

Noise, Vibration and Annoyance from Rail Transit Systems: Results and Implications of the TCRP D-12 Study

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2011 Rail Conference

TCRP PROGRAM AND OBJECTIVES

- Contract Award, September 2005
- Completed, December 2009

- Agency Survey
- Literature Review
- Community Annoyance Survey
- Field Measurements
- Dosage-Effect Relationships

TRANSIT AGENCY SURVEY

- North American agencies with rail transit operations
- 30 of 55 agencies completed online survey
- Within the previous year:
 - 17 (53%) reported no complaints
 - 10 (33%) reported 1-5 complaints
 - 2 (7%) reported 6-10 complaints
 - 1 (3%) reported 50+ complaints

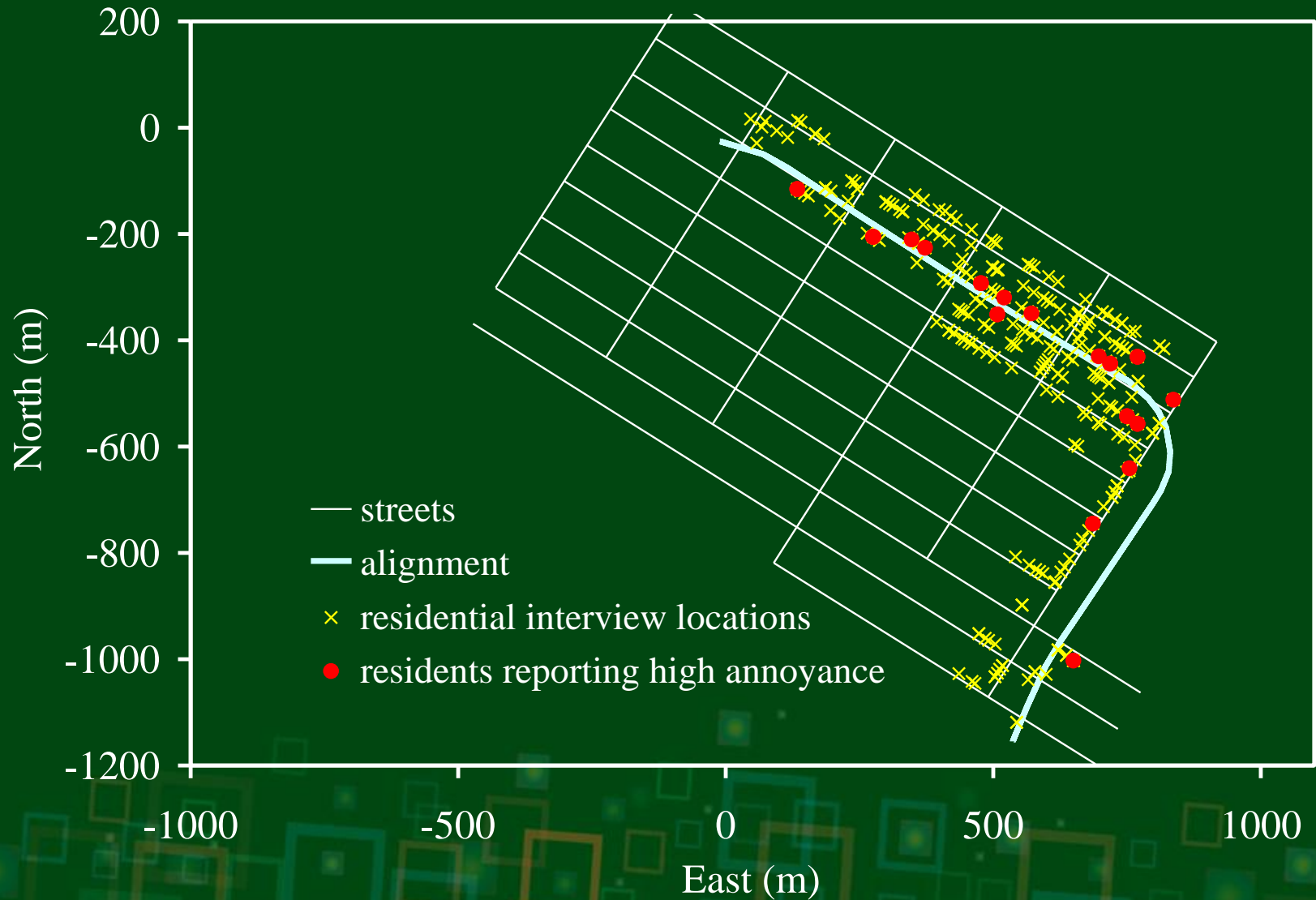
NATIONAL STANDARDS

- Velocity and acceleration common metrics
- Overall weighted vibration level, de-emphasize vibrations $< 16\text{Hz}$ and $> 100\text{Hz}$
- At frequencies where most vibration occurs, weighted vibration = un-weighted velocity
- All vibration criteria: inside buildings
- 20 dB variation in National guidelines
- A-weighted sound – common metric

