2020 Census Research and Testing
2015 Address Validation Test

A New Design for the 21st Century

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Executive Summary

The purpose of the 2015 Address Validation Test (AVT) was to assess the performance of various methods to develop the 2020 Census address frame and determine workloads for the 2020 Census Address Canvassing operation. We conducted the AVT between September 2014 and February 2015.

The test had two components. The first, the Master Address File (MAF) Model Validation Test (MMVT), consisted of a *full-block canvass* intended to assess the ability of a set of statistical models to predict blocks that have experienced address changes that are not recorded in the MAF. If effective, the statistical models would offer an inexpensive solution to the problem of determining which census blocks require updates or which do not. To study the effectiveness of the models, we collected address data in an address listing operation in a national sample of 10,100 blocks. The results of the fieldwork were compared to the predictions from the statistical models.

The second component of the AVT was the Partial-Block Canvassing (PBC) Test. This component was a proof of concept to assess an alternative approach that used geographic activities (a) to detect unrecorded changes in blocks, and (b) to identify *portions* of blocks where change is detected and updates to the address list are expected, thus enabling a partial-block canvass that could reduce workloads and cost. To detect possible changes within the 10,100 MMVT sample blocks, geographers at headquarters reviewed aerial imagery over time compared to counts of addresses in the MAF. In a subset of these blocks, listers updated the address list in the portions of these blocks where the in-office review identified possible changes. The primary purpose of the PBC Test was to collect information regarding the effectiveness of this new canvassing method. In addition, because the in-office imagery review is a critical component of the PBC process, data collected by PBC listers also allow us to assess the performance of the interactive review.

The results of the 2015 AVT directly inform the design decisions that the Census Bureau will render in Fiscal Year (FY) 2015. This report documents (1) the performance of several statistical models for determining blocks that require canvassing and for measuring MAF coverage and (2) the effectiveness of in-office review and feasibility of partial-block canvassing.

<u>Key Observations from the MMVT</u>

The statistical models we applied were not effective at identifying specific blocks with many adds or deletes.

- The rate of error capture was too low.
- The rate of erroneous canvass was too high.

The statistical models were not effective at predicting national totals of MAF coverage errors for several reasons:

- The model parameters reflected the condition of the MAF in 2009. The current condition of the MAF is not represented well by the 2009 model.
- We are only halfway through the decade, and the MAF has improved under the Geographic Support System Initiative (GSSI). An effective model would have to reflect these updates better.

Key Observations from the PBC

1. The PBC methodology was implemented successfully. Work-area polygons and instructions can be created to communicate the extent of the targeted areas. Listers can effectively navigate to work areas and collect accurate address and attribute information. Improvements to polygon delineation and instructions need to be made to clarify assignments and avoid confusion in the field.

2. Imagery review detected adds in the 615 PBC blocks, and PBC listers were able to capture 81 percent of MMVT adds in the same 615 blocks. Additional research is needed to understand imagery review deficiencies and identify improvements to both the in-office imagery review and the in-field PBC processes. In particular, further work is needed to research the 19 percent of MMVT adds that the PBC process did not find.

Recommendations

1. Do not use statistical models to predict which blocks or areas need in-field canvassing.

2. Conduct additional research and analysis using counts of adds, deletes, and changes, as well as address-level analysis to fully understand differences between MMVT and PBC listing results and to gain greater insight into the effectiveness of imagery review.

3. Improve clarity of written instructions and work-area polygon definitions for PBC listers. Test the PBC methodology with traditional listing staff.

4. As part of the Census Bureau's reengineered address canvassing for the 2020 Census, establish a program to
    - evaluate the state of the MAF regularly (annually or semi-annually),
    - assess the effectiveness of the in-office methods as they evolve during the decade, and
    - test and improve the in-field canvassing procedures.

1 Address Validation Test Introduction

Enumerating more than 133.3 million housing units, the 2010 Census was the largest and most costly census in history. The 2020 Census Program managers and staff are committed to conducting the 2020 Census at a lower cost per household (adjusted for inflation) than the 2010 Census, while maintaining high quality results. We will accomplish this using evidence from our past and future research and tests, providing results to support our data-driven Census design decisions, and through our continued solicitations for advice and recommendations from external stakeholders such as the National Academy of Sciences (NAS), the Office of the Inspector General (OIG), the Government Accountability Office (GAO), and the Census Bureau's Scientific Advisory Committee (CSAC) and National Advisory Committee (NAC).

In September 2014, senior Census Bureau managers outlined four Key Innovation Areas of the 2020 Census. These four Key Innovation Areas are at the core of our research, testing and operationalization efforts leading up to the next census:

1. Reengineering Address Canvassing—eliminate a nationwide in-field address canvassing in 2019;
2. Optimizing Self-Response—communicate the importance of the 2020 Census to the United States population and generate the largest possible self-response, eliminating the need to follow up with those households;
3. Utilizing Administrative Records—use data that the public has already provided to the government to reduce the Non-Response Follow-Up workload; and
4. Reengineering Field Operations—use technology to more efficiently and effectively manage the 2020 Census fieldwork.

The results and analysis in this report center on the first Key Innovation Area: Reengineering Address Canvassing. For the 2010 Census, U.S. Census Bureau employees canvassed nearly every block in the nation. From that operation and other data, we know the majority of census blocks do not require updates that affect census coverage (i.e., contain erroneously omitted or included housing units). This is because either no change has occurred in those blocks in the years since the last census, or that the address updates to the MAF during those years account for the change. The fundamental strategy for reengineering the address canvassing operation is to determine the specific set of census blocks that require updating prior to the next census and to use in-office methods wherever feasible. Here, success is defined as reaching a solution that substantially reduces the in-field listing workload of the operation (and thus the dollar costs), while maintaining an acceptable level of accuracy.

To support advancement of a reengineered address canvassing, we conducted an address canvassing test between September 2014 and February 2015. We use the outcomes of this test, the 2015 Address Validation Test (AVT), to assess the performance of various methods to develop the 2020 Census address frame and determine workloads for the 2020 Census address canvassing operation.

The test contains two components. The first, the MAF Model Validation Test (MMVT), consists of a *full-block canvass* that will assess the ability of a set of statistical models to predict blocks that have experienced address changes that are not recorded in the MAF. If effective, the statistical models can offer an inexpensive solution to the problem of determining which census blocks require updates or which do not. To do this, we collected address data in an address listing operation in a national sample of 10,100 blocks. We compared results of the fieldwork to predictions from the statistical models. The second component of the AVT is the Partial-Block Canvassing (PBC) Test. This component is a proof of concept to assess an alternative approach that uses geographic activities (a) to detect unrecorded changes in blocks, and (b) to identify *portions* of blocks in which we detect change and expect updates to

the address list, thus enabling a partial-block canvass that could reduce workloads and cost. To detect possible changes within the 10,100 MMVT sample blocks, geographers at headquarters conducted an interactive review of various materials—primarily aerial imagery over time compared to counts of addresses in the MAF. In a subset of these blocks, listers updated the address list in the portions of these blocks where the in-office review identified possible changes. The primary purpose of the PBC Test was to collect information regarding the effectiveness of this new canvassing method. In addition, because the in-office imagery review is a critical component of the PBC process, data collected by PBC listers also allow us to assess the performance of the interactive review.

The results of the 2015 AVT directly inform the design decisions that the Census Bureau will render in Fiscal Year (FY) 2015. This report documents (1) the performance of several statistical models for determining blocks that require canvassing and for measuring MAF coverage and (2) the effectiveness of in-office review and feasibility of partial-block canvassing.

This report consists of two principal components: 1) a section discussing the MMVT and the statistical models, and 2) a section discussing the PBC Test. Because of the substantial differences in purpose of the two AVT components, it is necessary to treat each separately in the report. The report also contains a final concluding section in which we present a comparison of weighted predicted adds from the review of aerial imagery in comparison to weighted numbers of observed adds from the MMVT as well as commentary regarding the integration of imagery review and statistical modeling to support decisions regarding address canvassing. We conclude the report with recommendations for additional analysis and research.

2 Analysis of Statistical Models using the Master Address File Model Validation Test Results

2.1 Introduction

As part of the effort to reengineer the 2020 Census Address Canvassing operation, we are researching the use of statistical models to identify census blocks that have changes in the address inventory that are not recorded in the Master Address File (MAF) through usual updating. If the statistical models are successful in this effort, they could be a mechanism, directly or in conjunction with other information, to reduce the amount of fieldwork for this operation. Another use of the statistical models is to predict the coverage errors in the MAF. That is, given the set of addresses in the MAF that we consider valid living quarters, we are researching statistical models that predict the count of addresses that are erroneously omitted (missing from the frame) and the count of addresses that are erroneously included (e.g., nonexistent or duplicative addresses).

To assess how well the statistical models perform, we conducted the MAF Model Validation Test (MMVT). For the MMVT, a 10,100 block sample was drawn to conduct a dependent listing operation where listers canvassed each block and made changes to the address list: verified, corrected, added and deleted addresses. The results of this dependent listing were used to evaluate the performance of various statistical models to predict where we would find erroneously omitted or included addresses. We refer to erroneously omitted addresses as *adds* and erroneously included addresses as *deletes* through the remainder of this section of the report.

The remaining portions of the MMVT section of the report discuss background, the specific research questions, methodology, limitations, research results, conclusions, and recommendations.

2.2 Background

This background section provides a brief description of the 2010 Census Address Canvassing operation and a summary of a relevant evaluation conducted as part of the 2010 Census Program for Evaluations and Experiments (CPEX).

2.2.1 2010 Census Address Canvassing

The 2010 Census Address Canvassing operation was the largest canvassing operation in census history. The primary purpose of the operation was to ensure the address frame and maps were as accurate as possible before the 2010 Census enumeration. The operation was conducted in about 3.5 months, beginning on March 30, 2009. The operation employed over 110,000 listers and about 8,000 crew leaders, traveling approximately 137 million miles and canvassing over 150 million addresses. Geographically, nearly every block in the nation was included in the operation, except for very remote areas of Alaska and Maine.

The listers were instructed to verify existing addresses, make changes to existing addresses where necessary (e.g., corrections or modifications to the mailing address, location address or location description fields), delete non-existent addresses, add new addresses, and where applicable flag addressees as either duplicates, nonresidential or uninhabitable. The address list from which the listers worked, the dependent list, contained about 145 million addresses from the MAF after applying rules to determine the set of eligible records appropriate for the 2010 Address Canvassing operation.

Table 2.1 displays the distribution of 2010 Census Address Canvassing operation outcomes (field collected, and headquarters-processed). From Table 2.1, in 2009,

- 62 percent of the resulting set of addresses were verified (determined valid with no change to the address),
- 13 percent were changed (determined to be valid, with a correction or modification made to some portion of the address fields),
- 13 percent were given a negative action (determined invalid because the address did not exist, it was a duplicate of another address, or it was found to be nonresidential), and
- 7 percent of addresses were added to the dependent list (new addresses not previously on the dependent list).

Of the adds, approximately 60 percent were *new adds* (not on the dependent list, and not on the MAF) and 40 percent were *matched adds* (not on the dependent list, but matched back to an existing address record on the MAF).

Table 2.1. 2010 Census Address Canvassing Results

Final Address Outcomes	Count	Percent of Total[1]
TOTAL	156,703,156	100.00
Add	10,776,894	6.88
New	6,624,155	4.23
Matched to Existing Record	4,152,739	2.65
Change	19,608,785	12.51
Move	5,450,563	3.48
Verify	97,635,517	62.31
Negative Actions	21,143,737	13.49
Does Not Exist	15,819,921	10.10
Duplicate	4,085,556	2.61
Nonresidential	1,238,260	0.79
Uninhabitable	551,566	0.35
Unduplicated Rejected Records	1,536,094	0.98

[1] Columns many not add to total due to rounding.
Source: 2010 CPEX Address Canvassing Assessment (Address List Operations Implementation Team, 2012).

2.2.2 2010 CPEX Address Canvassing Statistical Models

The purpose of the 2010 CPEX was to evaluate the 2010 Census operations and, for some of the planned studies, test new methodology that could offer improvements to either or both the quality and cost effectiveness of the next decennial census. One study in this 2010 program, the *2010 Census Address Canvassing Targeting and Cost Reduction* (Boies, Shaw, Holland, 2012), was designed to determine the feasibility of using statistical models in advance of the canvassing operation to identify census blocks that require updates. One of the primary areas of focus for these models was adds and deletes, as these categories directly affect census coverage. This early research showed that predictive modeling can be an effective method for identifying areas (census blocks) for a reduced in-field canvass.

2.3 Methodology

To support the 2020 Census Program, the Census Bureau has been testing various statistical models to determine which census blocks require canvassing. A subset of these statistical models also permit the estimation of MAF coverage error, using the predicted count of adds or deletes per block. This section details our research questions for this study, the statistical models that have been developed *prior* to the MMVT, and our evaluations of those statistical models.

2.3.1 Research Questions

The MMVT was the first test to measure the performance of the statistical models derived using the results of the 2010 Census Address Canvassing operation conducted in 2009. These 2009-based statistical models and their evaluations in the MMVT were designed to support two principal goals. First, the Census Bureau seeks to *implement a Reengineered Address Canvassing operation in the 2020 Census*. Instead of the nearly 100-percent in-field canvass, this reengineered operation will be conducted via a set of in-office activities (e.g., statistical modeling and imagery review) and in-field activities. Second, the Census Bureau seeks to *measure the coverage error of the MAF* on a regular basis. To address these two goals, we answer the following research questions:

1) How well do the statistical models perform at identifying areas for canvassing?

2) How well do the statistical models perform at measuring MAF coverage error?

2.3.2 Statistical Models

To date, three types of generalized linear models have been considered for this research: logistic, negative binomial, and Poisson regression models. Logistic regression was chosen to model binary response data, and negative binomial and Poisson for count response data (typically useful in distributions with rare events). Given the high frequency of zero values, representing census blocks with no adds or no deletes, zero-inflated versions of each of the negative binomial and Poisson models were developed to achieve better model fits. The predicted count given to each block from these zero-inflated distributional models is the mean of the predicted distribution for each block given the value of its independent variables. While not addressed in this report, each of these statistical models has a set of underlying assumptions. It should be noted that the zero-inflated Poisson models did not perform as well as the zero-inflated negative binomial models and are therefore not part of this report.

These models were all defined to predict either the presence or count of some quantity of adds or deletes from the 2010 Census Address Canvassing operation. While some address-level models were developed, all of the models presented here are block level. Table 2.2 details the subset of four statistical models that were selected for evaluation in this report. For each model, this table provides the type of regression model (either zero-inflated negative binomial or logistic regression), the intended use (either identifying census blocks for canvassing, or for identifying census blocks for canvassing and measuring MAF coverage), and information about the dependent and independent variables. Note that independent variables used for each model come from data obtained prior to 2010 Census Address Canvassing. Further details about these 2009-based statistical models will be provided in forthcoming documentation.

Table 2.2. 2009-Based Statistical Models

Attribute	Statistical Models			
	Model #A1	Model #A2	Model #J1	Model #K1
Model Type[1]	ZINB	ZINB	LR	LR
Potential Model Application:				
Identify Blocks for Canvassing	✓	✓	✓	✓
Measure Coverage	✓	✓		
Dependent Variable	Add Count	Delete Count	2+ Adds or Deletes	1+ Adds
Independent Variables:				
# of Variables	24	46	39	15
Census 2000		✓	✓	✓
MAF (pre-2009)	✓	✓	✓	✓
DSF[2]	✓	✓	✓	✓

[1] Model Types: ZINB = zero-inflated negative binomial regression, LR = logistic regression
[2] Independent Variable Source: DSF = United States Postal Service Delivery Sequence File

2.3.3 Answering the Research Questions

The MMVT field test was conducted to provide data to assess the performance of the statistical models. The MMVT sample of 10,100 blocks was selected (described in detail in Section 2.5.1 *MMVT Design: Sample Design*). Canvassing fieldwork was done on each of the 10,100 blocks using a dependent list of valid addresses in those blocks. After the fieldwork, an analytical dataset was prepared as detailed in Section 2.5.2 *MMVT Design: Data Collection and Processing.*

Before receiving the MMVT fieldwork results, statistical models were finalized and predictions were made for every block in the sample. For each statistical model, a predicted count (for the zero-inflated negative binomial models) or probability (for the logistic regression models) was placed on each sample block. This was done by using the same 2009 model parameters with updated values for the 2013 predictor variables.

Research Question #1
How well do the statistical models perform at identifying areas for canvassing?

To answer this first question, research mimicked the proposed use of the models to identify blocks for canvassing. The MMVT sample blocks were sorted in descending order by either the predicted add rate or delete rate (the predicted count of adds or deletes / total addresses on the dependent list for the zero-inflated negative binomial models) or predicted probability (for the logistic regression models). Once sorted, blocks were selected from the top of the list until a given threshold or workload of addresses was reached. MMVT outcomes were then used to assess how many adds or deletes would have been captured or missed by each model's selection of blocks for canvass. For this report, the focus is on the 20, 25 and 40 percent address canvassing thresholds.

To assist with gauging the relative performance of these four models, two reference models were created: the benchmark add rate model and the benchmark delete rate model. The former sorted the MMVT sample blocks in descending order by each block's add rate (the number of adds from the MMVT / total addresses on the dependent list), and again made selections of blocks from the top of the list until a given threshold or workload of addresses was reached. In a similar fashion, the benchmark delete rate model calculated a block's delete rate and made selections first from the blocks with the highest delete rates. Using the MMVT results, this produced the best possible block selections had we

known the "truth" from the fieldwork. While these were obviously *not obtainable* in production, these two benchmarks were valuable when measuring and comparing the performance of various statistical models.

We then evaluated how well each model performs at selecting blocks that warrant canvassing, i.e. blocks that contained change (adds or deletes). We calculated the rate of how many blocks were identified for canvass of those that had a large number (5 or more) or any (1 or more) adds or deletes in MMVT. We also calculated a false canvassing rate which identified how often a block was selected to be canvassed when it did not have a large number, or any adds or deletes. These metrics were compared to the benchmark add rate and delete rate models as well.

Finally, we created tables that directly compare the predicted counts to the actual MMVT counts of outcomes with a cross tabulation of blocks. These tables show how often the models were accurately predicting the change that occurred within the blocks. The results of this analysis can be found in Section 2.6.2 *Results: Using Statistical Models to Identify a Canvassing Workload*.

Research Question #2
How well do the statistical models perform at measuring MAF coverage error?

To answer this second question, a direct comparison was made between weighted estimates of adds and deletes based on MMVT results as well as two types of national estimates of predicted counts of adds and deletes of our zero-inflated negative binomial models for the MMVT sample blocks. The results of this analysis can be found in Section 2.6.3 *Results: Using Statistical Models to Measure MAF Coverage Error*.

2.3.4 Estimation Methodology

For all sample-based estimates, the Horvitz-Thompson estimation method was used. Standard errors were calculated using stratified delete-a-group jackknife variance estimation, using 20 random groups. Standard errors are either presented alongside the estimates in the same table or in an identically formatted table in Appendix A-3. Statements of comparison in this section of the report are statistically significant at the 90 percent confidence level ($\alpha = 0.10$). "Statistically significant" means that the difference is not likely due to random chance alone.

2.3.5 Assumptions

Analysis of the performance of the statistical models was based on using the MMVT data collected by field staff as the "truth." While largely done well, field work does have errors. We ignore any errors due to field work in this analysis, as the particulars of these errors are not known nor quantified.

2.4 Limitations

While initially designed in 2013, the MMVT sample was not fielded until September through December 2014. Largely, this occurred due to budget uncertainties. *This time lag presented certain challenges* when determining final address outcomes. For the purposes of the analyses here, the adds and deletes are determined with respect to the dependent list. This was done in an attempt to provide consistency with the time period for which the statistical models were predicting. For the analyses that compare sample-based and model-based estimates of coverage, it was a limitation that housing units built since 2013 cannot be accurately removed from the sample-based estimates. Additionally, while not presented here as part of the model evaluations, it would be necessary to consider which adds would be present and

determined valid in the MAF subsequent to the 2013 dependent list when measuring coverage for the MAF at a different point in time.

The MMVT analysis is limited to the sampling frame and does not necessarily extend to the entire nation. The MMVT estimates are based on the probability based sample of 10,000 blocks as specified in Section 2.5.1. The MMVT sampling frame consisted of blocks containing addresses of living quarters, excluding Alaska, Hawaii, Puerto Rico, American Indian Reservations, military bases, national parks, and prisons. To the extent that excluded areas are different from the sampling frame, results may or may not be indicative of the results that would have been obtained if all blocks had been in the frame.

A third limitation was the number of data sources used for this round of statistical models. To date, the research has focused on using only select data sources as predictors of coverage errors. These data sources include address data from Census 2000, the MAF (including various United States Postal Service Delivery Sequence File variables), the American Community Survey and also data from the National Land Cover Database. There has been only *limited exploration of other data sources*, e.g., Internal Revenue Service and Property Tax data.

Lastly, to operationalize the MMVT, staff were required to use legacy software and systems (e.g., Automated Listing and Mapping (ALMI), Community Address Updating System (CAUS), and Geography Division's Demographic Area Address Listing (DAAL) processing) which presented some challenges for this test.

2.5 MMVT Design

The MMVT was designed to support several activities. First, its design supports the evaluation of multiple 2009-based statistical models developed to predict which census blocks require address updates, and also a separate evaluation of a subset of those same models developed to estimate MAF under- and overcoverage. Second, the design of the MMVT supports the development and evaluation of new 2013-based statistical models. In addition to these two purposes, the design also permits the testing and evaluation of in-office imagery review and Partial-Block Canvassing as additional contributors to 2020 Census reengineered address canvassing. These alternative methods will be evaluated independently, before they are analyzed and synthesized into a proposed combined workflow for the 2020 Census reengineered address canvassing operation.

2.5.1 Sample Design

The MMVT was a national sample that consisted of two parts: a probability sample of 10,000 blocks with housing and a convenience sample of 100 blocks without housing, referred to as *zero blocks*. At the time that the sample was designed, the focus of the statistical model development was on blocks with housing, and we had more information on which to base the sample design. We identified a set of zero population and housing blocks to gather more information that might be insightful for the development of statistical models for these blocks. The remainder of this section describes the design of the probability sample of blocks with housing. MMVT estimates in this report are only from the probability-based sample of 10,000 blocks.

The sampling frame for the probability sample contained blocks with living quarters addresses in the continental U.S. (48 states plus the District of Columbia); Alaska, Hawaii, and Puerto Rico were not eligible. The MMVT frame also excludes blocks with American Indian Reservations, military bases, national parks, and prisons.

Before sampling, we stratified the frame blocks into eight mutually exclusive groups based on the measure of size of the block, i.e., the number of addresses in the block as of July 2013. (This number was derived from an address list used for the American Community Survey, resulting in an approximation of the number of addresses that were determined to be on the 2013 MMVT dependent list when the criteria were applied to the MAF.) We chose to use measure of size to define strata because in the 2010 Census Address Canvassing operation, on average, blocks with a greater number of addresses contained a much greater number of adds and deletes per block. Given the small quantity of large blocks in the frame (e.g., blocks containing more than 80 addresses), these larger blocks were sampled at higher rates relative to smaller blocks.

The overall block sampling rate for blocks that contained one or more housing units was 0.16 percent. Table 2.3 shows that across the eight strata, this rate ranged from 0.05 percent in the stratum with the smallest blocks to 3.68 in the stratum with the largest blocks. This resulted in sample weights ranging from under 100 to about 2,150. Overall, this design resulted in less than one percent (0.80 percent) of all housing units in the MMVT sampling frame being selected into sample.

