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16. ABSTRACT

This report provides an exploration of procurement methods utilized by state and provincial agencies throughout North America to provide a comparative analysis to operations within the California Department of Transportation (Caltrans). The primary goal of this investigation is to explore comparable institutions that manage statewide fleets of vehicles or equipment to unveil methods, strategies, or metrics that may assist Caltrans to improve their current production and procurement methods. In addition to the immediate goals of evaluating and clarifying the Caltrans production and procurement process, the survey provides an exploratory analysis of the agencies that currently build, have built, and agencies that may have considered or have never considered building equipment. Additional information on renting, leasing, and alternative procurement methods was collected to identify when traditional purchasing methods were not the preferred method of vehicle acquisition.

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UCR | College of Engineering- Center for Environmental Research & Technology

Evaluation of Equipment Production and Procurement Practices

Final Report

Prepared for:

Caltrans

Division of Equipment

Agreement Number 65A0558

College of Engineering - Center for Environmental Research & Technology

University of California Riverside

August 2017

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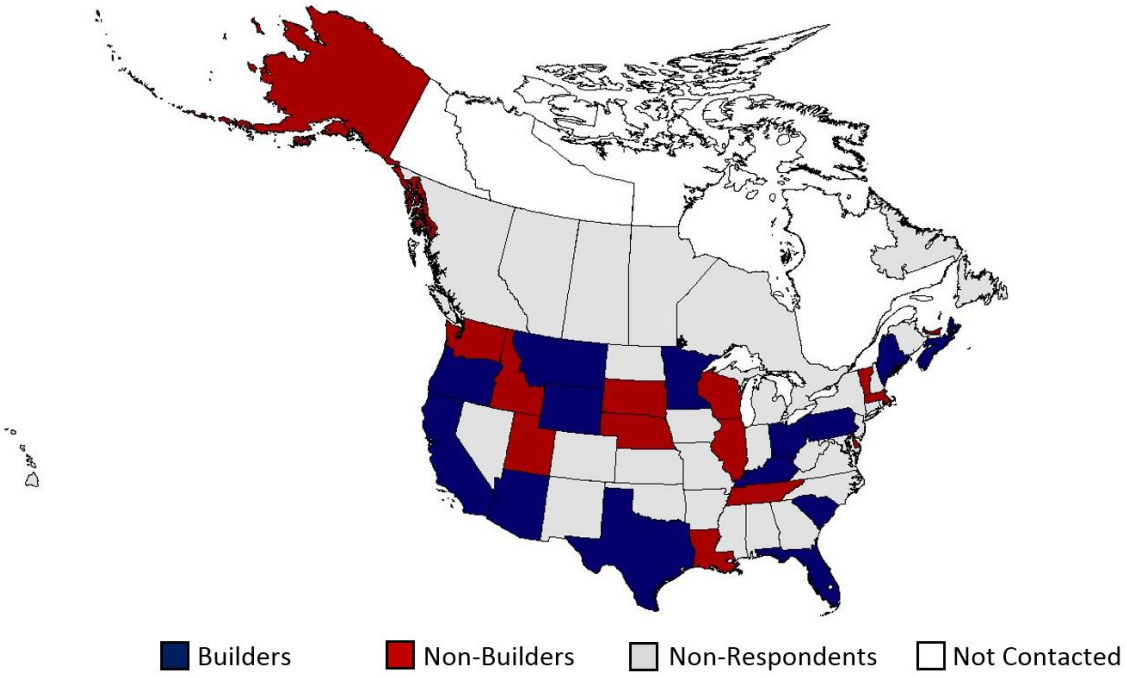
Table of Contents

EXECUTIVE SUMMARY

This report provides an exploration of procurement methods utilized by state and provincial agencies throughout North America to provide a comparative analysis to operations within the California Department of Transportation (Caltrans). The primary goal of this investigation is to explore comparable institutions that manage statewide fleets of vehicles or equipment to unveil methods, strategies, or metrics that may assist Caltrans to improve their current production and procurement methods. In addition to the immediate goals of evaluating and clarifying the Caltrans production and procurement process, the survey provides an exploratory analysis of the agencies that currently build, have built, and agencies that may have considered or have never considered building equipment. Additional information on renting, leasing, and alternative procurement methods was collected to identify when traditional purchasing methods were not the preferred method of vehicle acquisition.

The definition of equipment building used throughout this survey was developed with the assistance of Caltrans' Division of Equipment (DOE) staff to refer to vehicles that have been assembled from major essential components such as the cab and chassis. The "self-built" agency is defined as an agency that procures and then assembles individual essential components to allow a vehicle to perform its intended function(s). Numerous agencies modify and enhance pre-existing vehicles by installing attachments (light bars, storage bins, racks) and parts that enhance the functionality of the purchased equipment (e.g., plows added to pickup trucks).



Given the minimal literature concerning government fleet equipment building, a survey was created to collect information and gauge attitudes regarding renting, purchasing, and fabrication of vehicles and vehicular equipment. Potential survey respondents received the survey in a variety of forms including an unfillable survey document, a fillable edition, and a survey link by email. Fleet and equipment managers, directors, engineers, and superintendents from fifty state Departments of Transportation as well as nine provincial Canadian Departments and Ministries of Transportation were contacted to participate in the survey between November 2015 and July 2016. Of those contacted, twenty-six respondents from U.S.

Departments of Transportation and two respondents from Canadian Departments of Transportation and Infrastructure agreed to participate.

Fleet operators were also provided the opportunity to respond by phone interview. During these interviews, the primary interviewer would request permission to record the conversation. Scheduling and recording interviews was completed at the discretion of the primary interviewer and resulted in thirteen taped interviews. The information gathered from the individuals that took the survey is considered to be representative of the transportation agency that the individuals belonged to at the time of survey submission. Throughout this report, survey responses are displayed by state or province rather than by the respondent's name. The majority of US individuals contacted can be found through the Equipment Management Technical Services Program 2016 State Contact List available at www.emtsp.org.

Survey results indicated that 50% of the participating agencies engaged in some form of vehicle building. Specific questions regarding motivations, challenges, and opinions on self-building were asked of these individuals. The most common vehicle equipment that agencies built included dump trucks, plow trucks, snow equipment, incidence response vehicles, and cone trucks. Motivations for building vehicles were diverse and included: cost, unique need, legal mandate, lack of in-state vendors, and keeping mechanics busy. Information regarding budget, percentage of mechanics involved in building, and time spent verifying self-built vehicle quality has been gathered and is presented in the report.

	AZ	CA	FL	KY	ME	MN	MT	NS	OH	OR	PA	SC	TX	WY
Cost		x	x	x	x		x		x			x		x
Quality		x					x	x				x		x
Unique Need	x	x			x						x			
Control						x								x
Convenience			x							x				
Creates Jobs							x			x				
Speed		x										x		
Equipment Standardization		x						x						
Required By Law									x				x	
Lack of In-State Vendors												x		

Forty-six percent of participants belonging to agencies that did not build were asked a different and much shorter set of questions regarding whether they had considered self-building, what challenges might influence this decision, and opinion questions. The remaining 4% represent one inconclusive survey where procurement was deemed to be handled at the county level for the state. However, the agency indicated that they did not build and so this agency can be grouped with the 46% of agencies that do not build unless determined that building occurs at the county level. In order to increase the possibility of a response, survey respondents were allowed to guess, provide ranges, or skip questions when unsure. The survey administers made every effort to best represent the intended responses of the survey participants.

The overall analysis of survey responses has provided some key findings which the authors have summarized as follows: 1) self-building of specialty vehicles is a common practice among approximately half of state DOTs with consistent reported financial and vehicle quality benefits; 2) state DOTs with developed or ongoing self-building expertise have more favorable and beneficial results when compared to states with limited self-building experience; 3) state DOTs with a higher proportion of specialty vehicles (snow removal, construction, heavy equipment) receive greater benefit from the self-building process; 4) states with proven self-building success would benefit from expanding the self-building process if provided with enhanced facilities and additional staffing. The main body of this report provides additional details regarding these findings.

1. INTRODUCTION

Managing a fleet requires making numerous competing decisions on a finite or even insufficient budget while facilitating operations and maintenance. One often beneficial method that some government agencies have adopted is the practice of building some of their own vehicles. The California Department of Transportation (Caltrans) has implemented effective and efficient self building procedures. Although there exists the possibility that other Departments of Transportation (DOTs) and fleet-bearing agencies may also engage in this practice, information relating to government fleet building is sparse and difficult to find. In an effort to explore the procurement practices of government agencies similar to Caltrans, a survey was developed to collect information on agency methods and discover which agencies also build vehicles.

2. BACKGROUND

Caltrans' Division of Equipment (DOE) currently builds and heavily modifies a sizeable percentage of their fleet. At their Sacramento headquarters shop, they build dump, cargo, and plow trucks from purchased cabs and chassis. The DOE has decided to build these vehicles largely because, to loosely paraphrase, there is no such thing as a dump truck store. Their unique need for vehicles that are typically built to specification has led the DOE to assemble vehicles of their own volition utilizing their own staff. Standardization of equipment parts has also been cited as a key benefit that influences their decision to build vehicles that are not necessarily specialized. Benefits of self-building cited by Caltrans include a better quality end-product and cost-savings for the department. This decision to self-build vehicles has also been supplemented by in-house comparative studies.

A 2013 study performed by the Caltrans Headquarters Shop and CTC & Associates has shown that self-building for Caltrans is both quicker and less costly than having a vendor build the same piece of equipment [1]. The vendor assembled method consisted of a cab and chassis being provided by Caltrans to an unnamed vendor and the vendor was given ample time to order components and begin planning before assembling plow trucks. Comparing completion times and per unit costs, the Headquarters shop was shown capable of building 30 plow trucks at over twice the rate and for roughly $25,000 to $35,000 less per plow truck, depending on the presence of a wing plow and spreader, than the selected commercial vendor. Allowing the vendor to procure cab and chassis resulted in an even larger price difference between vendor and Headquarters Shop assembled vehicles. A similar assessment was performed for dump trucks also supporting the conclusion that building vehicles would be more economic and less time-intensive than acquiring the same vehicles from a vendor.[2] A period of three years passed between the Headquarters Shop and vendor building periods featured in the study over which the price of the chassis increased by roughly $10,000. Subtracting the costs of the chassis, price savings were still well over $50,000 per dump truck. The Headquarters Shop also found that managing vendor-made vehicles required more Engineering and Quality Assurance staff than managing vehicles that had been self-built at their facility. The combination of years of self-building and the analysis of their process versus that of a vendor's has left the DOE with little doubt that self-building is overall beneficial relative to: cost effectiveness, production timeliness, vehicle quality, and vehicle consistency.

Despite the overall positive benefits of the DOE's self-building process, the number of vehicles that they can build is greatly limited by staff availability and facility capacity. Considering the limitations that they face, the DOE is looking to improve its self-building process. Adopting metrics or benchmarks, eliminating wasteful steps in the process, reorganizing the Headquarters Shop workspace, or considering new technologies and possible staff positions specifically relating to self-building could all be potential

improvements. However, prioritization and implementation of these improvements will require analysis of current methods employed by Caltrans and an understanding of methods used by other entities similar to Caltrans.

There exists a wealth of information concerning commercial vehicle building practices and the methodologies and principles that guide the industry. However, on the subject of vehicle building by government agencies, information is sparse. The only resources that could be found were two 2013 EMTSP videos from the Minnesota Department of Transportation and Michigan Department of Transportation detailing their fabrication process, an additional video from the Minnesota Department of Transportation with a more in-depth look at their phases of building, and occasional passing mentions on other DOT websites.[3][4] and [5] No reports or formal investigations on government fleet vehicle building were found during the course of a literature search. Given the dearth of information available, a survey was considered to allow for an investigative look into the subject and help explore government vehicle-building practices. It is the intention of this survey to provide context as to why agencies decide to build or not to build, address the challenges that building agencies face when assembling their own vehicles, and hopefully lead to a larger dialogue concerning government fleet building practices.

3. QUESTIONNAIRE DESIGN, DISTRIBUTION, & COLLECTION

3.1 Creating the Survey

The survey questionnaire was comprised of thirty-two questions with sixteen questions directed towards all respondents, three questions asked of agencies that did not build, and thirteen questions specifically for building agencies. The last three questions of the survey sought information about agency replacement practices, software products that the agency used, and whether or not they could identify any prior studies they had performed on the subject of vehicle building or replacement. The last survey question was a very deliberate effort to obtain reports to compensate for a lack of agency vehicle building literature. While designing the survey, questions were created with the intent to capture legal, technical, political, and fiscal considerations of agencies during the procurement process and particularly during vehicle building. Working with the DOE to determine the effectiveness of questions, the survey was developed through multiple iterations. A decision to make the survey branched so as to ask different questions of building and non-building agencies was agreed upon early in development.

The survey attempted to be diverse in terms of the question types used employing open-ended prompts along with a few yes/no and multiple choice questions. Question types were mostly composed of ranking questions with a numerical quantity being assigned for comparative evaluation. The assignment of a numerical quantity allowed a summation of answers across all responents. The DOE was particularly helpful when creating survey question number four which asked for fleet composition by unit number or percentage. These fleet categories are based loosely on the categories Caltrans uses to define their equipment composition which were simplified and combined allowing twelve categories to be condensed into nine. Fleet composition was determined to be a useful factor in determining whether or not agencies tended to build in categories that were a smaller or larger portion of their fleet.

The original intention regarding the flow of the survey was to go from general to more specialized questions which would make the branching point seem less abrupt. Questions went from agency demographic questions to fleet demographic questions settling into fleet procurement questions. Considering that little is written about the subject matter, open ended prompts were near impossible to avoid. Three multiple choice opinion questions were added at the end to make the survey lighter after the more detailed percentage questions. Branching was more easily handled in the online survey where the

change was automatic and required no action on the part of the respondent. Branching in the paper survey did lead to confusion and made the survey seem more daunting to respondents due to the large number of questions asked.

Perhaps more important to the survey than the questions themselves was the definition of what constituted a self-built vehicle. Over the course of the survey, the meaning behind the term 'self-built' evolved while developing the survey. Initially, the definition of self-building focused on the process of changing an item's function rather than building a piece of equipment. This was then clarified to be a modification and it was decided that modification would be considered as entirely separate from building. Building was agreed to be a process of assembling major components into a new entity. The joining of cab and chassis was determined to be the deciding test by which a vehicle could be considered self-built. This definition was developed through the explicit help of the DOE and Caltrans' Chief of Office, Fleet Asset Management, and Quality Assurance, Lisa Kunzman.

3.2 Determining Survey Contacts

When deciding which entities should be sent the survey, fleets of similar size and composition compared to Caltrans were determined to be the primary population of interest. Lisa Kunzman expressed an explicit interest to include respondents from Canadian provinces. In searching for potential respondents, county and city level fleets were considered. However, all attempts to reach these fleets both inside and outside California did not yield any completed surveys. Targeting state and provincial level fleets resulted in far greater success. An initial list of contacts for US Departments of Transportation was developed using the National Contact List from the Equipment Management Technical Services Program (EMTSP) website.[6] A basic search was done on all individuals whose contact information was featured on this list checking for possible changes in employment or position by making frequent use of state employee directories. Contact information for individuals in fleet management positions for Canadian provincial Departments and Ministries of Transportation was obtained through thorough internet searches on provincial department websites.

An email proclaiming that the respondent had been selected for a procurement survey associated with Caltrans was sent to individuals on the contact list along with an attached survey document. Following non-response, the contact list individuals were sent a shorter email than featured in the first round of surveys. If the request went without response a second time, alternative contacts were found through the AASHTO Equipment Reference Book, agency websites and directories, or alternative sites such as Linked-In and contact lists for other fleet surveys. Alternative contacts would then be sent the same information, documents, or survey links as the initial contacts. Given the highly specialized nature of the survey, non-response was assumed to be a symptom of not contacting the 'right' person at the agency that could answer the survey questions. Diversifying the respondents contacted resulted in a far greater amount of completed surveys and interviews than the initial contact list.

