Tire Pressure Monitoring System – Special Study (TPMS-SS)
Supporting Statement for Information Collection Request

Prepared By:

Charlene T. Doyle
&
Kirk Allen
National Highway Traffic Safety Administration

February 2010

TABLE OF CONTENTS

B. Collections of Information Employing Statistical Methods

The proposed study will employ statistical methods to analyze the information collected from respondents. The following sections describe the procedures for respondent sampling and data tabulation.

B.1. Describe the potential respondent universe and any sampling or other respondent selection method to be used.

The potential respondent universe consists of passenger vehicles from model years 2004 to the present. This should comprise approximately 90 to 100 million vehicles[1]. Other factors that will influence which drivers are interviewed are the drivers willingness to be interviewed and the researchers being available to conduct an interview at the time that the driver arrives at the gas station (i.e., is not already conducting another interview).

The response rate should not greatly reduce the total amount of data gathered. In most cases, researchers will simply not approach drivers of vehicles which appear to be older than model year 2004. Although the researchers will not be able to determine with 100% accuracy if a vehicle is from a model year 2004 or newer, the researchers will be able to do a rough sorting on this characteristic of the vehicle. In addition, if a driver informs the researchers that the vehicle is 2003 or older, the researchers will then move along to the next vehicle entering the fueling area. Some drivers of eligible vehicles will refuse, e.g., because they are in a hurry. The amount of time invested in identifying ineligible vehicles should be relatively small in proportion to the time required to perform tire pressure measurements and driver interviews. As discussed in the previous paragraph, old vehicles will reduce the eligible vehicle pool by approximately one-third. Some amount of driver lack of cooperation is also reasonable. Including both sources, it is estimated that 50% of vehicles entering a gas station can be surveyed during times when the researchers are not already occupied with an interview. As stated in A12 above, the goal is to collect tire pressure readings from 10,000 vehicles.

Data collection will be conducted in three levels. First is the PSU, second is the gas station(s) within each PSU, and third are the vehicles at each gas station. More details are provided in Section B.2.

B.2. Describe the procedures for the collection of information.

The criterion measure of interest is the operating target of TPMS – the percentage of vehicles with at least one tire under-inflated by at least 25%. Other information collected through the

---

1 Based on vehicle registration counts provided by R.L. Polk & Co., there were 91 million registered passenger vehicles of model years 2001 and newer in the calendar year 2007 – this range of years is compatible with the present study conducted on model year 2004 and newer passenger vehicles in calendar year 2010.

Interview and Supplemental forms will be used to imply causality of why TPMS does (or does not) have the effect intended by the mandate.

To provide population estimates and standard errors, the data will be weighted based on the probability of each sampled vehicle being selected. The stages of selection are defined as follows:

1. Selection of the PSU – 24 will be selected out of 1195 total;
2. Selection of the gas station within the PSU – twenty-one gas stations per PSU, with the precise sampling population varying according to PSU (e.g., based on size and ease of travel for the researchers, availability of cooperating gas stations);
3. Selection of the vehicle at the gas station – consideration will be given to the vehicle body type, model year, and TPMS status, as discussed below.

The base sampling weight (BW) for each vehicle is thus defined as follows:

$$BW_{ijk} = \frac{1}{P(PSU_i) \times P(GS_{j|i}) \times P(vehicle_{k|j})}$$

where BW_{ijk} is the sampling weight for each vehicle in the study
$P(PSU_i)$ is the probability of selecting PSU indexed *i*
$P(GS_{j|i})$ is the probability of selecting Gas Station indexed *j* in PSU *i*
$P(vehicle_{k|j})$ is the probability of selection vehicle *k* at Gas Station *j* in PSU *i*

The final sampling weight (FW) will be adjusted for non-response, according to the following:

$$FW_{ijk} = BW_{ijk} \times \frac{1}{R_{j|i}}$$

where FW_{ijk} is the Final Sampling Weight
$R_{j|i}$ is the response rate for Gas Station *j* in PSU *i*

The response rate will be calculated using the data from the Daily Site Information Form, which contains tallies for both the number of vehicles who participated and the number who refused or were unable to participate.