Table 2.3. MMVT Sample Design: Frame and Sample Results by Stratum

Stratum: Number of Units	MMVT Sampling Frame			MMVT Sample Results					
	Blocks[2] (x1,000)	Units[2] (x1,000)	Units/ Block	Blocks	Units (x1,000)	Units/ Block	Pct Blocks	Pct Units	Sample Weight
TOTAL[1]	6.29	130.2	20.7	10,000	1,037	103.74	0.16	0.80	629.39
S1: 1-10	3.28	14.0	4.3	1,529	6	4.24	0.05	0.05	2,146.19
S2: 11-20	1.30	19.5	15.0	1,434	22	14.99	0.11	0.11	908.39
S3: 21-30	0.67	16.6	25.0	1,123	28	24.93	0.17	0.17	593.80
S4: 31-80	0.78	36.3	46.3	2,555	119	46.65	0.33	0.33	306.23
S5: 81-140	0.15	15.7	104.1	1,089	113	103.57	0.73	0.72	138.78
S6: 141-200 ...	0.05	8.5	166.2	589	99	167.38	1.18	1.16	86.87
S7: 201-300 ...	0.03	8.0	242.2	576	140	243.14	1.92	1.75	57.22
S8: 301+	0.03	11.7	462.2	1,105	511	462.22	3.68	4.37	22.83

[1] Columns may not add to total due to rounding.
[2] Sampling Frame Blocks and Units are displayed in millions. For display purposes, we use the term units to refer to addresses in this table.

2.5.2 Data Collection and Processing

The MMVT used the DAAL procedures with some minor modifications and the automated instrument referred to as the ALMI. The DAAL program is a dependent address listing for the demographic surveys that the Census Bureau conducts. The MMVT fieldwork was conducted from September 2014 through December 2014. A listing check was conducted to make sure that the listers completed their work, and to see if they were following instructions. The results of the listing and listing check were combined in data processing and used to update a copy of the January 2015 MAF. This latter step allowed the analysis to account for such situations as adds in the fieldwork that had already been added to the MAF during regular update processes. Then a data set was prepared for analysis.

Final address outcomes were determined based on how each address was updated in the MAF, its existence on the dependent list, and whether it was geocoded to an MMVT sample block. Addresses geocoded to a block not selected for the MMVT sample were considered out-of-scope for the analysis.

This was necessary to apply the sample weights (inverse of the probability of selection) appropriately for estimation purposes.

2.5.3 Cost

The total cost of the MMVT was approximately $4.27 million (2014 dollars). This figure includes initial and refresher training, listing, listing check, Regional Office costs and observations. The training costs for the existing and new field staff employees who conducted the MMVT were $1.52 million, or about 36 percent of the total costs. The listing costs were of a similar magnitude, summing to $1.45 million, or about 34 percent of the total costs. Listing check represented about 10 percent of the MMVT costs. About $560,000 in Regional Office costs and $270,000 in observations made up the remaining 20 percent of the MMVT costs.

2.6 Results

The purpose of the MMVT was to assess the performance of various statistical models. The development, evaluation and ultimately the future application of these models support two principal goals:

1) ***Implement a Reengineered Address Canvassing operation in the 2020 Census; and***

2) ***Measure the coverage error of the MAF.***

2.6.1 MMVT Listing Outcomes

As part of the processing of the data after the listing operation, each address was assigned a final MMVT outcome. These final outcomes resemble the 2010 Census Address Canvassing operation results as much as possible. The sample addresses were weighted and tabulated by MMVT outcome, and standard errors were calculated. These results are presented in Table 2.4. To be eligible for this table, the address had to be assigned to one of the 10,000 blocks in the probability-based sample. As a reminder, addresses in the convenience sample of 100 zero population and housing blocks are not included in the analysis covered in this report.

The dependent list was drawn from the MAF as of July 2013, but the MMVT data collection occurred in the months of September through December 2014. The estimates of 5.7 million adds and 7.6 million deletes presented in Table 2.4 are determined relative to the initial dependent list. If the data collection period had occurred closer to the time that the dependent list was created, these estimates would have likely differed (see Section 2.4 *Limitations*).

In the MMVT, nearly two-thirds (or 64.4 percent) of all address outcomes from the dependent listing were verifications (the address on the dependent list exists). An additional 23.8 percent required only a change to any of the address components (e.g., corrections or modifications to the mailing address, location address or location description fields) or relocating the address spatially within the same sample block (i.e., moving the map spot associated with the address). Finally, 1.7 percent were moves between blocks. Addresses with any of these three positive outcomes (verify, change and move) would be retained in a census production environment for enumeration purposes.

Table 2.4. MMVT Listing Outcomes: Weighted Distribution[1]

Final Address Outcome	Addresses				Blocks with 1 or more Address Outcome			
	Estimate[2] (x1,000)	SE (x1,000)	Pct[2] (%)	SE (%)	Estimate[3] (x1,000)	SE (x1,000)	Pct[3,4] (%)	SE (%)
TOTAL.....	141,894	837	100.0	-	6,247	7	99.2	0.1
Add.....	5,688	592	4.0	0.4	1,373	30	21.8	0.5
New.....	2,454	134	1.7	0.1	775	25	12.3	0.4
Matched.....	3,234	539	2.3	0.4	843	28	13.4	0.4
Change.....	33,796	482	23.8	0.3	3,556	40	56.5	0.6
Move.....	2,393	215	1.7	0.1	607	26	9.6	0.4
Verify.....	91,371	485	64.4	0.5	5,116	36	81.3	0.6
Negative Actions....	8,181	314	5.8	0.2	1,982	33	31.5	0.5
Delete.....	7,592	310	5.4	0.2	1,863	35	29.6	0.6
Duplicate.....	447	35	0.3	<0.1	200	12	3.2	0.2
Nonresidential	141	22	0.1	<0.1	82	11	1.3	0.2
Uninhabitable.....	466	34	0.3	<0.1	250	13	4.0	0.2

[1] The unweighted distribution of observed address outcomes can be found in Table A-1.1 in Appendix A-1.
[2] Values may not add to total due to rounding.
[3] Columns do not add to the Total because blocks can contain more than one type of outcome.
[4] Denominator for Block Percent was the weighted total estimate of blocks from the sample. Total does not equal 100 percent as some blocks had no valid outcomes after data processing.

In blocks containing one or more housing units, the MMVT estimated number of adds were contained in about 21.8 percent of blocks (weighted). Similarly, deletes were in about 29.6 percent of blocks. Looking specifically at adds, 43.1 percent of the estimated number of adds were new adds while 56.9 percent matched an existing MAF address. Table 2.5 provides a distribution of the estimated 5.7 million MMVT adds by the first time the address appears on a MAF (if it matches to the MAF). Approximately 39.2 percent of all adds were present in the July 2013 MAF, but did not meet the criteria to be on the MMVT dependent list. Approximately one-third of this subset of addresses lacked a valid census block assignment (geocode). The other two-thirds did not meet the criteria to be included on the dependent list for other reasons.

Table 2. 5. MMVT Adds by First Appearance on MAF

First Appearance on MAF	Addresses				Blocks with 1 or more Adds			
	Estimate[1] (x1,000)	SE (x1,000)	Pct[1] (%)	SE (%)	Estimate[2] (x1,000)	SE (x1,000)	Pct[2,3] (%)	SE (%)
TOTAL ADDS.....	5,688	592	100.0	0.0	1,373	30	21.8	0.5
Present in July 2013 MAF	2,230	156	39.2	4.7	751	25	11.9	0.4
Present in Jan or July 2014 MAF	898	525	15.8	8.5	107	9	1.7	0.1
Present in Jan 2015 MAF	106	15	1.9	0.3	48	7	0.8	0.1
Not present in the MAF	2,454	134	43.1	4.2	775	25	12.3	0.4

[1] Values may not sum appropriately due to rounding.
[2] Columns do not add to the Total because blocks can contain more than one type of outcome.
[3] Denominator for Block Percent was the 6.3 million total of weighted number of blocks in the sample.

2.6.2 Using Statistical Models to Identify a Canvassing Workload

In this analysis, we measured the performance of the statistical models in several ways. First, we estimated the capture rate of adds and deletes identified in the fieldwork at the address level. For the addresses themselves, we estimated how many identified adds and deletes are captured out of the total number. We present these results for canvassing thresholds of 20 percent, 25 percent, and 40 percent.

Second, we turned to what we consider important blocks to be identified—those with five or more adds (or deletes); similarly, for blocks with one or more adds (or deletes). These are the blocks we most want to identify for further action. Thus, we estimated the capture rate of such blocks and compared this rate across models. This analysis was done using the same three canvassing thresholds.

Third, we measured the rate of false canvassing predictions. These were blocks that identified by the model to be canvassed, but for which the amount of change (e.g., 5 or more adds) does not occur.

Finally, we present tables that show how well our predicted measures (e.g., counts of predicted adds or probability of 1 or more adds) compared to what was observed in the fieldwork.

Research Question #1
How well do the statistical models perform at identifying areas for canvassing?

While many models have been developed and evaluated, currently, these were the four top-performing models (Models #A1, A2, J1 and K1). For comparison, two types of benchmark models—the add rate and delete rate models—were evaluated on the same metrics (for details, see Section 2.3.2 *Methodology: Statistical Models*).

We first present, for these three canvassing thresholds, capture rates for adds and deletes, and descriptive statistics about the canvassing workload (addresses per block and percent blocks canvassed).

Table 2.6. Statistical Model Performance for Identifying Areas to Canvass. Address-Level Analysis. Rate of Capture of Adds and Deletes[1]

Simulated Canvassing Workload and Results[2]	Statistical Models				Benchmark Models	
	Model #A1	Model #A2	Model #J1	Model #K1	Add Rate	Delete Rate
20% Canvass (27.3 million Addresses)						
Add Capture Rate.....	47.2	47.0	27.2	47.1	93.0	35.7
Delete Capture Rate	34.5	53.5	38.6	46.3	31.8	84.9
Addresses per Block	9.2	11.9	99.5	16.5	24.4	21.4
Percent Blocks Canvassed.....	47.3	36.5	4.4	26.2	17.8	20.2
25% Canvass (34.1 million Addresses)						
Add Capture Rate	55.2	53.5	33.1	53.5	96.5	42.5
Delete Capture Rate	40.9	61.4	44.3	51.7	37.8	90.4
Addresses per Block	10.4	12.2	84.1	16.8	27.5	23.4
Percent Blocks Canvassed.....	52.0	44.5	6.4	32.3	19.7	23.1
40% Canvass (54.5 million Addresses)						
Add Capture Rate	70.1	70.7	53.0	71.4	100.0	56.6
Delete Capture Rate	58.5	77.5	62.8	69.7	51.2	98.7
Addresses per Block	13.7	14.4	56.2	19.5	36.5	30.3
Percent Blocks Canvassed.....	63.3	60.3	15.4	44.5	23.7	28.5

[1] Corresponding standard errors (SEs) can be found in Table A-3.1 in Appendix A-3.
[2] The following denominators were used for calculations in this table: canvassing threshold – 136.3 million weighted MMVT estimate of addresses on the dependent list, add capture rate – 5.7 million MMVT adds, delete capture rate – 7.6 million MMVT deletes, percent blocks canvassed – 6.3 million 2010 tabulation blocks

Table 2.6 details the results of four model performance metrics at three canvassing thresholds. The first two metrics are the add and delete capture rates. For the MMVT, they were calculated as the percentage of all weighted adds (or deletes) captured at a particular canvassing level. The denominator was the approximately 5.7 million adds and 7.6 million deletes estimated from the MMVT.

The next metric is addresses per block. Across the set of census blocks identified by a particular model for canvassing (which was different for each model), this is defined as the average number of addresses on the dependent list for each block. The final metric is the percent of blocks canvassed, where the denominator of 6.3 million is the weighted estimate of the total number of blocks with housing from the MMVT.

With all the metrics defined, let's discuss some observations about the model results at the 20 percent canvassing level. For three of the four models (Models #A1, A2 and K1), the add capture rates are not significantly different from each other, with point estimates around 47.0 percent. The add capture rate of 27.2 percent for Model #J1 is statistically different from the other three models. The percent blocks canvassed using this model is markedly lower at 4.4 percent. While the add capture rates are not significantly different, Models #A2 and #K1 do contrast on the percent of blocks canvassed at 36.5 percent and 26.2 percent respectively. With the increase in percent blocks canvassed under Model #A2, does come a benefit by way of the improved delete capture rate of 53.5 percent.

Tables 2.7 and 2.8 are analogous in many ways to the prior tables, showing capture rates of adds or deletes, respectively, for the four statistical models at three specified levels of canvassing. But here, we measure the capture rates for important blocks—those with many (five or more) adds or deletes, or any (one or more) adds or deletes. The estimated number of blocks that contain the specified number of adds

(Table 2.7) or deletes (Table 2.8) based on MMVT results are presented. The percentage of blocks identified for canvass based on the model prioritization is given as the "Total Blocks" (in the sampling frame). Then, for the specified event, e.g., finding blocks with five or more adds ("Blocks w/ 5+"), the estimated capture rates are provided for each model.

Moving down Tables 2.7 and 2.8, the false canvassing rate indicates the percentage of blocks marked for canvass by the model that did not contain the specified number of adds (Table 2.7) or deletes (Table 2.8). As in Table 2.6, the benchmark add and delete rate models are reflective of what would be expected if the sorting was based on perfect prior knowledge of the field test outcomes. It should be noted that the false canvassing rates will be generally large, as many blocks have no observed adds or deletes.

In general, it would be good for a model to have a lower total block *canvass* rate (see the first row of each section), while having a higher block *capture* rate of adds and deletes. The models in general appear to follow this pattern. We can see that Model #A1 has the highest block capture rate of any adds (blocks with 1+), but canvasses a higher percentage of blocks than the others. Both Model #A2 and Model #K1 have lower total block canvass rates than their capture rates of blocks with 5 or more adds. Similar patterns are seen in the model performance when looking at deletes in Table 2.8.

Table 2.7. Statistical Model Performance for Identifying Areas to Canvass. Block-Level Analysis. Rate of Capture of Blocks with Adds (1+) or Many Adds (5+)[1]

Type of Rate at Different Canvassing Thresholds	Estimated Blocks (x1,000)	Rates of Block Canvas, Block Capture, and False Add Canvassing (%)					
		Statistical Models				Benchmark Models	
		Model #A1	Model #A2	Model #J1	Model #K1	Add Rate	Delete Rate
20% Canvass (27.3 million Addresses)							
Total Blocks……	6,294	47.3	36.5	4.4	26.2	17.8	20.2
Blocks w/5+……	188	43.2	45.1	33.8	47.7	94.9	38.6
Blocks w/1-4 ……	1,185	56.0	42.3	10.1	37.8	79.4	32.1
Blocks w/1+……	1,373	54.2	42.7	13.3	39.2	81.5	33.0
5+ False Canvassing Rate	NA	97.3	96.3	76.8	94.6	84.1	94.3
1+ False Canvassing Rate	NA	75.0	74.5	33.2	67.4	<0.1	64.4
25% Canvass (34.1 million Addresses)							
Total Blocks……	6,294	52.0	44.5	6.4	32.3	19.7	23.1
Blocks w/5+……	188	52.8	54.7	41.8	52.6	98.1	44.7
Blocks w/1-4 ……	1,185	62.4	51.0	15.6	43.1	88.9	37.4
Blocks w/1+……	1,373	61.1	51.5	19.2	44.4	90.1	38.4
5+ False Canvassing Rate	NA	97.0	96.3	80.6	95.1	85.1	94.2
1+ False Canvassing Rate	NA	74.4	74.8	34.9	70.1	<0.1	63.8
40% Canvass (54.5 million Addresses)							
Total Blocks……	6,294	63.3	60.3	15.4	44.5	23.7	28.5
Blocks w/5+……	188	71.7	72.0	63.0	73.2	100.0	60.4
Blocks w/1-4 ……	1,185	73.1	70.5	34.0	61.0	100.0	48.3
Blocks w/1+……	1,373	72.9	70.7	38.0	62.6	100.0	50.0
5+ False Canvassing Rate	NA	96.6	96.4	87.8	95.1	87.4	93.7
1+ False Canvassing Rate	NA	74.9	74.4	46.2	69.3	8.2	61.8

[1] Standard errors are found in Table A-3.2 in Appendix A-3.

Looking at Tables 2.7 and 2.8 it is clear to see that Model #J1 sets block canvassing preferences very differently from the other models. It focuses on large blocks, reaching the housing unit canvassing threshold by canvassing a very low percentage of all blocks. While the capture rates of blocks with adds for Model #J1 are not as high as those of other models, the false canvassing rate of blocks with one add is lower. Of the blocks Model #J1 has chosen for canvass, a higher percentage had observed adds. In fact, under this criterion, it does better than the benchmark add rate model at the 20 and 25 percent canvassing threshold for blocks with five or more adds.

Table 2.8. Statistical Model Performance for Identifying Areas to Canvass. Block-Level Analysis. Rate of Capture of Blocks with Deletes (1+) or Many Deletes(5+)[1]

Type of Rate at Different Canvassing Thresholds	Estimated Blocks (x1,000)	Rates of Block Canvas, Block Capture, and False Delete Canvassing (%)					
		Statistical Models				Benchmark Models	
		Model #A1	Model #A2	Model #J1	Model #K1	Add Rate	Delete Rate
20% Canvass (27.3 million Addresses)							
Total Blocks……	6,294	47.3	36.5	4.4	26.2	17.8	20.2
Blocks w/5+……	305	39.7	54.3	38.2	48.9	38.9	86.8
Blocks w/1-4 ……	1,558	52.3	48.1	6.9	37.3	28.1	64.7
Blocks w/1+……	1,863	50.3	49.1	12.0	39.2	29.9	68.3
5+ False Canvassing Rate	NA	95.9	92.8	57.5	91.0	89.4	79.2
1+ False Canvassing Rate	NA	68.5	60.1	18.3	55.7	50.3	<0.1
25% Canvass (34.1 million Addresses)							
Total Blocks……	6,294	52.0	44.5	6.4	32.3	19.7	23.1
Blocks w/5+……	305	47.8	61.5	47.4	54.7	46.7	92.5
Blocks w/1-4 ……	1,558	59.5	56.1	11.5	42.2	31.3	75.2
Blocks w/1+……	1,863	57.6	57.0	17.4	44.3	33.9	78.1
5+ False Canvassing Rate	NA	95.5	93.3	64.3	91.8	88.5	80.6
1+ False Canvassing Rate	NA	67.2	62.1	20.2	59.5	49.0	<0.1
40% Canvass (54.5 million Addresses)							
Total Blocks……	6,294	63.3	60.3	15.4	44.5	23.7	28.5
Blocks w/5+……	305	66.3	80.5	70.0	74.5	60.3	99.4
Blocks w/1-4 ……	1,558	73.8	74.4	28.7	60.8	37.6	95.9
Blocks w/1+……	1,863	72.6	75.4	35.5	63.1	41.3	96.4
5+ False Canvassing Rate	NA	94.9	93.5	78.0	91.9	87.7	83.1
1+ False Canvassing Rate	NA	66.1	63.0	31.9	58.1	48.5	<0.1

[1] Standard errors are found in Table A-3.3 in Appendix A-3.

Tables 2.9 and 2.10 show how the predictions from Model #A1 (zero-inflated negative binomial adds model) line up with what was observed in MMVT. It should be noted that most blocks in MMVT had no adds and no deletes (as can be observed in the total line at the bottom of the tables), so the percentage of blocks with no observed adds or deletes will be large no matter what category. It should also be noted that the bottom two categories of predicted adds (20+) had a small sample size, so their standard errors (see Tables A-3.4 and A-3.5 in Appendix A-3) are much larger; many of these estimates are not significantly different than 0.

Table 2.9. Statistical Model Performance for Identifying Areas to Canvass. For Adds: Block-Level Predictions vs MMVT Observed Estimates for Model #A1[1]

Model #A1 Predicted Adds	Estimated Number of Blocks (x1,000)	Estimated Percent of Blocks with [N] Observed Adds								
		0	1	2	[3, 4]	[5, 9]	[10, 19]	[20, 49]	[50, 99]	[100, ∞)
[0.00, 0.25)....	795	92.9	5.8	0.5	0.3	0.5	0.0	0.0	0.0	0.0
[0.25, 0.50)....	1,347	89.8	7.3	1.6	0.7	0.3	0.2	<0.1	0.0	0.0
[0.5, 1.0).....	1,786	85.2	11.0	1.7	1.0	0.7	0.1	0.2	0.0	0.1
[1.0, 1.5).....	785	73.2	16.9	6.2	2.2	0.8	0.6	0.1	0.1	0.0
[1.5, 2.0).....	416	69.9	15.3	6.7	4.6	2.3	0.9	0.2	0.0	0.1
[2.0, 2.5).....	303	60.2	24.4	7.5	4.6	2.3	0.8	<0.1	0.1	<0.1
[2.5, 3.0).....	212	55.7	20.6	10.1	7.0	4.2	1.1	0.9	0.3	0.2
[3, 5).....	378	49.1	21.2	10.3	8.5	6.2	2.5	1.5	0.4	0.3
[5, 10).....	220	37.8	16.8	12.5	12.2	11.2	4.6	3.1	1.1	0.6
[10, 20).....	45	33.2	13.0	8.5	8.9	12.6	9.6	7.8	4.1	2.3
[20, 50).....	5	13.6	18.1	3.8	7.7	11.7	15.9	9.4	15.4	4.4
[50, ∞)	1	36.4	0.0	12.2	36.4	0.0	0.0	8.1	0.0	6.8
Total.....	6,294	78.2	12.4	3.9	2.5	1.7	0.7	0.4	0.1	0.1

[1] Corresponding standard errors can be found in Table A-3.4 in Appendix A-3.

From Table 2.9, which looks at the percentage of blocks with adds, we can make several observations. When we predicted a very small number of adds in a block (e.g., less than 1.0, even between 1.0 and 2.0), the MMVT fieldwork found very few blocks with five or more adds. In the rarer cases when the models predicted a block with many adds (e.g., more than 5.0), such blocks still often had only a few adds, and only occasionally produced many adds.

Similar results can be seen in Table 2.10, which looks at blocks with deletes. Even though Model #A1 predicts the number of *adds* in a given block, it has a similar pattern at identifying where there are or are not a large number of deletes. Similar tables for the other three MMVT models are provided in Appendix A-2. For all three models, this seems to be a common pattern.

Table 2.10. Statistical Model Performance for Identifying Areas to Canvass. For Deletes: Block-Level Predictions vs MMVT Observed Estimates for Model #A1[1]

Model #A1 Predicted Adds	Estimated Number of Blocks (x1,000)	Estimated Percent of Blocks with [N] Observed Deletes								
		0	1	2	[3, 4]	[5, 9]	[10, 19]	[20, 49]	[50, 99]	[100, ∞)
[0.00, 0.25)....	795	87.9	9.5	1.6	0.3	0.7	0.0	0.0	0.0	0.0
[0.25, 0.50)....	1,347	83.7	11.8	2.6	0.9	0.9	0.1	<0.1	0.0	0.0
[0.5, 1.0).....	1,786	78.4	13.6	3.9	2.9	0.9	0.1	0.1	0.1	0.0
[1.0, 1.5).....	785	68.3	18.4	6.5	4.0	1.4	1.0	0.3	0.1	<0.1
[1.5, 2.0).....	416	61.5	20.1	7.3	6.3	3.0	1.4	0.3	0.1	0.0
[2.0, 2.5).....	303	47.5	22.3	15.8	6.4	5.7	1.4	0.7	0.2	<0.1
[2.5, 3.0).....	212	40.0	24.2	12.6	12.4	8.2	1.2	1.3	<0.1	0.1
[3, 5).....	378	33.5	20.2	12.2	17.7	10.7	3.9	1.1	0.4	0.3
[5, 10).....	220	20.9	13.6	9.7	17.5	21.4	9.4	4.3	2.6	0.5
[10, 20).....	45	20.7	9.4	7.5	9.1	17.3	16.0	10.4	5.0	4.6
[20, 50).....	5	7.9	25.5	0.9	3.1	12.7	17.9	15.3	5.1	11.6
[50, ∞)	1	36.4	0.0	2.7	0.0	36.4	2.7	12.2	0.0	9.5
Total.....	6,294	70.4	14.9	5.5	4.4	3.0	1.1	0.5	0.2	0.1

[1] Corresponding standard errors can be found in Table A-3.5 in Appendix A-3.

2.6.3 Using Statistical Models to Measure MAF Coverage Error

In this analysis, we measured the ability of the statistical models to predict MAF coverage error on the national level. For the zero-inflated negative binomial models, we present the results observed in the MMVT fieldwork versus what was predicted, in terms of numbers of adds or deletes. This was aggregated over all blocks in the MMVT sample as well as all blocks in the MMVT sampling frame.

Research Question #2
How well do the statistical models perform at measuring MAF coverage error?