SOCIAL SURVEY

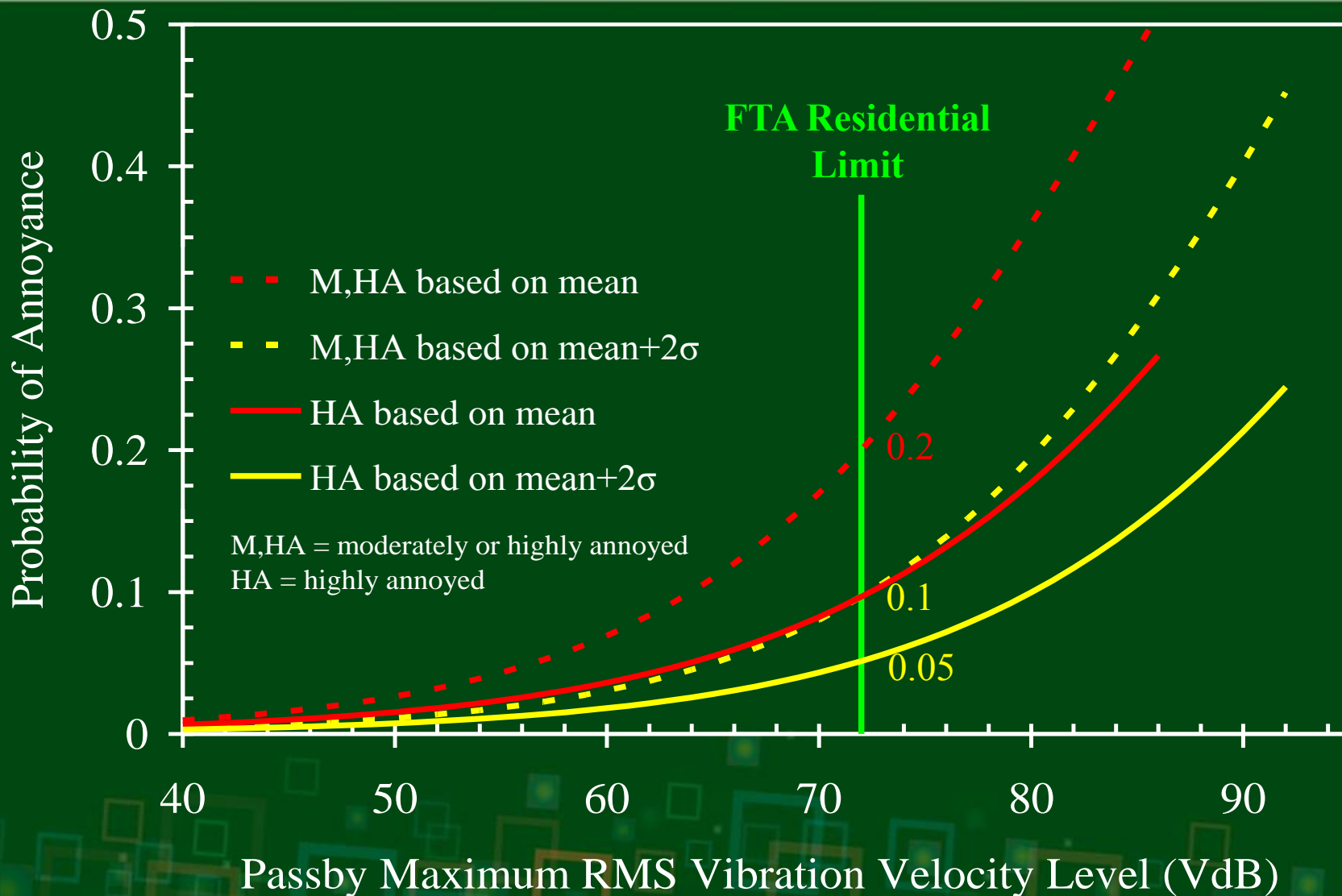
- 1306 telephone surveys (5 min.)
- New York, Dallas, Sacramento, Toronto, Boston
- Outdoor grid measurements to project vibration/noise at survey locations
- Outdoor to indoor adjustments from 41 residential measurements
- Exposure range – sample out to 100m