Response was also encouraged by stressing the casual nature of the survey. So as to not cause an undue burden, respondents were encouraged to take as much time as they would like on the survey. Over the course of the survey, respondents were able to decide whether or not they wanted to answer questions and how precise their answer should be. Accommodations were made when requested which resulted in the fillable survey format as wisely suggested by the respondent from the Tennessee Department of Transportation. An online edition of the survey was also created and distributed. In fact, the first survey completed was an online survey. Given that the survey allowed for greater anonymity and greater ease in skipping questions, the online survey requests were typically sent after non-response from both initial and alternative contacts after the course of multiple emails failed to produce communication.

3.3 Conducting the Survey

Before beginning the survey, it was decided that should a respondent chose to be interviewed that the individual conducting the interview would attempt to record responses. The presence of an audio recording request depended on both the respondent and the interviewer's own judgement. Respondents who indicated that they were busy were not asked for courtesy's sake and out of respect for the respondent's time. On occasion, faster paced conversations with respondents that were very knowledgeable were not recorded as time was spent writing comments down instead of looking for an opening to ask. Indicating the possibility of a recorded interview in email requests or the survey itself could have helped avoid the unpredictability of gathering a recording. All respondents were asked whether or not they would like to be recorded without pressuring and ensuring that anonymity would be preserved.

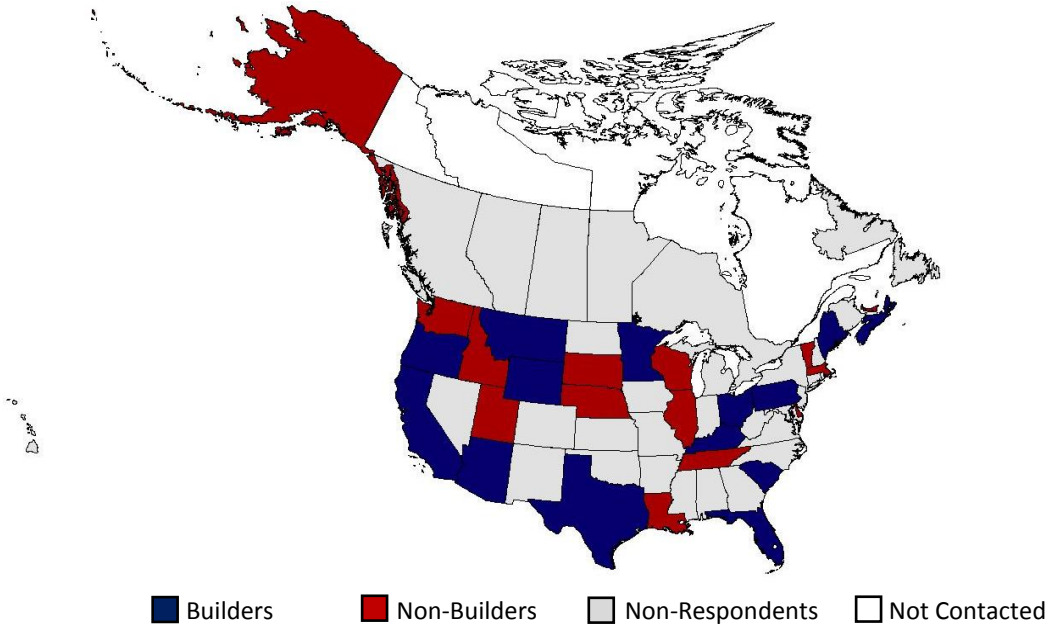
The survey was conducted under the belief that there are no inappropriate survey responses, only potentially misunderstood survey questions. All responses from survey participants are considered valid and any confusion that may have arisen is due to the complicated nature of some of the survey questions. Respondents were occasionally contacted to explain any answers that were seen as unusual. However, survey respondents were not encouraged to edit these responses. One of the advantages of the phone interviews that went through the questions one-by-one was the dialogue between respondent and interviewer that encouraged the respondent to ask for clarification when needed. The majority of survey responses were usually submitted survey forms that the respondent had completed on their own. Given the busy schedules of fleet managers, the survey form was essential in providing convenience and integral in ensuring a decent survey completion rate. The online survey allowed for greater quality control of responses though this may have been a negative. The exploratory nature of this survey considers qualitative and uncertain answers as valid a response as precise replies which online survey error controls do not. For example, ensuring that a response is only composed of numeric characters invalidates answers that may be given by a range or can only be expressed as less than or greater than a particular number. However, without the error controls the online survey is no different from the survey form aside from the handling of the branching point. All surveys sent and interviews recorded have been saved and may be edited or rescinded by the respondent at any time.

4. SURVEY RESULTS & ANALYSIS

A grand total of 26 state fleets and 2 Canadian provincial fleets agreed to participate in the survey. Given that 59 agencies were contacted in hopes of survey completion, the response rate for this survey was roughly 44%.The survey responses included 16 phone calls, 13 document submissions, and 5 online surveys completed through Qualtrics.com. A complete list of responding agencies is listed below.

Before analyzing the collected survey data, it is important to note that Wisconsin was not able to answer questions relating to procurement due to the fact that vehicle acquisition is handled mainly at the county level. As implied earlier in this report, attempts to contact counties in Wisconsin were unsuccessful. The agency did confide that they possessed a fleet of police vehicles, sedans, pick-ups, and bucket trucks which were not built. Wisconsin DOT can then be regarded as an agency that does not build for the intentions of this report. With this in mind, 14 respondents, or 50% of survey participants, agreed that they constructed vehicles in a manner consistent with this survey's definition of self-building while the other 50% of respondents confided that they did not build vehicles. The information collected from all respondents will be presented in more or less the same order as the questions asked in the survey while providing respondent context and information when relevant. However, self-building will be referred to throughout the course of this analysis far before being introduced in the survey.

Figure 4.1. Map of Survey Respondents



United States Respondents:

Alaska Department of Transportation

Arizona Department of Transportation

California Department of Transportation

Delaware Department of Transportation

Florida Department of Transportation

Idaho Department of Transportation

Illinois Department of Transportation

Kentucky Transportation Cabinet

Louisiana Department of Transportation and Development

Maine Department of Transportation

Minnesota Department of Transportation

Montana Department of Transportation

Massachusetts Department of Transportation

Nebraska Department of Roads

Ohio Department of Transportation

Oregon Department of Transportation

Pennsylvania Department of Transportation

South Carolina Department of Transportation

South Dakota Department of Transportation

Tennessee Department of Transportation

Texas Department of Transportation

Utah Department of Transportation

Vermont Agency of Transportation

Washington Department of Transportation

Wisconsin Department of Transportation

Wyoming Department of Transportation

Canadian Provincial Respondents:

Nova Scotia Department of Transportation and Infrastructure Renewal

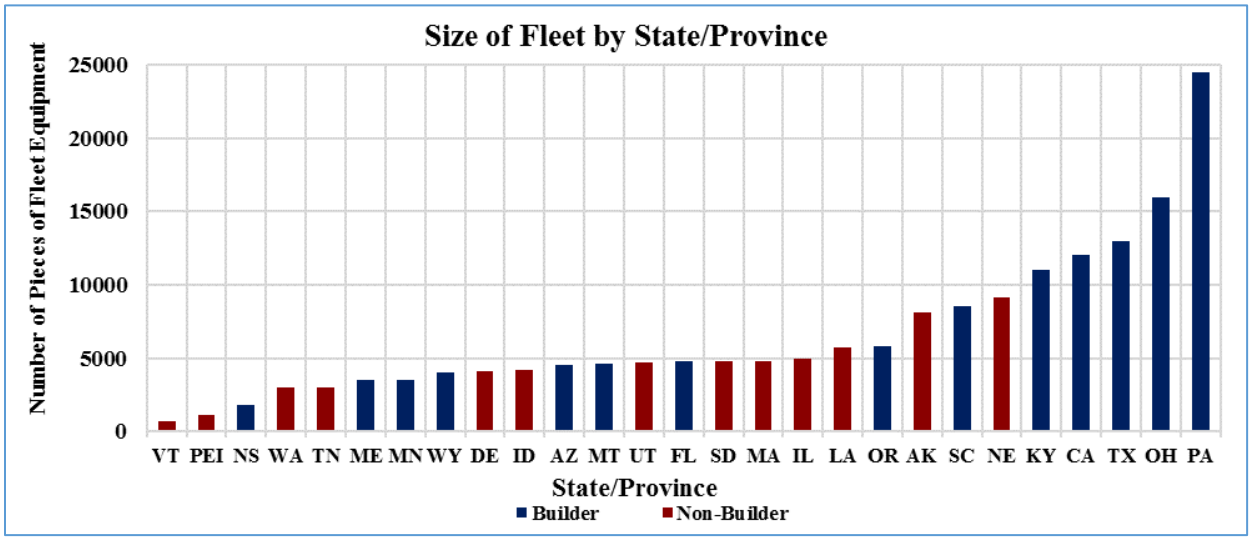
Prince Edward Island Department of Transportation, Infrastructure, and Energy

4.1 Agency Demographics

The survey began by asking for information relating to the size of the responding agency's fleet, number of employees working at their agency, and the number of mechanics employed by their agency. One key issue concerning the employee question was that it did not clarify whether mechanics should be included or excluded resulting in uncertainty. Employee numbers have not been compared in this report for this reason. The mechanic and fleet size questions were asked to determine which agencies were comparable to Caltrans in terms of size and scale. It is worth noting that the observations included in this report are specific to individual DOTs and not to the more general population of government fleets. The findings here are self-contained and these graphs are intended to be observed in color.

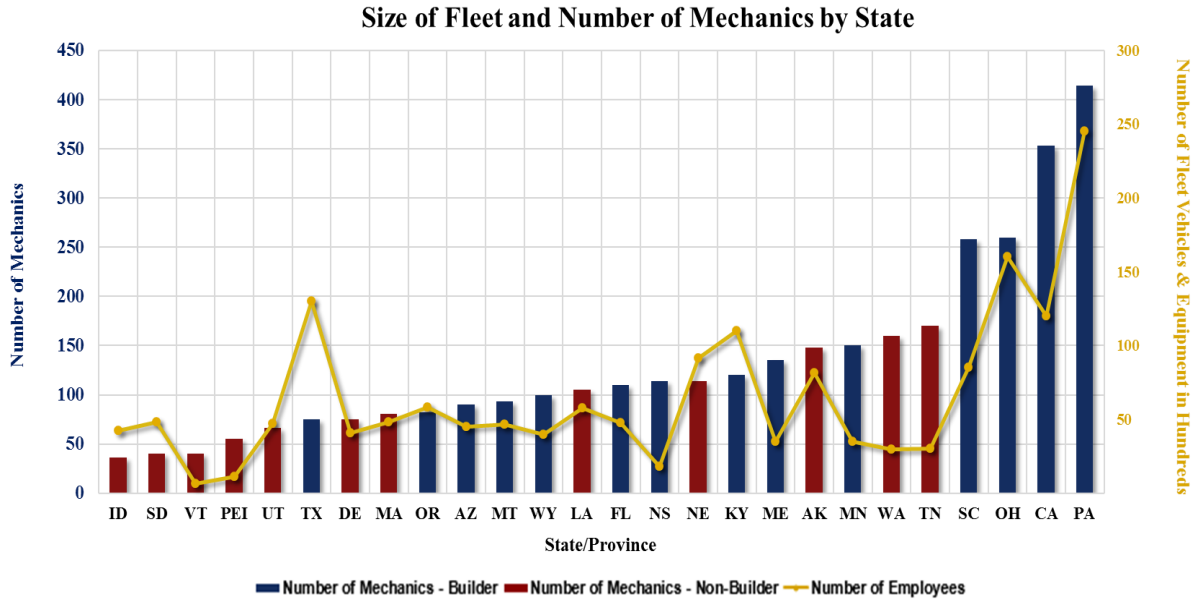
Among the surveyed population, larger fleets tended to include self built fleets though on the whole there exists quite a bit of variation among moderately sized fleets. The number of fleet equipment reported in surveys does not directly reflect the amount of vehicles contained in a fleet as it includes non-self-propelled equipment in addition to non-functioning vehicles. Performing a t-test to determine if there existed a significant difference between the number of fleet equipment in agencies that build and the agencies that are not builders shows a statistically significant difference in the sample; $t(17)=2.158$, $p=0.046$. A significance level of 0.05 was chosen for all statistical tests in this report such that when $p \leq 0.05$ there exists a statistically significant difference or relationship. From the t-test result, it can be determined that building agencies in our sample tended to have larger fleets.

Figure 4.2. Size of Fleet by State/Province



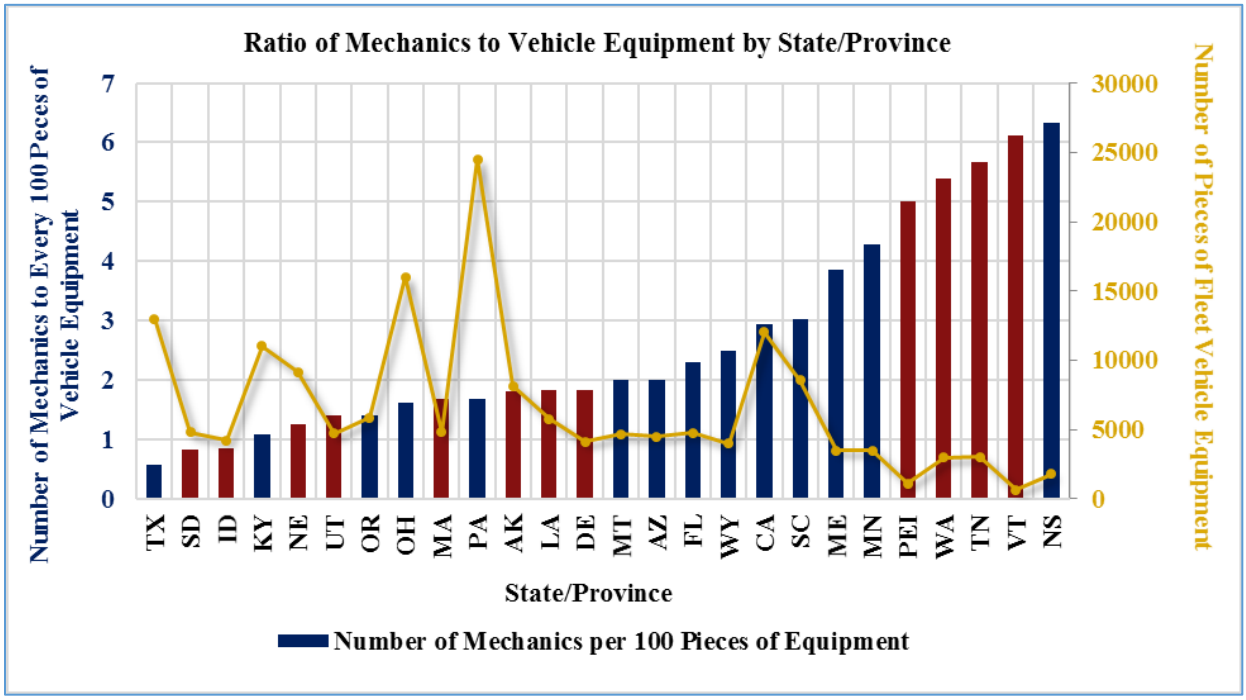
Mechanic numbers were also collected for state fleets in the hope of observing a pattern. A t-test determined that there did exist a statistically significant difference between the number of mechanics employed by agencies that build and the number of mechanics for agencies that did not; $t(18)=2.400$, $p=0.027$. Building agencies had an average of 168 mechanics with a standard deviation of 109 mechanics while agencies that did not build had an average of 91 mechanics with a standard deviation of 48. In the survey sample, self-building fleets had more mechanics than non-building fleets.

