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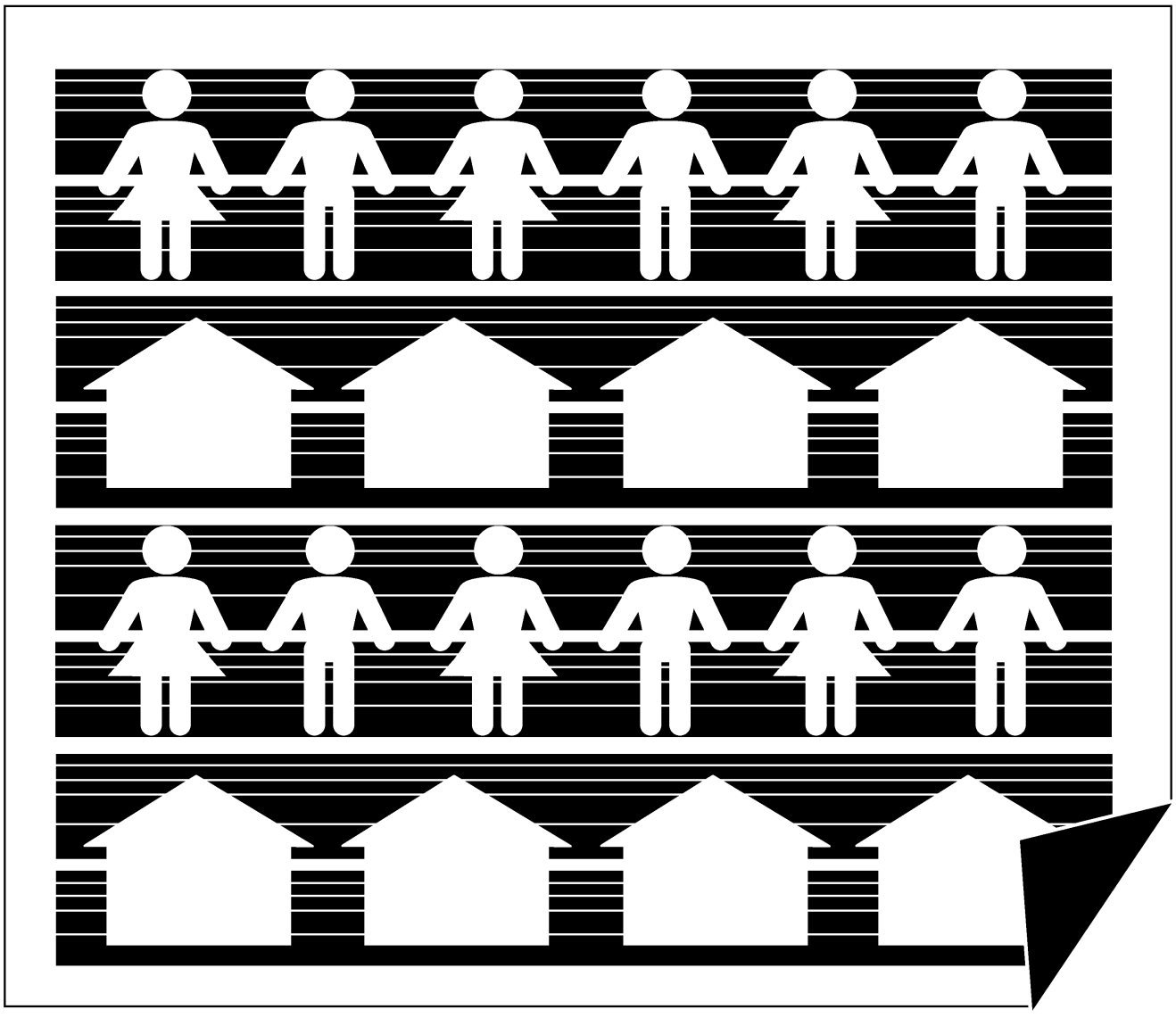
1990 Census of
Population and Housing

Evaluation and Research Reports

Effectiveness of Quality Assurance



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CONTENTS

CHAPTER 1.
Introduction and Background

GENERAL QUALITY ASSURANCE PHILOSPHY FOR 1990

In the early 1980's, the Census Bureau looked at its quality control approach and the analyses for 1980 census operations attempting to answer several questions. What was the quality of the product? What were the errors and what were the deficiencies in the process? Particular interest was placed on the quality control techniques used and, where problems existed, what were these problems and how could they have been prevented? In this light, what should be the approach for the 1990 census?

The Census Bureau recognized the problems of relying on the inspection and repair method that was used for 1980 operations. This approach had not been completely successful. It was decided that the Deming philosophy with its approach toward total quality improvement would better serve the decennial census program.

Four major components to the 1990 quality assurance approach were decided upon, namely: build quality into the system; constantly improve the system; integrate responsibility for quality with production; and, clearly differentiate between quality assurance and quality control.

To ''build quality in'' an operation as large as a decennial census is not easy. It was necessary to identify ways to approach such a large-scale operation completed by a temporary workforce during a very short period of time. Several areas were identified:

- Design operations to be straight-forward and efficient
- Train the staff
- Measure what has been learned during training
- Measure performance and give feedback during the operation
- Assume the staff wants to do a good job; it is our responsibility to give them the tools to improve

The operations were designed with the intent that the system could be constantly improved. However, a system cannot constantly improve in such a decentralized environment unless tools are provided to the staffs and supervisors to do so. A major challenge was to design a system where it was possible to measure the quality of the work, quantify error characteristics, and provide the information back to management in a time frame where it could be used.

The integration of the responsibility for quality with production grew out of experience in 1980 when the production and quality responsibilities resided in different management areas. Production was the responsibility of one group in one part of the organization, while quality was the responsibility of the quality control area in another part of the organization. Management always asked how things were going, but it was perceived in terms of quantity, not quality, of work. Therefore, the perceived priority within the organization's structure was on the production side. The quality control staffs seemed to always be a ''thorn'' to the production staffs. This promoted an adversarial relationship within the organization.

To eliminate this antagonism, the production side was made responsible for quality, also. With this added responsibility, not only did the job have to get done; the job, now, had to be done well.

Quality assurance is different from quality control. But, it is difficult for most people to understand the difference. The Census Bureau has long implemented quality control and has applied it to virtually all operations. Quality assurance is a much broader idea. It includes the whole concept of management responsibility for how well an operation functions. Quality assurance includes all components of management: production, timeliness, and accuracy. Quality assurance is the responsibility of everyone—no one is exempt. Quality control is only one part of the broader quality assurance concept.

The Census Bureau employs a lot of the separate components of quality assurance, but integrating it under one umbrella was a change in philosophy and management approach. This change was one of the most difficult aspects of the new philosophy to implement during the 1990 decennial census.

Quality Assurance for 1990

To support the new philosophy, a concerted effort was made to design quality inspection plans integral to an overall quality assurance approach. Staff consulted and met with sponsors and users of the specifications. Certain aspects were specified to enable measurement of learning, continued performance improvement, and overall process quality. Staff also specified and assisted in the development of systems, both manual and automated, to provide management and supervisors with information. This information supported continual improvement of the process, of a unit of clerks, and of an individual.

It was necessary to sell the new philosophy by educating both management and staff through the use of seminars on this approach. Several pilot programs, outside the

decennial area, were undertaken to show the effects of the new approach on the process. The various aspects of the approach were tested during the census test cycle. It was necessary to be constantly vigilant as it was a cultural change for all—and it was easy to revert to the old ways. There was success on some fronts and less success on others.

To obtain both timely and accurate measurements of performance, was one of the Census Bureau's major goals. To achieve this, an attempt was made to simplify manual records and summaries, and software was developed to support the quick capture of data quality. An active quality inspection activity was maintained to measure the performance, both during training and during production.

Another goal of the new approach was to make sure trainees understood their job before leaving training. An important aspect of ''building quality in'' is to train the worker well on what they are to do. Staff worked hard on specifying what was to be covered in training. It was important to make sure the trainees understood the job before they left the training room. To achieve this goal, practice work was instituted wherever possible and tests were developed to be given after training to obtain a measure of learning.

Another goal, and perhaps the most visible, was to provide timely feedback. Without effective feedback the system would remain static. Feedback makes the worker aware that others are interested in how well their job is going. Effective feedback enables the worker to know how well he/ she is performing, and in what areas there can be improvement. For feedback to be effective, it must be timely and relevant to the main components of the tasks being performed. Feedback given 2 weeks after the work has been completed or on components of the system over which a worker has no control is of little benefit to anyone.

The new quality assurance approach was pervasive throughout the census. It was integrated at all levels and across virtually all operations. The remainder of this section will focus on the areas of automation, communication, training, and measurement techniques to illustrate some of the specific actions taken to bring about improvement in total quality.

Automation—The increased use of automation made it possible to apply the new quality assurance approach to areas that would have been impossible in 1980. With the placement of automation equipment at the field district office level, more consistent application of procedures could be expected. The software would do the more complicated tasks the diversified staffs could not be expected to do throughout the country. Here, consistency in implementation is equated to quality. Automation and the associated ability to control the materials by identification number permitted the census materials to be processed on a flow basis as they were received. In 1980, all forms for a defined geographic area had to be collected before any questionnaire could be processed. This allowed the processing in both the district offices and the processing offices to proceed; thus enhancing productivity directly and quality indirectly.

The increased use of automation made it possible for the Census Bureau to improve the capture, analysis, and dissemination of information on the status of the operations. For example, in the processing offices there was the Computer Assisted Tracking System (CATS) to monitor material work flow. Software and computer facilities enabled the Census Bureau to perform extensive analysis of data incorporating statistical techniques in the decision mechanisms and making the results available on a timely basis to the processing and field management staff as well as headquarters. The keying operations in the processing offices and the clerical edit operation and reinterview program in the field were operations where the computer played major roles.

For keying, sample selection, quality decisions on work units, and information reports on keyers and errors were produced by the computer. The computer calculated the appropriate statistics from the inspected data during verification. This information was provided to supervisors immediately and stored for headquarters' personnel for monitoring.

In the clerical edit operation, the computer aggregated data and generated output on the quality level and characteristics of errors for the supervisors to review.

For operations in the field where enumerators were required to visit housing units to obtain information, a reinterview program was established to detect falsification of data. One component of this operation involved the computer analysis of content and workflow data for each enumerator's geographic area. From this analysis, enumerators with workflow or content characteristics significantly different from coworkers in the same geographic area were identified for reinterview, unless the situation could be explained by the supervisor. This system enabled the Census Bureau to expand coverage and to minimize field reinterview cost.

One of the basic properties for an effective quality assurance program is the speed with which feedback is given. Automation provided a means by which data and its interpretation could be turned around rapidly. During processing of the 1980 census, it was not unusual for the manual recordkeeping to have a backlog of several weeks, making the value of such data worthless for feedback. Automation also improved production because operations were accomplished in much less time. Check-in of the mail returns was faster and better. We generated new listings for nonresponse followup, and did not have to use the same address register over and over again.

Communication—One of the elements for a successful quality assurance program is effective communication. This includes the ability to obtain, evaluate, interpret, and distribute information to improve the planning and design

of an operation, as well as to help identify problems and their causes during implementation. In general, good communication is one of the keys to producing the best product possible.

Working Groups—Working groups at the headquarters level was one effort to maintain good communication. Interagency groups were important during the planning and implementation of quality assurance operations that required the assistance of outside agencies. Working groups were established with the Government Printing Office for the printing of the 1990 questionnaires and forms, and with the U.S. Postal Service for the various postal operations such as the Advance Post Office Check and Casing operations.

These working groups' initial focus was to bring together representatives from each agency to plan and design the best system possible. This was accomplished by reviewing ideas, understanding each agency's guidelines, and taking advantage of the experience and expertise within each agency. These working groups met periodically to discuss assignments, set priorities, and review specifications and procedures. This type of cooperation established respect and a better understanding of the operation and each agency's responsibility. Once the various operations started, the working groups stayed intact. The emphasis then changed to monitoring the operation and resolving problems. All problems were discussed with each member of the working group to develop the best solution.

Internal census working groups were developed to plan and design the best system possible for various operations for which the Census Bureau had sole responsibility. Working groups normally consisted of an analyst from each discipline necessary to design and implement a specific operation. These individuals made up the communication team to plan and monitor the implementation of the operation. Their functions included evaluating ideas, defining objectives and requirements, reviewing specifications and procedures, as well as monitoring and problem solving.

Reduced Supervisor Ratio—To improve employees' performance, supervisors must provide timely and accurate feedback. One barrier to doing this is the lack of enough time. After reviewing the supervisor's tasks, the Census Bureau decided to require first line supervisors to manage fewer employees. This enabled each supervisor to have more time for reviewing employees' work, interpreting the feedback data, and providing the necessary counseling and retraining to improve workers' weaknesses.

Quality Circles—By definition, a quality circle is the concept of management and employees, as a team, periodically discussing quality status, issues, and problem resolutions.This concept was primarily used in the processing offices. The quality circle group for a specific operation generally met once a week. The results from each meeting were documented and distributed to all employees and management staff. Suggestions were implemented where possible. This was especially useful in the coding operations.

On-Site Observers—Another organizational component established to improve operational performance was on-site observers in both field and processing offices. This observer was referred to as a quality assurance technician (quality assurance technician). Their primary responsibilities included enhancing local management's awareness of quality assurance objectives and importance, as well as assisting in monitoring the adherence to the quality assurance requirements.

A quality assurance technician was in each of the 13 Regional Census Centers and each of the 7 processing offices. To perform their responsibilities, each quality assurance technician performed analysis and on-site observation to monitor the quality assurance requirements. If a quality assurance technician identified inconsistencies, the information was articulated in person, or by telephone, to local management for investigation and appropriate action. The quality assurance technician also acted as a consultant. This was especially important in assisting local management to make administrative or operational decisions that did not adversely affect quality assurance requirements.

The primary skills essential to performing their tasks were a thorough knowledge of the operations and their quality assurance requirements and the ability to effectively communicate these. All recommendations, problem identification, advice, and status reports had to be communicated orally to management and documented.

Problem Resolution—In the processing offices, a problem resolution system was established. The purpose of this system was two-fold; first, it provided local management with a vehicle to identify problems or request clarification to procedures or software and receive quick resolution. Secondly, it allowed appropriate headquarter divisions an opportunity to participate in the decision to minimize any negative affect on their specific requirements.

All problems were documented and transmitted to headquarters for review. The Decennial Operations Division consulted with the sponsoring division who generated the specification. After a solution was reached, it was documented and sent to various subject matter divisions for clearance. Upon clearance, the resolution was transmitted to all processing offices.

Training—One component of the total quality assurance concept is the education and training of production staff. The goal as management was to institute training on the job. The census created over 400,000 temporary jobs in more than 2 dozen major field and processing operations. The majority of the jobs were for field enumerators. We strengthened enumerator training, pay, and management. Enumerator training was more interesting and relevant to

the job. It included learn-by-doing exercises and more training on map-reading. The Census Bureau improved the level of supervision given the enumerators by reducing the ratio of enumerators to crew leaders. Crew leaders reviewed enumerators' work daily to detect errors in the early phases of work.

The Census Bureau worked to improve the training materials for all 1990 census operations. Training sessions, held during the test censuses and the 1988 Dress Rehearsal, were observed and recommendations were made for improvements. Many of the training sessions used a multimedia format. The Census Bureau prepared a series of video tapes for many of the operations in the processing offices, including a general quality assurance overview video. Two divisions, Field Division and Geography Division, used computer-based instruction for part of their training. The computer-based instruction helped standardize the training that was held at multiple sites. The computer-based training also improved the quality of any additional training necessitated by staff turnover while the operations were underway.

As part of the Census Bureau's training to prepare to process the questionnaires, a 3-week integrated test was held in January 1990 at the Baltimore Processing Office. One purpose of the test was to train supervisors from the seven processing offices with hands-on implementation of software and work flow procedures. Comments and observations from the test were reviewed and adjustments to operations were made to improve the efficiency of the processing.

Measurement Techniques—Regardless of the operation, one of the basic objectives of a successful quality assurance system is the ability to accurately measure performance by identifying errors, documenting the characteristics of the errors, and providing information to management on error level and characteristics so that feedback can be given. Due to the diversity of decennial operations, the methodologies used to meet this objective differed. The following discussion focuses on the primary techniques used.

Pre-Operational Sampling—For some census operations neither a prior sample frame existed nor time constraints allowed for sampling completed work. The address list development operations are such an example.

For the Prelist operation, since the listers were creating the address list, no prior lists existed from which a sample could be selected. Selecting a sample after the workunit was completed also was not feasible due to operational constraints which included: (1) verification of a sample after the initial listing would require the lister to be idle while this listing was done and the quality decision determined; (2) any decision would be reached after a substantial amount of work already would have been completed; and, (3) such an approach would require an independent staff of quality assurance listers in the field at the same time as the regular listers presenting a difficult management and public perception problem.

These characteristics resulted in the development of an early sample of work done prior to the actual start of the operation. A body of work was used to match to the actual data as it was done, thereby providing immediate measurement of the quality of the job. The benefits of this approach were: (1) quality assurance listings were completed weeks ahead of time, managed under their own organizational structure and controls; (2) quality assurance data were immediately available to supervisory personnel to be used to measure the quality of the listing work; and (3) the initial identification of the sample was used as a means for listing managers to gain experience prior to the start of the operation.

If a workunit showed an unacceptable level of errors, the supervisors researched the case to determine if the enumerator was indeed accountable for the error, and if so, took the appropriate action ranging from a discussion of the specific case to retraining or reassignment to a different area. In severe cases the workunit would be reworked by a different individual.

Data on all aspects of the quality assurance operation were maintained for both concurrent monitoring and the creation of a post-operational database for analysis.

A variant of this technique was used for the coding operations. A sample of the non-computer coded cases was selected prior to coding, replicated three times and distributed among three workunits and coded independently. A measure of the individual coding quality level for each coder was obtained by comparing the coding results for this sample against the ''true'' codes determined by the three coders using the majority rule to decide on differences among the coders.

Post-Operational Sampling—For the majority of the census processing operations, it was possible to measure the quality and provide feedback by selecting a sample from the workunit subsequent to the operation. These operations included most of the clerical and all of the data entry operations.

The quality assurance was independent or dependent based on the level of automation of the processing operation. Automation allowed for an independent verification in all of the data entry operations. Other clerical processing operations were dependently verified.

During independent verification sample cases were selected, the operation replicated, and the results compared to the original data. If the number of detected differences exceeded a predetermined tolerance, the workunit was rejected and was redone.

For the dependent verification, a sample of work was reviewed to determine the level of errors. If this number exceeded a predetermined tolerance, the workunit was rejected.

The quality statistics were monitored at both the workunit and clerk level. Workunit data was used to determine workunit acceptance. The clerk data provided characteristics of errors at the individual clerk level. It then was used

to identify areas of difficulty where additional training may be required or where procedures may be incomplete.

Post-operational sampling using independent verification was used for all data entry operations. Post-operational sampling using dependent verification was used for most clerical processing jobs. Some of these included: Edit Review, Search/ Match, Microfilm Duplication, and the FACT 90 operations.

Concurrent Monitoring—For some operations either there did not exist an adequate sample frame from which to select a pre-operational sample or the selection of such a sample would have interfered with the actual enumeration process. The selection of a post-operational sample also would have interfered with the enumeration process.

In these situations a procedure was designed to verify that the census employee understood the proper census procedures before being allowed to work independently. For these operations, supervisory personnel monitored/ observed the census employee's work for a specified period. At the end of this period, based on the number of errors detected, a decision was made as to whether the employee could work independently or should be reassigned.

The operations where this technique was used included: Urban Update/ Leave, Update/ Leave, and Telephone Assistance.

Reinterview—The enumeration method used in most of the country was either Mailout/ Mailback or Update/ Leave with self-enumeration. Approximately 60 percent of the housing units were enumerated by the household mailing back the census questionnaire. In the remaining 40 percent, consisting of list/ enumerate and nonresponse cases, the enumeration was conducted by census enumerators.

To protect against census enumerators falsifying data during the enumeration process, a sample of work was selected daily from the enumerators to be reinterviewed. By comparing the reinterview responses to the original responses for selected roster items, it was determined whether potential data falsification occurred. The cases that showed evidence of potential data falsification were researched by the supervisory staff to determine if actual falsification had occurred and, if so, appropriate administrative action was taken.

Suppression of Pre-Operational Sample—The suppression of addresses to measure the proportion of addresses added by enumerators was used in the Precanvass operation. Enumerators were instructed to canvass their geographic area, adding and updating the address list, as necessary . A measure of the ability to perform was obtained by measuring the proportion of suppressed addresses returned as adds.

Contents of the Report

This publication is one in a series of evaluation and research publications for the 1990 Census of Population and Housing. This report presents results of evaluations for a variety of 1990 decennial census quality assurance operations. This report provides results from census preparatory operations, data collection operations, data capture/ processing operations, and other operations, such as search/ match and the quality assurance tech programs.

The quality assurance program was implemented to improve the quality of the operations and increase productivity. This report describes the analysis of each operation and the effectiveness of each quality assurance plan. The results from these analyses can be used to improve the overall design of future operations required to conduct a high quality decennial census.

ORGANIZATION OF THE REPORT

The organization of this report focuses on the analysis of the major operations for which quality assurance plans were utilized. Chapters include preparation for the census, data collection, data capture/ processing activities, and ''other'' operations.

The chapters are organized into two or three major headings and the appendixes A and B. Within each major heading and its component part, there are six sections: the *introduction and background, methodology, limitations, results, conclusions, and reference.* The first section presents background and a brief description of the quality assurance operation being discussed. The second section gives the sample design and statistical technique(s) used to analyze the operation. The third section discuss any constraints and/ or limitations that might have impact on interpreting the results. The fourth section gives the results of the evaluation of the quality assurance process. The fifth section of each chapter presents a summary of the data and any major recommendations for the future. The final section will reference any documentation needed to broaden the understanding of the topic.

Finally, in appendix A, there is a glossary of terms that may be found throughout the report. It is hoped that the report is written in understandable terms, but it is impossible to cover these topics without the use of some words unique to the census or the quality assurance environment. The appendix B has facsimiles of all forms used throughout this publication.

CHAPTER 2.
Preparatory Operations

The conduct of the 1990 decennial census required much effort during the preparatory phase. Since the census was taken primarily by households receiving a questionnaire, one major preparatory operation was the production of the questionnaire packages. This chapter includes discussions of the activities for the preparation of both questionnaire packages made up for the short and the long forms.

Another critical preparatory activity is the creation of the address list. For some areas of the country, an address list was purchased from a commercial vendor. In other areas, where a commercial list was not available or could not be used, census enumerators created the address list in an operation, called the Prelist. This chapter also includes a discussion of the quality assurance for the Prelist operation.

SHORT-FORM PACKAGE PRODUCTION

Introduction and Background

For the 1990 decennial census, approximately 82.9 million short-form packages consisting of a short-form questionnaire (see form D-1 in appendix B), instruction guide, motivational insert, and a return and an outgoing envelope were produced. These materials were produced using the following process: printing and imaging of the questionnaires, printing of the instruction guides and motivational inserts, construction of the outgoing and return envelopes, and assembly and packaging of the pieces. After the contract for this process was awarded, the Census Bureau met with the Government Printing Office and the contractor to discuss any adjustments to the quality assurance requirements or production system to optimize efficiency of the short-form package production.

Before printing the questionnaires, a prior-to-production run was performed by the contractors to demonstrate their ability to produce a large-scale, full-speed production run that would meet specifications. This included using a test address file containing bogus addresses.

During production, representatives of the Census Bureau or the Government Printing Office repeatedly visited the contractor's sites to ensure that the contractor followed the quality assurance specifications and to monitor the quality of the various processes. This included reinspection of the contractor's samples by the government representative to confirm the contractor's findings.

Methodology

The quality assurance plan consisted of visual and mechanical on-line verification of samples of the package components during each stage of the production process. A systematic sample of clusters of two or three consecutive package components was used as the quality assurance samples. If a systematic error was detected, a clean out (expanded search) was performed forward and backward of the defective sample cluster to isolate the problem. The contractors corrected all errors and recorded the results of the inspection on the appropriate quality assurance recordkeeping forms. The results were used for feedback, process improvement, and later analysis.

An independent verification was performed by the Data Preparation Division in Jeffersonville, Indiana, where a subsample of the inspected questionnaires was selected and reinspected.

Limitations

The reliability of the evaluation for the operation was affected by and dependent upon the following:

1. The correctness of the quality assurance records provided by the contractor.
2. The legitimacy of the samples delivered by the contractor.
3. The sampled questionnaires at the end of the rolls (for the roll-to-roll printing) representing the questionnaires throughout the roll.
4. The use of the number of random errors detected as the numerator in calculating the outgoing error rates. If no random errors were detected, the estimated outgoing error rate was 0.0 percent.
5. The assumption of simple random sampling in calculating estimated error rate standard errors.

Results

The technical specifications for printing forms to be filmed traditionally have been highly demanding with respect to the quality of paper, printing, and finishing work (addressing, trimming, folding, etc). These rigorous technical requirements were driven by the data conversion system and by the need to safeguard against the introduction of data errors in processing questionnaires. While selected printing specifications for the forms to be filmed were relaxed somewhat for the 1990 census, the printing contract specifications—monitored by means of quality assurance

requirements that were an integral part of the contracts—gave the Census Bureau a wide ''margin of safety,'' ensuring a top quality product and minimizing the introduction of data errors at conversion.

In view of the fact that development of the 1990 software for the filming equipment was not finalized until after the conclusion of all printing, the margin of safety was considerably wider than in the 1980 census or than anticipated for 1990. Despite the detection of errors documented in this report, *no forms processing or data conversion problems attributable to bad printing (or other manufacturing steps) are known to have occurred with the 1990 forms.* In addition to ensuring against widespread random or systematic errors, the quality assurance contractual requirements served to guard against any escalation in the degree (or seriousness) of errors to the point where the ''true'' (but unknown) tolerances might have been strained or exceeded.

For the roll-to-roll printing process, the questionnaires were offset printed on a web press. A large roll of paper was run through the press and, upon printing approximately 48,000 questionnaires, the paper was immediately re-rolled.

The results for the inspected questionnaires were recorded on Form D-854, Roll-to-Roll Questionnaire Printing Verification Quality Assurance Record. (See form in appendix B.)

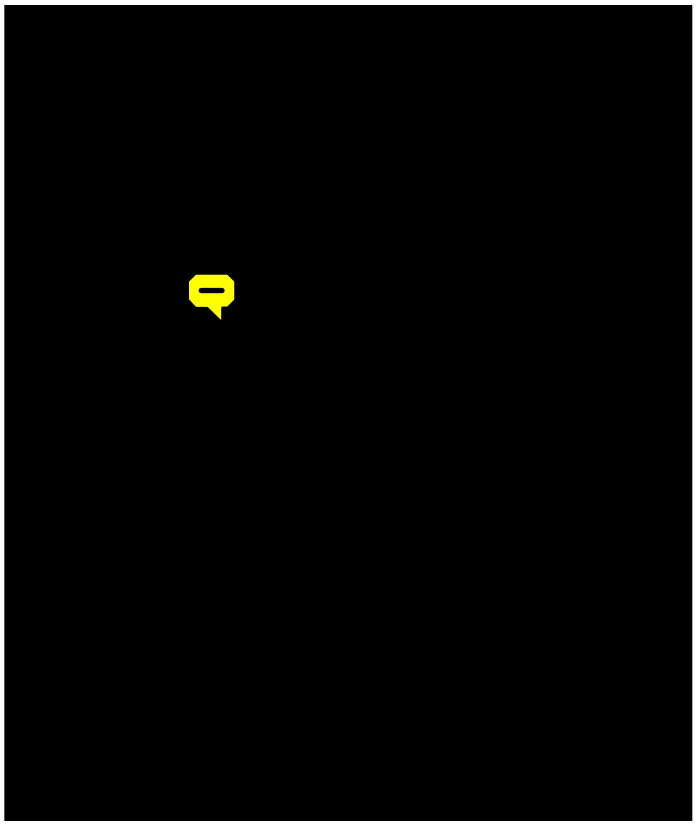
Of the 2,381 printed rolls of questionnaires, 5.1 percent (122 rolls) were detected to be in error. Due to the 100 percent verification of every roll, there is no standard error. The rolls were either ''cleaned out'' or rejected entirely.

Figure 2.1 shows the distribution of the types of errors detected. Some individual samples contained more than one type of error. The error types were as follows:

Code	Description
C	Any unprinted spot in the index squares or vertical bars is out-of-tolerance.
E	Poor type quality or uniformity.
B	Any measurement of the circle wall thickness is out-of-tolerance.
A	Any measurement of the black ink density is out-of-tolerance.
J	Other, specify.
G	Black and blue inks are out-of-register.
D	Any black spot is out-of-tolerance.
F	Image is misplaced or skewed.
H	Show-through is out-of-tolerance.

The most frequently occurring error was out-of-tolerance unprinted spots in the index squares or vertical bars. Poor type quality or uniformity was the second most frequent error. Most of these errors occurred during the first half of the operation. The quality assurance plan enabled early detection of the errors and helped reduce the problem.

For the imaging, trimming, and folding process, the questionnaires were addressed and encoded using ion deposition imagers. Variable respondent addresses, an



interleaved 2 of 5 bar code, a census identification number, a binary coded decimal code, variable return addresses with corresponding postnet bar codes, and synchronization control numbers were imaged on each questionnaire.

The results of the post-imaging inspection were recorded on Form D-856, Addressed 100 Percent (Short) Questionnaire Verification Quality Assurance Record. (See form in appendix B.)

The post-imaging estimated incoming error rate was 3.1 percent, with a standard error of 0.2 percent. The estimated outgoing error rate was 0.8 percent, with a standard error of 0.1 percent. Figure 2.2 gives the distribution of the types of errors detected during this inspection. Some clusters contained more than one type of error. The error types were as follows:

Code	Description
T	Other, specify (relative to personalization).
L	BCD code not within specifications.
C	Any unprinted spot in the index squares or vertical bars is out-of-tolerance.
J	Other, specify (relative to printing).
D	Any black spot is out-of-tolerance.
K	Bar code not within specifications.
B	Any measurement of the circle wall thickness is out-of-tolerance.
A	Any reading of the black ink density is out-of-tolerance.
M	Postnet bar code not within specifications.
E	Poor type quality or uniformity.
X	Other, specify (relative to finishing).

Code	Description
U	Improperly trimmed.
G	Black and blue inks are out-of-register.
N	Misplaced or skewed image.
V	Improperly folded.
W	Torn or damaged.
F	Imaged is misplaced or skewed.
O	Poor type quality or uniformity.

Error type T, mostly wrinkled forms and scumming (black grease or oil) during printing, was the most frequently occurring error. The second most frequent error was the binary coded decimal code not within specifications followed by out-of-tolerance unprinted spots in the index squares or vertical bars. The other error types, not directly related to imaging, were able to ''slip'' through the pre-imaging inspection because the quality assurance plan was designed to detect systematic, not random, errors.

No quality assurance records were received for the printing of the instruction guides and motivational inserts. The reason for this is not known.

The results of the inspected outgoing and return envelopes were recorded on Form D-852, Envelope Printing/ Construction Verification Quality Assurance Record. (See form in appendix B.)

No quality assurance records were received from one of the plants that constructed some of the envelopes. The reason for this is not known. For the records received, from the 1,988 samples inspected, the estimated incoming error rate was 4.8 percent, with a standard error of 0.5 percent. The estimated outgoing error rate was 3.3 percent, with a standard error of 0.4 percent.

Over 80 percent of the errors were attributed to poor type quality or uniformity. However, these errors were not critical. The other detected errors were uniformly distributed.

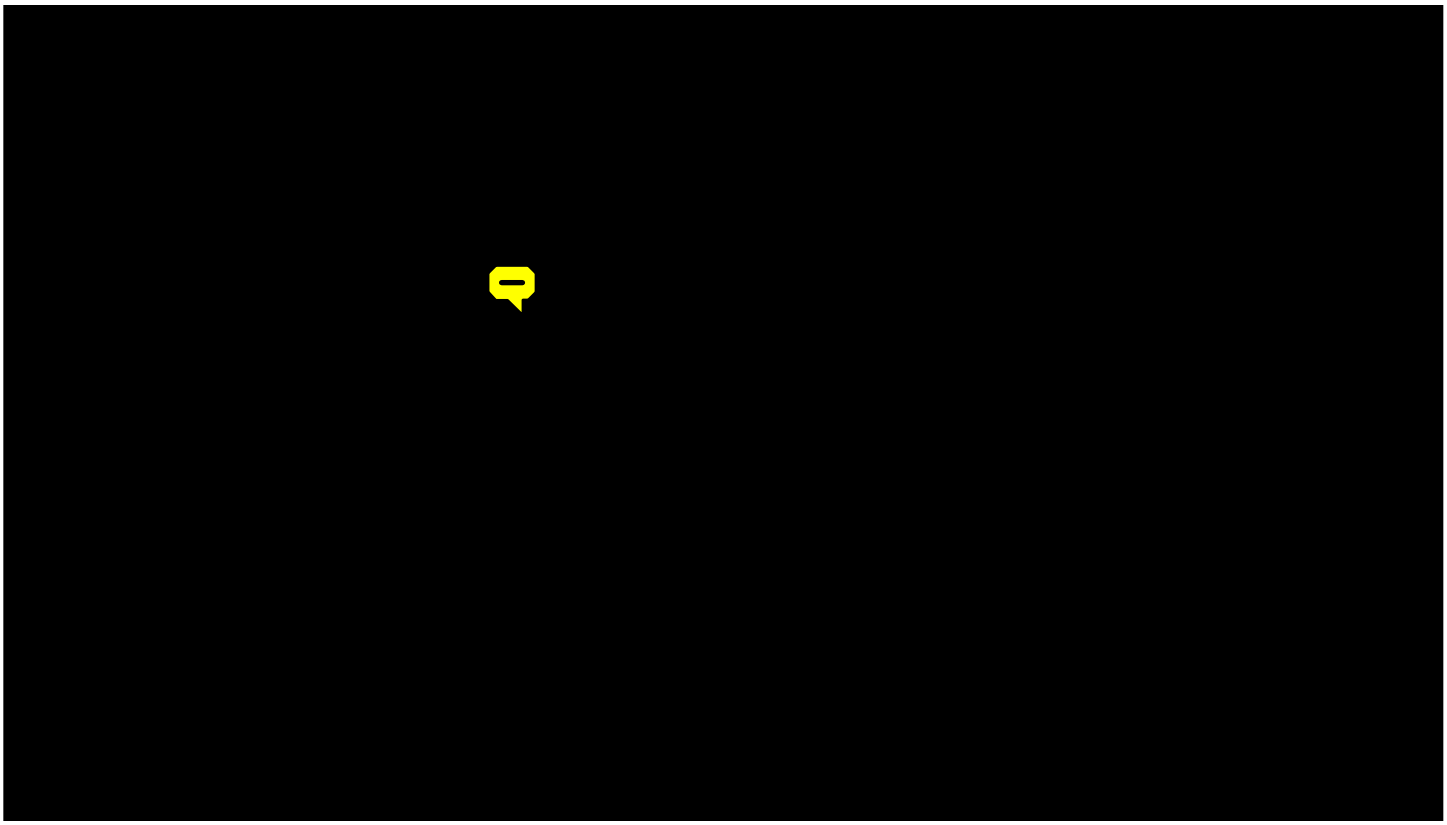
For the assembly process of the packages, a questionnaire, instruction guide, return envelope, and motivational insert were inserted into the outgoing envelope.

The results of the inspected packages were recorded on Form D-853, Sample Package Assembly Verification Quality Assurance Record. (See form in appendix B.)

Based on the 5,382 samples inspected, the estimated incoming error rate was 9.0 percent, with a standard error of 0.4 percent. The estimated outgoing error rate was 6.7 percent, with a standard error of 0.3 percent. Figure 2.3 shows the distribution of the types of errors detected. The types of errors were as follows:

Code	Description
C	Any material is torn or damaged.
D	Other, specify
E	Error unspecified.
B	Mailing package does not contain the proper contents.

Over 60 percent of the errors detected were attributed to torn or damaged material. These defective pieces were not critical to usage, but were discarded. Bad print quality



of the envelopes was the second most frequent error. Regarding the E error type, these samples were detected to be in error, but the type of error was not annotated on the quality assurance form. The contractor's inspectors were very meticulous, even the most minor of defects were counted as errors.

For the packaging verification, there were two types of packages: Mail-Out/ Mail-Back and Update/ Leave. For the mail-out/ mail-back packages, a sample of ZIP Codes and the 5-digit and residual sorts within the sampled ZIP Codes were inspected. For the update/ leave packages, the materials were sorted by the appropriate field district office. A sample of address register areas within each district office was inspected.

The results of the inspection were recorded on Form D-802, Packaging Verification: Mail-Out/ Mail-Back Quality Assurance Record and Form D-803, Packaging Verification: Update/ Leave Quality Assurance Record. (See forms in appendix B.)

For the mail-out/ mail-back packages, approximately 8.1 percent of the sampled ZIP Codes (74 samples out of 915 samples) contained missing mailing packages. The standard error on this estimate is 0.8 percent. The missing mailing packages accounted for 0.06 percent of the sampled mailing packages. The standard error on this estimate is 0.0 percent.

For the update/ leave packages, approximately 12.6 percent of the sampled address register areas (131 samples out of 1,041 samples) contained missing packages. The standard error on this estimate is 1.0 percent. The missing packages accounted for 0.04 percent of the sampled packages. The standard error on this estimate is 0.0 percent.

The missing packages for both the mail-out/ mail-back and update/ leave packages consisted of questionnaires damaged during the imaging and/ or assembly operations. The sequence numbers of the damaged questionnaires were recorded and materials were regenerated. The regenerated packages were shipped as individual packages rather than as bulk for the appropriate ZIP Codes. Thus, *the missing packages were accounted for in the sampled ZIP Codes and address register areas.*

Conclusions

The contractors were very cooperative with the on-site government inspectors in allowing use of their equipment, access to their facilities, and implementing the quality assurance plan.

The quality assurance system had a positive effect on the production of the short-form packages. The quality assurance system allowed for the detection and correction of systematic as well as random errors at each phase of the production of the packages. The on-line verification performed by the contractors during each stage of production worked well. This on-line verification made it easy to rectify unacceptable work and improve the production process over time.

The technical requirements for the production of the short-form packages were more stringent than necessary to process the questionnaires. Thus, regardless of the seemingly high error rates, the quality of the production of the packages was sufficient for the process.

As a result of the analysis of the production of the short-form packages, the following are recommended:

1. Completion and receipt of the quality assurance forms needs to be monitored closely to ensure the forms for each production phase are completed correctly and received on a timely basis at the Census Bureau.
2. Continue the practice of periodically having government trained personnel on site to ensure the quality assurance specifications are correctly followed and to monitor the quality of the production of the packages.
3. Require the contractor to produce prior-to-production samples.
4. Even though this was not a problem with the production of the short-form packages, a method to control addresses changed or deleted by the contractor should be developed for future printing jobs requiring addressing.
5. Maintain the printing standards by which defects are gauged. However, to further reduce the outgoing error rate, the sampling interval for the verification of the packaging of the questionnaires should be decreased to detect missing pieces.
6. Since the collection of the sequence numbers of the damaged questionnaires was sometimes confusing, a more acceptable method of recording, regenerating, and inserting the damaged questionnaires back into the flow should be developed.

Reference

[1] Green, Somonica L., 1990 Preliminary Research and Evaluation Memorandum No. 103, ''Quality Assurance Results of the Initial Short-Form Mailing Package Production for the 1990 Decennial Census.'' U.S. Department of Commerce, Bureau of the Census. December 1991.

LONG-FORM PACKAGE PRODUCTION

Introduction and Background

For the 1990 decennial census, approximately 17.2 million long-form packages consisting of a long-form questionnaire (see form D-2 in appendix B), instruction guide, motivational insert, and a return and an outgoing envelope were produced. These materials were produced using the following multi-step process: printing and imaging of the outer leafs (pages 1, 2, 19, and 20) of the questionnaires; printing of the inside pages (pages 3-18) of the questionnaires; printing of the instruction guides and motivational

inserts; printing and construction of the outgoing and return envelopes; gathering, stitching, and trimming of the questionnaires; and assembly and packaging of the pieces. After the contract for this process was awarded, the Census Bureau met with the Government Printing Office and the contractor to discuss any adjustments to the quality assurance requirements or production system to optimize efficiency of the long-form package production.

Before printing the questionnaires, a prior-to-production run was performed by the contractors to demonstrate their ability to produce a large-scale, full-speed production run that would meet specifications. This included using a test address file containing bogus addresses.

During production, representatives of the Census Bureau or the Government Printing Office repeatedly visited the contractors' sites to ensure that the contractors followed the quality assurance specifications, and to monitor the quality of the various processes.

Methodology

The quality assurance plan consisted of visual and mechanical on-line verification of samples of the package components during each stage of the production process. A systematic sample of clusters of two or three consecutive package components was used as the quality assurance samples. If a systematic error was detected, a clean out (expanded search) was performed forward and backward of the defective sample cluster to isolate the problem. The contractors corrected all errors and recorded the results of the inspection on the appropriate quality assurance recordkeeping forms. The results were used for feedback, process improvement, and later analysis.

The contract required the selection of a sample of questionnaires; some were inspected and the others were not. The sampled questionnaires were shipped to the Census Bureau's Data Preparation Division in Jeffersonville, Indiana, where a subsample of the inspected questionnaires was selected and reinspected. This served as an independent verification of the quality of the production of the packages. The uninspected questionnaires served as the ''Blue Label'' samples; that is, randomly selected copies packed separately and inspected only by the Government Printing Office when there was a problem. However, for this printing process, the Census Bureau was given a dispensation by the Government Printing Office to allow review of the samples by the Data Preparation Division, if necessary.

Limitations

The reliability of the evaluation for the operation was affected by and dependent upon the following:

1. The correctness of the quality assurance records provided by the contractors.
2. The calibration and accuracy of the equipment used to measure the printing attributes.
3. The legitimacy of the samples delivered by the contractors.
4. The re-creation and re-insertion into the work scheme of all questionnaires containing actual addresses that were used as samples for the binding and assembly operations.
5. The representation of the outer leafs throughout the roll (for the roll-to-roll printing) by the sampled outer leafs at the end of the rolls.
6. The use of the number of random errors detected as the numerator in calculating the outgoing error rates. If no random errors were detected, the estimated outgoing error rate was 0.0 percent.
7. The assumption of simple random sampling in calculating estimated error rate standard errors.

Results

There was a cooperative effort between the Government Printing Office and the Census Bureau (especially the Administrative and Publications Services Division, the Decennial Planning Division, and the Statistical Support Division) in producing the long-form packages. This joint effort allowed for the best experience in this type of printing, with special emphasis regarding quality assurance, that the Census Bureau has seen in a decennial setting.

The technical specifications for printing forms to be filmed traditionally have been highly demanding with respect to the quality of paper, printing, and finishing work (addressing, trimming, folding, etc). These rigorous technical requirements were driven by the data conversion system and by the need to safeguard against the introduction of data errors in processing questionnaires. While selected printing specifications for the forms to be filmed were relaxed somewhat for the 1990 census, the printing contract specifications—monitored by means of quality assurance requirements that were an integral part of the contracts—gave the Census Bureau a wide ''margin of safety,'' ensuring a top-quality product and minimizing the introduction of data errors at conversion.

In view of the fact that development of the 1990 software for the filming equipment was not finalized until after the conclusion of all printing, the margin of safety was considerably wider than in the 1980 census or than anticipated for 1990. Despite the detection of errors documented in this report, *no forms processing or data conversion problems attributable to bad printing (or other manufacturing steps) are known to have occurred with the 1990 forms.* In addition to ensuring against widespread random or systematic errors, the quality assurance contractual requirements served to guard against any escalation in the degree (or seriousness) of errors to the point where the ''true'' (but unknown) tolerances might have been strained or exceeded.

The quality assurance system had a positive effect on the production of the packages. It allowed for the detection and correction of systematic errors at each phase of the production of the packages.

The overall quality of the printing of the questionnaires and production of the packages was better than originally anticipated.

For the roll-to-roll printing process, the outer leafs (pages 1, 2, 19, and 20) of the questionnaires to be filmed were offset printed on a web press. A large roll of paper was run through the press and, upon printing approximately 36,000 outer leafs, the paper was immediately re-rolled.

The results for the inspected outer leafs were recorded on Form D-854, Roll-to-Roll Questionnaire Printing Verification Quality Assurance Record. (See form in appendix B.) Of the 1,185 printed rolls of outer leafs, 9.2 percent (109 rolls) were detected to be in error. Due to the 100 percent verification of every roll, there is no standard error. Figure 2.4 shows the distribution of the types of errors. The error types were as follows:

Code	Description
J	Other, specify.
A	Any measurement of the black ink density is out-of- tolerance.
C	Any unprinted spot in the index squares or vertical bars is out-of-tolerance.
G	Black and blue inks are out-of- register.
E	Poor type quality or uniformity.
D	Any black spot is out-of-tolerance.

Error type J, mostly due to paper shrinkage and scumming (black grease or oil) during printing, was the most frequently occurring error. Out-of-tolerance black ink density readings and out-of-tolerance unprinted spots in the index squares or vertical bars were the second and third most frequent errors, respectively.

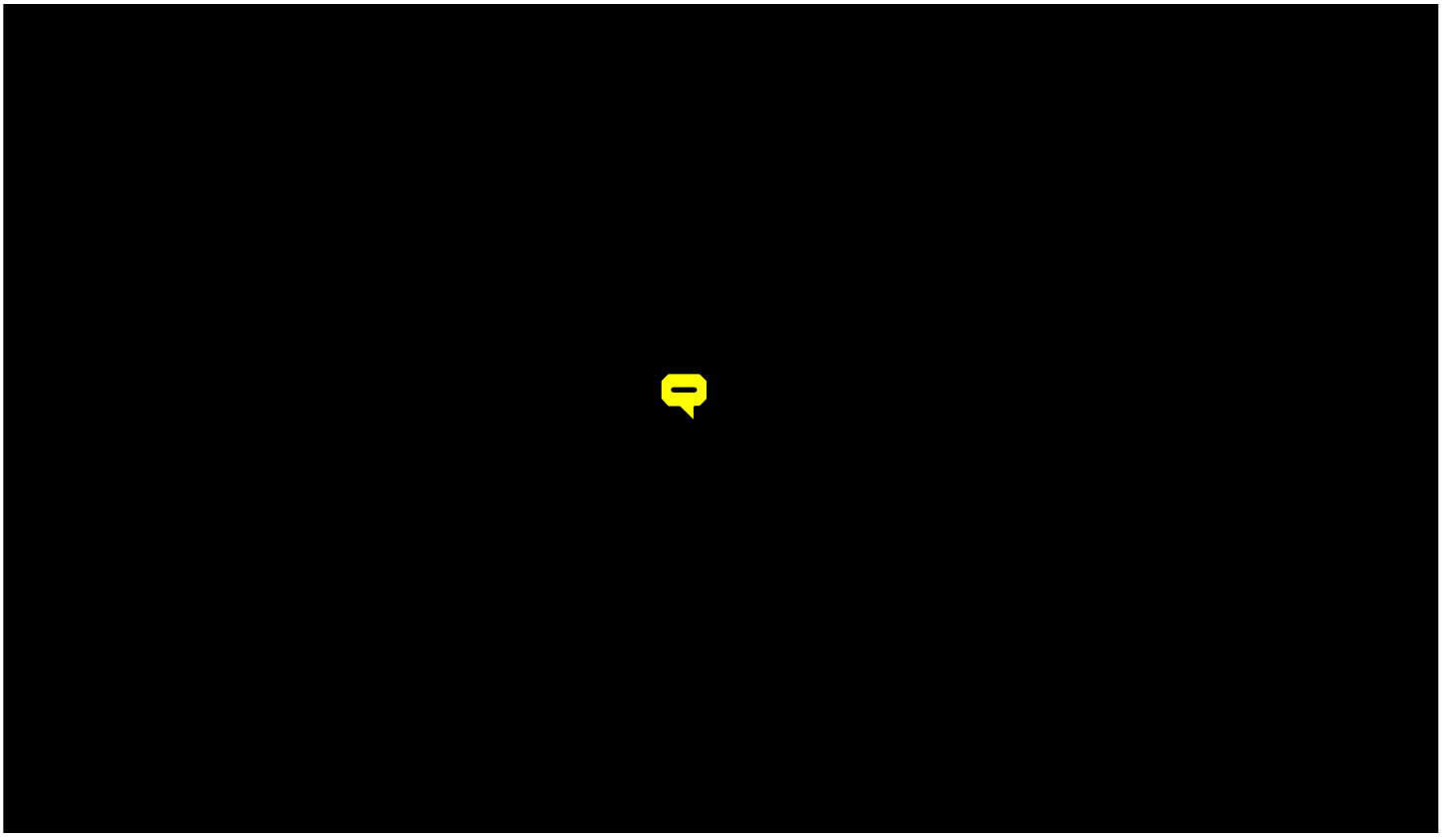
For the imaging process of the outer leafs, the outer leafs were addressed and encoded using inkjet spray. Variable respondent addresses, an interleaved 2 of 5 bar code, a census identification number, a binary coded decimal code, variable return addresses with corresponding postnet bar codes, synchronization control numbers, and an imaging alignment character (''X'') were imaged on each outer leaf.