Table 2.11 provides coverage estimates based on the MMVT data collection and derived from the distributional model predictions--Model #A1 for adds, Model #A2 for deletes. The model-based predictions were created two ways: one based on weighting the predictions for the 10,000 sample blocks, the other based on summing predictions on the 6.3 million blocks in the MMVT sampling frame. Here we can see that the two sets of model-based estimates are very close. This implies that the selected MMVT sample was representative of the frame. In general we can see that the predictions of adds and deletes is higher than what was observed in MMVT.

Table 2.11. Statistical Model Performance for Measuring MAF Coverage Sample-Based and Model-Based Estimates of Coverage in the MMVT Frame

Types of Addresses	Sample-Based Estimate		Model-Based Estimate Applied to Sample Blocks (Weighted)[4]		Model-Based Estimate Applied to All Frame Blocks (Unweighted)[6]
All Estimates (x1,000)	Estimate	SE	Estimate	SE[5]	Estimate
Addresses to Canvass[1]……	135,897	0	135,897	0	135,897
Adds[2]……..	5,688	592	8,533	96	8,587
Deletes[3]……..	7,592	310	8,546	293	8,707
Net……..	133,993	654	135,884	285	135,777

[1] Addresses to canvass represent addresses that were present and determined valid within the MMVT sampling frame as of July 2013.
[2] Model #A1 was used to determine the count of Adds.
[3] Model #A2 was used to determine the count of deletes.
[4] Model-based estimate #1 was calculated using the weighted add and delete predictions for the MMVT sample blocks.
[4] Standard Errors on Model-based estimate #1 only incorporates sampling error and does not represent any error due to modeling.
[6] Model-based estimate #2 was calculated by tabulating the add and delete predictions for all 6.3 million blocks in the MMVT sampling frame.

The tally of addresses to canvass is the number of addresses that were present and determined valid within the MMVT sampling frame on the MAF in July 2013. The data collection occurred in the fall of 2014. It is difficult—perhaps impossible—to distinguish addresses that were missing from the MAF in July 2013 from those that are new additions to the housing inventory by late 2014. In general, the model-based predictions are not very accurate for predicting coverage errors.

2.7 Conclusions and Recommendations

In this section we draw conclusions about the results of MMVT based on the two research questions. We also put forward some recommendations for the use of statistical models in a reengineered address canvassing as well as some thoughts about future research.

2.7.1 Conclusions

Research Question #1
How well do the statistical models perform at identifying areas for canvassing?

The current statistical models are not effective at identifying specific blocks to canvass. The rate of error capture was too low, and the rate of erroneous canvass was too high.

Research Question #2
How well do the statistical models perform at measuring MAF coverage error?

The current distributional models are ineffective at measuring MAF coverage error. The distributional models reflect the condition of the MAF in 2009. The difference between the predictions and the MMVT results could be attributed to a couple of factors. The period since the previous canvass was roughly 5 years for the MMVT relative to 10 years for the 2010 Census Address Canvassing. It is also likely that the MAF is in better condition relative to the 2010 Census Address Canvassing due to the ongoing updates and enhancements to the updating mechanisms under the Geographic Support System Initiative. These differences cause the distributional models to overestimate MAF coverage error at the national level.

2.7.2 Recommendations

At this time, we recommend that we do not use statistical models to predict which blocks or areas need in-field canvassing.

We recommend a limited amount of research into the use of modeling techniques that take into account spatial relationships among adds or deletes. It is possible that spatial modeling methods could improve the current models or generate new models.

3 Analysis of the Partial-Block Canvassing Test

3.1 Introduction

3.1.1 Scope and Purpose of this Report Section

This section of the Address Validation Test (AVT) Report presents background, results, conclusions, and recommendations from the Partial-Block Canvassing (PBC) Test. In addition to the Master Address File (MAF) Model Validation Test (MMVT—see section 2), the PBC Test was a component of the AVT conducted from September 2014 to February 2015.

3.2 Overview

3.2.1 Partial-Block Canvassing Test

The concept of partial-block canvassing (PBC) as an in-field address verification and updating methodology developed from discussions between Census Bureau staff and members of the National Academy of Sciences Geographic Resources Subcommittee. Each group recognized that targeted in-field activities to collect address and geo-locational information for specified portions of census blocks for which the MAF was incomplete might be more efficient and effective than traditional full-block canvassing. Given that the concept was new to the Census Bureau, the PBC component of the AVT was initiated to develop materials and methods as well as to acquire information with which to evaluate those materials, methods, and techniques, and if adopted as an address canvassing methodology, to identify methods and materials that were successful and those needing improvement.

The primary purpose of the PBC Test was to determine the effectiveness of:

1) the process for identifying blocks in which housing unit and address changes were clustered (as opposed to being distributed throughout a block);
2) instructions and other materials identifying a specified work area (i.e., portion of the block) and the ability of PBC listers to navigate to and within the work area; and
3) the ability for PBC listers to effectively and accurately collect address information within the specified work area.

Planning for the PBC Test began in Spring 2014. Initial phases of the team's work focused on establishing the PBC Test schedule, identifying the scope and parameters of the test, developing the PBC methodology and materials for use in the field, and coordinating with the Technology Management Office (TMO) regarding requirements for enhancements to the Census Bureau's corporate Listing and Mapping Application (LiMA) device to facilitate the test. The PBC Test schedule was tied to the existing timeline of software development of the LiMA, Mobile Case Management (MCM), and other supporting systems (originally intended to be deployed for the Computer Assisted Person Interview (CAPI) Tech Refresh). The PBC Test would be the first use of the LiMA in a production environment.

Given the timing of the decision to develop and implement the PBC Test, it was not possible to hire and train additional field staff working out of the Census Bureau's six Regional Offices. As a result, the decision was made to utilize professional staff from Census Bureau headquarters and the regional offices. The number of blocks to be included in the test was established based on expectations related to the availability of professional staff as well as availability of laptops on which the LiMA would be deployed. In addition, by selecting geographers and other professional staff to conduct fieldwork, the PBC Test could benefit from participants' high-level geographic, conceptual, and operational expertise and feedback in this initial testing of PBC in the field.

To determine the number of blocks for inclusion in the test, the PBC Team estimated that each lister could work 20-30 blocks during one week in the field. Based on an expected availability of 30-35 laptops, the size of the PBC test was set at 600 to 1,000 blocks. Section 3.3.2.2 below discusses the process by which specific blocks were identified for the test.

PBC Test production listing in the field began on December 16, 2014 and continued until January 17, 2015. PBC Test Quality Control (QC) listing also began on December 16, 2014, but continued until February 9, 2015. Both production listing and QC listing were conducted by professional staff from Census Bureau headquarters as well as the six Regional Offices. Prior to production listing, PBC Team members tested preliminary procedures and materials during three LiMA small field tests conducted in July, September, and late-October/early-November 2014. In addition to testing PBC-related functionality within the LiMA (in addition to other LiMA functionality), the small field tests provided valuable opportunities to test PBC procedures and materials prior to going into production.

3.2.2 Relationship to the MAF Model Validation Test

The TIGER/MAF Assessment and Classification (TRMAC) Team identified blocks through interactive review of imagery to detect changes to the residential landscape with a focus on blocks in which new housing units were clustered in a portion of the census block. The TRMAC Team selected blocks from within the 10,100-block sample identified for the MMVT in order to facilitate comparison of fieldwork results obtained through PBC with a traditional, full-block canvassing operation.

3.3 Research Questions and Methodology

The PBC methodology offers the potential to implement a more efficient approach to address canvassing without the expense of a full address canvass for blocks that contained clustered changes. In this section, we discuss research questions, methods, budget and staffing, training, and listing device and supporting systems.

3.3.1 Research Questions

A primary purpose of the PBC Test was to obtain information with which to evaluate and assess the effectiveness of methods, materials, and procedures. Research questions included:

- Can we create sub-block polygons and descriptive instructions for the targeted areas, from the blocks identified during the in-office imagery review phase?
- Can listers effectively navigate to, collect accurate address structure, and attribute information in the field for these targeted areas?
- In what types of areas and situations is the PBC methodology most appropriate compared to traditional full-block canvassing.

Comparison of PBC results with MMVT results for the 615 blocks that were in both tests provided an opportunity to evaluate the effectiveness and efficiency of PBC as a methodology in comparison to a traditional full-block canvassing. Specific research questions included:

- Did listers in each test locate and record the same updates? If not, what were the differences and the reasons for the differences?
- Did listers in the MMVT find updates that were not detected in the in-office imagery review portion of PBC?
- Is the PBC methodology more efficient than full-block address canvassing at capturing adds and deletes?

3.3.2 Methods

The PBC process contained an in-office component encompassing imagery review, with comparison of detected changes to contents of the MAF for each census block reviewed, and a component in which assignment areas, work areas, and canvassing instructions were defined. The in-office component resulted in selection of 615 blocks in which canvassing would occur. The in-field component of the PBC utilized traditional listing methods, with, of course, the exception that listers canvassed only a portion of each assigned block. Quality control (QC) for the PBC Test was conducted in 174 of the 615 production test blocks by sending a second lister to canvass the same area as the production lister. The QC lister did not review or check the work of the first lister, but the two results were available for comparison and for use in measuring the overall quality of the PBC production listing.

The in-office methods used in this operation are discussed in more detail below. The imagery review process discussed below will be an ongoing process and is a key component of “In-Office Canvassing.”

3.3.2.1 Imagery Review

Imagery review is a critical first step in the PBC process to identify census blocks in which housing unit changes have occurred and for which the MAF is incomplete. Imagery review also is used to identify blocks in which changes are clustered in a portion of the block. The PBC Test utilized the imagery review process developed by the TRMAC Team as part of the in-office canvassing component of the Census Bureau’s re-engineered address canvassing for the 2020 Census.

The TRMAC Team reviewed imagery for all 10,100 MMVT blocks to select the blocks that would be possible PBC Test candidates. The criteria to be included as candidates for the PBC Test were:

- Observable housing unit growth (Figure 3.1).
- Visible indicators of future housing unit growth (Figure 3.2).
- Where housing unit undercoverage likely existed, as identified by comparing MAF counts to the number of units observed in the current imagery where housing unit change did not occur (Figure 3.3).
- Historically problematic housing unit types, for example mobile home parks and small multi-units.

The imagery review process occurred from August through November 2014, conducted by seven professional geographers (working part time on the imagery review, as other work allowed) in ArcGIS. Results were reviewed and validated by three professional geographers on the PBC project team working part time on the effort September through November 2014. Only 1,903 MMVT blocks were determined to be possible PBC candidates based on imagery review. These were reviewed further during the PBC block selection phase described in Section 3.3.2.2 below.

The IR process includes the following:

1. Comparison of two vintages of imagery (one 2009/2010 and one as current as possible) to identify stability or housing unit change that has occurred since the 2009 Address Canvassing operation and the 2010 Census. At the time of imagery review for PBC, available "current" imagery could have been up to two years old. For future imagery review processes, "current" imagery should be no more than one year old at the time of review.

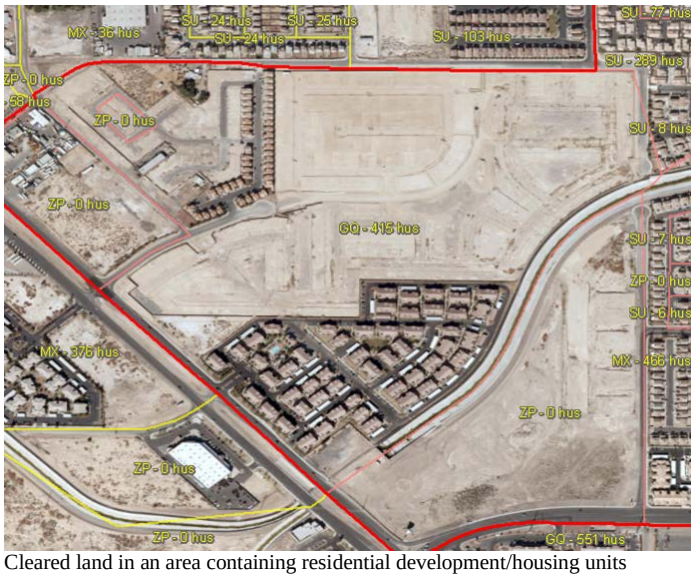
Figure 3.1: Observed Housing Unit Growth

2010 Imagery

Current Imagery

2. Use of the “current” vintage of imagery to detect evidence of possible future residential growth.

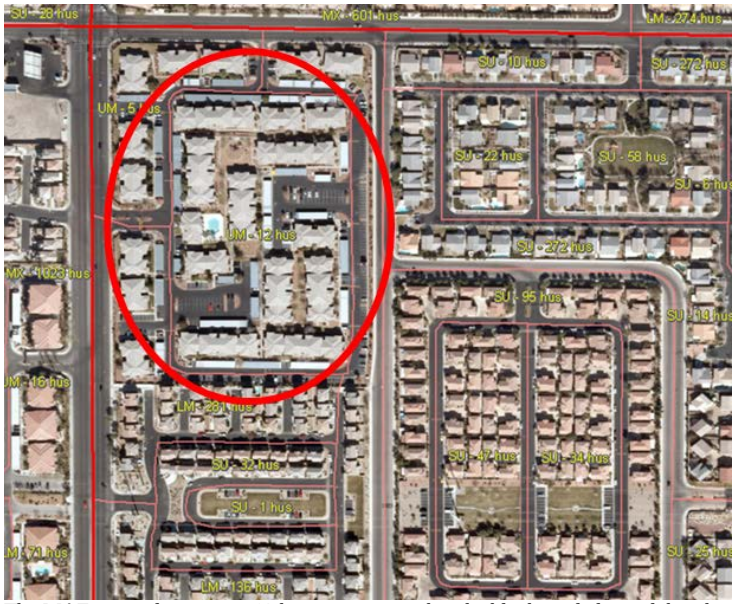
Figure 3.2. Block Identified as Containing Future Growth



Cleared land in an area containing residential development/housing units indicates future housing unit growth may be occurring.

3. Use of the “current” vintage of imagery in conjunction with MAF counts, MAF structure points (MSPs), and housing unit classification based on MAF housing unit type to assess potential undercoverage.

Figure 3. 3. Undercoverage Identified



The MAF currently contains 12 housing units within the block circled in red, but there appears to be 12 apartment buildings within the block, each containing multiple units.

3.3.2.2 Creation of Assignment Areas, Polygons, Work Areas, Instructions

After the TRMAC Team completed review for all 10,100 MMVT blocks and winnowed the number of potential candidate PBC blocks to 1,903, the PBC Team reviewed the blocks more closely to select the final set of blocks suitable for testing the PBC methodology in the field. The PBC Team then created work area polygons and instructions for the partial-block areas. Three PBC Team members (professional geographers) participated in these tasks. Work on this phase began in mid-October 2014, was completed in mid-November of 2014, and took approximately 80 hours of staff time to complete. The result of this process was a universe of 615 PBC blocks, out of the initial 1,903 blocks identified during the initial TRMAC IR. Details of the candidate block selection and creation of work area polygons and instructions for the partial-block areas are presented in the subsections below.

Candidate Block Selection

PBC Test candidate block selection took place in the ArcGIS software environment. The PBC Team chose blocks where they suspected that fieldwork would result in add actions. The team mainly chose blocks that included observed housing growth or areas of suspected new residential construction, but also chose some blocks containing historically problematic housing types (mobile home parks and small multi-units) where they suspected undercoverage. For purposes of this test, the PBC Team decided to focus on adds, given that undercoverage is of greater concern in terms of MAF accuracy and completeness and given the uncertainty whether addresses associated with demolished houses would be reused with new construction. As a result, the PBC Team made no attempt to select blocks containing deletes or other kinds of changes to addresses.

PBC Team members researched blocks using the MAF Browser to determine if addresses were missing and discarded any blocks where the MAF appeared to already contain the change. Staff also examined aerial imagery to determine if growth within the block was sufficiently clustered to make the block a suitable PBC candidate. Staff discarded blocks where the entire block showed growth, where growth was scattered in many different parts of the block, or where the block was so small that the expected cost savings was minimal.

The PBC Team made no attempt to select blocks in every state, but did ensure geographic diversity by picking blocks from states in different regions.[1] In a later process, the PBC Team discarded some candidate blocks for operational reasons, specifically where the blocks were geographically remote and would result in long travel times between blocks and substantial costs without corresponding gains in knowledge and results. This remoteness exclusion removed all the PBC candidate blocks in Idaho, Nebraska, Nevada, Utah, and Vermont as well as some scattered blocks within other states. The process resulted in selection of 615 census blocks for inclusion in the PBC Test, which were then grouped into work assignments for individual listers.

Creation of Partial-Block Work Areas and Instructions

A primary goal of the PBC Test was to determine which kinds of instructions were most effective in the field and which types of instructions caused lister confusion.[2] After choosing the PBC candidate blocks,

[1] States that were not reviewed for PBC selection purposes include: Alabama, Arkansas, Kentucky, Louisiana, Michigan, Mississippi, Missouri, Montana, Oregon, South Dakota, Tennessee, Wisconsin, and Wyoming. The District of Columbia and North Dakota were reviewed but no suitable PBC candidate blocks were found. Alaska, Hawaii, and Puerto Rico were not in scope for the MMVT.

[2] While a large literature exists on issues of wayfinding, a preliminary literature review did not yield any studies dealing with the specific issue of how to define and describe a canvassing zone. Most literature dealt with point to point navigation and routing, which is quite different from defining an area to be canvassed.

the PBC Team created PBC work areas, as delineated by PBC Polygons. The PBC work areas represented that portion or portions of the candidate block where the expected Add actions were located. Most blocks had only one PBC work area, in some cases the PBC Team saw growth in multiple parts of the block and created multiple work areas. In total, the PBC Team created 705 work areas within the 615 candidate blocks.

The PBC Team wrote detailed instructions for each work area to both assist navigation to the work area and to focus attention on the specific work to be accomplished. In early small field tests, the PBC Team delineated work area polygons, but provided only the generic instruction to "Canvass the entire area" of the polygon. During these small field tests, PBC Team members had difficulty associating the polygon on the map with features on the ground and realized that without imagery the polygon alone was not sufficient for identifying where to start and stop canvassing. In addition to basic navigational information, some instructions also provided "clues" to the lister about what to look for in the field. For example, some instructions specifically prompted the user to check the residential status of all the units in a mixed commercial and residential structure. A secondary goal of the PBC Test was to see if these specific clues aided listers in finding hard to locate units that a traditional, unaided canvass might miss.

When writing instructions, the PBC Team used a variety of instruction types depending on the situation, and coded each work area according to the type of instruction used. The goal was to minimize the amount of unnecessary work (i.e., verify actions) while capturing the entire targeted area of growth. The PBC Team also had to ensure that the work areas and instructions referenced landmarks that would be identifiable on the ground.

Six basic types of instructions were used and also described in detail during training (for more details about the instruction types see Appendix B-1):

Type A: Bounded Street Segment: 320 work areas
Type B: Whole Street: 169 work areas
Type C: Branching Roads: 93 work areas
Type D: Targeted Address/Structure: 56 work areas
Type E: Exclusion: 9 work areas
Type F: Other: 58 work areas

3.3.3 Budget and Staffing

Census Bureau headquarters and regional office professionals provided the staffing for the PBC fieldwork. The timing of the decision in Spring 2014 to develop and implement the PBC Test as part of the AVT in Fall 2014 precluded hiring and training new field representatives to carry out the PBC listing in the field. The decision to use professional staff also provided the opportunity for these individuals to gain valuable in-field experience implementing address canvassing procedures, testing and providing feedback on the new PBC methodology, and using the LiMA.

Thirty-five professional staff (mostly headquarters and regional office geographers) conducted production listing and quality control listing in 37 assignment areas between December 16, 2014 and February 9, 2015. The number of staff available to work on the PBC Test was limited by the number of available laptops; as a result, two listers were each assigned two work areas.

Assignments were made to minimize travel wherever possible, taking advantage of the locations of regional office and work-at-home geographers in relation to work assignment locations. For example, the two geographers in the Philadelphia Regional Office participating in the PBC Test were assigned work areas in Pennsylvania, Delaware, and New Jersey. The three work-at-home geographers based in

the Boston, Massachusetts area were assigned work areas in New England. In general, headquarters staff received work area assignments in the eastern half the nation. After assignments were made, individual listers were asked to submit estimates for travel costs prior to finalization to ensure the test remained within budget.

Total travel costs for the PBC Test were $53,796. The PBC team did not collect hours and salary costs for PBC listers, in part because the distances between individual blocks and travel times involved would not be reflective of actual distances and costs if the PBC methodology were to be adopted. Given that PBC blocks were only selected from the MMVT sample, it was not possible to achieve efficiencies by selecting PBC candidate blocks based on proximity to other blocks identified for fieldwork.

3.3.4 Training

Summary

The PBC methodology requires that listers navigate to a specific location, and then collect specific address information for a portion of a block. Successful data collection depended on the ability to communicate this information to the lister in the LiMA and other assignment information, as well as provide procedures and sufficient training. The approach to the PBC training was to emphasize to listers the PBC goal of involving more investigative geographic work, along with the more typical listing procedures.

Components of Training

The PBC Team developed the procedures, documentation, and training for the PBC Test in fall 2014 in preparation for the training session on December 12, 2014, conducted via WebEx. The procedures were designed for PBC listers, taking into account the varying backgrounds and levels of canvassing and field experience. Apart from PBC Team members who had participated in the LiMA small field tests as well as two PBC listers who were part of the LiMA development team, none of the PBC listers had experience using the LiMA.

PBC training topics included:

- Overview of PBC and the importance of testing this new methodology for a reengineered address canvassing.
- How and why the partial-block assignments were chosen and delineated.
- The PBC lister's role and expectations regarding performance of canvassing within the allotted timeframe for the test.
- How to list partial blocks plus guidance on polygons and how to follow the polygon instructions.
- An overview of the LiMA and MCM (individual laptops were not available for a preferred hands-on training method).

Technical materials provided for the listers were explained, including PBC-specific functionality added to the LiMA specifically for the PBC Test and the additional tools provided on the laptops for PBC:

- KML files to view work areas overlaid on imagery via Google Earth to assist with planning and navigation.
- Spreadsheets with assignment locations and descriptions, including street intersections and latitude/longitude coordinates for those intersections to assist in locating each work area.
- Quick-reference materials containing LiMA screen shots and information about how to use the LiMA and how to handle various types of structures.

Practical and logistical information and tips on performing fieldwork were covered, including pre-fieldwork preparation and research on the individual assignments, navigation to partial-block work areas,

managing assignments, and post-fieldwork activities, such as feedback forms, returning laptops, documenting travel, and attending the debriefing meeting. The PBC procedures document, field reference "cheat sheets," and training PowerPoint slides are not included with this report due to space considerations, but are available upon request.

Recommendations

Based on feedback from listers:

- More comprehensive training related to traditional canvassing procedures would be beneficial in preparing listers for fieldwork.
- Training would be more effective if listers had individual laptops or smartphones for use and practice during training.

3.3.5 Listing Device and Supporting Systems

Summary

The PBC Test was the first use of the LiMA and MCM applications as well as the Computer Assisted Personal Interview (CAPI) technology refresh (CAPI tech refresh) laptops in a production operation. Use of the LiMA and MCM in the PBC test provided a valuable early opportunity to test the LiMA and its integration with MCM and other systems, including the Master Control System (MCS), which interfaces with the Regional Office Sample Control (ROSCO) system, and ROSCO which is used to create lister assignments and "close out" completed blocks and cases for processing. PBC Team staff prepared input files containing PBC blocks, and assigned blocks to individual listers in ROSCO. The LiMA ran on a Windows 8 touch screen device for the PBC Test.

Critical LiMA functionality for the PBC test included the ability to:

- Add a new address.
- Edit an existing address.
- Delete an address.
- Add street names.
- Collect category/type and contact information for group quarters.
- Collect a manual and GPS latitude and longitude coordinates for housing units.
- Display a PBC work area polygon and related instructions.
- Display the list of addresses within a work area block.
- Display a point location for residential structures.

Findings

The LiMA and MCM development teams successfully developed three new PBC-specific functionalities needed for the PBC Test:

1. Display of the PBC work area polygons and instructions, used to communicate the assigned work areas to listers.
2. Ability for listers to complete a block without taking an action on (e.g., verifying) all addresses within the block.
3. Ability to reassign a block from one lister to another.