Figure 4.3. Mechanics and Pieces of Vehicle Equipment by State/Province



When considering the equipment and vehicle numbers of agencies, the ratios of mechanics to equipment was considered to be a potentially interesting statistic. Unsurprisingly, smaller fleets had appreciably higher mechanic to vehicle ratios making fleet size and the calculated ratio negatively correlated; r= -0.48, p=0.0117. Considering that the ratio of mechanics to vehicles is inversely proportional to the number of vehicles and that bigger fleets tend to have more mechanics, this result is to be expected. However, the ratios are presented here for those who may be interested.

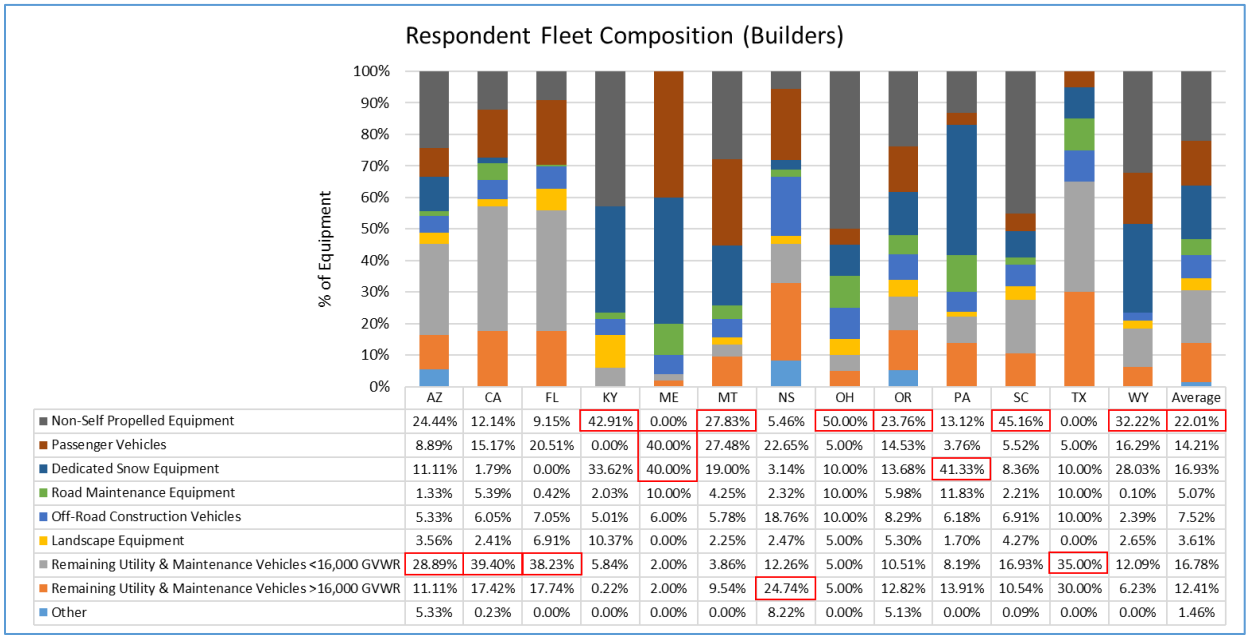
Figure 4.4. Ratio of Mechanics to Vehicle Equipment by State/Province



4.2 Fleet Demographics

In order to separate the vehicles from the non-self-propelled equipment in the obtained fleet size numbers, a fleet composition question was included in the survey. Respondents were asked to provide numbers or percentages that indicated how much of their agency's fleet belonged in provided categories. Categories included: non-self-propelled equipment, passenger vehicles, dedicated snow equipment, road maintenance equipment, off-road construction vehicles, landscape maintenance equipment, a category for vehicles with a gross vehicle weight rating (GVWR) less than 16,000, another for vehicles over 16,000 GVWR, and an 'other' category for equipment that could not fit easily into the previous categories. The intention of this question was to compare the vehicles that agencies admitted to self-building to fleet compositions to see if these vehicles composed a smaller or larger portion of their fleet. Placing equipment into the categories was left to the discretion of the respondent though respondents were encouraged to place equipment in the most specific category applicable. On more than one occasion, respondents noted that the fleet composition question discouraged them from completing the survey. The information here should be regarded with some caution given the wide range of interpretation of categories and the difficulties encountered in deciding which pieces of equipment should be placed where. Equipment placed in the 'other' category included jackhammers, traffic sensors, lifts, pavement testing equipment, cement mixers, carts, incident response vehicles, and more.

Figure 4.5. Respondent Fleet Composition (Builders)

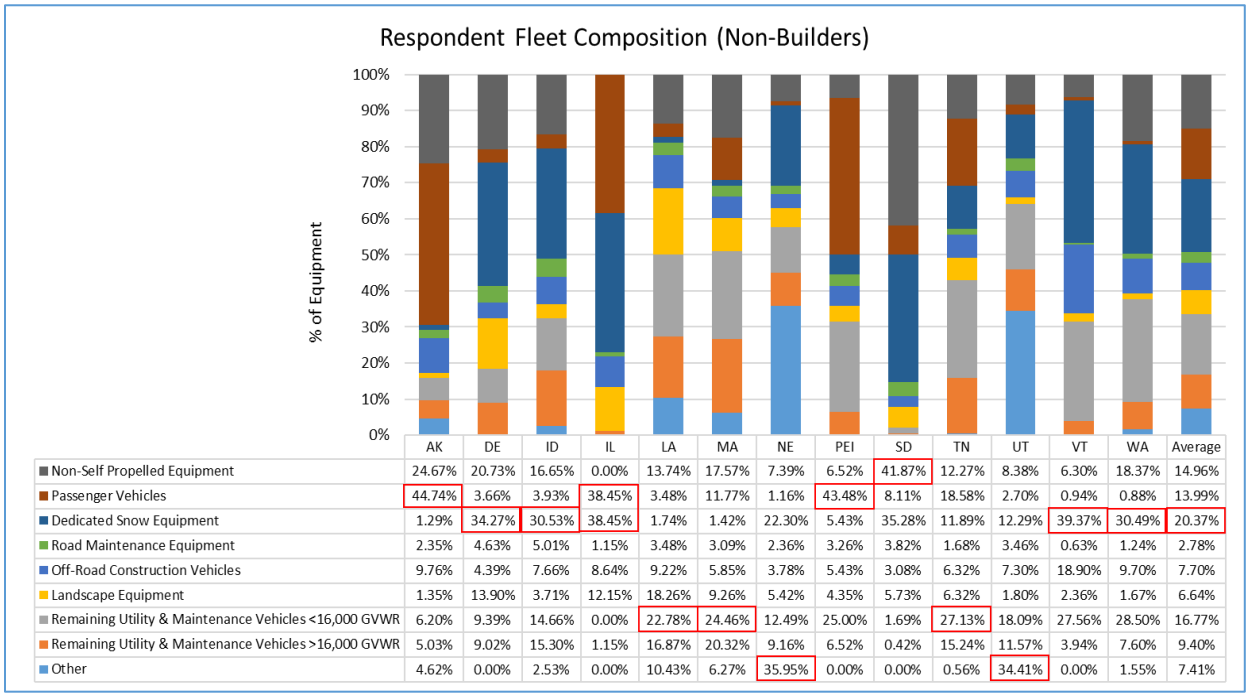


	AZ	CA	FL	KY	ME	MT	NS	OH	OR	PA	SC	TX	WY	Average
Non-Self Propelled Equipment	24.44%	12.14%	9.15%	42.91%	0.00%	27.83%	5.46%	50.00%	23.76%	13.12%	45.16%	0.00%	32.22%	22.01%
Passenger Vehicles	8.89%	15.17%	20.51%	0.00%	40.00%	27.48%	22.65%	5.00%	14.53%	3.76%	5.52%	5.00%	16.29%	14.21%
Dedicated Snow Equipment	11.11%	1.79%	0.00%	33.62%	40.00%	19.00%	3.14%	10.00%	13.68%	41.33%	8.36%	10.00%	28.03%	16.93%
Road Maintenance Equipment	1.33%	5.39%	0.42%	2.03%	10.00%	4.25%	2.32%	10.00%	5.98%	11.83%	2.21%	10.00%	0.10%	5.07%
Off-Road Construction Vehicles	5.33%	6.05%	7.05%	5.01%	6.00%	5.78%	18.76%	10.00%	8.29%	6.18%	6.91%	10.00%	2.39%	7.52%
Landscape Equipment	3.56%	2.41%	6.91%	10.37%	0.00%	2.25%	2.47%	5.00%	5.30%	1.70%	4.27%	0.00%	2.65%	3.61%
Remaining Utility & Maintenance Vehicles <16,000 GVWR	28.89%	39.40%	38.23%	5.84%	2.00%	3.86%	12.26%	5.00%	10.51%	8.19%	16.93%	35.00%	12.09%	16.78%
Remaining Utility & Maintenance Vehicles >16,000 GVWR	11.11%	17.42%	17.74%	0.22%	2.00%	9.54%	24.74%	5.00%	12.82%	13.91%	10.54%	30.00%	6.23%	12.41%
Other	5.33%	0.23%	0.00%	0.00%	0.00%	0.00%	8.22%	0.00%	5.13%	0.00%	0.09%	0.00%	0.00%	1.46%

The respondent fleet composition is grouped as builders and non-builders, and each category was normalized to percentage. (Figure 4.5 & 4.6) Under the bar chart, a percentage table was generated to show the portion of each category for each state, and the largest portion in the column was squared in red. From the builders' fleet composition, the category with the largest percentage of items was non-self propelled equipment, which was shown in 6 out of 13 builders. The second largest percentage of items was equipment with less than 16,000 GVWR category, which was shown in 4 out of 13 builders. Another interesting finding is that, based on the bar chart, Arizona, California and Florida possess similar fleet composition. From the non-builders' fleet composition, 5 out of 13 non-builders have dedicated snow

equipment category as the largest portion in their fleet. In addition, states have similar fleet composition can also be found within non-builders. This time, it's Delaware, Idaho, Vermont and Washington who have almost the same composition of their fleet.

Figure 4.6. Respondent Fleet Composition (Non-Builders)



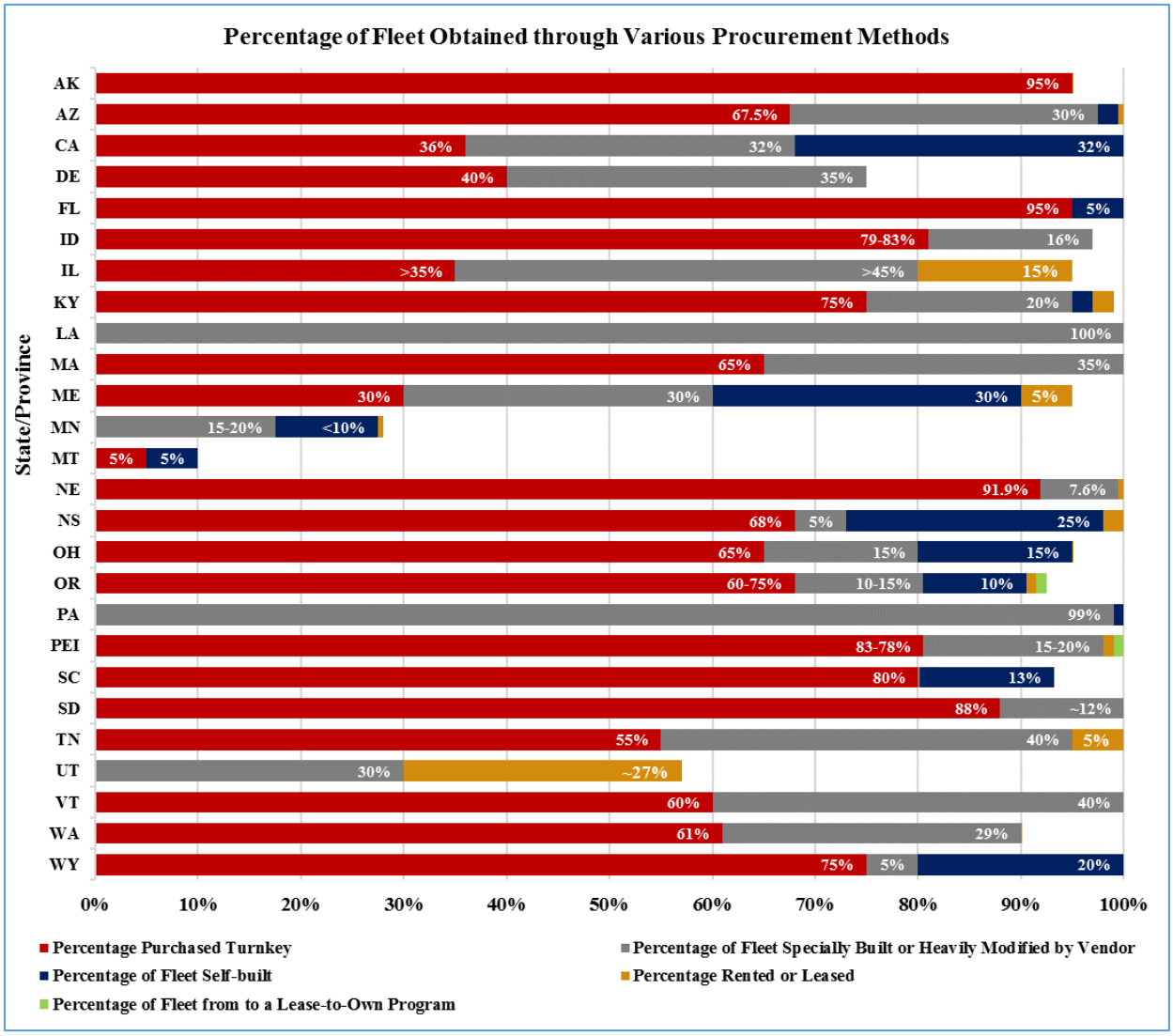
	AK	DE	ID	IL	LA	MA	NE	PEI	SD	TN	UT	VT	WA	Average
Non-Self Propelled Equipment	24.67%	20.73%	16.65%	0.00%	13.74%	17.57%	7.39%	6.52%	41.87%	12.27%	8.38%	6.30%	18.37%	14.96%
Passenger Vehicles	44.74%	3.66%	3.93%	38.45%	3.48%	11.77%	1.16%	43.48%	8.11%	18.58%	2.70%	0.94%	0.88%	13.99%
Dedicated Snow Equipment	1.29%	34.27%	30.53%	38.45%	1.74%	1.42%	22.30%	5.43%	35.28%	11.89%	12.29%	39.37%	30.49%	20.37%
Road Maintenance Equipment	2.35%	4.63%	5.01%	1.15%	3.48%	3.09%	2.36%	3.26%	3.82%	1.68%	3.46%	0.63%	1.24%	2.78%
Off-Road Construction Vehicles	9.76%	4.39%	7.66%	8.64%	9.22%	5.85%	3.78%	5.43%	3.08%	6.32%	7.30%	18.90%	9.70%	7.70%
Landscape Equipment	1.35%	13.90%	3.71%	12.15%	18.26%	9.26%	5.42%	4.35%	5.73%	6.32%	1.80%	2.36%	1.67%	6.64%
Remaining Utility & Maintenance Vehicles <16,000 GVWR	6.20%	9.39%	14.66%	0.00%	22.78%	24.46%	12.49%	25.00%	1.69%	27.13%	18.09%	27.56%	28.50%	16.77%
Remaining Utility & Maintenance Vehicles >16,000 GVWR	5.03%	9.02%	15.30%	1.15%	16.87%	20.32%	9.16%	6.52%	0.42%	15.24%	11.57%	3.94%	7.60%	9.40%
Other	4.62%	0.00%	2.53%	0.00%	10.43%	6.27%	35.95%	0.00%	0.00%	0.56%	34.41%	0.00%	1.55%	7.41%

Following the initial agency demographic questions, the survey explored procurement requesting percentages that reflected how much of their agency's fleet was obtained through a variety of potential procurement methods. Turnkey purchases, renting/leasing, lease-to-own programs, specialty vendor vehicle purchases, and self-building if applicable were considered to be possible methods of procurement that an agency might employ. During these questions, it was revealed that quite a few agencies such as Alaska DOT, Montana DOT, and others modify their own vehicles outside of what could be considered up-fitting. This was not accounted for as the intention prior to conducting the survey was to lump modification and turnkey purchases together. As completed surveys increased, it became clear that modification should be regarded as a separate method far outside of the realm of turnkey. Some gaps in figure 4.7 can be attributed to an undisclosed modification percentage as most notably seen in the case of Montana. As an aside, Kentucky indicated during their interview that they modify vehicles to keep the warranty and technical support offered by the original manufacturer.