The selection of each PSU is straightforward – there are 1195 total PSUs within the National Automotive Sampling System (NASS) sampling structure[2] and 24 of these have been selected. The mechanism for selecting gas stations may vary by PSU. Prior to data collection, cooperation will be sought from the gas stations. Therefore, pre-established cooperation will facilitate the process. This affects the sampling probability in terms of the number of pre-arranged gas stations that can be identified within each PSU. In some cases, it may be necessary for contact to be made between NHTSA and individual station managers, possibly aided by the researchers.

2 The NASS system covers all areas of the United States and includes urban, suburban, and rural localities. Although the system was organized in 1979, it is considered representative of the overall vehicle population in the United States and continues to be used in determining nationwide crash statistics.

The vehicle selection procedure will attempt to control for two characteristics likely to influence tire inflation pressure – vehicle age and body type. The 2001 Tire Pressure Special Study found vehicle age to be an important factor in the amount of under-inflation. For example, cars over six years old were nearly twice as likely to have underinflated tires as vehicles less than or equal to three years old. This could be due to both structural characteristics of the tires and the maintenance habits of the drivers. By contrast, the percentage of over inflated tires was nearly identical across age groups. The likelihood of underinflation depended on the body type as well – 32% of pickup trucks, SUV's, and vans had at least one tire underinflated by 8 psi or more, compared to 27% of cars.

Data collection will take place with the expectation that both body style *and* vehicle age need to be accounted for. The TPMS status for a large number of make-models was determined from internet resources, on model years back to 2000. It was noted whether the make-models were equipped with Direct TPMS, Indirect TPMS, or no TPMS, and whether this equipment was optional or standard. The number of vehicle registrations for these make-models was obtained using data from R.L. Polk & Co. To make efficient use of data collection hours, model years will be restricted to 2004 and newer. It was during these model years that the percent of vehicles equipped with Direct TPMS increased from around 5% to a large majority of vehicles. Vehicles from MY 2008 and newer should all be equipped with Direct TPMS, per the mandate.

The model year restrictions and body type composition will be estimated to determine the probability of individual vehicle selection ($P(vehicle_{k|j})$ above). Researchers will count the number of vehicles entering the gas stations for each of the body styles (car, truck, SUV, van). Observational data is preferable because it approximates the eligible vehicle pool at each location. Counts obtained from outside sources (e.g., vehicle registration rolls) are unlikely to account for variability at a level that matches the customer base for a certain gas station.

The probability of selection vehicle *k* is defined as follows:

$$P(vehicle_{k|j}) = \frac{n_{t|j}}{E(N_{t|j})}$$

where $n_{t|j}$ is the number of vehicles of type *t* surveyed at Gas Station *j*

$E(N_{t|j})$ is the expected number of vehicles of type *t* at Gas Station *j* during the entire survey period

The sample size target will be identified such that statistically significant differences can be found for a given model year for each of the two body style categories (cars and non-cars). Rather than seek an analytical solution to the minimal sample size, hypothetical datasets were generated to approximate the anticipated sample. Vehicles are randomly assigned to one of five model years with equal probability. The probability of assignment to one of the body style categories is varied such that 8 PSU's have 30% cars and 70% non-cars, another 8 PSU's have 50% each cars and non-cars, and the final 8 PSU's have 70% cars and 30% cars. The percentage of vehicles with TPMS varies by model year. For cars, Model Year 1 has 10% TPMS, Model Year 2 has 10% TPMS, Model Year 3 has 20% TPMS, Model Year 4 has 67% TPMS, and Model Year 5 has 100% TPMS. These hypothetical Model Years 1 to 4 represent passenger vehicle model years 2004 to 2007, and hypothetical Model Year 5 represents passenger vehicle