NEW YORK TEST AREA



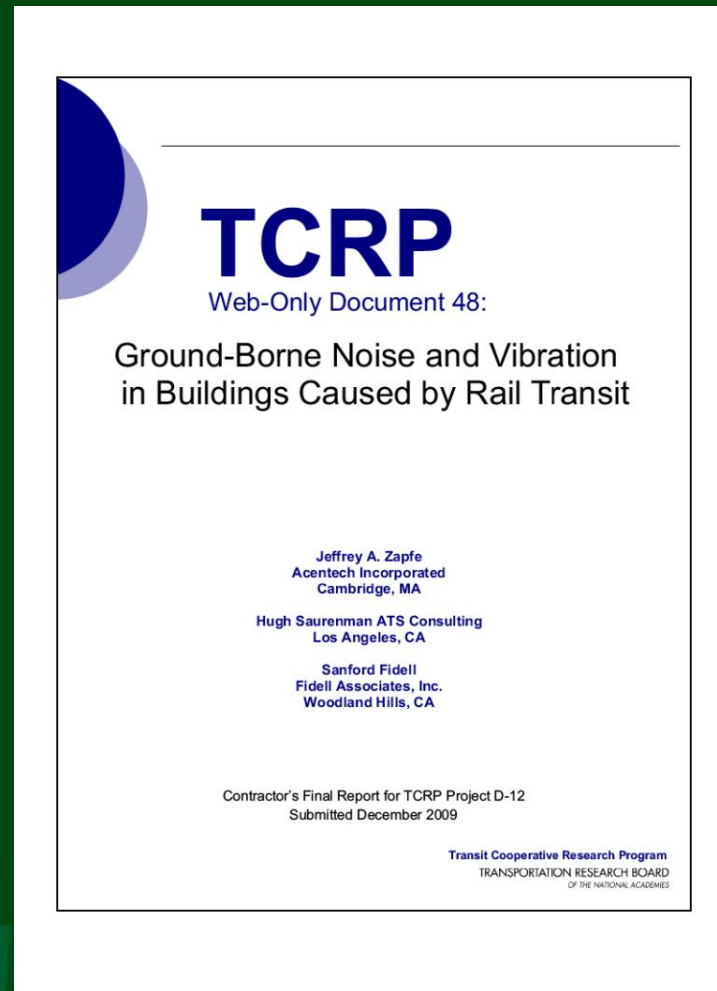
DOSE RESPONSE CURVE

PASSBY MAXIMUM VIBRATION LEVEL



D-12 REPORT

http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_webdoc_48.pdf



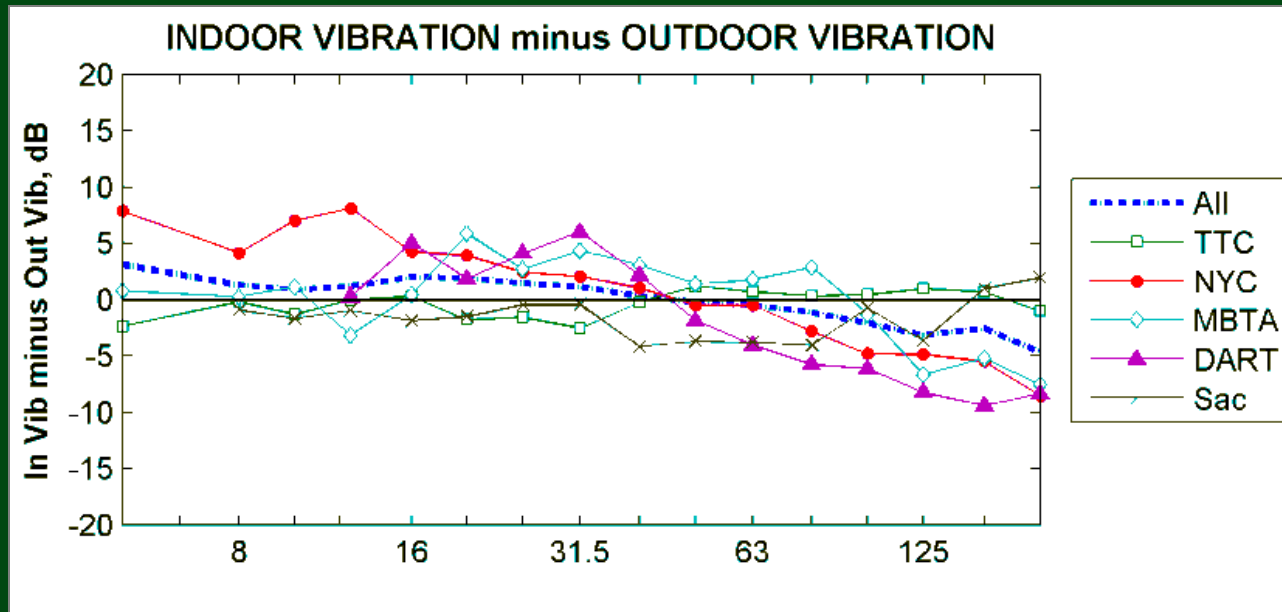
MORE FROM D-12

Outdoor-to-Indoor Relationships

- Simultaneous indoor/outdoor measurements made at 41 homes
- ± 5 dB variation observed for seemingly identical buildings