The results of the post-imaging inspection were recorded on Form D-863, Addressed Sample Questionnaire Outside Leaf Verification Quality Assurance Record. (See form in appendix B.)

The post-imaging estimated incoming error rate was 2.4 percent, with a standard error of 0.7 percent. The estimated outgoing error rate was 0.0 percent. Figure 2.5 gives the distribution of the types of errors detected during this inspection. The error types were as follows:

Code	Description
A	Any reading of the black ink density is out-of-tolerance.
J	Other, specify (relative to printing).
T	Other, specify (relative to personalization).
D	Any black spot is out-of-tolerance.
N	Misplaced or skewed image.
P	Code numbers do not match.

Error types A (out-of-tolerance black ink density readings) and J (mostly attributed to paper shrinkage) were the



most frequently occurring errors. The third most frequent error, error type T, was due to tracking (trails of ink) on the forms during imaging.

Most of the errors were found during the roll-to-roll printing stage rather than from the imaging process. This implies that either the errors were random or went undetected during the roll-to-roll printing phase.

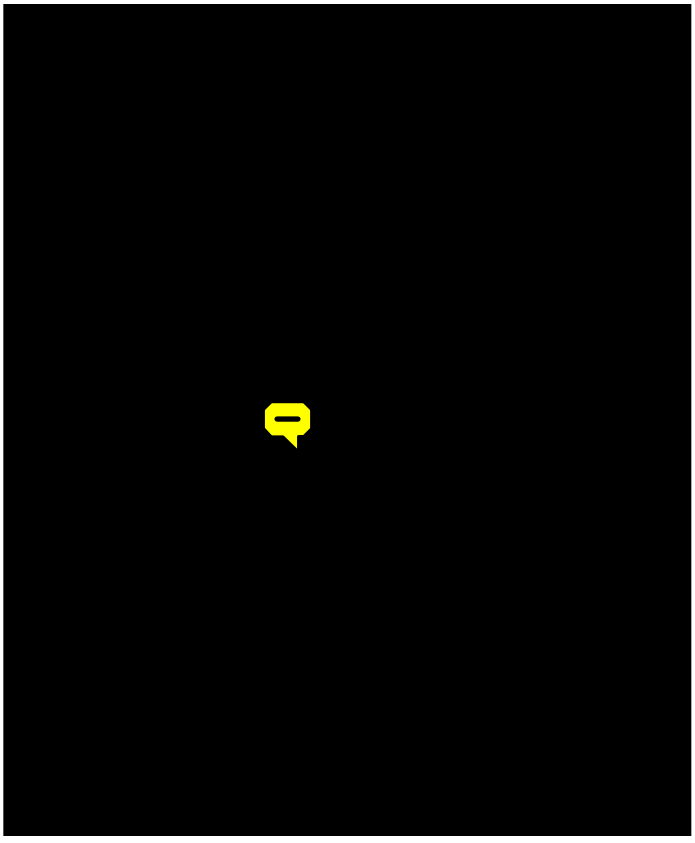
For the inside pages (pages 3-18) of the questionnaires, a large roll of paper was run through the press printing the inside pages. After being printed, the inside pages were trimmed and folded.

The results for the inspected signatures (entire grouping of inside pages 3-18) were recorded on Form D-862, Sample FOSDIC Questionnaire Signature Printing Verification Quality Assurance Record. (See form in appendix B.)

The estimated incoming error rate was 3.2 percent, with a standard error of 0.4 percent. The estimated outgoing error rate was 0.0 percent. Figure 2.6 shows the distribution of the types of errors detected. The error types were as follows:

Code	Description
D	Any black spot is out-of-tolerance.
C	Any unprinted spot in the index squares or vertical bars is out-of-tolerance.
B	Any measurement of the circle wall thickness is out-of-tolerance.
J	Other, specify.
E	Poor type quality or uniformity.
A	Any measurement of the black ink density is out-of-tolerance.
G	Black and blue inks are out-of-register.

Out-of-tolerance black spots (type D) was the most frequently occurring error. Out-of-tolerance unprinted spots in the index squares or vertical bars (type C) was the second most frequent error. Out-of-tolerance circle wall thickness measurements (type B) and error type J (black grease or oil during printing) were the next most frequent errors.



Quality assurance records were received for the printing of the motivational inserts, but not for the instruction guides. The reason for this is not known.

The results for the inspected items were recorded on Form D-851, Instruction Guide and Motivational Insert Printing Verification Quality Assurance Record. (See form in appendix B.)

For the printing of the motivational inserts, eleven clusters out of 1,239 inspected clusters were detected to be in error. The estimated incoming error rate was 0.9 percent, with a standard error of 0.3 percent. The estimated outgoing error rate was 0.0 percent. Unfortunately, the type of errors detected for the defective clusters were not specified on the quality assurance forms.

The results of the inspected outgoing and return envelopes were recorded on Form D-852, Envelope Printing/ Construction Verification Quality Assurance Record. (See form in appendix B.)

Quality assurance records for only 109 samples (less than 5 percent of the envelopes produced) were received. None of the samples were detected to be in error. However, since all of the samples were selected in the same time frame instead of throughout the process, no inference can be made about the production of the envelopes.

The binding operation consisted of gathering the inner pages into the outer leaf, stitching (stapling the pages together on the spine), trimming, and folding. The results for the inspected questionnaires were recorded on Form D-849, Sample FOSDIC Questionnaire Gathering, Stitching, and Trimming Verification Quality Assurance Record. (See form in appendix B.)

The estimated incoming error rate was 1.6 percent, with a standard error of 0.2 percent. The estimated outgoing error rate was 0.3 percent, with a standard error of 0.1 percent.

Figure 2.7 shows the distribution of the types of errors detected. Some clusters contained more than one type of error. The error types were as follows:

Code	Description
D	Missing staple(s).
F	Improperly applied staple(s).
E	Misplaced staple(s).
H	Improperly trimmed.
C	Other, specify (relative to gathering).
I	Other, specify (relative to trimming).
B	Unsequential pages.
G	Other, specify (relative to stitching).
J	Error Unspecified.

The most frequently occurring error was missing staples. Improperly applied staples was the second most

frequent error followed by misplaced staples and improperly trimmed questionnaires. The errors were not critical to usage and were manually corrected.

The assembly operation consisted of inserting a questionnaire, an instruction guide, a return envelope, and a motivational insert into the outgoing envelope. The results of the inspected packages were recorded on Form D-853, Sample Package Assembly Verification Quality Assurance Record. (See form in appendix B.)

Based on the 12,688 samples inspected, the estimated incoming error rate was 0.3 percent, with a standard error of 0.1 percent. The estimated outgoing error rate was 0.03 percent, with a standard error of 0.02 percent.

Figure 2.8 shows the distribution of the types of errors detected. Some sampled packages contained more than one type of error. The types of errors were as follows:

Code	Description
D	Other, specify
C	Any material is torn or damaged.
B	Mailing package does not contain the proper contents.
A	Address on the questionnaire is not visible through the window of the outgoing envelope.

Almost 65 percent of the errors detected were attributed to the envelopes not sealing properly due to the inserter applying either too much or too little water on the glue flap of the envelopes. Torn or damaged material was the second most frequent error. These errors were minor and not critical to usage. All errors found were corrected.

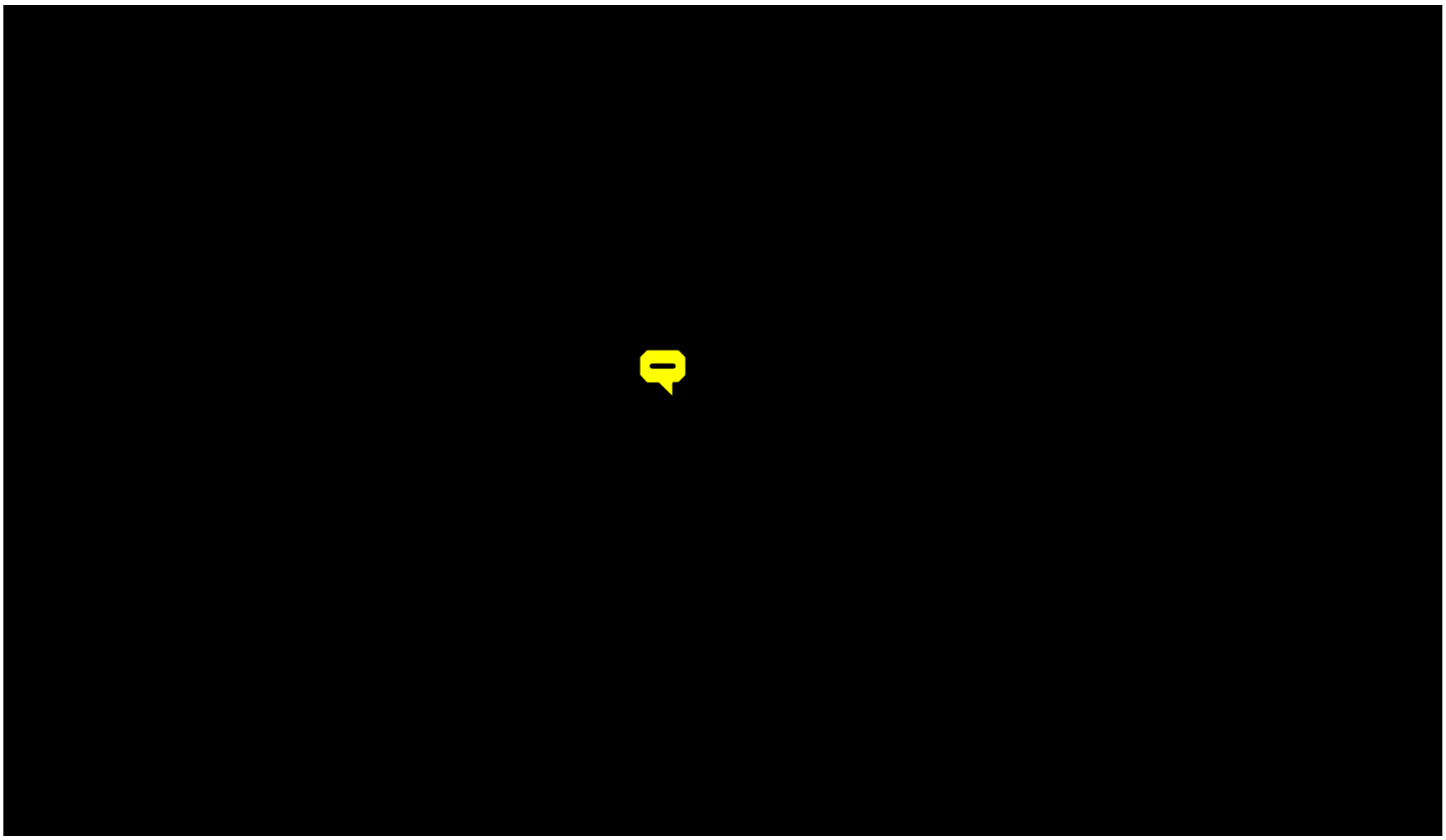
For the packaging verification, there were two types of packages: Mail-Out/ Mail-Back and Update/ Leave. For the mail-out/ mail-back packages, a sample of boxes from each pallet was inspected. For the update/ leave packages, a sample of address register areas within each district office was inspected.

The results of the inspection were recorded on Form D-802, Packaging Verification: Mail-Out/ Mail-Back Quality Assurance Record and Form D-803, Packaging Verification: Update/ Leave Quality Assurance Record. (See forms in appendix B.)

For the mail-out/ mail back packages, approximately 3.4 percent of the sampled boxes contained missing mailing packages. The standard error on this estimate is 0.3 percent.

The missing mailing packages consisted of questionnaires either damaged or selected during the imaging, binding, and/ or assembly operations and not yet replaced. During the operations, the sequence numbers of any damaged questionnaires found were recorded and materials were regenerated. These regenerated packages were mailed out as individual packages rather than with the bulk material for the appropriate ZIP Codes. *Thus, the missing mailing packages in the sampled ZIP Codes noted in this report were accounted for and replaced.*

The contractor experienced several problems with this area of the packaging verification for the update/ leave packages. They were unable to effectively perform the verification or store the packages for postal pick-up. Staff members from the Census Bureau and the Government



Printing Office performed the verification at the plant so that the questionnaires would be dispatched. Due to the severity of the problems, the staff members from the Census Bureau and the Government Printing Office performed a revised inspection of the packages (described below) and no quality assurance records were maintained.

First, the sequencing of the packages was checked in three consecutive boxes per pallet. The first and last sequence numbers in the middle box were checked against the last sequence number in the first box and the first sequence number in the third box, respectively.

Second, each pallet was weighed. The weight of all pallets for a district office, minus the estimated weight of the skids (wooden or rubber supports on the bottom of the pallet), was divided by the average weight per package. This gave an estimate of the total number of packages in a district office. This estimate was compared to the expected number of packages for each district office. If the difference between the expected and estimated number of packages was less than 2 percent, the district office was shipped. If the difference was greater than 2 percent, the warehouse was searched for any missing pallet(s). Due to time constraints, if no other pallets were found, the district office was shipped as is.

Also, because of time constraints and the contractor's ineffectiveness to perform the verification, the requirement for the contractor to regenerate spoiled or missing packages was waived. The Census Bureau's Field Division handled the missing packages by using the added units packages.

Conclusions

The Census Bureau's improved working relationship with the Government Printing Office greatly improved the printing process from previous decennial experiences. In turn, the contractors were cooperative with the on-site government inspectors (as specified in the contract) by allowing use of their equipment, access to their facilities, and implementing the quality assurance plan.

The quality assurance system had a positive effect on the production of the long-form packages. The quality assurance system allowed for the detection and correction of systematic errors at each phase of the production of the packages. The on-line verification performed by the contractors during each stage of production worked well. This on-line verification made it easy to rectify unacceptable work and improve the production process over time by detecting defective materials before they reached later steps in the process.

The contractor lost control of the packaging verification process. If staff members from the Census Bureau and the Government Printing Office had not performed the verification of the Update/ Leave packages, serious problems would have been encountered by the Census Bureau's Field Division personnel. However, even though many problems were encountered during the packaging verification process, the overall quality of the production of the packages was sufficient for the process.

As a result of the analysis of this process, the following are recommended:

1. Continue the practice of periodically having government trained personnel on site to ensure the quality assurance specifications are correctly followed and to monitor the quality of the production of the packages.
2. Continue to require the contractor to produce prior-to-production samples. This enabled the Census Bureau and the Government Printing Office to determine if the contractor had the capability, and identified problems that could be corrected before production began.
3. Even though this was not a problem with the production of the long-form packages, a method to control addresses changed or deleted by the contractor should be developed for future printing jobs requiring addressing.
4. Since the the collection of the sequence numbers of the damaged questionnaires was sometimes confusing, an easier method of recording, regenerating, and inserting the damaged questionnaires back into the flow needs to be developed.
5. Maintain the printing standards by which defects are gauged.
6. Completion and receipt of the quality assurance forms for every phase of the production process need to be monitored closely or automated to ensure the forms are completed correctly and received on a timely basis at the Census Bureau.

Reference

[1] Green, Somonica L., 1990 Preliminary Research and Evaluation Memorandum No. 138, ''Quality Assurance Results of the Initial Long-Form Mailing Package Production for the 1990 Decennial Census.'' U.S. Department of Commerce. Bureau of the Census. April 1992.

PRELIST

Introduction and Background

The 1988 Prelist operation was performed in small cities, suburbs and rural places in mailout/ mailback areas where vendor address lists could not be used. During the 1988 Prelist, enumerators listed housing units in their assignment areas to obtain a complete and accurate mailing address for each living quarter, to record location description for non-city delivery addresses, to annotate census maps to show the location of all living quarters, and to assign each living quarter to its correct 1990 census collection geography. This operation provides mailing addresses for the census questionnaire mailout.

During the 1988 Prelist, a quality assurance operation was designed to meet the following objectives: 1) to build quality into the system rather than relying on inspection to protect against major errors, 2) to control coverage errors

in listing addresses, and 3) to provide feedback to enumerators and managers on errors to improve the quality performance of the operation.

The first objective was accomplished by providing a system that minimizes the occurrence of errors. The second objective was accomplished by implementing an independent sample to identify mistakes and estimate the quality performance. The third objective was accomplished by analyzing errors to identify the type, magnitude, and source of errors on a flow basis.

The prelist operation was conducted in four waves controlled geographically by the following Regional Census Centers (RCC's): Atlanta, San Francisco Bay Area, Boston, Charlotte, Chicago, Dallas, Denver, Detroit, Kansas City, Los Angeles, New York, Philadelphia, and Seattle. The 1988 Prelist operation occurred from July 11, 1988 thru January 6, 1989, and included 65,593 Address Register Areas with 27,895,927 total housing units, for an average of 425 housing units per Address Register Area. More detailed information on the 1988 Prelist operation can be found in [1].

Methodology

To help the supervisor monitor the quality of the listing, sampled addresses were listed in advance in sampled blocks within the address register areas, as well as map spotted. During production, each enumerator listed and map spotted all living quarters within his/ her assigned geographic area. To identify possible coverage and content errors, the field supervisor matched the sample addresses obtained during the advance listing operation to the addresses listed by the enumerators during the actual operation.

If the number of nonmatches was greater than one, the field supervisor reconciled all nonmatches to determine whether the advance lister or enumerator was accountable for the errors. If the enumerator was judged to be responsible, the supervisor rejected the work and either provided additional training of the enumerator or released the enumerator if prior additional training had already been conducted. In either case, the work was reassigned to another enumerator for recanvassing.

This quality assurance operation was initially conducted on the first block of the first address register area completed by each enumerator so that problems could be identified early in the operation and corrective action taken before they became widespread. Thereafter, the quality assurance operation was conducted in predetermined subsequent address register areas after their completion. During the reconciliation, the field supervisor documented the reasons for the listing errors. This information, along with other data that may prove helpful, was regularly communicated to the enumerators.

The results of the quality assurance program were documented on the Form D-169, Quality Control Listing and Matching Record (see form in appendix B). The Form D-169 was used to indicate the advance listing results by the field operation supervisor and the matching results by the enumerator's supervisor.

A summary of the matching operation along with the action taken by the crew leader was collected on the Form D-169A, Summary of Matching (see form in appendix B).

All information on the quality assurance Form D-169 and D-169A were transmitted to the Census Bureau's Data Preparation Division. The Data Preparation Division edited and keyed all pertinent information. After keying the data, software was developed in Data Preparation Division to establish a database. The database processed the quality assurance data used for this report. For more detailed description on the data edited and keyed, see [3] and [4].
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Limitations

1. Estimates in this report relating to the accuracy of the mailing address information are under-estimated. The criteria for an address being correct during quality assurance of Prelist may be different than what was needed for mail delivery. For example, if the household name was missing during Prelist and the advance listing also did not provide a name for a rural type address, the listing could be considered correct under the quality assurance definition. However, the address would be rejected during computer editing that was done prior to sending the addresses to the post office for validation. In most cases the consistency theory that quality assurance used to detect errors and estimate quality worked very well.

2. The statistical analysis and results are based on the data captured from form D-169 only.

Results

The quality of the information gathered for the living quarters is expressed in the term of ''listing error rate.'' This is an estimate of the proportion of the living quarters missed or the living quarters listed with incorrect location information. The location information relates to the mailing address and geography data such as block number, map spotting and location description. Table 2.1 provides data on the estimated number of listing errors, listing error rate and the relative standard error at the national and regional levels. The relative standard error provides the relative reliability of both estimates; thus, the standard error can be calculated for each estimate.

The national listing error rate was 2.40 percent which indicated that approximately 665,645 living quarters were initially listed incorrectly. The data indicated that the regional census centers of Boston and Seattle experienced extremely high listing problems with a listing percentage error rate of 11.79 (most of the errors occurred at the beginning of the operation) and 6.15 percent, respectively. In fact these two areas accounted for 65 percent of the listing errors recorded. The combined listing error rate for these two areas was 8.97 percent. The data appeared to indicate that Boston experienced difficulties in obtaining correct block numbers and street designations. On the other hand, Seattle seemed to have difficulties obtaining accurate location description.

Table 2.1. **Address Listing Errors at the National and Regional Level**

Regional census centers	Address listing errors		
	Number	Percent	Relative standard error
National	665,645	2.40	2.5
Atlanta	30,197	0.96	2.5
Bay area	5,064	0.58	36.21
Boston	342,206	11.79	1.36
Charlotte	66,366	2.01	10.45
Chicago	20,790	0.64	14.06
Dallas	27,121	1.17	26.50
Denver	11,107	0.84	33.81
Detroit	30,230	0.93	14.00
Kansas City	14,430	0.68	26.47
Los Angeles	2,479	0.42	.153
Philadelphia	20,211	0.89	1.00
Seattle	87,444	6.15	4.87

The relative standard error for each statistic ranged from a low of .15 percent to 36 percent regionally.

To assure that the quality of the listing remained high throughout the course of the operation, the enumerator's supervisor evaluated the work at the beginning and periodically. These phases are referred to as: qualification and process control.

During qualification and process control, the listing error performance rate are estimated at 3.21 percent and 1.45 percent, respectively.

All the regions experienced improvements except in the Atlanta, Charlotte, and Philadelphia regions where the listing error rate remained constant throughout the operation.

Type of Listing Errors

During listing, the crew leader documented the listing errors into three categories 1) missing or incorrect block number, 2) missing or incorrect street name, and 3) all other errors. Table 2.2 provides the proportion of all listing errors that were in each category, at the regional and national levels.

Notice in table 2.2, that the majority of the errors are classified under the ''Other'' reason category (50.7 percent). In the comments section on form D-169, crew leaders indicated location description caused most of the errors. The location description was important in helping to locate living quarters during field activities. The crew leaders attributed errors to location description only if the information was not consistent with the living quarter's location on the ground.

The difficulty in obtaining correct location descriptions seems to be consistent across the country. The studies of the 1988 Dress Rehearsal Test Census suggested that the most frequent errors made by the advance listers and enumerators were incorrect/ incomplete mailing address information and location description.

The geographic problem (reason number 1) had the second highest rate at 27.8 percent.

Table 2.2. **Type of Listing Errors at the National and Regional Level**

Regional census center	Type of listing errors		
	Block number (percent)	Street designation/ box route number, PO box number (percent)	Other (percent)
National	27.8	21.5	50.7
Atlanta	13.9	10.0	76.1
Bay area	3.1	3.0	93.9
Boston	42.8	41.2	16.0
Charlotte	28.1	27.9	44.0
Chicago	29.2	28.4	42.4
Dallas	31.5	20.7	47.8
Denver	36.4	23.2	40.4
Detroit	34.8	20.1	45.1
Kansas City	17.7	11.2	71.1
Los Angeles	17.1	22.5	60.4
Philadelphia	35.4	18.6	46.0
Seattle	10.3	7.8	81.9

In addition to listing by the enumerator, several activities were done to implement the quality assurance program: Advance Listing, Address Matching and Address Reconciliation. Below are explanations and data on the performance of each activity.

1. *Advance Listing*—The advance listing component was necessary to provide something against which the prelist enumerator's work could be compared. The advance listing error rate is the proportion of living quarters listed by the advanced listers with incorrect location information. The location information relates to the mailing address and geography data such a block number, map spotting and location description. The magnitude of this error rate has been a major concern during the census and previous test censuses. Table 2.3 shows the advance listing errors at the regional and national levels. The national advance listing error rate was 11.44 percent.

   The causes of the high advance listing errors as compared to the enumerators' listing errors could be attributed to several factors, including:

   a. The lack of practice during the advance listers' training. Prelist enumerators did perform practice listings during training.

   b. Advance listers were crew leaders in training and they did the advance listing outside the area in which they would serve as a crew leader. Therefore, the areas listed by the advance listers might not have been as familiar to them as some areas were to the prelist enumerator.

Table 2.3. **Advance Listing Errors by Regional and National Levels**

Regional census center	Percent
National	11.44
Atlanta	17.35
Bay area	23.56
Boston	5.32
Charlotte	11.32
Chicago	4.20
Dallas	7.00
Denver	4.37
Detroit	9.09
Kansas City	9.36
Los Angeles	56.23
Philadelphia	21.65
Seattle	10.88

c. Better feedback was provided to the enumerator. There was more opportunity for improved performance.

Even though the national advance listing estimated error rate is still high, it did show an improvement over 1988 Dress Rehearsal (23 percent). No comparable data was provided from the 1987 Test Census.

2. *Address Match*— The crew leader matched the advance listing sample addresses for each sampled Address Register Area to the enumerator-supplied address information. This address match provides information on the quality of the enumerator's listings.

The address match rate is the percentage of sample addresses listed by the advance listers that matched the addresses listed by the prelist enumerators. This statistic is measured prior to any determination of enumerator/ advance lister accountability. This statistic indicates the consistency between the address information obtained from both the advance lister and the enumerator.

It is estimated that both the enumerators and advanced listers listed the same information for 85 percent of the living quarters. In other words, the crew leaders did not have to visit the field to validate 85 percent of the sample addresses. This appeared to be very consistent across the country (except in the western part of the country.) The estimated address match showed an improvement over the 1988 Dress Rehearsal (67 percent).

3. *Reconciliation and Accountability*—The reconciliation phase required the crew leader to visit the housing unit in the field when the advance lister and enumerator listing information disagreed. This phase was added to the quality assurance design as the result of the analyses on the previous test censuses. The methodology during the 1988 Prelist Dress Rehearsal automatically assumed the enumerator listing was incorrect when disagreement occurred between the enumerator and the advanced listing versions. The study showed that the advance listing was in error a majority of the time which penalized the enumerator unfairly and required unnecessary recanvassing of Address Register Areas.

During the field reconciliation, 82.63 percent of the nonmatched living quarters were caused by the advance listers compared to the 17.30 percent caused by the enumerators. The quality assurance plan design assumed that each lister would be responsible for half of the nonmatches. It was important to keep this ratio approximately equal to avoid the crew leader from making premature assumptions that the nonmatched addresses were listed incorrectly by the advance lister; therefore, not validating these addresses in the field. The analyses showed that 22,107 (34.77 percent) Address Register Areas required field reconciliation.

Conclusions

1. Nationally, the quality of the 1988 Prelist listing shows a significant improvement over the 1988 Dress Rehearsal. Even so, it is estimated that about 665,645 (2.4 percent) living quarters were missed or location information incorrectly listed. Most of these addresses (90 percent) were not corrected during the Prelist operation. These addresses had to depend upon other decennial operations to add them to the address list.

2. The quality of the listing generally continued to improve throughout the operation. A major objective of the quality assurance plan was to provide constant and accurate feedback to enumerators enhancing their performance throughout the operation. The data suggests that this feedback policy helped to improve the quality of enumerators work by 55 percent. Efforts should continue to be made to develop techniques to provide reliable information on the quality of the enumerators' performance for similar such operations likely to be done for year 2000.

3. To improve the quality assurance ability to detect and provide proper feedback on the accuracy of the mailing addresses, the quality assurance criteria for a good mailing address should be the same as prelist requirements.

4. The quality assurance theory to detect listing errors did not identify missing critical address data when both the advanced lister and enumerator failed to provide this information.

5. Additional research is needed to identify and test ways to prevent problems related to obtaining accurate location description, that will serve as guidelines to both the advance lister and enumerator for any future operations.

6. The quality assurance program was designed to detect Address Register Areas listed very poorly. Once these Address Register Areas were identified, the focus was to correct listing problems in the sampled Address

Register Areas by recanvassing them. During the prelist operation, it was estimated that 8.15 percent of the Address Register Areas had high error levels. The quality assurance plan only measured performance on half of the Address Register Areas; no decisions were made on the even-numbered Address Register Areas. In the future, all Address Register Areas must be subject to review.

7. One of the most important components in the quality assurance program was to provide the crew leaders with reliable information to help monitor the enumerator quality listing performance. This was essential in determining whether the addresses were listed correctly by the enumerator without the enumerator's supervisor spending an excessive amount of time in the field validating the housing unit listings.

   To meet this challenge, the quality assurance program introduced the advance listing with the primary purpose of listing a sample of addresses prior to production listing.

   The enumerator's supervisor used the advance listed addresses to provide a quality assessment of the production listing. It was estimated that almost 89 percent of the addresses used by the enumerator's supervisor to check the enumerators' accuracy was correct. Even though this percentage was high and an improvement over the 1988 Dress Rehearsal, it was significantly less than expected.

   In the future, efforts need to be made to assure the information is as accurate as possible. The 1989 Prelist implemented the practice listing for the advance lister training as one measurement to improve performance.

8. Additional research is necessary to determine an alternative method to identify error and measure lister performance such as the use of administrative records. While the advance listing process has problems, it still appears to be accurate in providing general information to assess the quality of listing.

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CHAPTER 3.
Data Collection Operations

Data collection for the 1990 decennial census took place out of district offices throughout the United States. Because of expected problems in the more densely populated areas, the mail returns for the areas covered by the type 1 district offices were sent into six of the seven processing offices. The mail returns for the other non-type 1 district offices were sent directly to the district offices.

For 1990, the Census Bureau attempted to provide telephone assistance to those persons requesting help in completing the questionnaire. The telephone assistance was conducted out of the offices to which questionnaires were returned by mail. In this chapter, the quality assurance plan for the assistance operation carried out in the six processing offices is discussed. No quality assurance was implemented for the assistance conducted out of the district offices.

When the questionnaires were received in the district offices, they underwent a clerical edit for completeness and consistency. A quality assurance plan was developed and what was learned is discussed in this chapter.

Not all households returned the questionnaire by mail. Nonresponse Followup was the field operation for collecting information from those households that did not return the questionnaire by mail. A reinterview program was created to protect against purposeful data falsification by the Nonresponse Followup enumerator. The results from this program are discussed in this chapter.

TELEPHONE ASSISTANCE

Introduction and Background

The Telephone Assistance operation was a process where respondents from type 1 areas (areas which cover the central city for the larger cities) called the processing office for clarification and/ or assistance in filling out their questionnaire. There was no telephone assistance implemented in the Kansas City Processing Office, which only received questionnaires from type 2 areas (areas which cover cities and suburban areas) and type 3 areas (areas which cover the more rural areas of the West and the far North). The telephone assistance operation was implemented for 16 weeks (April through July 1990). The majority of the processing offices completed the operation by week 11.

Three reasons for conductng the Telephone Assistance operation were: 1) to assist the respondents by answering questions they may have had regarding their questionnaire, 2) to fill out the questionnaire over the telephone, if the questionnaire identification number could be provided and the respondent insisted, and 3) to inform the respondent that an enumerator would come to their household to complete the questionnaire, if the questionnaire identification number could not be provided.

The effectiveness of the Telephone Assistance operation was measured by a quality assurance plan which daily monitored a sample of telephone calls from a sample of clerks. The purposes for monitoring the clerks' calls were: 1) to make sure proper procedures were followed in assisting respondents who called for help, and 2) to provide feedback to aid clerks having difficulties assisting the respondents.

The telephone assistance calls were rated by the monitors on a scale of 1 to 5; that is, 1—poor, 2—fair, 3—satisfactory, 4—good, and 5—excellent, based on how well the telephone assistance clerks performed the three characteristics listed below.

The quality level of each clerk was rated based on these three characteristics: 1) proper introduction, 2) questions answered properly, and 3) quality of speech. No ''errors'' were recorded for this operation. The ratings between monitors within a processing office and between processing offices were subject to variability since monitors interpreted standards differently. Steps were taken during training to limit this variability. However, some subjectivity may still exist and care must be exercised when interpreting any differences found in between-office comparisons.

Methodology

The quality assurance plan used a sample, dependent verification scheme. The following sampling procedures were implemented.

1. *Sampling Scheme*—For the first week of the operation, a sample of eight telephone assistance clerks, per telephone assistance unit/ subunit, per shift, per day were selected for monitoring. Four supervisor-selected clerks were identified first and then four clerks were selected randomly. The clerks selected by the supervisor were chosen based on the clerks' deficiencies suspected by the supervisor. After the first week, two supervisor-selected clerks and two randomly selected clerks were monitored each day. A clerk could have been selected by the supervisor multiple times.
2. *Monitoring*—For each clerk sampled, four telephone calls were monitored at random for the day and shift they were selected. A quality assurance monitoring recordkeeping form was completed for each monitored clerk, indicating how well the clerk performed the following:

a. Introduction—properly introduced and identified himself or herself to the respondent.

b. Questions answered properly—gave correct and appropriate answers for all questions and followed procedures correctly.

c. Speech quality—spoke clearly and at an acceptable pace and volume.

3. *Recordkeeping/ Feedback*—All quality assurance monitoring records were completed as the monitoring took place. Quality assurance output reports (daily and weekly) were generated for the supervisors to use to provide feedback to the clerks. The telephone assistance monitors were supposed to write comments on the quality assurance monitoring records for any below satisfactory ratings given. These comments were used to provide feedback to the clerks. (See an example of Form D-2291, Quality Assurance Monitoring Record for Telephone Assistance, in appendix B.)

A 20-percent sample of all completed recordkeeping telephone assistance forms were received at headquarters from the processing offices. Seventy-five quality assurance forms from each processsing office were selected from the 20- percent sample to evaluate the operation

Limitations

The reliability of the analysis and concusions for the quality assurance plan depends on the following:

- Accuracy of the clerical recording of quality assurance data.
- Accuracy of keying the quality assurance data into the Automated Recordkeeping System.
- The evaluation of the clerks for the monitoring operation was subjective.
- One clerk may be in the sample mulitple times causng negative bias in the data due to the supervisor selecting clerks with problems.
- The monitor's desk was often within view of the telephone assistance clerk being monitored.

Results

Overall, data were available for 2,900 monitored clerks. (Note: clerks were counted once each time they were monitored.)

Summary of the Automated Recordkeeping System Data—Table 3.1 is a comparison of the quality level of the assistance clerks' monitored calls. For each clerk monitored, there should have been 12 ratings given; that is, 4 calls per clerk times 3 characteristics per call. On the average, the processing offices did not monitor 4 calls per clerk. Over all processing offices, there were approximately 2.2 percent below satisfactory ratings, and 88.8 percent above satisfactory ratings issued. Feedback was given to each clerk whose rating was below satisfactory on the measurement scale.

Table 3.1. **Number of Clerks, Monitored Calls, and Ratings by Processing Office**

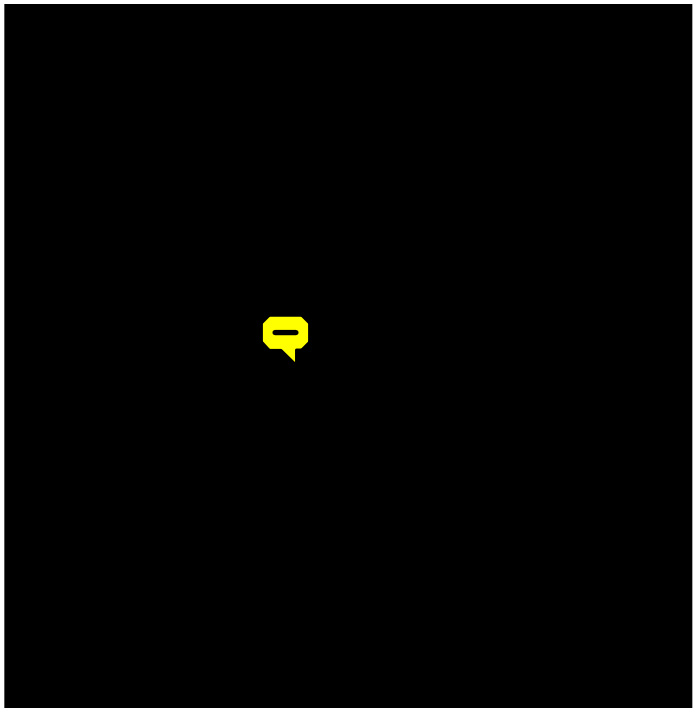
Processing office	Number of clerks monitored	Average number of calls monitored per clerk[1]	Number of ratings			
			Total	Below satisfactory	Satisfactory	Above satisfactory
Baltimore	234	3.4	2,398	39	167	2,192
Jacksonville ..	614	2.7	5,064	254	1,225	3,585
San Diego ...	832	3.5	8,662	61	521	8,080
Jeffersonville .	668	2.8	5,593	21	169	5,403
Austin	297	3.7	3,338	140	234	2,964
Albany.....	255	2.1	1,587	58	86	1,443
Total	2,900	3.1	26,642	573	2,402	23,667

Note: The Kansas City Processing Office is not included in this table because the telephone assistance operation was not implemented in that office.

[1]The average number of calls monitored was computed as follows: total number of ratings divided by three characteristics per call divided by the number of monitored clerks.

Summary of Quality Levels of All Monitoring Characteristics—The quality levels of all characteristics were measured on an ordinal level measurement scale of 1 to 5. The below satisfactory total included both poor and fair ratings combined. The above satisfactory total included both good and excellent ratings combined.

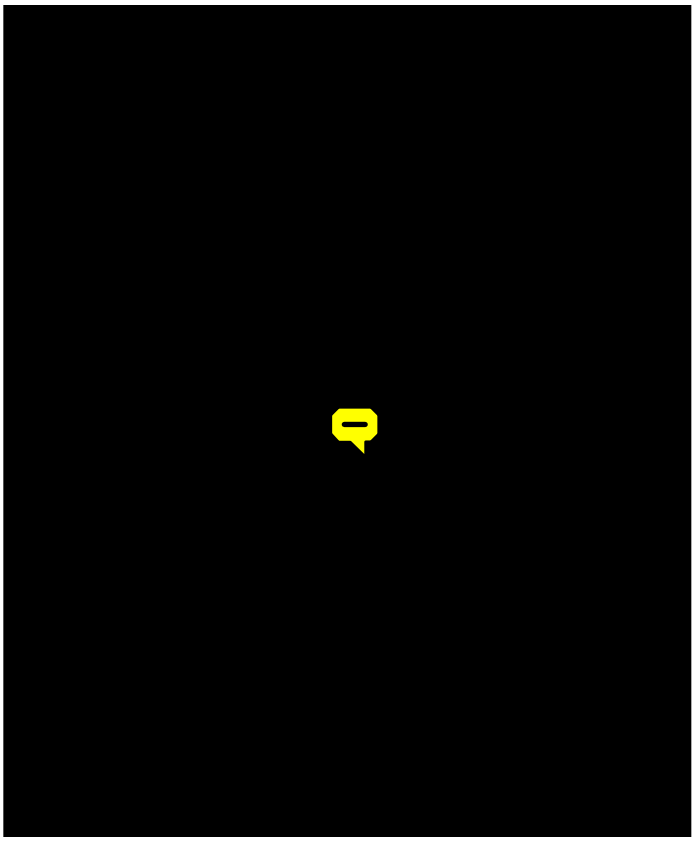
Figure 3.1 shows that the Jacksonville Processing Office reported the largest percentage of below satisfactory ratings with 5.0 percent. This office also reported the



smallest percentage of above satisfactory ratings at 70.8 percent. These percentages were significantly different compared to the other five offices at the alpha= .10 level. The Census Bureau believes this is mostly due to the subjective nature of the monitoring process. It is known that for the first week and part of the second week, monitoring was not conducted as specified in the Jacksonville office because of the high volume of Spanish lanuage calls received. The office reporting the smallest percentage of below satisfactory ratings was the Jeffersonville Processing Office with 0.4 percent. This office also reported the most above satisfactory ratings at 96.6 percent. These percentages were significantly different compared to the other processing offices.

Learning Curve for Above Satisfactory Ratings—Figure 3.2 shows a downward trend in the above satisfactory ratings issued during weeks 2 to 4. This happened because not all processing offices were included, and also there were untrained clerks assisting with calls. The processing offices hired what they believed was a sufficient number of assistance clerks. In the first few weeks, there were more calls than clerks hired to handle them. The processing offices used clerks who had not had telephone assistance training and gave them a quick overview of the operation. This caused the above satisfactory ratings to decrease slightly until the new, less trained clerks became more familiar with their new assignment.

In weeks 11 to 14, not all processing offices were included. The San Diego Processing Office assisted a large number of Hispanic and Asian Pacific Islander callers. This is one reason why they had more above satisfactory ratings than the other processing offices. There is no known reason why the Jeffersonville and Jacksonville Processing Offices had a smaller number of above satisfactory ratings, except that they monitored fewer calls than the San Diego Processing Office during these weeks.



In weeks 15 and 16 there was a decrease in the number of above satisfactory ratings because not all processing offices were receiving calls. Also, there was a smaller sample size used by those processing offices still conducting the operation.

Sampled Quality Assurance Forms Data Summary

A sample of the quality assurance Monitoring Records, Form D-2291, was selected from each office. The sampled data were used to determine the distribution of ratings for the three characteristics.

For each call, a clerk was given a rating of 1 to 5 depending on their performance. For analysis purposes, the poor/ fair ratings were labeled below satisfactory and the good/ excellent ratings were labeled above satisfactory. The totals of all ratings for each characteristic are not always the same. This is because some processing offices did not rate each characteristic for every call.

The characteristics most detected with below satisfactory ratings were ''proper introduction'' and ''questions answered properly.'' These characteristics each had about 38 percent of the below satisfactory ratings issued for the 3 characteristics used. Tables 3.2, 3.3, and 3.4 are a distribution of ratings for monitoring characteristics for each processing office.

Summary of Quality Assurance Data

A goodness-of-fit test was used to test whether or not the data summary tables fit the automated recordkeeping system data distribution in figure 3.1. When comparing by processing office, there was sufficient evidence at the alpha= .10 level to indicate a significant difference for the Jacksonville office. There was no significant difference for the remaining offices. The quality assurance summary data for these offices were a good representation of the automated recordkeeping system summary data. The Jacksonville office showed a significant difference because the sample selected from the recordkeeping forms contained more below satisfactory ratings than the automated recordkeeping system data revealed.

Conclusions

Overall, the processing offices did a good job monitoring the clerks. However, there were problems in the beginning of the operation because procedures called for

Table 3.2. **Number of Ratings (Percent) for ''Proper Introduction''**

Processing office	Below satisfactory (percent)	Satisfactory (percent)	Above satisfactory (percent)	PO totals (percent)
Baltimore	2 (0.7)	20 (6.6)	279 (92.7)	301 (100.0)
Jacksonville..	13 (6.2)	71 (33.8)	126 (60.0)	210 (100.0)
San Diego ...	0 (0.0)	25 (9.3)	245 (90.7)	270 (100.0)
Jeffersonville.	2 (0.9)	2 (0.9)	215 (98.2)	219 (100.0)
Austin	16 (7.5)	12 (5.7)	184 (86.8)	212 (100.0)
Albany.....	9 (3.9)	10 (4.4)	210 (91.7)	229 (100.0)
Total	42 (2.9)	140 (9.7)	1,259 (87.4)	1,441 (100.0)

Table 3.3. **Number of Ratings (Percent) for ''Questions Answered Properly''**

Processing office	Below satisfactory (percent)	Satisfactory (percent)	Above satisfactory (percent)	PO totals (percent)
Baltimore	7 (2.3)	24 (8.0)	270 (89.7)	301 (100.0)
Jacksonville..	12 (5.9)	85 (41.5)	108 (52.7)	205 (100.0)
San Diego ...	0 (0.0)	17 (4.6)	252 (68.3)	269 (100.0)
Jeffersonville.	1 (0.5)	17 (7.8)	200 (91.7)	218 (100.0)
Austin	11 (5.3)	11 (5.3)	187 (89.5)	209 (100.0)
Albany.....	10 (4.5)	16 (7.1)	198 (88.4)	224 (100.0)
Total	41 (2.9)	170 (11.9)	1,215 (85.2)	1,426 (100.0)

Table 3.4. **Number of Ratings (Percent) for ''Quality of Speech''**

Processing office	Below satisfactory (percent)	Satisfactory (percent)	Above satisfactory (percent)	PO totals (percent)
Baltimore	0 (0.0)	23 (7.6)	279 (92.4)	302 (100.0)
Jacksonville .	13 (6.3)	72 (34.6)	123 (59.1)	208 (100.0)
San Diego ...	0 (0.0)	13 (4.8)	256 (95.2)	269 (100.0)
Jeffersonville.	0 (0.0)	8 (3.7)	211 (96.3)	219 (100.0)
Austin	7 (3.3)	13 (6.2)	191 (90.5)	211 (100.0)
Albany	5 (2.2)	11 (4.8)	212 (93.0)	228 (100.0)
Total	25 (1.7)	140 (9.7)	1,272 (88.5)	1,437 (100.0)

decreasing by half the number of clerks to be monitored after the first week. This caused the processing offices to assume they could decrease the number of calls to be monitored as well. In addition, fewer clerks were monitored than specified because of a lack of monitoring equipment, and the heavy volume of calls requiring many additional clerks to answer incoming calls. After the operation stabilized, most offices began implementing the quality assurance plan as specified.

The monitoring records were not always completed as specified in the procedures. The supervisor assisted those clerks needing extra help interacting with the respondents.

The operation was successful because it allowed the Census Bureau to fully answer the respondent question(s). It also enabled the Census Bureau to fulfill the request for a questionnaire to be completed by phone, mailed to the respondent, or instructions to be given so the process would be implemented correctly. The telephone assistance quality assurance monitoring was appropriate because it assured the Census Bureau that the respondents were receiving the necessary information.

The quality assurance plan helped identify those clerks who had problems with 1) assisting the respondents and 2) meeting the standards of the three monitoring characteristics. The supervisors/ monitors provided positive and negative feedback to the assistance clerks in a timely manner.

This was a subjective quality assurance plan and the reports analyzed are very subjective in nature. Due to this subjectivity, it is difficult to measure the impact the plan had on the operation. However, based on the analysis, the following recommendations were suggested for similar future operations:

- Provide sufficient monitoring stations and install the equipment before the telephone operation begins. Early and complete monitoring provides the best opportunity for improvement.
- Change the measurement levels on the recordkeeping forms to have three rating levels (poor, average, and good) rather than five (poor, fair, satisfactory, good, and excellent). This would make it easier for the monitor to rate the clerks.
- Place monitors' desk out of view of the clerks. This will eliminate the clerks from knowing when they are being monitored.
- Monitor how often and what type of incorrect information is given out to the respondents.

Reference

[1] Steele, LaTanya F., STSD 1990 Qualit Assurance REX Memorandum Series # N2, ''Summary of Quality Assurance Results for the 1990 Telephone Assistance Operation.'' U.S. Department of Commerce, Bureau of the Census. May 1991.

CLERICAL EDIT

Introduction and Background

Mail return questionnaires in type 2 (areas which cover central city for the larger cities), type 2A (areas which cover cities, suburban, rural, and seasonal areas in the south and midwest), and type 3 (areas which cover the more rural areas of the west and far north) district offices were reviewed in the clerical edit operation to ensure all recorded information was clear and complete, and all required questions were answered. A quality assurance check was designed to provide information on the frequency and types of errors made so feedback could be provided to the edit clerks. In this way, large problems could be avoided and all staff could continuously improve.

Methodology

The questionnaires were clustered into work units, consisting of a maximum of 30 long-form or 100 short-form questionnaires each. A sample of questionnaires was selected from each work unit for verification.