model years 2008 and newer. At this time, it is not possible to precisely estimate the proportion of passenger vehicles from these model years which will be in use during the anticipated survey period in 2010. For non-cars, these respective values are 20%, 40%, 50%, 87%, and 100%. These values were determined from the analysis of Polk data of registered vehicle counts and cross-referenced with the TPMS status. The effectiveness of TPMS was varied from 20% to 80% in 10% increments, defined as the reduction in the percent of vehicles with at least one tire under-inflated (e.g., 50% reduction could mean 20% of non-TPMS vehicles have one tire under-inflated, compared to 10% of TPMS vehicles); the effectiveness is assumed constant across vehicle age and body type in these simulations. The percent of non-TPMS vehicles with at least one tire under-inflated was varied by model year (i.e., vehicle age) approximately as found in the 2001 Tire Pressure Special Study. For cars, these values are, for Model Years 1 through 5 (oldest to youngest), 15%, 10%, 10%, 5%, 5%; and for non-cars, 25%, 20%, 15%, 15%, 10%. These values are reasonable based on reporting from the 2001 TPSS, even accounting for the present survey being conducted in 2010 with vehicles a minimum of two years old. Baseline sample sizes per PSU were defined, and a small adjustment was added to introduce sample size variability by PSU – one-third were increased by 25 vehicles, one-third by 50, and the final third by 100. The resulting sample sizes assessed were 5000, 7400, 9800, and 12200. This is the ***total sample size*** for the entire survey, for two vehicle types (cars and non-cars) and five model years. This is ***not*** the sample size for an individual body style and model year. It is also worth noting that inclusion of model year 2008 and newer means that 20% of the data will not be subject to a within-year comparison, because there is no non-TPMS group from 2008 onwards.

For each combination of TPMS effectiveness and total sample size, 50 datasets were generated with model year and body type randomly assigned. Each hypothetical dataset is used to estimate the effectiveness of TPMS. A statistically significant effect is desired at the $\alpha = 0.05$ level, as measured by the Rao-Scott χ^2, which penalizes the usual contingency table χ^2 to account for inflated variance in complex survey designs (i.e., the calculation $\chi^2 \div$ *Design Effect* decreases the likelihood of an effect being termed "significant"). For each body type and model year combination, the 2×2 table is constructed by *TPMS status* and *Underinflation*. It is desired to have approximately an 80% chance of finding a statistically significant effect for all body type and model year combinations.

It is more conservative, statistically, to base desired sample size on the contingency table analyses for cars, because they have lower percentage of vehicles TPMS-equipped *and* a lower percentage of non-TPMS vehicles under-inflated. If TPMS is quite effective (80% reduction), the simulated data estimate an overall 0.850 probability of finding a statistically significant effect across four model years, based on a ***total*** sample size of 5000. By individual model year, it is most difficult to detect the effect for the newer vehicles, which have a lower non-TPMS under-inflation likelihood – the probability of finding a statistically significant effect in favor of TPMS is reduced to 0.620. If TPMS is less effective (50% reduction), the power of the statistical test is reduced. With 12,200 ***total*** vehicles sampled, the probability of detecting a statistically significant difference for cars across the four applicable model years falls to 0.805 and is only 0.580 for the "newest" model year where under-inflation is rare.

A total sample size goal in excess of 10,000 is reasonable in terms of statistical considerations and in comparison with the 11,530 vehicles assessed during the 2001 TPSS.

B.3. Describe methods to maximize response rates and to deal with issues of non-response.

NHTSA has chosen to conduct the Tire Pressure Monitoring System – Special Study through the infrastructure of the National Automotive Sampling System (NASS). NASS sites are located at 24 sites throughout the country, and are staffed with experienced researchers. These researchers have been formally trained to collect and elicit cooperation from such sources as the general public, service stations/tow yards, hospitals and police departments.

The NASS Researchers will use their proven techniques (in the NASS CDS cooperation rates from Hospitals, Tow Yards, and Crash Involved Motorists exceed 80 percent) to garner the cooperation of survey participants. To obtain cooperation with the vehicle owners, the researchers will discuss why the survey is taking place, and explain the need to collect such data. Respondents are informed in the survey introduction that their answers will be kept private, used only for statistical purposes, and the data will be protected to the full extent of the law.