MORE FROM D-12

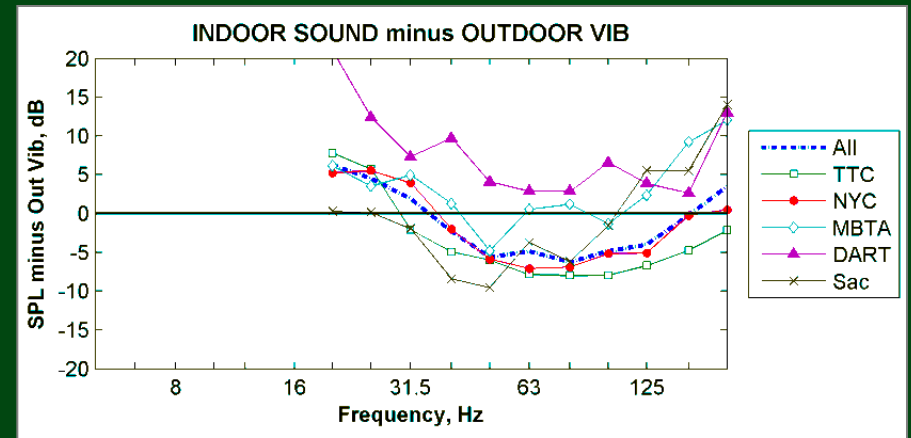
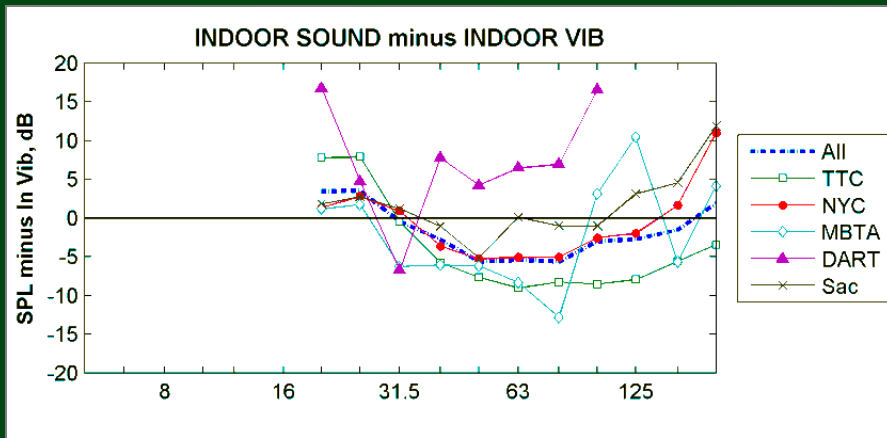
Outdoor-to-Indoor Vibration



- Average indoor/outdoor adjustment = 0 dB
- Indoor \leq (Outdoor + 5dB) 95% of time
- Annoyance predictions based on outdoor vibration, as good as indoor vibration

MORE FROM D-12

Vibration to Sound



- FTA recommends approximating sound pressure level as:
$$L_p = L_v \text{ (US units)}$$
- D-12 data suggests a more representative relationship is:
$$L_p = L_v - 5 \text{ dB}$$

WHAT HAS D-12 STUDY TAUGHT US?

- Current FTA impact thresholds are reasonable
- Additional study unlikely to improve predictions of human annoyance
- On average, outdoor vibration is a good predictor of indoor vibration
- D-12 data suggests, $L_p = L_v - 5 \text{ dB}$
Implication is that current procedures lead to over-specifying mitigation for groundborne noise

IMPLICATIONS OF AN EXTERIOR-BASED CRITERION

- Predictions of community annoyance as good as interior-based criteria
- Measurements and predictions much easier and less expensive
- Predictions not dependent on building-specific peculiarities
- Would need to develop adjustments based on building categories
- Would allow verifying predictions without measuring inside each residence

IMPLICATIONS OF CHANGING VIBRATION TO SOUND CONVERSION

- There will always be a large degree of uncertainty when predicting indoor vibration levels
- Current procedure builds in “safety factor”
- If predictions based on average value:
 - Less mitigation could be needed
 - Reduced design/construction costs
 - Increased potential for under-predictions

WHERE DO WE GO FROM HERE?

- Consider changing to impact thresholds based on exterior vibration
- Need more data to confirm indoor/outdoor and vibration to sound relationships
 - Should include testing of large number of buildings
- Should evaluate use of “safety factors”
- Should confirm accuracy of current prediction procedures
 - Could justify reducing safety/uncertainty factors

VIBRATION PREDICTION PROCEDURE

- Committee has been formed to create an ANSI standard
- D-12 results suggest that the standard should include:
 - Guidelines on how to deal with uncertainty
 - Updated guidelines on vibration-to-noise adjustments based on available data
 - New guidelines on outdoor-to-indoor vibration effects