For the first 10 working days of the operation, the sampling rate was 10 percent. After the first 10 working days of the operation, the sampling rate was reduced to 2 percent for short-form questionnaires and 3.3 percent for long-form questionnaires.

Each edit clerk or verifier trainee was given a maximum of two work units to determine whether training was successful. These work units were 10 percent verified. A work unit was unacceptable if it had an estimated error rate greater than 50 percent on an item basis. If the first work unit was unacceptable, feedback on the type of error(s) was given by the supervisor. The work unit was then given to a qualified edit clerk to be re-edited, and a second work unit was given to the trainee clerk. If the second work unit was also unacceptable, the work unit was given to a qualified edit clerk to be re-edited, and the trainee was removed from the clerical edit operation. If either of the two work units was acceptable, the trainee was assumed to have successfully completed training and was qualified to perform the clerical edit operation.

The sample questionnaires were verified using a dependent verification scheme. During verification the verifier assigned an error for:

1. An item not being edited, but should have been.
2. An item being edited incorrectly.
3. An item being edited, but should not have been.

Verifiers corrected all detected errors on the sample questionnaires.

For each work unit, the verifier completed a record, indicating the number of edit actions and the number of edit errors, and identifying the question on which the error occurred and the type of error. All data from these records were keyed into a computer system located in the district office. The computer system generated cross-tabulation reports, outlier reports, and detailed error reports. The supervisors used these reports to identify types and sources of errors. The supervisors also used the cross-tabulation reports, outlier reports, detailed error reports, and completed quality assurance records to provide feedback to the edit clerks and verifiers to try to resolve any problems.

Limitations

Quality assurance records were received from approximately 70 percent of the type 2, 2A, and 3 district offices. Data for the remaining 30 percent of the type 2, 2A, and 3 district offices are assumed to be similar to those records that were received.

A total of 120 edit clerks were used to estimate the error rate for the entire operation. One clerk was selected from each of the 120 sample district offices. It is assumed that there was no bias in the selection of clerks, and the 120 clerks chosen represent all clerks from all type 2, 2A, and 3 district offices.

The 120 district offices and sample clerks from these district offices were selected using simple random sampling. The standard errors were calculated assuming simple random sampling.

The estimated error rate for a particular type of error is computed as the number of errors for that particular type divided by the total number of edit actions. Since an edit action could be taken with no error occurring, the sum of the estimated error rates by type does not equal 100 percent.

This report assumes that the verifier is correct. Since a verifier was not necessarily a more experienced or expert edit clerk, an item determined by the verifier to be in error may have been a difference in opinion or interpretation of procedures.

Results

Before analyzing the data, each clerical edit quality assurance record underwent a weighting process. Since only a sample of questionnaires in each work unit was verified, each record received a weighting factor in order to estimate the error rate for the entire operation rather than the sample error rate. The weighting factor for a work unit was computed as the number of questionnaires in the work unit divided by the number of questionnaires verified in the work unit rounded to the nearest whole number.

Operational Error Rates by Week

The overall weighted, estimated incoming error rate was approximately 7.4 percent with a standard error of 0.51 percent. Table 3.5 shows the sample number of work units edited, sample number of questionnaires verified, weighted estimated error rates, and standard errors for each week.

Figure 3.3 illustrates the weighted estimated weekly error rates. The estimated error rate increased from March 11 to March 25 and decreased from March 25 to May 6. The estimated error rate increased again from May 6 to May 20 and decreased from May 20 to July 8. No apparent reasons can be given for these increases and decreases.

Table 3.6 shows the sample number of work units edited, sample number of questionnaires verified, and the weighted estimated error rates for each of the 3 district office types. The weighted estimated error rates for type 2, 2A, and 3 district offices were approximately 7.9, 5.5, 7.8 percent, respectively. The estimated error rate for type 2A district offices is statistically different from the estimated error rates from type 2 and 3 district offices.

Table 3.5. **Estimated Weekly Error Rates**

Date (1990)	Sample number of work units edited	Sample number of questionnaires verified	Weighted estimated error rate (percent)	Standard error (percent)
March 11-17	11	67	2.8	3.1
March 18-24	54	343	6.9	1.7
March 25-31	379	2,719	14.6	4.0
April 1-7	791	4,286	9.7	1.5
April 8-14	889	3,728	7.6	1.0
April 15-21	821	2,647	6.0	0.8
April 22-28	602	1,592	5.3	0.9
April 29-May 5	418	1,034	4.4	1.7
May 6-12	222	503	4.0	1.2
May 13-19	302	757	6.5	3.2
May 20-26	354	727	8.0	1.5
May 27-June 2	276	707	5.6	1.4
June 3-9	307	689	5.1	1.5
June 10-16	211	396	4.7	1.7
June 17-23	149	247	2.7	1.2
June 24-30	74	113	0.7	0.5
July 1-7	44	46	0.5	3.9
July 8-August 4 (4 weeks)	27	52	0.4	0.4
Overall	5,931	20,653	6.9	0.5

Table 3.6. **Estimated Error Rates By District Office Type**

District office type	Sample number of work units edited	Sample number of questionnaires verified	Weighted estimated error rate (percent)	Standard error (percent)
Type 2	1,894	6,682	7.9	0.9
Type 2A	2,187	7,180	5.5	0.5
Type 3	1,850	6,791	7.8	1.0
Overall	5,931	20,653	6.9	0.5

Learning Curve

A learning curve was determined by assigning all edit clerks the same starting week in the operation regardless of when they began. A learning curve reflects the duration of time worked regardless of date. The 582 sample work units edited during learning curve week 1 represent the first week of work for all sample clerks regardless of when they started.

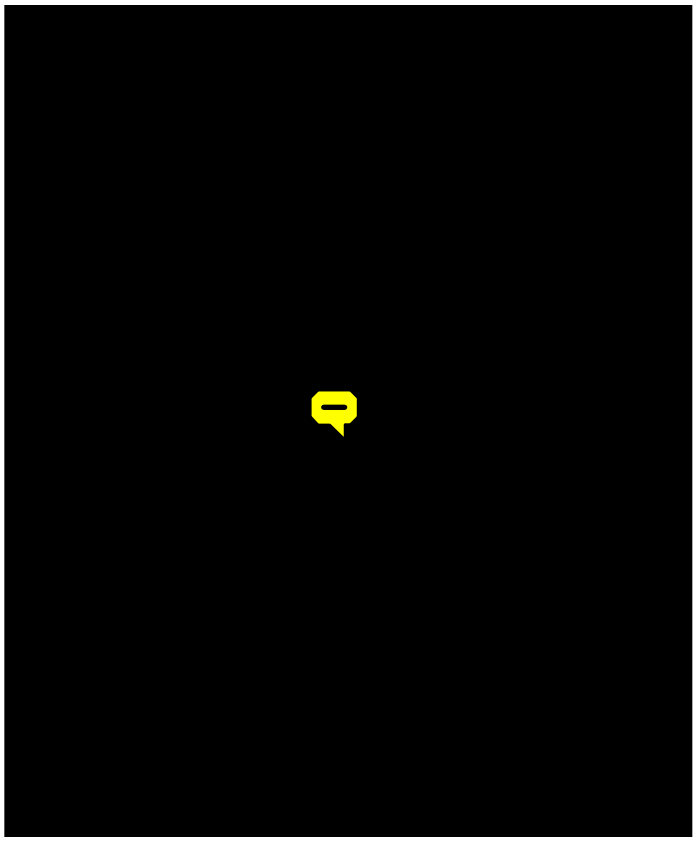
Table 3.7 shows the sample number of work units edited, sample number of questionnaires verified, weighted estimated error rates, and standard errors for each learning curve week.

Figure 3.4 illustrates the weighted estimated weekly learning curve error rates.

The curve shows there was learning throughout. There is no known explanation for the large jump seen in weeks 7 and 8.

Types of Errors

Errors committed by edit clerks were classified as one or more of the following types of errors: (1) erase, (2) fill, or (3) followup. An erase error occurred if an edit clerk failed

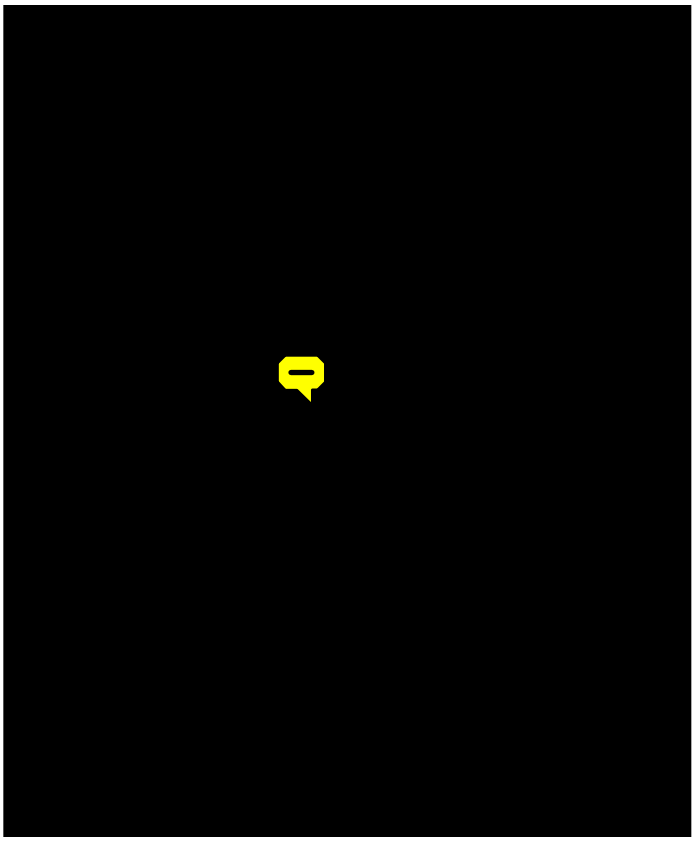


to erase stray marks or write-in answers which crossed two or more Film Optical Sensing Device for Input into Computer (FOSDIC) circles. For example, if a respondent wrote in ''father'' across two or more FOSDIC circles and filled the circle corresponding to ''father/ mother,'' the edit clerk should have erased the word ''father.'' If this was not done, the edit clerk was charged with an erase error.

A fill error occurred if an edit clerk failed to fill an item. For example, if the questionnaire passed edit, the edit clerk should have filled the ''ED'' box in item E of the ''For Census Use'' area. If this was not done, the edit clerk was charged with a fill error.

Table 3.7. **Estimated Weekly Learning Curve Error Rates**

Week	Sample number of work units edited	Sample number of questionnaires verified	Weighted estimated error rate (percent)	Standard error (percent)
1	582	4,171	11.3	2.6
2	1,020	5,626	11.0	1.3
3	934	3,161	6.3	0.9
4	778	2,004	5.9	0.9
5	576	1,349	4.9	1.5
6	416	913	4.0	1.7
7	353	745	5.4	1.5
8	296	668	8.3	1.4
9	254	638	3.8	1.5
10	276	650	2.4	1.5
11	199	406	3.0	1.7
12	121	185	4.6	2.0
13	65	74	0.5	0.5
14-16	61	63	0.4	2.8
Overall	5,931	20,653	6.9	0.5



A followup error occurred if an edit clerk failed to circle the question number for any housing question and/ or population question which was not properly answered by the respondent. A followup error also occurred if an edit clerk failed to write the question number above the person column for any incomplete population question on the 100-percent portion of the questionnaire. A circled question number or question number written above a person column indicated the question should be asked during the followup operation if the questionnaire failed edit and was sent to telephone followup.

More than one type of error may occur on an item. The estimated error rate for a particular type of error is computed as the number of errors for that particular type divided by the total number of edit actions for a time period. Since an edit action could be taken with no error occurring, the sum of the estimated error rates by type does not equal 100 percent.

The most common type of error committed by edit clerks was followup errors. The estimated error rate for followup errors was 4.5 percent. The estimated error rates for fill and erase errors were 3.7 percent and 2.5 percent, respectively. Table 3.8 illustrates the estimated error rates by type of error for learning curve weeks 1-2, 3-16, and the entire operation.

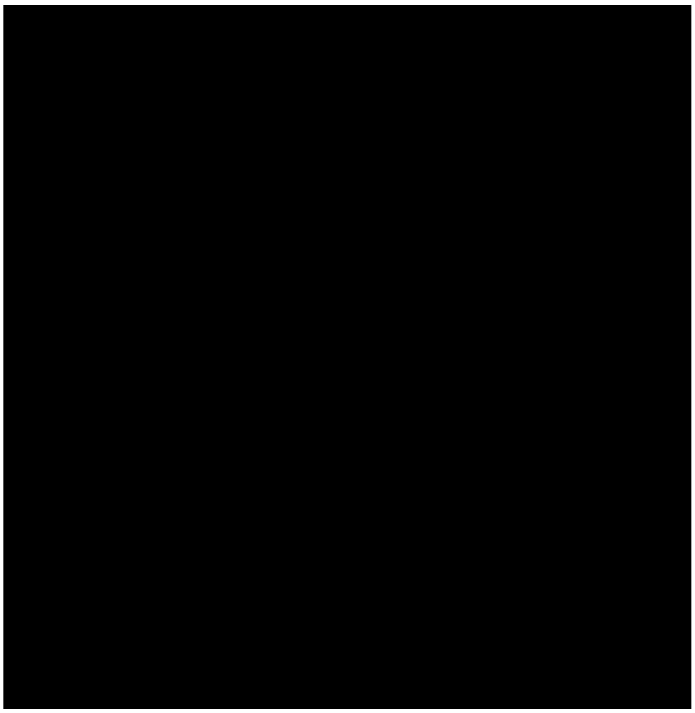
The comparison of the estimated error rates between each type are statistically different.

Errors By Item

Figure 3.5 illustrates the items which accounted for approximately 73 percent of all errors by item. The error

Table 3.8. **Estimated Error Rates by Type**

Estimated error rate (percent)	Type of error		
	Learning curve weeks 1-2	Learning curve weeks 3-16	Entire operation
Erase	3.3	2.0	2.5
Fill	5.6	2.6	3.7
Followup	6.8	3.3	4.5



Item Legend

2	Relationship
4	Race
5	Age and year of birth
7	Spanish/ Hispanic origin
14	Migration
22	Place of work
28	Industry
29	Occupation
31	Work experience in 1989
32	Income in 1989
2	Relationship
99	This was recorded when an error occurred but could not be charged to a specific item.
A	For Census Use Area—total number of persons
B	For Census Use Area—type of unit
DEC	Decision whether the questionnaire passes or fails edit
E	For Census Area containing the ''ED'' circle
F	For Census Area—coverage
H1	Coverage
H5	Property size
H7	Monthly rent
H20	Yearly utility cost

frequency for an item is computed as the frequency that an item occurred in error divided by the sum of frequencies for all unique items in error. The estimated item error rate cannot be calculated because the number of times an item was answered is not available.

The DEC, A, E, F, and H1 errors may be related. Item DEC represents the decision whether the questionnaire passes or fails edit. Item A pertains to the ''For Census Use'' (FCU) area in which clerks determine the total number of persons on the questionnaire. Item A is coded as the greater of the number of names listed on the household roster (question 1a) and the number of completed person columns. Item E pertains to the ''For Census Use'' area in which clerks filled in the ''ED'' box if the questionnaire passed edit. Item F pertains to the ''For Census Use'' area coverage items. Question H1 asks the respondent if the names of all persons living in the household are listed on the household roster.

Conclusions

The purpose of the quality assurance plan was to estimate the quality of the operation, determine and correct source(s) of errors, and provide information useful for giving feedback to the edit clerks. The quality assurance plan fulfilled these purposes. The operational error rates and learning curve show a general decrease in error rates over time. This implies that feedback was given and performance improved.

Based on data from the first 2 weeks of the operation (learning curve data), it is estimated that, without feedback, the error rate would have been approximately 11.1 percent. The actual operational weighted, estimated, error rate was approximately 6.9 or 7.4 percent. Therefore, the estimated error rate decreased approximately 37.8 percent, at least partially as the result of feedback. The estimated error rates for each type of error decreased from the first 2 weeks to the remaining weeks of the operation.

References

[1] Williams, Eric, 1990 Preliminary Research and Evaluation Memorandum No. 173, ''1990 Decennial Census Quality Assurance Results for the Stateside Clerical Edit Operation.'' U.S. Department of Commerce, Bureau of the Census. August 1992.

[2] Schultz, Tom, STSD 1990 Decennial Census Memorandum Series # B-18, ''1990 Decennial Census Quality Assurance Specifications for the Clerical Edit Operation.'' U.S. Department of Commerce, Bureau of the Census. November 1988.

NONRESPONSE FOLLOWUP REINTERVIEW

Introduction and Background

The Nonresponse Followup operation was conducted in mail-back areas for the purpose of obtaining accurate information from households that did not return a questionnaire. During the Nonresponse Followup operation, enumerators visited each nonresponse unit to determine the occupancy status of the unit on Census Day. Based on the status, the enumerator completed the appropriate items on the census questionnaire, even if the household respondent said that he/ she returned a questionnaire by mail.

This operation was conducted in 447 out of the 449 district offices. The two district offices that did not conduct Nonresponse Followup were List/ Enumerate areas only. The operation lasted from April 26, 1990, through July 27, 1990. During that period of time, the Nonresponse Followup enumerators interviewed over 34 million housing units.

The primary function of census enumerators during Nonresponse Followup was to visit each housing unit and gather data according to specific procedures. The enumerators under no circumstances were to ''make up'' data. If they did, this was referred to as fabrication or falsification and was, of course, illegal, punishable by termination of employment and possible fines.

The reinterview program was a quality assurance operation whose major objective was to detect Nonresponse Followup enumerators who were falsifying data and to provide the information to management so the appropriate administrative action could be taken to correct the problem.

Methodology

This section provides information on the quality assurance design and implementation for Nonresponse Followup operation [1].

Reinterview Program—During Nonresponse Followup, a reinterview program was instituted where a reinterview enumerator verified the housing occupancy status and household roster from a sample of cases. Reinterview was not conducted on the cases completed during closeout of the district offices. The objectives of the reinterview program were to detect data falsification as quickly as possible and to encourage the enumerators' continuous improvement over time. To meet these objectives, a sample of enumerators' completed questionnaires were reviewed and the corresponding housing units reinterviewed. The questionnaires were selected based on one of two sample methods, random and administrative.

Sampling Methods—The random sample was designed to identify early fabrication when not much data existed for monitoring fabrication. Each original enumerator's assignment was sampled for reinterview every other day for the first 16 days of the Nonresponse Followup operation. It was believed this sample would catch those enumerators that would fabricate early in the operation and would provide information to deter other enumerators from starting this type of behavior. The administrative sample was designed to take advantage of control and content data, to identify those enumerators whose work was significantly

''different'' that it might indicate potential fabrication of data. This sample was to start in the third week of Nonresponse Followup when there was expected to be enough data on the enumerators to indicate trends. The reinterview staff selected questionnaires from only those enumerators who had vacancy rate, average household size, miles per case, and/ or cases per hour significantly different from other enumerators in their same assignment area that could not be explained by the supervisor.

Reinterview and Fabrication Validation Process—After the sample was selected, the reinterviewer proceeded to verify the household status and the household roster on Census Day by telephone or personal visit. Once the reinterviewer obtained the information from the respondent, a preliminary decision (accept or reject) was made on the potential of fabrication. The decision on ''suspected fabrication'' (reject) was based on the following criteria.

1. The unit status from the original interview was different from the unit status obtained during reinterview.
2. The household roster from the original interview contained at least a 50 percent difference from the household roster obtained during reinterview.

Limitations

The data in this report are based on a sample of records from district offices across the country. There were limitations encountered while analyzing the data which are given below:

The reliability of all estimates was dependent upon the quality of the data entered on the Reinterview Form and proper implementation of the reinterview procedures.

All estimates were based on information from the random sample phase of the reinterview program. Random selection of cases was continued throughout the Nonresponse Followup operation within some district offices. Data from the administrative sample were not used to obtain the Nonresponse Followup estimates because of unmeasured biases due to improper implementation and the sample not being random. The administrative sample will be assessed separately from these estimates.

Data from type 3 district offices were not included to compute the Nonresponse Followup estimates. Type 3 district offices conducted both the Nonresponse Followup and List/ Enumerate operations and the data was to be included in the List/ Enumerate evaluation.

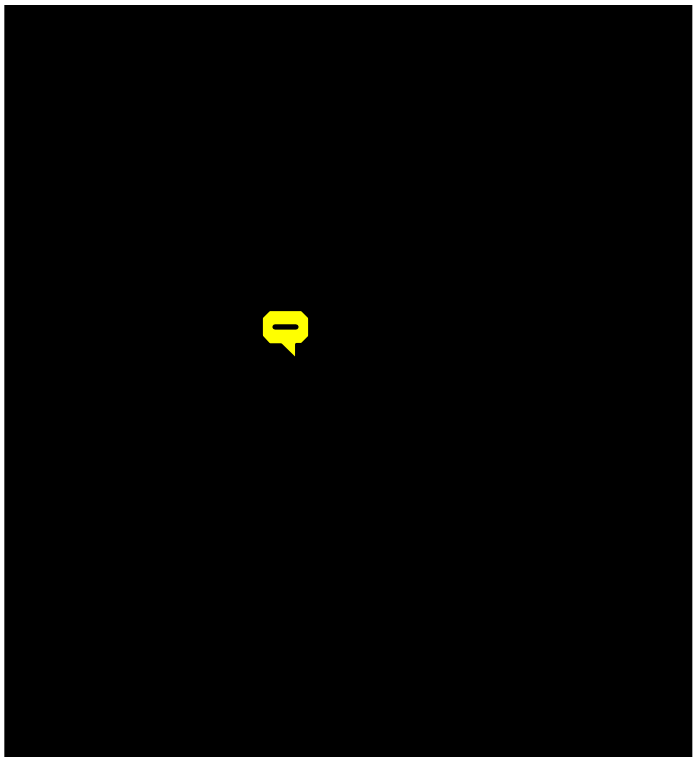
Results

Based on data from the reinterview program, it was estimated, overall, that enumerators intentionally provided incorrect data for 0.09 percent of the housing units in the Nonresponse Followup operation. This indicated that between 20,000 and 42,000 Nonresponse Followup questionnaires were fabricated during the 1990 census at the 90 percent confidence level.

The overall estimate of 0.09 percent can be compared to the ''erroneous fictitious'' persons estimate of 0.5 percent (standard error of 0.10 percent) for the Post Enumeration Survey [2]. Data for the Post Enumeration Survey estimate were taken from a combination of census operations, such as Field Followup, Vacant Delete Check, and Nonresponse Followup, not just for Nonresponse Followup. Also, the Post Enumeration Survey estimation is of persons, while the Nonresponse Followup Reinterview estimate is of households. Based on these data, it can be concluded that data falsification was not a significant problem within the census data collection process.

Four types of offices conducted the Nonresponse Followup operation; type 1 (metropolitan areas containing approximately 175,000 housing units), type 2 (usually a suburban area containing approximately 260,000 housing units), type 2A (suburban, rural, and seasonal areas in the south and midwest containing approximately 270,000 housing units), and type 3 (rural areas of the west and far north containing approximately 215,000 housing units). Type 3 district offices were not selected in the evaluation sample because the List/ Enumerate operation also took place in those district offices. Figure 3.6 provides the estimated fabrication rate for each of the three district office types.

The degree of reported fabrication was stable across the country, except in type 2 district office areas (suburban areas with approximately 260,000 housing units or more) which experienced an estimated fabrication rate of 0.05 percent. The estimated fabrication rate in type 2 district offices was ''greatly'' different from the national estimate. It was expected that metropolitan areas (type 1 district offices) would have a higher fabrication rate than suburban



or rural areas, but in fact, type 1 district offices do not have a significantly different estimate from type 2A district offices.

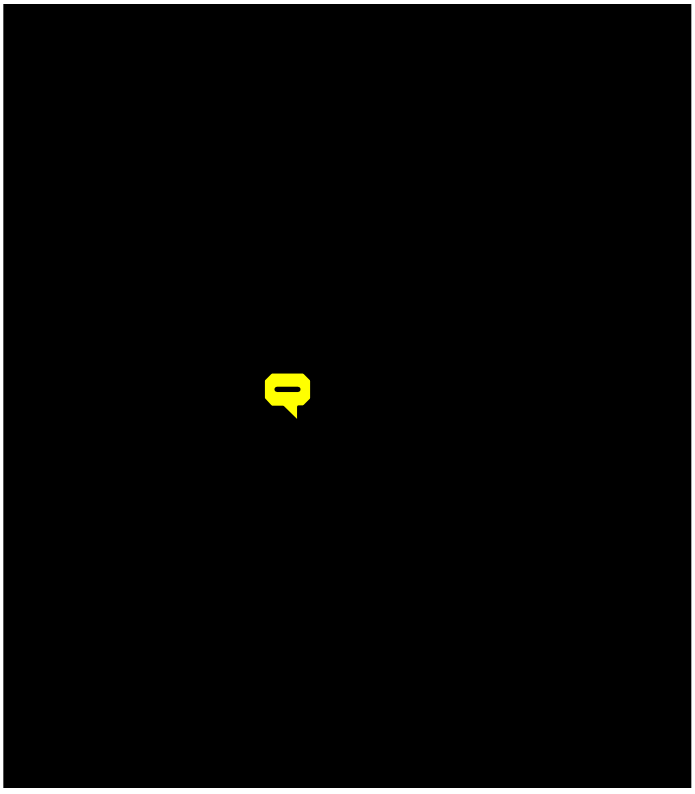
The time between the start and end of the Nonresponse Followup operation were divided into three time periods (approximately 3 weeks each) as follows:

- Period 1 = Beginning of the operation through May 13th.
- Period 2 = May 14th through June 3rd.
- Period 3 = June 4th through the end of the operation.

The estimated fabrication rate ranged from 0.09 percent the first 3 weeks to 0.12 percent the last 3 weeks. Even though the point estimate for the last weeks was higher than the other weeks the difference was not found to be significant.

The enumerator completed one of three forms during Nonresponse Followup; long form, short form, or deletion record. The long form and short form were predesignated for occupied and vacant units. The deletion records were used to account for address listings no longer in existence. Figure 3.7 provides a pictorial presentation on the degree of fabrication in each of the form types at the national and district office type levels.

As shown in figure 3.7, the data indicate that, across the country regardless of the type of area, a higher percent of deletion records were fabricated compared to the long or short forms. The differences between the deletion records and both the long and short forms were greatly significant.



The data also suggest no significant difference between short and long forms. This implies that in many cases, an enumerator fabricated by classifying a housing unit as non-existent.

One concern was whether fabrication occurred more frequently, based on type of housing unit. Three types of units was defined; occupied, vacant, and non-existent (not a living quarters). The housing unit type represented the *final* housing unit status listed during the reinterview operation.

The data suggested, nationally, that there was no significant difference in the fabrication rate by type of housing unit (occupied 0.09 percent, vacant 0.09 percent, and not a living quarters 0.10 percent). In type 2A district offices, non-existent housing units had a point estimate (0.32 percent) above the national estimate but it was not significantly different.

The Nonresponse Followup enumerator was to conduct the interview with someone living in the household. If the enumerator was unable to locate anyone in the household after numerous attempts, the enumerator was allowed to interview neighbors, landlords, etc.

The national fabrication rate for those cases where the housing information was collected from a proxy is 0.14 percent and 0.09 percent for cases where the information is collected from an actual household member. No significant difference was found at the 90 percent confidence level at the national level or for the district office type data.

The reinterviewer dependently verified the household roster obtained by the original enumerator. Another item of interest was whether there was an effect on fabrication due to the number of household members listed on the roster by the census enumerator.

Table 3.9 shows that the household roster which contained six or more household members was the least likely to be fabricated and the household roster with zero (vacant or delete) members was the most likely to have been fabricated. The household roster with zero was more likely to have been fabricated than those households with two or more members, but is not more likely than a household with one member. A household roster with one household member is greatly significant from a household roster which contains five, six, or more household members. This suggests that more work should be done to study household rosters with zero or one persons.

Once enumerators were confirmed to have falsified data, it is estimated that 37.0 percent were released, 21.0 percent resigned, 20.0 percent were warned or advised, and 7.0 percent were recorded as no action taken. It was expected that more than 50 percent of the enumerators would be released. The status of the remaining cases (15.0 percent) could not be assessed from the data. In the future the reinterview program should be designed to assure that proper action is taken on enumerators who had fabricated cases.

It was estimated (shown in table 3.10) that the enumerators provided incorrect housing unit status (occupied, vacant, or delete) or incorrect household rosters for 3.82

Table 3.9 **Fabrication by Number of Persons in Household**

Number of persons in household	Fabrication	
	Percent	Standard error
0	0.17	0.036
1	0.10	0.034
2	0.04	0.014
3	0.08	0.022
4	0.06	0.020
5	0.01	0.007
6+	0.02	0.012

Table 3.10. **Enumerator Error Rate at the National and District Office Type Levels**

District office type	Roster/ unit status errors		Reasons for errors		
	Percent	Standard error	Roster percent	Unit status percent	Relative standard error
National	3.82	0.550	41.04	58.96	1.506
Type 1	3.44	0.416	43.39	56.61	4.428
Type 2	3.53	1.110	39.69	60.31	2.175
Type 2A	4.68	0.652	41.31	58.69	2.422

percent of the housing units during Nonresponse Followup. When these problems existed, the housing unit was investigated further to see if the problem was due to fabrication. The data suggest that only a very small percentage of enumerator errors (.09 percent) was intentional. The estimated enumerator error rate is lower than the 1988 Nonresponse Followup Dress Rehearsal rate of 4.1 percent [3].

The enumerator error rate remained constant from the beginning to the end of the 1990 Reinterview operation. The estimated enumerator error rate was above average (4.68 percent), but not significantly different in the type 2A areas. The main reason for the enumerator errors was the difference in the housing unit status (58.96 percent) recorded by the original enumerator and the reinterviewer. This was less than the housing unit status differences of 81.82 percent during the 1988 Nonresponse Followup Dress Rehearsal.

During the Nonresponse Followup operation, the reinterview program sampled 4.8 percent of the Nonresponse Followup questionnaires. Even though this sampling rate was equal to what was projected, there was bias in the sampling universe of the random and administrative phase. The random phase continued throughout the operation as compared to the first 2 weeks and the data suggested that there was no consistent pattern in the implementation of the administrative sample. This resulted in 82 percent of questionnaires being selected at random. The remaining 18 percent of the questionnaires were selected based on the enumerator's performance as compared to other enumerators in the same assignment area (the administrative sample). It was projected that 40 percent of the reinterview questionnaires would be sampled during the administrative phase.

The reinterview was to take place as close to the date of the original interview as possible. It was estimated that the average time between the original interview and the reinterview was approximately 5.1 days, greater than the desired lag time of less than 4 days. Even though the 5.1 days was higher than planned, it is significantly less than the 16.8 days experienced during 1988 Dress Rehearsal.

Conclusions

The data indicate that no extensive fabrication took place at the national level. The majority of the questionnaires targeted as suspected fabrication were not falsified. This indicates that research should be done to refine our definition of ''suspected'' fabrication. There should be a better method of detection than the current method of the ''Fifty-Percent Rule'' and the difference in housing unit status.

A reinterview system must be designed to detect enumerators with a lower degree of fabrication at a higher confidence level. Whether the system design is random, administrative, or a combination of the two, the system's reliability should be significant for all degrees of fabrication.

In addition to identifying fabrication, the reinterview operation should provide information on the accuracy of the population assigned to each household. Immediate reconciliation should be designed to correct under/ over coverage of Nonresponse Followup.

The use of administrative analysis must be refined to predict instances of fabrication. Research should continue on better identifying variables as well as the use of statistical models to predict instances of fabrication. This will enhance our coverage and ability to identify enumerators that falsify census data in a more cost effective manner. A concurrent evaluation should be used to evaluate the effectiveness of the administrative sample. This study will help to evaluate and refine the administrative model used to detect fabrication.

To further improve the reinterview program, the automation capability to monitor the reinterview process and results from the beginning to the end of the operation must be emphasized. This may help the managers to monitor each reinterview case more effectively and provide appropriate information to the district offices/ regional census center's such as falsification, lag time, workload, number of cases completed, etc.

Within the analysis, there were indicators of fabrication that should be studied further, such as households with zero or one person and delete households.

Last resort cases were originally thought of as indicators of fabrication, but the data showed that there was not a problem of fabrication with those cases.

Even though the lag time between the original interview and reinterview was an improvement over the experience of the 1988 Dress Rehearsal, work is needed to improve. Perhaps the use of telephone capabilities will improve this.

References

[1] Williams, Dennis, STSD 1990 Decennial Memorandum Series # O-2 Revision 1, ''Specification for the 1990 Nonresponse Followup Opeation.'' U.S. Department of Commerce, Bureau of the Census. July 1989.

[2] Griffin, Deborah and Moriarity, Chris, 1990 Preliminary Research and Evaluation Memorandum No. 179. ''Characteristics of Census Errors.'' U.S. Department of Commerce, Bureau of the Census. September 1992.

[3] Williams, Dennis, STSD 1988 Dress Rehearsal Memorandum Series # O-8, ''1988 Nonresponse Followup Reinterview Results.'' U.S. Department of Commerce, Bureau of the Census. January 1990.

CHAPTER 4.
Data Capture/ Processing Operations

Once the questionnaires were collected and were in the seven processing offices, the data were captured. All questionnaires for the 1990 decennial census were data captured by camera and processed through the Census Bureau developed Film Optical Sensing Device for Input to Computers equipment. After capture and scanning, the data were sent through an edit program. A clerical operation, called Edit Review, was carried out to channel the questionnaires through the edit process and remedy edit problems. The quality assurance program for the four components of the Edit Review operation is discussed in this chapter.

While most of the responses on the questionnaire were self-coded by the respondent (responses had specific answer cells marked by the respondent), there were several questions that elicited responses that could not be coded by the respondent. These items required clerical operations to convert the responses to machine readable codes. The coding operations took place in several offices by computer or by clerks. This chapter covers the quality assurance programs for the three coding operations.

Most of the data from the questionnaires were captured during the filming operations, and some data was captured through data keying. These capture operations ranged from the capture of addresses obtained during the listing (Prelist) and updating operations, to the capture of responses on the questionnaires that required conversion to codes. In this chapter, quality assurance for data keying for the 1988 Prelist, the Precanvass, the 100- Percent Race Write-In, the Collection Control File, and the Long Form data capture operations are covered.

EDIT REVIEW

Split

Introduction and Background—This section documents the results from the quality assurance plan implemented for the 1990 Decennial Census Edit Review Questionnaire Split operation. The Split operation and its associated quality assurance were scheduled to last from April 2 through December 18, 1990, however, records were received with dates from March 28 through December 28, 1990. The operation took place in all seven processing offices.

In the split process, after questionnaires were filmed, run through a Film Optical Sensing Device for Input to Computers, and processed through the computer edit, the questionnaires were sorted into four categories:

1. *Accept*—These questionnaires passed all edits and were not part of the Post Enumeration Survey sample. The questionnaires went to the census questionnaire library.
2. *Post Enumeration Survey*—These questionnaires passed all edits but were designated for Post Enumeration Survey processing and sent to the Post Enumeration Survey library.
3. *Repair*—These questionnaires failed the automated edits and were sent to the Repair operation.
4. *Markup*—These questionnaires failed content and coverage edits and were sent to the Markup operation.

The sorting was performed by clerks wanding barcodes or keying the identification number of each questionnaire and following the instructions on a computer terminal as to which of the four categories a questionnaire should be included.

The purpose of the quality assurance plan was: (1) to identify the causes of errors and provide feedback to the clerks in order to improve the subsequent quality of the Split operation and (2) to identify the batches that failed the quality criteria in order to rectify these batches.

Methodology—A work unit consisted of the questionnaires from one camera unit. Each camera unit consisted of 4 boxes of questionnaires, approximately 1,800 short forms or 400 long forms.

The clerks were trained to scan the barcode and/ or key-in the questionnaire identification number and to place the questionnaires into the pile as instructed by the computer. The supervisors were instructed on how to interpret the quality assurance output and give effective feedback.

In order to qualify for the Split operation, a clerk had to have one of their first three work units pass verification. If a clerk failed on each of their first three work units, they were reassigned to another operation. Otherwise, they remained on the Split operation.

In order for a work unit to pass the quality assurance, it must have had a critical error rate (see below for a description of error types) less than 1 percent *and* a total error rate less than 5 percent.

The method of splitting a camera unit was a two-way split method. This involved placing the questionnaires from a camera unit into two piles: Accept, Markup, Post Enumeration Survey, or Repair and ''others.'' This method required a series of four passes. At each pass all questionnaires not yet separated were wanded or keyed. The

computer determined the largest remaining category and then indicated to the clerk how to separate that questionnaire category from ''others.'' The questionnaries from the separated category were then boxed until no more questionnaries remained. The computer also determined if the expected number of questionnaires in a work unit were placed in the correct box. In essence, this was a 100-percent computer verification. Each split acted as a verification on the previous split with the remaining questionnaires being rewanded.

Questionnaires which were placed in the incorrect pile were considered to be in error. There were two types of incorrect placement errors: critical and non-critical.

Critical Errors—A critical error occurred when a questionnaire was placed in an incorrect pile such that the error could not be corrected or the Post Enumeration Survey operation was adversely impacted.

Non-Critical Errors—A non-critical error occurred when a questionnaire was placed in an incorrect pile such that the error could be corrected or the error was inconsequential.

Although missing questionnaires are not counted as an error, they contribute to the critical and total error rates. Moreover, a large percentage of missing questionnaires might tend to indicate a poorly split work unit.

Questionnaires which were not expected by the computer (within a camera unit) but were wanded or keyed during the split were extra questionnaires. These were questionnaires that were boxed in incorrect camera units. Clerks were alerted to extra questionnaires by a flashing screen with an appropriate message. Extra questionnaires were not counted as questionnaires going to Repair or as errors. These questionnaires were sent to Repair for the purpose of being rerouted through the filming process where they were assigned a new camera unit identification number. There are no data available on extra questionnaires nor are they represented in any of the counts.

The critical error rate is defined as the number of questionnaires found in incorrect piles (counted as critical errors, as defined above), divided by the number of questionnaires that were supposed to be in the camera unit, as determined by the computer.

The total error rate is defined as the sum of all errors divided by the total number of questionnaires that were supposed to be in the camera unit, as determined by the computer.

Questionnaires which were expected by the computer but were not wanded or keyed during the split were classified as missing. The percentage of missing questionnaires was defined as the number of questionnaires expected but not seen by the computer during the Split operation divided by the total number of expected questionnaires for the camera unit.

A work unit required further review by the supervisor for any of three reasons. The latter two of these reasons constituted a failure of the work unit. All work units which failed were resplit.

1. *Missing Questionnaires*—When the number of missing questionnaires exceeded 2 percent of the expected number of questionnaires in a work unit (as counted during filming), the supervisor was instructed to search for the missing questionnaires. If all questionnaires were found, the clerk who split the work unit would wand/ key the newly found questionnaires. If they were not found, the supervisor weighed the forms to determine a revised expected number of questionnaires. If some were found and some were not, the clerk would wand/ key the questionnaires that were found and the supervisor then weighed all the forms again to determine the revised expected number of questionnaires. This revised expected number was not used in any of the error rates in this report.

2. *Critical Errors*—A work unit was rejected when the critical error rate exceeded 1 percent.

3. *Total Errors*—A work unit was rejected when the total error rate exceeded 5 percent.

A clerk was given a warning after each rejected work unit. Feedback was given regarding the types of errors and clerks were retrained when necessary. If a clerk received a warning on three consecutive work units, it was recommended the clerk be removed from the operation.

All rejected work units were resplit by the same clerk.

All quality assurance data were compiled by computer. No clerical recordkeeping was necessary.

For each split work unit, a computer file was generated containing the number of missing questionnaires and the number of incorrectly placed questionnaires by clerk. If a work unit exceeded any of the decision criteria, the supervisor provided feedback to clerks regarding the types of errors made. The supervisors also were able to identify the clerks having the most difficulties and the types of errors that occurred most frequently.

The Decennial Operations Division generated printouts for each work unit that contained the number of questionnaires that should be in each pile according to the automated edits. Someone other than the clerk who performed the split checked that the number of questionnaires in each pile looked reasonable. This included checking that the largest pile corresponded to the pile on the list having the greatest number of questionnaires, the second largest pile corresponded to the second greatest number of questionnaires, and so on. The clerk also verified that the printout, which contained the number of questionnaires that should be in the pile, was attached to the appropriate box.

Limitations—The reliability of the evaluation for the Split operation is affected by the following:

- The accuracy in transferring the data files from the Decennial Operations Division to the Decennial Statistical Studies Division.

- The revised expected number of questionnaires were not included in the file that was generated by the Decennial Operations Division.

Results—The error rate estimates in this section are from 100-percent inspection and thus there is no variance on these estimates.

Table 4.1 summarizes the overall critical and total estimated error rates for all questionnaires by processing office. The quality of the Split operation was good in that the overall critical and total estimated error rates of 0.20 and 0.34 percent, respectively, were very low.

Table 4.2 shows the critical and total estimated error rates for short forms by processing office.

Table 4.3 shows the estimated critical and total long form error rates by processing office. The critical and total error rates on a questionnaire basis, were greater for long form (0.21 and 0.42 percent, respectively) than short form (0.20 and 0.32 percent, respectively) questionnaires.

Table 4.4 provides data on the distribution of correctly and incorrectly split questionnaires, as well as, missing questionnaires. The diagonal of the table displays the number of questionnaires that were correctly split by category. The cells above the diagonal represent non-critical errors while the cells below the diagonal present critical errors (except the Repair/ Markup error which is non-critical). The table also shows the number of missing questionnaires by the pile the questionnaire was supposed to be in.

The number of questionnaires which passed through the Split operation was 122,446,453. The number of missing questionnaires was 471,249 (0.4 percent). These were questionnaires expected by the computer but not wanded or keyed during the operation. Of the missing questionnaires, 421,784 (89.5 percent) were accepts. Of the non-missing questionnaires 106,652,511 (87.1 percent) were supposed to be accepts.

Overall, 99.3 percent of the questionnaires were split correctly. Of the remaining 0.7 percent of questionnaires, 0.2 percent resulted in a critical error, 0.1 percent in a noncritical error, and 0.4 percent were classified as missing.

The most frequent type of error was a critical error, the Repair/ Accept error (questionnaire should have been sent to Repair but was placed in the Accept pile). These errors made up about 48 percent of all errors and almost 82 percent of all critical errors.

The most frequent type of non-critical error was the Accept/ Repair error. These errors made up almost 18 percent of all errors and about 42 percent of all non-critical errors.

Approximately 2.8 percent of all work units had to be resplit as a result of exceeding the acceptable quality criteria. About 1.6 percent of the work units were rejected only for a critical error rate that exceeded one percent. A total of 0.09 percent of the work units were rejected only for a total error rate that exceeded five percent. Approximately 1.0 percent of the work units exceeded both the critical and total error rate tolerances. These percentages do not add up to 2.8 percent because of rounding.

Figure 4.1 depicts a quality learning curve represented by production error rates for the average clerk for critical errors. The quality learning curve for total errors is similar to the critical learning curve.

Table 4.1. **Overall Error Rates by Processing Office**

Processing office	Expected number of questionnaires	Critical error rate (percent)	Total error rate (percent)
Baltimore	15,645,306	0.29	0.55
Jacksonville	21,116,671	0.22	0.38
Kansas City	17,362,804	0.22	0.35
Albany	14,518,911	0.17	0.30
Jeffersonville	18,066,459	0.17	0.30
Austin	19,427,629	0.17	0.28
San Diego	16,779,922	0.15	0.25
Total	122,917,702	0.20	0.34

Table 4.2. **Overall Short Form Error Rates by Processing Office**

Processing office	Expected number of questionnaires	Critical error rate (percent)	Total error rate (percent)
Baltimore	12,680,184	0.29	0.51
Jacksonville	17,732,608	0.22	0.36
Kansas City	13,587,771	0.21	0.33
Albany	11,645,205	0.17	0.27
Austin	16,018,913	0.17	0.27
Jeffersonville	14,656,117	0.17	0.29
San Diego	14,169,421	0.15	0.23
Total	100,490,219	0.20	0.32

Table 4.3. **Overall Long Form Error Rates by Processing Office**

Processing office	Expected number of questionnaires	Critical error rate (percent)	Total error rate (percent)
Baltimore	2,965,122	0.32	0.72
Jacksonville	3,384,063	0.23	0.45
Kansas City	3,775,033	0.23	0.39
Austin	3,408,716	0.20	0.35
Albany	2,873,706	0.19	0.40
Jeffersonvillle	3,410,342	0.17	0.35
San Diego	2,610,501	0.16	0.34
Total	22,427,483	0.21	0.42

Table 4.4. **Distribution of Correct, Incorrect, and Missing Questionnaires**

Pile questionnaire is supposed to be in	Pile questionnaire placed in				
	Missing	ACC	PES	MAR	REP
ACC	421,784	106,567,856	3,757	7,539	73,359
PES	10,414	21,184	2,792,274	3,799	53,674
MAR	7,782	12,939	1,522	2,535,712	17,917
REP	31,269	200,064	9,231	13,984	10,131,642

ACC-Accept; PES-Post Enumeration Survey; MAR-Markup; and REP-Repair.

The points on the x-axis represent the expected number of questionnaires in the split population. There were 122,917,702 questionnaires that were split by the clerks. The chart illustrates a cumulative and an interval quality learning curve. The cumulative curve represents the ongoing average error rates of all clerks after a certain number of questionnaires were split. Therefore, if a particular clerk worked on only one questionnaire, he/ she is represented in this cumulative learning curve. The overall critical error rate was 0.20 percent. The interval curve represents the average error rates between two consecutive points on the x-axis. For example, the point ''70000'' on the x-axis of the critical interval curve represents the average clerk's error rate after completing at least 60,000 questionnaires but fewer than 70,000 questionnaires.

Clerks' interval quality learning curve estimated error rates followed an overall downward trend through a clerk's first 50,000 questionnaires. However, the average clerk seemed to stop learning since quality deteriorated after having split at least 50,000 questionnaires.

It is estimated that, without quality assurance, the critical and total error rates for split would have been about 0.24 and 0.44 percent, respectively. The operational critical error rate was 0.20 percent; therefore, out of the 122,917,702 questionnaires in the split population, approximately 50,062 more questionnaires (0.04 percent) were split without critical errors due to the quality assurance plan. The total error rate was 0.34 percent; therefore, out of the 122,917,702 questionnaires in the split population, approximately 121,869 more questionnaires (0.10 percent) were split correctly because of the quality assurance plan.

Conclusions—There were 111,485 (97.2 percent) work units that did not fail critical or total tolerances. Within these work units there were an estimated 168,148 critical errors that remained in the system after the Split operation. These errors were never corrected. There were also an estimated 88,173 non-critical errors that were needlessly recycled.

The computer generated data file was a very efficient, automated recordkeeping file. The file contained accurate and detailed data on missing questionnaires and on the misfiling of questionnaires. There were zero duplicate records and only very few records had inconsistent data.

Feedback appeared to improve the quality level, as evidenced by a continual decrease in clerks' estimated error rates through the first 50,000 questionnaires split.

The critical quality learning curve indicates a steady increase in error rates for critical interval error rates after a clerk had split 50,000 questionnaires. This increase may be attributed to two factors:

1. A sense of monotony may have set in at this point due to the tedious and routine process of the Split operation.

2. Split clerks were temporarily assigned to assist with backlogs in other operations because of a decreased workload in the Split operation.

For any similar operation in the future, it is recommended that new clerks be trained and replace an ''old'' clerk after the ''old'' clerk splits 50,000 questionnaires. The

critical quality learning curve indicates that learning ceased and quality deteriorated after a clerk had split about 50,000 questionnaires. This indicates that if it is possible, move these split clerks to another operation at this point and train others with no prior split experience to replace the original split clerks. Train a third set of clerks again when these new clerks split 50,000 questionnaires. Overlap between the groups of clerks would allow the overall error rates to be minimized.

Reference—

[1] Boniface, Christopher J., 1990 Preliminary Research and Evaluation Memorandum No. 197. ''Quality Assurance Results of the Edit Review Questionnaire Split Operation.'' U.S. Department of Commerce, Bureau of the Census. November 1992.