Use of the LiMA and MCM early in their development presented several challenges and issues, including:

1. The application development schedule, laptop availability and provisioning, and security approval, caused a delay to the PBC Test fieldwork start date. Since the PBC test fieldwork could not start until mid-December, there was a greater temporal lag between the MMVT fieldwork and the PBC fieldwork than originally anticipated.

2. Some fieldwork scheduled to occur the first week of the PBC Test fieldwork was delayed and rescheduled since the files used in MCM and LiMA took longer than expected to process and load onto the laptops. In addition, laptop connectivity issues caused a delay in the download of assignment information for some staff.

All issues with both the LiMA and the MCM were resolved. While some issues caused slight fieldwork delays, most listers were able to complete their full assignment on time. Several listers experienced extreme slowness in blocks with a high number of addresses. Developers were unable to deploy the fix for this issue until late in the fieldwork period; as a result, several listers had to either skip assigned PBC blocks or extend their fieldwork to complete assignments.

3.4 Limitations Affecting Comparison of PBC and MMVT Data

This section describes the primary limitations encountered by the PBC Test, including limitations with listing fieldwork, data files, and other areas. These limitations affected data collection and results of the PBC work plus comparisons with the MMVT.

3.4.1 Listing Limitations

Listing limitations included differences in staffing, training, and timing of fieldwork between MMVT and the PBC Test:

Differences in Staffing
Census Bureau professional staff conducted PBC Test fieldwork. The MMVT used existing Field Representatives (FRs) and newly hired FRs. While differences in skill levels between PBC canvassers and MMVT canvassers, particularly in terms of geographical expertise and spatial skills, potentially could have affected the results of listing in each test, we have not analyzed the data to ascertain whether this was the case. There is some concern that the use of professional geographers to carry out the PBC methodology may have skewed results toward greater success. On the other hand, professional FRs may have achieved greater success given their previous listing experience and familiarity with listing procedures. Additional testing of the PBC methodology with FRs is recommended.

Differences in Training
PBC listers received one-half day of training. PBC training focused on the new concepts of canvassing partial blocks and using the newly developed LiMA software. Professional FRs were trained for the MMVT with Demographic Area Address Listing (DAAL) refresher self-training, while new hires were provided a full three days of DAAL training. Both the experienced and newly hired staff were then provided with a day of training specific to MMVT (explaining the few differences and objectives between regular DAAL and the MMVT).

Differences in Timing of Fieldwork
MMVT canvassing began on September 2, 2014 and completed on December 15, 2014. The PBC Test began listing in the field on December 16, 2014 and continued until January 17, 2015, with QC listing continuing until February 9, 2015. Given the impact that the temporal difference between the two tests could have on comparison of results, PBC listers were asked to note as part of their feedback whether there were signs of new construction having occurred within the three months prior to going into the field. It is possible that addresses added by the PBC lister but not by the MMVT lister in the same area may have been built after the MMVT lister was in the field. Further analysis is needed at the individual address level, in comparison to PBC lister notes, to identify the number of instances in which this occurred.

Differences in Types of Listing Devices
The MMVT used the existing ALMI software with which DAAL listers already were familiar and only needed training on items specific to the MMVT. The PBC Test utilized the LiMA in the field. The two listing devices provided listers with ability to carry out similar functions and tasks, so at a basic level, listing operations were similar. A key difference between the two devices, however, related to the ability to edit address numbers. MMVT listers using the ALMI had the ability to change a housing unit's address number if the number was incorrect on the address list, whereas PBC listers using the LiMA were required to first delete the incorrect address and then enter the correct address number for the unit. This two-stage approach to correcting addresses in the LiMA was adopted in response to erroneously modified addresses (submitted during previous listing operations for other programs) which were attributed to the ease with which addresses could be changed in the ALMI. In addition, the ALMI and the LiMA code similar actions in different ways, based on the different workflows and codes available within each device, and create different output files. These differences created challenges when comparing the MMVT and PBC results.

Differences in Vintage of Address Lists
Both tests were dependent listing operations in which canvassers were provided with lists of addresses contained in the MAF for the blocks in their respective assignments. The address list for the MMVT was current as of Spring 2013 whereas the address list for PBC was current as of Spring 2014. This meant that a PBC lister's address list might have contained addresses that did not appear on the MMVT lister's address list. The MMVT lister, upon detecting the address in the field, would add it to the address list as a new address. The same address, however, would represent a "verify" action to the PBC lister. Differences in the vintages of address lists posed analytical challenges to MMVT and PBC Team members, specifically when trying to compare numbers of "true" adds; that is, addresses that truly are new to the MAF. On the other hand, the difference in vintages provides the opportunity to identify areas in which the DSF or local government address lists (or both) can be relied upon to provide address updates, and in which in-field canvassing might not be necessary. Future research needs to be conducted on this topic.

3.4.2 Data Files Limitations

Comparing the PBC matching output file and the MMVT DAAL transaction file required the PBC Team to utilize the post-processed files created by the MMVT Team to assign an action to records rejected during the DAAL processing. Using the MMVT file was critical when comparing added units from the two operations.

Differences in Matching and Processing
The PBC results were matched to the MAF using matching and geocoding software developed in 2012 for processing large administrative records files and address files from local entities. The matching and geocoding software attempts to match to every address associated with a MAF Unit, including preferred and non-preferred location and mailing addresses. The output from the matching process is a table that contains the matched MAF identifier (MAFID), block, Delivery Sequence File (DSF) history, and other MAF attributes for the MAF unit that matched to the PBC address record. The matching and geocoding software does not update the MAF.

The MMVT results were processed using the DAAL MAF update software. The DAAL software was developed in 2003 to update the MAF with address updates from the Current Survey and Community Address Update System update block field listing assignments using the Automated Listing and Mapping Instrument (ALMI). The DAAL software attempts to match to every address, including preferred and non-preferred location and mailing addresses, on the MAF unit prior to completing the transaction in the MAF. The output from the DAAL software processing is a transaction file that details

the result of each transaction. The DAAL software rejects certain transactions because of improper field actions or invalid legal values, and every update to the MAF must pass edit checks and contain legal values. The DAAL software also rejects group quarter (GQ) transactions since the software is expecting GQ updates from a different source.

3.4.3 Other Limitations

Other limitations faced by the PBC Test process were the availability of 2010 imagery and the availability of high-resolution imagery to represent 2010, as described below.

Availability of 2010 imagery
The PBC Test required two reviews comparing the 2010 imagery with "current" imagery: 1) imagery review of all MMVT blocks and, 2) the subsequent PBC candidacy review of blocks with residential housing unit change. During both the imagery review and PBC candidacy identification phases, sufficient server storage space was not available to load the entire set of 2010 imagery for the MMVT blocks, and the imagery had to be served up and archived on an ongoing basis so that all areas could be reviewed. This caused the TRMAC and PBC teams to spend additional time conducting the review due to "downtime" while the imagery was being switched; however, this did not adversely affect the overall schedule.

The 2010 imagery also was needed for the PBC analysis, and the analysis work was delayed in part due to the unavailability of server space to load the 2010 imagery.

Availability of high resolution 2010 and current imagery
In a few areas, the TRMAC interactive reviewers and PBC candidacy reviewers did not have 2010 and/or current imagery of sufficient resolution to assess residential housing unit change and MAF undercoverage relative to imagery. While the teams were able to identify enough PBC candidates for use in the PBC Test, the opportunity to select PBC candidates from all MMVT blocks was limited due to the insufficient imagery. In total, 161 out of 10,100 (1.6 percent) were unable to be reviewed due to imagery quality/resolution issues.

3.5 Results

This section describes the primary results of the PBC Test, including direct comparison with MMVT and PBC Test listing fieldwork, data files, and matching to the MAF/TIGER database, the PBC listers' observations, and an evaluation of the PBC methodology. In this section, we present the objective analyses of these data, while offering explanations and other insights as to why and how PBC Test fared in direct comparison to MMVT.

This analysis section of the PBC Test results is organized into the following categories:
- 3.5.1 PBC Test Inputs and Outputs
- 3.5.2 Matching to the MAF/TIGER Database
- 3.5.3 PBC Test Findings
- 3.5.4 Lister Feedback Analysis

3.5.1 PBC Test Inputs and Outputs

The PBC Test had both technical inputs and outputs and lister-focused inputs and outputs. For example, technical inputs include requirements for files, software, and systems; lister-focused inputs include materials provided to listers to assist in their work, such as Keyhole Markup Language (KML) files to

display on Google Earth and PDF maps of all their work areas. Technical outputs include files transmitted with fieldwork results from the laptops, while lister-focused outputs include lister feedback forms and information from the debriefing meeting. The details of both technical and lister-focused inputs and outputs are provided in Appendix B-2.

3.5.2 Matching to the MAF/TIGER Database

Section 3.5.2 summarizes processing of field actions taken on the LiMA during PBC. The PBC listing file contained 17,627 records, which included 10,189 add actions. Of those add actions 2,954 matched to a geocoded MAF unit in the MAF. The results of the PBC listing were delivered as an Address Update File (ADDUP), which was then transformed into the layout required for matching address data to the MAF. The newly created input file from the PBC listing was matched against a refreshed copy of the Development database. The output from the matching and geocoding process includes a matched MAFID (if a match is found), census tract and census block information, and other data about the matched MAF Unit.

Table 3.1 lists all actions from PBC listing after matching and processing described above in this section and the matching and processing limitations in Section 3.4. The total number of addresses returned from field data collection always equals 1) the number of records sent out on the address list in the LiMA, and 2) any additional addresses that the fieldworker adds to the LiMA address list.

There are three types of add actions in this table:

1) true adds, which are adds that do not match to existing addresses in the MAF;
2) adds that matched to addresses already contained in the MAF but which were ungeocoded; and
3) addresses that already existed in the MAF but did not meet requirements for inclusion on the address list (such as listed in the MAF as nonresidential).

Overall, PBC listers took 17,627 actions while in the field, of which 10,189 (57.8 percent) were adds. Of these, 4,301 addresses were new to the MAF and an additional 2,931 were addresses that were in the MAF, but had not been geocoded to a specific census block.

Table 3.1. PBC Processing Results

PBC Actions	GEO Action Code	Number of PBC Actions	Percent of Total PBC Actions
Total Actions		**17,627**	**100.00**
Adds:			
True Adds		4,301	
Adds Matched to Ungeocoded Addresses in the MAF		2,931	
All Other Adds Matched to MAF		2,957	
Total Adds	A	10,189	57.80
Deletes	D	387	2.20
Duplicates	L	20	0.11
Changed to Nonresidential	N	2	0.01
HU Converted to GQ	G	1	0.01
GQ Converted to HU	H	1	0.01
Verify	V	7,027	39.86

3.5.3 PBC Test Findings

This section presents the PBC Test findings based on data analysis, focusing on the PBC fieldwork efficiency, the utility and success of the PBC polygons and instructions, and the effectiveness of the imagery review within the PBC blocks.

The overall PBC process consisted of three separate, sequential steps: Imagery Review, PBC Polygon and Instruction Creation, and PBC fieldwork. This section assesses the effectiveness of each of these component elements:

- 3.5.3.1 PBC Fieldwork Results: this first subsection includes a comparison of the efficiency of PBC to a traditional full-block canvass as represented by MMVT, focusing in particular on the overall ratio and distribution of add actions.
- 3.5.3.2 PBC Polygon/Instruction Findings: the second subsection evaluates PBC Test findings on polygons and instructions and how well PBC listers were able to accomplish the intended canvassing work for the assigned work areas.
- 3.5.3.3 Imagery Review Detection Findings: the third subsection presents findings on the imagery review process and how well it identified areas of housing unit change or coverage issues in the 615 PBC blocks as compared with the MMVT full-block canvassing results.

Each of these PBC phases is presented with summary findings, case studies, discussion of the findings, and recommendations.

3.5.3.1 PBC Fieldwork Results

Differences in timing, address filter, instrument, processing, documentation, and staff between the MMVT and PBC constrained the ability to fully compare the two processes. In spite of these limitations, the PBC analysis did yield several meaningful results.

PBC methodology is more efficient compared with traditional full-block canvassing in capturing added housing units. Overall, PBC returned more adds in the same blocks than MMVT. PBC listers took

many fewer total actions per block but found a roughly equivalent number of adds per block. MMVT had a total of 9,343 total adds, while PBC had a total of 10,189 adds for the same blocks (Table 3.2). The larger number of adds in the PBC Test can, in part, be attributed to the three to four month difference between the time in which the two tests were in the field. It is unlikely, however, that the later timing would account for all of the difference. Potentially, the PBC instructions and targeting of growth areas helped to yield more adds using the PBC method rather than using a traditional full block canvass (during MMVT). Additional research is needed to fully assess the effectiveness of the PBC methodology.

In the same 615 PBC blocks, PBC listers only needed to make 13 percent of the total actions required by MMVT listers canvassing the full block (17,627 actions versus 135,596). Over half of the MMVT actions were verifies, many of which can be effectively verified "in office" through the TRMAC IR, and do not require resource intensive fieldwork. These results suggest that the PBC methodology requires less work to capture added housing units, translating into fewer hours and miles spent canvassing in the block (but not fewer miles to reach the block).

Table 3.2. Comparison of MMVT and PBC Add Actions in Relation to all Actions in PBC Blocks

Actions in All PBC Blocks	MMVT		PBC Test	
	Number of Actions	Percentage of Total Full-Block Actions	Number of Actions	Percentage of Total PBC Actions
Total Adds	9,344	6.89	10,189	57.80
All Other Actions	126,251	93.11	7,438	42.20
Total Actions	**135,595**	**100.00**	**17,627**	**100.00**

Other Actions include: Change, Move, Verify, Delete, Duplicate, Nonresidential, Uninhabitable using the ALMI for MMVT, and Verify, Delete, Duplicate, Nonresidential, and GQ/HU Conversions using the LiMA for the PBC Test. The two listing devices had different possible actions and processing of those actions and are not directly comparable.

Looking only at add actions (Table 3.3), true adds (again, addresses that were truly new to the MAF) accounted for a higher percentage of all PBC adds (42.21 percent) compared to all MMVT adds (32.14 percent). Adds matched to ungeocoded addresses in the MAF accounted for a higher percentage of all MMVT adds (38.46 percent) compared to all PBC adds (28.77 percent). This could be explained, in part, by the difference in the vintages of the address lists utilized in each test—2013 vintage for the MMVT and 2014 vintage for the PBC Test—assuming some of the ungeocoded addresses on the MMVT list had been resolved through other operations prior to the production of the address list for the PBC Test.

Table 3.3. Comparison of Types of MMVT and PBC Add Actions in PBC Blocks

Actions in All PBC Blocks	MMVT		PBC Test	
	Number of Actions	Percentage of Total Full-Block Add Actions	Number of Actions	Percentage of Total PBC Add Actions
Total Adds	**9,344**	**100.00**	**10,189**	**100.00**
True Add	3,003	32.14	4,301	42.21
Adds Matched to Ungeocoded Addresses in the MAF	3,594	38.46	2,931	28.77
All Other Adds Matched to MAF	2,747	29.40	2,957	29.02

All MMVT add actions were analyzed in the 615 PBC blocks. Of the 9,344 MMVT add actions, 80.9 percent matched to an address also found by PBC listers. Of the remainder, 10.1 percent of MMVT adds were in or near the PBC polygon, but were not identified by the PBC lister. An additional 7.9 percent were in portions of blocks not near the PBC work area. For 1.1 percent of the MMVT adds, we were unable to determine whether the address matched to a PBC add due to differences in address description or location description for the housing unit.

When PBC did not find an add found by MMVT, the main reasons for the omission were:

- The area was provided to the PBC lister, but the instruction was poorly-worded or the polygon was poorly-defined, leading to lister confusion. In these instances, in-office imagery review detected changes.
- The add represented a situation not detected by the imagery review step, and therefore was not provided as a work area to the PBC lister. Several factors contributed to the inability for in-office imagery reviewers to detect change: quality and vintage of imagery, inability to distinguish between residential and non-residential structures, inability to detect changes within residential structures.

Recommendation

Conduct further research into the MMVT adds that PBC did not find, to implement improvements to the in-office canvassing and PBC work area delineation processes.

3.5.3.2 PBC Polygon/Instructions Findings

In this section, we discuss situations in which analysis revealed that differences between MMVT and PBC results appeared to be due to problems with, or interpretation of, the PBC process, PBC instructions, polygons, or both. These issues are presented as case studies. The main findings on the effectiveness of PBC Polygons/Instructions for conducting canvassing are:

- Incomplete Polygons
- Correct Polygons with Incomplete Instructions
- Unanchored Instructions
- Poor Features as the Basis for Creating Polygons

No Title 13 data are included in the examples below. Addresses are for illustrative purposes only to provide a clearer understanding of what the lister would have seen in both an instruction and on the ground. None of the addresses mentioned below are real.

PBC Polygon/Instructions Finding 1: Incomplete Polygons

Summary
This issue points to a problem in the workflow used for the test, where the initial TRMAC reviewer set only a block-level flag and then handed the block off to a second person who created the polygon.

Case Study
The MMVT returned 54 adds on Johnson Parkway which did not appear on the PBC list. These adds were at a multi-unit suburban structure at 660 Johnson Parkway. Upon inspection, these were all legitimate adds. The building at 660 Johnson Parkway was located adjacent to the PBC polygon but not included in either the polygon or the instruction, which referenced only 620 and 640 Johnson Parkway, similar multi-unit structures along the same road. Examination of the current imagery indicates that the structure at 660 Johnson Parkway was apparently under construction at the time of the imagery used for TRMAC review.

Discussion
In this case, the TRMAC reviewer correctly flagged the block as having both observed growth (620 and 640) and future growth (660) areas. However, when a polygon was created, only the new buildings visible in the imagery were included and the adjacent construction zone that would later become 660 was excluded.

Recommendation
When designing the review tool used for production, it is essential that this workflow be more integrated and seamless. The initial TRMAC reviewer should be able to clearly designate the entirety of the growth area within the block, so that the process of change identification and polygon creation is more integrated. In-office procedures also need to make it clear that areas of observed growth and of suspected future growth should be included in PBC polygons. In addition, field training and procedures should give field listers more leeway to add addresses for structures immediately outside their polygon that appear to be new.

PBC Polygon/Instructions Finding 2: Correct Polygons Including an Incomplete Instruction

Summary
This case illustrates the important point that sometimes it is possible to provide *too much* specific information to the fieldworker. In this case, it is likely that sending out the polygon with no specific instruction at all would have led to a better result, especially if imagery had been available in the LiMA to help the lister understand exactly what was in the polygon. To some extent, these overly specific instructions were a result of not having imagery available in the device.

Case Study
MMVT returned five addresses on Rialto Lane that PBC did not include. Upon inspection, these five single-unit houses were clearly located within the PBC polygon.

Discussion
In this case, the problem was with the instruction, not the polygon. The polygon and instruction correctly included the Rialto Lane area in the polygon. However, Rialto Lane was a very short street, which in overhead imagery appeared to be merely an extension of another street, Dion Street. The PBC Team member wrote an instruction that said “Canvass the Entirety of Dion St” without making any reference

to Rialto Lane. In training, PBC field staff were told that if there was a conflict between the polygon and the instruction that it should be the instruction that takes precedence. In this case, the fieldworker clearly saw the houses on Rialto Lane, even noting their presence in the feedback, but did not list them, because based on the instruction, he did not think he was supposed to.

Recommendation

Training materials should be clear that the instructions should take precedence over the polygon. Future training and procedures should stress that if there are conflicts between the polygon and the instructions, the lister should contact the help desk.

PBC Polygon/Instructions Finding 3: An Unanchored or Poorly Anchored Instruction is a Bad Instruction

Summary

During full block canvassing, the lister must take an action on every address in the list which "anchors" the lister to the correct block. In PBC, by contrast, the address list does not necessarily anchor the lister in the same way, as the lister is instructed to work one specific area or structure and this can result in ignoring the overall context.

Case Study

Case 1: MMVT returned 75 adds which were not within the PBC list. Upon inspection, it turned out that these 75 adds were all in a single apartment building at 201 River Ave. This building was clearly within the PBC polygon.

Case 2: The PBC lister returned 40 adds, all associated with a multi-unit structure at 5555 W 120th St. However, the same lister also took 300 verify actions. 120 of these verify actions were associated with a multi-unit structure at 5553 W 120th St, while the other 180 verify actions were associated with a multi-unit structure at 5557 W 120th St. This is a lot of unnecessary verify actions.

Discussion

In the first case, the instruction was to "Canvass the multi-unit structure on the corner of River Ave and 74th St." The lister actually canvassed a different apartment building (200 River Ave) on the adjacent corner of River Ave and 74th St, a building that was not only outside the PBC polygon but in a different block altogether.

On one level, the lister was simply disoriented, which also happens in traditional full-block canvassing, so it is hard to say if PBC methodology is at fault in this case study. However, there is a specific element of PBC methodology that might raise the risk. In a traditional canvassing situation, the lister is able to use the existing addresses on the list as a check to make sure they are listing the right block. A mistake like this would become quickly apparent as the lister saw that none of the addresses in their list were visible on the ground. In short, imagery may have helped the lister understand which building was which, but the real problem was the vagueness of the instruction.

PBC instructions often included "anchor" addresses on each side of the targeted address. In this case, while the targeted address was 5555 W 120th St, the instruction read "Canvass from 5553 W 120th St to 5557 W120th St". In a suburban or rural context, telling the lister to canvass the two anchor addresses (i.e., 5553 and 5557 in this example) had no significant effect on the efficiency of the process, as those anchor addresses were generally single-family homes and could quickly be verified. However, in the urban multi-unit context, the anchor addresses could contain hundreds of apartments needing to be verified and thus represent a decrease in the cost savings associated with PBC.

Recommendations

- Including existing MAF addresses within the block as "anchor points" within the PBC instruction. Instructions referencing anchor addresses need to contain precise wording to assure accuracy without jeopardizing efficiency. In the first case study, it would mean an instruction like "Canvass the multi-unit structure located on River Ave between the intersection with 74th St and 199 River Ave." This kind of instruction will let the lister know that the building must be on the same side of the street as 199 River Ave, which 200 River Ave obviously is not.
- Write more specific PBC instructions in multi-unit areas, so that the anchor MAF addresses are not unnecessarily canvassed for multi-units. In the second case, it would mean an instruction like: "Canvass any structures located between 5553 W 120th St and 5557 W 120th St. Such an instruction would allow the canvasser to correctly obtain the 40 adds within the structure at 5555 W 120th St without having to verify the 300 addresses in 5553 and 5557. Use parcel data in writing PBC instructions, where available. The use of parcel data would also help to avoid this kind of error. If parcel data had been available to the in-office staff, most likely the in-office PBC staff would have been able to actually supply the Basic Street Address (BSA) for the correct structure and provide an even more ideal instruction: "Canvass the multi-unit structure at 201 River St, get within-structure unit identifiers."

PBC Polygon/Instructions Finding 4: Bad Features Make Bad Polygons

Summary

Unaligned road features can make it very difficult for the PBC lister to understand exactly how to interpret the instruction and the polygon in relation to what is seen on the ground. The issue would not arise for the full-block canvasser in some instances where the feature is not part of the block boundary and is only the boundary of the PBC polygon.

Case Study

MMVT returned 26 adds which were not present in PBC. Upon inspection, these were all correct adds representing townhomes along a segment of Harbor Drive. This road appeared to be within the PBC polygon.

Discussion

In this case, the instruction read "Canvass Area South of Harbor Drive and West of Giles Rd." The instruction was not well worded, but in this case the issue was more likely due to the extent of the polygon. The problem was that the Harbor Drive feature itself was badly misaligned and located in the wrong location on the map.

Recommendation

We should not select areas with misaligned features for PBC work. In-office staff should clean up all inaccurate features before any block goes to the field (for PBC or full-block). To this end, the in-office review application should include a special flag to indicate when misaligned features are present so that correcting the features becomes an integral part of preparing the area for fieldwork.