When the categories used in this question were first developed, each category was conceived to be independent of the others. Adding the percentages together, it became apparent that vendor built vehicles could be considered an extension of turnkey, rental vehicles could also to some degree be considered turnkey, and numbers would overlap exceeding the 100% that was expected. For responses where the sums of all responses were well above 100%, the percentage for heavily modified vehicles was subtracted from turnkey to obtain a percent of vehicles that had been obtained turnkey and had not been built by a vendor. If the sum of all considered procurement methods still exceeded 100%, rental percentage was subtracted from the turnkey. This was repeated for the lease-to-own percentage and if all else failed, the self-built percentage was subtracted. In some cases, this resulted in adjusted values below 100%. Figure 7

also provides an idea of which agencies build and what percentage of their fleet is built. Percentages under 5% are not labeled for readability purposes.

Figure 4.7. Percentage of Fleet Obtained through Various Procurement Methods



Purchasing turnkey was the most popular option among fleets with the average percentage equal to roughly 54.497% with a standard deviation of 31.851. Four agencies reported 0% turnkey purchases including a few who claimed that instead of purchasing turnkey they had their equipment specially made by a vendor. The average percentage of fleet equipment specially made or heavily modified by a vendor was 25.896% with a standard deviation of 25.696 suggesting great variability in this procurement category. The self-built percentage of fleets also had a great degree of variability ranging from less than 1% to 32%. Agencies whose fleet was more than 20% built included California, Maine, Nova Scotia, and Wyoming. The average percentage of self-built vehicles in a fleet was 13.077% with a standard deviation of 10.720. Renting and leasing had an average value of 2.293% with four fleets that rented at a rate greater than 5%. Lease-to-own was the least popular procurement option with just two agencies engaging in the practice. Both agencies reported that 1% of their fleet was obtained through this method. Some agencies chose to skip one or more of the procurement percentage questions resulting in gaps.

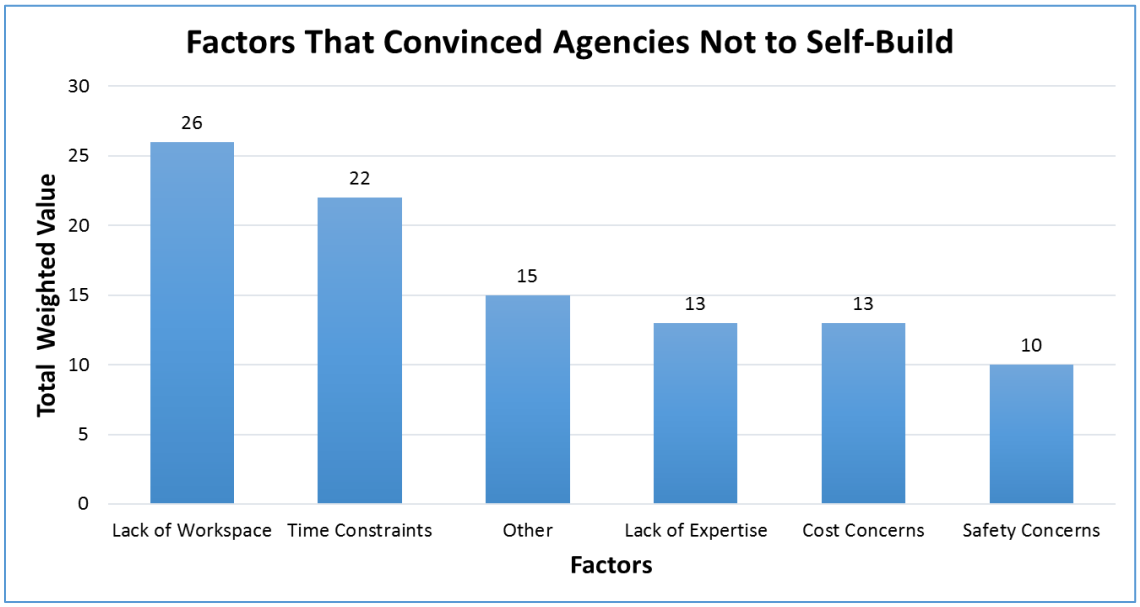
Approaching the self build branching point in the survey, respondents were asked if they up-fitted their vehicles with lights, decals, or anything that did not change the vehicle's intended function. All but one agency that answered this question confirmed up-fitting. Respondents were then asked if they had built a vehicle within the last five years which 14 agencies responded that they had. Washington reported that they did build vehicle attachments, but this was not counted as self-building given the project self-build definition. They also chose to answer non-self-building questions. South Dakota previously self-built until 3 years ago. This specific question asks if a vehicle has been built within the last five years and so technically their response would be a 'yes', but they are considered to be a non-self-building agency. The remaining 11 agencies agreed that they did not build vehicles.

4.3 Questions Pertaining to Non-Self-Building Agencies

At this point in the survey, non-building agencies were asked three questions before continuing onto opinion and replacement questions. The first question asked respondents whether or not they had ever considered self-building within the last five years. Four states including Alaska, Idaho, South Dakota, and Utah replied that they had considered building vehicles. Six states and one province composed of Delaware, Illinois, Massachusetts, Nebraska, Prince Edward Island, Tennessee, and Vermont indicated that they had not considered building. Of the non-building respondents, three agencies confirmed that they had self-built in the past. As mentioned earlier, South Dakota had built as recently as 2013. A struggle to get mechanics was cited as their primary issue for stopping along with the discovery that self-building was only slightly cheaper. Massachusetts at one point also self-built, but found that there was too much time involved and that they did not have sufficient staffing. Utah is the third agency that admitted to building in the 1960's/1970's. They had difficulty keeping mechanics and eventually transitioned to outsourcing. In all three agencies, a shortage of mechanics or mechanic skill was a factor that led them to abandon the practice.

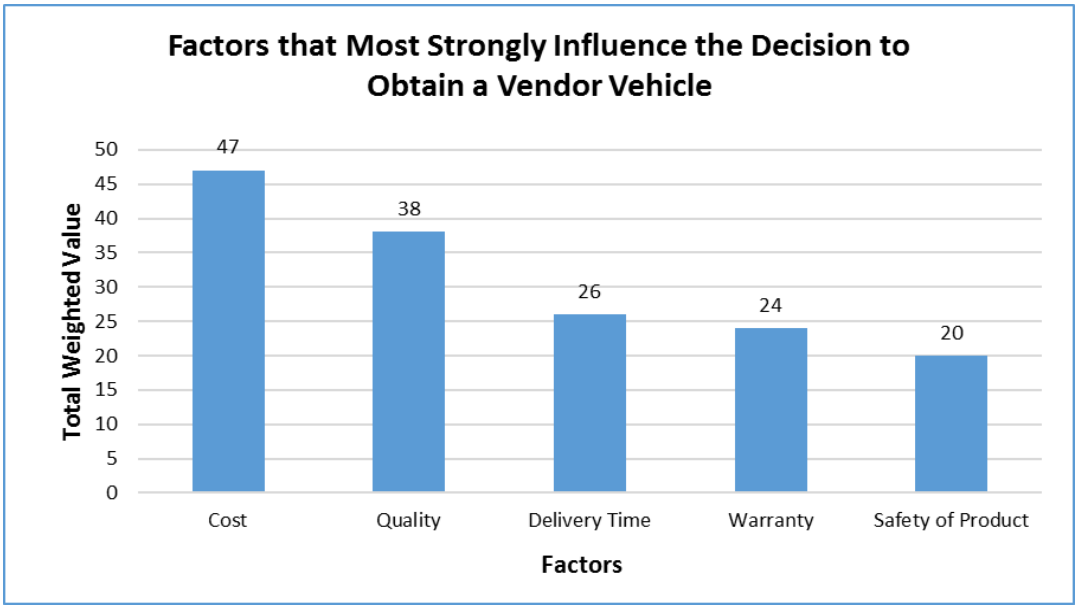
Following the self-building interest question, agencies that had considered self-building and a few that had not were provided with a list of factors that might have led to this decision not to self-build and were asked to rank the factors in order according to how strongly each factor impacted this decision. Factors provided included time constraints, end product safety concerns, cost concerns, lack of staff expertise, and lack of workspace. An 'other' category was also available and allow non-builders to clarify some specific reasons that keep them away from self-building. To get the most influential factors that convinced agencies not to self-build, we don't want to just easily count the frequency of each answers. Instead, a method called "Total Weighted Value" is conducted. To answer this question, every respondent was asked to rank factors in order from 1 to 5 where 5 will correspond to the issue that most strongly convinced agency not to self-build. By multiplying the value of each factors by its frequency, we can get the product, i.e. the total weighted value, of that factor. And then, rank the total weighted value from largest to smallest. The factor with the highest weighted value is the most influential. Based on the following bar chart (Figure 4.8), it's obvious that lack of workspace is the most convincing factor to non-builders. As to 'Other', the responses included competition with private enterprise (Idaho), lack of staff (Utah and Vermont), and liability, which is actually answered by a self-builder Pennsylvania. Idaho also noted in their survey that start-up costs and the costs of obtaining a facility factored into their decision not to build.

Figure 4.8. Factors That Convinced Agencies Not to Self-Build Ranked



Non-building agencies were then asked another ranking question concerning the factors that influenced their agency's decision to purchase from a vendor. This question was intended to mirror a similar one asked of builders and to hopefully identify non-builder motivations. The optional factors included: cost, delivery time, warranty, safety of end product, and quality. By calculating and ranking the total weighted value, cost has the highest value, which means it most significantly influences the decision to obtain a vendor vehicle. Following that, the influences of other factors are ranked in order as quality, delivery time, warranty and safety of product.

Figure 4.9. Factors that Most Strongly Influence the Decision to Obtain a Vendor Vehicle



4.4 Questions Pertaining to Self-Building Agencies

Building agencies were asked a considerably longer set of questions. Questions emphasized the types of vehicles agencies built and their motivations for building these vehicles. The first builder specific question asked the respondent if their agency self-certified their self-built vehicles to comply with Federal Motor Vehicle Safety Standards. Seven DOT agencies confirmed to performing the certification of their self-built vehicles themselves including Arizona, California, Maine, Nova Scotia, Ohio, South Carolina, and Texas. Florida, Kentucky, Minnesota, Montana, Oregon, Pennsylvania, and Wyoming were agencies that build, but do not perform the vehicle certification process by themselves. No other questions regarding certification of vehicles were asked.

Three percentage questions were asked of respondents concerning the estimated percentage of their agency's fleet built, the estimated percentage of mechanics involved in building, and the estimated percentage of their agency's vehicle acquisition budget that went towards self-building. Analyzing this data, it was found that there exists an extremely weak to non-existent correlation between an agency's percentage of mechanics that build and the percentage of the fleet built; r=0.147, p=0.666. Multiplying these percentages by given fleet and mechanic numbers likewise does not lead to a correlation between the estimated number of mechanics that build and the estimated number of vehicles in the fleet that were built; r= 0.0314, p=0.927. This suggests that there does not exist a relationship between the percentage of mechanics that build and the percentage of an agency's fleet that is built among those surveyed. There also does not exist a relationship between the estimated number of mechanics that build and the estimated number of fleet vehicles that are built. These results suggest great diversity in terms of agency mechanic composition and built equipment numbers in our survey sample.

Figure 4.10. Percentage of Fleet Built and Percent of Mechanics Involved in Building