Markup

Introduction and Background—This section describes and documents the results from the quality assurance plan implemented for the 1990 decennial census edit review—questionnaire Markup operation. The Markup operation and its associated quality assurance lasted from March 26 through October 6, 1990. The operation took place in six of the seven decennial census processing offices with the exception being the Kansas City Processing Office, which did not service any type 1 district offices (areas which cover the central city for the larger cities).

Edit Review Markup was the clerical operation which reviewed questionnaires that were completed and mailed in by respondents or completed by enumerators during nonresponse followup in type 1 districts and failed the automated edits for coverage or content. This operation only received questionnaires which failed the edit due to incomplete or incorrectly marked items. Questionnaires sent to Markup, for which the items that failed the edits could be completely repaired, were returned to camera preparation for reprocessing. The remaining questionnaires were sent to Telephone Followup.

The purpose of the quality assurance plan was to ensure clerks were performing the operation as intended and to identify areas of difficulty. Feedback was provided to assist the clerks and to continually improve the process. The quality assurance plan also identified work units that needed to be redone.

Methodology—A clerk had to qualify to work on the operation. Qualification for the operation was based on ''live'' work units. (A work unit consisted of all questionnaires in a camera unit failing the coverage or content edits, for a reason other than processing error.) A work unit had a variable number of questionnaires and included only short forms or long forms. If there were 30 or fewer short forms or 10 or fewer long forms in a work unit, all questionnaires were verified in that work unit. If there were more than 30 short forms or 10 long forms in a work unit, a sample of 30 short-form or 10 long-form questionnaires were selected for qualification. A clerk qualified if his/ her error rate was less than 5 percent on either of the first two work units completed. Any clerk who failed to qualify after the second work unit was either retrained or removed from the operation.

For work units done by qualified clerks, a 5-percent sample of questionnaires within a work unit were dependently verified. The quality assurance clerks examined the sampled questionnaires using the same procedure as the Markup clerks. The quality assurance clerks verified that each item requiring review either had been fixed or the appropriate indication had been made on the questionnaire.

Two types of errors were defined: omissions and incorrect edit actions. Omission errors indicate actions which the Markup clerk failed to follow. Each edit action which was omitted counted as one error. Incorrect action errors indicate actions which the Markup clerk performed erroneously. Each incorrect action was counted as one error.

The following formula was used to estimate error rates:

$$\frac{\text{Number of omitted edit actions \$ Number of incorrect edit actions}}{\text{Total number of edit actions}}$$

Incoming error rates estimated the quality of the work performed by the clerks. Outgoing error rates estimated the quality of the data as it left the operation after all detected errors in the sampled questionnaires had been corrected.

Work units with an error rate of greater than 3 percent were reworked. If the clerk's cumulative error rate for a week was greater than 3 percent, he/ she was given a warning and retrained. After retraining, a ''qualification'' work unit was given to the clerk. If the clerk's error rate was less than 5 percent, he/ she was able to continue working in the Markup unit. Otherwise, the clerk was removed from the operation.

The Markup recordkeeping system was clerical. Verification results were recorded on the Markup Operation Quality Record (see form D-1984 in appendix B). The original copy of each quality record was used by the supervisor for feedback to the clerk and to keep on file. A copy was sent to the processing office's quality assurance section for data capture and production of a summary record for use by the supervisor of each Markup unit. The supervisors used these reports to identify both the clerks with the highest error rates and the types of errors that occurred most frequently. The supervisor also used this information to provide feedback to the clerks.

To calculate standardized statistics for determining outliers (processing office(s) significantly different from the others), it was assumed that the six processing offices are a sample from a population of processing offices and thus, the estimate of the variance is as follows:

$$\sigma^2 = \frac{\$\$p_i\text{-}p\$^2}{n\text{-}1}$$

where:

p_i= the proportion of sample questionnaires that are incorrect in the i^{th} processing office;
p = the proportion of the overall number of sample questionnaires that are incorrect; i.e., the sample estimated error rate; and
n = sample size.

Thus, asymptotically standard normal statistics are calculated as follows:

$$X_i = \frac{p_i \$ p}{\$\frac{\$\$p_i \$ p\$^2}{n\$1}}$$

The resulting standardized statistics are ranked from low to high and, in that ranking, the k^{th} value is referred to as the k^{th} order statistic. The standardized statistics were compared to a table of expected values for standardized order statistics at the α= .10 level of significance. For more information on this methodology, see [1].

Limitations—The reliability of the evaluation for the operation was affected by the following:

- Accuracy of clerical recording of quality assurance data onto the form D-1984.
- Accuracy of keying the quality assurance data into the Automated Recordkeeping System.
- Consistency in implementation of the procedures by each processing office.
- The assumption of simple random sampling in standard error calculations.

Results—Table 4.5 summarizes the overall estimated error rates for all questionnaires by processing office. The overall incoming and outgoing estimated error rates for the Markup operation were both 1.3 percent. The estimated error rates ranged from 0.7 percent to 1.9 percent in the Baltimore and Albany Processing Offices, respectively. There were no statistical differences among the six processing offices. Thus, the processing office error rates were from the same distribution.

Table 4.6 shows the estimated short form error rate by processing office. The overall estimated error rate for short- form questionnaires within all six processing offices was 2.2 percent. There were no statistical differences among the six processing offices. Thus, the processing office error rates were from the same distribution.

Table 4.7 shows the estimated long form error rate by processing office. The overall estimated error rate for long-form questionnaires for all six processing offices was 1.0 percent. There were no statistical differences among the six processing offices. Thus, the processing office error rates are from the same distribution.

Table 4.5 **Overall Estimated Error Rates by Processing Office**

Processing office	Number of items verified	Number of items in error	Estimated error rate (percent)	Standardized error rate	Standard error (percent)
Albany.	251,166	4,773	1.9	+ 1.3	.03
Austin	280,708	4,319	1.5	+ 0.5	.02
Jeffersonville .	229,974	3,363	1.5	+ 0.3	.03
Jacksonville . .	185,003	2,320	1.3	-0.2	.03
San Diego . . .	192,226	2,062	1.1	-0.6	.02
Baltimore	231,659	1,633	0.7	-1.5	.02
Total	1,370,736	18,478	1.3	NA	.01

NA = not applicable

Table 4.6. **Error Rates by Processing Office for Short Forms**

Processing office	Number of items verified	Number of items in error	Estimated error rate (percent)	Standardized error rate	Standard error (percent)
Albany.	85,048	2,511	3.0	+ 1.2	1.90
Jeffersonville .	64,280	1,702	2.7	+ 0.7	.06
Jacksonville . .	54,248	1,294	2.4	+ 0.3	.07
San Diego . . .	59,332	1,168	2.0	-0.3	.06
Austin	122,329	2,374	1.9	-0.4	.04
Baltimore	53,533	586	1.1	-1.7	.05
Total	438,770	9,635	2.2	NA	.02

NA = not applicable

Table 4.7. **Error Rates by Processing Office for Long Forms**

Processing office	Number of items verified	Number of items in error	Estimated error rate (percent)	Standardized error rate	Standard error (percent)
Albany.	166,118	2,262	1.4	+ 1.3	.03
Austin	158,379	1,945	1.2	+ 0.9	.03
Jeffersonville .	165,694	1,661	1.0	+ 0.2	.02
Jacksonville . .	130,755	1,034	0.8	-0.5	.02
San Diego . . .	132,894	894	0.7	-0.9	.02
Baltimore	178,126	1,047	0.6	-1.2	.02
Total	931,966	8,843	1.0	NA	.01

NA = not applicable

Figure 4.2 compares short-form and long-form estimated error rates within each processing office. The difference between the estimated error rates for short forms and long forms ranged from a high of 1.7 percentage points in Jeffersonville to a low of 0.5 percentage points in Baltimore. Overall, and for each of the six processing offices, there was sufficient evidence at the α= .10 level to indicate a significant difference between short forms and long forms.

Table 4.8 provides data on the distribution of error types, omission and incorrect action, for short forms by processing office.

Table 4.9 shows the distribution of error types, omission and incorrect action, for long forms by processing office.

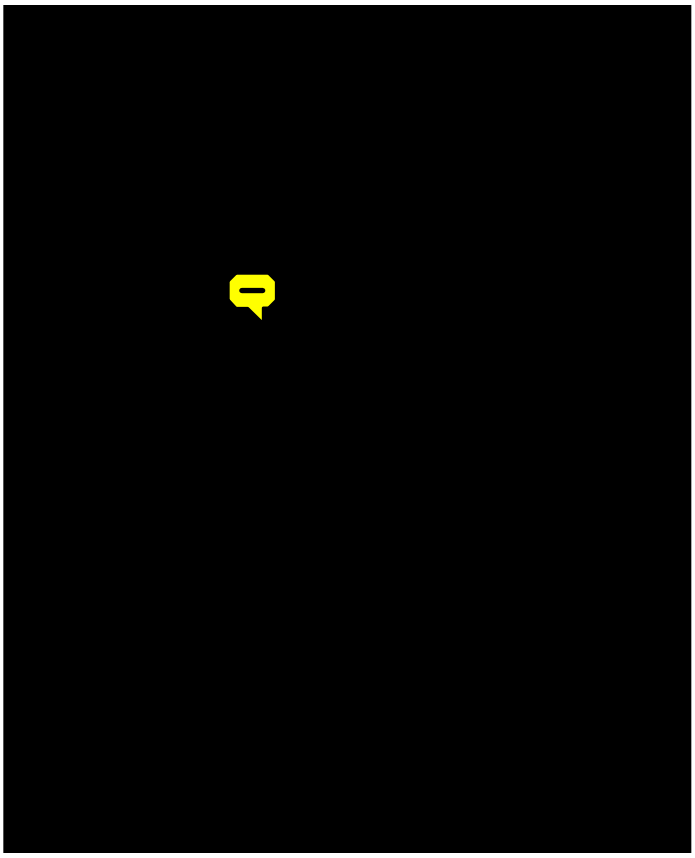


Table 4.8. **Distribution of Short Form Error Types by Processing Office**

Processing office	Number of omissions	Number of incorrect actions	Omission estimated error rate		Incorrect action estimated error rate	
			Percent	Standard error	Percent	Standard error
Albany.	1,774	737	2.1	.05	0.9	.03
Jeffersonville .	1,222	480	1.9	.05	0.8	.04
Austin	1,682	692	1.4	.03	0.6	.02
Jacksonville . .	703	591	1.3	.05	1.1	.04
San Diego . . .	679	489	1.1	.04	0.8	.04
Baltimore	367	219	0.7	.04	0.4	.03
Totals . . .	6,427	3,208	1.5	.02	0.7	.01

Both short form and long form results show the same statistical differences. The results of a chi-square test, indicate that errors (both omissions and incorrect actions) are independent of the processing offices.

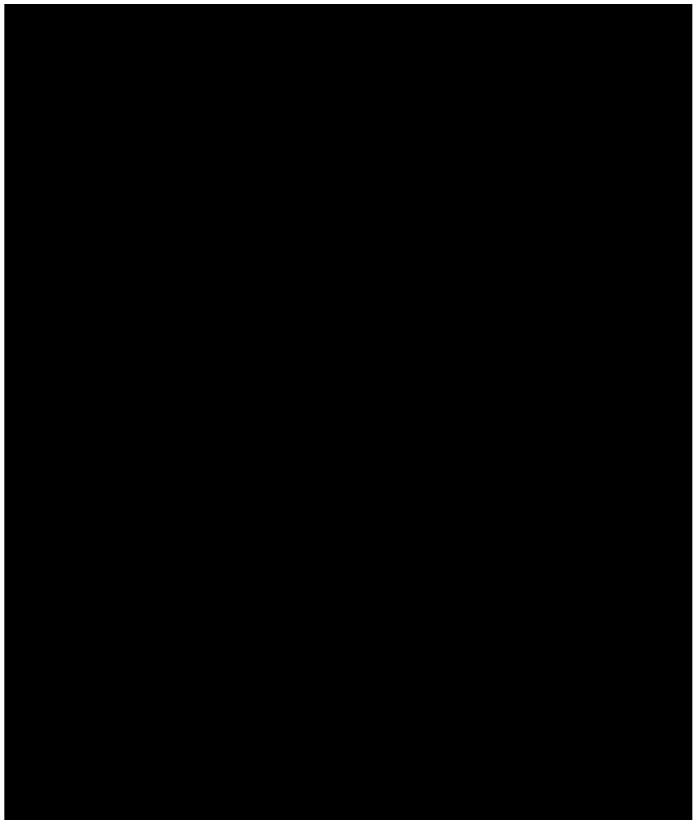
A t-test at the $\alpha = .10$ level indicates a significant difference between the two totals for long form omission and incorrect action errors. Additionally, a Wilcoxon Rank Sum Test at the $\alpha = .10$ level indicates that the omission and incorrect action error rate distributions are shifted away from one another. Thus, overall, the omission estimated error rate is significantly higher than that for incorrect actions.

Table 4.9. **Distribution of Long Form Error Types by Processing Office**

Processing office	Number of omissions	Number of incorrect actions	Omission estimated error rate		Incorrect action estimated error rate	
			Percent	Standard error	Percent	Standard error
Albany.	1,519	743	0.9	.02	0.5	.02
Jeffersonville .	1,309	352	0.8	.02	0.2	.01
Austin	1,405	540	0.9	.02	0.3	.01
Jacksonville . .	715	319	0.6	.02	0.2	.01
San Diego . . .	473	421	0.4	.02	0.3	.02
Baltimore	813	234	0.5	.02	0.1	.01
Totals . . .	6,234	2,609	0.7	.01	0.3	.01

Figure 4.3 represents the average estimated error rate for all clerks by week starting with each clerks' first week for short- and long-form questionnaires. The first week a clerk worked is denoted by week 1, regardless of when they began working on the operation. For example, a clerk that starts in week 10 of the operation is starting his/ her first individual week. Week 11 of the operation is that clerk's second week, etc. The chart shows that both short and long form estimated error rates continued to decrease over time indicating that learning took place. The bulk of the learning for both long- and short-form questionnaires was accomplished in the first 10 weeks the individual was on the job.

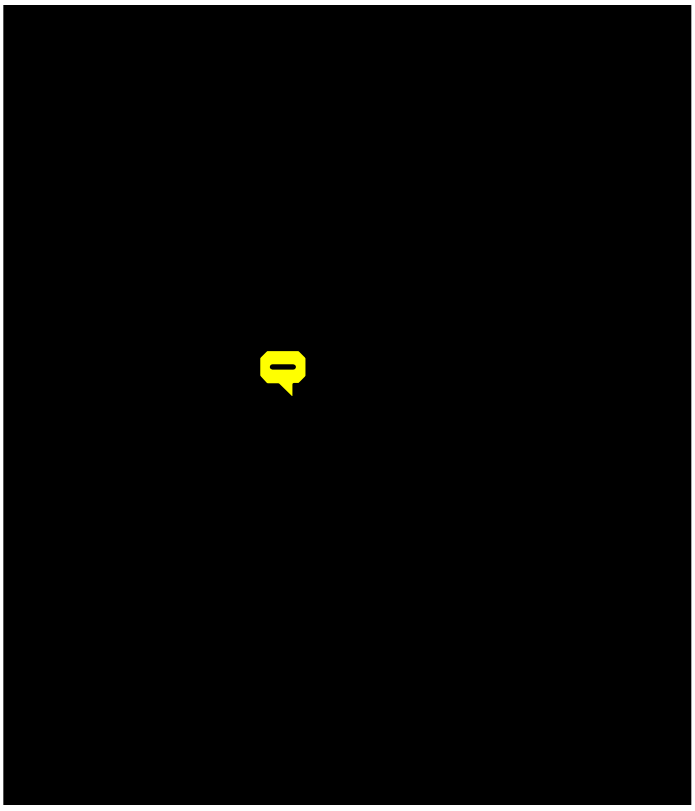
Figure 4.4 shows the overall operational learning curve for all clerks for both short-and long-form questionnaires starting with week 1 of the operation. The chart represents



the overall estimated error rates for each particular week of the operation; whereas, figure 4.3 displayed the overall estimated error rates for each particular week of the individual clerk. The highest mean estimated error rates for short and long forms were 6.3 and 3.7 percent, respectively (both during the first week of the operation). Overall, estimated error rates followed a downward trend from week 1 to week 28 of the operation. Estimated error rates increased for both short and long forms from weeks 3-5 and 17-19. The reason for these increases may be that the number of new clerks was highest during these particular weeks.

It is estimated that, without quality assurance, the estimated error rates for short and long forms would have been about 3.5 and 1.8 percent, respectively. The weighted operational short form estimated error rate was 2.5 percent; therefore, out of the 8,705,455 short-form items in the Markup population, approximately 89,421 more short-form items (1.0 percent) were ''marked-up'' correctly due to the quality assurance plan. The weighted operational long form estimated error rate was 1.0 percent; therefore, out of the 18,451,319 long form items in the Markup population, approximately 145,897 more long-form items (0.8 percent) were ''marked-up'' correctly because of the quality assurance plan.

Conclusions—The quality assurance plan fulfilled its purpose. The individual learning curve shows that learning took place. Estimated error rates for clerks decreased steadily over time. This implies that feedback on types of errors was given to clerks on a timely basis and resulted in improved quality. Supervisors were able to identify areas of difficulty for clerks using the daily Automated Recordkeeping System reports and the Markup Operation Quality Record.



Estimated error rates were low for both short forms (2.2 percent) and long forms (1.0 percent) and were under statistical control. These facts suggest that to further improve the quality of the process, the process would require changing.

One possible reason for the short form estimated error rates being higher than the long form estimated error rates is the relatively high item non-response rate on long-form questionnaires for items not asked on the short-form questionnaire. This high non-response rate would tend to make long forms easier to markup, since most of the items would be blank and the clerks only had to circle the items. Thus, nonresponse on long forms would increase the total number of long form items verified with a very low number of errors among these items, which would lower the long form error rate.

Overall, omission errors made up 68.5 percent of all errors (short and long forms). The fact that this percentage is high indicates that clerks may not have had a thorough understanding of the operation. Omission errors by definition indicate that clerks failed to take action. A reason that many clerks failed to act is probably because they did not know what action to take, due to some deficiencies in training them.

In all processing offices, the clerks *more frequently* failed to act (thereby committing an omission error) than they committed an incorrect action. One possible reason for this difference may be because ''Person Item'' omission errors tend to occur in clusters. ''Person Item'' refers to the seven population questions for each person on pages 2 and 3 of both the short- and long-form questionnaires and the additional population questions per person beginning on pages 6 and 7 on the long form. If clerks were not thoroughly trained on ''Person Item'' error flags, they would tend to commit an omission error for each person listed on the form.

There were early differences in the interpretation of the qualification procedures by all of the processing offices. At the beginning of the operation, some clerks' work was to be 100 percent verified; that is, short form work units with 30 or fewer questionnaires or long form work units with 10 or fewer questionnaires were all checked. This was not always done. Moreover, at least one processing office had clerks processing additional work units while waiting for their qualifying results. This might have had serious quality implications. For example, if a clerk failed the qualifying work unit, those additional work units processed by the clerk may contain large numbers of similar errors. If the work unit passed sample verification and moved on to the next processing unit, unchecked errors might have appeared in subsequent processing operations.

The Markup Operation Quality Records were not always filled out properly. Two of the processing offices did a good job in completing the forms; the other four processing offices did not always list the specific items that were in error. Therefore, it is uncertain exactly how the processing offices used the records for feedback.

Training, especially at the start of the operation, needs to be improved. Clerks need to have a thorough understanding of the operation. The fact that 68.5 percent of all errors were omission errors indicate that clerks may not have had a thorough understanding of the operation.

Standardized test decks (a set of work prepared to cover the types of situations a clerk will encounter) should be created for qualification, as originally planned. The late switch to ''live'' work units for qualification caused confusion at all the processing offices and may have adversely affected quality at the beginning of the operation. If test decks had been used, clerks would have been qualified at the start and there would have been no backlog of work to be verified at the beginning of the operation. In addition, a wider range of error flags and items could have been checked with test decks.

Qualification procedures should be clear at the start of the operation. The clerks should be assigned the qualifying work units ahead of the other work units and not be permitted to process work units until they are qualified.

Clerks should be trained thoroughly in filling out the quality assurance forms at the start of the operation. The supervisors should, also, inspect the quality assurance forms at the beginning of the operation to see if the verifiers are completing the forms properly. This will help ensure that quality assurance records are filled out completely and accurately. In turn, this will aid the supervisors in seeing what types of difficulties each clerk is experiencing.

References

[1] Gupta, Shanti S., ''Percentage Points and Modes of Order Statistics from the Normal Distribution,'' *Annual Mathematical Statistician*. Volume 32. pp. 888-893. 1961.

[2] Boniface, Christoper J., 1990 Preliminary Research and Evaluation Memorandum No. 107, ''1990 Decennial Census: Quality Assurance Results of the Edit Review—Questionnaire Markup Operation.'' U.S. Department of Commerce, Bureau of the Census. December 1991.

Telephone Followup

Introduction and Background— For the Telephone Followup operation, clerks telephoned a questionnaire respondent to obtain omitted information or to clarify existing responses. The Telephone Followup operation was implemented for 24 weeks. Although telephone followup was done in both district offices and processing offices, a quality assurance operation was applied only in the processing offices; this report presents results from this operation.

The quality assurance plan for the Telephone Followup operation consisted of two parts, a monitoring process and a resolution process, which are analyzed separately. The monitoring, implemented in all processing offices except the Kansas City Processing Office, was used to determine how clerks conducted themselves on the phone. The main goal of monitoring was to identify specific areas where clerks performed poorly and provide feedback to improve their performance. The resolution part was used to evaluate clerks based on how well they resolved items marked for followup. The primary goal was to determine abnormally high or low rates of unresolved actions, or respondent refusals, by telephone followup clerks, and use this information to provide feedback where appropriate.

Methodology—The quality assurance plan used a sample independent verification scheme. . The following sampling procedures were implemented for the monitoring and resolution processes of the Telephone Followup operation.

1. *Monitoring*
   a. *Sampling Scheme*—For the first week of the operation, a sample of eight telephone followup clerks per telephone followup unit/ subunit, per shift, were selected each day for monitoring. Four supervisor-selected clerks were identified first and then four additional clerks were selected randomly. The clerks selected by the supervisor were chosen based on any deficiencies suspected by the supervisor. In subsequent weeks, four clerks (two supervisor-selected and two randomly-selected clerks) were monitored each day per unit/ subunit, per shift. A clerk could have been selected by the supervisor multiple times.
   b. *Monitored Characteristics*—For each clerk sampled, four telephone calls were to be monitored at random throughout the day. A quality assurance record was completed for each monitored clerk, indicating how well the clerk performed the following:
      1. *Introduction*—properly introduced and identified him or herself to the respondent.
      2. *Speech Quality*—spoke clearly and at an acceptable pace and volume.
      3. *Asked Questions Properly*—asked questions as worded to obtain correct or omitted answers for all edit items; probing, when necessary, was neutral and to the point; and procedures were followed.
   c. *Recordkeeping/ Feedback* —The Form D-1986, Telephone Followup Monitoring Quality Report, was completed as the monitoring took place (see form in appendix B). Quality assurance output reports (daily and weekly) were generated for the supervisors to use in providing

feedback to the clerks. The telephone followup monitors were to write comments on the quality assurance monitoring records for any below satisfactory ratings given. These comments were used to provide additional feedback to the clerks.

2. *Resolution*

   a. *Quality Assurance Sample*—The quality assurance sample for this process consisted of five randomly selected questionnaires, short and/ or long, per clerk, per day. The five questionnaires were inspected to ensure the completeness of the work, and to obtain resolution rate estimates.

   b. *Sampling Scheme*—Each day, one completed quality assurance sample was selected at random from each clerk. There was to be at least one quality assurance sample completed per day, from each clerk. If a clerk failed to complete a quality assurance sample (five questionnaires) for a given day, all questionnaires for that clerk were checked. The sampling scheme called for at least one long form questionnaire to be included in each clerk's quality assurance sample.

   c. *Recordkeeping/ Feedback*—The Form D-1998, Telephone Followup Resolution Quality Record, was completed for each clerk's quality assurance sample (see form in appendix B). Quality assurance output reports were generated daily and weekly for the supervisor to use in providing feedback to the clerks).

The processing offices sent a 20-percent sample of all completed quality assurance monitoring and resolution forms to headquarters. From that sample, approximately 110 forms were selected for analyzing the monitoring operation and 100 forms for the resolution operation per processing office

Limitations—The reliability of the analysis and conclusions for the two parts of the quality assurance plan depends on the following:

- Accuracy of the clerical recording of quality assurance data.
- Accuracy of keying the quality assurance data into the Automated Recordkeeping System.
- The evaluation of the clerks for the monitoring operation was subjective.
- One clerk may be in sample multiple times causing negative bias in the data due to the supervisor selecting clerks with problems.
- The monitors' desk was often within view of the telephone followup clerk being monitored.
- There was variation among the processing offices in the way they implemented the sampling scheme.
- The frequency with which any particular housing or population question item was investigated during the resolution process is unknown; only the frequency with which that item was left unresolved or refused is known.
- Standard errors were calculated assuming simple random sampling.

Results—The data used to analyze the Telephone Followup operation came from the Automated Recordkeeping System and a sample of the Quality Assurance Monitoring and Resolution Records. Overall, Automated Recordkeeping System data were available for 8,088 monitored clerks (note that clerks were counted once each time they were monitored).

The quality levels of all monitoring characteristics were measured on an ordinal measurement scale of 1 to 5. The below satisfactory total included both poor and fair ratings (1 and 2) combined. The above satisfactory total included both good and excellent ratings (4 and 5) combined.

1. *Summary of the Automated Recordkeeping System Monitoring Data*

   a. *Overview*—Table 4.10 presents the number of clerks, monitored calls, and clerk ratings by processing office. Overall, the monitoring clerks issued approximately 3.9 percent below satisfactory ratings, and 78.8 percent above satisfactory ratings. The estimate of the minimum number of clerks to be monitored over the entire Telephone Followup monitoring operation by each processing office was 1,200. The processing offices that monitored fewer than the expected amount were Baltimore, with 1,097, and Austin, with 385. These results are examined further in the following sections.

Table 4.10. **Number of Clerks, Monitored Calls, and Clerk Ratings by Processing Office**

Processing office	Number of clerks monitored	Estimated[1] average number of calls monitored per clerk	Number of ratings			
			Total	Below satisfactory	Satisfactory	Above satisfactory
Baltimore	1,097	1.7	5,507	166	1,171	4,170
Jacksonville . . .	1,451	3.5	15,226	550	2,574	12,102
San Diego.	1,839	3.8	21,008	650	4,549	15,809
Jeffersonville . .	1,797	3.2	16,994	389	1,726	14,879
Austin	385	3.7	4,255	244	402	3,609
Albany	1,519	3.3	15,095	1,066	3,064	10,965
Total	8,088	3.2	78,085	3,065	13,486	61,534

Note: The Kansas City Processing Office is not included in this table because the monitoring part of telephone followup was not implemented in that office.

[1]The estimated average number of calls monitored was computed as follows: total number of ratings divided by three (characteristics per call) divided by the number of monitored clerks.

b. *Summary of Quality Levels of All Monitoring Characteristics*—Figure 4.5 shows the frequency with which each rating was assigned. The Albany processing office reported the largest percent of below satisfactory ratings issued with 7.1 percent. The largest percent of satisfactory ratings were issued in the San Diego Processing Office, with 21.7 percent, with the Baltimore processing office close behind at 21.3 percent. The variation in rating assignment across processing offices is probably due to the subjective nature of the monitoring process.

2. *Headquarters Sample Monitoring Data Summary*—The sampled monitoring quality assurance data were used to determine the distribution of ratings for the three characteristics: 1) proper introduction, 2) questions asked properly (probing), and 3) quality of the clerks' speech. The total number of ratings for each characteristic are not always the same. This is because some processing offices did not rate each characteristic for every call. This is perhaps due to the clerk not getting a chance to ask the respondent for the omitted information before the respondent decided not to answer the question(s).

Of the three characteristics, the one with the most below satisfactory ratings was ''Proper Introduction.'' This characteristic had approximately 44.4 percent of the below satisfactory ratings issued for the three characteristics. Tables 4.11 to 4.13 provide distributions of ratings for the monitoring characteristics by processing office.

A chi-square goodness-of-fit test was used to test whether the quality assurance summary data in tables 4.11 to 4.13 fit the Automated Recordkeeping System Monitoring data distribution in table 4.10. When comparing processing offices, at the 10-percent significance level, there is a statistically significant difference only for the Albany Processing Office. Thus, the quality assurance summary data for the other five processing offices were a good representation of the Automated Recordkeeping System Monitoring summary data. The Albany Processing Office showed a statistically significant difference because the sample selected from the quality assurance forms contained more below satisfactory and satisfactory ratings than the Automated Recordkeeping System data.

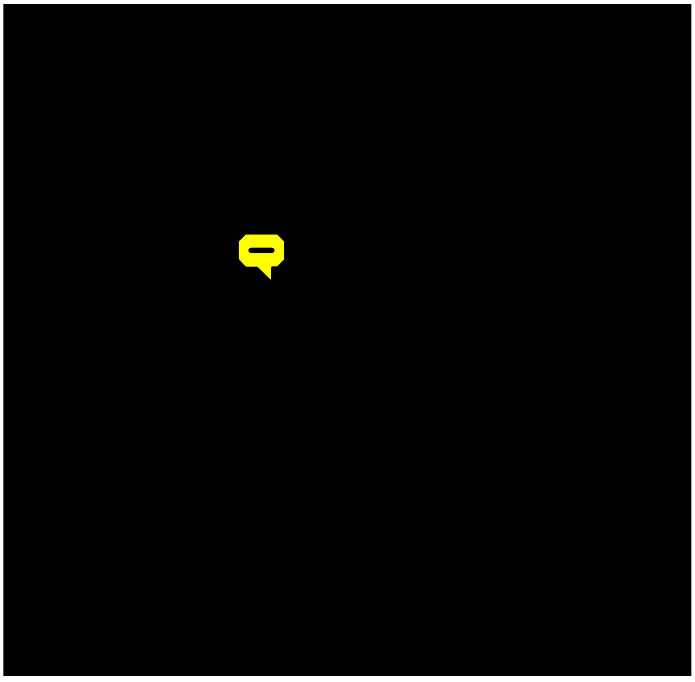


Table 4.11. **Number of Ratings (Percent) for ''Proper Introduction''**

Processing office	Below satisfactory (percent)	Satisfactory (percent)	Above satisfactory (percent)	Total (percent)
Baltimore	10 (3.3)	48 (15.9)	244 (80.8)	302 (100.0)
Jacksonville ..	21 (5.1)	92 (22.4)	297 (72.4)	410 (100.0)
San Diego ...	11 (2.5)	101 (22.5)	336 (75.0)	448 (100.0)
Jeffersonville .	31 (8.7)	40 (11.2)	287 (80.2)	358 (100.0)
Austin	58 (14.1)	38 (9.2)	316 (76.7)	412 (100.0)
Albany.....	46 (9.5)	128 (26.4)	310 (64.0)	484 (100.0)
Total	177 (7.3)	447 (18.5)	1,790 (74.2)	2,414 (100.0)

Table 4.12. **Number of Ratings (Percent) for ''Questions Asked Properly''**

Processing office	Below satisfactory (percent)	Satisfactory (percent)	Above satisfactory (percent)	Total (percent)
Baltimore	4 (1.3)	42 (13.5)	266 (85.3)	312 (100.0)
Jacksonville ..	17 (4.2)	59 (14.5)	330 (81.3)	406 (100.0)
San Diego ...	6 (1.4)	95 (21.4)	342 (77.2)	443 (100.0)
Jeffersonville .	5 (1.4)	47 (13.1)	306 (85.5)	358 (100.0)
Austin	17 (4.1)	55 (13.3)	340 (82.5)	412 (100.0)
Albany.....	106 (19.3)	140 (25.5)	302 (55.1)	548 (100.0)
Total	155 (6.3)	438 (17.7)	1,886 (76.1)	2,479 (100.0)

Table 4.13 **Number of Ratings (Percent) for ''Quality of Speech''**

Processing office	Below satisfactory (percent)	Satisfactory (percent)	Above satisfactory (percent)	Total (percent)
Baltimore	3 (1.0)	38 (12.2)	271 (86.9)	312 (100.0)
Jacksonville ..	16 (3.9)	63 (15.5)	328 (80.6)	407 (100.0)
San Diego ...	6 (1.4)	96 (21.6)	342 (77.0)	444 (100.0)
Jeffersonville .	4 (1.1)	41 (11.5)	313 (87.4)	358 (100.0)
Austin	8 (1.9)	40 (9.7)	364 (88.3)	412 (100.0)
Albany.....	30 (6.3)	103 (21.5)	346 (72.2)	479 (100.0)
Total	67 (2.8)	381 (15.8)	1,964 (81.4)	2,412 (100.0)

3. *Summary of the Automated Recordkeeping System Resolution Data*—There were 47,793 resolution data records entered into the Automated Recordkeeping System, showing that 1,766,720 edit actions needed to be resolved. Approximately 3.8 percent of these edit

actions were unresolved and 2.4 percent received refusals from respondents.

Table 4.14 presents the number of resolution clerks, edit actions, unresolved items, and refusal items used during the Telephone Followup operation. Clerks were counted once each time their quality assurance sample was turned in and a quality assurance resolution record was completed for their workload. The processing office with the most edit actions was Jeffersonville with 27.9 percent of all actions. The Baltimore Processing Office had the highest estimated percentage of unresolved edit actions, 28.9 percent. The Jeffersonville Processing Office had the highest estimated percentage of refusal edit actions, 22.4 percent, with the Kansas City Processing Office close behind at 22.2 percent.

4. *Headquarters Sample Resolution Data Summary*—The sampled resolution quality assurance data were used to determine 1) the estimated unresolved and refusal rates, and 2) the number of items detected in error. Based on 2,972 resolution data records, there were a weighted estimated 988,235 edit actions that needed resolution. Approximately 5.0 percent of these edit actions were unresolved, and 2.4 percent were refusals.

   Table 4.15 presents the number of resolution clerks and weighted estimated edit actions, unresolved, and refusal actions from the quality assurance sample. The clerks were counted once each time a quality assurance record was turned in. The processing office with the most edit actions was Jeffersonville with 29.0 percent of all actions. The Baltimore Processing Office had the highest percent of unresolved edit actions, 29.3 percent. The Kansas City Processing Office had the highest percent of refusal edit actions, 32.8 percent.

Table 4.14. **Number of Resolution Clerk, Unresolved, and Refusal Edit Actions by Processing Office**

Processing office	Number of clerks	Total number of edit actions	Unresolved actions		Refusal actions		Estimated percent of resolved
			Number	Percent	Number	Percent	
Kansas City . .	6,300	170,879	14,061	8.2	9,340	5.5	86.3
Baltimore	9,464	329,097	19,657	6.0	7,219	2.2	91.8
Jacksonville . .	6,817	256,053	14,133	5.5	4,947	1.9	92.6
San Diego . . .	6,353	175,942	2,290	1.3	2,911	1.7	97.0
Jeffersonville .	10,765	492,190	5,745	1.2	9,444	1.9	96.9
Austin	7,179	290,440	9,522	3.3	6,949	2.4	94.3
Albany.	915	52,119	2,543	4.9	1,353	2.6	92.5
Total	47,793	1,766,720	67,951	3.8	42,163	2.4	93.8

Note: The Kansas City Processing Office assisted the Albany Processing Office with their resolution workload for the Telephone Followup operation. This is the only part of the Telephone Followup operation the Kansas City Processing Office implemented.

Table 4.15. **Number of Sampled Resolution Clerks and Weighted Unresolved and Refusal Edit Actions by Processing Office**

Processing office	Number of clerks	Total number of edit actions	Unresolved actions		Refusal actions		Estimated percent of resolved
			Number	Percent	Number	Percent	
Kansas City . .	263	114,485	14,175	12.4	7,910	6.9	80.7
Baltimore	400	171,300	14,550	8.5	4,950	2.9	88.6
Jacksonville . .	423	130,960	6,880	5.3	1,320	1.0	93.7
San Diego . . .	483	110,400	840	0.8	1,040	0.9	98.3
Jeffersonville .	478	286,800	7,860	2.7	7,440	2.6	94.7
Austin	435	145,480	4,400	3.0	1,360	0.9	96.1
Albany.	490	28,810	970	3.4	120	0.4	96.2
Total	2,972	988,235	49,675	5.0	24,140	2.4	92.6

a. *Questionnaire Items*—Below is an item legend listing the census questionnaire items referred to in this section.

Item Legend

Housing Questions

H1 Anyone not added to questionnaire that should be added
H2 Description of building
H6 Value of property
H7 Monthly rent
H20 Yearly cost of utilities and fuels
H22 Annual insurance payment on property

Population Questions

P1 Household roster and usual home elsewhere
P2 Relationship
P32 Work experience/ income received in 1989

b. *Unresolved Data*—Pareto diagrams were created using the census questionnaire housing and population questions and questions of unknown type to identify errors that happened more often than others. Figure 4.6 is the pareto chart for housing questions. Based on this chart, housing question 22 (H22) was unresolved most frequently. This question was left unanswered 15.9 percent of the time.

Figure 4.7 presents the pareto chart for the population questions. Population question 32 (P32) was unresolved most frequently. This question was left unanswered 11.4 percent of the time.

There were a total of 531 unresolved items in error. Of these, 52.4 percent were population questions and 15.6 percent were housing questions. The type of question for the other 32.0 percent of the errors was not identified on the quality assurance forms.

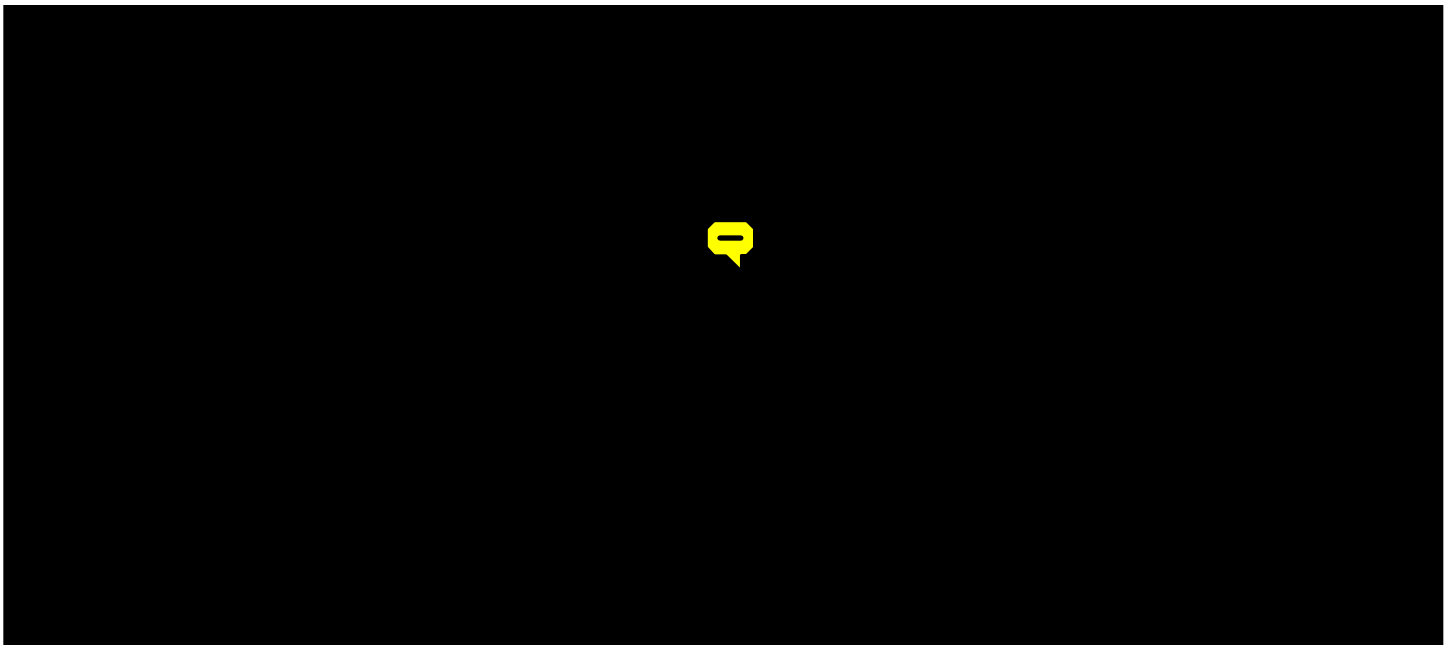


Figure 4.8 is the pareto chart for questions without housing/ population status identified. Question 1 was left without housing or population status information entered on the quality assurance forms 38.0 percent of the time. In figures 4.6 and 4.7, the housing and population question 1 was missed only four and two times, respectively. Figure 4.9 shows that if the housing and population status were known, it would affect the unresolved frequencies for question 1 in figures 4.7 and/ or 4.8. The frequencies for housing and population question 1 could change the items listed as the most frequent unresolved items.

Note: any item number not shown in figures 4.7 or 4.8 were completely resolved during telephone followup. Items for which neither the person number nor item number were known, were not analyzed separately.

5. *Refusal Data*—Pareto diagrams were constructed for refusal data to identify items with a greater refusal frequency. Separate figures were created for housing and population questions and questions of unknown type. Figure 4.9 presents the data for the housing questions. Housing questions H6, H7, and H20 were most frequently refused. These questions were left unanswered 12.7 percent of the time.

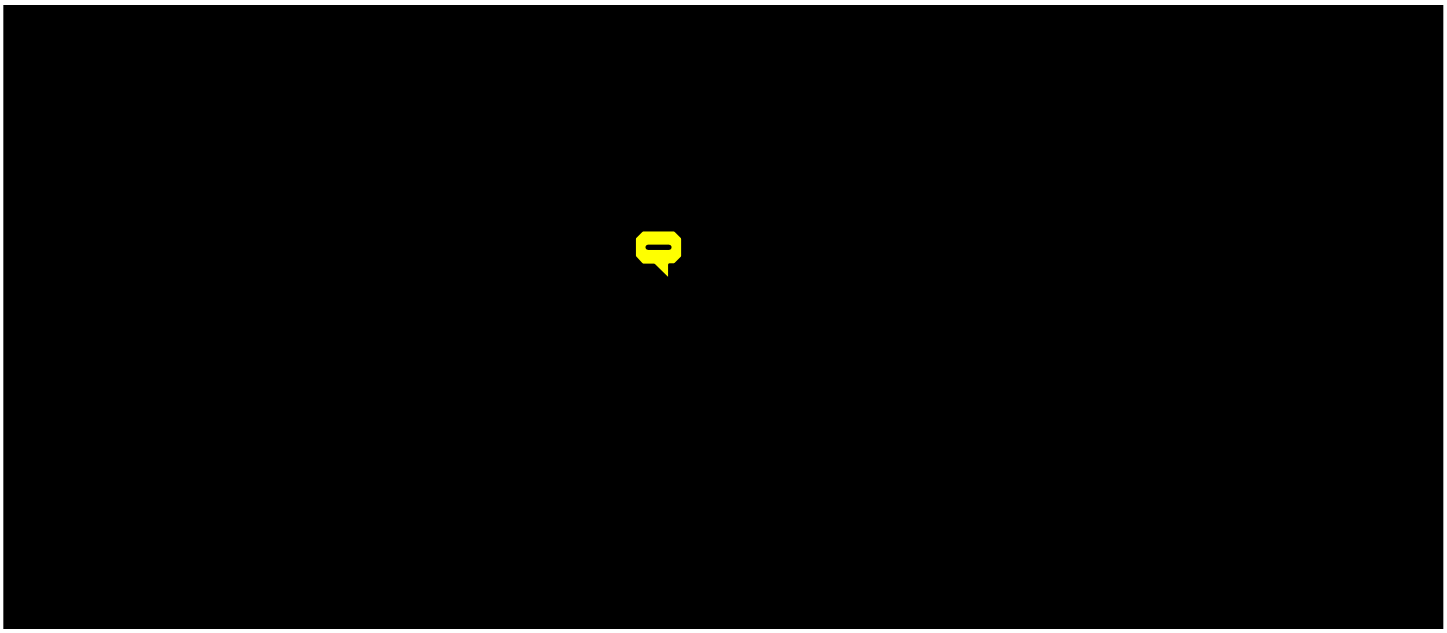


Figure 4.10 presents the pareto chart for the population questions. Population question 32 (P32) was most frequently refused. This question was left unanswered 28.4 percent of the time.

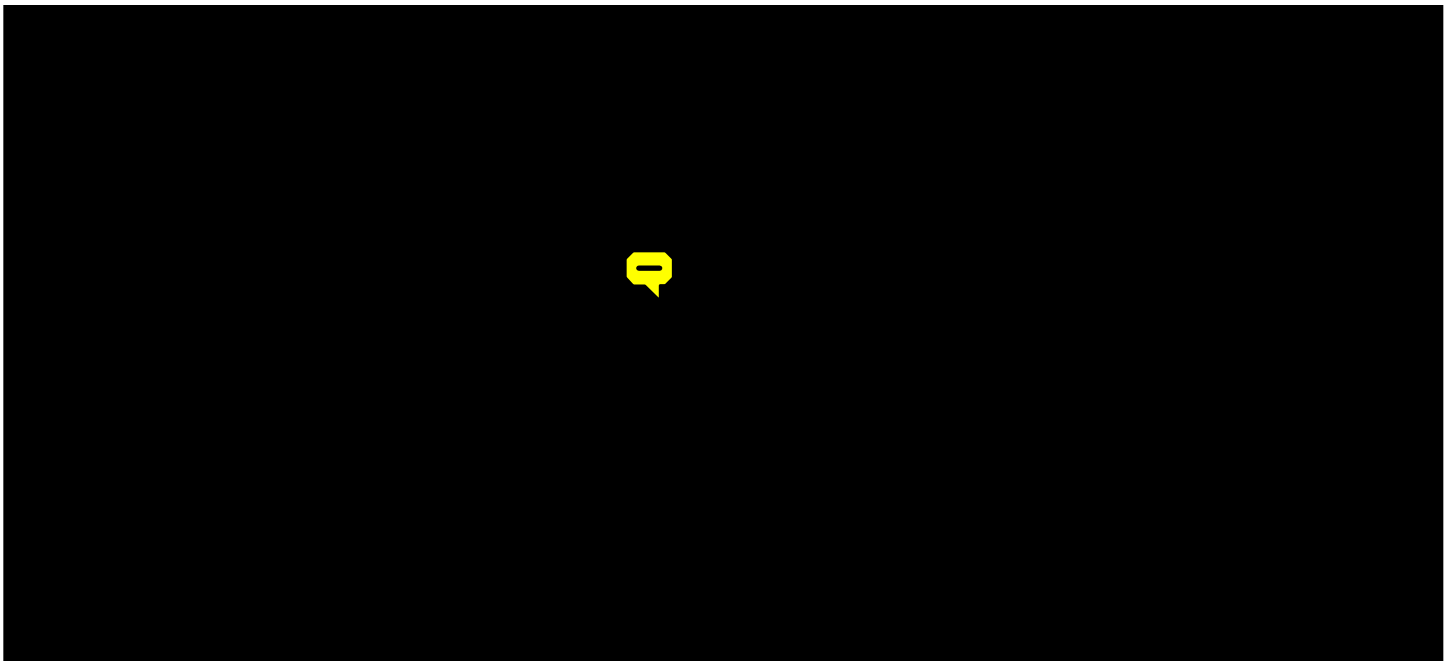
There were a total of 276 items not answered because of respondent refusal. Of these, 63.8 percent were population questions and 19.9 percent were housing questions. The other 16.3 percent of the refusals were of unknown type. As these only represent 22 refusals, they were not analyzed separately.

Conclusions—Overall, the quality assurance monitoring and resolution processes went well. However, there were problems with the monitors/ supervisors not completing the quality assurance forms as instructed in the procedures. The quality assurance forms were turned into the quality assurance sections in a timely manner. Some processing offices experienced a backlog of telephone followup calls and had insufficient staff to monitor the required number of clerks.