3.5.3.3 Imagery Review Detection Findings

The main findings on the ability of imagery review to identify partial-block areas are

- Duplicates
- Deletes
- Data Resources
- Undetectable by Imagery

No Title 13 data are included in the examples below. Addresses are for illustrative purposes only to provide a clearer understanding of what the lister would have seen in both an instruction and on the ground. None of the addresses mentioned below are real.

Imagery Review Detection Finding 1: Today's Adds Are Often Tomorrow's Duplicates

Summary

There are many duplicate adds from fieldwork, and they tend to be clustered in blocks that contain multi-units and group quarters.

Case Study

MMVT returned 103 "true" adds in the block in this case study. These adds all shared the same basic street address of 3000 Johnson Place. The apartment complex at that address was built and completed prior to 2010 and there was no evidence of either change since 2010 or undercoverage. Within the MMVT transaction file, each add record had a within-unit (apartment) designator that consisted of a letter and three numbers (e.g., A113). Upon examination of the full MMVT transaction file and data in the MAF browser, we determined that each of these adds corresponded to a delete record which was identical in every respect except for the fact that the delete record did not contain the letter (e.g., A113 was simply 113). All of the deleted records matched exactly to MAF records that had good returns from the 2010 Census and were consistently present in the DSF (without the letter) since well before 2010.

Discussion

Four buildings existed within the apartment complex, designated A, B, C, and D. The lister appended these designators to each apartment number. Instead of processing these actions as changes, the lister deleted the existing 103 addresses and then added 103 addresses with the letters appended to the front. The added records were different enough from the deleted records to pass the automated matching algorithm that GEO uses to reject matching transactions, and 103 duplicate addresses were born.

We assume that the lister saw the letters somewhere in the field, either on the side of the building, on the building map that the property manager provided, or perhaps even on the mailboxes and apartment doors themselves. It is understandable that the lister would have looked at the evidence in the field and decided to make the change. It was, however, an unnecessary change. In this case, one could easily tell from looking at the block and the imagery that it was not possible that 103 new addresses were created within the apartment complex. The roofline of the complex had not changed. It is also implausible that 103 existing addresses with good decennial census returns would have had their apartment numbers changed.

The evidence suggests that these kinds of erroneous adds are especially likely to happen in the context of multi-unit apartment buildings.[3] In these contexts, the lister is often relying upon field clues, which may be confusing, incomplete, or contradictory. For example, the numbers on the door may not match the numbers on the mailboxes. The building plan that the building manager provides may not match either. A related set of problems involve listers adding addresses as housing units that should properly be considered sub-units of group quarters, such as nursing homes (this was fairly common in the MMVT adds as well, with 376 occurrences). Automated matching can only mitigate the most obvious of these kinds of errors.

Recommendation

This research suggests that a very promising use for imagery review-applied values would be for the no change and built-out designations to serve as a screen for incoming address records (whether from the field or from programs like LUCA or GSS-I) to flag them for manual review in the office before updating the MAF.

Imagery Review Detection Finding 2: Yesterday's Omissions or Deletes Are Often Today's Adds

Summary

Many of the *adds* for a given field operation would not have been needed if a previous field operation had not *deleted* something.

Case Study

The MMVT returned 54 "true" adds. All of these adds shared the basic street address of 11111 W 10th St, a fifty-four story building. This apartment building contained 432 apartments with good Census returns from 2010 and another 54 apartments in the MAF that did not have 2010 returns but had also been present in the DSF. The addresses followed the numbering pattern of 1A to 1H, 2A to 2H, etc., to 54A to 54H. Upon examination, it turns out that all 54 of the true MMVT adds had a "C" designator (1C was added, so was 2C, etc.) and that these corresponded to the 54 addresses that were not in the 2010 Census.

Discussion

In this particular case, for reasons that are not known, the 2010 Census address canvasser deleted the 54 "C" addresses.[4] The MMVT lister located the 54 units and added them to the address list. TRMAC imagery review could not detect this deficiency, because there was no actual change in the imagery, and in a multi-unit context (where undercoverage is hard to clearly determine) we rely on the baseline 2010 Census data being correct.

One could say it would be appropriate to send a field lister to the block in this case study to rectify this situation, but that second lister, while working the entire block, may also encounter other ambiguous field cues and take other delete actions in other buildings even while correcting the deletes made by the previous field lister. This can lead to an ongoing cycle of deletes and adds. Cases like this illustrate the

[3] Not exclusively large multi-units, however. The 60 blocks also yielded many cases where this event occurred in the context of a small building with only two units. In this case, the lister often started with "121 Main St" and "121 Main St Apt 2" and decided to delete "121 Main St" and replace it with "121 Main St Apt 1". Again, in these cases "121 Main St" had a good Census return and was present on multiple DSFs, but the lister did not know that and perhaps saw a number on a door or mailbox or perhaps simply did not think it looked right to have a "2" without a "1".

[4] In some other cases of this general kind, the problem was not that the lister deleted the address, but that the address did not make the filter for some reason, and the lister failed to add it.

value of change detection and targeting only those areas where we suspect something has changed since the last Census or where it is easy to isolate areas of obvious undercoverage.

Is it necessary to send whole blocks out to the field to capture this subset of adds, which again appear to be a rather large proportion of the total? Obviously, imagery-based review as implemented in this test will not capture these kinds of issues, but there may be other alternatives, such as those provided in the recommendations below for this lesson learned.

Recommendation
An address edit that reviews patterns of apartment numbers might identify such cases. We could ask respondents how many apartments are in their building (as done in the American Community Survey) and then flag and target those specific buildings where the MAF does not appear to have enough units based on those responses. In smaller buildings (but likely not larger), most residents should know how many apartments their buildings contain.

Imagery Review Detection Finding 3: Room for Improvement: TRMAC Resources

Summary
In some cases, the "baseline" imagery used in the imagery review process was from 2010, but was from a month and day in 2010 later than the date on which the structure was completed. Therefore, no change was detectable between the 2010 and the current image. Quality imagery available during imagery review phase is also critical for correct block classification, including imagery resolution (or clearness of imagery at the appropriate zoom level) and tree cover (leaf off provides the most accurate housing unit analysis).

Case Study
The MMVT lister returned 227 adds that were not during imagery review. In this case, the adds were 227 apartments within a large apartment building. Similarly, in another instance, the MMVT lister returned 117 adds that were not detected during imagery review, again in a large apartment building. Upon further review, all were valid and necessary adds.

Discussion
In the first case, the issue was straightforward. The new apartment structure was large and the change would have been easily detectable in aerial imagery. The structure, however, was completed in 2010. Because it was a large block that already had many multi-units in it, the imagery reviewer did not see any obvious undercount.

In the second case, the issue was also simple: the imagery was too fuzzy. What appeared to be a stable parking lot in the fuzzy imagery was clearly visible as a construction site (with cranes in action) in finer resolution imagery from the same timeframe that was available during this review. If such imagery had been available at the time of review, the reviewer likely would have correctly classified the block.

Recommendation
The solution to these problems is to ensure that the vintage of the "baseline" (or "2010") image is prior to the baseline date for 2010 fieldwork. In most areas, that would mean that having a "baseline" image that came from 2009 would actually be more appropriate. Just as important is to ensure that the current imagery is as up-to-date as possible, and that both the baseline and current image are of sufficient resolution.

Imagery Review Detection Finding 4: Hard-to-Locate Units

Summary
One limitation of aerial imagery review is that imagery generally cannot be used to detect changes in the number of units within a structure or changes in residential/non-residential use within structures. In a fully developed in-office canvassing process, imagery review will be just one piece of the process. Other data sources and datasets are necessary for obtaining a more complete picture of the residential landscape. The statistical modeling efforts described in the first section of the AVT report also play an important role in determining where to send listers for either full- or partial-block canvassing, or to take other in-office actions.

Case Study
The MMVT returned 11 "true" adds. Upon inspection, all 11 were valid adds that apparently occurred since 2010. Imagery review did not detect any of them. In this case, these adds were undetected during imagery review because they were all subdivisions of existing structures and overhead imagery could not detect the change.

Discussion
Some types of housing units are difficult to detect by any means. Basement or garage conversions, for example, may not be reported to local officials or the US Postal Service. In addition, separate apartment numbers or mailboxes may not be posted for these units, making them difficult to identify in the field.

Recommendation
This category of adds appears to be relatively small in the context of the overall number of adds, but large enough to require a solution. Further research is needed to determine the best way to capture this important segment of housing change and identify a variety of appropriate sources of information to help located these kinds of units.

3.5.4 Lister Feedback Analysis

The PBC Team obtained valuable feedback from the PBC Test listers to evaluate the PBC methodology and to solicit ideas for changes and improvements to the PBC methodology. The listers responded with issues, improvements, and suggestions that provided insight on what worked well, did not work well, and what assisted them in their fieldwork. Although listers responded that the PBC methodology is feasible overall, they did provide feedback and suggestions primarily indicating that work area instructions and training/procedures can use improvement, as detailed below.

Listers provided feedback in:

- Data collection feedback forms during the fieldwork at the PBC assignment summary and individual work area levels; and
- Debriefing meetings and follow up questionnaires to capture participants' final thoughts on the operation held via WebEx and simultaneously in a HQ training room on January 29 and 30, 2015.

Listers noted several common themes in their feedback, which are categorized into subsections below. The complete table of listers' responses to work area, assignment questions and common themes are detailed in separate tables for each question in Appendices B-3 (Work Area Questions) and B-4 (Assignment Area Questions).

3.5.4.1 Overall Feasibility Feedback

Summary

Listers commented that PBC is a feasible and sound operation. PBC listers successfully navigated to and canvassed the PBC work area, but noted that clear instructions and work area polygons were critical.

3.5.4.2 PBC Polygons and Instructions Feedback

Summary

Locating the polygon on the ground and understanding the instructions are key components to canvassing the PBC work area correctly. Overall, the listers reported that they were able to find and work their assigned areas, but they also provided suggestions for how polygons and instructions can be improved.

Findings

- Overall the listers found the instructions and polygons to be clear and acceptable for conducting fieldwork. Approximately 50 work areas (less than ten percent) required five or more minutes to interpret.
- Listers reported most work areas were easy to find and navigate to in the field. In only 26 work areas (less than five percent) did listers report difficulty locating the work area, 19 of which were due to instructions not matching the polygon or instructions being confusing or poorly written, the others were due to lack of signage in the field, or a tough to navigate area.
- Few listers reported significant problems with their work areas. Of those who reported significant issues, half indicated the issue was polygon related and half indicated it was due to instructions. Rarely were both the polygon and instruction problematic. Most listers reported that instructions could have been clearer. Nine (approximately 25 percent) listers felt the instructions may have left out a potential housing unit and suggested providing additional guidance or training to address this type of situation. Eight listers stated that misinterpretation of unclear instructions may have resulted in errors in the field.
- In a few instances, listers reported that the polygons and instructions too narrowly defined for the situation they encountered on the ground. In only 26 work areas (less than five percent), the lister went beyond the polygon and in only 17 instances, the lister went beyond the instruction to conduct the fieldwork.
- Approximately one-third of listers found at least one instruction that was confusing or unclear, making the work area difficult to canvass, difficult to determine where to begin or end, or requiring interpretation.
- Listers indicated that their preferred combination of primary PBC canvassing tools (polygons, instructions, and imagery) include polygons, instructions and imagery (75 percent). Table 3.5 compares different combinations of using PBC polygons, instructions, and imagery with and without the GPS You Are Here Indicator (YAHI) functional.

Table 3.5. Utility of PBC Polygons, Instructions and Imagery

	Under which conditions do you believe you could accurately conduct PBC - when the YAHI is working?	Under which conditions do you believe you could accurately conduct PBC - when the YAHI is NOT working?	What is your preferred condition?
Polygon, instruction & imagery	50%	81%	75%
Polygon & instruction	75%	31%	28%
Polygon and imagery	31%	19%	16%
Polygon only	38%	3%	3%

- Most PBC listers responded that imagery would be beneficial in determining location, starting point and orientation within a block. Listers noted that imagery would be especially helpful in areas with missing or misaligned roads, in areas with no reference points (e.g., roads or MSPs), and in finding units not visible from the street. They emphasized that including imagery on the LiMA would be particularly important when the YAHI is not functioning, provided that the imagery can be toggled on and off.

Recommendations

As listed in the findings above, polygons and instructions can be improved by:

- Ensuring that instructions align with or match the polygon;
- Writing instructions that are clear, in order to reduce any confusion and erroneous results;
- Ensuring the polygon and instructions include the entirety of the area needing canvassing (i.e., not defining polygons and instructions too narrowly for situations encountered on the ground); and
- Including imagery on the LiMA, to aid in understanding the polygon and instruction.

3.5.4.3 Skills, Training and Materials Feedback

PBC listers were asked to provide feedback on their assessment of the skills they used to conduct PBC listing, and on improvements to the training and materials provided.

Skills

Summary

One objective of testing PBC methodology with professional geographers was to obtain their assessment on the types of skills needed to conduct PBC fieldwork. Specific questions included: Would the typical temporary decennial hires be enough for this type of investigative fieldwork? Should we include some type of spatial abilities testing and hiring requirements for field listers, and particularly for PBC?

Findings

Table 3.6 lists skillsets that PBC listers used when carrying out fieldwork, in order of most to least commonly cited during the debriefing and follow-up questionnaire. The three top responses included geographic skills, computer skills, and fully comprehending PBC procedures and goals, ostensibly to be able to make appropriate decisions and judgment while in the field.

Table 3.6. Skillsets Needed for PBC Listers

Geographic skills such as orientation, sense of direction, navigating, use of maps, identifying addresses, determining scale/distance, and routing
Use of software/device skills such as LiMA, OptiMap, operating a laptop
Comprehending the procedures and goals of PBC/address status definitions and structure types/understanding Census Bureau purpose
Listing/canvass methodology and skills such as working ground to list or book
Imagery analysis/interpreting/understanding Google street view
Time management skills/good use of time such as advance preparation planning
Critical thinking/investigating

Recommendations

- Require listers to have spatial abilities, basic understanding of imagery, critical thinking, and investigative aptitude.
- Include spatial abilities testing during the hiring process, and follow-up observations during training and fieldwork.

Training

Summary

Listers noted that training should include hands-on training exercises with the instrument and device, and more thorough training on basic address canvassing concepts. For this test environment, the PBC Team faced limitations in these two areas. Primarily the schedule was a driver that prevented laptops loaded with the LiMA and MCM applications to be available for the training. The training also focused on the new PBC methodology, and did not provide enough detail on traditional canvassing methodology and steps.

Findings

- There were not individual laptops available at the time of training for each lister, when this hands-on training format would have greatly increased lister familiarity and competence with the LiMA and MCM.
- Two-thirds of the listers stated that they needed additional training and procedures on PBC concepts and address canvassing concepts, along with LiMA data collection procedures.

Recommendations

Include the following in future PBC training, and possibly apply to full-block canvassing training (where relevant):

Canvassing - General

- Practical exercises with the laptops, LiMA and MCM during training.
- More information about working multi-units in the LiMA (including detaching and attaching).
- More information about group quarters.
- Time and data on which to practice before going to the field.
- Assignment preparation and route planning training for new listers.

PBC-Specific

- Additional specific PBC examples and scenarios.
- Information about challenging situations and methods to overcome obstacles.
- More detailed, clearer procedures for following PBC instructions.
- Video of a PBC expert as part of training.

Materials

Summary

PBC listers reported the materials provided to conduct the test were helpful, and generally sufficient to navigate to the work area and conduct the fieldwork, but could use improvement.

Findings

Table 3.7 lists the top responses from PBC lister feedback forms on which materials were useful to conduct their fieldwork.

Table 3.7. Materials Needed for PBC Fieldwork

Which materials did you find useful in preparing and conducting your fieldwork?	
Response	Percent of Listers
Assignment Area polygon spreadsheet	81
Procedures	78
Google maps URL with PBC polygons	78
Google Earth KML with PBC polygons	75
Assignment Area PDF map	75
PBC assignment routing & planning for travel arrangements	69
Using OptiMap to route your work	63
Cheat Sheets	59

The listers also noted that the PBC Procedural Help Desk, the PBC Technical Help Desk, the GPS application on their own smartphone and other navigation applications, and advance preparation helped them to do their canvassing work.

When asked what additional information was needed or materials would have been useful, the top responses from listers were:

- Imagery in the LiMA.
- GPS with routing capabilities.
- Combine all materials and other documents into a technical guide and procedural manual.
- Provide more detailed instructions about how to input GQs and multi-unit information in LiMA and more choices or options within LiMA.

LiMA and MCM Feedback

The PBC Test was the first production field use of LiMA, MCM, and other technical infrastructure. Listers provided feedback regarding LiMA, MCM, and laptop functionality; that is, what worked, what did not as well as suggested improvements and enhancements. Specific responses from lister feedback forms on technical issues are included in Appendix B-5.

3.6 PBC Key Lessons Learned, Conclusions and Recommendations

3.6.1 Key Lessons Learned

1. Polygons and instructions can be created to communicate the extent of the targeted areas, and listers can effectively navigate to, collect accurate address structure and attribute information in the field for these targeted areas – but improvements need to be made:

- When designing the review tool used for production, it is essential that this workflow be more integrated and seamless. The initial imagery reviewer should be able to clearly designate the entirety of the growth area within the block, so that the process of change identification and polygon creation is more integrated. In-office procedures also need to make it clear that areas of observed growth and of suspected future growth should be included in PBC polygons. In addition, field training and procedures should give field listers more leeway to add addresses for structures immediately outside their polygon that appear to be new.
- Sometimes the instructions were too specific and the polygon encompassed the area but the instruction did not (e.g., the instruction stated "Canvass the Entirety of Dion St." without making any reference to Rialto Lane – which was a named road feature that appeared to be a short road extension of Dion Street without a different name). We should use the "bud and branch" instruction type to assure all housing units targeted in the PBC area are collected – regardless of incorrect street name information. Also, future training and procedures should stress that if there are conflicts between the polygon and the instructions, the lister should contact the help desk.
- Include existing MAF addresses within the block as "anchor points" within the PBC instruction in order to avoid a lister collecting housing unit information in the incorrect location—outside the polygon and instruction (or even outside the block)— but to not require that action be taken on the existing addresses in order to achieve greater efficiency.
- Ensure instructions match the polygon.
- Include imagery on the LiMA to aid in understanding the polygon and instruction, and to help locate housing units not visible from the street.
- Use BSA information within an instruction, provided one can confirm it is correct on the ground (via parcel data, or imagery) and/or know it will be provided to the lister in the LiMA.
- Missing and misaligned street features and misaligned block boundaries should be fixed in the office before any block goes to the field, for either full block canvassing or PBC to avoid confusion and error.

2. Imagery review detected adds in PBC blocks, and PBC listers were able to capture 81 percent of MMVT adds in the PBC blocks. But, research needs to be done to more fully understand imagery review detection deficiencies and identify improvements to both the imagery review and PBC processes: future work is needed to research the 19 percent of MMVT adds PBC didn't find, and compare the imagery review detection with the MMVT results for the 10,100 MMVT blocks to assess the ability of the imagery review to detect change, identify the types of situations in which adds were not detected, and identify improvements to that process. The PBC missed adds most often because:

- The add represented a situation not detectable by the imagery review step, and therefore was not provided as a work area to the PBC lister. Known improvements to address this situation include:
  - Looking at within structure identifiers (WSIDs) within a building to identify whether there is a gap in the numbering pattern.
  - Assuring the imagery is from 2009, not 2010 – as some new construction occurring after 2010 Address Canvassing but before the 2010 imagery was flown was missed in the imagery review phase.
  - Identifying other sources of data that will detect changes and hidden units not easily detectable from imagery review.

- The area was provided to the PBC lister, but the instruction was worded poorly or the polygon was poorly-defined, leading to lister confusion.

3.6.2 PBC Conclusions and Recommendations

The PBC Team selected blocks that were in the MMVT test in order to be able to make efficiency and coverage comparisons between the two processes, with the MMVT test serving as a proxy for "traditional" full-block canvassing. However, as discussed earlier, differences in timing, address filter, instrument, processing, documentation, training and staffing between the two operations constrained this comparison. Despite these limitations, there are key takeaways to our efforts including:

Cost of Test vs. Cost of Doing Production PBC

Given the decision to select PBC Test blocks from within the 10,100 MMVT sample blocks, PBC assignments were distributed over large distances, with the result that listers spent many hours driving to and from assigned areas as a result. While clusters of PBC-appropriate blocks might be identified in a true production process, it also is reasonable to expect that PBC blocks might be scattered. This especially might be the case in rural areas in which new houses are few and are scattered. A potential solution is to stockpile blocks that require fieldwork. These assignments might not be sent to the field until sufficient workload existed within an area to make it cost effective, either other PBC or full-block canvassing, or other field data collection operations.

Efficiency of PBC Methodology

The efficiency of the PBC methodology comes from sending field listers to specific areas in which we have evidence that there is undercoverage in the residential housing stock. This is quite different from traditional canvassing where the purpose is to both validate and update the address list.

The PBC methodology, with its preceding imagery review phase, is a more investigative and focused process. It identifies areas where residential change is detected, then assigns "in office" staff to consult recent imagery, local partnership files, the latest DSF, and other sources and make a determination not only to whether updates to the address list are likely, but where precisely are those changes occurring and the corresponding addresses are not within the MAF. Listers are sent to specific locations in which updates are expected/anticipated, rather than sending them to list an entire block.

Efficiency Comparison: When we compared "add" actions between PBC versus MMVT, we determined PBC process was more efficient in capturing the targeted add actions than was MMVT.

Imagery Review to MMVT Comparison: Imagery review identified 1,901 initial PBC blocks (prior to reduction to the 615 for fieldwork) which contained adds for roughly 66.2 percent of all MMVT work areas. This suggests that imagery review was effective in finding the majority of add areas that MMVT found also. In the remaining areas, MMVT found more adds but was more inclined to find adds that could not be detected in imagery review, such as splits of existing units like basement apartments or conversion from a commercial space into a residential space. These type of adds are not readily apparent to the observers eye during interactive review.

Technical Tools Required for PBC

PBC listers stated that loading recent imagery on the LiMA device would have helped them with their assignments. There are a number of reasons they mentioned it. First, if the YAHI was not operational (due to a weak GPS signal), the imagery could help them find their assignment areas more readily and

reduce the time and costs trying to complete an assignment. Additionally, imagery was helpful to the PBC lister if the residential unit was in a gated community or was obscured from the street.

4 AVT Conclusion and Recommendations

In this report, we have presented results and analysis from the MAF Model Validation Test (MMVT) and the Partial-Block Canvassing (PBC) Test, both components of the Address Validation Test (AVT). Although the two components of the AVT were managed separately and had different purposes, there are important relationships between the two tests. The 10,100 MMVT sample blocks provided the universe from which blocks were selected for the PBC Test. This relationship provided the opportunity to compare results from the PBC Test to results from the MMVT. In addition, this relationship provided the opportunity to compare the results from the in-office review of imagery for the 10,100 MMVT blocks to MMVT field results. These analyses contribute to the Census Bureau's understanding of the way in which in-office methods—particularly imagery-based analysis—can be used to evaluate the completeness of the MAF.

4.1 Comparison of Detected Adds from Imagery Review to Observed Numbers of Adds from the MMVT

As part of the PBC process, an interactive review of imagery for the 10,100 MMVT sample blocks was conducted to determine whether there were changes to the numbers of housing units visible in imagery. Reviewers also determined whether the number of addresses in the MAF for a block was consistent with the number of housing units visible in imagery. Although the primary purpose of this review was to identify blocks that were suitable for PBC, the TRMAC Team staff conducting the review also recorded the number of new or deleted addresses detected within each block. These imagery-based detected adds can be compared to observed numbers of adds from MMVT fieldwork to assess the extent to which imagery review results were consistent with field observations. Blocks in which no changes are detected in imagery and for which the number of addresses in the MAF are consistent with the number of housing units visible in imagery are considered stable; we would not expect to observe adds in the field. For blocks in which the number of addresses in the MAF is not consistent with the number of housing units visible in imagery, whether or not change is detected in imagery, we would expect to observe adds or deletes in the field; the difference between MAF counts and imagery-based counts provides an expected number of observed adds and deletes.