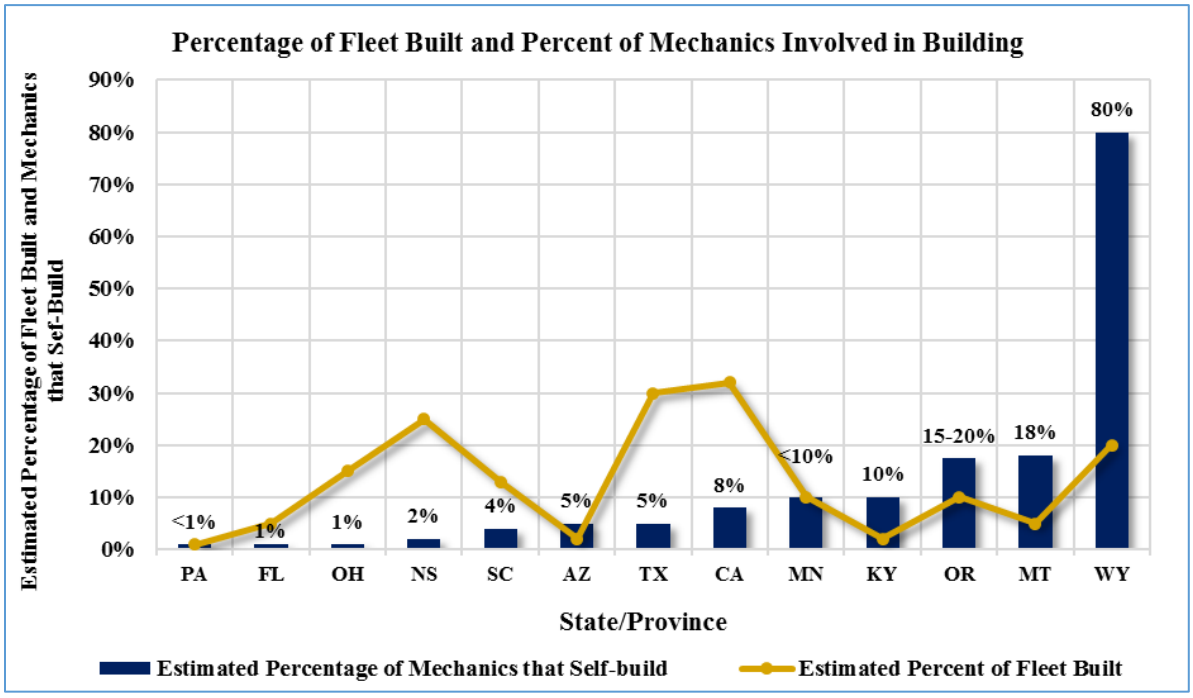
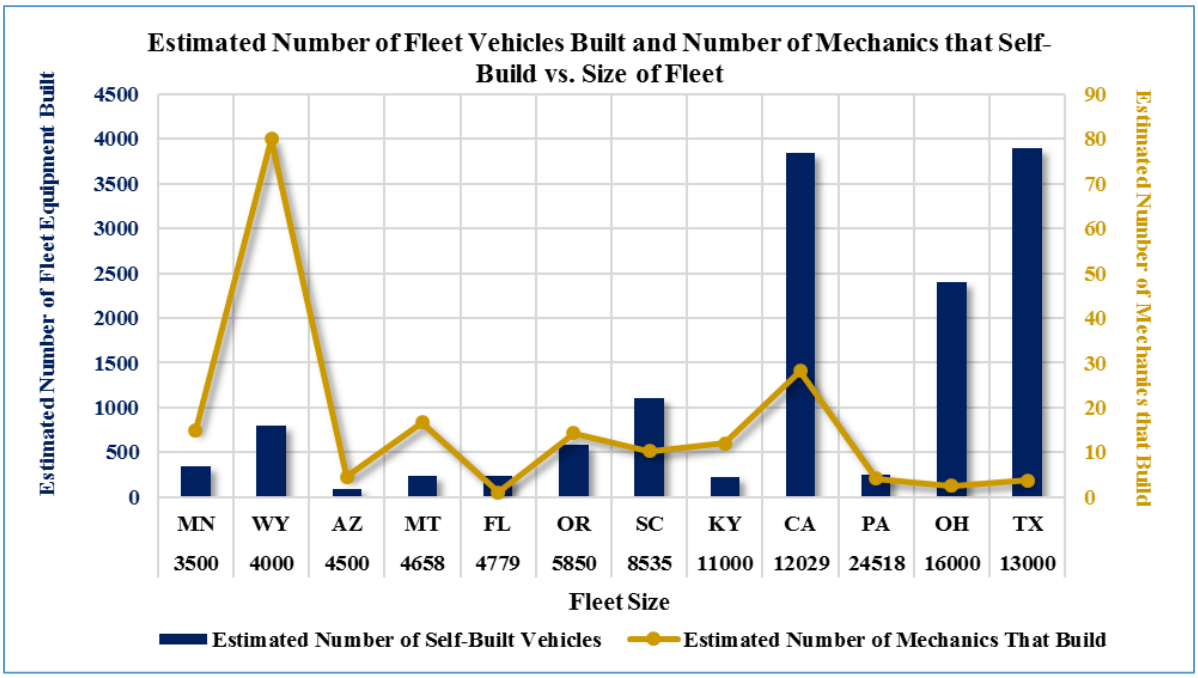
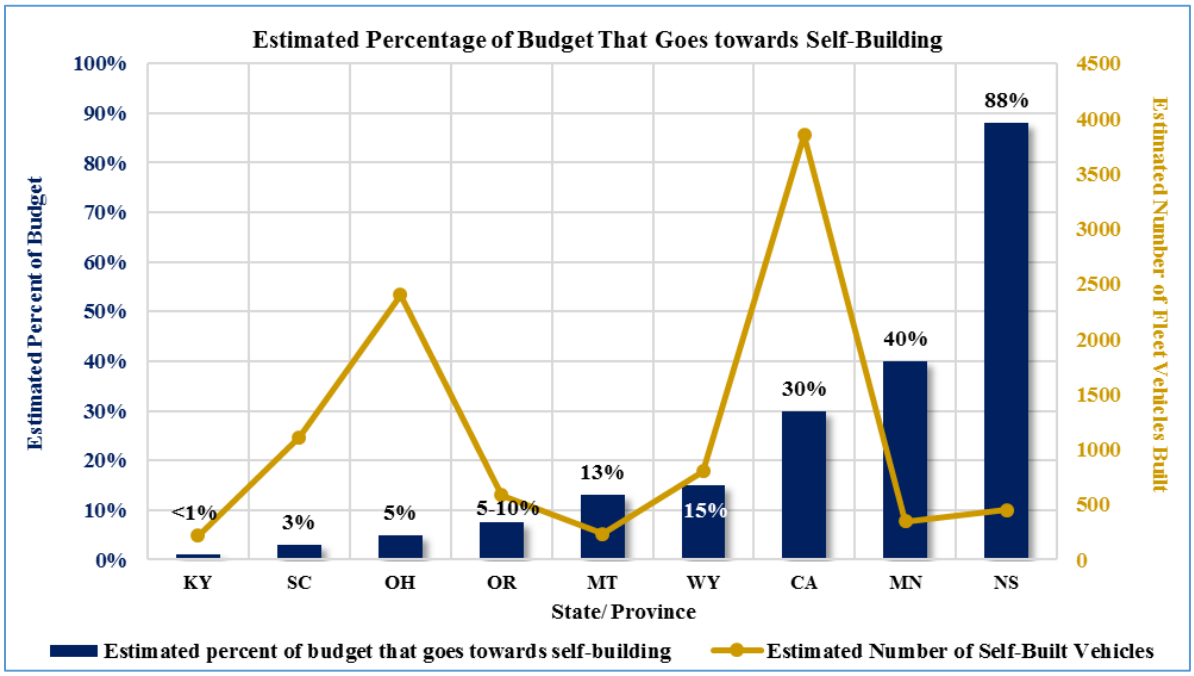


Figure 4.11. Estimated Number of Fleet Vehicles Built and Number of Mechanics that Self-Build vs. Size of Fleet



However, there existed a strong positive correlation between the percent that an agency spent on self-building and the percent of the fleet that was built; r=0.606, p=0.048. Intuitively, this indicates that agencies that invest more in self-building have a greater percentage of their fleet built. Despite the relationship between budget and percentage, there was not a correlation between the budget percentage that went towards building and the number of self-built vehicles estimated in the fleet; r=0.036, p=0.916. This could be accounted for by agencies that invest a smaller portion of their total budget, but are able to build more because their budget on the whole is larger. Another weak positive correlation was found between the number of mechanics that build and the estimated percentage of the fleet built. The weak correlation exists with fleet self-built percentage despite the lack of correlation between the number of mechanics that build and the number of fleet vehicles built; r=0.264, p=0.431. This may suggest that while agencies with more mechanics that build might not necessarily build more vehicles, they are more likely to build a larger percentage of their fleet. Phrased another way, agencies in our sample that build more of their own fleet are more likely to have a greater number mechanics that assist in building than agencies that build a smaller percentage of their fleet, but agencies that build a larger quantity of vehicles may not necessarily have more mechanics than agencies that build a smaller number of units.

Figure 4.12. Estimated Percentage of Budget That Goes towards Self-Building



Moving away from the percentage questions, building agencies were asked for the top three vehicle types that they most frequently assembled. Respondents were encouraged to list more than three if applicable or as many as they could recall if under three. Responses are listed by agency in the table below. Plows and dump trucks were most frequently mentioned by building agencies. A variety of equipment such as plows and spreaders were also included.

Respondents were then asked to describe why their agency decided to build these vehicles. Responses to this question are summarized in the matrix below. Cost was the most cited benefit as to why these vehicles were built which was mentioned by 7 agencies. Unique need and quality tied for the second most frequent motivation with four agency responses each. A number of unique and interesting responses arose from this question and the interviews that followed. South Carolina for one indicated that they would love to outsource, but they are unable to do so due to a lack of in-state vendors. Quality control also plays a role in their decision to outsource and is supported by an anecdote where they hired someone to build that used a cutting torch instead of a magnetic drill resulting in oversized holes. Oregon also proved to be an interesting case where self-building is employed to keep mechanics and engineers busy during the off-season. They also consider building easier given that they would need to perform a great deal of modification otherwise which has been represented by 'convenience' in the matrix. Nova Scotia builds its equipment for the long term outfitting vehicles with high quality standardized parts for durability. Minnesota DOT builds in combination with a third party vendor dividing the building process into three phases and outsourcing the installation of the hydraulic system and some of the hardware mounting. Both Ohio and Texas have laws requiring the use of inmate labor to build their trucks. Ohio's law dates from the 1800's and they keep staffing on-site to help Ohio Penal Industries build according to Ohio DOT specifications. Texas' law, Senate Bill 338, was established in 1963 which led to the creation of Texas Correctional Industries. Montana claimed that during an in-house study they found that they could build trucks for $150,000 that other agencies bought for $160,000 - 220,000. Wyoming did indicate in their interview that one of the benefits they experience from building is standardization of their trucks such that any truck within any one of their five districts is the same as other trucks in other districts. Kentucky

likewise supported their decision with an internal study on their incidence response and geotechnical group vehicles showing that they could save 25 – 35% by building in-house.

Table 4.1. Vehicles That Are Self-Built Organized by Agency

Agency	Vehicle Types Built
Arizona DOT	Cone Truck Bodies for Traffic Control
California DOT	Dump Trucks; Cargo Trucks; Plow Trucks; Cone Trucks
Florida DOT	Sign Truck Body; Tree-Trimming Body; Specialty Body
Kentucky TC	Incidence Response; Highway Construction; Geotechnical Water Trucks
Maine DOT	36,000 GVWR; 16,000 GVWR
Minnesota DOT	Snow Plow Trucks
Montana DOT	Plow Trucks; 1 Ton Dump Trucks; Attenuator Trucks; Weed Spray Trucks
Nova Scotia TIR	Tandem Snow Plow; Single Axle Snow Plow; Paint Trucks; Salt Box with Spinner
Ohio DOT	Dump Trucks; Snow & Ice Equipment (hoppers, spreaders, plows, etc.); Stake Rack/ Utility Body Vehicles
Oregon DOT	Herbicide Applicators; Deicers; Wing Plows; 1 Ton Truck
Pennsylvania DOT	Weld Truck Flat Bed; Cone Placement Truck
South Carolina DOT	Incidence Response; Dump Trucks; Flatbed Trucks; Anything in cab/chassis configuration
Texas DOT	Dump Trucks, Trailers, Herbicide/Deicing Trucks
Wyoming DOT	Tandem Axle Plow Trucks; Single Axle Plow Trucks; Material Spreaders; Plows

Table 4.2. Motivations for Self-Building Organized by State/Province

	AZ	CA	FL	KY	ME	MN	MT	NS	OH	OR	PA	SC	TX	WY
Cost		x	x	x	x		x		x			x		x
Quality		x					x	x				x		x
Unique Need	x	x			x						x			
Control						x								x
Convenience			x							x				
Creates Jobs							x			x				
Speed		x										x		
Equipment Standardization		x						x						
Required By Law									x				x	
Lack of In-State Vendors												x		

In addition to using total weighted value to determine which factor most strongly convinced agencies not to self-build, we also used Table 4.3 to clearly show how each non-builder answered this question. Different from self-builders, the factors in this table are not motivations but discouragements. Instead of lack of workspace being the most convincible factors, time constraints are now most frequently answered by 7 non-builders.

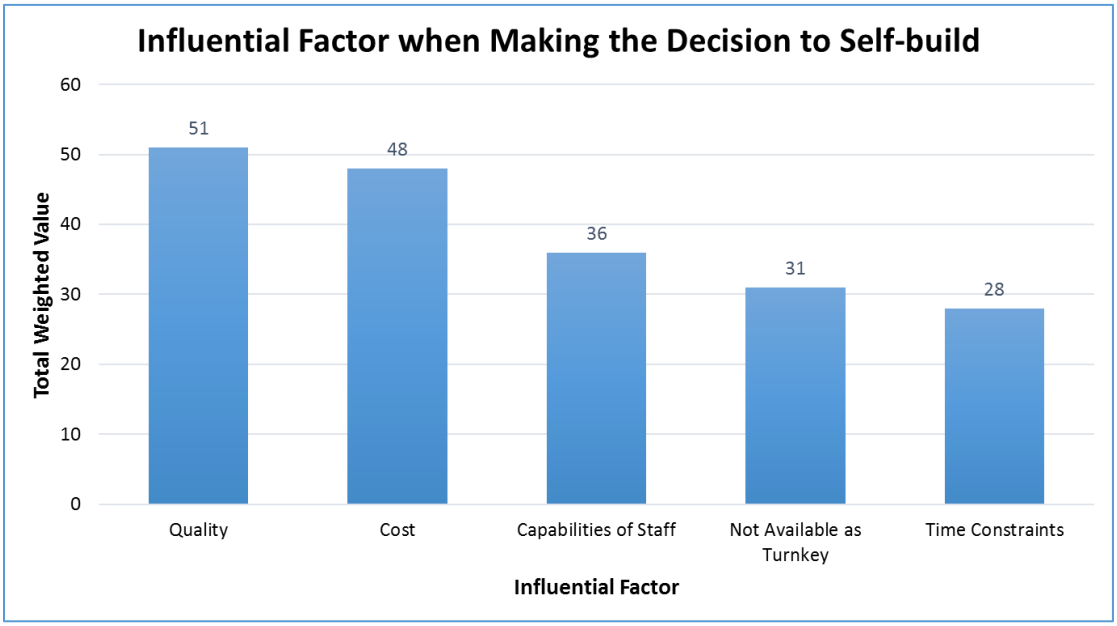
Table 4.3. Discouragements for Non-Self-Building Organized by State/Province

	AK	ID	MA	SD	TN	UT	VT
Time Constraints	x	x	x	x	x	x	x
Lack of Workspace	x	x	x		x	x	x
Cost Concerns	x	x	x	x	x	x	
Lack of Expertise	x	x	x	x	x		
Safety Concerns	x		x		x	x	
Lack of Staff						x	x
Competition with Private Enterprise		x					

The first ranking question asked of builders presented self-builders with a list of five factors asking respondents to rank the choices according to how much the factor would influence the decision to self-build. Listed factors included: ‘Not Available as Turnkey’, ‘Cost’, ‘Time Constraints’, and ‘Capabilities of Staff’. Still using the “Total Weighted Value” method, we can see from the bar chart below (Figure 4.13) that quality edged out cost by just three units as the most influential factor. Following by cost, capabilities of staff, not available as turnkey, and time constraints that were voted as the less influential factor among survey participants. For this question, Oregon ranked ‘work’ as their number one most

influential factor citing that keeping technicians busy was the most influential factor that impacted their decision to build.

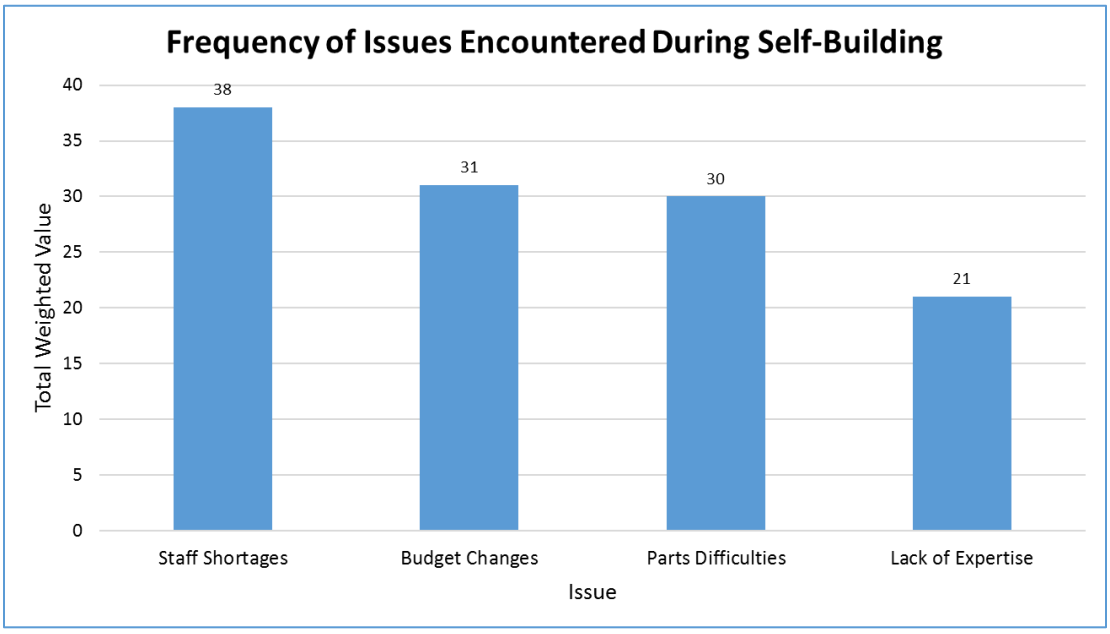
Figure 4.13. Factors that Influence Decision to Self-Build Ranked from Most to Least Important



The second and final ranking question presented a list of issues that might occur during self-building and asked respondents to rank each factor according to how frequently the issue was encountered. Listed factors included: staff shortages, lack of expertise, parts difficulties, and budget changes. The most frequently encountered problem among the surveyed building agencies was staff shortages. Budget changes ranked below staff shortages as the second most frequently encountered problem. Parts difficulties was chosen as the third most common issue and lack of expertise was ranked as the least commonly experienced problem. A number of states indicated that they did not encounter one or more of these problems at all. The least applicable response was 'lack of expertise' with four states agreeing that they did not encounter this problem in some cases indicating that this was because their mechanics were trained in-house.