The quality assurance monitoring and resolution records were not always completed as specified in the procedures. For the monitoring portion of the Telephone Followup operation, it did appear as though feedback was given to the clerks as needed.

The Telephone Followup operation was successful because it allowed the Census Bureau to obtain omitted data from the questionnaires and keep record of any edit actions not resolved by the telephone followup clerks or respondent(s).

The quality assurance monitoring plan helped identify those clerks who had problems with 1) obtaining the



necessary omitted data, and 2) meeting the standards of the three monitoring characteristics. The quality assurance resolution plan helped determine 1) which clerks were not getting answers for all unresolved edit actions, and 2) how many and which questions were being refused by the respondent(s). Positive and negative feedback was provided by the supervisors/ monitors in a timely manner.

The Census Bureau is unable to demonstrate if they achieved the purpose of the quality assurance plan and the resulting feedback, that is, to improve subsequent performance by the individual telephone followup clerk. It is believed, though, that those clerks that remained throughout the operation did improve through feedback.

The quality assurance plan did have an impact on the quality of the telephone followup resolution operation by providing the estimated percentage of unresolved and refusal edit actions marked for followup. The quality assurance plan impacted the quality of the monitoring Telephone Followup operation by providing feedback to the clerks.

For similar future operations, the following suggestions are recommended:

- Train all staff that will be monitoring telephone calls or checking the resolution of completed questionnaires, how to properly complete quality assurance forms.
- Change the measurement levels on the monitoring quality assurance forms to have three rating levels (poor, average, and good) rather than five (poor, fair, satisfactory, good, and excellent). This would make it easier for the monitor to rate the clerks.
- Add a column on the resolution quality assurance form to enter the total number of housing and/ or population question(s) marked for telephone followup.
- Place monitors' desk out of view of the clerks. This will eliminate the clerks from knowing when they are being monitored.
- On the quality assurance recordkeeping form be able to identify whether a clerk was selected for quality assurance by the supervisor or at random.

Reference—

[1] Steele, LaTanya F., 1990 Preliminary Research and Evaluation Memorandum No. 117, ''Summary of Quality Assurance Results for the Telephone Followup Operation Conducted Out of the Processing Offices.'' U.S. Department of Commerce, Bureau of the Census. January 1992.

Repair

Introduction and Background—This section documents the results from the quality assurance plan implemented for the 1990 decennial census Edit Review—Questionnaire Repair operation. The Repair operation and its associated quality assurance were scheduled to last from April 2 through December 18, 1990; however, records were received with dates from March 26 to December 27, 1990. The operation took place in all seven 1990 decennial census processing offices.

Edit Review Repair was the clerical operation which reviewed all questionnaires that failed a limited automated edit due to a Film Optical Sensing Device for Input to Computers misread or identification number problem.

The quality assurance plan monitored the clerks by examining a sample of questionnaires daily. The purpose of the quality assurance plan was to ensure that clerks were performing the operation as intended by identifying

areas where they were having difficulty and enabling feedback on problems identified. In addition, the quality assurance data allowed supervisors to provide feedback to the clerks. The quality assurance plan also identified extremely poor quality work that needed to be redone.

Methodology—A clerk had to qualify to work on the operation. Test decks (a set of work prepared to cover the types of situations a clerk will encounter) were originally scheduled to be used for qualification, but they were not developed in time for the operation. Therefore, qualification for the Repair operation was based on ''live'' work units. (A work unit consisted of all questionnaires from a camera unit which were sent to the Repair unit.) Each work unit had a variable number of questionnaires, based on types of failures, and included only short-form or long-form questionnaires. If there were 50 or fewer questionnaires (either short form or long form) in a Repair work unit, all questionnaires were verified in that work unit. If there were more than 50 questionnaires in a work unit, a sample of 50 questionnaires was selected for qualification. A clerk qualified if his/ her error rate was less than 10 percent on either of their first 2 work units. Any clerk who failed to qualify after the second work unit was either retrained and requalified or removed from the operation.

For each work unit, the Repair clerk, after editing and correcting the forms, placed questionnaires into several piles depending on where each questionnaire was to go next. The quality assurance clerk selected a 5 percent sample of short-form questionnaires and a 10 percent sample of long-form questionnaires within a work unit. The quality assurance clerks examined the sampled questionnaires using the same procedures as the Repair clerks. The quality assurance clerks verified that all sampled questionnaires had been properly repaired according to procedures. For questionnaires that the production clerk did not repair, the quality assurance clerk verified that the questionnaire could not be repaired. Moreover, the quality assurance clerks verified that the questionnaires were placed in the right pile. All detected errors were corrected.

A Repair clerk was charged with one error for each questionnaire that was repaired incorrectly or placed in the wrong pile. A clerk could receive a maximum of one error on any questionnaire. The edit failures which were sent to the Repair unit were coded M, X, XP, A, and G and defined as follows.

M: Mechanical error—The questionnaire could not be read by the computer.

X: The identification number was either missing or invalid.

XP: The identification number was valid, but the questionnaire was from another processing office's jurisdiction.

A: Item A, in the FOR CENSUS USE area of the questionnaire, and the number of data defined persons differed.

G: Short form Age ''grooming'' failure—There was a written entry but the P2 circles were not filled for Age (item E).

The following formula was used to calculate error rates:

$$\frac{\text{number of questionnaires in error}}{\text{total number of questionnaires verified}} \times 100$$

Work units were rejected if two or more errors were detected.

If a clerk's weekly error rate was greater than 2 percent, he/ she was given a warning and retrained. After retraining, a ''qualification'' work unit was given to the clerk. If the clerk's estimated error rate was less than 10 percent, he/ she was able to continue working in the Repair unit. Otherwise, the clerk was removed from the operation.

The Repair quality assurance recordkeeping system involved manually recording the quality assurance data on a three-part nocarbon required Questionnaire Repair Quality Record, Form D-2011 (see form in appendix B). The original of each quality record was used by the supervisor for feedback to the clerk and kept on file in the unit. A copy was sent to the processing office's quality assurance section for data capture and generation of daily and weekly summary reports for use by the Repair unit supervisor.

The supervisor used the reports to identify the clerks with the highest error rates and the types of errors that occurred most frequently. The supervisor used this information to provide feedback to the clerks highlighting the weak points.

To calculate standardized statistics for determining outliers (processing office(s) significantly different from the others), it is assumed that the seven processing offices are a sample from a population of processing offices and thus, the estimate of the variance is as follows:

$$\sigma^2 = \frac{\$\$p_i - p\$^2}{n-1}$$

where:

p_i = the proportion of sample questionnaires that are incorrect in the i^{th} processing office;

p = the proportion of the overall number of sample questionnaires that are incorrect; i.e., the sample estimated error rate; and

n = sample size.

Thus, asymptotically standard normal statistics are calculated as follows:

$$X_i = \frac{p_i \$ p}{\$\frac{\$p_i \$ p\$^2}{n \$ 1}}$$

The resulting standardized statistics are ranked from low to high and, in that ranking, the k^{th} value is referred to as the k^{th} order statistic. The standardized statistics were compared to a table of expected values for standardized order statistics at the $\alpha = .10$ level of significance. For more information on this methodology, see [1].

Limitations—The reliability of the evaluation for the Repair operation is affected by the following:

- The accuracy of clerical recording of quality assurance data onto form D-2011.
- The accuracy of keying the quality assurance data.
- All standard errors are calculated assuming simple random sampling.
- Varying conditions of the materials received in the processing offices may have impacted the estimated quality of work in various operations. For example, the quality of the questionnaires received in one processing office may have been poorer than those received in another processing office. Thus, the Repair operation would have been more difficult in the first processing office which may lead to higher error rates for that processing office.
- The assumption that the verifier is correct. Hence, what is referred to as an error may really be a difference in opinion or interpretation of procedures.

Results—Table 4.16 summarizes the overall estimated error rates for all questionnaires by processing office. The overall estimated incoming error rate for the Repair operation was 2.5 percent. The estimated incoming error rates ranged from 1.4 percent (Baltimore) to 5.0 percent (Albany).

The normalized estimated error rates are shown in the standardized error rate column in table 4.16. There were no statistical differences among the seven processing offices. Thus, the processing office error rates were from the same distribution.

Table 4.16. **Overall Estimated Error Rates by Processing Office**

Processing office	Number of questionnaires verified	Number of questionnaires in error	Estimated error rate (percent)	Standard error (percent)	Standardized error rate
Albany	95,232	4,715	5.0	.07	+ 1.9
Jacksonville	253,423	7,739	3.1	.03	+ 0.4
Austin	92,716	2,700	2.9	.06	+ 0.3
Jeffersonville	83,189	1,600	1.9	.05	-0.5
Kansas City	140,095	2,604	1.9	.04	-0.4
San Diego	101,284	1,459	1.4	.04	-0.9
Baltimore	118,121	1,605	1.4	.03	-0.9
Total	884,060	22,422	2.5	.02	NA

NA = not applicable.

Table 4.17 shows the estimated error rates of short forms by processing office. The overall estimated error rate for short form questionnaires across all seven processing offices was 2.4 percent.

Table 4.18 shows the estimated error rates of long forms by processing office. The overall estimated error rate for long form questionnaires across all seven processing offices was 3.0 percent.

For both short forms and long forms, at the .10 level of significance, there was no statistical difference among the seven processing offices. Thus, the processing office error rates are from the same distribution.

Table 4.19 provides data on the distribution of error types for the short forms among the processing offices. The total number of short form errors for each error type is

Table 4.17. **Estimated Error Rates by Processing Office for Short Forms**

Processing office	Number of questionnaires verified	Number of questionnaires in error	Estimated error rate (percent)	Standard error (percent)	Standardized error rate
Albany	67,509	3,216	4.8	.08	+ 1.9
Austin	65,181	1,885	2.9	.06	+ 0.4
Jacksonville	199,233	5,522	2.8	.04	+ 0.3
Jeffersonville	60,844	1,017	1.7	.05	-0.6
San Diego	73,307	1,084	1.5	.04	-0.7
Kansas City	97,174	1,410	1.5	.04	-0.7
Baltimore	82,913	1,120	1.4	.04	-0.8
Total	646,161	15,254	2.4	.02	NA

Table 4.18. **Estimated Error Rates by Processing Office for Long Forms**

Processing office	Number of questionnaires verified	Number of questionnaires in error	Estimated error rate (percent)	Standard error (percent)	Standardized error rate
Albany	27,723	1,499	5.4	.14	+ 1.7
Jacksonville	54,190	2,217	4.1	.09	+ 0.7
Austin	27,535	815	3.0	.10	-0.0
Kansas City	42,921	1,194	2.8	.08	-0.2
Jeffersonville	22,345	583	2.6	.11	-0.3
Baltimore	35,208	485	1.4	.06	-1.1
San Diego	27,977	375	1.3	.07	-1.1
Total	237,899	7,168	3.0	.04	NA

Table 4.19. **Distribution of Short Form Error Types by Processing Office**

Processing office	Error type					
	M	X	XP	A	G	Total
Kansas City	106	435	22	826	21	1,410
Baltimore	48	284	6	489	293	1,120
Jacksonville	259	2,037	29	2,419	778	5,522
San Diego	60	297	3	431	293	1,084
Jeffersonville	55	290	5	483	184	1,017
Austin	115	676	10	720	364	1,885
Albany	228	787	29	1,182	989	3,216
Total	871	4,806	104	6,550	2,922	15,254

displayed. The results of a chi-square test indicate that errors are independent of the processing offices. At the national level, Item A error frequency is significantly greater than any other error type at the .10 level.

Table 4.20 provides data on the distribution of error types, for long forms among the processing offices. The results of a chi-square test indicate that errors are independent of the processing offices. Pairwise t-tests at the .10 level indicate a significant difference between Item A errors and all other error types at the national level.

Table 4.21 shows the overall (short and long form) distribution of errors by error type. Overall, Item A errors made up 42.8 percent of all errors which is significantly different from all other error types at the .10 level.

Figures 4.11 and 4.12 represent learning curves for the weighted estimated error rates by production for the average clerk for both short and long forms, respectively. A combined learning curve (combining both short and long forms) is not included, since it is similar to the short form learning curve in figure 4.11. The reason for the similarity is that Repair clerks worked primarily on short forms and hence, the short form results dominate the long form results.

For figures 4.11 and 4.12, the quality assurance samples for both short and long forms were weighted to represent the entire Repair population. The points on the x-axes represent the weighted number of questionnaires in the Repair population.

Both figures illustrate a cumulative and an interval learning curve. The cumulative curves represent the ongoing average estimated error rates of all clerks after a certain number of questionnaires were reached. For example, the average short form clerk had an estimated 3.1 percent error rate after his/ her first 260,000 questionnaires. Thus, the point ''260,000'' represents a cumulative total of all clerks from 0 to 260,000 questionnaires. This definition includes all clerks in that range. Therefore, if a particular clerk worked on only one questionnaire, he/ she is represented in this cumulative learning curve. The interval curves represent the average estimated error rates between two consecutive points on the x-axis. For example, the point ''260,000'' on the x-axis of the short form interval curve represents the average clerk's estimated error rate after completing at least 227,500 questionnaires but less than 260,000 questionnaires. Moreover, the average short form clerk had an estimated error rate of 1.4 percent between 227,500 and 260,000 questionnaires.

The rise in the short form interval learning curve at 292,500 questionnaires is an anomaly and cannot be explained. The increase after 390,000 questionnaires is mainly because points ''390000'' and ''650000'' represent only 1.3 percent of the short-form questionnaires. Approximately 98.7 percent of the Repair workload had been processed before point ''390000.'' Moreover, only 26 clerks ''repaired'' more than 390,000 questionnaires and only 2 clerks ''repaired'' more than 650,000. Thus, the estimated error rates have a relatively large variance as the number of clerks decrease. The cumulative curve shows a steady downward trend, indicating quality improvement in the clerks' work.

The long form interval learning curve in figure 4.12 follows an overall downward trend throughout the operation. The ascents from 10,650-14,200 and 17,750-21,300 probably reflect the fact that Repair clerks were constantly being moved to other operations to assist with backlogs. Observation reports indicate that all processing offices at one time or another had to move Repair clerks to other operations. The ascents from 28,400-31,950 and 35,550-56,800 represent only 1.4 and 1.8 percent of the long form workload. Thus, these estimated error rates are somewhat unreliable. The long form cumulative curve shows an overall downward trend from the start to the end of production. This steady decline in long form production estimated error rate shows that there was continual quality improvement in the clerks' work throughout the operation.

It is estimated that, without quality assurance, the estimated error rates for short and long forms would have been about 3.3 and 3.6 percent, respectively. The weighted operational short form estimated error rate was 2.4 percent; therefore, out of the 12,923,240 short form questionnaires in the Repair population, approximately 120,147 more short form questionnaires (0.9 percent) were ''repaired'' correctly due to the quality assurance plan. The weighted operational long form estimated error rate was 3.0 percent; therefore, out of the 2,378,990 long form questionnaires in the Repair population, approximately 13,734 more long form questionnaires (0.6 percent) were ''repaired'' correctly because of the quality assurance plan.

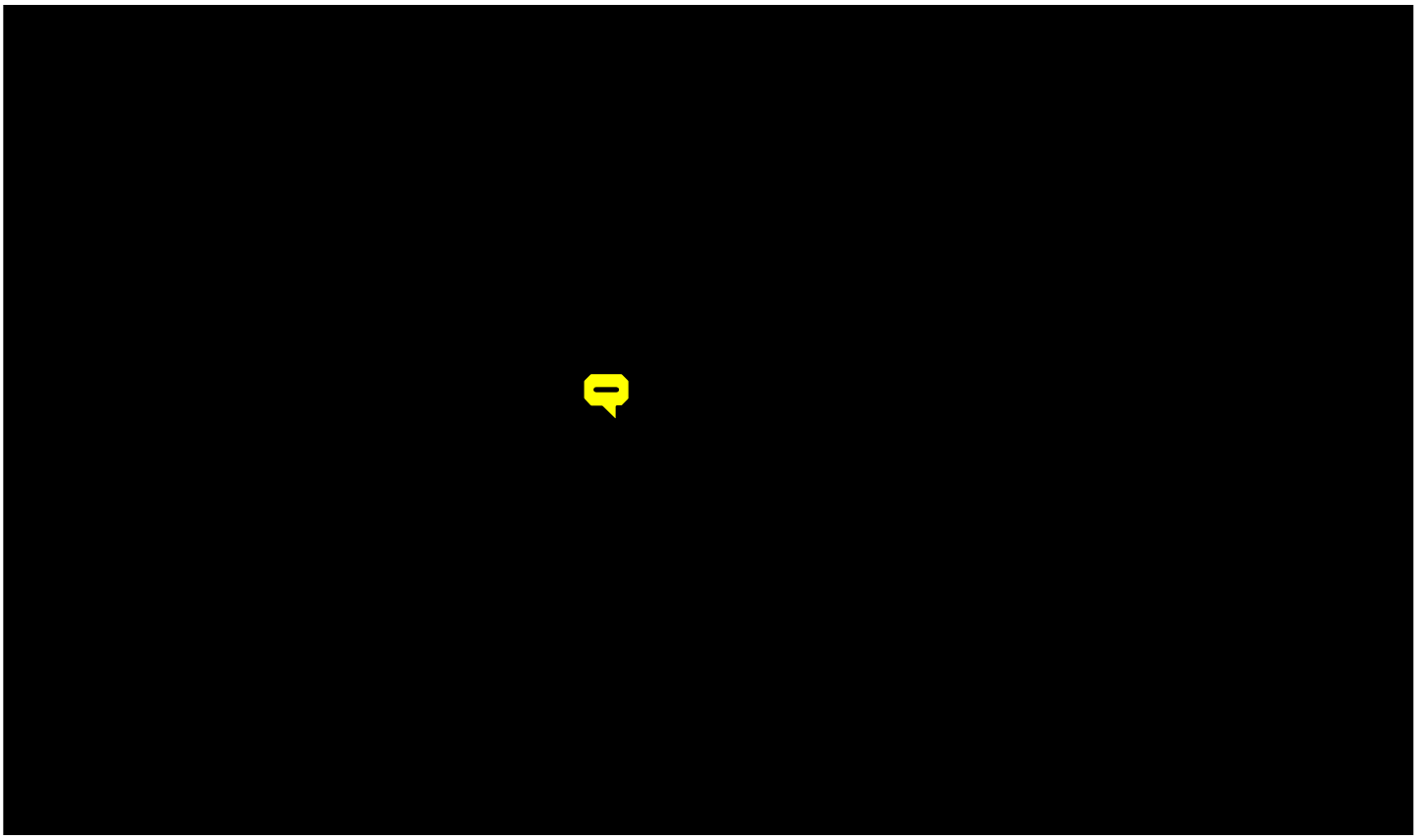
Conclusions—The quality assurance plan fulfilled its purpose. The learning curves show that learning took place.

Table 4.20. **Distribution of Long Form Error Types by Processing Office**

Processing office	Error type					
	M	X	XP	A	G	Total
Kansas City . .	136	414	30	573	41	1,194
Baltimore	117	159	6	202	1	485
Jacksonville . .	496	888	7	820	6	2,217
San Diego . . .	39	137	0	198	1	375
Jeffersonville .	83	235	2	261	2	583
Austin	175	342	4	291	3	815
Albany.	284	493	19	694	9	1,499
Total	1,330	2,668	68	3,039	63	7,168

Table 4.21. **Proportion of Repair Errors by Error Type**

Error type	Frequency	Percent of total
A.	9589	42.8
X.	7475	33.3
G.	2985	13.3
M.	2201	9.8
XP.	172	0.8
Total.	22422	100.0



Estimated error rates for clerks decreased steadily over time. This implies that feedback on types of errors was given to clerks on a timely basis and resulted in improved quality. Supervisors were able to identify areas of difficulty for clerks.

The quality of the overall operation was good in that the overall estimated error rates on a questionnaire basis for short- and-long form questionnaires (2.4 percent with a standard error of 0.02 and 3.0 percent with a standard error of 0.04, respectively) were relatively low.

Overall, Item A errors made up 42.8 percent of all errors (short and long forms). An Item A error indicates that Item A in the FOR CENSUS USE area and the number of data defined persons on the questionnaire differ. Observations and trip reports indicated that a significant number of type 2/ 3 district office questionnaires with Item A errors were being sent to expert review. This type of error originated in the district offices and most were sent to expert review at the processing offices. This suggests that some questionnaires were edited incorrectly in the Clerical Edit operation at the district offices.

The following recommendations are made based on the results of the Repair operation.

- A better system for handling an operation's backlogs needs to be devised. It is recommended that the causes of the backlogs be reviewed to determine what contingency planning might have alleviated the quality implication found in the evaluation of this operation.
- Standardized test decks should be created for qualification. The late switch to ''live'' work units for qualification caused confusion at all of the processing offices and may have caused backlogs in getting clerks qualified. If test decks had been used, clerks would have been uniformly qualified at the start, there would have been no initial backlog of work to be verified,and a wider range of error flags could have been checked.
- Simplify or automate the quality assurance recordkeeping. Automating the quality assurance forms would allow a more accurate and timely database system from which feedback could be given. If simplified, train clerks thoroughly in filling out the quality assurance forms at the start of the operation. Also, the supervisors should inspect the quality assurance forms at the beginning of the operation to ensure the verifiers are completing the forms properly. This will help ensure that quality assurance records are filled out completely and accurately. In turn, this will aid the supervisors in seeing what types of difficulties each Repair clerk is experiencing.

References—

[1] Gupta, Shanti S., ''Percentage Points and Modes of Order Statistics from the Normal Distribution,'' *Annual Mathematical Statistician,* Volume 32. pp. 888-893. 1961.

[2] Boniface, Christopher J., 1990 Preliminary Research and Evaluation Memorandum No. 160, ''1990 Decennial Census: Quality Assurance Results of the Edit Review—Quesionnaire Repair Operation.'' U.S. Department of Commerce, Bureau of the Census. July 1992.

CODING

Industry and Occupation

Introduction and Background—Keyed write-in responses to the industry and occupation items from long-form questionnaires (see items 28 and 29 in form D-2 in appendix B), Military Census Reports, and Shipboard Census Reports were assigned standard codes using a combination of automated and clerical coding methods. Automated coding was done at headquarters. Clerical coding was done at the Kansas City Processing Office.

Coding of industry and occupation responses was first attempted by the automated coder. If the automated coder assigned codes to both the industry and the occupation item, the case was complete and left the processing flow. Cases not completed by the automated coder passed to the clerical portion of the operation.

Clerical coding operated on two levels—residual and referral coding. Cases first passed to residual coding, where coders used the 1990 Alphabetical Index of Industries and Occupations (Index), and Employer Name Lists as references for assigning codes. If residual coders were unsuccessful in coding an item (industry or occupation), the case was sent to referral coding, where referral coders assigned the final code using additional reference materials.

Three-way independent verification was used to monitor the quality of both computer and clerical coding. Samples of cases were selected from: cases completely coded by the computer (computer sample), cases passed to residual coding (residual sample), and cases passed to referral coding (referral sample). Each sampled case was replicated, resulting in three ''copies,'' or quality assurance cases. These three copies were distributed among work units assigned to different coders. After the work units containing corresponding quality assurance cases were completed, the copies were matched and compared. Three situations were possible for the three clerically assigned codes:

1. Three-way agreement—all codes the same.
2. Three-way difference—all codes different.
3. Minority/ majority situation—two codes the same, one different.

A computer coded item was considered ''in error'' if the clerically assigned majority code was not a referral and was different from the computer assigned code. A clerically coded item (residual or referral) was considered in

error if it was the minority code where a clear majority existed. For tracking ''error'' rates, assignment of a referral code by a residual coder was considered a coding action.

Using these definitions of ''error,'' error rates (or ''minority rates'' when referring strictly to clerical coding) were tracked for each coder and coding unit. For each type of item (industry and occupation) the computer also tracked production, referral, and three-way difference rates. These statistics were reported for individual coders and coding units so that supervisors could identify problems as they occurred and give constructive feedback to coders in their unit.

Clerical coders were formally trained in 2 week sessions. The first week focused on coding industry responses. The industry training module ended with a series of three qualification tests. After coding the industry responses on a practice test deck, each coder coded three additional test decks. A test deck consisted of a set of industry and occupation responses similar to what a coder would encounter in production. Those who scored 70 percent correct (or better) on any of the three tests passed and went on to receive occupation training. Those who scored less than 70 percent on all three test decks were released.

Occupation training was similar to industry training—a week of classroom work followed by a series of tests. Coders completed a practice test deck, then proceeded to code the occupation responses of the three test decks used for the industry tests. Coders had to achieve a score of 70 percent or better on at least one of the test decks to qualify for production coding.

Methodology—*Error rate* was defined as the number of coding ''errors'' divided by the number of coding actions. Using definitions given previously, the error rate for a clerical coder is the relative number of minority codes assigned by that coder, and is usually called the *minority rate*. When discussing clerical coding, the terms error rate and minority rate are interchangeable. The term minority rate will generally be used when discussing clerical coding, and the term error rate will be used when referring to automated coding or a mixture of automated and clerical coding.

Test decks were primarily a teaching tool. Coding the test decks enhanced the training by giving ''hands on'' experience. A second purpose was to weed out persons that did not meet a minimum quality standard.

Two questions are of interest with regard to the test deck scores: 1) Did scores increase from test to test; that is, did learning occur during testing? and 2) Are test deck scores correlated with coder performance (error rates)?

If trainees learned from their errors, then the expected value of each successive test score should be higher than the previous one, assuming the test decks are of equal difficulty. To determine whether this was the case, a repeated measures analysis of variance was performed, treating the training sessions as blocks and the test deck scores as repeated measurements of an attribute (knowledge) on the same subject (the trainee). This type of analysis attempts to take into account the correlation between measurements taken on the same subject.

The analysis of variance tables for the effects of interest (the ''within subject effect''—learning) were generated using the SAS procedure General Linear Models (PROC GLM). To fit a repeated measures model, PROC GLM uses only complete observations; that is, cases with nonmissing values for all three industry/ occupation test deck scores (1,072 observations for the industry analysis, and 1,012 observations for the occupation analysis).

Limitations—A minority code is not necessarily incorrect. Cases came up in which supervisors judged the minority code to be correct. Since we are really interested in the probability that an item is miscoded rather than in the minority (the majority of I&O cases were coded by one coder only), using these definitions to gauge the level of error adds bias which is impossible to quantify without further study.

The minority/ error rate is a better estimate of the true error rate when there is a unique ''true'' code for each write-in. Unfortunately it is possible for all three codes in a three-way difference to be ''true.'' Further, while the minority rate for an individual coder lies in the interval [0,1,] the overall error rate based on these definitions is at most one-third, since two other coders must agree against the minority coder for an error to occur.

Some of the statistics presented in this report are based on a sample of cases. While the sample selection procedure was actually systematic random sampling, it is assumed for variance estimation purposes that simple random sampling was used. The quality assurance items were post-stratified into those coded by the computer, those coded by a residual coder (not a referral code), and those coded by a referral coder.

Estimated error rates from the 1980 census were computed based on a different verification method. The majority code from post production three-way independent coding was compared to the actual production code. Because of the differences in the estimators used, comparison of the values and their standard errors alone is not enough to make a meaningful inference.

The test decks consist of different responses, thus certain test decks may be more (less) difficult than others. Because of this fact, it is impossible to determine whether differences in successive test scores are due to learning or to the differences in the test decks.

To answer the question ''Are test deck scores correlated with coder performance?'', the estimated correlation coefficient between a coder's average industry/ occupation score and the corresponding (industry/ occupation) average minority rate was examined. Since coders did not begin production coding unless their maximum score was 70 percent or better on both the industry and the occupation tests, we are limited to the ''high'' end of this relationship. It is conceivable that coders who did not pass the

qualification tests would have performed equally well had they been allowed to continue. However, since nearly all the trainees passed, this may be a moot point.

Results—

Training/ Test Deck Scores—On average, industry test deck scores increased weakly—about 2 percentage points from the first to the second test and the second to the third test, for an average net gain of about 4.1 percentage points (standard error 0.41 percent).

Occupation test deck scores behaved quite differently, falling 2.5 percentage points on average from the first to the second test, and increasing 0.65 percentage points on average from the second to the third test, for an average net decrease of 1.72 percentage points (standard error 0.28 percent). This probably is due to differences in the test decks.

Ninety-nine percent of the trainees obtained a qualifying score of 70 percent correct (or better) on at least one of the three industry tests. Of those trainees that continued occupation training, less than 0.5 percent failed to qualify as production coders. It was more likely for a trainee to quit than to fail.

Significant correlations exist between a coder's average industry score, average occupation score, industry error rate, and occupation error rate (see table 4.22). Coders with higher test scores generally had lower error rates. Coders with higher/ lower average industry test scores tended to have higher/ lower average occupation test scores.

The F-statistic for the between subject effect (session) is significantly greater than its expected value ($p < .01$). This suggests that the mean scores for first, second, and third tests differ from training session to training session.

This is true for both industry and occupation scores. If the attributes of coders in each training session were similar, we might suspect there were differences in the effectiveness of the training—''good'' sessions and ''bad'' sessions. There is no apparent trend in the session averages over time.

The effect of primary interest is the within subject (time/ test) effect. If learning occurred, we would expect the means of successive test scores to be significantly greater. In both analysis of variance tables, the adjusted F-statistics for these effects are significant. This suggests that the mean scores of the first, second, and third tests differ from each other (regardless of training session).

Examination of adjacent pair contrasts (test2-test1, test3-test2) indicate that these differences are also significantly different from zero, but not in the way we would expect. Table 4.23 shows the average differences, along with their standard error.

The p-values for the off diagonal sample coefficients under the null hypothesis ($\rho = 0$) are all < 0.0001.

Analysis of Error Rates—To estimate the quality of coding, each case (an industry item and an occupation item) in the quality assurance sample is coded independently by three different coders. The outcome of these three independent codings is used to determine whether a code is ''correct'' or ''incorrect.''

Table 4.22. **Estimated Correlation Coefficients (ρ) Between Characteristics**

Characteristic	Industry error rate	Occupation error rate	Average industry score	Average occupation score
Industry error rate	1.0	0.32	-0.29	-0.34
Occupation error rate	0.32	1.0	-0.36	-0.44
Average industry score	-0.29	-0.36	1.0	0.63
Average occupation score	-0.34	-0.44	0.63	1.0

Table 4.23. **Average of Test(j)-Test(i), i< j**

Difference	Industry	Standard error	Occupation	Standard error
Test 2—Test 1	2.3	0.34	-2.5	0.26
Test 3—Test 2	1.8	0.35	0.65	0.23
Test 3—Test 1	4.1	0.41	-1.72	0.28

According to rules defined earlier, an item in the residual sample is ''in error'' if it is the minority code. The other two codes in a minority/ majority situation are said to be ''correct.'' For the computer, the error rate is the number of times the clerical majority code was not a referral *and* did not match the computer assigned code divided by the number of items coded by the computer.

During production, a referral code was considered an assigned code for quality assurance purposes. Thus, a referral code which was the minority code was considered ''in error.'' This rule is useful in detecting the situation where coders defer cases to the referral lists rather than risk being ''wrong.'' The minority rates reported on all Management Information System reports were calculated using this convention. Note: *Unless otherwise stated, all error/ minority rates discussed in this report are calculated by considering a referral code as an assigned code.*

A significant portion of the minority codes (23.0 percent of industry and 17.4 percent of occupation) were referral codes. Also, 18.8 percent of the industry minority codes and 11.8 percent of occupation minority codes were meaningful codes that were in the minority because the other two independent coders referred the item.

Whatever the decision about how referral codes affect the error definition, the error definition can be used to compute the probability that a particular item (industry or occupation) was coded/ acted upon correctly. This probability, the ''success rate'' is one minus the error rate. Success rates are estimated for each code source in table 4.24. Success rates for items coded by the computer are based on computer coded items from all three samples (computer, residual, and referral).

Perhaps a better indicator of the quality of coding is the non-referral three-way agreement rate. In some sense,

Table 4.24. **Estimated Accuracy of Coding**

Cases coded by. . .	Industry			Occupation		
	Percent coded	P(correct)	Standard error	Percent coded	P(correct)	Standard error
Automated coder. .	57.8	0.90	0.0005	36.8	0.87	0.0008
Residual coding. . .	36.0	0.87	0.0006	56.8	0.86	0.0005
Referral coding . . .	6.2	0.86	0.001	6.4	0.87	0.001
Overall.	100.0	0.89	0.0004	100.0	0.87	0.0004

there is more confidence in the final code when all three coders agree. Table 4.25 shows the non-referral three-way agreement rates for each coding source.

Ideally, we would like to increase the number of three-way agreements, and decrease the number of three-way differences. This might be achieved by studying the three-way differences and refining the coding procedures for those types of responses.

Day Shift vs. Night Shift—Most of the clerical coding was done by residual coders. Residual coding was done on two shifts—day and night. Table 4.26 compares various quality measures for the two shifts. Estimated standard errors are given in parenthesis for estimates based on a sample. The production rate, expressed in items coded per hour, is not broken down by industry and occupation, since coders coded both response types simultaneously. Except for the production rate, the estimates in table 4.26 (including their standard errors) are expressed as percentages.

Table 4.25. **Non-Referral Three-Way Agreement Rates**

Code source	Industry	Occupation
Computer coded items.	75.5	67.2
Residual coded items.	48.2	45.7
Referral coded items	46.7	46.4

Table 4.26. **Residual Coding—Day Shift Versus Night Shift**[1]
[I= Industry, O= Occupation]

Residual coding	Day	Night	Overall
Production rate (items/ hour).	76.30	89.06	82.81
Minority rate (standard error) (percent)	12.79 (0.09) I 13.48 (0.07) O	12.70 (0.07) I 13.62 (0.06) O	12.74 (0.06) I 13.56 (0.05) O
Referral rate (percent)	13.29 I 9.22 O	12.85 I 9.26 O	13.05 I 9.24 O
Three-way difference rate (standard error) (percent)	9.37 (0.07) I 11.21 (0.07) O	9.45 (0.07) I 11.34 (0.06) O	9.41 (0.05) I 11.28 (0.04) O

[1]Figures computed from Computer Assisted Clerical Coding System data.

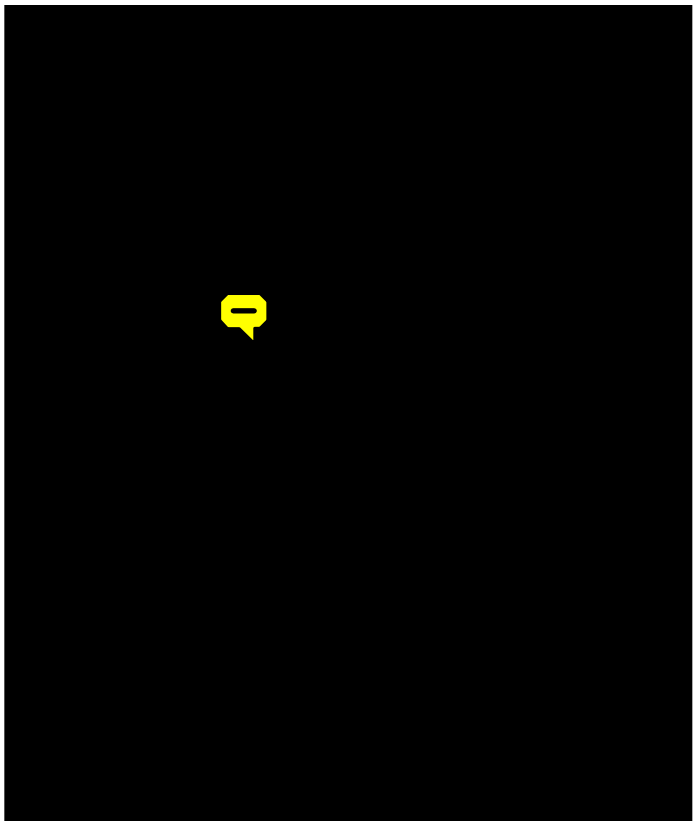
The night shift had a higher production rate than the day shift. According to observation reports filed by Decennial Statistical Studies Division staff who visited during the operation, the night shift management vigorously stressed the importance of production and promoted competition between the coding units. The night shift units created charts describing the relative standing of each coder and coding unit in terms of production rates. This may have contributed to the night shift's higher productivity.

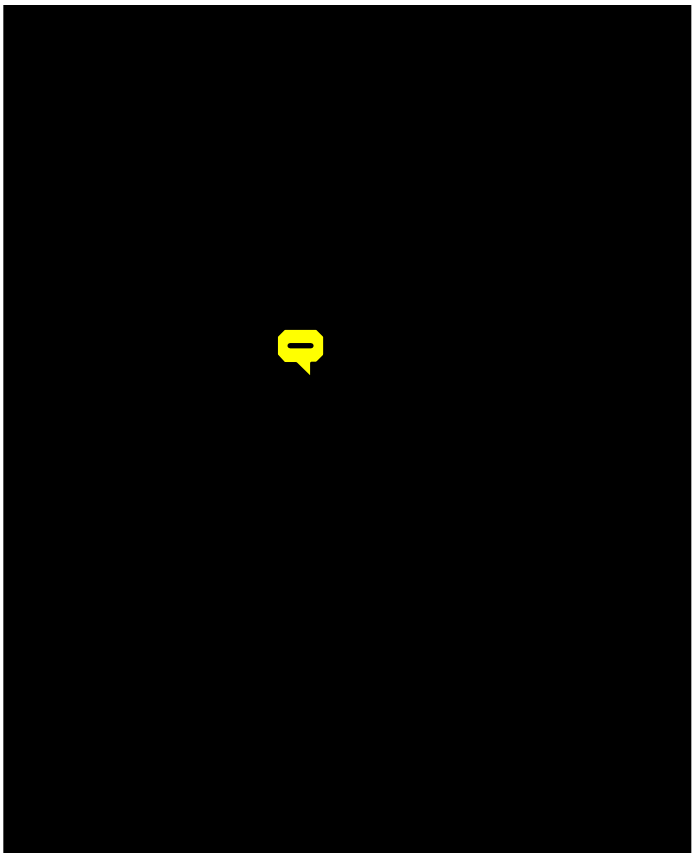
Learning Curves—The Computer Assisted Clerical Coding System tracked industry and occupation item minority rates, referral rates, three-way difference rates, and production rates. This section discusses how these quality measures changed as coders gained on-the-job experience.

Minority rates measure the level of agreement/ consistency between coders. Figure 4.13 shows the average industry and occupation minority rates as a function of coding experience measured in weeks. The minority rate for occupation was consistently higher than that for industry items.

Figures 4.14 and 4.15 compare these averages by shift. Both industry and occupation minority rates remained stable over the course of the operation. No significant difference is apparent between day and night shifts.

Figure 4.16 shows the average production rate as a function of coding experience. As expected, production rates increased steadily as a coder gained experience—rapidly at first, then more slowly. With minority rates holding steady during the same period, coders learned to code faster with the same level of quality.





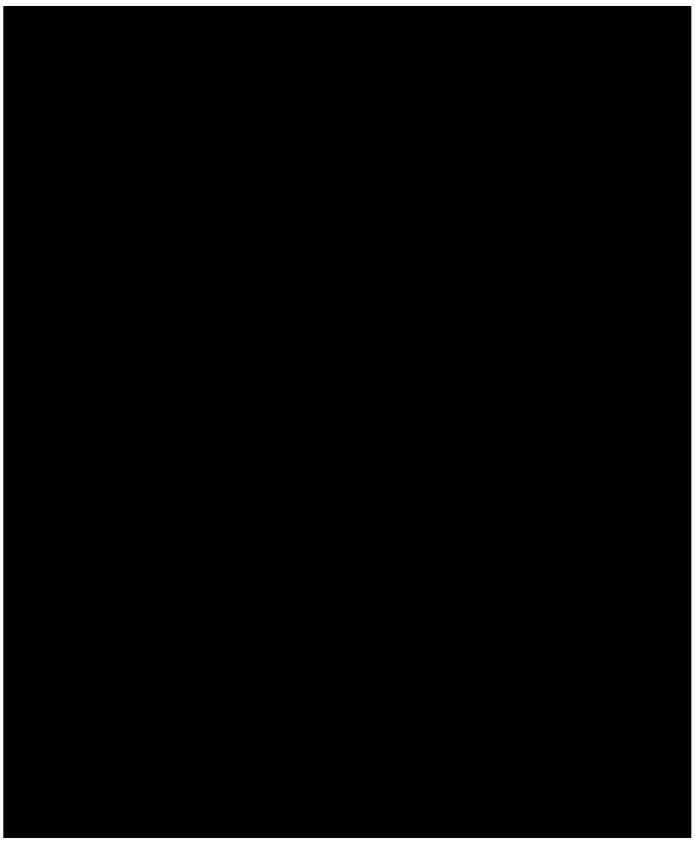


Figure 4.17 compares the production rates of the day and night shift. The graph shows that the night shift consistently outproduced the day shift.

The referral rate is the proportion of items which were assigned to referral coding. These items were considered by the residual coders to be too difficult to code using only the Index and Employer Name Lists. Because the Computer Assisted Clerical Coding System counts a referral code as a valid code to calculate a coder's production rate, there is perhaps some incentive for coders to refer a case rather than spend more time searching for a meaningful code.

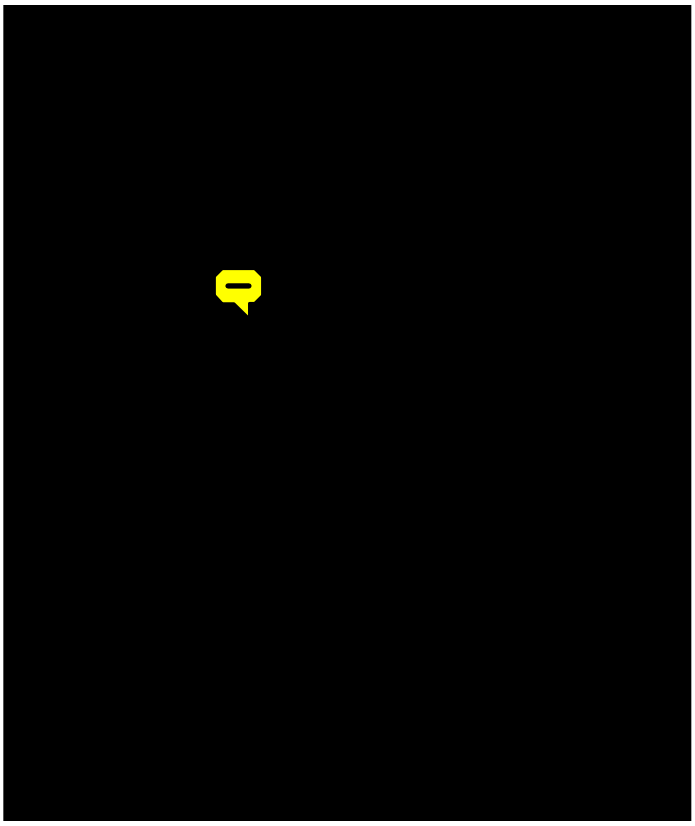
Figure 4.18 shows the referral rate for industry and occupation items as a function of coder experience. Surprisingly, the referral rate for industry items was higher than that for occupation items. A slight upward trend is apparent among the occupation referral rate in figure 4.18, while the mean industry referral rate remained stable. This is seen more clearly in figures 4.19 and 4.20 which compare these two types of referral rates by shift. There was no practical difference in referral rates between shifts.

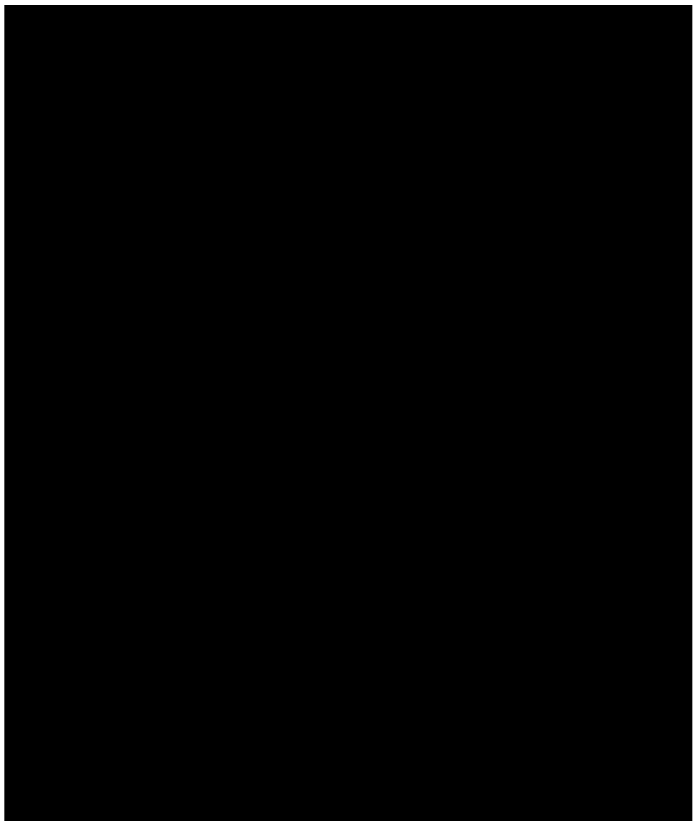
Except for an initial surge in the production rate and a slow increase in the referral rate on occupation items, the amount of time a coder had been coding seemed to have very little effect on any of the quality measures under study. Type of response (industry versus occupation) and shift had much greater effects.

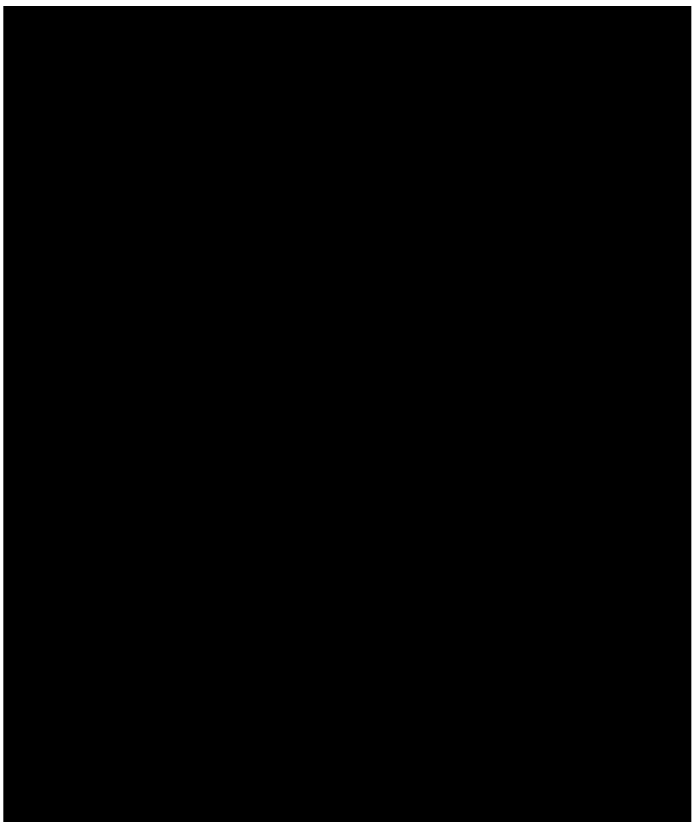
From the outset, industry items were expected to be easier to code. Ironically, industry items had a higher referral rate, which implies that residual coders were more confident about coding occupation items than industry items. A possible explanation is that the computer coded the ''easy'' industry items, leaving the more difficult cases to the residual coders. Minority rates and three-way difference rates were lower on industry items. This means there was generally more agreement on industry codes than occupation codes; that is, when coders were able to assign a code, then the case was straightforward.