MMVT listers added 23,448 addresses in the 10,100 blocks within the MMVT universe and these adds were compared to imagery review results. Of these, 5,081 were determined to be "false adds." This category includes add actions that should have been coded as address changes, erroneous listing of group quarters rooms as individual housing units, or other erroneous actions. Of the 18,367 "good adds," imagery review detected 12,984 (70.7 percent). Imagery review did not detect 5,383 of the MMVT adds. Of these, 2,682 (14.6 percent of all adds; 49.8 percent of missed adds) were located in structures that appeared in both vintages of imagery under review and, thus, were not detectable through imagery-based methods. This category includes conversions of commercial or other non-residential structures to residential uses, identification of additional housing units within existing multi-unit buildings, and identification of additional living quarters, such as basement or garage apartments, within single-family houses. Issues related to vintage of imagery resulted in 996 undetected adds (5.4 percent of all adds; 18.5 percent of missed adds). In many of these instances, the date of the "current" imagery preceded construction of new housing units; thus, there appeared to be no changes for imagery reviewers to detect. Imagery reviewers missed 1,168 MMVT adds (6.4 percent of all adds; 21.7 percent of missed adds) due to poor quality of imagery; tree-cover obscuring structures; difficulties in reviewing imagery for large,

complex blocks; or reviewer error. In addition, reviewers' uncertainty about whether the land cleared for development would result in residential or commercial uses accounted for some of these missed adds.

The following changes have been identified to improve the imagery review process:

- Improve the resolution and currency of imagery.
- Utilize a grid overlaid on blocks so that reviewers can more easily track which areas have been reviewed.
- Improve quality control.
- More inclusive classification of areas exhibiting signs of potential future growth.

It is important to note, however, that nearly half of all missed adds were in situations that are not detectable through imagery review. Other sources of information about address- and housing unit-level change (building and occupancy permits, administrative records, commercial address lists, for example) will be needed to supplement imagery review.

Table 4.1 presents a weighted matrix of detections from imagery by observed number of adds. Of the 5.7 million blocks for which imagery review would detect no adds, 4.7 million (82.1 percent) had no observable adds from fieldwork. In other words, imagery reviewers correctly identified blocks as stable and complete 82.1 percent of the time. In an additional 632,000 blocks (11.1 percent) for which imagery review detected no adds, in-field canvassing observed only one new address. This suggests that in-office imagery review can successfully identify blocks as stable and complete, and thus not requiring fieldwork or updating through other in-office methods. Standard errors for these numbers are provided in Appendix C-1, table C-1.1.

Table 4.1 Weighted Matrix of Predictions from Imagery by Observed Number of Adds[1,2]

Detected from Imagery Review	Observed Number of Adds in Block							Total Blocks (×1,000)
	0	1	2	3 to 4	5 to 10	11 to 20	≥21	
-100 to -2	62.1	13.4	10.8	0.4	10.9	0.0	2.4	24
-1	56.8	17.8	13.5	6.9	3.0	0.0	2.1	66
0	82.1	11.1	3.0	1.9	1.3	0.3	0.3	5,696
1	42.7	28.7	14.5	8.6	3.9	1.1	0.5	355
2 to 10	27.9	22.3	10.2	13.9	14.5	5.4	5.8	127
11 to 20	11.1	13.4	2.6	0.9	15.0	37.9	19.1	13
≥21	12.6	4.9	0.3	0.3	1.6	14.3	65.8	14
Total Blocks (×1,000)	4,921	779	247	159	113	37	38	6,294

[1] Standard errors are found in Table C-1.1 in Appendix C-1.
[2] Table gives row percentages -- the weighted number of blocks in the cell divided by the weighted number of blocks in the row (given in the total column).

4.2 Recommendations

4.2.1 Ongoing, Targeted Fieldwork to Measure MAF Coverage

Results from the AVT have demonstrated the utility of imagery review to guide decision-making and operational planning for address canvassing. On the other hand, the test showed that the statistical models were not an effective tool for use in address canvassing. The MMVT demonstrated the value of fieldwork to gather information for use in assessing the effectiveness of in-office methods. Indeed, planning has begun for the implementation of an annual in-field address listing program to gather information to assess and inform in-office canvassing methodologies, to measure the coverage of the MAF, and to acquire address updates.

We recommend that the annual in-field address listing program can and should be a critical component of the Census Bureau's reengineered address canvassing for the 2020 Census.

4.2.2 Additional Analysis of MMVT and PBC Results

The MMVT and PBC Test each produced valuable data relating to housing unit and address changes detected in the field and in imagery. Each of these sources of predicted and actual change is a key element in the Census Bureau's reengineered address canvassing. Analysis for this report focused specifically on 1) evaluation of statistical model results compared to address/housing unit changes observed in the field and 2) evaluation of PBC as a new field data collection methodology. Census Bureau staff engaged in the analysis of the data acquired through the AVT components, however, believe there are additional insights to be gained through further analysis. For example, we need to understand the specific housing landscape contexts that pose difficulties for change detection using imagery compared to detection of new or deleted units through in-field observation. We need to understand the types of housing contexts in which in-office methods are less successful, and, thus, provide focal points for in-field canvassing. This additional research is needed to inform both design decisions and operational planning for the 2020 Census.

We recommend additional research and analysis using counts of adds, deletes, and changes, as well as address-level analysis to gain greater insight into the effectiveness of imagery review.

5 References

Address List Operations Implementation Team (2012), "2010 CPEX: 2010 Census Address Canvassing Operational Assessment," Washington, D.C., January 10, 2012. http://www.census.gov/2010census/pdf/2010_Census_Operational_Assessment.pdf

Boies, John L., Kevin M. Shaw, and Jonathan P. Holland (2012), "2010 CPEX: Address Canvassing Targeting and Cost Reduction Report," DSSD 2010 Census Program for Evaluations and Experiments Memorandum Series A-09, July 12, 2012. http://www.census.gov/2010census/pdf/2010_Census_Address_Canvassing_Targeting_and_Cost_Reduction_Evaluation_Report.pdf

6 Appendices

Appendix A-1: MMVT Unweighted Outcomes

Table A-1.1. MMVT Listing Outcomes: Unweighted Distribution

Final Address Outcome	Addresses
TOTAL	1,103,465
Add	36,782
New	15,164
Matched	21,618
Change	302,482
Move	14,603
Verify	683,711
Negative Actions	64,181
Delete	58,475
Duplicate	4,482
Nonresidential	1,224
Uninhabitable	1,706

Appendix A-2: Additional Results of Block-Level Predictions vs MMVT Observed Estimates

Table A-2.1. Statistical Model Performance for Identifying Areas to Canvass. For Adds: Block-Level Predictions vs MMVT Observed Estimates for Model #A2[1]

Model #A2 Predicted Deletes	Estimated Number of Blocks (x1,000)	Estimated Percent of Blocks with [N] Observed Adds								
		0	1	2	[3, 4]	[5, 9]	[10, 19]	[20, 49]	[50, 99]	[100, ∞)
[0.00, 0.25)..	2,744	90.7	7.8	1.0	0.3	0.2	<0.1	<0.1	0.0	0.0
[0.25, 0.50)..	1,037	83.3	9.2	3.8	1.2	1.4	0.4	0.2	0.1	0.2
[0.5, 1.0).....	1,057	75.7	16.9	4.0	2.2	0.5	0.5	<0.1	<0.1	<0.1
[1.0, 1.5).....	483	65.5	19.0	8.3	4.4	1.4	0.8	0.6	0.0	0.0
[1.5, 2.0).....	254	54.5	23.1	10.8	6.3	3.2	0.4	1.0	0.3	0.3
[2.0, 2.5).....	166	49.9	22.6	11.9	9.3	3.5	1.2	0.9	0.4	0.2
[2.5, 3.0).....	110	46.6	18.6	10.4	11.3	9.0	2.8	1.0	<0.1	0.3
[3, 5).....	214	41.5	24.4	8.9	10.2	9.5	3.3	1.3	0.4	0.4
[5, 10).....	132	43.9	14.2	10.1	11.0	13.1	3.3	3.0	1.1	0.4
[10, 20).....	54	33.8	16.4	7.5	13.2	13.0	9.4	4.7	1.7	0.2
[20, 50).....	28	28.3	10.4	10.0	14.5	13.2	11.6	6.3	4.6	1.0
[50, ∞).....	16	43.1	4.2	7.3	5.2	7.5	8.9	8.7	7.8	7.4
Total.....	6,294	78.2	12.4	3.9	2.5	1.7	0.7	0.4	0.1	0.1

[1] Corresponding standard errors can be found in Table A-3.6 of Appendix A-3.

Table A-2.2. Statistical Model Performance for Identifying Areas to Canvass. For Deletes: Block-Level Predictions vs MMVT Observed Estimates for Model #A2[1]

Model #A2 Predicted Deletes	Estimated Number of Blocks (x1,000)	Estimated Percent of Blocks with [N] Observed Deletes								
		0	1	2	[3, 4]	[5, 9]	[10, 19]	[20, 49]	[50, 99]	[100, ∞)
[0.00, 0.25)..	2,744	92.6	5.9	0.8	0.4	0.3	<0.1	<0.1	<0.1	<0.1
[0.25, 0.50)..	1,037	77.7	17.1	3.1	1.1	0.7	0.1	0.1	<0.1	0.0
[0.5, 1.0).....	1,057	60.3	27.9	7.3	3.2	0.9	0.3	0.1	<0.1	<0.1
[1.0, 1.5).....	483	43.5	28.2	15.4	8.5	3.2	0.6	0.1	0.5	0.1
[1.5, 2.0).....	254	33.9	27.8	17.7	14.7	4.4	1.1	0.3	0.1	<0.1
[2.0, 2.5).....	166	29.8	19.4	16.5	23.3	8.9	1.3	0.8	0.0	0.1
[2.5, 3.0).....	110	27.8	15.2	14.7	26.3	11.6	2.9	0.7	0.7	0.2
[3, 5).....	214	18.3	11.8	13.5	23.7	24.0	6.9	1.4	0.2	0.1
[5, 10).....	132	14.0	11.8	12.6	13.8	33.2	10.4	3.4	0.5	0.4
[10, 20).....	54	16.8	7.7	6.4	9.1	15.6	29.5	10.1	3.0	1.7
[20, 50).....	28	8.3	3.9	3.7	12.2	14.4	20.0	17.5	16.9	3.2
[50, ∞).....	16	6.9	2.4	1.5	2.4	6.2	7.4	41.7	17.3	14.2
Total.....	6,294	70.4	14.9	5.5	4.4	3.0	1.1	0.5	0.2	0.1

[1] Corresponding standard errors can be found in Table A-3.7 of Appendix A-3.

Table A-2.3. Statistical Model Performance for Identifying Areas to Canvass. For Adds: Block-Level Predictions vs MMVT Observed Estimates for Model #J1[1]

Model #J1 Predicted Probability of 2+ Adds or Deletes	Estimated Number of Blocks (x1,000)	Estimated Percent of Blocks with [N] Observed Adds								
		0	1	2	[3, 4]	[5, 9]	[10, 19]	[20, 49]	[50, 99]	[100, ∞)
[0.9-1.0].....	216	32.8	15.3	11.8	14.3	13.3	6.1	3.9	1.8	0.8
[0.8-0.9).....	334	44.5	23.8	12.8	7.5	7.5	2.1	1.2	0.3	0.3
[0.7-0.8).....	428	54.4	21.7	10.5	7.6	3.5	1.1	0.7	0.2	0.2
[0.6-0.7).....	525	67.4	19.4	6.0	2.9	2.4	0.8	0.9	<0.1	0.1
[0.5-0.6).....	550	72.3	14.8	6.8	3.0	1.3	1.0	0.3	0.1	0.4
[0.4-0.5).....	615	75.5	17.0	3.3	2.5	0.8	0.8	0.1	0.1	0.0
[0.3-0.4).....	798	83.8	11.3	2.9	1.0	0.6	0.3	0.1	0.1	<0.1
[0.25-0.3)....	586	89.6	8.7	0.9	0.8	<0.1	<0.1	0.0	0.0	<0.1
[0.2-0.25)....	706	93.0	5.7	0.6	0.6	0.1	<0.1	<0.1	0.0	0.0
[0.1-0.2).....	810	91.5	7.7	0.4	0.3	<0.1	<0.1	<0.1	<0.1	<0.1
[0-0.1).....	534	95.8	3.3	0.8	<0.1	<0.1	<0.1	0.1	<0.1	<0.1
Total.....	6,103	78.2	12.4	4.0	2.5	1.6	0.7	0.4	0.1	0.1

[1] Corresponding standard errors can be found in Table A-3.8 of Appendix A-3.

Table A-2.4. Statistical Model Performance for Identifying Areas to Canvass. For Deletes: Block-Level Predictions vs MMVT Observed Estimates for Model #J1[1]

Model #J1 Predicted Probability of 2+ Adds or Deletes	Estimated Number of Blocks (x1,000)	Estimated Percent of Blocks with [N] Observed Deletes								
		0	1	2	[3, 4]	[5, 9]	[10, 19]	[20, 49]	[50, 99]	[100, ∞)
[0.9-1.0].....	216	17.2	10.5	10.3	16.1	21.6	12.7	6.8	3.1	1.8
[0.8-0.9).....	334	28.9	18.0	13.7	19.6	13.5	4.6	1.0	0.5	0.2
[0.7-0.8).....	428	42.5	22.5	13.9	10.0	7.6	1.9	0.8	0.9	<0.1
[0.6-0.7).....	525	51.9	24.5	11.1	6.9	3.6	1.2	0.8	0.1	<0.1
[0.5-0.6).....	550	60.8	20.9	7.8	6.7	2.8	0.8	0.1	0.1	<0.1
[0.4-0.5).....	615	65.2	22.4	6.3	4.1	1.2	0.6	0.2	0.1	<0.1
[0.3-0.4).....	798	73.6	17.2	4.5	2.7	1.6	0.2	0.1	<0.1	<0.1
[0.25-0.3)....	586	80.5	14.2	3.4	0.9	0.9	<0.1	<0.1	<0.1	<0.1
[0.2-0.25)....	706	88.5	9.2	1.3	0.7	0.2	<0.1	<0.1	0.0	<0.1
[0.1-0.2).....	810	93.9	5.8	0.1	<0.1	0.1	<0.1	0.1	<0.1	<0.1
[0-0.1).....	534	95.4	4.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total.....	6,103	70.1	15.0	5.5	4.5	3.1	1.1	0.5	0.2	0.1

[1] Corresponding standard errors can be found in Table A-3.9 of Appendix A-3.

Table A-2.5. Statistical Model Performance for Identifying Areas to Canvass. For Adds: Block-Level Predictions vs MMVT Observed Estimates for Model #K1[1]

Model #K1 Predicted Probability of 1+ Adds	Estimated Number of Blocks (x1,000)	Estimated Percent of Blocks with [N] Observed Adds								
		0	1	2	[3, 4]	[5, 9]	[10, 19]	[20, 49]	[50, 99]	[100, ∞)
[0.9-1.0].....	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
[0.8-0.9).....	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
[0.7-0.8).....	6	66.4	0.0	33.2	0.0	0.0	0.0	0.4	0.0	0.0
[0.6-0.7).....	21	63.9	30.5	0.0	0.0	0.7	0.7	4.3	0.0	0.0
[0.5-0.6).....	351	73.4	15.6	4.6	3.1	2.3	0.4	0.4	0.2	<0.1
[0.4-0.5).....	414	69.3	14.7	7.8	3.9	3.2	0.4	0.4	0.2	0.1
[0.3-0.4).....	789	63.6	17.5	6.7	5.0	4.2	1.5	0.8	0.3	0.4
[0.25-0.3)....	1,785	72.9	14.5	5.2	3.5	1.9	1.1	0.5	0.2	0.1
[0.2-0.25)....	2,926	87.3	8.9	1.7	1.0	0.6	0.3	0.2	<0.1	<0.1
[0.1-0.2).....	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
[0-0.1).....	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total.....	6,294	78.2	12.4	3.9	2.5	1.7	0.7	0.4	0.1	0.1

[1] Corresponding standard errors can be found in Table A-3.10 of Appendix A-3.

Table A-2.6. Statistical Model Performance for Identifying Areas to Canvass. For Deletes: Block-Level Predictions vs MMVT Observed Estimates for Model #K1[1]

Model #K1 Predicted Probability of 1+ Adds	Estimated Number of Blocks (x1,000)	Estimated Percent of Blocks with [N] Observed Deletes								
		0	1	2	[3, 4]	[5, 9]	[10, 19]	[20, 49]	[50, 99]	[100, ∞)
[0.9-1.0].....	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
[0.8-0.9).....	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
[0.7-0.8).....	6	99.6	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0
[0.6-0.7).....	21	40.7	50.9	7.1	0.0	0.0	0.7	0.7	0.0	0.0
[0.5-0.6).....	351	71.6	13.9	7.5	3.0	2.3	0.7	0.7	0.2	0.1
[0.4-0.5).....	414	63.4	18.0	4.1	6.7	5.3	1.5	0.6	0.2	0.2
[0.3-0.4).....	789	45.6	22.2	10.0	9.8	7.7	2.5	1.4	0.5	0.2
[0.25-0.3)....	1,785	61.6	18.3	7.5	6.3	3.9	1.5	0.5	0.4	0.1
[0.2-0.25)....	2,926	83.5	10.2	3.0	1.7	0.9	0.4	0.2	0.1	<0.1
[0.1-0.2).....	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
[0-0.1).....	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total.....	6,294	70.4	14.9	5.5	4.4	3.0	1.1	0.5	0.2	0.1

[1] Corresponding standard errors can be found in Table A-3.11 of Appendix A-3.

Appendix A-3: Standard Errors for Select Tables

Table A-3.1. Standard Errors of Statistical Model Performance for Identifying Areas to Canvass. Address-Level Analysis. Rate of Capture of Adds and Deletes

Simulated Canvassing Workload and Results[2]	Statistical Models				Benchmark Models	
	Model #A1	Model #A2	Model #J1	Model #K1	Add Rate	Delete Rate
20% Canvass (27.3 million Addresses)						
Add Capture Rate	5.9	6.0	3.1	6.0	0.8	4.5
Delete Capture Rate	1.5	1.7	2.1	2.0	1.5	0.5
Addresses per Block	0.1	0.4	3.2	0.4	0.6	0.6
Percent Blocks Canvassed	0.6	1.1	0.1	0.6	0.4	0.5
25% Canvass (34.1 million Addresses)						
Add Capture Rate	5.1	5.3	4.0	9.7	0.4	5.0
Delete Capture Rate	1.7	1.7	2.1	1.8	1.7	0.4
Addresses per Block	0.1	0.2	2.1	0.3	0.6	0.5
Percent Blocks Canvassed	0.5	0.8	0.2	0.5	0.4	0.5
40% Canvass (54.5 million Addresses)						
Add Capture Rate	3.5	3.6	5.9	3.5	0.0	6.3
Delete Capture Rate	1.8	1.5	1.7	2.7	2.2	0.1
Addresses per Block	0.1	0.1	1.0	0.3	0.6	0.6
Percent Blocks Canvassed	0.4	0.5	0.3	0.7	0.4	0.5

[2] The following denominators were used for calculations in this table: canvassing threshold – 136.3 million weighted MMVT estimate of the dependent list, add capture rate – 5.7 million MMVT adds, delete capture rate – 7.6 million MMVT deletes, percent blocks canvassed – 6.3 million 2010 census tabulation blocks

Table A-3.2. Standard Errors of Statistical Model Performance for Identifying Areas to Canvass. Block-Level Analysis. Rate of Capture of Blocks with Adds (1+) or Many Adds (5+)

Type of Rate at Different Canvassing Thresholds	Estimated Blocks (x1,000)	Rates of Block Canvas, Block Capture, and False Add Canvassing (%)					
		Statistical Models				Benchmark Models	
		Model #A1	Model #A2	Model #J1	Model #K1	Add Rate	Delete Rate
20% Canvass (27.3 million Addresses)							
Total Blocks……..	5	0.6	1.1	0.1	0.6	0.4	0.5
Blocks w/5+……..	10	2.9	3.4	2.3	3.6	0.7	2.9
Blocks w/1-4 ……..	29	1.4	1.6	0.5	1.5	1.0	1.5
Blocks w/1+……..	30	1.2	1.3	0.5	1.3	0.9	1.3
5+ False Canvassing Rate	NA	0.3	0.3	1.5	0.5	0.9	0.5
1+ False Canvassing Rate	NA	0.9	1.4	2.1	1.3	0.0	1.7
25% Canvass (34.1 million Addresses)							
Total Blocks……..	5	0.5	0.8	0.2	0.5	0.4	0.5
Blocks w/5+……..	10	3.0	3.1	2.5	3.3	0.3	3.4
Blocks w/1-4 ……..	29	1.2	2.0	0.8	1.6	0.7	1.4
Blocks w/1+……..	30	1.0	1.7	0.8	1.3	0.6	1.3
5+ False Canvassing Rate	NA	0.3	0.3	1.1	0.4	0.8	0.5
1+ False Canvassing Rate	NA	0.8	0.9	1.8	1.0	0.0	1.5
40% Canvass (54.5 million Addresses)							
Total Blocks……..	5	0.4	0.5	0.3	0.7	0.4	0.5
Blocks w/5+……..	10	2.1	2.4	3.3	2.8	0.0	3.9
Blocks w/1-4 ……..	29	1.1	1.4	1.4	1.4	0.0	1.5
Blocks w/1+……..	30	1.0	1.2	1.2	1.2	0.0	1.3
5+ False Canvassing Rate	NA	0.2	0.2	0.7	0.3	0.7	0.4
1+ False Canvassing Rate	NA	0.7	0.8	1.5	1.0	1.5	1.3

Table A-3.3. Standard Errors of Statistical Model Performance for Identifying Areas to Canvass. Block-Level Analysis. Rate of Capture of Blocks with Deletes (1+) or Many Deletes(5+)

Type of Rate at Different Canvassing Thresholds	Estimated Blocks (x1,000)	Rates of Block Canvas, Block Capture, and False Delete Canvassing (%)					
		Statistical Models				Benchmark Models	
		Model #A1	Model #A2	Model #J1	Model #K1	Add Rate	Delete Rate
20% Canvass (27.3 million Addresses)							
Total Blocks……..	5	0.6	1.1	0.1	0.6	0.4	0.5
Blocks w/5+……..	18	1.9	2.3	2.3	2.9	2.2	0.9
Blocks w/1-4 ……..	37	1.5	1.3	0.5	1.5	1.3	1.9
Blocks w/1+……..	35	1.3	1.0	0.4	1.2	1.1	1.4
5+ False Canvassing Rate	NA	0.3	0.7	2.6	0.9	0.9	1.6
1+ False Canvassing Rate	NA	1.0	1.7	2.1	1.3	1.6	0.0
25% Canvass (34.1 million Addresses)							
Total Blocks……..	5	0.5	0.8	0.2	0.5	0.4	0.5
Blocks w/5+……..	18	2.1	2.0	2.7	2.5	2.1	0.6
Blocks w/1-4 ……..	37	1.5	2.0	0.6	1.4	1.3	0.8
Blocks w/1+……..	35	1.3	1.6	0.6	1.1	1.1	0.6
5+ False Canvassing Rate	NA	0.3	0.5	1.7	0.7	0.8	1.2
1+ False Canvassing Rate	NA	1.0	1.1	1.4	1.2	1.4	0.0
40% Canvass (54.5 million Addresses)							
Total Blocks……..	5	0.4	0.5	0.3	0.7	0.4	0.5
Blocks w/5+……..	18	2.1	1.2	2.5	1.8	2.6	0.1
Blocks w/1-4 ……..	37	1.2	1.0	1.2	1.3	1.4	0.5
Blocks w/1+……..	35	1.1	0.8	1.1	1.1	1.2	0.4
5+ False Canvassing Rate	NA	0.3	0.4	1.1	0.5	0.8	1.0
1+ False Canvassing Rate	NA	0.8	0.9	1.8	1.2	1.4	0.0

Table A-3.4. Standard Errors for Statistical Model Performance for Identifying Areas to Canvass. For Adds: Block-Level Predictions vs MMVT Observed Estimates for Model #A1