In an effort to understand the relationship between budget and building, a multiple choice question was presented to respondents asking if increases or decreases in budget lead to increased or decreased rates of building and increased or decreased rates of turnkey purchasing. The most common response with six replies was that increases in budget would lead to more turnkey acquisitions and less self-building. This response was usually justified by noting that buying more and building less would allow mechanics to devote their time to other tasks such as maintenance. The second most common response with four responses was that none of the options presented were applicable because more budget would generally entail both more building and more turnkey purchasing. Both Nova Scotia and Wyoming indicated that an increase in budget would result in more self-building. Nova Scotia chose to elaborate on this response noting that they use higher quality and more costly parts in their equipment to avoid purchasing turnkey items which tend to require more maintenance and the rebuilding of plow gear.

Figure 4.14. Frequency of Issues Encountered During Self-Building Ranked

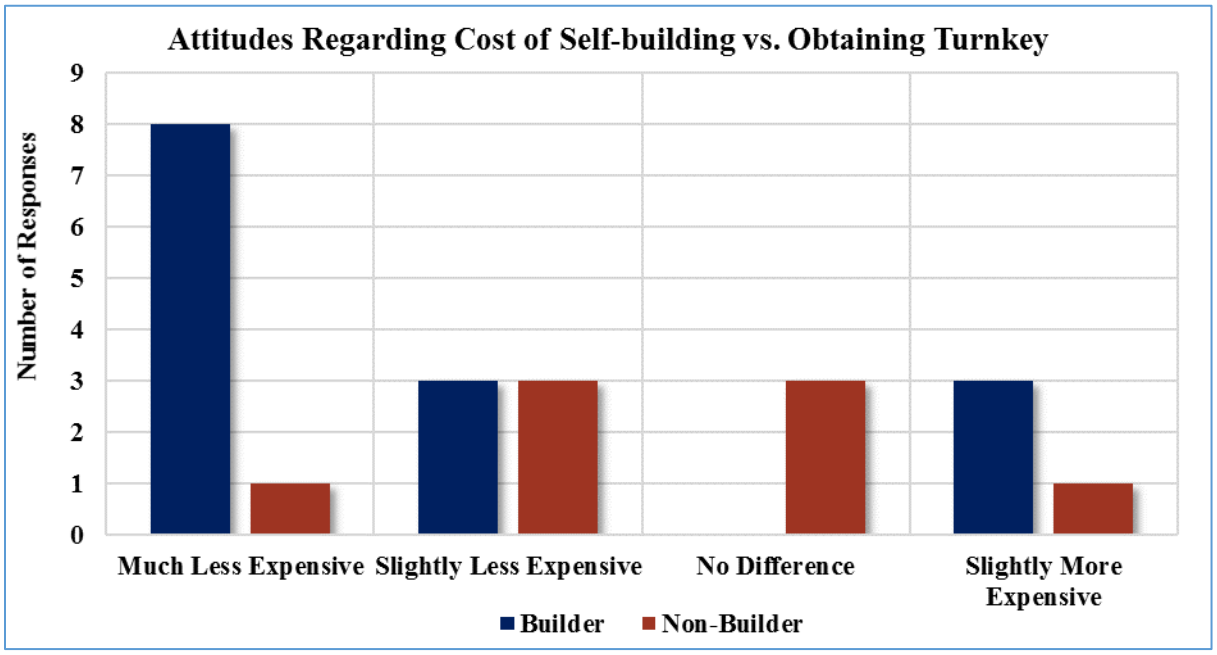


Questions relating to the duration of time spent verifying equipment and how this compared to turnkey vehicles concluded the self-building agency specific questions. The time reported by agencies verifying the quality of self-built equipment ranged from 2 hours to days. Ohio noted that they have two full-time employees that verify the quality of their vehicles. Seven of thirteen agencies stated that they spent more time verifying the quality of vendor-built vehicles than they did on self-built vehicle equipment. Four of the thirteen agencies that responded to this question stated that there was no difference between the time that was spent verifying vendor-built vehicle equipment versus the time spent on equipment that was self-built. For one agency this question was not applicable and one other agency verified spending less time quality-checking vendor-built vehicle equipment versus self-built.

4.6 Opinion Questions

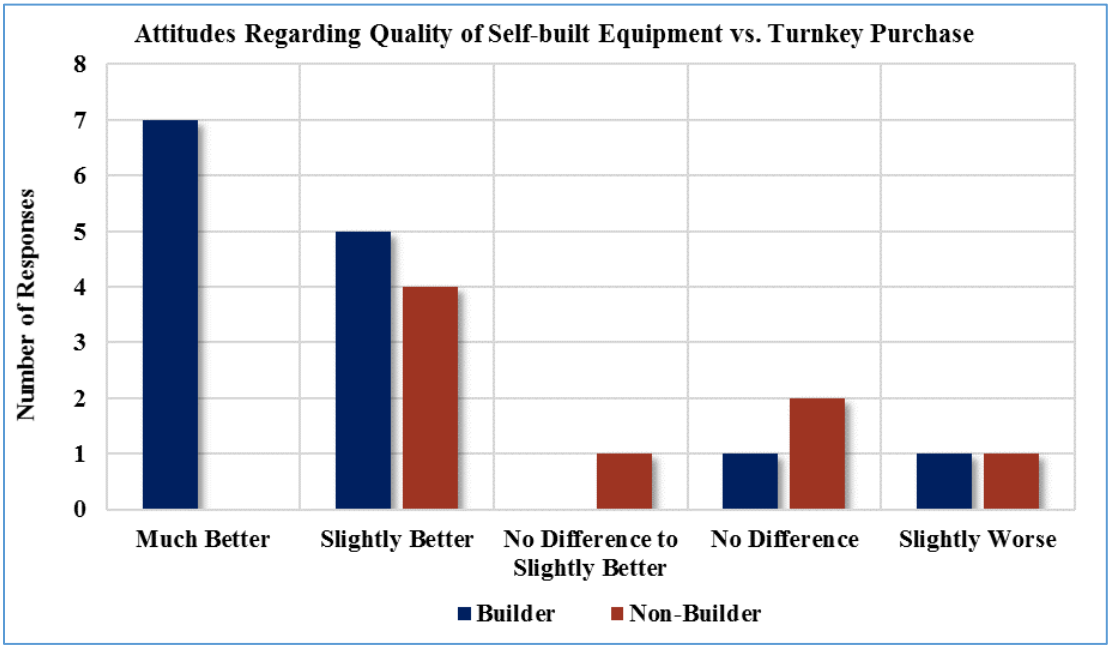
A series of lighter multiple choice opinion questions was asked of all respondents as the survey approached its end. The first opinion question asked the respondent to rate how much more expensive or cheaper they thought self-building to be in comparison with purchasing turnkey. The majority of survey respondents thought building to be cheaper with the vast majority of self-building respondents agreeing that the process was much less expensive. All three of the self-building respondents that ranked self-building as slightly more expensive ranked quality ahead of cost in the self-building influences question. These three agencies also build for reasons other than cost savings such as unique need, quality, and job creation. Responses from non-building agencies tended around slightly less expensive to no difference.

Figure 4.15. Attitudes Regarding Cost of Self-building vs. Obtaining Turnkey



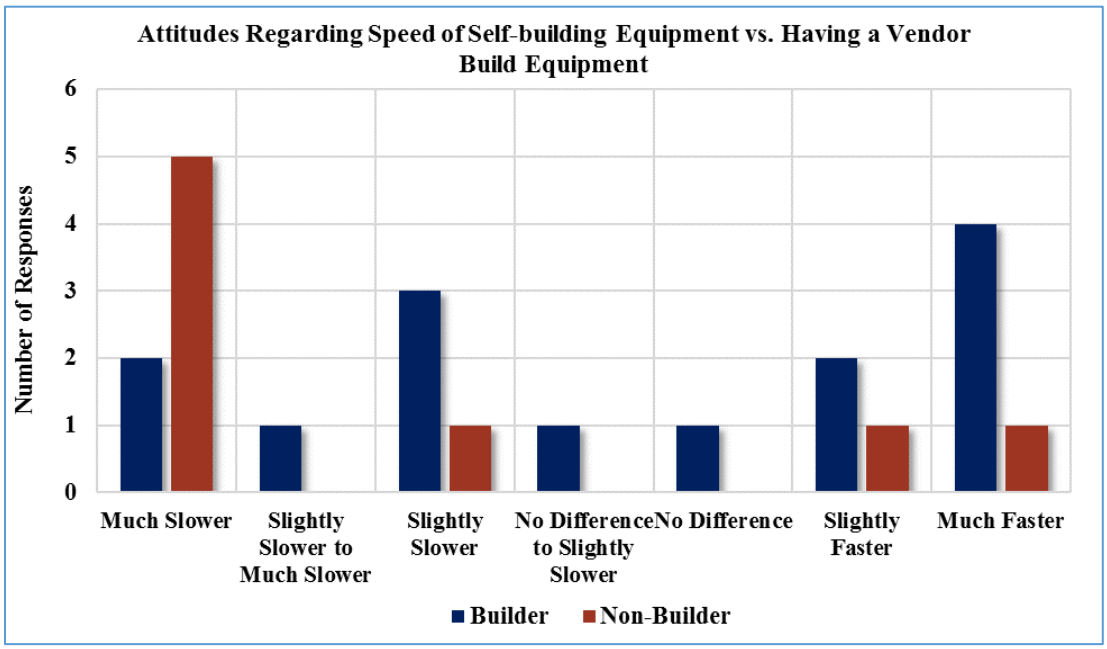
In terms of quality, building agencies viewed self-built equipment as having much better quality than their turnkey counterparts. All non-building agencies ranked self-building quality from slightly better to much worse. The 'No Difference to Slightly Better' response was not an original option listed in the multiple choice question. If a respondent felt that they would be more comfortable with a range response, this was accommodated for in survey analysis. It may be worth noting that the self-building agency that ranked the quality as slightly worse also ranked lack of expertise as their agency's number one most frequently encountered problem.

Figure 4.16. Attitudes Regarding Quality of Self-built Equipment vs. Turnkey Purchase



Non-building agencies agreed that self-building would probably be slow. Beyond that, there existed a much broader distribution of responses amongst self-builders than seen in the previous opinion questions. Seven out of fourteen self-building agencies ranked the speed of self-building below 'No Difference'.

Figure 4.17. Attitudes Regarding Speed of Self-building Equipment vs. Having a Vendor Build Equipment

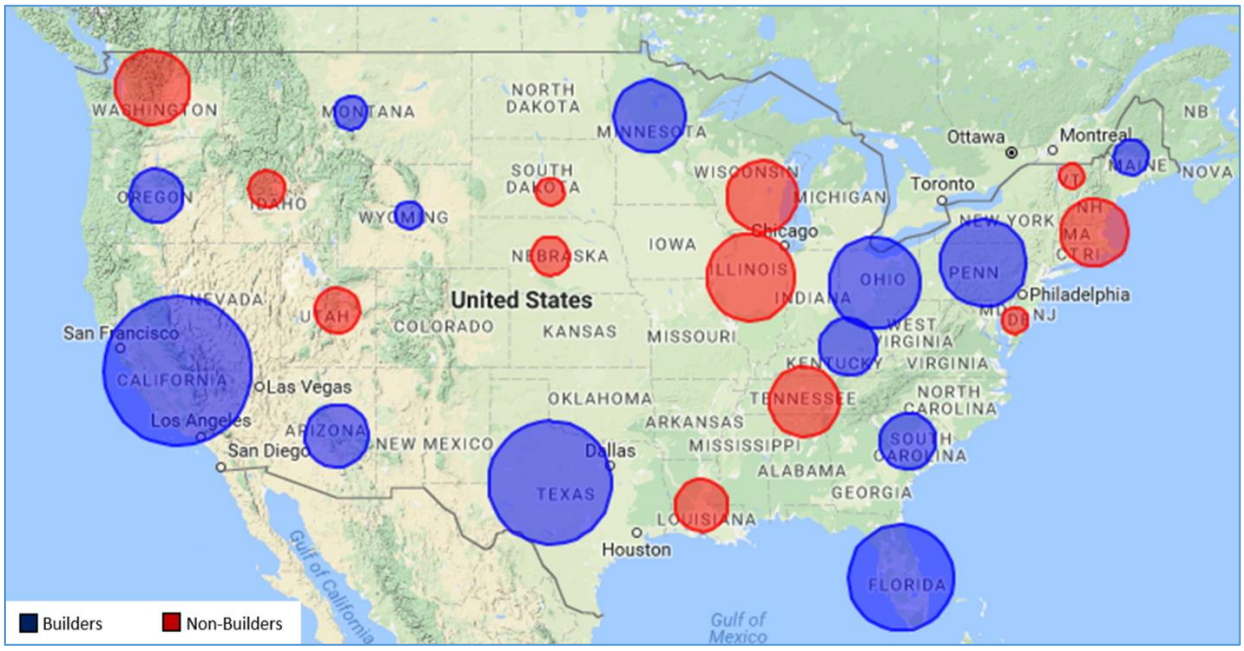


The opinion questions concluded the procurement survey though three additional questions on replacement were attached to the end of this survey. The primary purpose of these questions was to gather information outside the scope of procurement for another project on replacement. These responses will be made available to any who may be interested in the results. A number of agencies did admit that they had at one point conducted an internal review or contacted other agencies for information relating to self-building. However, none of these reports were available to the public or had been published. Many agencies stressed that the studies had been informal and for in-house purposes only.

4.7 Additional Analysis of Survey Results and Existing Public Data

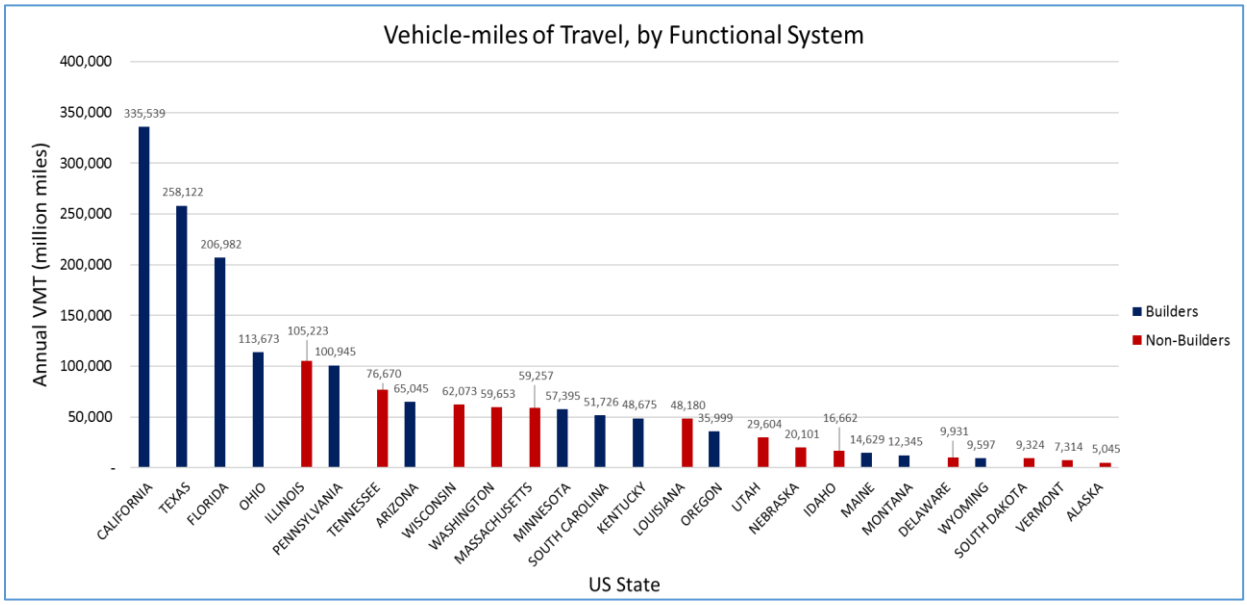
After several discussions with Caltrans, some additional analyses were conducted. The research team further evaluated the characteristics of both self-builders and non-builders. Survey results and existing public data were selected and either analyzed independently or combined with the survey results. The primary purpose of this section is to determine if there is any clear pattern or obvious differences between builders and non-builders. The initial evaluation consisted of Vehicle Miles Traveled (VMT). VMT is a measure of the extent of travel on all public roads in the United States. The following two figures present states' VMT by functional system data from FHWA website. The functional system includes both rural and urban public roads. Within each figure the road type is separated by: interstate, other freeways and expressways, other principal arterial, minor arterial, major collector, minor collector, and local roads. In Figure 4.18, the VMT data is shown on the US map by using different circles for each respondent state. To discriminate self-builders and non-builders, they are still colored as blue and red. The center of each circle is the longitude and latitude published on Google, and the magnitude of each circle is the actual VMT value adjusted by using square root and weighting factor.