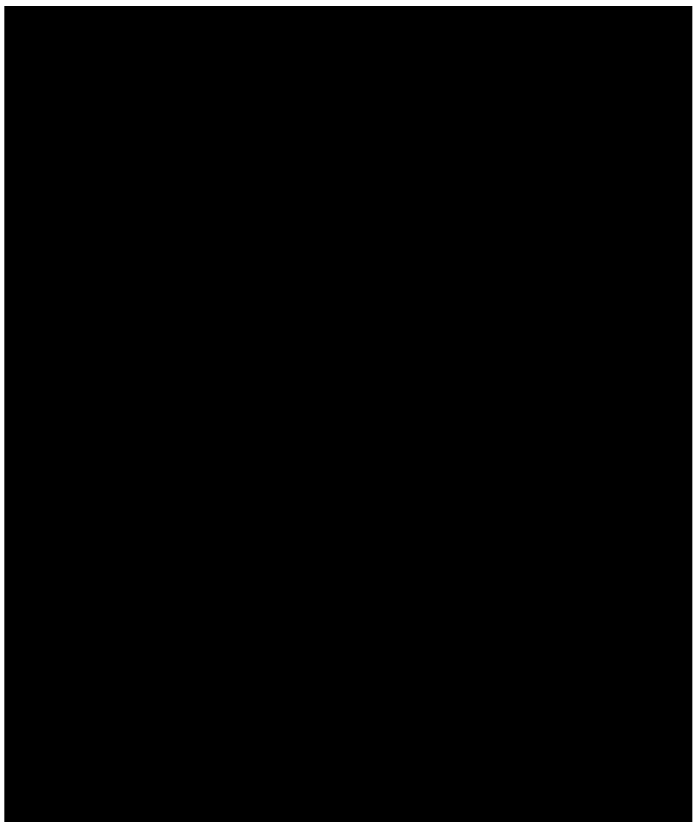
The night shift had a notably higher production rate than the day shift. With respect to all other quality measures, the two shifts performed similarly. Both shifts thus coded items with the same consistency, but the night shift did so faster. The night shift management stressed production, and tried to promote a competitive environment. Perhaps this contributed to the differences in production rates.

Comparison With 1980 Census—The 1990 I&O coding process was largely automated, while its 1980 predecessor was not at all automated. The automated coder coded about 47 percent of all items. This reduced the workload going into clerical coding. The Computer Assisted Clerical Coding System, with its on line references and automatic data collection features, made the coding process less cumbersome and easier to monitor than the paper driven process used in 1980. Table 4.27 compares the 1980 and 1990 Industry and Occupation coding operations on a few key points.









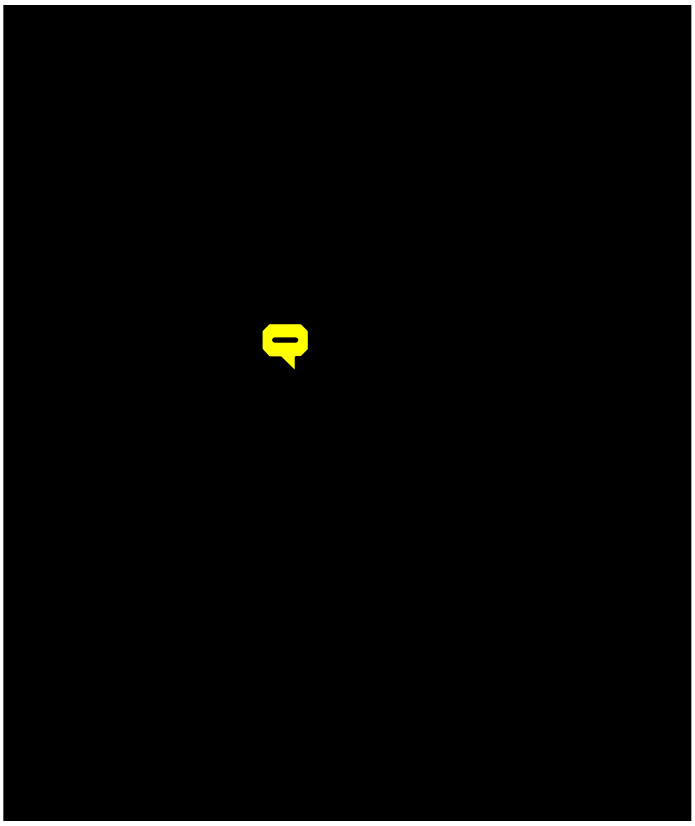


Table 4.27. **Comparison With 1980 Census**

Method of coding	1980 Clerical	1990 Automated and clerical
Estimated error rate	13.0 ± 0.5 Industry 18.0 ± 0.6 Occupation	9.0 ± 0.06 Industry 11.0 ± 0.05 Occupation
Operation time	13 months	7 months
Number of items processed	43.2 million	44.3 million
Number of processing sites	3	1
Number of coders (at peak production)	1200	600+

The estimated error rates reported in this table for the 1990 operation were computed without including indeterminate cases caused by referrals. This adjustment is thought to make 1980 and 1990 error rates more comparable; however, error rates for 1980 and 1990 were computed by different methods, and should not be compared based on standard error alone.

Conclusions—In terms of processing time and convenience, the Industry and Occupation coding operation was much better in 1990 than in 1980. The operation owes a great deal to the success of the automated coder and the Computer Assisted Clerical Coding System. The automated coder greatly reduced the workload of clerical coders. The Computer Assisted Clerical Coding System made clerical coding more convenient and easier to monitor than the paper driven process used in 1980. Automatic monitoring and report generation enabled managers to detect and correct problems as they occurred.

Codes were assigned more consistently in 1990 than in 1980. Codes assigned by the computer are inherently more consistent since the coding algorithm will always code a particular set of strings in the same way. The estimated error rates, though based on different verification systems, indicate greater consistency of coding in 1990. This is primarily due to the high productivity of the automated coder.

Because any learning effect displayed in the test deck scores was confounded by possible differences in the difficulty of the test decks, it cannot be determined whether or not the differences in the three test scores are due to learning. It is likely that the differences in scores are due to differences in the test decks.

In addition to differences from test to test, there were differences in scores from session to session. While some sessions were better than others, there is no apparent pattern; that is, sessions getting progressively better or worse.

The testing functioned mainly as a teaching tool, not as a weeding out process. About 1 percent of the trainees did not pass the industry coding phase of training. Of trainees who passed the industry tests and took at least one occupation test, less than one-half of 1 percent failed. Trainees were more likely to quit than to fail. Trainees decided for themselves whether they wanted to quit rather than being dismissed on the basis of test scores.

In future operations of this type, it might prove useful to monitor the feedback that is given in terms of frequency, timeliness, and content. Also of interest would be how often a particular type of statistic (a unit minority rate, an individual referral rate, etc.) leads to the detection of a problem. With such data it would be easier to determine how well the monitoring/ feedback approach works, and to determine which reports/ statistics were most useful in detecting problems.

Advances in computing may lead to better automated coding algorithms. It is much easier to control the quality of an automated process than to control a clerical operation involving hundreds of individuals. Likewise, improved technology will hopefully increase the speed and efficiency of clerical coding systems like the Computer Assisted Clerical Coding System.

References—

[1] Mersch, Michael L., 1980 Preliminary Evaluation Results Memorandum No. 68, ''Results of Processing Center Coding Performance Evaluation.'' U.S. Department of Commerce, Bureau of the Census. January 1984.

[2] Brzezinski, Edward, 1990 Preliminary Research and Evaluation Memorandum No. 137, ''Evaluation of the Accuracy of the Three-Way Independent Verification Quality Assurance Plan for Stateside Industry and Occupation Coding.'' U.S. Department of Commerce, Bureau of the Census. March 1992.

[3] Russell, Chad E., 1990 Preliminary Research and Evaluation Memorandum No. 222, ''1990 Industry and Occupation Coding: An Analysis of Training Test Deck Scores.'' U.S. Department of Commerce, Bureau of the Census. April 1993.

[4] Russell, Chad E., 1990 Preliminary Research and Evaluation Memorandum No. 201R, ''Quality Assurance Results for the 1990 Stateside Industry and Occupation Coding Operation.'' U.S. Department of Commerce, Bureau of the Census. February 1993.

General and 100-Percent Race Coding

Introduction and Background—The General and 100-Percent Race Coding operation assigned numeric codes to write-in entries keyed from 1990 decennial census long-form questionnaires. The operation can be thought of as five suboperations each coding the responses from the ancestry, race, language, Spanish/ Hispanic origin, and relationship items (see items 13, 4, 15a, 7, and 2, respectively in form D-2 in appendix B). The 100-Percent Race Coding operation assigned numeric codes to race write-ins responses keyed from short-form questionnaires (see item 4 in form D-1 in appendix B). The same coding scheme was used for both the 100-Percent and Sample Race Coding operations.

Write-in responses from the short- and long-form questionnaires were keyed into computer files. The responses to General Coding and 100-Percent Race items were extracted from these files, to form a set of ancestry responses, a set of relationship responses, a set of Spanish/ Hispanic origin responses, a set of language responses, and two sets of race responses (one for the Asian Pacific Islander responses and one for American Indian responses). The sets of responses were sorted alphabetically and ''collapsed,'' resulting in a record for each unique write-in with a counter indicating how many times that unique write-in occurred.

The following example uses the Ancestry item to illustrate the General Coding process. The procedure was basically the same for other types of write-ins (including Hundred Percent Race coding items), except that a different set of numeric codes was used. Ancestry codes were six-digit codes, and all other types (race, language, etc.) were three-digit codes. For example, the ancestry code 009032 might mean ''Flemish German,'' and the race code 920 might mean ''American Indian.''

Item 13 of the 1990 decennial census questionnaire (long form) asks: *''What is . . .'s [person one's] ancestry or ethnic origin? Ancestry means ethnic origin or descent, ''roots'' or heritage.''* The response to this question was written in by the respondent in the box provided. This response and the responses to the same question asked about each person in the household comprise the universe of *ancestry* write-ins coded in the Ancestry Coding operation.

Each unique write-in was compared to coded write-ins in the corresponding *master file*. The master files were created using write-ins from the 1980 census, 1986 Test Census, and 1988 Dress Rehearsal. When a write-in matched (character by character) an entry in the master file, the number of responses ''contained'' in that case was added to the counter for that entry. These counters accumulated the number of times a particular write-in was encountered in the census.

Unique write-ins which did not match an entry in the master file were added, and had to be coded manually. Coding was done by subject matter experts in the Population Division at headquarters. The process was semiautomated: portions of the master file would be displayed on the coder's computer screen. Cases with a blank in the code field would be filled in by the coder. A verifier also could change codes assigned by others that they thought were inappropriate. Future occurrences of added write-ins would be automatically ''coded'' by the computer.

Methodology—A sample of each coder's work was selected for dependent verification. If the verifier disagreed with the code assigned, a ''difference'' was said to occur. Differences were of three types:

1. Nonsubjective—indicating a violation of coding procedures.
2. Subjective—indicating a difference of opinion among experts (but no direct violation of procedures).
3. Procedural change—indicating a difference resulting from a change in a coding convention occurring after coding but before verification.

The difference rate measures the level of ''disagreement'' among the coders that the code assigned was the most appropriate code for that response.

Dependent verification of a coder's work was used to monitor the coding process. All of the first 1,000 codes assigned by a coder were verified by another coder, usually the coding supervisor. After the first 1,000 codes, a 5-percent sample was verified. In addition, cases coded with 300 or more responses at the time of coding were verified.

Differences were classified into three categories: nonsubjective, subjective, and procedural change type differences. A nonsubjective difference occurred when the verifier considered the code to be inconsistent with the coding procedures. The verifier wrote ''NS'' next to such cases, and wrote in the correct code. For example, coding the race response ''Black'' as ''White,'' or coding the ancestry response ''Puerto Rican'' as ''Spanish'' would be against coding procedures and would be considered nonsubjective differences by the verifier.

If the assigned code did not directly contradict the coding procedures, but the verifier thought that another code might be more appropriate, the verifier assigned a subjective difference to the code. For instance, the coder might code the write-in ''Sanish'' as ''Spanish,'' while the verifier might have coded it as ''Danish.'' As another example, does the string ''Indian'' indicate an *American* Indian, a *South American* Indian, or a person from India? Such differences were marked with an ''S'' on the quality assurance listing along with the code the verifier would have assigned.

When a coding procedure was changed it took time for the information to circulate among all coders and even more time to revise the written coding procedures. It was possible that a procedure could change before a coder's work was reviewed. Certain codes might then seem totally inappropriate upon review when scrutinized in the light of the new procedures. To avoid this, the category of procedural change differences was developed. As an example, the character string ''Irish Scotch'' had been interpreted as referring to two ethnic groups from Ireland and Scotland. A procedural change revised this convention, as it was likely that this write-in referred to the Scotch Irish, a distinct ethnic group. During verification, writeins coded according to the former ''Irish Scotch'' convention were marked with a ''PC'' to indicate that the new procedures no longer sanctioned such a code, which was the norm when the write-in was coded.

Limitations—A difference is not the same as an error. While a nonsubjective difference is likely to indicate that an error has been made (either by the coder or the verifier), a subjective difference reflects only that the verifier would have assigned a different code, not that the code assigned is inappropriate. Consider the write-in ''Sanish.'' ''Sanish'' could be coded ''Spanish,'' ''Danish,'' or ''Uncodable'' without violating coding procedures according to the coder's judgement. While difference rates are a measure of coding quality, they are merely *correlated* with error rates.

The estimated difference rates for the 1990 operations (overall, nonsubjective, subjective, and procedural change type) are estimated using the Horvitz-Thompson estimator. To simplify the calculation of the standard errors of these estimates, it is assumed that the quality assurance cases are selected independently. This is not the case, since systematic sampling was used.

Different verifiers are more/ less likely to call a code a subjective difference. Consider the case of ''Sanish.'' Some verifiers would understand assigning a code of ''Spanish'' and not take issue with such an assignment. Others may wish to stress the importance of the possibility that the answer is ''Danish.'' The likelihood that a verifier assigns a difference is subject to a verifier effect. *Unless otherwise noted, all difference rates reported in this report include all three types of differences.*

Difference rates (called ''outgoing error rates'') from the 1980 Independent Coder Evaluation are presented for comparison. These measures, also of coder ''disagreement'' were obtained differently and are likely to have different statistical properties. Neither the 1980 outgoing error rates or the 1990 difference rates are measures of outgoing data quality. The 1980 figures are on an individual write-in basis, while each coding action in 1990 had the potential to affect many responses. The difference rates should be viewed as comparing the level of disagreement (not of error) per coding action (not per write-in).

Results—

Comparison With 1980 General Coding—The 1990 General and 100-Percent Race Coding operations were extremely successful. All of the race write-ins (both short and long form) were coded, marking the first time that write-in responses were coded on both long- and short-form questionnaires.

The 1990 General Coding operation was completed in less time by fewer coders than the 1980 General Coding operation. This is attributed to the use of automation (the automated coder, unduplicating the responses, and the computer assisted coding system). Also, fewer questionnaire items were coded in the 1990 General Coding operation than in the 1980 operation.

Outgoing data were more consistent due to the design of the 1990 operation. In 1980, individual responses were coded, allowing for two occurrences of an identical write-in to be coded differently. In 1990, codes were assigned to each unique response. Every occurrence of a particular write-in was guaranteed to have the same code, whether that code was right or wrong.

Results of quality assurance verification are given in table 4.28, along with other operational statistics.

Table 4.28. **Summary of Coding Results**

Coding operation	Number of responses coded	Number of coders	Months to complete	Codes added to master file	Difference rate (standard error)	Nonsubjective differences[1]	Subjective differences[1]	Procedural change differences[1]
Ancestry	35,248,408	16	6	921,251	1.47 (0.17)	38	42	20
Language	4,080,609	4	6	56,863	1.90 (0.26)	22	61	17
Relationship	505,797	1	6	10,115	0.74 (0.35)	70	30	0
Hundred percent race (short form)	9,882,310	6	4.5	236,216	3.95 (0.17)	35	52	13
Race (long form)	2,204,746	2	2	19,451	3.6 (0.58)	15	84	1
Spanish/ Hispanic origin	805,943	2	5	26,539	1.16 (0.57)	0	100	0

[1]Expressed as a percentage of the total number of differences.

In general, the estimated difference rates are the same or lower for the same items coded in 1990, except for the race item. This is probably attributed to the large number of responses collected (race write-ins were 100-percent coded). Hundred-percent coding, coupled with migration over the last decade, resulted in a much more diverse population of race write-ins than in 1980. As new write-ins were encountered, including many Canadian and South American Indian tribes, race code categories became more numerous and coding became more complex and open to dissent between coder and verifier.

Conclusions—The 1990 General Coding operation demonstrated that with the help of new technologies (the automated coder, and Computer Assisted Coding systems) it is possible to code write-ins more efficiently than by purely clerical methods. Difference rates were generally lower than 1980 error rates on items common to both. For the first time, a write-in item was coded from *all* (short and long form) census questionnaires. That this and the other General Coding items could be coded so quickly by such a small group of coders is a remarkable achievement.

According to the quality assurance plan, cases with more than 300 responses were to be verified with certainty. Because the write-ins entered the system in four ''waves,'' the final number of times a write-in occurred was not known until after all the responses had been received. This should be considered when designing quality assurance systems for similar operations in the future.

The computer assisted coding system did not validate a coder's initials when the coder entered the system. As a result, a few coders worked under two different sets of initials. Since the computer sampled quality assurance cases at a rate which depended upon how many cases a coder (referenced by a particular sequence of initials) had coded, 100-percent verification was sometimes done after a coder had completed their first 1,000 codes. The lack of identification validation did not cause serious operational problems. It did cause some difficulty interpreting the quality assurance reports. Had detailed statistics been generated by the management information system at the coder level the consequences could have been more serious. It is recommended that computer based systems validate the identity of a user, especially if it affects the way the system operates.

Reference—

[1] Russell, Chad E., 1990 Preliminary Research and Evaluation Memorandum No. 175, ''Quality Assurance Results for the 1990 General Coding and Hundred Percent Race Coding Operation.'' U.S. Department of Commerce, Bureau of the Census. August 1992.

Place-of-Birth, Migration, and Place-of-Work

Introduction and Background—The purpose of the Place-of-Birth, Migration, and Place-of-Work coding operation was to assign numeric codes to keyed write-in responses to the Place-of-Birth, citizenship, migration, Place-of-Work, and employer questions on long-form 1990 Decennial Census questionnaires. The Place-of-Birth/ Migration/ Place-of-Work coding operation was broken up into its constituent parts: Place-of-Birth, Migration, Place-of-Work/ Place, and Place-of-Work/ Block coding. Each of these distinct operations consisted of two parts: machine coding and clerical coding. The latter was performed by clerks using the computer assisted clerical coding system.

Identical write-in responses to Place-of-Birth, Migration, and Place-of-Work/ Place questions were grouped into clusters. The computer attempted to match the write-in responses to reference files and then assign a code with an associated level of accuracy. Computer codes assigned with high level of accuracy are referred to as *machine coded*. The Place-of-Work/ Block responses were not clustered until after machine coding. Clusters, or individual Place-of-Work/ Block responses, coded with a low accuracy level (and those which the computer could not code) were sent to the clerical coding unit.

Clerical coding was performed by the Data Preparation Division in Jeffersonville, Indiana, and the Field Division in Charlotte, North Carolina. Clerical coding operated on two levels, production and referral coding. Production coders attempted to code all clusters they were assigned. Clusters that the production coders were not able to code were referred to the referral unit. Referral coders received additional training and reference materials not available to the production coders. Referral coders did not have the option of referring clusters to a higher authority. Both production and referral coding were semiautomated using the automated coding system.

Methodology—The quality assurance plan for the Place-of-Work/ Place-of-Birth/ Migration coding involved three aspects: training/ qualification, verification, and quality circle meetings. Coders were trained and tested before beginning to code. During production, each coder was monitored. The data collected from the quality assurance monitoring were furnished to supervisors to help them make decisions and provide useful feedback to coders. By holding quality circle meetings, coders were given the opportunity to give their input on how to improve the coding operation.

Coder Training—Classroom training sessions were given to all Place-of-Birth, Migration, Place-of-Work/ Place, and Place-of-Work/ Block coders. A separate training package was used for each type of coding. Following each type of training, coders were assigned up to three test decks to determine whether they were qualified to begin.

The first or practice test deck was scored but did not count for or against the coders. Following the practice test deck, up to two additional test decks were assigned. To begin production, a coder had to code at least one test deck with an acceptable level of quality. A coder failed a qualification test deck if the number of errors exceeded the allowable errors for the type of coding.

Supervisors discussed errors with the coders before they began the next test deck. Coders who failed both test decks were retrained and given one more chance to qualify.

Verification Scheme—A three-way independent coding verification scheme was employed for the Place-of-Birth/ Migration/ Place-of-Work coding operation. A sample of clerical and machine coded clusters was replicated twice, resulting in three ''copies'' of the clustered response. The three identical clusters were assigned to three different coders for coding. The sampling rates for each type of coding were: computer: Place-of-Work, 1.0 percent; Migration, 0.3 percent; Place-of-Work/ Place, 4.0 percent; and Place-of-Work/ Block, 1.0 percent; and clerical: Place-of-Birth, 5.0 percent; Migration, 5.0 percent; Place-of-Work/ Place, 5.0 percent; and Place-of-Work/ Block, 5.0 percent.

A work unit was designed to take about 2 hours to code. The work unit sizes of the Place-of-Birth, Migration, Place-of-Work/ Place, and Place-of-Work/ Block operations were 200, 75, 100, and 50 clusters, respectively.

The machine assigned code was always used as the production code for machine coded clusters. For clerical quality assurance clusters, the majority code, as determined by the three independent coders, was used as the production code. For three-way differences, the code from the lowest numbered work unit was used as the production code.

If two out of three coders agreed on the same code and the third coder disagreed, the dissenting code was the minority code and the dissenting coder was charged with an error. This error counted toward increasing the coder's error rate. If the minority code was a referral, the coder was charged with an error. The referral rate was not based on the quality assurance sample.

Quality Circles—The quality circles gave coders the opportunity to suggest ways to improve the operation and their jobs. Some of the comments and suggestions resulted in changes to the procedures, training, or other parts of the operation.

Recordkeeping—All quality assurance data were collected and maintained by the Geography Division on the VAX cluster of minicomputers. Reports were generated daily, showing the production codes and clerically assigned codes for all quality assurance cases where a coder assigned a minority code to a cluster.

Weekly reports were generated for the supervisors. These were produced for supervisors to monitor the progress of the coders and provide constructive feedback.

Limitations—

Reviewing Place-of-Work/ Place Minority Reports—The Place-of-Work-Block coding system was set up by coding areas which made it difficult to review the minority reports. A coding area had to remain open in order to review the minority reports for that coding area. This interfered with the process, since the system would only allow one open coding area per unit at any given time.

Qualification Test Decks—Several errors were found in the computer-based instruction version of the test decks. The errors were due to changes in the software and reference files. As a result, the scoring of the test decks was not completely accurate. Unfortunately, it was not possible to change the computer-based instruction during qualification.

Error Definition—A minority code is not necessarily an incorrect code. Minority codes usually indicated when a coder was in error; however, several minority codes were found to be correct upon review. Minority rates are strongly correlated with, but should not be mistaken for, a coder's *true* error rate.

Computer Response Time—Variations in the response time of the computer system, related to the number of coders using the system simultaneously, caused the production rates of the coders to fluctuate unpredictably. Production standards were abolished early because of this variability.

Results—

Place-of-Birth—The overall estimated error, referral, and three-way difference rates for the Place-of-Birth Computer-Assisted Clerical Coding operation were 4.1, 7.7, and 0.8 percent, respectively. The standard error of the estimated error rate was 0.8 percent. The overall production rate for Place-of-Birth coding was 53.3 clusters coded per hour.

During the first 2 weeks of production, the average Place-of-Birth coder had an estimated error rate of 4.6 percent. The final estimated error rate for the operation was 4.1 percent, a relative decrease of 10.6 percent over the course of the operation. This is attributed to learning resulting from supervisor feedback.

The average size of Place-of-Birth clusters input to machine coding was 45.5 responses per cluster. The average size of Place-of-Birth clusters sent to clerical coding was 2.2 responses per cluster. This indicates that most of the large clusters were machine codable.

The average error rate on Place-of-Birth qualification test decks was 3.9 percent. The percentage of Place-of-Birth qualification scores exceeding the error tolerance (failing) was 6.5 percent.

The error rates for Place-of-Birth production coders were found to be dependent on *first* qualification test deck error rates. That is, high/ low first qualification test deck error rates were associated with high/ low production estimated error rates. However, no significant correlation was detected between the *final* (last) test deck score and error rates during production.

Migration—The overall estimated error, referral, and three-way difference rates for the Migration Computer Assisted Clerical Coding operation were 7.3, 19.9, and 1.7 percent, respectively. The standard error of the estimated error rate was 0.8 percent. The overall production rate for Migration coding was 56.7 clusters coded per hour.

During the first 2 weeks of production, the average Migration coder had an estimated error rate of 7.7 percent. The final estimated error rate for the operation was 7.3 percent, a relative decrease of 5.7 percent over the course of the operation.

The average size of Migration clusters input to machine coding was 4.1 responses per cluster. The average size of Migration clusters sent to clerical coding was 1.3 responses per cluster.

The average error rate on Migration qualification test decks was 9.1 percent. The percentage of Migration qualification test deck scores exceeding the error tolerance (failing) was 30.3 percent.

The data suggest that the *final* qualification test deck error rates were correlated with production error rates. However, no significant correlation was shown between production error rates and *first* test deck error rates.

Place-of-Work/ Place—The overall estimated error, referral, and three-way difference rates for the Place-of-Work/ Place Computer Assisted Clerical Coding operation were 3.0, 13.5, and 0.5 percent, respectively. The standard error of the estimated error rate was 0.05 percent. The overall production rate for Place-of-Work/ Place coding was 89.0 clusters coded per hour.

During the first 2 weeks of production, the average Place-of-Work/ Place coder had an estimated error rate of 3.3 percent. The final estimated error rate for the operation was 3.0 percent, a relative decrease of 10.3 percent over the course of the operation.

The average size of Place-of-Work/ Place clusters input to machine coding was 3.1 responses per cluster. The average size of Place-of-Work/ Place clusters sent to clerical coding was 1.1 responses per cluster.

The average error rates on Place-of-Work/ Place qualification test decks completed in the Jeffersonville and Charlotte Processing Offices were 6.2 and 15.6 percent, respectively. The error rate in Charlotte was significantly higher than the error rate in Jeffersonville. The percentages of Place-of-Work/ Place qualification scores above tolerance (failing) in Jeffersonville and Charlotte were 5.8 and 43.0 percent, respectively.

Place-of-Work/ Block—The overall estimated error, referral, and three-way difference rates for the Place-of-Work/ Block Computer-Assisted Clerical Coding operation were 8.8, 57.0, and 2.5 percent, respectively. The standard error of the estimated error rate was 0.03 percent. The overall production rate for Place-of-Work/ Block coding was 46.7 clusters coded per hour.

During the first 2 weeks of production, the average Place-of-Work/ Block coder had an error rate of 10.7 percent. The final estimated error rate for the operation was 8.8 percent, a relative decrease of 17.9 percent over the course of the operation.

The average size of Place-of-Work/ Block clusters sent to clerical coding was one response per cluster.

The average error rates for Place-of-Work/ Block qualification test decks completed in Jeffersonville and Charlotte were 12.6 and 21.2 percent, respectively. The error rate in Charlotte was significantly higher than the error rate in Jeffersonville. The percentages of Place-of-Work/ Block qualification scores above tolerance in Jeffersonville and Charlotte were 17.8 and 46.3 percent, respectively.

The error rates for the Place-of-Work/ Block Coding operation in Jeffersonville and Charlotte were found to be dependent on *first* qualification test deck error rates. That is, high/ low first qualification test error rates led to high/ low production estimated error rates. In contrast, the production estimated error rates for Place-of-Work/ Block in Jeffersonville were shown to be dependent on *final* qualification test deck error rates.

Quality Circles—Minutes were collected from 19 quality circle meetings—14 held in Jeffersonville and 5 in Charlotte. These meetings resulted in 501 comments and suggestions—332 in Jeffersonville and 169 in Charlotte. Table 4.29 shows the types of comments brought up during the quality circle meetings held in Jeffersonville and Charlotte.

The majority of the procedural comments from Jeffersonville were questions on how to code particular responses. Most of these questions should have been answered by the supervisor.

Workloads—Table 4.30 illustrates the total workloads assigned to the automated coder, the number of machine-coded clusters, clerical clusters, the quality assurance sample size, and the total automated coding system workload for each type of coding. Note that the quality assurance sample is the additional workload that was added to the automated coding system.

Table 4.29. **Distribution of Comments From Quality Circle Meetings**

Type of comment	Jeffersonville		Charlotte	
	Number of comments	Percent of total	Number of comments	Percent of total
Training	47	14.2	44	26.0
Procedures/ coding charts	190	57.2	34	20.1
Software/ computer reference files	62	18.7	16	9.5
Quality assurance	13	3.9	12	7.1
On site/ work site	2	0.6	43	25.4
General/ other	18	5.4	20	11.8
Total	332	100.0	169	100.0

Table 4.30. **1990 Decennial Census Workloads**

Item	POB	MIG	POW-PL	POW-BL
Total responses	37,650,494	15,281,848	5,652,626	NA
Total clusters (assigned to automated coder)	827,931	3,727,299	1,807,178	10,664,381
Machine clusters (clusters coded by the automated coder)	465,036	3,137,986	1,635,873	4,970,245
Clerical clusters (clusters NOT coded by the automated coder)	362,895	589,313	171,305	5,694,136
Quality assurance sample	40,416	71,029	117,896	850,980
Machine QA clusters	1,370	4,039	33,576	28,855
Clerical QA clusters	39,046	66,990	84,308	NA
Total clusters assigned to C-ACC	403,311	660,342	289,201	NA

Where: POB—Place-of-Birth, MIG—Migration, POW-PL—Place-of-Work/ Place, POW-BL—Place-of-Work/ Block

Coding Rates—Table 4.31 shows the overall estimated error, production, referral, and three-way difference rates for each coding operation coding.

Learning Curve Analysis—Learning curves were constructed to examine the improvement in error rates as a function of coding experience. The measure of experience in this case is time in production. It was important that a coder's first week of production be compared to the performance of other coders during their first week of production, regardless of when they started coding.

A quadratic model (figure 4.21) for Place-of-Birth learning appears to fit the estimated error rate data (R-square= .665 vs. .372). However, the fit is still poor.

Figure 4.22 illustrates the Migration learning curve. Although the operation lasted 22 weeks, the longest a coder performed MIG production coding was 14 weeks. Most Migration production coders eventually were sent to Place-of-Work Place or Place-of-Work/ Block production coding.

Figure 4.23 illustrates the 5-week Place-of-Work/ Place estimated error rate curve in Jeffersonville.

Figure 4.24 shows the production learning curve for the Place-of-Work/ Place operation in Jeffersonville. There appears to be no notable change in the Place-of-Work/ Place production rate. This is probably due to the relatively short production time. The longest that a coder performed Place-of-Work/ Place production coding was 5 weeks.

Figure 4.25 illustrates the Jeffersonville, Indiana Place-of-Work-Block estimated error rate learning curve. Although the operation lasted 17 weeks, the longest that a coder performed Place-of-Work/ Block production coding was 16 weeks.

Figure 4.26 shows the Charlotte, North Carolina Place-of-Work/ Block estimated error rate learning curve. There was a 2-month gap in production coding, only the first 12 weeks were be used to estimate the learning curve. The coders were not thoroughly retrained before they began the last 2 weeks of production coding.

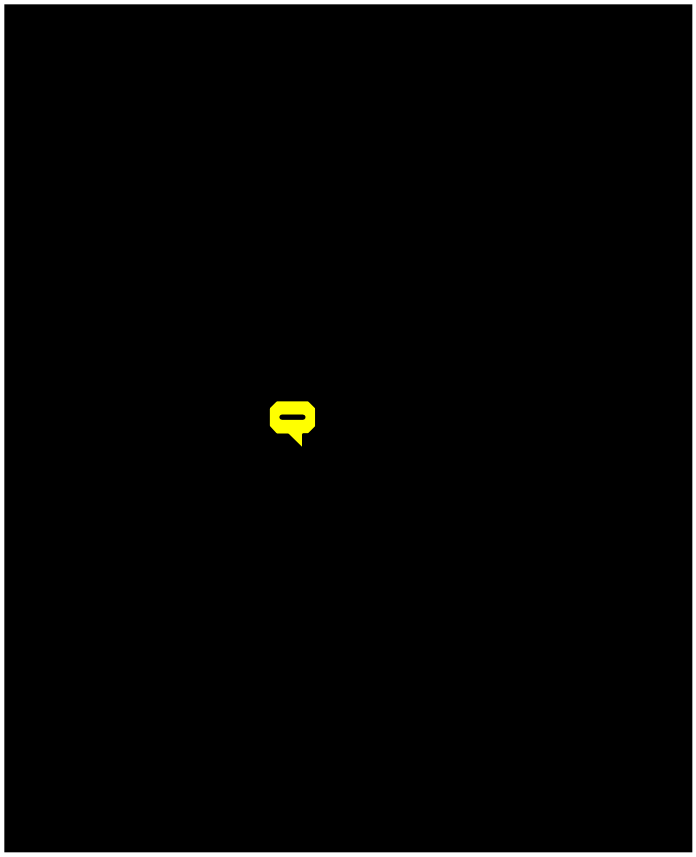
Figure 4.27 indicates the production rates increased significantly during the coders' eighth week of production. The system operated faster when there were fewer coders coding. The higher production rates observed were caused by having few coders (six) on the system during that week. In fact, the last 5 weeks represent production rates based on less than 7 coders in a given week.

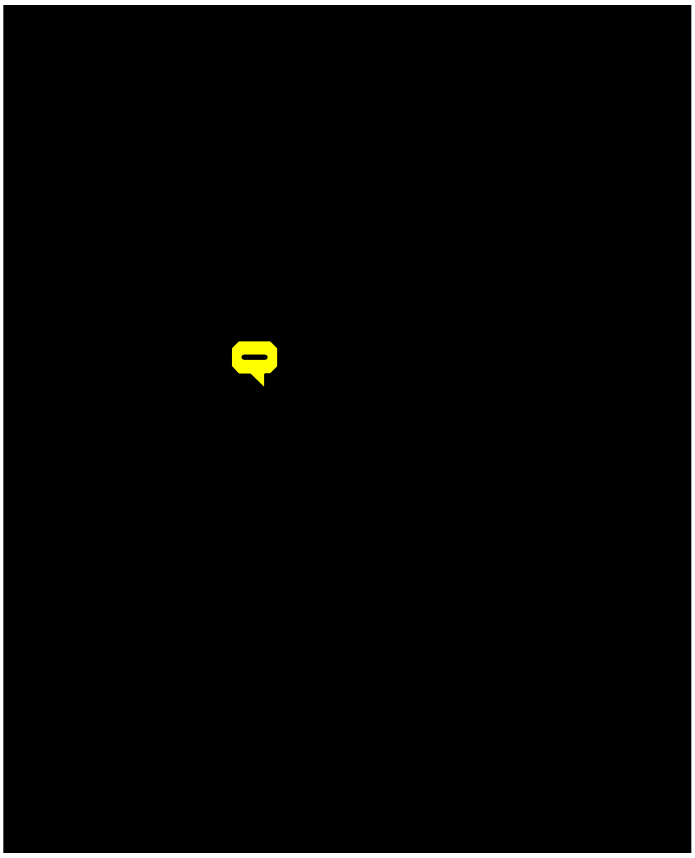
Figure 4.28 illustrates the Migration production learning curve from December 3, 1990, through May 5, 1991. Fewer than 7 coders were involved in production coding during the final 5 weeks.

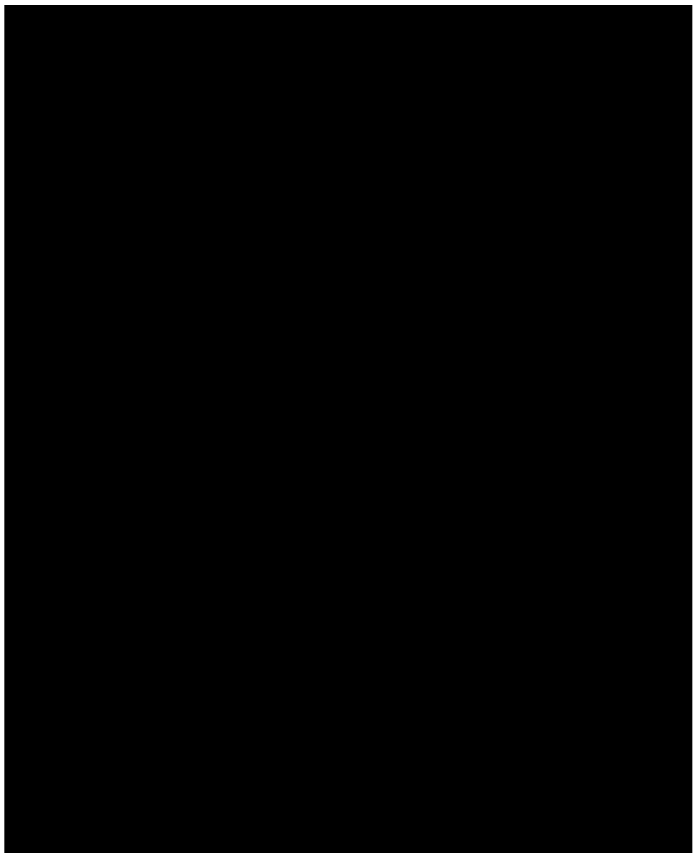
Figure 4.29 illustrates the production learning curve for Place-of-Work/ Block coding in Jeffersonville. The slight upward trend in the graph is most likely explained by improved machine capacity due to fewer coders using the system.

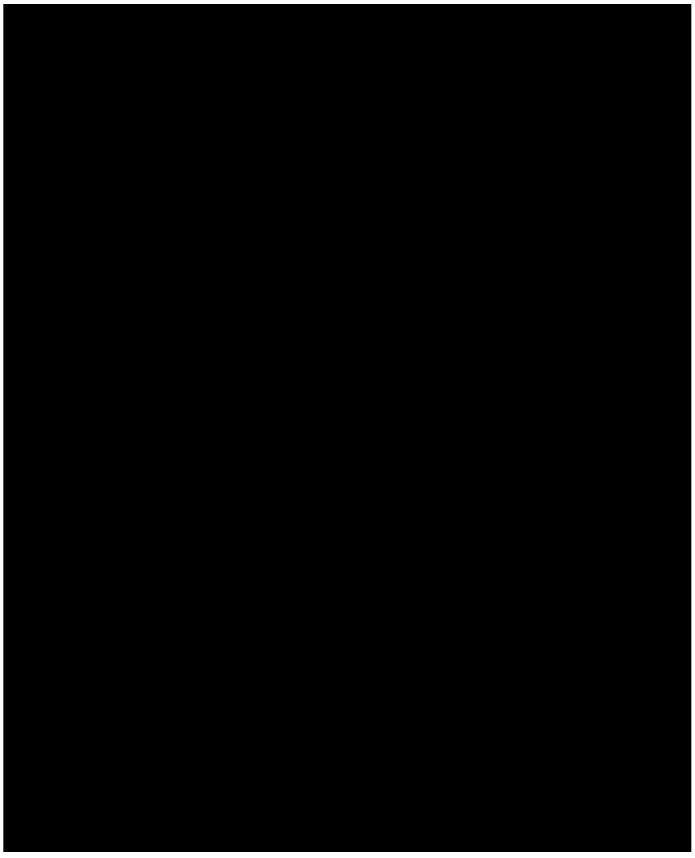
Table 4.31. **1990 Decennial Census Coding Rates**

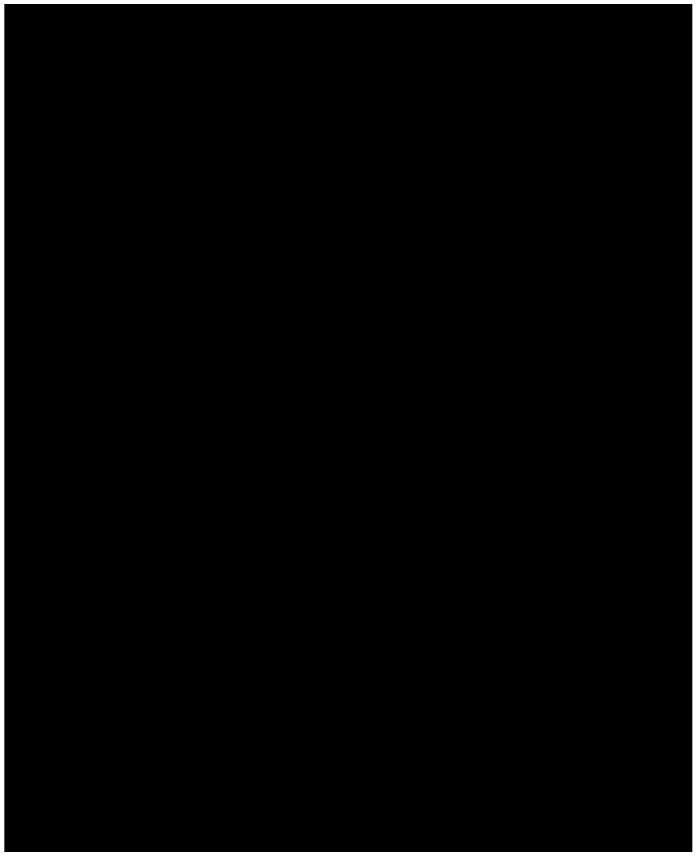
	POB	MIG	POW-PL	POW-BL
Total workload	403,311	660,342	289,201	5,694,136
Quality assurance sample	58,569	100,485	126,462	850,980
Estimated error rate	4.1	7.3	3.0	8.8
Production rate	53.3	56.7	89.0	46.7
Referral rate	7.7	19.9	13.5	57.0
Three-way difference rate	0.8	1.7	0.5	2.5

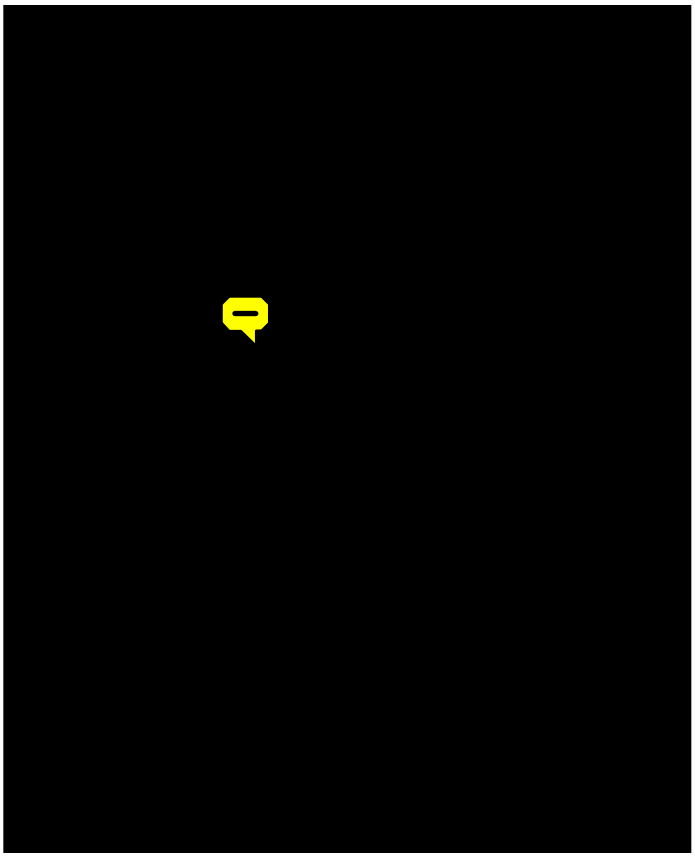


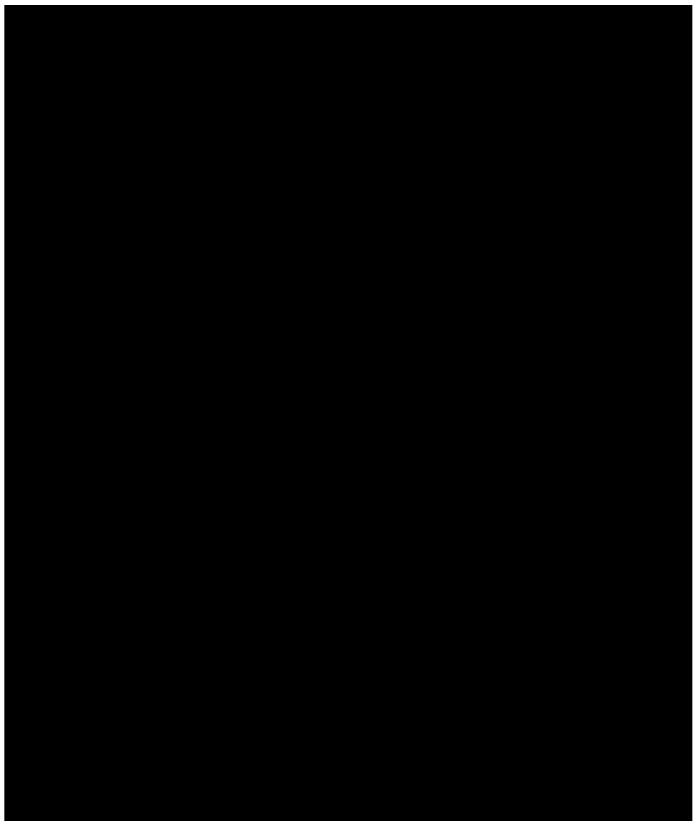


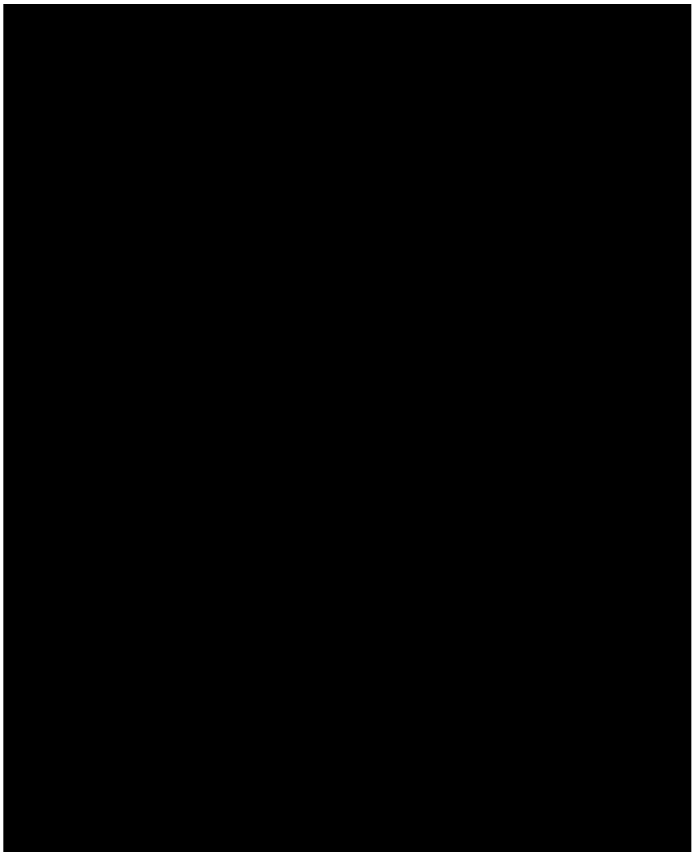












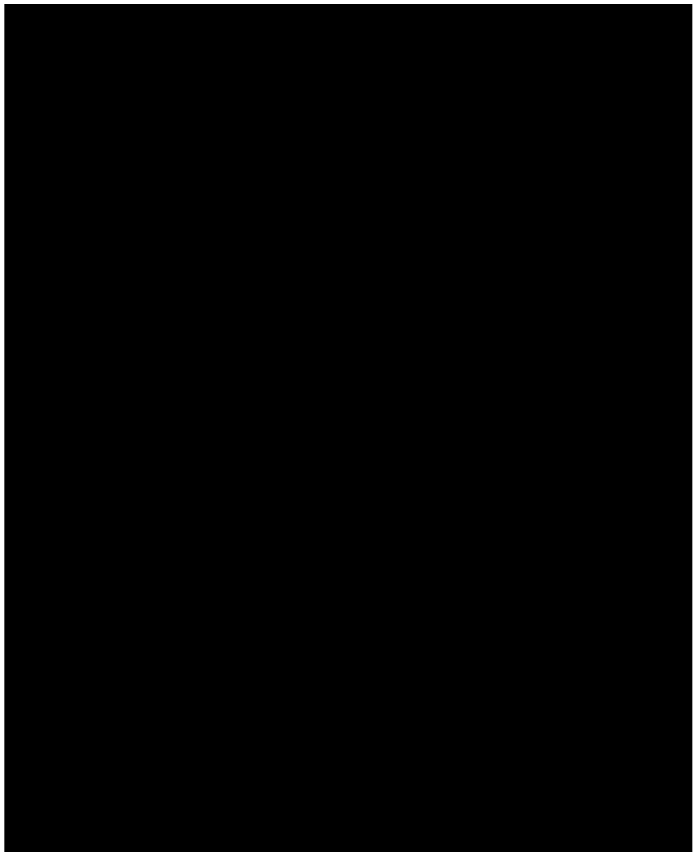
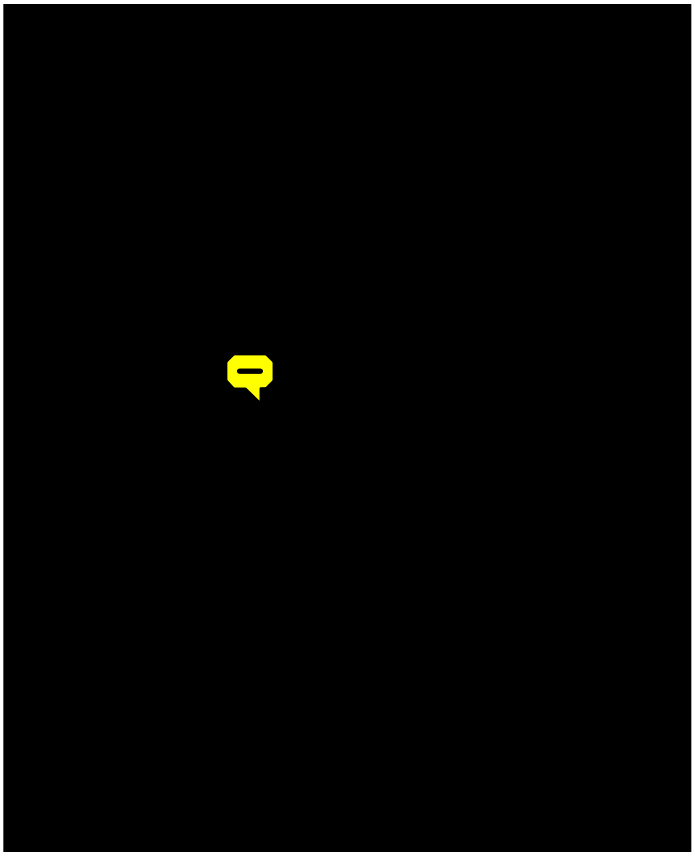


Figure 4.30 illustrates the Charlotte Place-of-Work/ Block production learning curve for Charlotte. The upward trend is probably due to fewer coders using the system toward the end of the operation. During the eleventh week, only 24 Place-of-Work/ Block coders, probably the best coders, performed production coding.