It is expected that the data collected will be reliable and of sufficient quality to be used to generalize to the universe studied. Non-response will be tabulated on the Daily Site Information Form based on the vehicle body type. The distribution of non-responding vehicles can be compared to the distribution of participating vehicles, as well as to the distribution of vehicles which enter the station for refueling during the four daily tally periods. Statistical weights will be adjusted for non-response (page 9). Benchmark comparison will be conducted using vehicle registration counts from R.L. Polk, & Co., to which NHTSA has access. These data can be aggregated by body-type at the county or state level for each PSU.

NHTSA has previously conducted two surveys that were similar to what is currently being proposed. The first of these was in 2001, and the survey was conducted at gas stations just as proposed with the present survey (research notes posted as DOT HS 309 316, DOT HS 309 317, DOT HS 309 318). A second study was conducted in 2003 when NHTSA data collectors visited the homes of participants (research report published as DOT HS 811 086). Based on these findings, potentially influential factors can be identified and attempts will be made to control for non-response along these factors. Some notes follow:

- In 2001, passenger cars were three percent less likely than light trucks & vans to have at least one tire under-inflated, controlling for vehicle age. In the present study, data collectors will note the vehicle body type of non-responding vehicles. When the data are analyzed, NHTSA's analysts will assess the non-response rate by vehicle body type.
- In 2001, driver gender was not analyzed in terms of under-inflation, but it was shown that males & females have different knowledge of how to determine the appropriate inflation pressure. In the present study, data collectors will record the gender of non-responding drivers. When the data are analyzed, NHTSA's analysts will assess the non-response rate by driver gender.
- In 2001, very few vehicles would have had TPMS and therefore it is not possible to infer the effects that TPMS might have across body type and gender based on these findings. The present study is the first opportunity to determine if there is an interaction between

TPMS presence, driver gender, and vehicle type.

- The 2003 study reports that the direct type of TPMS is more effective than the indirect type of TPMS and no TPMS. For drivers who are unable or unwilling to participate, it is unfortunately not always possible to visually determine the presence of TPMS. Therefore, it is not possible to determine if the tendency to participate differs for vehicles with TPMS compared to those without TPMS.
- Other factors that may influence tire inflation pressure are age of the vehicle and amount of wear on the tire. It is infeasible to collect these data from respondents who are too busy to participate. Current NHTSA employees who worked on the 2001 survey were consulted to verify this statement.

B.4. Describe any tests of procedures or methods to be undertaken.

Data collection forms and instructions are being developed by staff in NHTSA's Office of Regulatory Analysis and Evaluation with input from the NASS Field Staff. The data collection forms and procedures will be evaluated in a pilot test of all data collection procedures throughout the country. At numerous locations, a two-person team consisting of contractor staff will pretest the data collection forms and methodology, as part of a one day pretest. This pretest should help refine procedures, forms, and cooperation for the start of the full study. Minor modifications to the data collection forms, as well as some changes in procedures may result. The data collection forms are included as Attachment D.

B.5. Provide the name and telephone number of individuals consulted on statistical aspects of the design and the name of the agency unit, contractor(s), grantee(s), or other person(s) who will actually collect and/or analyze the information for the agency.

Survey Design and Estimation:	Kirk Allen, National Center for Statistics and Analysis (NCSA), NHTSA (NVS-431; 202.366.9308)
Data Analysis:	Kirk Allen, NCSA, NHTSA (NVS-431, 202.366.9308) Charlene Doyle, NCSA, NHTSA (NVS-431, 202.366.1276)
Data Collection:	Gary Toth, NCSA, NHTSA, COTR for Contracts (NVS-411, 202.366.5378)
Data Collection Contractors:	Calspan Corporation. (Contract DTNH22-06-C-00022) KLD Associates, Inc. (Contract DTNH22-06-C-00024).