Figure 4.18. Vehicle-miles of Travel, by Functional System



To be more precise, the VMT data is also shown in a bar chart (Figure 4.19). A t-test is performed to determine if there existed a significant difference between VMT of building agencies and non-building agencies; t(14)=2.06, p=0.058. Although the p-value is slightly over 0.05, it still can be determined that building agencies in our sample tended to have larger VMT.

Figure 4.19. Vehicle-miles of Travel, by Functional System



To compare the amount of VMT supported by the state's DOT, the size of each fleet is analyzed with both VMT and total state motor-vehicle registrations. In figure 4.20, the annual VMT of each state is divided by the fleet size, which can be interpreted as how many vehicle miles traveled each piece of equipment is able to serve in each year. According to the figure, it can be proved by those spikes on the

green line that builders usually have higher VMT. But for the VMT serving rate itself, the p-value didn't show a statistically significant difference between builders and non-builders.

Figure 4.20. Annual State VMT Served by Fleet Size

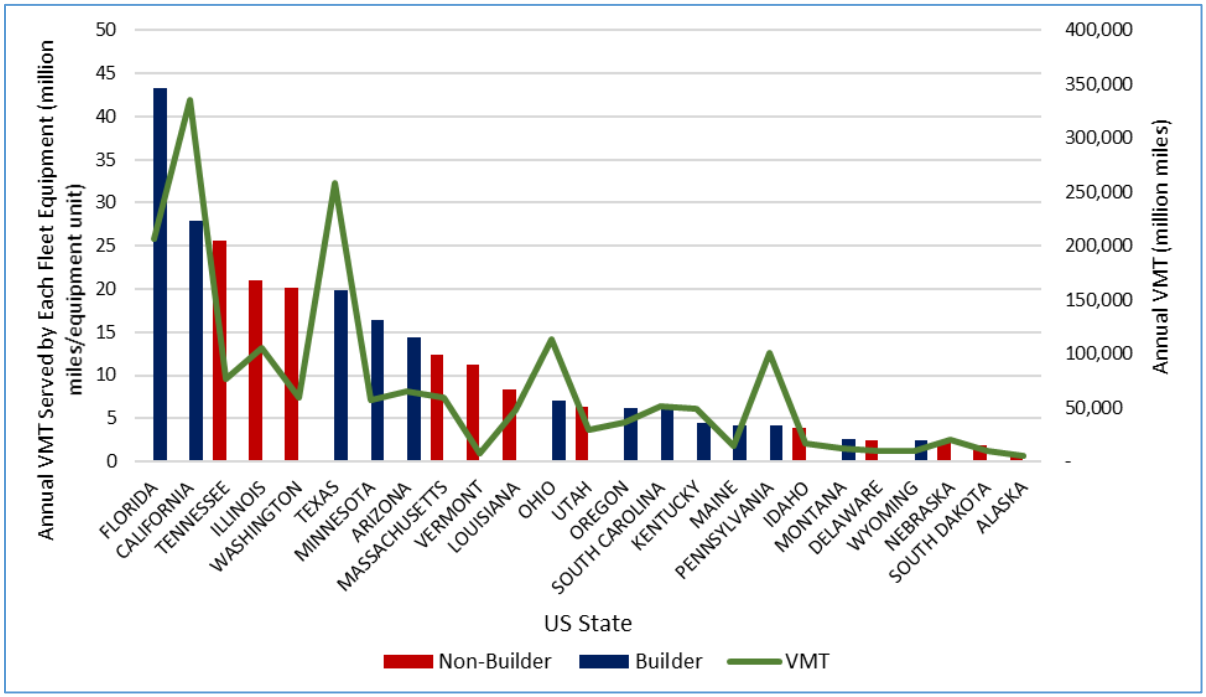
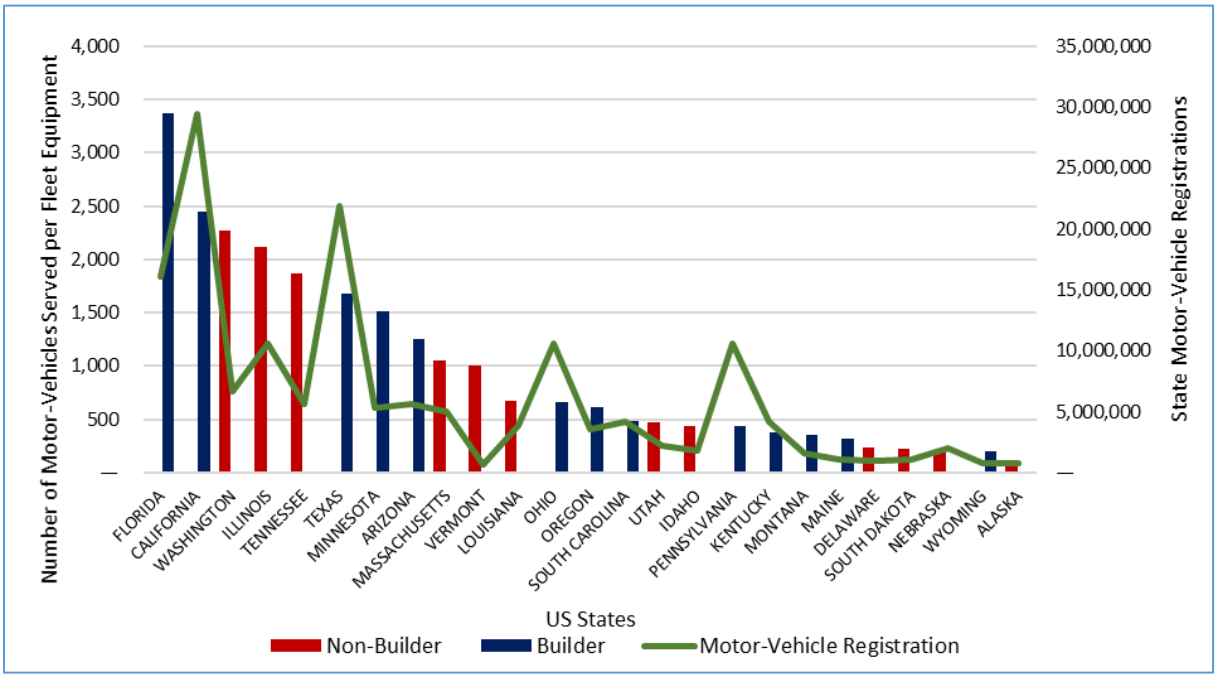


Figure 4.21. State Motor Vehicle Registrations Served by Fleet Size

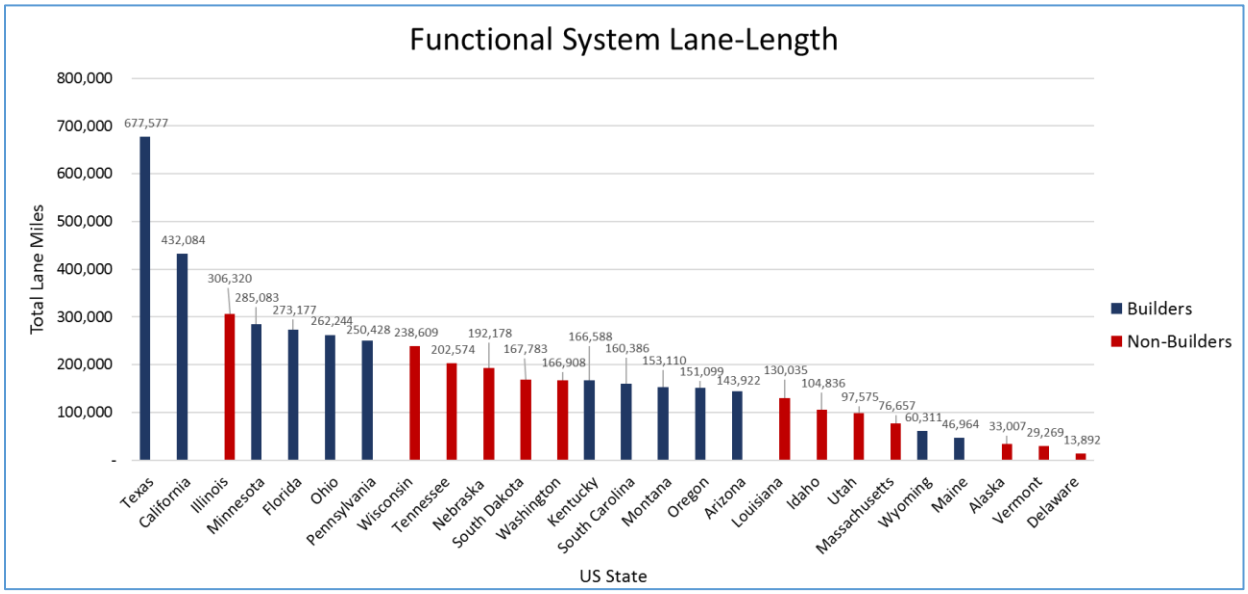


Similarly, in figure 4.21, the total motor-vehicle registrations of each state is divided by the fleet size, which can be interpreted as how many registered vehicles are served by each individual piece of fleet

equipment. But just as the VMT serving rate, the p-value of motor-vehicle serving rate also didn't show a statistically significant difference between builders and non-builders. It's understandable due to the annual VMT and state motor-vehicle registrations being highly correlated with a correlation coefficient of 0.99031.

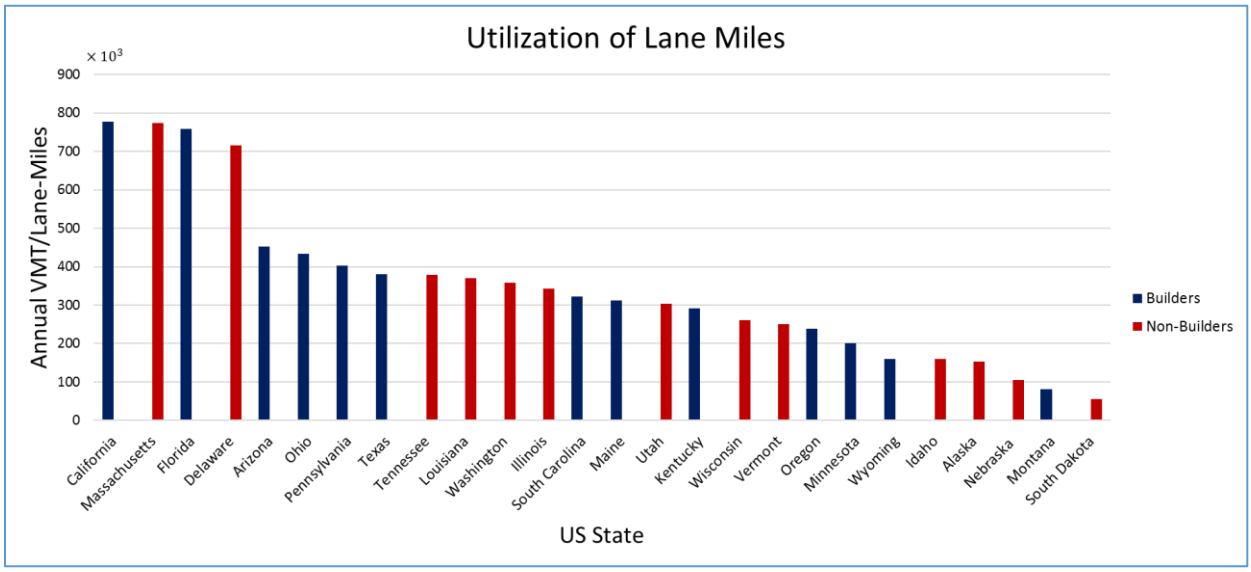
Another item evaluated by the research team is the Functional System Lane-Length (Figure 4.22). Relative to the lane mile itself, a t-test is performed to determine if there exists a significant difference between lane miles of building agencies and non-building agencies; $t(18)=1.91$, $p=0.072$. Based on the p-value, it's inconclusive whether building agencies tended to have higher functional system lane-length. Evaluating the correlation between VMT and lane miles, the coefficient is 0.837, which is not low, meaning VMT and lane miles are correlated.

Figure 4.22. Functional System Lane-Length



Perhaps a more meaningful evaluation of both VMT and lane mile is to compare a ratio, by using VMT divided by lane miles (Figure 4.23). The ratio can be interpreted as the utilization of Functional System Lane-Length, or the average annual daily traffic for a section of road by the land-length. Unfortunately, there still doesn't exist a clear pattern showing utilization differed from self-builders and non-builders. But within the top 8 agencies who have higher utilization of lane miles, 6 of them are builders.

Figure 4.23. Utilization of Functional System Lane-Length



The final characteristic evaluated is Fatality Rate per 100 Million Annual Vehicle Miles Traveled. Similar to the VMT, the fatality rates are also presented into two figures (Figure 4.24 & 4.25), both geographically and statistically. After performing the t-test, the p-value still didn't show a statistically significant difference between builders and non-builders. But the research team did see an opposite result between VMT and fatality rate. Those agencies with higher VMT are having lower fatality rates.