Conclusions —The quality assurance plan was developed to ensure that the computer assisted clerical coding system for the 1990 decennial census operated under a process control system. The quality assurance system improved the quality of the computer assisted clerical coding system production coding over the course of the operation. The quality assurance reports provided daily and weekly information concerning the coders performances to the supervisors for feedback. The supervisors felt that the reports were useful in detecting coders that were having difficulties understanding or following the procedures, with the notable exception of the Weekly Outlier Reports. These would have been more useful had they covered a time period longer than a week. As they were, they simply burdened supervisors. The quality circle program collected several recommendations which resulted in revisions to the procedures and improvements to the overall computer assisted clerical coding system. There was no convincing evidence of correlation between test deck scores and production error rates for all of the operations. Ideally, test deck error rates should be correlated positively (and strongly) with later production error rates. If they are not, then the test decks cannot serve their purpose, which is to predict whether the coders will perform adequately during production. If the test deck approach is to be used in the future, the test decks themselves should be tested carefully for their predictive ability early in the census cycle.



The Daily Supervisory Dependent Review of Coders Report showed only the final codes, not the matched reference file records. To verify that minority coders were in fact incorrect, the supervisors were required to translate these codes into names using a hard copy equivalency list. This made it very time consuming to review the reports and difficult to provide timely feedback to coders based on these reports. Modifying the Geography Division software to allow supervisors the capability to display the record that the coder matched in the reference file, rather than the numeric code, would make the supervisory review much easier. The Weekly Coder Outlier Report was generated too frequently to be effective. A report containing the last 4 weeks of outliers, by coder within coding unit, might be more useful while easing the paper burden on supervisors.

An on site quality circle coordinator and the coordinators from headquarters should be identified while the project is still in the testing and design phase. The site coordinator should be a permanent census employee physically located at the coding site and assigned to headquarters. This would bring the coordinator into the project prior to starting production, and allow the coordinator time to become familiar with all aspects of the project.

The computer sampling programs should be tested prior to production and preferably during the dress rehearsal of future censuses to ensure their accuracy.

‘‘Large’’ clusters that are not exact (machine) matches should be included with certainty in the quality assurance sample. The remainder of the clerical and computer quality assurance clusters should be selected randomly from the remaining clusters.

The average quality assurance sample size for Migration and Place-of-Work/ Block work units was small, 11 and 7 clusters, respectively. Although the percent of quality assurance clusters within a work unit should not be changed, it is recommended that a coder complete a sufficient number of work units, that is accumulate a certain number of quality assurance cases, such as three consecutive Migration work units or four consecutive Place-of-Work/ Block work units, before their error rate is estimated and compared to the rectification level.

Reference—

[1] Falk, Eric T. and Russell, Chad E., 1990 Preliminary Research and Evaluation Memorandum No. 145, ‘‘1990 Place-of-Birth, Migration, and Place-of-Work Computer-Assisted Clerical Coding Quality Assurance Results.’’ U.S. Department of Commerce, Bureau of the Census. May 1992.

DATA KEYING

Race Write-In

Introduction and Background—The census questionnaires requested information on race for all persons. Respondents had the option of selecting one of the specific categories listed on the questionnaire or entering a write-in answer to identify an American Indian tribe or an Other Asian/ Pacific Islander race not listed. Write-in responses were accepted for both the race question (item 4 on the census questionnaire) and the Hispanic origin question (item 7); however, only the race question was keyed during the Race Write-In Keying operation. Keyed race responses were assigned numeric codes for inclusion in the 100-percent edited detail file.

The Race Write-In Keying operation was implemented by Decennial Management Division (formerly Decennial Operations Division) and was performed at each of the seven processing offices. The operation lasted from May 16, 1990, through December 31, 1990. During this period of time, approximately 15,245,991 race write-in entries were keyed from 5,404,102 short-form questionnaires on microfilm using the Microfilm Access Device machines. A total of 111,307 camera units (batches made up of questionnaires) were processed. Long forms and other census questionnaires were processed in other operations.

The Decennial Statistical Studies Division designed the quality assurance plan to be implemented during the Race Write-In Keying operation. The plan was designed to detect and correct keying errors, to monitor the keying, and to provide feedback to the keyers, to prevent further errors.

The collected quality assurance data were analyzed, and the results were documented (see [1]). The primary objectives of the data analysis were to determine the quality of keying of race write-in entries, to identify and examine variables that may affect keying, and to evaluate the effectiveness of the quality assurance plan.

The Decennial Statistical Studies Division also designed an independent study of the 1990 race write-in keying quality assurance plan. The study compared a keyed sample of race write-in entries to the corresponding final census file of race write-in responses.

The results were analyzed and documented (see [2]). The objectives of the independent study were to estimate the quality of the final keyed file of race write-in responses, to obtain insight into the types and reasons for the errors, and to assess the impact of critical errors on the usage of the race write-in data.

Methodology—

Quality Assurance Plan—The race write-in keying quality assurance plan involved a two-stage quasi-independent sample verification, first on the batch level, then on the within-batch or questionnaire level.

1. *Batch level*—The first 30 batches for each keyer were verified. If a keyer's sample field error rate for these 30 batches did not exceed 2.5 percent, then a 20 percent sample of batches was selected for verification thereafter. If a keyer's sample field error rate for the most recent 5-day period exceeded 2.5 percent at any time, then all batches completed by that keyer were verified until the field error rate for a 5-day period was less than 2.5 percent.

2. *Questionnaire level*—The questionnaire sampling rate within each batch was determined by the number of questionnaires with race write-in entries. If the number of questionnaires with race entries was less than or equal to 40, all keyed questionnaires were verified. If the number was greater than 400, 10 percent of the keyed questionnaires were verified. Otherwise, 40 keyed questionnaires were verified.

Each field on a sampled questionnaire was keyed by another keyer (verifier) and was compared to the corresponding keyer entry using a soft verification algorithm called soundx that only detected and identified significant differences (spacing differences, for example, were allowed). An error was charged to the keyer if the difference between the keyer and verifier versions exceeded the tolerance of the algorithm.

If the keyed batch failed the tolerance check, a listing was generated for all differences between the keyer and verifier field entries. If the keyer was responsible for one or more errors, he/ she repaired the entire batch.

During this process, summary data were collected and maintained in a datafile. The file contained information on the batch, volume, sample size, type of error, time, and quality decisions. After the operation was completed, specific data were extracted and analyzed to meet the quality assurance plan objectives.

Independent Study—A sample of 1,101 batches (approximately 1 percent) was selected for the independent study, 406 of which were included in the census quality assurance operation.

For each batch in the evaluation sample, every race write-in field with a response was keyed by two persons, one of whom was termed the production keyer and the other the verifier for description purposes. Two files of keyed entries were created for each batch, a production keyer file and a verifier file. These two files were merged to create an evaluation file, and if the production keyer's and verifier's entries differed, then the verifier version was included on the evaluation file. A difference listing was produced by batch, listing the production keyer and verifier versions of fields which were keyed differently. This listing and the corresponding source documentation were reviewed by a third person who determined which of the two keyed versions was correct. If the verifier version was determined

to be incorrect, then that entry in the evaluation file was corrected. For the purpose of this study, it was assumed that the keyed race write-in responses on this file accurately represent the data on the questionnaires.

After the independent study evaluation file was created, all race write-in entries on the file were compared to the corresponding entries keyed during the census operation, using the soundx algorithm. The differences detected by the algorithm were analyzed for their significance, origination, cause, and type.

Limitations—The following limitations should be considered when reviewing the results.

Quality Assurance Plan—

1. The estimates in this report not only depend on the amount of sampling error but also on the efficiency of the verifiers and accuracy of the procedures. The independent study shows evidence that estimates from quality assurance data are understated.

2. Many of the errors detected may not have been attributable to a keyer, but may have occurred due to a respondent entry that was illegible or interpreted differently by the keyer and verifier. This type of ''respondent error'' cannot be measured.

Independent Study—

1. A field keying error was critical if it was determined that the race was coded incorrectly. Therefore, the code that would be assigned to an entry had to be determined in order to classify an error as critical, and this determination of code assignment was made by the analyst for this evaluation. The analyst is not a race expert and since the assignment of codes was sometimes subjective, there may be instances where the correct or most appropriate code assignment was not determined.

   Different race codes were sometimes combined for census tabulations. Therefore, it is possible that a critical error may have affected tabulations at one level of aggregation without affecting those at another level of aggregation.

2. It became evident during the analysis for this evaluation that there were cases of race write-in responses which were not covered in the keying procedures or training, and the treatment of these cases depended on the judgement of the keyer or unit supervisor. Therefore, it was possible that a census keyer may have treated a response differently from the way an evaluation keyer treated it, yet did not make a procedural error. For this evaluation, such cases, termed respondent errors, were distinguished from cases which were obvious nonsubjective, procedural mistakes, termed keyer errors. For some of the error rates discussed in this independent study, both types of cases were included in the calculations.

3. Causes of error were determined by comparing the keyed entries to the source documentation; that is, the microfilm of questionnaires. In some cases categorizing the errors into causes depended on the judgement, or educated guess, of the analyst.

4. All verified batches could have failed verification one or more times, but they must have passed eventually. Therefore, there could have been multiple versions of keyed responses for the batches, including one version that passed and other versions which failed verification. For the purpose of this evaluation, only one version could be compared to the final evaluation file, and only the version which passed verification was available for comparison. Therefore the error rate estimates underestimate the actual error rates for the production keyers and these rates should not be used in a comparison with results from the quality assurance operation.

Results—

Quality Assurance Plan— It was estimated that the keyers committed keystroke mistakes (or omissions) in 0.51 percent of the fields keyed with a standard error of 0.01 percent. This error rate represents initial production keying. Some of these errors were corrected during later stages of the operation.

Table 4.32 shows the field error rates for race write-in keying at the national and processing office levels.

There were two boxes within the race question on the census questionnaire for which write-in responses were accepted. One box was to identify a specific American Indian tribe; the other box was to identify a specific Other Asian/ Pacific Islander race not already listed. Based on the quality assurance sample, 25 percent of race write-in entries were in the American Indian category and 75 percent were in the ''Other'' category. Kansas City was the only processing office that keyed a majority of entries in the American Indian category. Table 4.33 shows the field error rates for each category at the national and processing office levels.

The Race Write-In Keying operation lasted approximately 34 weeks. During this period, the start dates varied between individual keyers as well as the number of batches

Table 4.32. **Field Error Rate**

Processing office	Race write-in entries keyed in error	
	Percent	Standard error (percent)
National	.51	.01
Kansas City	.33	.06
Baltimore	.61	.03
Jacksonville	.42	.03
San Diego	.45	.02
Jeffersonville	.69	.05
Austin	.59	.04
Albany	.54	.04

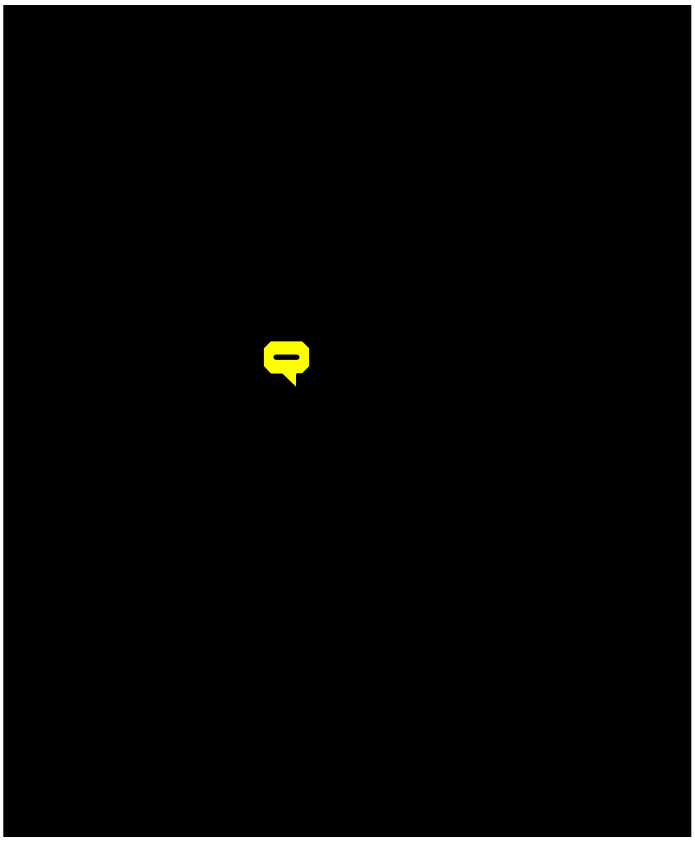
each one keyed. Analysis of the keyers' performance revealed a trend of declining field error rate over time as shown in figure 4.31.

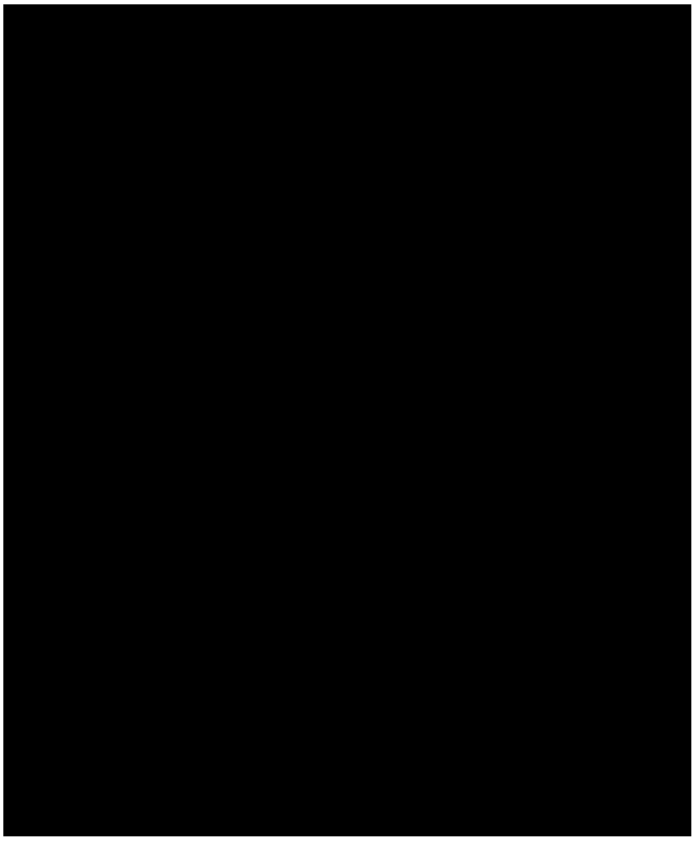
This decline in error rate represents a ''learning curve,'' which can be attributed to feedback and experience. Each interval on the horizontal axis represents 5 keying days; that is, ''1'' represents days 1 to 5. The field error rate for each keyer, on the average, decreased from 2.15 percent for the first batch keyed to 0.33 percent for the last batch keyed.

There appears to be some relationship between production rate and quality as shown in figure 4.32. As production rate increased, the field error rate decreased (quality increased). Each interval on the horizonal axis represents an increment of 0.1 keystrokes/ second; that is, ''0'' represents 0-0.1 keystrokes/ second. The latter portion of the graph is skewed due to a small number of batches keyed at relatively fast rates.

Table 4.33. **Field Error Rate by Type of Race Write-In Entry**

Processing office	Type of race write-in entry			
	American Indian		Asian/ Pacific Islander	
	Error (percent)	Standard error (percent)	Error (percent)	Standard error (percent)
National	.52	.02	.51	.01
Kansas City	.44	.08	.31	.06
Baltimore	.55	.05	.62	.03
Jacksonville	.48	.07	.42	.03
San Diego	.45	.03	.45	.02
Jeffersonville	.68	.08	.68	.04
Austin	.62	.06	.58	.03
Albany	.50	.05	.55	.05





The national average batch size was 38 questionnaires and 91 race write-in entries. This varied from the smallest average of 20 questionnaires and 44 entries at Jeffersonville to the largest average of 76 questionnaires and 196 entries at San Diego.

Approximately 71 percent of the batches contained fewer than 40 questionnaires. There is no apparent linear relationship between quality and batch size.

A batch was to fail the quality assurance tolerance check when its sample field error rate exceeded 2.5 percent. Typically, errors were clustered within rejected batches, as was the case during race write-in keying. The average field error rate of rejected batches was 5.21 percent while that of accepted batches was 0.25 percent.

Rejected batches were repaired by the original keyer and all errors were to be corrected. These batches were then to be reverified. Of the repaired and reverified batches, almost 8 percent still had a large number of errors remaining and needed to be repaired for a second time.

Repaired batches were not necessarily reverified as specified, but were resampled for verification at a rate of approximately 52 percent. Because not all rejected and repaired batches were reverified, an estimate of at least 79 batches were forwarded to the final race data file with significant amounts of error that should have been detected and corrected during the quality assurance process.

The race write-in keying quality assurance process was designed to detect and correct all erroneous or omitted race write-in entries within all verified questionnaires. Due to cost, workload, and time constraints, only 34 percent of the camera units (batches) and 16 percent of the questionnaires with race write-in entries were verified during the quality assurance process. Camera units and questionnaires that were not verified went directly to the final race datafile with undetected errors. Therefore, an estimated 0.42 percent of the race write-in entries in the final race datafile still remained in error.

Independent Study—The percentage of critical errors contained in the census race data after completion of the keying operation was an estimated 0.54 percent. The estimated critical error rate for the American Indian field was 0.66 percent, and the estimated critical error rate for the Other Asian/ Pacific Islander field was 0.49 percent. An error was critical if it was determined that the race was coded incorrectly. These estimates are not comparable to the census quality assurance error estimates because the census operation did not distinguish between critical and non-critical errors. Tables 4.34 and 4.35 show the critical error rates at the national and regional levels.

It became evident during the analysis for this evaluation that there were cases of race write-in responses which were not covered in the keying procedures or training, and the treatment of these cases depended on the judgement of the keyer or unit supervisor. For this evaluation, such cases, termed respondent errors, were distinguished from cases which were obvious nonsubjective, procedural mistakes, termed keyer errors. Keyer errors accounted for 38 percent of all critical errors in the keyed race data; the remaining 62 percent were respondent errors.

Table 4.34. **Critical Field Error Rate**

Region	Race write-in entries with critical errors	
	Percent	Standard error (percent)
National	.54	.03
Northeast	.56	.07
Midwest	.62	.07
South Atlantic	.63	.07
South Central	.47	.06
West	.51	.05

Table 4.35. **Critical Field Error Rate by Type of Race Write-In Entry**

Region	Type of race write-in entry			
	American Indian		Asian/ Pacific Islander	
	Error (percent)	Standard error (percent)	Error (percent)	Standard error (percent)
National	.66	.04	.49	.03
Northeast	1.06	.14	.45	.06
Midwest	.67	.11	.59	.07
South Atlantic	.70	.08	.60	.08
South Central	.58	.07	.40	.06
West	.55	.06	.49	.05

The percentage of critical keyer errors contained in the census race data after completion of the keying operation was an estimated 0.19 percent. The estimated critical keyer error rates for the American Indian field and the Other Asian/ Pacific Islander field are 0.19 percent.

The percentage of critical respondent errors contained in the census race data after completion of the keying operation was an estimated 0.32 percent. The estimated critical respondent error rate for the American Indian field was 0.43 percent which was significantly different from that of the Other Asian/ Pacific Islander field, 0.28 percent.

There were three primary causes for keyer errors: keying from the wrong column or field, correcting or modifying the respondent entry, and other keystroke or procedural mistakes. Of all critical keyer errors, these three causes accounted for 66 percent, 19 percent, and 15 percent, respectively.

The causes of respondent errors usually related to how the write-in response appeared on the questionnaire/ microfilm. Listed are five situations that caused keyers difficulty and their respective contribution to the respondent error total:

- Subjective (8.4 percent)—the response was very difficult to read.
- Erased (26.7 percent)—the response appeared to have been erased but was still legible.
- Outside box (9.9 percent)—a portion of the response was written outside the write-in box.
- Crossed out (32.8 percent)—the response appeared to have been crossed out but was still legible.
- None/ na/ same (8.4 percent)—the response was an uncodable entry such as ''none,'' ''N/ A,'' or ''same.''
- Other (13.7 percent).

Each of these conditions may have caused a keyer to key data incorrectly, especially if no procedure or instruction for the situation was given.

A comparison was made between the keyer error rates derived from the census quality assurance operation and the evaluation study. This comparison was limited to batches that passed verification. The results indicated that the census keyer field error rate for these batches was 0.51 percent based on the quality assurance data and 1.14 percent based on the evaluation.

The difference between the two estimates can be partially explained by how the keyers handled responses that were difficult to interpret. The completed Forms D-2114, Race Keying Verification Record, were used by verifiers to help understand how the production keyers handled these responses. Therefore, for many of the responses which required some keyer judgement, the verifier knew exactly what was keyed by the production keyer and may have keyed the same entry. On the other

hand, an evaluation keyer, working independently from census production, may have keyed the response differently. This could explain some of the difference between the quality assurance estimate and the independent study estimate of production keyer error.

Conclusions—

Quality Assurance Plan—It was estimated that 0.51 percent of the race write-in entries were keyed in error. This field error rate estimate represented all errors detected by the soundx algorithm, regardless of the origin or reason of the mistake.

The quality assurance plan specified that all rejected and repaired batches were to be reverified to detect any remaining errors. However, these batches were resampled for reverification at a rate of 52 percent and approximately 79 batches went to the final race datafile with significant amounts of error. In order to ensure maximum efficiency, each specific requirement of the quality assurance plan must be implemented.

The sample error tolerance level of 2.5 percent was used for all verified batches regardless of the number of questionnaires. As in the Race Write-In Keying operation, when the sampling scheme varies, dependent upon the batch size, the tolerance should vary similarly. This ensures accuracy in identifying poorly keyed batches.

Independent Study—The overall quality of the 100-Percent Race Write-In Keying operation was very good. Based on this evaluation, approximately 0.54 percent of the race write-in fields keyed contained a critical error; that is, the field containing a keying error was coded incorrectly.

Approximately 62 percent of the critical errors on the final census race file are respondent errors. Procedures for future keying operations should explicitly address these situations so that the keying of these cases will most accurately reflect the intentions of the respondent and minimize the amount of keyer judgement involved.

The verification for the quality assurance of the census keying did not detect a significant number of existing production keyer errors. Based on results from the census operation, the overall estimated field error rate of the census production keyers, for batches that passed verification, was 0.51 percent. Based on the final evaluation file, the census production keyers had an overall field error rate of 1.14 percent among sample batches.

Some of this difference can be explained by respondent errors. Two keyers from the same unit may have treated a response similarly, but the keyed entry still remained in error. The use of Form D-2114 probably contributed to the discrepancy by biasing the verifier's interpretation of a questionable response. It is likely that the majority of entries listed on the form were respondent errors.

Approximately 44 percent of production keyer errors, identified by the evaluation, were keyer errors. It is difficult to explain why these errors were not detected by census verifiers more successfully.

It should be pointed out that the keying operation and the independent evaluation keying were conducted within different production environments. The census keying was performed under tougher time constraints and the quality of the verification may have suffered somewhat as a result.

Nevertheless, it is imperative that research is conducted to understand the variables which contribute to this problem.

References—

[1] Roberts, Michele A., 1990 Preliminary Research and Evaluation Memorandum No. 241, ''1990 Decennial Census—100-Percent Race Write-In Keying Quality Assuance Evaluation.'' U.S. Department of Commerce, Bureau of the Census. July 1993.

[2] Wurdeman, Kent, 1990 Preliminary Research and Evaluation Memorandum No. 205, ''Independent Study of the Quality of the 100-Percent Race Write-In Keying.'' U.S. Department of Commerce, Bureau of the Census. November 1992.

Long Form

Introduction and Background—During the 1990 census, a sample of 1 in 6 housing units was selected to receive long-form questionnaires. These questionnaires required much more detailed respondent information than the short-form questionnaires, and many of the data collected were write-in entries. All responses were keyed and coded to maximize consistency.

The Decennial Statistical Studies Division designed the quality assurance plan to be implemented during the Long-Form Keying operation. The plan was designed to detect and correct keying errors, to monitor the keying, and to provide feedback to the keyers to prevent further errors.

At the time of this publication, the quality assurance data still are being analyzed. The primary objectives of the data analysis are to determine the quality of keying of long-form questionnaires, to identify and examine variables that may affect keying, and to evaluate the effectiveness of the quality assurance plan.

Methodology—For batches with 30 or more long-form questionnaires, a systematic sample of 1 in 15 long forms (6.67 percent) was selected for verification. For batches with fewer than 30 long forms, a random sample of 2 was selected.

Each field on a sample questionnaire was keyed by another keyer (verifier) and was matched to the corresponding keyer entry. One error was charged to the keyer for each verified field keyed in error, omitted, or in a duplicated record. A numeric field was in error if the keyer information did not exactly match the verifier information, or if the field was keyed by the verifier but omitted by the

keyer. Alpha fields (letters and numbers) were verified by the soundx algorithm which allowed for minor discrepancies (that is, spacing). An alpha field was in error if it exceeded the soundx tolerance level.

If the keyed batch failed the tolerance check, a listing was generated for all differences between the keyer and verifier field entries. If the keyer was responsible for one of more errors, he/ she repaired the entire batch. Feedback was given to keyers and verifiers for instruction and continued improvement.

Limitations—The following limitations should be considered when reviewing the results.

1. The estimates in this report not only depend on sampling error but also on the efficiency of the verifiers and accuracy of the procedures. Independent studies from other operations show evidence that estimates from quality assurance data may be understated.

2. Many of the errors detected may not have been attributable to a keyer, but may have occurred due to a respondent entry that was illegible or interpreted differently by the keyer and verifier. This type of ''respondent error'' cannot be measured.

Results—It was estimated that the keyers committed keystroke mistakes (or omissions) in 0.62 percent of the fields keyed. This error rate represents initial production keying. Some of these errors were corrected during later stages of the operation.

Table 4.36 shows the field error rates at the national and processing office levels.

All processing offices seem to have performed similarly except for Jeffersonville and Baltimore which had the highest error rates at 0.85 percent and 0.81 percent, respectively, and Kansas City which had the lowest error rate at 0.32 percent.

There were two types of long-form fields keyed during this operation, alpha and numeric. Alpha fields contained a combination of letters and numbers; numeric fields contained only numbers. Alpha fields had an error rate of 0.64 percent, which was higher than the numeric field error rate of 0.55 percent. Table 4.37 shows the field error rates by type of field at the national and processing office levels.

The alpha fields had higher error rates consistently for all of the processing offices, as is typical of other keying operations, due to the greater complexity of keying and length of fields.

The Long-Form Keying operation lasted approximately 33 weeks. During this period, the start dates varied between individual keyers as well as the number of batches each one keyed. Analysis of the keyers' performance revealed a trend of significantly declining field error rate over time (learning) at all of the processing offices, except Baltimore and Albany. This decline can be attributed to feedback and experience.

Table 4.36. **Field Error Rate**

Processing office	Percent of long form fields keyed in error
National	.62
Kansas City	.32
Baltimore	.81
Jacksonville	.65
San Diego	.63
Jeffersonville	.85
Austin	.62
Albany	.50

Table 4.37. **Field Error Rate by Type of Long-Form Field**

Processing office	Type of field	
	Alpha (percent error)	Numeric (percent error)
National	.64	.55
Kansas City	.32	.30
Baltimore	.81	.72
Jacksonville	.67	.57
San Diego	.65	.56
Jeffersonville	.88	.75
Austin	.65	.55
Albany	.54	.45

The production rate of long form keying was 1.46 keystrokes/ second at the national level. This rate was fairly consistent for all processing offices.

The national average batch size was nine questionnaires. Approximately 56 percent of the batches processed during long-form keying contained 9 long forms.

Questionnaires were to be sampled for verification at a rate of 1 in 15 (6.67 percent) for batches with 30 or more long forms, and 2 for batches with fewer than 30 long forms. The actual verification rate for batches with 30 or more long forms was very close to what was expected at 6.47 percent. That for batches with fewer than 30 long forms was slightly less than expected.

A batch was to fail the quality assurance tolerance check when its estimated keying error rate exceeded 2.5 percent. Typically, errors are clustered within rejected batches, as was the case during long form keying. The average field error rate of rejected batches was 8.85 percent, compared to the overall average error rate of 0.62 percent.

Rejected batches were repaired by the original keyer and all errors were to be corrected. These batches were then to be reverified. (Errors in verified batches that were not rejected were corrected by the verifier.) Analysis shows that more batches were reverified than what was expected based on the number of rejected batches. This could have been due to supervisory initiative.

Conclusions—Overall, the quality of the keying was very good. The quality assurance plan for the Long-Form Keying operation was successful in facilitating improvement in the keying over the course of the operation. This

was accomplished by identifying sources of error and providing prompt feedback to keyers, concentrating on those whose errors occurred with unacceptable frequency.

It was estimated that 0.62 percent of the long-form fields were originally keyed in error. This field error rate estimate represented all errors detected by ''exact match'' verification for numeric fields and by the soundx algorithm for alpha fields, regardless of the origin or reason of the mistake.

The sample error tolerance level of 2.5 percent was used for all verified batches regardless of the number of questionnaires. As in the Long-Form Keying operation, when the sampling scheme varies, dependent upon the batch size, the tolerance should vary similarly. This ensures accuracy in identifying poorly keyed batches.

1988 Prelist

Introduction and Background—During the 1988 Prelist operation, addresses were obtained by census enumerators in prelist areas (suburban areas, small cities, towns, and some rural areas), areas for which census address listing capability is limited. The 1988 Prelist Keying operation was implemented by Decennial Management Division (formerly Decennial Operations Division) in the Baltimore Processing Office and the Kansas City Processing Office. The keyed prelist addresses were used to update the master census address file for the purposes of delivering census questionnaires and conducting subsequent follow-up operations.

The Decennial Statistical Studies Division designed the quality assurance plan to be implemented during the 1988 Prelist Keying operation. The plan was designed to detect and correct keying errors, to monitor the keying, and provide feedback to the keyers to prevent further errors.

The collected quality assurance data were analyzed, and the results were documented (see [1]). The primary objectives of the data analysis were to determine the quality of keying of prelist addresses, to identify and examine variables that may affect keying, and to evaluate the effectiveness of the quality assurance plan.

The Decennial Statistical Studies Division also designed an independent study of the 1988 prelist keying quality assurance plan. The study, implemented by Data Preparation Division, compared a sample of prelist address registers to the corresponding final keyed census prelist address file.

The results were analyzed and documented (see [2]). The objectives of the independent study were to estimate the quality of the final keyed file of prelist addresses, to obtain insight into the types and reasons for the errors, and to assess the impact of critical errors on the usage of the prelist data.

Methodology—

Quality Assurance Plan—A 10-percent systematic sample was selected for verification from each keyed address register containing at least 100 addresses. For registers with fewer than 100 addresses, all (100 percent) were verified.

The verifier keyed all numeric fields (block number, map spot number, house number, unit designation, ZIP Code) plus the street name field in the appropriate addresses. An exact match was required. If the verifier's entry differed from the keyer's entry, the terminal beeped and the verifier rechecked his/ her own entry with the address register. The verifier visually compared (scanned) each remaining alpha field (letters and numbers) in the address (occupant name, road name, location description, remarks) to the keyer's entry. Minor discrepancies (that is, spacing) were permitted in these alpha fields.

If the keyed address register failed the tolerance check, a listing was generated for all differences between keyer and verifier field entries. If the keyer was responsible for one or more errors, he/ she repaired the entire register.

During this process, summary data were collected and maintained in a datafile. The file contained information on the batch, volume, sample size, type of error, time, and quality decisions. After the operation was completed, specific data were extracted and analyzed to meet the quality assurance plan objectives.

Independent Study—A sample of 129 address registers, with an average of 435 addresses each, was selected to ensure 90 percent reliability that the field error rate estimates, at the processing office level, were within 20 percent of the true field error rates. The sample was stratified based on the estimated field error rate for each address register, calculated from the datafile created during the 1988 prelist keying quality assurance operation.

After the sample address registers were selected, all addresses within each sample address register were compared to the corresponding keyed information at the field level. (A listing of the keyed file was output for this purpose.) An exact match was required for each field.

Field tallies and differences were recorded on the Field Tally Form and Field Difference Form, respectively. These forms were sent to census headquarters, where summary data were keyed into a datafile. This file was used to calculate the independent study results.

Limitations—The 1988 prelist keying evaluation [1] was based on data collected during the quality assurance process. The data primarily provided quality information on the keyers' performance and results of the plan implementation. The independent study assessed the quality of the prelist data file after keying. Therefore, it was difficult to make a comparison between the results from the two evaluations.

Results—

Quality Assurance Plan—The 1988 prelist quality assurance plan estimated that 0.48 percent of the fields were keyed in error. This represented a 52 percent improvement

over the 1988 Dress Rehearsal field error rate of 1.0 percent. Table 4.38 shows the field error rate and standard errors at the national and processing office levels.

The field error rate decreased significantly throughout the operation. The overall field error rate dropped from 0.95 percent in the first weeks of keying to 0.44 percent by the end of the operation. Regression analysis shows that the field error rate dropped more sharply at Kansas City. The field error rate decreased 0.0019 percent for every 5 working days at Kansas City, compared to 0.0015 percent at Baltimore.

The field error rates for accepted and rejected address registers were 0.46 and 9.17 percent, respectively.

The street name field had the greatest percentage of error at 1.49 percent.

There was an inverse relationship between production rate (keystrokes/ hour) and field error rate; that is, the faster keyers had lower error rates. Regression analysis shows a decrease of 0.0059 in field error rate for every 1,000 increase in keystrokes/ hour.

The national field error rate for scan-verified fields was 0.38 percent, and 0.49 percent for key-verified fields. However, scan-verified fields accounted for only 9.2 percent of verified fields, and they had little impact on the overall field error rate.

Independent Study—The independent study estimated that a total of 1.53 percent of the fields on the 1988 prelist address file were in error due to differences between the address registers and keyed information. Table 4.39 shows the field error rate and standard errors at the national and processing office levels.

These error rates represent differences between the original address registers and the keyed prelist address file, regardless of the magnitude or impact of the errors. It is difficult to compare these error rates to those of the 1988 prelist keying quality assurance evaluation or other keying operations because of the different definitions for error.

Table 4.38. **Quality Assurance Plan Field Error Rate**

Processing office	Error rate (percent)	Standard error (percent)
National	.48	.14
Baltimore	.62	.17
Kansas City	.31	.22

Table 4.39. **Independent Study Field Error Rate**

Processing office	Error rate (percent)	Standard error (percent)
National	1.53	.02
Baltimore	2.09	.05
Kansas City	1.22	.03

It is estimated that 0.35 percent of the fields on the prelist file contained a ''critical error.'' In this evaluation, an error was determined to be critical if the keying differences were significant enough to misrepresent the original field information. This type of error could potentially affect the deliverability of the census questionnaire to the address or cause difficulty in locating the address during subsequent follow-up activities. This definition of critical error is unique to this operation based on the use of the keyed information. Critical errors could also potentially impact future address list development operations, such as the Advance Post Office Check and Casing.

Although this definition for critical error and the definition for field error from the quality assurance evaluation are not exactly the same, they are similar and somewhat comparable. The field error rate for data from the quality assurance evaluation was 0.48 percent. Based on the slight variation in error definition and the different stages of the keying process during which the two sets of data were collected, a critical error rate of 0.35 percent is about what was expected for this evaluation. Table 4.40 shows the critical error rates at the national and processing office levels.

It is estimated that the fields containing critical errors affected 1.30 percent of the addresses on the prelist file. This indicates that approximately 362,647 addresses in prelist areas could have had difficulty in receiving census mail if these errors were not corrected during subsequent address list development operations. The house number and unit designation fields contained critical error rates of 0.57 percent and 2.28 percent, respectively, and accounted for 241,232 (67 percent) of the affected addresses.

Another impact of critical errors on the prelist file is that they could hinder the Census Bureau's ability to locate rural type addresses during follow-up activities. Of the 4,547,041 (16.3 percent) rural addresses in prelist areas, it is estimated that 3.19 percent of the addresses contain critical errors in the fields necessary to properly locate the housing unit. The location description field contained a critical error rate of 1.07 percent and accounted for 34 percent of the rural addresses affected.

The independent study also identified field keying ''errors'' (differences) that actually improved the quality of the prelist file. This situation relates to the general keying policy of ''KEY WHAT YOU SEE.'' In some instances the keyers inserted data into a blank in the address register in fields such as block number, ZIP Code, street name, etc.,

Table 4.40. **Critical Field Error Rate**

Processing office	Error rate (percent)	Standard error (percent)
National	.35	.01
Baltimore	.41	.02
Kansas City	.32	.01

based on surrounding data. Even though the inserted data was obviously correct it was still an error (not critical because it did not *negatively* impact the file) because it violated procedures.

When examining the keying errors or fields that were keyed differently from the prelist address registers, many of these differences were found to be minor; that is, spacing and single keystroke errors. It is estimated that 78.4 percent of these errors were not critical and would not impact the use of the final file.

Conclusions—

Quality Assurance Plan—The quality assurance plan for the 1988 Prelist Keying operation was successful in improving the keying over the course of the operation. This was accomplished by identifying sources of keying errors and providing prompt feedback to keyers, concentrating on keyers whose errors occurred with unacceptable frequency.

There was also a marked decrease in field error rates from the 1988 Dress Rehearsal prelist keying. A new, automated keying system was largely responsible for the improvement. The quality assurance plan was also modified to take advantage of the more advanced system.

Although field error rates were used as accept/ reject criteria for this operation, record error rate may be a more practical determinant of keying quality, as records primarily represent addresses, and most address fields are critical to deliverability. Errors in one or more important fields could adversely affect deliverability.

Due to the high field error rate tolerance limits, very few work units required repair. However, the few rejected work units had field and record error rates well above the respective tolerance limit. This is an indication that the quality assurance plan detected keyed address registers containing gross amounts of field or record errors. However, the primary goal of the quality assurance plan was to obtain data to provide feedback to the keyers.

Independent Study— The quality of the keying of 1988 prelist addresses appears to be high with an error rate of 1.53 percent. However, this 1.53 percent represents all fields that were keyed differently than the original prelist address registers, regardless of the magnitude or impact of the errors. This error rate cannot be compared to the original 1988 prelist keying quality assurance evaluation or other keying operations because of the different definitions for error.

In the independent study, critical errors were defined as those keying differences that were significant enough to misrepresent the original field information. This type of error could potentially impact the use of the final prelist address file for delivering census questionnaires or locating addresses for follow-up. Critical errors could also potentially affect the quality of future address list development operations.

It is estimated that 0.35 percent of the fields on the 1988 prelist address file contained critical errors. This is a more accurate representation of the quality of the final prelist address file than the 1.53 percent error rate mentioned above, because of the error definition.

This evaluation shows that the majority of keying differences occurred in alpha fields. These fields are larger (longer) and more complex than numeric fields and have more opportunities for error. Most of the keying differences in alpha fields were not critical. In fact, only 8.6 percent of these differences were serious enough to potentially impact the final prelist address file.

Soundx is an automated method of verifying alpha fields, which allows for minor spelling, spacing, and keystrokes errors. Soundx has been successfully implemented in keying operations subsequent to 1988 prelist keying. (See other reports under Data Keying.)

ZIP Code was one of the most important fields that required keying. The prelist keyers recognized this and sometimes interpreted the information in the address registers (that is, several addresses in an apartment complex or a row of housing units on the same street) to fill in missing ZIP Codes while keying, if the correct ZIP Code was obvious. This would have been considered an error in the original quality assurance evaluation because the keyed information did not match the address register. However, if the interpreted ZIP Code was correct, it may have improved an otherwise unusable address. In a controlled environment, with specific guidelines and record-keeping, keyer interpretation may improve the final data file, particularly in situations where prior clerical editing would be costly and unnecessary.

The current evaluation method in keying operations is to charge the keyer with an error for every difference between the original written document and the keyed file. However, these differences cannot always be attributed to keyer error. For example, the keyer may be required to interpret unclear handwriting which may be interpreted differently by the verifier. Also, there are many reasons for keying differences such as interpretation, omission, duplication, keystrokes error, spacing, etc.

Many keying differences were noncritical in nature. Since the keyer is instructed to key as accurately as possible, any deviation from the original document is an error attributable to keyer performance. These errors should be used to provide feedback to the keyer to improve the quality of the work. However, only critical errors, which by definition could impact the final file, should be rectified. Noncritical errors which would not affect the file do not have to be rectified, as this would be time-consuming without significantly improving the final file.

References—

[1] Boodman, Alan, 1990 Preliminary Research and Evaluation Memorandum No. 29, ''1988 Prelist Keying Quality Assurance Evaluation.'' U.S. Department of Commerce, Bureau of the Census. September 1990.

[2] Roberts, Michele, 1990 Preliminary Research and Evaluation Memorandum No. 220, ''1988 Prelist Keying Independent Study Quality Assurance Evaluation.'' U.S. Department of Commerce, Bureau of the Census. March 1993.

Precanvass

Introduction and Background—The Precanvass operation was performed in urban and major suburban areas to verify the accuracy and completeness of the address list, obtained from commercial sources, after it had been updated through a post office check. Census enumerators compared addresses in specific geographic areas to those in their precanvass address registers, adding missing addresses, making corrections, and deleting duplicate, nonexistent and commercial addresses. At the end of the field operation, these updates were keyed at the Baltimore, Jacksonville, Kansas City, and San Diego Processing Offices.

The Decennial Statistical Studies Division designed the quality assurance plan to be implemented during the Precanvass Keying operation. The plan was designed to detect and correct keying errors, to monitor the keying, and to provide feedback to the keyers to prevent further errors.

The collected quality assurance data were analyzed, and the results were documented (see [2]). The primary objectives of the data analysis were to determine the quality of keying of precanvass addresses, to identify and examine variables that may affect keying, and to evaluate the effectiveness of the quality assurance plan.

The Decennial Statistical Studies Division also designed an independent study of the precanvass keying quality assurance plan. The study, implemented by Data Preparation Division, compared a sample of precanvass address registers to the corresponding final keyed census precanvass address file.

At the time of this publication, the independent study data still are being analyzed. The objectives of the analysis are to estimate the quality of the final keyed file of precanvass addresses, to obtain insight into the types and reasons for the errors, and to assess the impact of critical errors on the usage of the precanvass data.

Methodology—

Quality Assurance Plan—During the Precanvass Keying Quality Assurance operation, every keyed address register was verified. Within each address register, a random sample of 20 addresses from each action code was selected for verification. Each address contained an action code to indicate its status (that is, add, delete, correction, etc.). If the register contained fewer than 20 addresses with a particular action code, all addresses with that code were verified.

Each field within a sample address was quasi-independently keyed by another keyer (verifier) and was matched to the corresponding keyer entry. If a difference existed between the two entries, the terminal ''beeped'' to allow the verifier to re-check his/ her entry.

If the keyed batch failed the tolerance check, a listing was generated for all differences between the keyer and verifier field entries. If the keyer was responsible for one or more errors, he/ she repaired the entire batch.

During this process summary data were collected and maintained in a datafile. The file contained information on the batch, volume, sample size, type of error, time, and quality decisions. After the operation was complete, specific data were extracted for analysis to meet the quality assurance plan objectives.

Independent Study—A random sample of 524 address registers (approximately 1 percent) was selected for the independent study.

For each address register in the evaluation sample, every address line was keyed by two persons, one of whom was termed the production keyer and the other the verifier for description purposes. Two files of keyed addresses were created, a production keyer file and a verifier file. These two files were merged to create an evaluation file, and if the production keyer's and the verifier's entries differed, then the verifier version was included on the evaluation file. A difference listing was produced by register, listing the production keyer and verifier versions of fields which were keyed differently. This listing and the corresponding source documentation were reviewed by a third person who determined which of the two keyed versions was correct. If the verifier version was determined to be incorrect, then that entry in the evaluation file was corrected.

For the purpose of this study, it was assumed that the keyed data on the evaluation file accurately represent the data on the address registers. Conclusions and statements about the quality of the data produced in the census Precanvass Keying operation and of the operation itself were made using the evaluation file as the basis for comparison.

Limitations—The following limitations should be considered when reviewing the results.

Quality Assurance Plan—The quality assurance verification was not designed to distinguish critical errors (those keying errors that may affect deliverability) from noncritical errors. Therefore, both are included in the calculations of error rate estimates.

Since the number of fields keyed by action code was not available, all field error rates were based on an estimate of the total number of fields keyed for the ''add'' and ''correction'' action codes. This estimate was derived from the number of records keyed for each action code.

Independent Study—For precanvass keying, a field keying error was determined to be critical if it was significant enough to potentially affect the deliverability of a census questionnaire to the address. The determination of whether or not a keying error was critical was made by the analyst for this evaluation. This determination was somewhat subjective.

Part of the results involves a discussion of the causes of error. Causes were determined by comparing the keyed entries to the source documentation; that is, the address registers. In some cases, categorizing the errors into causes depended on the judgement, or educated guess, of the analyst performing this evaluation.

Results—

Quality Assurance Plan—The overall pre-verification field error rate was 0.17 percent. The overall post-verification field error rate was 0.08 percent. The pre-verification field error rate is an estimate of the quality of keyed data prior to verification, and the post-verification field error rate is an estimate of the quality of keyed data after corrections were made from verification and repair. Both of these figures are substantially below the field error tolerance level of 1.0 percent. For this operation, a work unit consisted of one address register.

