all analyses w/comprehensive EPA/CARB data set (pre- and post-1986)
- Refine all speed/acceleration modules
- FTP/RSD cutpoint (estimating HE fraction)
- Complete load trigger model (vehicle data)
- Add I/M module
- Incorporate other vehicle classes
- Address temperature and fuel effects

Validation

- Validation of all model components using both bottom-up and top-down approaches
- Validation and peer-review are the cornerstone of model algorithm development
- Make data available to all parties and assemble data on the Internet
- Develop and disseminate documentation for all models and model algorithms
- New national efforts needed in validation