Figure 4.24. Fatality Rate per 100 Million Annual Vehicle Miles Traveled

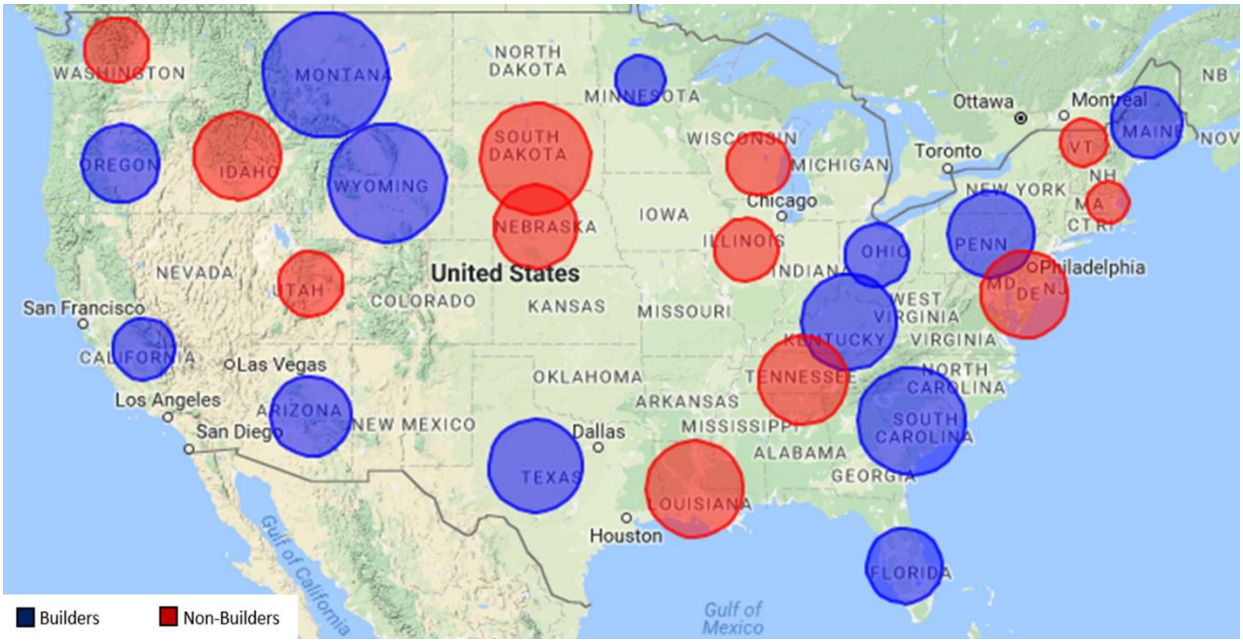
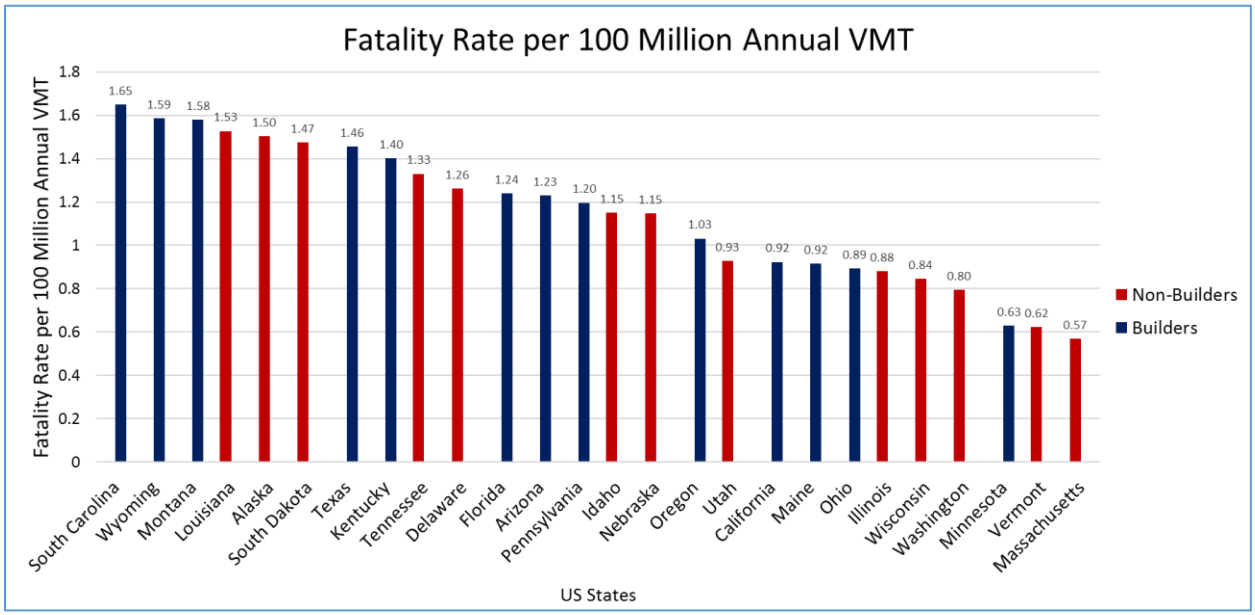


Figure 4.25. Fatality Rate per 100 Million Annual Vehicle Miles Traveled



5. SUMMARY & CONCLUSION

Utilizing the survey responses and information obtained during interviews, we have gained insight into the agencies that build, previously built, and have no interest in building. Using statistical tests, it was determined that agencies that build on average have larger fleets and a greater number of mechanics than agencies that do not. Whether these larger numbers are a consequence or an influence is uncertain. Fleet sizes were characterized by asking respondents to divide their agency's fleet into categories and estimate what percentage of their agency's fleet was obtained through various procurement methods. While interpretations of categories varied and confusion occurred, it was determined that non-self-propelled equipment and dedicated snow equipment composed the bulk of given fleet equipment and that the most popular methods of procurement among participants were turnkey purchasing, heavy vendor modification/building, self-building, renting/leasing, and lease-to-own programs in that order without taking into account modification.

Participants were split into two categories depending on whether or not they had recently built a piece of equipment with a cab or chassis. The survey sample was determined to be 50% non-building agencies and 50% building agencies. The majority of non-self-building agencies in our survey sample admitted that they either had no interest in self-building or had not considered it before. Three agencies confessed that they had self-built in the past and described the issues that they experienced including lack of staff and minimal cost savings. Among the non-building agencies, lack of workspace was considered the most influential factor that deterred the decision to build. In opinion questions, the bulk of non-builders agreed that self-building was slow and the cost savings would be moderate to non-existent. The majority of non-builders also valued cost and quality when deciding whether or not to obtain a vehicle from a vendor.

All building agencies gave an estimated value that reflected how much of their fleet was self-built where the average built value was 13%. Building agencies then described the types of equipment that they built ranging from material spreaders and trailers to cone trucks and tandem axle plows. Cost, quality, and unique need were the three most frequently cited reasons for building though unique cases also cited

inmate labor laws and the need to keep mechanics occupied as motives to build. Quality was ranked as the number one influential factor impacting the decision to build surpassing cost by one response. The majority of building respondents indicated that if they had more budget they would chose to purchase more turnkey rather than build while others indicated that budget changes would not impact their equipment building rate at all.

Among building respondents, there did not exist a correlation between the number or percentage of mechanics that assisted in building and the number or percentage of built fleet vehicles. However, there did exist a positive correlation between the percent of budget spent on building and the percentage of fleet built though this correlation proved non-existent between the percent of budget spent on building and the number of equipment items built. This may be due to larger fleets that spend a smaller percent of their budget to build just as many pieces of equipment as agencies that devote a larger portion of their overall smaller budget. A weak correlation was also found between the number of mechanics that built and the percent of fleet equipment built. Staff shortages were the most frequently encountered issue among self-building agencies. Self-building agencies also agreed that building tended to be cheaper and produce a higher quality product than purchasing from a vendor. However, on the subject of self-building speed the responses of builders were more varied.

The intention of this survey has been to characterize the qualities of agencies that both do and do not build. Given our small target population for this survey, each response had the capacity to drastically change the observations given in this report with each agency response acting as a unique glimpse into the different challenges and goals of the organization. There still exists much to be said concerning the practice of government agency fleet building. How liability is handled, methods for maximizing worker efficiency, unique technologies or practices that can help expediate the process or assist mechanics can be considered topics worth future investigation. Regardless of what still remains unknown, the information shared by all respodents has helped to provide a contextual foundation to the act of self-building that did not exist before.

6. REFERENCES

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[2] California Department of Transportation. *Addendum to Light-Duty 4-Yard Dump Truck Comparison*.

[3] Ellingsworth, R. (2013). Minnesota DOT Snow Plow Truck Fabrication Process [Video]. *2013 Midwest & Northeast Equipment Management Joint Meeting*. Retreived from http://www.emtsp.org/equipment-partnerships/joint-meetings/2013-midwest-northeast-equipment-management-joint-meeting/?vid=14

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[6] Equipment Management Technical Services Program. Contact List. Retreived from http://www.emtsp.org/contact-list/

APPENDIX A: PROCUREMENT SURVEY

- **Note: You may guess, estimate, or provide a range for any question. I encourage you to answer as many questions as you are able and consult with colleagues if you are unsure. If you have any concerns, comments, or questions, feel free to contact me at christina.valen@ucr.edu. All questions are voluntary. Thank you for your participation and I look forward to speaking with you!**

Q1. Approximately how many vehicles and pieces of vehicle equipment are currently in your agency's fleet? (Include both working and nonfunctioning vehicles)

Q2. Approximately how many employees currently work at your agency?

Q3. Approximately how many mechanics does your agency currently employ?

Q4. Give an approximate percentage or quantity that represents how much of your agency's fleet belongs in each of the equipment categories below. Equipment that belongs in more than one category should be placed in the most specific category possible. Equipment that is difficult to classify can alternatively be placed in 'other'.

- Non-Self-Propelled Equipment: i.e. trailers, air compressors, generators, NAFA codes 0100 - 109, 118 - 0912, etc.
  % or units
- Passenger Vehicles: i.e. passenger vans, station wagons, SUVs, sedans, and buses, etc.
  % or units
- Dedicated Snow Equipment: i.e. snow blowers, hopper spreaders, NAFA codes 110 - 117, 9260 - 9263, etc.
  % or units
- Road Maintenance Equipment: i.e. millers, rollers, sweepers, paint striping trucks, NAFA codes 9400 – 9480, etc.
  % or units
- Off-road Construction Vehicles: i.e. loaders, graders, dozers, excavators, forklifts, NAFA codes 9000 - 9350, 9500 - 9570, 9700 - 9990, etc.
  % or units
- Landscape Maintenance Equipment: i.e. tractors, chippers, mowers, tree trimmers, NAFA codes in 9600 -9623, etc.
  % or units
- Remaining Utility and Maintenance Vehicles < 16,000 GVWR: i.e. work vans, pickup trucks, cargo body trucks, NAFA codes in 1000 – 4754, etc.

____ % or ____ units

- Remaining Utility and Maintenance Vehicles > 16,000 GVWR: i.e. wreckers, dump trucks, truck tractors, NAFA codes 5000 - 8890, etc.

  ____ % or ____ units

- Other:

  ____ % or ____ units

Q5. Of the vehicles and vehicle equipment in your agency's fleet, what percentage would you estimate was purchased turnkey (ready to deploy after up-fitting with decals, lights, radios) from an outside vendor?

____ %

Q6. Approximately what percentage of your agency's fleet is currently rented or leased from an outside party and has been for a period longer than 30 days? This does not include lease-to-own programs.

____ %

Q7. Approximately what percentage of your agency's fleet was obtained by or is currently part of a lease-to-own program?

____ %

Q8. Approximately what percentage of your agency's fleet was specially built or heavily modified by an outside vendor to meet user specifications (built to agency defined specifications)?

____ %

Q9. Does your agency prep, up-fit, or perform minor modifications to fleet vehicles? This includes decals, light bars, radios, and anything else that does not change the vehicle's intended design function.

☐ YES ☐ NO

The addition of decals and a light bar to the pickup on the left is considered to be up fitting.

Image Source: http://www.dot.ca.gov/hq/eqsc/QualityStandards/FleetID/FI-3/I-007PU-DE.pdf

Self-building will be defined as the act of combining individual components to perform a function by in-house staff. Any piece of fleet equipment that has been built by department staff from major essential components such as the body and chassis will be called "self-built".

Source: Ed Giroux, Caltrans Division of Equipment

The above vehicle would be considered one possible example of a self-built piece of equipment.

Q10 Has your agency self-built a vehicle or a piece of vehicle equipment within the last five years?

☐ YES ☐ NO

- **<u>Note: You will not be asked *all* questions from Q11 through Q26. Some questions will only be asked of certain agencies depending on previous responses. All questions have been put here for your review.</u>** **If Q10 = NO: Please answer Q11-Q13 & Skip to Q27.** **If Q10 = YES: Please skip Q11-Q13.**

Q11 To your knowledge, has your agency ever investigated self-building a vehicle or a piece of vehicle equipment within the last five years? ☐YES ☐NO

Q12 If you answered 'Yes' to the previous question, rank the following factors in order from 1 to 5 where 1 will correspond to the issue that most strongly convinced your agency not to self-build. You can substitute 1 of the 5 options with 'other' if need be.

_____ Time Constraints

_____ Lack of Staff Expertise

_____ End Product Safety Concerns

_____ Lack of Workspace

_____ Cost Concerns

_____ Other:

Q13 Rank the following factors from 1 to 5 where 1 will be the most influential factor and 5 will be the least influential when deciding to obtain a vehicle from a vendor.

_____ Cost

_____ Delivery Time

_____ Warranty

_____ Safety of End Product

_____ Quality

Q14 Does your agency self-certify vehicles that have been self-built to comply with Federal Motor Vehicle Safety Standards? ☐ YES ☐ NO

Q15 Approximately what percentage of your agency's current fleet would you say is self-built?

_____ %

Q16 Does your agency self-build any equipment that is available turnkey from a vendor's existing product line (i.e. Caterpillar, John Deere, Honda, etc.)? If yes, please describe the equipment.

Q17 Please List the three vehicle types that your agency most frequently builds. You are welcome to list less or more than three vehicle types in the space below:

#1:

#2:

#3:

Other:

Q18 Why does your agency decide to build these vehicles? E.g. Convenience, unique need, cost, etc.

Q19 Please rank the following options from 1 to 5 where 1 will be the most influential factor and 5 will be the least influential factor when making the decision to self-build.

_____ Not Available as Turnkey

_____ Quality

_____ Cost

_____ Time Constraints

Capabilities of Staff

Q20 Which of the following statements reflects how changes in budget affect your agency's decision to self-build? [Select all that apply]

- ☐ Increases in budget result in more turnkey acquisitions and less equipment self-building
- ☐ Increases in budget result in more equipment self-building and less turnkey acquisitions
- ☐ Decreases in budget lead to more turnkey acquisitions and less equipment self-building
- ☐ Decreases in budget lead to more equipment self-building and less turnkey acquisitions

Q21 Would you like to elaborate on your response to the previous question?

Q22 Approximately what percentage of your vehicle acquisition budget goes towards self-building?

%

Q23 Approximately what percentage of your agency's mechanics would you say are involved in assembling self-built vehicles and vehicle equipment?

%

Q24 Each option presented below represents a problem or issue that can occur during self-building. Rank these options from 1 to 4 where 1 will be the most commonly encountered problem and 4 will be the least common.

Staff Shortages

Lack of Expertise

Parts Difficulties

Budget Changes

Q25 What is the average amount of time your agency spends verifying the quality of self-built vehicle equipment per equipment unit?

☐ Hours ☐ Days ☐ Weeks ☐Other:

Q26 On average, does your agency spend less time, more time, or about the same amount of time verifying the quality of vendor-built vehicle equipment than it spends verifying the quality of self-built vehicle equipment?

- O Less Time Verifying Vendor-Built Quality
- O More Time Verifying Vendor-Built Quality

- O No Difference in Time Verifying Vendor-Built Quality
- O Not Applicable

Q27 through Q29 will ask for your professional opinion on self-built versus vendor-built and turnkey vehicle equipment.

Q27 How would you compare the cost of self-building a piece of equipment versus obtaining it turnkey?

- O Much Less Expensive
- O Slightly Less Expensive
- O No Difference
- O Slightly More Expensive
- O Much More Expensive

Q28 How would you compare the quality of a self-built piece of equipment versus a piece of equipment obtained turnkey?

- O Much Worse
- O Slightly Worse
- O No Difference
- O Slightly Better
- O Much Better

Q29 How would you compare the speed of self-building a piece of equipment versus having a vendor build the same piece of equipment (not counting travel)?

- O Much Slower
- O Slightly Slower
- O No Difference
- O Slightly Faster

○ Much Faster

QR1 How does your agency decide which pieces of equipment to replace in your fleet?

QR2 Does your agency use fleet management software or programming scripts to handle equipment lifecycle assessment?

QR3 Has your agency performed any internal studies concerning self-building or fleet replacement?