Model #A1 Predicted Adds	Estimated Number of Blocks (x1,000)	Estimated Percent of Blocks with [N] Observed Adds								
		0	1	2	[3, 4]	[5, 9]	[10, 19]	[20, 49]	[50, 99]	[100, ∞)
[0.00, 0.25)..	27	1.2	1.0	0.4	0.3	0.4	0.0	0.0	0.0	0.0
[0.25, 0.50)..	38	1.1	0.9	0.4	0.3	0.2	0.2	<0.1	0.0	0.0
[0.5, 1.0).....	43	1.1	0.9	0.4	0.3	0.2	0.1	0.1	0.0	0.1
[1.0, 1.5).....	36	1.9	1.4	0.9	0.5	0.3	0.4	0.1	0.1	0.0
[1.5, 2.0).....	21	2.9	2.1	1.3	1.1	0.7	0.4	0.2	0.0	0.1
[2.0, 2.5).....	18	2.8	2.5	1.5	1.3	0.6	0.4	<0.1	0.1	<0.1
[2.5, 3.0).....	13	2.8	2.5	2.2	1.7	1.0	0.5	0.5	0.3	0.1
[3, 5).....	13	1.8	1.6	1.3	1.1	0.9	0.7	0.4	0.1	0.1
[5, 10).....	9	2.5	1.7	1.2	1.4	1.2	0.7	0.6	0.2	0.3
[10, 20).....	3	4.4	1.8	1.5	1.5	1.7	1.4	1.1	1.0	0.5
[20, 50).....	1	5.0	6.9	1.7	6.2	4.3	7.4	3.2	5.1	1.8
[50, ∞).....	<1	41.8	0.0	11.7	41.8	0.0	0.0	7.4	0.0	8.5
Total.....	5	0.5	0.4	0.2	0.2	0.1	0.1	0.1	<0.1	<0.1

Table A-3.5. Statistical Model Performance for Identifying Areas to Canvass. For Deletes: Block-Level Predictions vs MMVT Observed Estimates for Model #A1

Model #A1 Predicted Adds	Estimated Number of Blocks (x1,000)	Estimated Percent of Blocks with [N] Observed Deletes								
		0	1	2	[3, 4]	[5, 9]	[10, 19]	[20, 49]	[50, 99]	[100, ∞)
[0.00, 0.25)..	27	1.8	1.8	0.7	0.3	0.4	0.0	0.0	0.0	0.0
[0.25, 0.50)..	38	1.3	1.1	0.6	0.4	0.4	0.1	<0.1	0.0	0.0
[0.5, 1.0).....	43	1.2	1.2	0.5	0.5	0.2	0.1	0.1	0.1	0.0
[1.0, 1.5).....	36	1.9	1.5	1.0	0.7	0.4	0.3	0.1	0.1	<0.1
[1.5, 2.0).....	21	3.1	2.7	1.0	1.5	0.6	0.4	0.1	0.1	0.0
[2.0, 2.5).....	18	3.2	1.9	2.5	1.3	1.6	0.5	0.4	0.1	<0.1
[2.5, 3.0).....	13	3.1	3.2	1.9	1.6	1.8	0.4	1.0	0.0	0.1
[3, 5).....	13	2.0	1.9	1.3	1.6	1.1	0.7	0.3	0.2	0.1
[5, 10).....	9	1.7	1.8	1.0	1.6	1.9	0.9	0.6	1.1	0.1
[10, 20).....	3	4.4	2.3	1.7	1.4	2.3	1.9	1.4	1.1	1.0
[20, 50).....	1	3.0	7.8	0.6	1.3	5.4	5.3	5.0	2.1	3.8
[50, ∞).....	<1	41.8	0.0	3.4	0.0	41.8	3.4	11.7	0.0	10.0
Total.....	5	0.6	0.6	0.3	0.2	0.2	0.1	0.1	0.1	<0.1

Table A-3.6. Standard Errors for Statistical Model Performance for Identifying Areas to Canvass. For Adds: Block-Level Predictions vs MMVT Observed Estimates for Model #A2

Model #A2 Predicted Deletes	Estimated Number of Blocks (x1,000)	Estimated Percent of Blocks with [N] Observed Adds								
		0	1	2	[3, 4]	[5, 9]	[10, 19]	[20, 49]	[50, 99]	[100, ∞)
[0.00, 0.25)..	38	0.6	0.6	0.2	0.1	0.1	<0.1	<0.1	0.0	0.0
[0.25, 0.50)..	32	1.5	1.1	0.6	0.4	0.4	0.3	0.1	0.1	0.2
[0.5, 1.0).....	34	1.2	1.1	0.8	0.6	0.2	0.2	<0.1	<0.1	<0.1
[1.0, 1.5).....	23	2.0	1.7	1.4	0.7	0.5	0.3	0.4	0.0	0.0
[1.5, 2.0).....	16	2.8	2.6	1.6	1.7	0.8	0.2	0.4	0.2	0.2
[2.0, 2.5).....	12	3.5	2.6	2.2	2.1	0.9	0.6	0.6	0.4	0.1
[2.5, 3.0).....	9	4.6	3.0	3.0	2.1	2.4	0.8	0.6	0.0	0.3
[3, 5).....	12	2.3	2.3	1.2	1.7	1.4	1.1	0.3	0.2	0.2
[5, 10).....	7	3.1	2.0	1.6	1.7	1.6	0.7	0.6	0.3	0.2
[10, 20).....	4	3.8	2.7	1.4	2.2	2.1	1.9	1.1	0.5	0.1
[20, 50).....	3	6.7	2.5	2.4	3.5	2.4	2.7	1.4	1.4	0.3
[50, ∞).....	3	10.9	1.5	3.1	1.8	2.1	2.5	2.5	2.6	2.6
Total.....	5	0.5	0.4	0.2	0.2	0.1	0.1	0.1	<0.1	<0.1

Table A-3.7. Standard Errors for Statistical Model Performance for Identifying Areas to Canvass. For Deletes: Block-Level Predictions vs MMVT Observed Estimates for Model #A2

Model #A2 Predicted Deletes	Estimated Number of Blocks (x1,000)	Estimated Percent of Blocks with [N] Observed Deletes								
		0	1	2	[3, 4]	[5, 9]	[10, 19]	[20, 49]	[50, 99]	[100, ∞)
[0.00, 0.25)..	38	0.6	0.4	0.2	0.1	0.1	<0.1	<0.1	<0.1	<0.1
[0.25, 0.50)..	32	1.4	1.4	0.8	0.3	0.3	0.1	0.1	<0.1	0.0
[0.5, 1.0).....	34	1.6	2.0	1.0	0.5	0.3	0.1	<0.1	<0.1	<0.1
[1.0, 1.5).....	23	2.5	2.2	1.7	1.1	1.0	0.2	0.1	0.4	<0.1
[1.5, 2.0).....	16	2.2	2.6	2.6	2.1	1.1	0.5	0.2	0.1	<0.1
[2.0, 2.5).....	12	3.2	2.8	2.5	3.3	2.0	0.5	0.4	0.0	0.1
[2.5, 3.0).....	9	3.3	2.4	2.9	3.7	2.3	1.2	0.3	0.4	0.1
[3, 5).....	12	2.1	1.5	1.9	2.5	3.0	1.4	0.5	0.1	<0.1
[5, 10).....	7	1.8	1.8	2.1	1.7	2.6	1.2	0.8	0.2	0.2
[10, 20).....	4	3.7	2.5	1.6	1.9	2.5	3.6	2.4	1.0	0.7
[20, 50).....	3	3.1	1.2	1.3	3.6	3.0	4.0	3.1	7.1	0.9
[50, ∞).....	3	4.1	1.0	0.7	1.3	1.9	2.5	10.7	6.6	3.6
Total.....	5	0.6	0.6	0.3	0.2	0.2	0.1	0.1	0.1	<0.1

Table A-3.8. Standard Errors for Statistical Model Performance for Identifying Areas to Canvass. For Adds: Block-Level Predictions vs MMVT Observed Estimates for Model #J1

Model #J1 Predicted Probability of 2+ Adds or Deletes	Estimated Number of Blocks (x1,000)	Estimated Percent of Blocks with [N] Observed Adds								
		0	1	2	[3, 4]	[5, 9]	[10, 19]	[20, 49]	[50, 99]	[100, ∞)
[0.9-1.0].....	9	2.0	1.2	1.1	1.4	1.0	0.8	0.5	0.3	0.2
[0.8-0.9).....	15	2.4	2.1	1.7	1.1	1.2	0.5	0.4	0.1	0.1
[0.7-0.8).....	18	2.4	2.0	1.6	1.3	0.6	0.3	0.3	0.1	0.1
[0.6-0.7).....	25	2.3	1.5	1.1	0.6	0.7	0.4	0.5	<0.1	0.1
[0.5-0.6).....	23	2.2	1.7	1.2	0.7	0.6	0.5	0.2	0.1	0.4
[0.4-0.5).....	29	1.9	1.9	0.7	0.7	0.3	0.4	0.1	0.1	0.0
[0.3-0.4).....	29	1.2	0.9	0.6	0.3	0.3	0.2	0.1	0.1	<0.1
[0.25-0.3)....	22	1.5	1.2	0.4	0.4	<0.1	<0.1	0.0	0.0	<0.1
[0.2-0.25)....	25	1.3	1.0	0.3	0.4	0.1	<0.1	<0.1	0.0	0.0
[0.1-0.2).....	32	1.6	1.4	0.3	0.3	<0.1	<0.1	<0.1	<0.1	<0.1
[0-0.1).....	32	1.3	1.1	0.6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total.....	9	0.5	0.4	0.2	0.2	0.1	0.1	0.1	<0.1	<0.1

Table A-3.9. Standard Errors for Statistical Model Performance for Identifying Areas to Canvass. For Deletes: Block-Level Predictions vs MMVT Observed Estimates for Model #J1

Model #J1 Predicted Probability of 2+ Adds or Deletes	Estimated Number of Blocks (x1,000)	Estimated Percent of Blocks with [N] Observed Deletes								
		0	1	2	[3, 4]	[5, 9]	[10, 19]	[20, 49]	[50, 99]	[100, ∞)
[0.9-1.0].....	9	1.2	1.3	1.4	1.5	1.6	0.9	1.2	1.0	0.3
[0.8-0.9).....	15	2.4	1.9	1.6	1.7	1.5	0.6	0.3	0.3	0.1
[0.7-0.8).....	18	2.5	2.2	1.6	1.4	1.1	0.6	0.2	0.5	<0.1
[0.6-0.7).....	25	2.1	2.1	1.6	1.2	0.7	0.3	0.2	0.1	<0.1
[0.5-0.6).....	23	2.4	1.9	1.1	1.1	0.9	0.3	0.1	<0.1	<0.1
[0.4-0.5).....	29	2.0	2.1	1.2	0.9	0.4	0.2	0.1	0.1	<0.1
[0.3-0.4).....	29	1.6	1.4	0.8	0.6	0.5	0.1	0.1	<0.1	<0.1
[0.25-0.3)....	22	2.1	1.7	1.0	0.4	0.4	<0.1	<0.1	<0.1	<0.1
[0.2-0.25)....	25	1.7	1.6	0.5	0.4	0.1	<0.1	<0.1	0.0	<0.1
[0.1-0.2).....	32	0.7	0.7	0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1
[0-0.1).....	32	1.2	1.2	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total.....	9	0.6	0.6	0.3	0.2	0.2	0.1	0.1	0.1	<0.1

Table A-3.10. Standard Errors for Statistical Model Performance for Identifying Areas to Canvass. For Adds: Block-Level Predictions vs MMVT Observed Estimates for Model #K1

Model #K1 Predicted Probability of 1+ Adds	Estimated Number of Blocks (x1,000)	Estimated Percent of Blocks with [N] Observed Adds								
		0	1	2	[3, 4]	[5, 9]	[10, 19]	[20, 49]	[50, 99]	[100, ∞)
[0.9-1.0].....	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
[0.8-0.9).....	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
[0.7-0.8).....	4	39.6	0.0	39.6	0.0	0.0	0.0	0.4	0.0	0.0
[0.6-0.7).....	7	12.2	12.4	0.0	0.0	0.7	0.7	4.5	0.0	0.0
[0.5-0.6).....	27	2.7	3.2	1.4	1.0	0.8	0.2	0.2	0.1	<0.1
[0.4-0.5).....	28	2.9	2.2	1.6	1.0	0.9	0.2	0.1	0.1	0.1
[0.3-0.4).....	26	2.0	1.5	1.0	0.9	0.6	0.4	0.3	0.1	0.3
[0.25-0.3)....	49	1.2	1.0	0.4	0.4	0.2	0.2	0.1	0.1	<0.1
[0.2-0.25)....	50	0.5	0.5	0.2	0.1	0.1	0.1	0.1	<0.1	<0.1
[0.1-0.2).....	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
[0-0.1).....	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total.....	5	0.5	0.4	0.2	0.2	0.1	0.1	0.1	<0.1	<0.1

Table A-3.11. Standard Errors for Statistical Model Performance for Identifying Areas to Canvass. For Deletes: Block-Level Predictions vs MMVT Observed Estimates for Model #K1

Model #K1 Predicted Probability of 1+ Adds	Estimated Number of Blocks (x1,000)	Estimated Percent of Blocks with [N] Observed Deletes								
		0	1	2	[3, 4]	[5, 9]	[10, 19]	[20, 49]	[50, 99]	[100, ∞)
[0.9-1.0].....	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
[0.8-0.9).....	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
[0.7-0.8).....	4	0.4	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0
[0.6-0.7).....	7	12.7	12.6	5.5	0.0	0.0	0.7	0.7	0.0	0.0
[0.5-0.6).....	27	3.4	2.3	1.9	1.0	0.8	0.3	0.2	0.1	<0.1
[0.4-0.5).....	28	2.5	2.6	1.1	1.6	1.0	0.4	0.2	0.1	0.1
[0.3-0.4).....	26	1.9	1.9	1.2	1.2	1.2	0.4	0.3	0.1	0.1
[0.25-0.3)....	49	1.7	1.3	0.8	0.6	0.3	0.2	0.1	0.2	<0.1
[0.2-0.25)....	50	0.7	0.5	0.3	0.2	0.1	0.1	<0.1	<0.1	<0.1
[0.1-0.2).....	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
[0-0.1).....	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total.....	5	0.6	0.6	0.3	0.2	0.2	0.1	0.1	0.1	<0.1

Appendix B-1: Types of PBC Instructions

Described in the tables below are six basic types of instructions associated with PBC Polygons:

A. Whole Street
B. Bounded Street Segment
C. Branching Roads
D. Exclusion
E. Targeted Address/Structure
F. Other

Table A. Whole Street

"Whole Street"
Typical wording: "Canvass the entirety of Johnson Court."
Description: • This is usually pretty straight-forward, however it is important to keep in mind that you must stay within your block boundary. Thus "entirety" really means the structures on the side(s) of the street *within your block*. Often this actually means only one side of the street, or one small segment of a street that continues beyond the block. LiMA will not let you take action outside the block, anyway, but keep this in mind so you do not waste time trying to navigate outside your block.
Notes: • The street may or may not be visible in the LiMA, or may be inaccurately represented. You need to find and canvass the road in the real world regardless of what is in the LiMA. • The street may or may not be visible in the imagery. You need to find and canvass the road in the real world regardless of what is in the imagery.

Table B. Bounded Street Segment

"Bounded Street Segment"
Typical wording: "Canvass Berks St. **from** 46 Berks St. **to** 50 Berks St." Or: "Canvass Berks St. **from** the intersection with Leah St. **to** the intersection with Hale St." Or: "Canvass Berks St. **from** 106 Berks St. **to** the intersection with Rachel St." Or: "Canvass Rooks Place **from** 32 Rooks Place **to** the end of Rooks Place."
Description: • These types of instruction will almost always include the words from and to, representing the segment of the road you need to canvass. • The segment will usually be defined by either an address or an intersection at each end, or the dead end of a road.
Notes: • Use the polygon to determine if you are canvassing one side or both sides of the street in question. If addresses on the same side of the street are given as the "from" and "to", you will only be canvassing the side of the street that contains those addresses. • Sometimes there will be a more complex instruction of this type that requires navigating multiple streets, such as "Canvass starting from 45 Rachel St., north to intersection with Johnson St., and then east on Johnson to intersection with Allison St." • Remember that, within the defined bounded segment, you are to follow the general canvassing "right-turn" rules. If your work area includes PBC Instructions that were written so that the starting ("from") address has you unintentionally listing the living quarters to your left, please try to reverse the order and start with the "to" address, so that you are always canvassing the living quarters to your **right**. • **If "from" and "to" are used in relation to an address, it means you should include that address in your work. Generally the "from" and "to" addresses will be existing addresses in the MAF that you will verify (at least in dependent listing) while the Add actions will be found between the "from" and "to" addresses.**

Table C. Branching Roads

"Branching Roads"
Typical wording: "Canvass starting at the intersection of Freedom Hwy. and Redwood Dr. Canvass Redwood Dr. and any roads that branch off of Redwood Dr."
Description: • This type of instruction is sometimes necessary when canvassing new subdivisions. The name of the main entry road to the new subdivision (e.g. "Redwood Drive") may be known, but the subdivision is in the process of developing and the names of the branch roads and cul-de-sacs within the subdivision may not be known. • It is most often with this type of instruction that the polygon may not match the instruction: the TRMAC reviewer may not have been able to know how far the new development would eventually reach. The instruction should always take precedence, even if it means going outside the polygon. • The assumption in these situations (which should almost always, if not always, be true, as this type of instruction should not have been given otherwise) is that the only outlet for the whole network of roads in the work area is the main entry road (e.g. Redwood Dr). If you find that there actually is another outlet, you may get confused. If the polygon and imagery do not provide a clear answer, call the PBC Test Procedural Help Desk.
Notes: • When canvassing a set of roads like this, remember always to follow the standard right-turn rule for canvassing. Unless there is an unexpected second outlet (see above), you should always be able to start at the intersection mentioned in the instruction and end back at the same intersection, by following the right-turn rule. • It is especially likely in this circumstance that you will see streets that do not appear in the LiMA or in the imagery. Again, always work the real streets, do not restrict yourself to what is in the LiMA or imagery. • Sometimes the instructions will provide the subdivision name instead of (or in addition to) the name of the main entry road. This may be because the TRMAC reviewer was unable to determine the name of the main entry road.

Table D. Extension

"Exclusion"
Typical wording: "Canvass the whole block but do not canvass Tealwood Dr. or any roads branching off Tealwood Dr."
Description: • This type of instruction is a mirror-image of the "branching roads" instruction. In this case, we assume a whole subdivision or neighborhood does *not* need to listed. • The instruction should only have been given when the subdivision/neighborhood has a single outlet road (e.g. "Tealwood Dr" is the only entry to the excluded network of roads). If the excluded subdivision actually has a second outlet road with a different name, you will find it difficult if not impossible to follow the instruction. Call the PBC Procedural Help Desk in that circumstance.
Notes: • You will canvass the whole block using the right turn rule, but when you get to Tealwood Dr. you will <u>not</u> turn down it. • This type of instruction is relatively rare and some of you may not ever encounter it. An example would be an older subdivision inside a larger rural block with dispersed new housing units.

Table E. Targeted Address/Structure

"Targeted Address/Structure"
Typical wording: "Get the within-structure unit designators for 1010 W. Main St." Or "Canvass the mobile home park at 14568 Mountain Hwy." Or "Check for residential apartments above storefront at 1567 Atwood Ave." Or "Check the lot at 613 Daniel St. to see if multiple units have been built." Or "Canvass the brick structure on the corner of Hwy. 9 and Johnson Rd., get Basic Street Address and within-structure designators." Or "Check residential status of structure at 615 Main St."
Description: • For this type of instruction, the TRMAC reviewer was able to determine a specific basic street address or identifiable structure that needs to be listed. • Most typically it will be a multi-unit apartment building where you need to get the apartment numbers, but it could also be a mobile home park (usually where there is a single basic street address and individual lot numbers), or a mixed-use commercial structure where the residential status of each unit is unclear.
Notes: • These types of instructions will be the kind that most commonly provide additional clues about what you are looking for (e.g. "check for residential apartments above storefronts"). • In some cases, the expected situation will not actually be there (e.g. there really is not a residential apartment above the storefront) and you may end up not doing anything in the work area. That is OK. Do not look for other work within the block.

Table F. Other

"Other"
You may run across instructions that do not follow any of the patterns above.

Appendix B-2: PBC Test Inputs and Outputs

Technical Inputs	LiMA and MCM requirements/user stories specific to PBC Test – created by the PBC Test team in conjunction with the LiMA product owner, and delivered to the LiMA stakeholder group.
	Customer Requirements (CR) created by the PBC Test team and delivered to relevant TMO and Field staff.
	Customer Requirements (CR) created by the PBC Test team and delivered to relevant TMO and Field staff.
	Four Survey Control Input Files (SCIFs) containing the universe of PBC blocks within the four assignment types - dependent listing, independent listing (note: this was wholly unused except for one lister), dependent QC and independent QC. These files were created by staff in DSSD with input information provided by the PBC team, and were processed by MCS for input into ROSCO for making the PBC lister assignments.
	A shapefile containing PBC identifiers, polygons, and instructions created by the PBC team, reformatted by staff in GEO, and delivered to TMO for loading into the LiMA.
	Lister information provided by the PBC team for making assignments within ROSCO, in conjunction with ROSCO FR codes obtained by FLD. The lister information was also used in provisioning the laptops, done by TMO.
Lister-Focused Inputs	Assignment information provided to the listers, including the following for each lister's assignment: • PBC polygon coordinates and nearby street intersection • PBC polygons overlayed on imagery in Google Maps • PBC polygons overlayed in Google Earth (KML) • PBC polygon PDF overview map • Guidance on planning, routing, and workload estimation
	Assignment information provided to the listers, including the following for each lister's assignment: • PBC polygon coordinates and nearby street intersection • PBC polygons overlayed on imagery in Google Maps • PBC polygons overlayed in Google Earth (KML) • PBC polygon PDF overview map • Guidance on planning, routing, and workload estimation
	Assignment information provided to the listers, including the following for each lister's assignment: • PBC polygon coordinates and nearby street intersection • PBC polygons overlayed on imagery in Google Maps • PBC polygons overlayed in Google Earth (KML) • PBC polygon PDF overview map • Guidance on planning, routing, and workload estimation
	Procedures and cheat sheets, including both PBC conceptual/methodological information, and MCM and LiMA instructions, created by the PBC team with assistance from FLD
	Training – conducted by the PBC team in person for staff at Census HQ and via WebEx for RO, WAH and teleworking staff.

	Work area feedback forms, Assignment feedback Forms & Questionnaires to collect observations and feedback from the listers.
	Debriefing materials – in preparation for the post fieldwork debriefing meetings held on 1/29/15 and 1/30/15.

Note: All inputs were created by the PBC team and provided to the listers.

Technical Outputs	Four address update (ADDUP) files containing the address information entered into the LiMA were created by TMO and delivered to the PBC team.
	Four matched ADDUP files, created by GEO by matching the ADDUP against the MAF, and delivered to the PBC team.
	Four "STRUCT" files containing MSPs corresponding to the addresses added and edited during the PBC Test, created by TMO and delivered to the PBC team.
	Four Survey Control Output Files (SCOFs) containing information about the blocks/cases assigned for the PBC Test, created by TMO and delivered to GEO.
Lister-Focused Outputs	Completed work area feedback forms, Assignment feedback Forms & Questionnaires, completed by the listers and sent to the PBC team.
	Debriefing meeting participation by all listers, and resulting debriefing summary document created by the PBC team.

Appendix B-3: Listers' Responses to Work Assignment Questions

WAQ4: Difficulty in locating the work area?
WAQ5: Any other issues or suggestions with the work area?

WAQ4: Difficulty in locating the work area?	PBC Work Assignment Count	Lister Count
No/other comments	819	35
No, prepped in advance	12	1
Instructions not matching the polygon in LiMA	11	5
Instructions were poorly written/not lining up with canvassing procedures/confusing to interpret	8	7
Confusing to locate, road not signed properly/missing	7	4
Instructions were good/clear/helpful	6	2
Used Imagery, google maps, or GPS to locate	5	4
Very remote area, dirt roads/long travel time/tricky to find	5	1
Got turned around/mixed up/navigation issues	4	3
Did not find starting point from instructions	2	2
Field did not line up with instructions	2	2
Instructions helpful to find hidden housing unit	2	2
Difficult to locate the address from the labeled mailbox. Some addresses not visible on the housing unit/difficult to locate building numbers	2	1
Limited access from highway	1	1
Addresses were located within the "donut hole" of the Work Assignment, outside the block	1	1
Development still under construction	1	1
Unable to work due to denied access to gated community	1	1
Development under construction and unable to enter	1	1
No gate guards or management contact, had to enter by following another vehicle	1	1

Remote location difficult to find without GPS signal	1	1
Used GPS on smartphone to locate	1	1
Difficult to locate gated community, no guards or management contact/locating HUs w/in gated community	1	1
Listing was outside of PBC area	1	1
Poor GPS directions to gated community	1	1
Unable to locate	1	1
YAHI was used to located housing unit, road not signed properly	1	1
Rerouted/detoured to work area	1	1
YAHI was incorrect	1	1
Difficult to determine block boundaries	1	1

WAQ5: Any other issues or suggestions with the work area?	**PBC Work Assignment Count**	**Lister Count**
No/no issues/none/HUs confirmed/other comments	564	35
Writing clearer instructions on deletes and adds with MSPs/listing multiunits versus HUs structures/confirm Street Names/starting points and in general	22	15
Ensure YAHI is working properly / YAHI issues / Imagery would have been helpful when YAHI is down	20	11
PBC area or polygon needs to line up better with instructions/alignment issues or spatially off/added HUs outside polygon	20	6
Improvements w/ software & glitches/device & connections to prevent delayed work/LiMA failing after collecting data, having to reset and losing prior data/data not loaded/device freezing	19	11
No HUs above or at business location/unable to verify HUs	17	12
Instructions may have left out a potential HU in polygon or area/more guidance/training needed to capture these or not/improve training and instructions for listing mobile homes or RV parks	17	9

Unable to work due to hazardous conditions/not able to access or verify the work area/denied entry to building	15	5
Unable to work or complete due to time constraints/delays and underestimating/premature completion/severe misalignment	13	5
Speeding up the processing time of several multiunits/LiMA/forced to finish work elsewhere due to slowness	13	4
Some HUs have missing or no HNs/not given/mislabeled HN/missing road signs/unable to verify road names	12	7
Mislocated MSPs/misaligned roads in TIGER/LiMA compared to ground/other inaccurate data, ZIP Codes, etc.	11	10
Work with community management to get additional info & approval for access/developers in new developing areas/local businesses	10	9
Some instructions had to be interpreted due to not clear or well written/causing or may cause the wrong desired result	10	8
Should be able to correct or delete mistakes, user or data /errors in LiMA/add notes for future construction	9	6
Structures or area appear abandoned/inhabitable/damaged	8	5
PBC block should not have been selected for canvassing / in office	8	5
Able to add new addresses within the block that is outside the PBC area/add addresses with two different street names/add street names without adding addresses/add new road features for MSPs	7	4
Worked with community/office to confirm address/gain access to gated community/confirmed numbering schema	7	2
Engage with management of GQs to capture correctly/possible GQ issue/GQ linked to HU/flow to a GQ operation?/GQ issues	6	6
Difficulty to determine which HUs belong to correct street or non-visible boundaries/confusion in the field/add street names w/ no HUs there/ability to add road features/incorrect MAF data	6	4
HUs within multiunit structures that were missed/not in LiMA/not numbered properly in LiMA/possible missed HU	6	3

Ability to record development growth status in LiMA and flag for future visit, canvassing, or review/new construction development	6	3
Unaddressed HUs/unable to ID HN/unable to verify unit type or designation, provide description	6	2
Ability to link multi-units to one MSP/multiple addresses to a unit/difficulty in adding additional units to multi-unit structures/MSPs	5	4
Posted signs of warning may have caused missed addresses in MTdb due to potential safety issues	4	4
Remote area had lack of wireless coverage/GPS	4	4
Partially worked area that felt unsafe and finished work from another location/felt unsafe in area	4	3
Adding procedures to address more scenarios	4	2
Some roads were blocked off or closed/detour	4	2
Difficulty in maneuvering the area in the field	4	2
Initial issue with loading data/data issues	4	1
Imagery was misleading/different road names	3	3
Imagery was used to list due to not able to access HU/determine from LiMA which block HU is in	3	2
Could get more accurate information for construction area from building permit office or site plan/contact developers	3	1
Snow cover made it difficult to see the empty MH pad / any indication of existing development	3	1
Did not work area due to safety concerns/felt unsafe	3	1
Able to browse addresses in the adjacent block to see any address that may not be in the MAF	2	2
Ability to differentiate/add units based solely on description	2	1
Ability to adjust work area within the block in the field	2	1
HUs were in another part of the block	2	1
Need to compare work area/data to MMVT	2	1

Need for better description options of HUs in LiMA	2	1
Able to list multiple units in LiMA at once to the same BSA	1	1
Research gated community properties in advance	1	1
Whole PBC polygon should have been listed	1	1
Device issues, battery kept falling out, needed fixing	1	1
Did more than the instructions asked to fix HUs/multiunits	1	1
Final address in instructions is in adjacent block, marked, “Does Not Exist”	1	1
Provide practice cases to familiarize the device and software	1	1
Area not worth visiting unless other work in proximity is needed	1	1
Created a sketch map to capture HUs and enter in LiMA at a later time when device/software issue was resolved	1	1

Appendix B-4: Lister's Responses to Assignment Area Questions

AAQ3: Issues with the laptop/device? If yes, explain to include impact on work.
AAQ4a: Issues with the MCM & LiMA software? If yes, explain to include impact on work.
AAQ4b: Suggestions to improve the MCM & LiMA software?
AAQ5a: Issues with the instructions / procedures? If yes, explain to include impact on work.
AAQ5b: Suggestions to improve instructions / procedures?
AAQ6a: Did you use imagery supplied from the supplemental application / sites (e.g. google earth, google maps, Bing maps, etc.)? If yes, which ones, and how was the imagery used from the supplemental application / sites? If imagery helped with listing a block, explain how you used imagery and how it helped?
AAQ6b: Do you believe it would be helpful to have imagery available in the LiMA application?
AAQ6c: Suggestions to improve working with imagery?
AAQ7: Any other issues delaying / impacting your work? If yes, explain?
AAQ8a: What specifically helped you to do your work?
AAQ8b: Was anything missing that would have improved your work? If yes, explain?
AAQ9: Any other issues not covered? If yes, explain?
AAQ10: Conclusion and general observations on your test (methodology, management, feasibility, etc.)?

AAQ3: Issues with the laptop/device? If yes, explain to include impact on work.	**Lister Count**
No/no issues/none /blank	13
Ability to recalibrate touchscreen/having to click outside of button for response/response or non-response to tapping issues/add a stylus	8
Verizon FTE connection/transmission issues/Bit locker recovery key message	4
YAHI not working	2
Device is heavy slick, needs a strap to wear around neck/difficult for use with folks with small hands/device gets hot/needs calculator & cordless mouse	2
Stylus needed for cold weather to avoid removing gloves	1
Mouse pad would turn off	1
Battery fall out/need spare battery	1
Slow performance/Wi-Fi issues	1
Device locking up/no response	1
Times out/locks too frequently/quickly	1
Inability to check email for updates	1

AAQ4a: Issues with the MCM & LiMA software? If yes, explain to include impact on work.	**Lister Count**
Slow response/processing time with LiMA/unresponsive, locking up, or freezing/software would get stuck in a loop with the Save & Exit screen/LiMA would crash/software issues/fatal error messages	12
Unable to transmit with LiMA servers/transmission errors/a need for case notes to transmit with cases/cases not loading properly/VPN issues	4
Connection errors and issues/YAHI not displaying due to connectivity/YAHI issues leading to possible inaccurate MSPs	4
No/no issues/none/blank	3
LiMA was sensitive to any movement/MCM has no geographic display of blocks / errors between LiMA and MCM	2
Would need to pan the map to return to working area/unwanted map jumping/not centered on work area	2
User unfriendly placement of buttons/ergonomics improvement/display issues	2
Syncing LiMA work units message displays without confirmation of receipt	1
LiMA map should mimic Google Maps, for better orientation	1
Keyboard pop up issues impeded view of screen/over sensitive screen to touch causing unwanted actions	1
MCM displaying duplicate cases and other cases missing/cleared by restarting	1
Issues already reported to respective teams	1

AAQ4b: Suggestions to improve the MCM & LiMA software?	Lister Count
Ability to add multiple addresses to the same MSP in LiMA/prompts if any more units need to be added to the same MSP/speed up adding multiple units/same as last autofill button except HN/add an address to multiple structures/correction of street name would apply to all addresses with the same name/move addresses to adjacent blocks/spawn new units from existing BSA	15
Improve ergonomics of touchscreen to prevent accidental errors or block complete/move keyboard/screen lock to prevent rotation/question & response placement/adjust box size on screen	9
Add imagery/routing application/review screen to confirm actions	7
Add additional functionalities to keyboard to go to next page vs only clicking arrow/delete entire multi structure MSPs/map zooms/sorting MCM case list/correct errors or mistakes/mass verifications/page # link top of page/change YAHI shape	6
No/no issues/none/blank	5
LiMA maps to display North arrow/display YAHI at bottom of work area/path measuring tools/centering map on work to confirm pop up boxes/no shifting	5
Catalog a transmission report for user to confirm/view receipt or success/case notes to transmit with cases	4
MCM needs to display geography of blocks/workload estimate for each WA	3
Allow the adding of non residential units/transitory locations/features	3
Display of typed characters to ensure correct spellings/actions performed in progress such as “cancelling”/hour glass	3
Improve compatibility of LiMA and MCM to reduce errors and conflicts w/ other apps	2
Add “navigation to work area” capability in MCM/voice capability for navigation	2
Add flag/field to capture notes on future construction	1
Assurance of correct data loaded	1
Reduce steps/screens “Did you contact anyone about this record” for efficiency	1
Improve processing speed of saving several records within a block/work area	1
Ungeocoded list/addresses in adjacent or non PBC blocks for reference	1
LiMA identify potential matches without having a ZIP code match	1

AAQ5a: Issues with the instructions/procedures? If yes, explain to include impact on work.	**Lister Count**
No/no issues/none/blank	14
Confusing or unclear instructions making work area assignments difficult to canvass/where to begin or end / needed to interpret, possible leading to error(s)/improve writing/more details	11
Yes, no explanation	3
Needed clarification/not sufficient/had to call for guidance for further action	3
Instructions did not line up with boundary or polygon	3
Confusion to take action on MSP or follow instructions exactly	1
Clearer instructions on unique situations such as unable to work a block due to no access	1
More instructions and guidance on wizards	1

AAQ5b: Suggestions to improve instructions / procedures?	**Lister Count**
No/no issues/none/blank	17
More detailed instructions and procedures to cover unattended gates/MH parks/fenced off areas/construction areas/no trespassing areas/adjacent blocks/GQs or large apt complexes/Does Not Exist records that are misgeocoded	9
Consistent instructions/line up with polygon/emphasize instructions takes precedence over polygon/use Google Earth or other apps in writing	5
Provide technical reference guides on GPS/YAHI/transmissions and other resources such as USPS website to verify ZIP codes/cheat sheet for tricks	4
Examples of instruction with pictures/example flow	3
Detailed procedures to reset a block in MCM for errors and accidental completes.	1
Create a crosswalk from ALMI to LiMA	1
Hands on training prior to canvassing	1
Instructions available in addition to the instrument	1
Develop a limited number of type of instructions with standard text for each type and have FLD review	1
Do not give specific addresses in instructions	1
Advance time to work with instructions on fake blocks for familiarization	1

AAQ6a: Did you use imagery supplied from the supplemental application/sites (e.g., Google Earth, Google maps, Bing maps, etc.)? If yes, which ones, and how was the imagery used from the supplemental application/sites? If imagery helped with listing a block, explain how you used imagery and how it helped?	**Lister Count**
Google maps and imagery, XY coordinates/street view/navigation map	19
Google earth/KMLs imagery	18
Yes, for preplanning/imagery used for preplanning	7
Bing maps	4
OptiMap	3
Print outs of block imagery/Arc Maps/Google maps was brought to the field	3
No/no issues/none/blank	2
Imagery supplied with the assignment	2
No, too difficult and takes too much time to switch back and forth on one screen	1
Imagery was not visible/available during listing	1
MapQuest	1

AAQ6b: Do you believe it would be helpful to have imagery available in the LiMA application?	**Lister Count**
Yes	23
No/no issues/none/blank	4
No, it may cause listers to do poor work and cause confusion due to alignment issues/interfere with training of listing ground to list/may be dependent and paralyzed with work if imagery is not available	3
Imagery will increase the accuracy of added MSPs, especially when YAHI is down	2
Especially in boundary areas/concerns on processing speeds and impact by imagery	1
The users should be cautioned not to rely on imagery without first ground confirmation	1
If imagery can be toggled on and off	1
System should download imagery for work areas and embed/transmit with data	1

AAQ6c: Suggestions to improve working with imagery?	**Lister Count**
No/no issues/none/blank	16
Ability to turn or toggle on/off imagery	5
Would assist in determining current location/direction within a block and starting point/areas needing road updates/areas with no reference points/when YAHI is down	5
Imagery/PBC polygons as a selectable layers or overlay in LiMA	4
Place imagery into MCM and LiMA applications	2
Allow KMLs and exported routes from OptiMaps/Google maps to be imported to MCM/LiMA or any other supplementary imagery such as Bing	2
Imagery needs to be aligned with MAF/TIGER to reduce confusion to lister/sync with LiMA	2
Have up to date imagery	1
Listers should use imagery as a reference for planning, but not rely on it completely for the potential of some of the imagery being outdated	1
Limit imagery to those who know how to use it, not all FRs and listers will know	1

AAQ7: Any other issues delaying/affecting your work? If yes, explain?	Lister Count
No/no issues/none/blank	13
Weather/temperature/traffic impacting work	9
Technical/software issues causing delays/processing times/insensitivity of touchscreen	5
Unattended passcode gates causing delays	4
Incorrect/inaccurate data/misaligned areas	2
Loss of signal/YAHI not working or issues	2
Hard hat construction area not allowing access	2
Some areas took more time than expected	1
Losing track of multiunit adds	1
Medical Issues	1
Lighter port unable to charge laptop, finishing another day	1
Filling out forms/Fillable PDF recommended	1

AAQ8a: What specifically helped you to do your work?	Lister Count
GPS application on smartphone/navigation apps/Garmin/Google maps/Google Earth/KMLs/OptiMap/overview map	14
Preparation work in advance/write ups	10
No/no issues/none/blank	6
LiMA and MCM applications and training to determine starting point	5
YAHI	4
Supporting documents/instructions to work area	4
Imagery	3
Technical/procedural help desk	2
Accurate XY coordinates	2
Working/talking with local management and residents	1

AAQ8b: Was anything missing that would have improved your work? If yes, explain?	**Lister Count**
No/no issues/none/blank	22
Mouse/stylus/weather proof bag/hand strap or clip for the laptop	3
Imagery	3
Routing of work within the applications/voice navigation	2
Ability to take a picture and send to help desk	1
Navigation application	1
Access to work email/OWA	1
Test blocks for practice/training	1
Hard copy print out of instructions	1
The authorization to rent the appropriate vehicle for the environment	1
A more efficient system to update and add units to large multi units	1
Advance time in receiving assignments for planning	1

AAQ9: Any other issues not covered? If yes, explain?	**Lister Count**
No/no issues/none/blank	27
Navigation/YAHI issues	2
Flat tires/breakdown	1
Technical issues with laptop power and Verizon connection	1
Lack of accurate data due to “No Trespassing” signs	1
Laptop sensitivity not able to respond to gloves	1
Personal security concerns and threats	1
More tutorials on laptop for cover more possible situations	1
There were “holes” in work areas that were not covered nor addressed	1
Need to work with finance in advance to ensure all expenses will be reimbursed/better understanding of work	1
Confusion in MCM application as double assignments appeared	1

AAQ10: Conclusion and general observations on your test (methodology, management, feasibility, etc.)?	**Lister Count**
Good test run and fieldwork/good to participate/test went well/instructions were clear/software worked and well-designed/LiMA is more user friendly than ALMI/YAHI helpful	11
Listing instructions need to improve/more instruction or guidance needed/modified for the purposes of QC/do not overcomplicate the operation/print instructions for listers/development of a true training guide and instruction manual/assign a unique ID to PBCs	10
PBC is a feasible/sound operation with good instructions and clear data/imagery/will be successful if the pieces fall into place with minimal troubles/easier than full listing	9
No/no issues/none/blank	8
Assignment took longer to complete than expected/assignments may be too large/independent listings took longer	5
Urban areas with small blocks, PBC seems less cost effective/not good use of time/most cost effective is applying PBC methodology to physically large blocks	5
Operation was well managed/well supported by the procedural help desk	2
Need assistance from FLD to assist in running operation/assistance from regional knowledge and local input	2
Can not assume access to gated communities, procedures need to be in place	1
Communication was reactionary, after someone making a mistake	1
Technical help desk was not very helpful/delayed response	1
Discovered that fieldwork or representative may not be for them	1
Some large blocks were difficult to navigate and long detours occurred	1
Suggest a stockpile of small isolated blocks to be worked when one is in the vicinity	1
MAF data is problematic if inaccurate/non-existent	1
Difficulty to determine where to list an address	1
Imagery is needed in LiMA	1
Streamline software	1
Ability to flag areas needing misalignments/data fixed	1

Data entry is nicely streamlined	1
HQ can save money and resources by not providing manuals, cheat sheets and reference guides since it is too much for listers	1
Requiring daily reports will help in thorough reporting and feedback	1
Safely can be a concern, especially for listers not paying attention to their surroundings	1
No imagery for the field listers, will lower the quality of work	1

Appendix B-5: Automation Improvements

Other hardware improvement recommendations made by the PBC listers include:

- The device was not registering the touch screen in cold weather.
- The YAHI/GPS indicator was not always functioning.
- The device would freeze up and needed to reboot, which slowed down fieldwork.
- Device was slow.
- Battery kept falling out of the device.
- Add a trackball for touch pad issues.
- Provide a stylus for the device.

Lister Recommendations for Improvements to the LiMA:

- The popup keyboard was slowing work down by blocking the screen view.
- Determining the correct ZIP Code from the drop down list with several ZIP codes listed.
- Allow BSA to be entered once for multiunit structures while allowing multiple unit designators to the same BSA to be added and deleted as needed (ie autofill BSA for units within large apartment complexes).
- Drop down list arrow would not display list consistently.
- Add / Implement a case level notes editor.
- Need the ability to move MSP, even to adjacent block.
- Include adjacent blocks in LiMA.
- Need the ability to add and edit streets in LiMA.
- Always have PBC instructions displayed consistently onscreen for the area worked.
- Need the ability to see only address list on the LiMA device.
- Load the feedback form onto the device.
- Add a navigation functionality on the LiMA device to include audio/voice.
- Need the ability to resize and move the LiMA case screen.
- Add a filter to MCM for displaying blocks.

Data or data transmission problems that need to be addressed:

- Alignment of roads and blocks in LiMA and in the field did not line up properly.
- Sometimes the data transmission work did not transmit nor verified it was transmitted.
- Add confirmation of saved and successfully transmitted work.

PBC Listers recommended that the following skillets were most helpful for new listers:

- Many listers cited advance research and planning in preparation for fieldwork was key to successfully conducting fieldwork.
- Navigational skills are key, and getting to the PBC work site efficiently is critical to the success of the fieldwork. Ability to relate the map to the real world.
- Route planning.
- Orientation and geographically-inclined staff.
- Time management and ability to pace.

A few listers recommended that managers plan out/do the route planning for the listers instead of the listers doing the planning work themselves. It was felt that new listers, who were inexperienced with the work would “waste time” getting to their various assignments or not get to them at all.

Appendix B-6: Categories of MMVT Adds in PBC Blocks

Category 1	Represents MMVT adds that had exact or near matches to a record in the PBC file
All other categories below represent MMVT adds that did not have a PBC match:	
Category 2	Primarily includes the kinds of "false adds" we discussed in the TRMAC-MMVT comparison sections—add actions that should have been coded as changes, erroneous listing of GQ rooms as housing units, or other clear MMVT errors.
Category 3	Represents good MMVT adds that TRMAC should have detected, but which already were tracked in the MAF, so should not have eligible for PBC. Most likely these were added to the MAF after the MMVT extract was created (ACS13) but before the PBC extract was created (ACS14).
Category 4	Represents MMVT adds that were within or near the PBC polygon. This means that TRMAC successfully identified the area of under-coverage within the block but that the PBC lister was unable to find. Category 4 represents potential failures of the PBC methodology in particular, either during the polygon creation phase, the instruction creation phase, or the field phase. There are several sub-categories of Category 4.
Category 5	Represents good MMVT adds which were note tracked in the MAF and which the TRMAC interactive review apparently did not detect. Because these adds were not near the PBC polygon, it is unlikely that the PBC methodology in particular had anything to do with why these were missed. It was that TRMAC did not identify the area to begin with. We have already discussed some of the reasons why TRMAC did not detect areas of adds in the previous TRMAC-MMVT comparison section, and so will not discuss this again in this section. Those same major reasons apply here: these adds were generally corrections to baseline errors undetected, housing growth of a type undetectable to TRMAC, or housing growth of a type that should have been detected but was not, due to imagery currency/clarity issues or reviewer error.
Category 6	Represents good MMVT adds where it is known that the PBC worker was unable to list the area due to safety, weather, or time constraints unrelated to the methodology of the test. These adds should not be considered in the analysis.
Category 7	Represents MMVT adds that were location description only or lacked a house number, making comparison to the MAF impossible. These were not located near the PBC polygon.

Appendix C-1: Standard Error Table Section 4

Table C-1.1 Weighted Matrix of Predictions from Imagery by Observed Number of Adds

Detection from Imagery Review	Observed Number of Adds in Block							Total Blocks (×1,000)
	0	1	2	3 to 4	5 to 10	11 to 20	≥21	
-100 to -2	8.9	6.3	8.8	0.4	5.7	0.0	1.6	6
-1	7.8	5.3	4.9	2.3	1.0	0.0	1.4	8
0	0.5	0.4	0.2	0.2	0.1	0.1	<0.1	22
1	2.8	2.6	2.1	1.5	0.9	0.3	0.2	20
2 to 10	2.9	3.5	2.4	2.5	2.6	1.1	1.9	10
11 to 20	5.1	8.7	1.7	0.7	8.2	14.6	6.9	3
≥21	7.2	2.6	0.2	0.2	0.9	7.3	10.2	3
Total Blocks (×1,000)	29	25	15	12	8	5	5	5

Appendix D-1: Acronyms and Abbreviations

20RPO – 2020 Research and Planning Office
AA – Assignment Area
ACS – American Community Survey
ADDUP – Address Update File
ALMI – Automated Listing and Mapping Instrument
AVT – Address Validation Test
BSA – Basic Street Address
CAPI – Computer Assisted Personal Interview
CPEX – Census Program for Evaluations and Experiments
CR – Customer Requirements
CAUS – Community Address Updating System
DAAL – Demographic Area Address Listing
DSF – Delivery Sequence File
DSSD – Decennial Statistical Studies Division
FLD – Field Division
FR – Field Representatives
FTCDO – Field Training Career Development Office
GEO – Geography Division
GPS – Global Positioning System
GQ – Group Quarters
GSSMG – Geographic Support System Matching and Geocoding
HN – House Number
HU – Housing Unit
IR – Interactive Review
LCO – Local Census Office
LiMA – Listing and Mapping Application
LQ – Living Quarters
MAF – Master Address File
MAFID – MAF Identification number
MCM – Mobile Case Management
MCS – Master Control System
MMVT – MAF Modeling Validation Test
MSP – MAF Structure Point
MTdb – MAF TIGER Database
PBC (T) – Partial-Block Canvassing (Test)
QC – Quality Control
QI – Quality Indicators
RO – Regional Office
ROSCO – Regional Office Survey Control System
SCIF – Survey Control Input File
SCOF – Survey Control Output File
TAC – Technical Assistance Team
TIGER – Topologically Integrated Geographic Encoding and Referencing
TMO – Technology Management Office
TRMAC – TIGER and MAF Assessment and Classification
USPS – United States Postal Service
WA – Work Area
WAH – Work at Home
YAHI – You Are Here Indicator
ZIP – Zone Improvement Plan