One goal of the quality assurance plan for this operation was to minimize differential undercoverage and reject unacceptable work; that is, registers with a high rate of field errors. Table 4.41 presents data on the field error rates by site for both accepted and rejected work units. The number of errors in failed work units can be considered to be the number of errors ''removed'' from the system by the tolerance check. Of the 55,124 work units initially keyed, 1,544 (2.8 percent) failed the verification by having a field error rates greater than the field error tolerance level of 1.0 percent. These work units were reviewed by the original keyer on a 100-percent basis (repaired) and were then reverified. The pre-verification field error rates in passed and failed work units were 0.08 percent and 2.44 percent, respectively.

The fields with the highest error rates were the fields that were keyed the fewest times, rural route/ post office box (3.35 percent), and unit description (1.72 percent). These fields accounted for 2.05 percent of all fields verified, but represented 11.28 percent of all keying errors, and may have had high error rates due to their relative infrequency. Since so few records (fewer than one in 20) contained these fields, keyers would not have expected to key them most of the time, increasing the likelihood of omission errors.

Table 4.41. **Field Error Rates by Site and Pass/ Fail Decision**

Item	Processing office			
	Baltimore	Jacksonville	Kansas City	San Diego
Field error rate (percent)				
Pre-verification	.21	.24	.11	.17
In passed work units	.09	.10	.05	.10
In failed work units	2.34	2.78	2.53	2.18
Post-verification	.09	.09	.05	.10
Percentage of field errors				
In passed work units	42.57	38.38	48.33	57.71
In failed work units	57.43	61.62	51.67	42.29
Work unit failure rate (percent)	3.84	4.01	1.76	2.37

Street name and house number were the fields most often miskeyed. These two fields accounted for 25.5 percent of all fields keyed, and represented 48.6 percent of all keying errors. They are among the most critical fields since they directly affect the deliverability of the address.

The most common field, action code, appeared on all nonblank address listing lines, and, in the case of records with action code D (delete) or X (no change), it was the only field keyed/ verified. As a result, action code represented nearly 42 percent of all verified fields, and had an error rate of only .03 percent, thus accounting for the low overall field error rates associated with the Precanvass Keying operation.

It was determined in the planning stage that, for coverage purposes, it was important to ensure the accuracy of the action codes. A miskeyed action code could cause an address to be marked as receiving a delete action, or could keep necessary corrections from being made. The overall unweighted field error rate excluding action code is .52 percent.

There was a distinct learning curve for the first month of the operation. The second month of Precanvass Keying coincided with the start of another keying operation, and to meet production goals, several of the better keyers were moved to the other operation. This caused the field error rates in precanvass keying to increase. It has also been experienced that error rates tend to rise slightly towards the end of a keying operation.

Even with the error rate fluctuations in the second month of keying, three of the four processing offices had an overall downward trend in field error rate. The exception was Kansas City, which actually displayed slightly lower field error rates during the first month of keying. Many Kansas City keyers had previous keying experience. Therefore, they required a smaller period of adjustment to a new system, and were more likely to have low field error rates at the beginning of an operation. Low error rates at the start of a process lessen the chance of observing significant improvement as the operation continues.

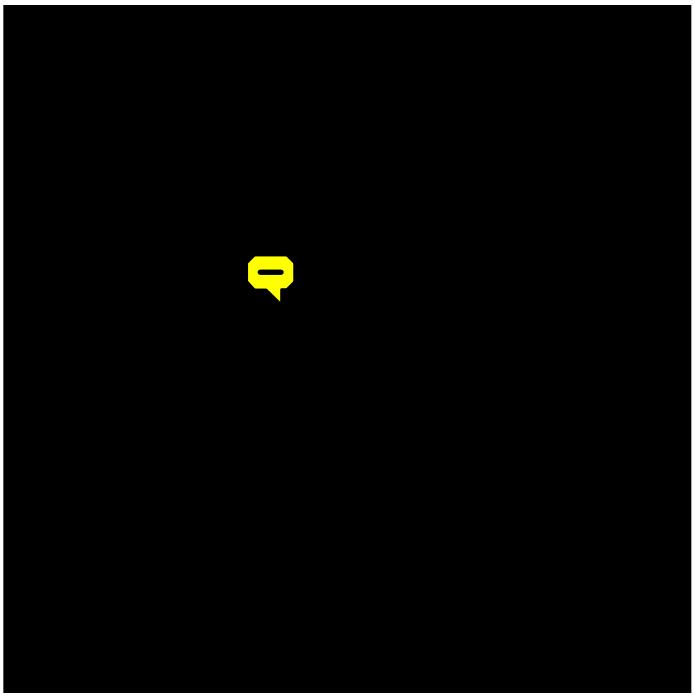
Independent Study—

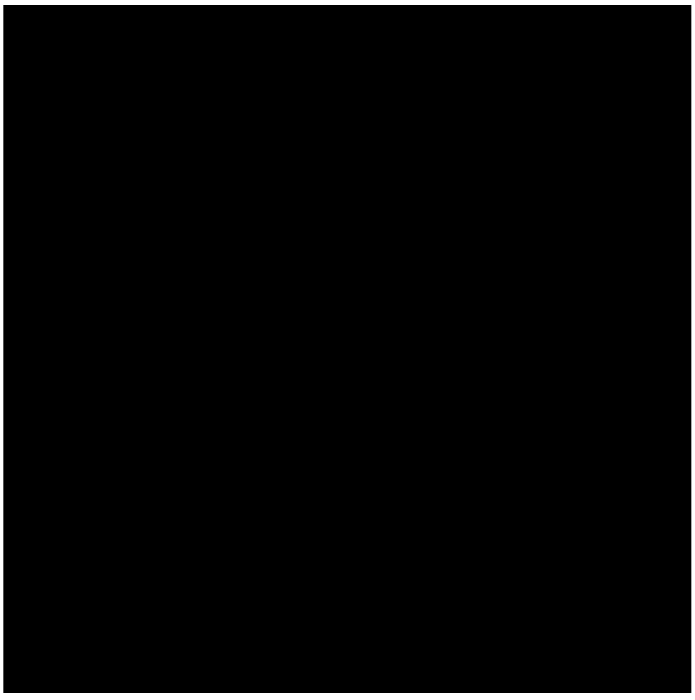
1. *Adds*—Addresses, which were missing from the address registers, were added on pages reserved just for adds, and all of the fields on each line were keyed. Each address line contained fields for geocode information and address information. This study focused on fields relating to address information necessary for mailing, i.e. house number, street name, ZIP Code, unit designation, and rural route/ post office box number.

   A keying error was determined to be critical if it (the difference between the census version and the evaluation version) was significant enough to potentially affect the deliverability of a census questionnaire to the address.

Figure 4.33 shows the percentage of critical errors in the final precanvass file by field type for add cases. The overall estimated field error rate is 0.48 percent. The rural route/ post office box field has the highest field error rate, but this field occurred infrequently in precanvass areas and the errors were clustered in a few areas resulting in a high standard error.

Figure 4.34 shows the distribution of errors by type for the mailing address fields. About 9 percent of the critical errors were subjective. An error was categorized as subjective when information on the address register was difficult to read and the interpretation differed between the census keyer and the evaluation keyer. Subjective errors usually occurred in the house number and unit designation fields.





About 24 percent of the errors were caused by a difference in procedural interpretation. A difference in procedural interpretation arose when the information on an address line was in some form which the procedures did not explicitly address, requiring some judgement for resolution, and the census keyer and the evaluation keyer handled the situation differently. Almost 90 percent of critical errors in the ZIP Code field were categorized as differences in procedural interpretation because the field was left blank in the address register and the census keyer (or evaluation keyer) keyed a ZIP Code based on information from other address lines while the evaluation keyer (or census keyer) keyed the field as a blank. About 65 percent of the street name errors were differences in procedural interpretation. Many of these occurred because blank fields were handled differently as with the ZIP Code field, and because information other than street name, such as unit designation or Post Office box was present in the street name field and the keyers handled the situation differently. The keying procedures did not adequately address these types of situations. About 29 percent of the critical errors were a result of the census keyer entering information from the wrong field on the page, usually from an adjacent line or column.

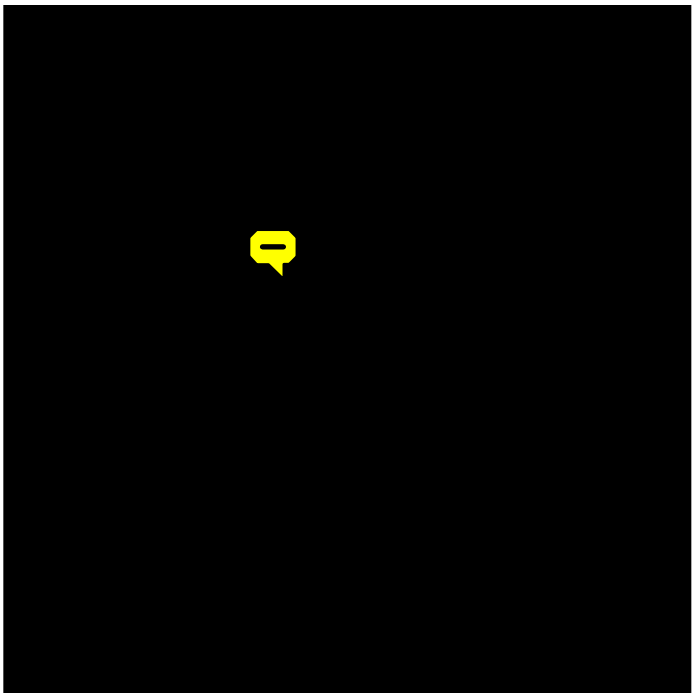
2. *Corrections*—During the Precanvass operation, enumerators could make corrections to addresses. Any of the mailing address fields could be corrected except for the house number. If a correction was made, only the particular field corrected was keyed.

   The critical error rate for correction cases, for the mailing address fields, was 0.79 percent. Most of the corrections were made to the unit designation.

   Figure 4.35 shows the distribution of critical errors for corrections to the mailing address fields. About 43 percent of the errors were due to subjective differences caused by corrections which were difficult to decipher. About 21 percent were due to keying an entry from the wrong field. Often the unit designation field and unit description field were mixed up. Nine percent were keystroke substitution errors, and about 23 percent of the errors were a result of a correction not being keyed.

3. *Evaluation of the Quality Assurance Plan*—A comparison was made between the census keyer field error rates derived from the quality assurance operation and the independent study evaluation. This comparison was limited to work units that passed verification.

   Based on the quality assurance operation, the national estimated field error rate for add cases was 0.11 percent with a standard error of 0.02 percent; that is, the keyer and verifier entries differed for approximately



0.11 percent of the fields verified. Based on the evaluation file, the national estimated field error rate was 0.69 percent with a standard error of 0.07 percent.

Based on the quality assurance operation, the national estimated field error rate for correction cases was 0.17 percent with a standard error of 0.05 percent. Based on the evaluation file, the national estimated field error rate was 1.11 percent with a standard error of 0.27 percent.

The difference between the quality assurance and independent evaluation error rate estimates is due in some part to a failure of the quality assurance operation to detect errors. This failure is attributable to census verifier errors, since the detection of keyer error depends on the verifiers' ability to correctly interpret and key address register entries. The result is underestimated field error rates.

Procedural interpretation may also have affected error rate estimation. A difference in procedural interpretation arose when the information on an address line was in some form which the procedures did not explicitly address, requiring some judgement for resolution. Therefore, it is quite possible that a census production keyer and verifier working under the same conditions would treat such a case similarly, but that an evaluation keyer, having received separate training and supervision, would treat the response differently. This caused about 24 percent of the errors in add cases.

Subjectivity also caused some discrepancies between the error rates. An error was categorized as subjective when information on the address register was difficult to read and the interpretation differed between the census keyer and the evaluation keyer. It is likely that the census keyer and verifier treated many of these cases similarly because of the quality assurance verification system. For any field, if the verifier's entry did not match the production keyer's entry, the terminal ''beeped'' and required the verifier to press the reset key to continue verification. In this manner, the verifier was alerted to a disagreement and he/ she could then re-check the source documents to ensure accuracy.

Conclusions—

Quality Assurance Plan— Overall, the quality of the keying was very good. The quality assurance plan for the Precanvass Keying operation was successful in facilitating improvement in the keying over the course of the operation. This was accomplished by identifying sources of keyer errors and providing prompt feedback to keyers, concentrating on keyers whose errors occurred with unacceptable frequency.

Due to the high field error rate tolerance limits, very few work units required repair. As a result, the post-verification error rate is not appreciably lower than the pre-verification error rate. However, the few rejected work units had field error rates well above the respective tolerance limit. This is an indication that the quality assurance plan was effective in identifying and removing work units containing a gross amount of field errors. Even though the main purpose of the quality assurance plan was not to do inspection and repair, extremely poor quality work was virtually eliminated.

Independent Study— The overall quality of the Precanvass Keying operation was very good. Based on the evaluation, approximately 0.48 percent of the keyed mailing address fields in add cases contained a critical error, and approximately 0.79 percent of the mailing address fields in correction cases contained a critical error; that is, the difference between the census version and the evaluation version was significant enough to potentially affect the deliverability of a census questionnaire to the address.

A large proportion of the critical errors on the final precanvass file, particularly errors in the street name and ZIP Code fields, were due to differences in procedural interpretation which occurred when the information entered by an enumerator was in some form which the procedures did not explicitly address, requiring some keyer judgement for resolution. Procedures for future keying operations should explicitly address these situations so that the keying of these cases will most accurately reflect the intentions of the enumerator and minimize the amount of keyer judgement involved.

The verification for the quality assurance operation of the census precanvass keying was not very successful in detecting production keyer errors. Some of this can be explained by entries which required some subjective interpretation, which two keyers from the same unit may treat similarly, but much of the discrepancy is difficult to explain.

It should be pointed out that the keying operation and the independent evaluation keying were conducted within different production environments. The census keying was

performed under tighter time constraints and the quality of the verification may have suffered somewhat as a result. Nevertheless, there is certainly much room for improvement in the verification for keying operations.

Although it is difficult to precisely measure the impact of critical errors, after examining the final census status for the census version and evaluation version of cases with a critical error, it appears likely that the critical errors did place additional burden on coverage operations that followed Precanvass, and that some relatively small number of housing units were not captured in the census as a result of keying error.

References—

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[2] Wurdeman, Kent, 1990 Preliminary Research and Evaluation Memorandum No. 206, ''Independent Study of the Quality of the 100-Percent Race Write-In Keying.'' U.S. Department of Commerce, Bureau of the Census. December 1992.

[3] Scott, Jimmie B., STSD 1990 Decennial Census Memorandum Series # K-18, ''Processing Specifications for the Independent Study of the Quality of 1990 Precanvass Keying.'' U.S. Department of Commerce, Bureau of the Census. May 1991.

[4] Scott, Jimmie B., STSD 1990 REX Memorandum Series # NN-1, ''1990 Evaluation Overview Independent Study of the Quality of Precanvass Keying.'' U.S. Department of Commerce, Bureau of the Census. May 1991.

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Collection Control File

Introduction and Background—During the 1990 census, several field operations were implemented at the 449 district offices across the country. Enumerators at each district office checked work out and in daily. This work flow was recorded on forms specific to each of 16 enumerator field operations. Data from these forms were keyed into a Collection Control File.

The Decennial Statistical Studies Division designed the quality assurance plan to be implemented during the Collection Control File Keying operation. The plan was designed to detect and correct keying errors, to monitor the keying, and to provide feedback to the keyers to prevent further errors. The Collection Control File Keying operation was the first census for which keying was performed at the district office level; therefore, it was the division's first attempt at implementing a quality assurance plan for such a decentralized process.

At the time of this publication, the quality assurance data still are being analyzed. The primary objectives of the data analysis are to determine the quality of keying of the collection control file, to identify and examine variables that may affect keying, and to evaluate the effectiveness of the quality assurance plan.

Methodology—Of the 449 district offices, the Decennial Statistical Studies Division selected a sample of 39 from which to receive and analyze data collected during the quality assurance process. Seven of the 16 operations keyed into the collection control file were selected for verification:

- Field followup checkin
- Group quarters checkin
- List/ enumerate checkin
- List/ enumerate corrections
- List/ enumerate merge
- Non-response followup checkin
- Structuring assignment

All forms for these seven keying operations were 100-percent verified. Each field on these forms was quasi-independently keyed by another keyer (verifier) and matched to the corresponding keyer entry. (Quasi-independent verification occurs when the verifier has some knowledge of whether or not his/ her field entry matched the keyer's entry.) One error was charged to the keyer for each verified field keyed in error, omitted, or in a duplicated record. Verifiers corrected all detected errors. Daily error summary reports flagged keyers performing above the error tolerance to signify that feedback, retraining, or reassignment may be necessary.

Limitations—The estimates in this report not only depend on sampling error but also on the efficiency of the verifiers and accuracy of the procedures. Independent studies for other data keying operations show evidence that estimates from quality assurance data may be understated.

Results—A total of 53,865 batches were keyed and verified at the 39 district offices. The record error rate for these batches was 1.29 percent, and the field error rate was 0.73 percent with a standard error of 0.12 percent. This sample field error rate was very close to the field error rate of 0.69 percent for all 449 district offices through September 13, 1990.

The keyer production rate was 0.94 keystrokes/ second, and varied considerably between the seven operations.

Of the 53,865 batches, 62.1 percent were keyed for the

Non-response Followup Check-In operation while only 0.21 percent were keyed for list/ enumerate corrections.

The number of different forms keyed within each batch varied from two forms for group quarters check-in and structuring assignment to five forms for field followup. The field error rates varied somewhat by form type within keying operation. Form type 1, the batch header record, had the highest field error rate at 2.81 percent.

There was no significant decrease of field error rates (''learning'') or increase of production rates throughout the 25 weeks. However, while each of the seven keying operations were in effect throughout the 25 week period, the bulk of keying for each operation took place during a fairly short period of time. Since the keyers had to switch frequently among the many different form types, it was unlikely that their production rates and error rates on any given form would improve significantly over the course of the operation.

Approximately 65.0 percent of the batches keyed had a field error rate of 0.24 percent or below.

A total of 996 keyers participated in at least one of the keying operations at some time during the operation. The number of keyers per district office varied from a low of 10 to a high of 48 with an average of 25.5 keyers.

Of the 996 keyers, 16.7 percent had a field error rate that did not exceed 0.24 percent, while 6.1 percent had a field error rate that exceeded 3.0 percent. Also, 21.0 percent of the keyers keyed fewer than 10 batches, while 15.8 percent keyed 100 or more batches.

Conclusions—The field error rate for the Collection Control File Keying operation was 0.73 percent. This was the first census for which keying was performed at the district office level, and the Decennial Statistical Studies Division's first attempt at implementing a quality assurance plan for such a decentralized process. Therefore, it is worthy to note that the field error rates for this operation were comparable to those of a centralized process. The keyers were responsible for keying many different form types and had to switch frequently from one to another. Also, the bulk of keying was performed during a relatively short period of time. For these reasons, there was no sign that ''learning'' (a decrease of field error rate) occurred during the operation.

CHAPTER 5.
Other Operations

To conduct and support the conduct of a decennial census, there were several miscellaneous activities for which quality assurance programs were designed and implemented. One such operation was the Search/ Match operation. This operation supported all postcensus coverage improvement activities by checking if potential added persons were already counted in the census.

A support activity was developed to assist the implementation of the quality assurance program. The Quality Assurance Technician Program was developed to assist in monitoring the implementation across the many decentralized locations. Monitoring was required in up to 25 questionnaire printing locations, the 13 regional census centers, and the 7 processing offices.

This chapter covers the Search/ Match Quality Assurance Program and the three Quality Assurance Technician Programs.

SEARCH/ MATCH

Introduction and Background—The Search/ Match Coverage Improvement operation was conducted to help ensure that all persons were enumerated at their usual residence. Search/ Match was designed to improve both within household and whole household coverage. The objective of the quality assurance Search/ Match operation was to improve the accuracy of the census counts by implementing specialized procedures to ensure the enumeration of individuals and households who otherwise might have been enumerated incorrectly or omitted from census counts. Clerks in the processing offices performed the actual Search/ Match operation to compare persons listed on search forms to those listed on filmed questionnaires. Those persons listed on search forms but not on filmed questionnaires were transcribed to continuation questionnaires. The Search/ Match operation was in progress for approximately 32 weeks (June through December 1990) in all processing offices.

A quality assurance plan was implemented for the Search/ Match operation to determine and correct any source(s) of errors and to obtain estimates of the quality of the search/ match process. The Search/ Match operation quality assurance plan was divided into six phases: 1) computer geocoding, 2) clerical geocoding, 3) browsing the address control file to determine if the basic street address existed on the address control file, 4) checking the search forms for which the basic street address was not found on the address control file, 5) checking the address control file for the camera unit and frame number and determining if the correct number of search cases had been printed on the Form D2107, Microfilm Access Device Print Request Form, and 6) determining if persons had been properly transcribed from search forms to census questionnaires.

Search forms were sorted by two criteria: 1) form type (Individual Census Reports, Military Census Reports, Parolee/ Probationer Information Records, Shipboard Census Reports, Were You Counted forms, and census questionnaires identified as Whole Household Usual Home Elsewhere), and 2) whether or not the forms were in the processing office area. Forms identified as being in the processing office area were sorted according to whether or not they were geocoded. Search forms not geocoded were sorted by whether or not they had a searchable address. For more detailed description on the quality assurance specifications for the Search/ Match operation, see [1].

Methodology—The quality assurance plan used a sample dependent verification scheme. Each phase of the quality assurance plan had its own sample of forms to be verified within each batch. The computer geocoding and address control file phases used a 5-percent verification sample, the clerical geocoding, basic street address not found on the address control file, and matching/ transcription used a 10-percent sample, and the camera unit/ frame number look-up phase selected one search form per batch. A 1-in-10 sample of all quality assurance Forms D-2112, Search/ Match Batch Control Record , received from the processing offices was selected for analysis. (See form in appendix B.) There were 175 records out of 10,641 records deleted from the analysis because of unreconcilable inconsistencies in the data.

Computer Geocoding—Ungeocoded search forms determined to be within the processing office boundary were grouped into batches of 50 by form type. If an ungeocoded search form address was searchable, it was computer or clerically geocoded. The computer geocoded forms were verified by matching the geocode for that address to the address control file browse program.

Clerical Geocoding—Search forms not computer geocoded were clerically geocoded using maps, block header records, and other reference materials. Fifty forms were batched together by form type and verified by matching the geocode for that address to the reference materials.

Address Control File Browse—Once a search form was geocoded, clerks browsed the address control file to determine if the basic street address existed on the address control file. If the search address was not found,

the processing offices sent a deliverability check card to the appropriate post office. A batch of 50 geocoding forms were verified by checking whether or not the basic street address existed on the address control file.

Basic Street Address Not Found on Address Control File—A deliverability check card was sent to the United States Postal Service including the search address for search forms which the basic street address was not found on the address control file. The United States Postal Service determined whether the search address is correct, incorrect, or deliverable. Batches of 50 geocoded forms that did not have the basic street address found on the address control file were verified twice to confirm that the basic street address was not found on the address control file.

Camera Unit/ Frame Number Lookup—Address identification numbers previously obtained in the address control file check and/ or geocode was used to look up the camera unit and frame number. Form D-2107, Microfilm Access Device Print Request Form, was used to locate and print a copy of the appropriate questionnaire(s) requested. A batch of 25 search forms were verified to ensure that the correct number of search cases were printed on the Form D-2107 print request form.

Matching/ Transcription—Clerks located the appropriate film reel(s) for the search address and matched the search form to the corresponding filmed questionnaire(s). A batch of 50 forms were verified to ensure that persons on search forms were either present on filmed questionnaires or had been transcribed to a census questionnaire. If all names matched, processing on that search form stopped. If some or none of the search person names matched, the clerks transcribed the nonmatched person(s) information to a census questionnaire. These transcribed questionnaires were then sent to data capture. The six phases of the operation were merged to form four phases that will be discussed in these results. The four phases are: 1) Geocoding, 2) Address control file browse, 3) Camera unit/ frame number lookup, and 4) Matching/ transcription. See Definition of Error Type Codes, below, for error types discussed in each phase of the operation.

Definition of Error Type Codes

Codes	Definition
A	Incorrect geocode
B	Not geocoded when it should be
C	Incorrect address match
D	Exact address not found when matching address present if found on the address control file
E	Basic street address not found when basic street address present on address control file
F	Identification or population count incorrectly transcribed
G	Correct address match but camera unit/ frame number incorrectly selected
H	Persons incorrectly transcribed
I	Persons not transcribed when they should have been

Limitations—The reliability of the analysis and conclusions for the quality assurance plan depends on the following:

- Accuracy of the clerical recording of quality assurance data.
- Accuracy of keying the quality assurance data into the database file.
- Proper implementation of the procedures.
- Missing data caused by illegible and/ or incompleted entries on quality assurance recordkeeping forms.
- No data were received from the Kansas City Processing Office. Hence, no results for the Kansas City Processing Office are presented.
- The number of items verified for one or more phases were sometimes less than the number of items in error across error types for that phase. Because of these inconsistencies, 175 records out of 10,641 were deleted from the file. The data were not reweighted to compensate for the deletions.
- Standard errors were calculated assuming simple random sampling.

Results—

Operational Results—During the implementation of the quality assurance operation, observers from Headquarters visiting the processing offices discovered that procedures were not being followed correctly. For example, oversampling existed; the random number tables used to determine the sample were sometimes used improperly or not at all; timely feedback which is essential to improving quality was not given; verifiers were not rotated; and inconsistencies were detected in the recorded data.

Batch Origin—

Erroneous Data—The Forms D-2112 were not always completed correctly and/ or entirely. Batches were assigned incorrect error type codes. Batch origin ''G''; that is, ''already geocoded in the district offices,'' forms were inadvertently given error type codes which should only be assigned to forms that needed to be geocoded. Batch origin ''G'' forms were supposed to go directly to the address control file browse phase of the operation.

After analyzing the data, it was discovered that the clerks/ verifiers recorded batch origin ''G'' errors under error types A (incorrectly geocoded) and error type B (not geocoded when it should have been) by mistake. There were 337 (16.9 percent) type A errors and 271 (11.2 percent) type B errors for batches that entered the processing offices as already geocoded in the district offices but were sent to geocoding.

Batch Origin Categories—Table 5.1 shows four batch origin categories and they are: 1) geocoded in district office, 2) not geocoded, 3) split for clerical geocoding, and 4) United States Postal Service check. A ''missing data items'' column was added to this table to reveal the volume of missing data items in the batch origin categories. There was a large volume of missing data due to illegible and/ or incomplete entries on the quality assurance recordkeeping forms. The estimated rate of missing data was 43.8 percent from all four phases discussed in this report.

Table 5.1 reveals the ''not geocoded'' category had the most batches. The Jacksonville Processing Office had the majority of the batches in all categories. The San Diego Processing Office had the most batches with missing data and the Albany Processing Office had the least amount. The Baltimore Processing Office had the least amount of batches in categories ''geocoded in district office,'' ''not geocoded,'' and ''United States Postal Service check.'' The San Diego Processing Office had the least amount for the category ''split for clerical geocoding.''

Geocoding—There were 38,424 geocoding items verified. The overall estimated error rates for ''incorrect geocode'' (A) was 2.62 percent (standard error was 0.08 percent) and for ''not geocoding when it should have been'' (B) was 3.71 percent (standard error was 0.10 percent).

Table 5.2 shows the Albany Processing Office had the largest percentage of type A sample errors (9.63 percent) for geocoding done incorrectly, and type B sample errors (9.10 percent) for geocoding not being done when it should have been. There was a statistical difference found with both types A and B errors in the Albany Processing Office when compared to the other processing offices at the .10 level of significance. Although the Jacksonville Processing Office reported the smallest sample percentage of errors for both type A and B errors with 1.38 and 1.46 percent, respectively, there was no significant difference when compared to the other processing offices. Jacksonville also had the largest number of items to be verified (13,809). This could be attributed to the fact that the Jacksonville Processing Office oversampled during the operation, reportedly because their clerks' error rates were too high.

Address Control File Browse—There were 28,650 address control file browse check items verified. The overall estimated error rates for ''incorrect address match'' was 0.62 percent (standard error was 0.05 percent), for ''exact address not found when matching address present is found on the address control file'' was 1.58 percent (standard error was 0.07 percent), and for basic street address not found when found present on the ''address control file'' was 1.04 percent (standard error was 0.06 percent).

Table 5.3 shows the Jacksonville Processing Office had the largest number of items verified (12,057). Oversampling may have been a contributing factor. The Jacksonville Processing Office had the smallest percentage of sample errors for types D (0.74 percent) and E (0.27 percent). However, there was not a statistically significant difference when comparing these error rates to the other processing office's error rates. The Jeffersonville Processing Office had the highest percentage of type C errors (1.52 percent) for ''incorrect address match.'' This was statistically significant when compared to the other processing offices at the .10 level of significance. The Albany

Table 5.1. **Number of Batches That Were Geocoded in District Office; Not Geocoded; Split for Clerical Geocoding; United States Postal Service Check; and Missing Data Items**

Processing office	Geocoded in district office	Not geocoded	Split for clerical geocoding	United States Postal Service check	Missing data items
Baltimore	16	283	43	0	288
Jacksonville ..	627	1,902	261	97	167
San Diego ...	288	1,538	38	18	1,226
Jeffersonville .	323	777	153	1	451
Austin	271	552	99	14	163
Albany.....	163	331	77	3	281
Total	1,688	5,383	671	133	2,576

Table 5.2. **Number of Items Verified, Estimated Sample Error Rates and Standard Errors by Processing Office**

Processing office	Number of items verified	Percent of verified	Type A	Standard error	Percent of error type B Standard error
Baltimore	4,644	1.44	.18	2.58	.16
Jacksonville ..	13,809	1.38	.10	1.46	.05
San Diego ...	9,468	2.97	.17	5.98	.14
Jeffersonville .	3,975	1.81	.21	3.25	.09
Austin	2,947	1.76	.24	2.85	.08
Albany.....	3,581	9.63	.49	9.10	.46
Total	38,424	2.62	.08	3.71	.10

Table 5.3. **Number of Items Verified, Estimated Sample Error Rates for Error Type, and Standard Errors by Processing Office**

Processing office	Number items verified	Percent of error type C	Standard error	Percent of error type D	Standard error	Percent of error type E	Standard error
Baltimore ...	3,227	0.31	.10	2.17	.26	0.81	.16
Jacksonville .	12,057	0.55	.07	0.74	.08	0.27	.05
San Diego ..	4,704	0.30	.08	2.17	.21	1.02	.15
Jefferson-ville	4,146	1.52	.19	1.37	.18	0.75	.13
Austin	2,876	0.56	.14	0.80	.17	0.52	.13
Albany.....	1,640	0.61	.19	6.89	.63	8.90	.70
Total ...	28,650	0.62	.05	1.58	.07	1.04	.06

Processing Office had the highest percentage of type D sample errors (6.89 percent) for ''exact address not found when matching address present on address control file browse'' and the highest percent of type E sample errors (8.90 percent) for ''basic street address was not found when basic street address was present on address control file.'' There was a statistical difference for both type D and E errors when comparing the Albany Processing Office to other processing offices at the .10 level of significance.

Camera Unit/ Frame Number Lookup—As shown in table 5.4, there were 31,590 camera unit/ frame number lookup items verified. The overall estimated error rate for ''identification or population count incorrectly transcribed'' was 0.48 percent (standard error was 0.04 percent) and for ''correct address match but camera unit/ frame number incorrectly selected'' it was 1.05 percent (standard error was 0.06 percent).

There were no statistically significant differences among the six processing offices at the .10 level of significance for either type F or G sample errors. The San Diego Processing Office had the largest number of items verified (11,415), and the highest percentage of type G sample errors (1.85 percent) for correct address match but camera unit/ frame number incorrectly selected. The Baltimore Processing Office had the smallest percentage of type G sample errors (0.16 percent). The Jacksonville Processing Office had the highest percentage of type F sample errors (0.81 percent) for identification or population count incorrectly transcribed while the Albany Processing Office had the smallest percentage (0 percent). Albany did not report any type F errors in the sampled data analyzed.

Matching/ Transcription—The number of type H errors represent the number of persons incorrectly transcribed from a search/ match form to a Census questionnaire. The estimated number of type H errors in the Search/ Match operation was 45,800. This number is an estimate of the possible erroneous enumerations that the Search/ Match operation contributed to the census count from transcription errors. At the 90-percent confidence level, it is estimated that between 42,602 and 48,740 people were possibly erroneously enumerated by the census due to the failure of the Search/ Match operation to recognize that they should not have been added.

The type I errors represent the number of persons not transcribed to census questionnaires when they should have been. The estimated number of type I errors in the Search/ Match operation was 30,500. This number is an estimate of the possible missed persons that the Search/ Match operation contributed inadvertently to leaving out of the census count. At the 90-percent confidence level, it is estimated that between 27,939 and 32,956 people were possibly missed by the census due to the failure of the Search/ Match operation to add them.

As shown in table 5.5, there were 42,288 matching/ transcription items verified. The overall estimated error rates for ''persons incorrectly transcribed'' was 0.95 percent (standard error was 0.04 percent) and for ''persons not transcribed when they should have been'' was 0.63 percent (standard error was 0.04 percent).

The Jacksonville Processing Office had the largest number of items verified (13,852), and the highest percentage of sample errors for error types H and I with 1.19 and 0.92 percent, respectively. The Baltimore Processing Office had the smallest percentage of type H and I sample errors with 0.67 and 0.19 percent, respectively. However, none of these differences were statistically significant.

Conclusions —The processing offices did not implement the quality assurance plan as specified. Procedures were not always followed as planned causing the following problems to occur: 1) oversampling, 2) random number tables not being used or used incorrectly, 3) no timely feedback, 4) no rotation of verifiers, and 5) quality assurance recordkeeping forms were not completed correctly and/ or entirely. These problems caused some processing offices to have: 1) more forms in sample than requested and more than the other processing offices, 2) the wrong form selected in sample, 3) clerks being unaware of their performance, 4) all clerks not having the opportunity to qualify as verifiers, and 5) incorrect and missing data.

A probable reason for the above problems is that in the beginning of the operation, the processing offices were overloaded with search/ match forms. The Census Bureau had not anticipated the large volume of search/ match, so the processing offices were not prepared staff-wise to handle the large workloads. The new hires were not being trained properly and had to learn the procedures as they

Table 5.4. **Number of Items Verified, the Estimated Sample Error Rates, and the Standard Errors by Processing Office**

Processing office	Number items verified	Percent of error type F	Standard error	Percent of error type G	Standard error
Baltimore	7,548	0.05	.03	0.16	.05
Jacksonville ..	8,652	0.81	.10	0.81	.10
San Diego ...	11,415	0.60	.07	1.85	.13
Jeffersonville .	1,436	0.21	.12	1.32	.30
Austin	1,171	0.68	.24	1.37	.34
Albany.....	1,368	0	0	0.22	.13
Total	31,590	0.48	.04	1.05	.06

Table 5.5. **Number of Items Verified, the Estimated Sample Error Rates and the Standard Errors by Processing Office**

Processing office	Number items verified	Percent of error type H	Standard error	Percent of error type I	Standard error
Baltimore	5,710	0.67	.11	0.19	.06
Jacksonville ..	13,852	1.19	.09	0.92	.08
San Diego ...	9,766	0.72	.09	0.60	.08
Jeffersonville .	8,287	1.00	.11	0.58	.08
Austin	7,484	1.03	.12	0.48	.08
Albany.....	3,189	0.78	.16	0.75	.15
Total	42,288	1.08	.04	0.72	.04

were implementing the process. As the operation continued and the newly hired staff became more familiar with the operation, the workloads became less cumbersome.

The volume of missing data was so great for this operation; for example, 35,540 missing error type entries out of 81,204 entries in sample, that it caused many limitations on how the data collected could be analyzed. The accuracy of the analysis depended on the available data.

The purpose of the quality assurance plan was to determine and correct the source(s) of errors and to obtain estimates of the quality of the various search/ match processes in the processing offices. This purpose was achieved in that the quality assurance plan helped identify the sources of errors within each phase of the operation by sorting forms into batches according to form type and forwarding the forms to the appropriate phase of the operation for verification purposes. After verification, corrections were made and any errors detected were noted on the quality assurance forms where further analysis was performed to determine the estimates of the quality of each phase of the operation. Because the quality assurance Search/ Match operation was implemented for the first time during the 1990 decennial census, there are no available data from the 1980 decennial census with which to compare the 1990 figures.

The implementation of the quality assurance plan was not as good as expected. This was because of the large volume of missing data, the inconsistencies in the recording of data, and the incorrect entries assigned under the batch origin ''G'' code; that is, ''form already geocoded in the district offices.'' The quality assurance plan did not have as much impact as anticipated because the processing offices failed to fully follow procedures. This caused inconsistencies in the way the processing offices implemented the operation. However, it should be noted that this was a complex plan which may have been difficult to implement.

When comparing processing offices for the Search/ Match operation, at the .10 percent significance level, there was a statistical difference among the six processing offices for error types A, B, C, D, and E, and there was no significant difference among the six processing offices for error types F, G, H, and I.

Even though the quality assurance Search/ Match operation had inconsistencies in the data, missing data, and incompletely followed procedures, the quality assurance plan was a vital tool for improving the quality of the operation and increasing productivity.

For future similar operations, the following are recommended:

- Provide training in the processing offices that allows all units involved in the Search/ Match operation to understand the flow of the process and the purpose of each phase. Include all shifts; that is, day and night shifts, in the training.
- Incorporate into the training session(s) more illustrations of how to complete the quality assurance recordkeeping form. Stress the importance of this form being completed correctly, legibly, and completely. This will reduce the amount of missing data, and illegible and incorrect entries on the quality assurance forms.
- Stress the importance of timely feedback (positive and negative) to ensure that all employees are implementing the procedures consistently, and to identify employees who may need further training.
- Procedures should be understandable and easy to follow, after which the procedures should be followed as written unless otherwise instructed from headquarters to alter them. This will eliminate problems encountered during the implementation of the process.
- Assuming that more than one type of search/ match form will be investigated for future quality assurance search/ match processes, a revision to the quality assurance search/ match recordkeeping form needs to be implemented to capture form types for all search/ match forms being inspected. This will allow for further analysis by search/ match form type.
- Have contingency plans in place should workload exceed estimate.
- Include operation as test objective during 2000 census planning.

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QUALITY ASSURANCE TECHNICIAN PROGRAM

Regional Census Centers

Introduction and Background—During the data collection phase of the census, 449 district field offices were established to implement a variety of census collection activities in the field. Each district office reported to one of 13 regional census centers. The regional census centers provided general administrative and technical support as well as monitored the general progress and proper implementation of the programs in their specific region.

To help meet the quality assurance objective for the 1990 census, the Regional Census Centers Quality Assurance Technician Program was developed and implemented in the field. From approximately February 1 to August 31,

1990, one person in each of the 13 regional census centers monitored quality assurance requirements. Seven field operations were monitored, in the areas of field enumeration, office processing, and falsification detection. The field enumeration operations monitored were List/ Enumerate (both advance listing and listing phases), Update/ Leave, and Urban Update/ Leave. (See glossary for definitions.)

The office processing operations monitored were Clerical Edit and Collection Control File Keying. The falsification detection operations monitored were List/ Enumerate Reinterview and Nonresponse Followup Reinterview.

The objectives of the Regional Census Centers Quality Assurance Technician program was to promote management awareness of the purpose and importance of the various quality programs and to monitor the adherence to the quality assurance procedures. This section will provide information on the design and performance of the Regional Census Centers Quality Assurance Technician Program as well recommend changes to improve the program in further censuses.

Methodology—To meet the first objective, the Regional Census Centers Quality Assurance Technician was to participate in management meetings at the regional census centers level and act as a consultant to management for matters related to quality assurance. The technician assisted in explaining the importance, philosophy, purpose, and results of the quality assurance program. Also, this person was expected to be the primary contact for regional census centers and district offices management for explanations concerning the rationale for specific quality assurance procedures.

To meet the second objective, three distinct methodologies were developed for use by the technician in monitoring compliance to the quality assurance requirements by the district office: administrative analysis, independent investigation, and personal observation.

The administrative analysis technique's basic approach was to review reports from the management information system and quality assurance summary reports supplied by the district offices. For each quality assurance requirement, a specific statistic (such as production rate, error rate, staffing estimate, average expenditure level, etc.) was reviewed. The statistics were chosen based on several factors, including availability of data at the district office total summary level, correlation between the management information system data and the level of performance of the quality assurance requirement, and computational efficiency. For each statistic, a numerical computation procedure was devised to measure the level of adherence to the quality assurance requirement for the district office as a whole. Guidelines were provided, based upon numeric tolerances, to determine if regional and district office management staffs were to be notified of the apparent inconsistencies.

The independent investigations allowed the technicians the freedom to initiate their own analyses, using whatever data was available, to confirm suspicions concerning potential quality assurance problems, to answer questions posed by management, or to check operations of interest.

The personal observation technique was useful in providing the technician with information and insights into the conduct of operations and quality assurance procedures. However, the physical distance between district offices and the number of operations minimized the effectiveness of this technique. (See [1] for additional information.)

Limitations—The reliability of many estimates depended on the quality of the data entered on the monitoring forms.

Results—The data obtained by the weekly administrative analysis suggested that 12 of 13 regions performed some level of monitoring. Within the 12, only about 30 percent of each requirement was monitored as expected.

The Urban Update/ Leave operation experienced the highest overall monitoring coverage rate, 63.12 percent, for the four regional census centers performing this operation. This high coverage rate may be due to the short duration of the operation and to fewer quality assurance requirements, thus requiring less time for monitoring and documentation.

No other field operation experienced an overall coverage rate of administrative analysis in excess of 50 percent. The List/ Enumerate operation experienced the lowest coverage rate over all applicable regional census centers, 22.07 percent. Two possible explanations exist for this low coverage rate: first, there is no record the quality assurance requirements were monitored in 3 of the 10 regions performing the List/ Enumerate operation; second, the late start of List/ Enumerate and the longer than expected duration of the operation due to bad weather in some regions may have contributed to truncation of the quality assurance monitoring.

The Collection Control File Keying operation experienced the second lowest overall coverage rate of the seven operations, at 22.58 percent. The major factor in the low Collection Control File Keying coverage rate was that the records show only five of the thirteen regions performed any administrative analysis. This may have been due to a lack of forwarding of automated quality assurance results data from the district offices to the regional census centers. During planning, a major concern was how well the technicians would implement the analysis procedures. The data from reviewing the quality assurance monitoring records suggest that the technicians had varying levels of difficulties. The analysis procedure error rate range from 20 to 38 percent for each quality assurance requirement monitored.

There were several barriers the technicians found when trying to implement the administrative analysis procedures. For several field operations, including Clerical Edit and Collection Control File Keying, the management information system data for the training requirement were not available. The management information system presented data for training and production combined for each of

these operations. Another barrier was that quality assurance data, produced by the district offices and required for several administrative analysis procedures, were not forwarded to the technicians consistently by all district offices. Other quality assurance data, especially data necessary for the computation of lag times for the reinterview operations, were not computed correctly by some district offices, and were omitted altogether by other district offices.

The technicians discovered numerous instances in which production data were entered into the management information system using incorrect operation codes. Thus, the data were accumulated and attributed to the wrong operations, making administrative analysis difficult. Almost unanimously, the technicians encountered management information system data that were behind actual production levels in the district offices, as confirmed by them from independent data sources. Budgeted cost data for List/ Enumerate training included production incentive bonuses for enumerators who remained on the job throughout the duration of the List/ Enumerate operation. However, these bonuses were not paid nor their actual costs entered into the management information system until the List/ Enumerate operation was completed; and then these actual costs were attributed to production, rather than to training.

The data suggest that the technician program was effective in detecting district offices having difficulties using the quality assurance procedures despite the problems discussed above. (See [2] through [11] for additional information.)

Conclusions —The Regional Census Centers Quality Assurance Technician Program accomplished all three of it objectives in general. The implementation of the quality assurance program within the district offices was monitored, problems were identified, and referred to regional census center and district office management for resolution.

Through the validation and referral process for potential problems, the technicians assisted the field offices in the correct preparation, interpretation, and use of quality assurance and management information system data. In addition, technician program provided headquarters with data on the level of implementation of quality assurance requirements for field operations while those operations were active, a timeliness never before attained.

The quality assurance monitoring workload required a full-time position in each regional census center. However, due to budget constraints, most regions allocated a part-time person to this position. To increase the effectiveness of this program for future censuses, it is recommended that each regional census center staffs one full-time equivalent person in this position.

Communication between the technicians and quality assurance analysts at headquarters was hampered by the lack of direct communication links. All communication between them was channeled through an intermediary group, reducing the timeliness and effectiveness of communication. Increased use of voice and electronic mail, database sharing, and hard copy media would increase the effectiveness, efficiency, timeliness, and responsiveness of monitoring.

During the course of quality assurance monitoring, the technicians discovered several anomalies with the management information system. Several recommendations were made.

- Expanding the operational category codes on the database would allow for full separation of training, production, and quality assurance data for all field operations.
- Enhance training for users of the management information system data and include more persons into the training. This will help field personnel, data entry clerks, supervisors, and data users to understand the structure of the category code system, which might reduce misclassification errors.
- Investigate the causes of delays in the incorporation of data into the database, in order to improve the timeliness of the system.

The regional census center technicians experienced some difficulties in implementing the analysis procedures. It is recommended that the persons selected to fill the positions be identified earlier in the census cycle and be required to have statistical training. This will provide the needed level of technical expertise to the position, and will allow for enhanced training.

Include practice exercises using the administrative analysis procedures with live or simulated management information system data in the training. Administrative analysis procedures would be enhanced by the inclusion of examples reinforcing the specific decision criteria, and by rewording the procedure text to eliminate any confusion that may have contributed to procedural misinterpretation. This will result in an enhanced set of tools for the technicians to use in their monitoring of quality assurance compliance.

The administrative analysis techniques used in the 1990 census by the technicians were time consuming, prone to error, and cumbersome because of the reliance on hard copy documentation. It is recommended that the entire monitoring process be automated as much as possible. Most of the input data for monitoring was provided by the management information system. Automating the compilation of data for each district office within a regional census center and automating the computation of analysis decisions could be possible. This should result in a more effective and efficient monitoring process. It would provide more time for the technicians to perform special investigations of quality assurance data and for consultation with regional and district office management on quality assurance matters.

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Processing Offices

Introduction and Background—During the data processing phase of the census, seven processing offices were established to implement a variety of activities to prepare census data for computer processing and tabulation. Processing offices were located in Albany, New York; Kansas City, Missouri; Jeffersonville, Indiana; Austin, Texas; Jacksonville, Florida; Baltimore, Maryland; and San Diego, California. Each office, for the most part, performed similar activities. The type of operations performed were checking in census questionnaires; filling in control information on census questionnaires needed for microfilming; actual microfilming and data keying of questionnaires; editing and conducting telephone tasks to assist respondent and to follow-up on missing census data on questionnaires. In addition, other administrative and work flow operations were implemented to support the main operations.

For most of these operations, there was a formal quality assurance plan to help measure the quality performance of the operation as well as provide information on the type and source of errors to improve performance.

To help meet the quality assurance objective, the Processing Office Quality Assurance Technician Program was developed and implemented in the processing offices. From approximately April 1990 to February 1991, one person monitored quality assurance requirements in each processing office except for Jacksonville, Florida, where no full-time technician was assigned. There, quality assurance analysts from headquarters performed the quality assurance technician's functions on a rotating basis.

The objectives of the Processing Offices Quality Assurance Technician Program were to promote management awareness of the purpose and importance of the various quality assurance programs and to monitor the adherence to the quality assurance procedures.

Methodology—To meet the first objective, the Processing Office Quality Assurance Technician was to participate in management meetings at the processing office and act as a consultant to management for matters related to quality assurance. The technician assisted in explaining the importance, philosophy, purpose, and any results of the quality assurance program. Also, this person was expected to be the primary contact for the processing office management for explanations concerning the rationale for specific quality assurance procedures.

To meet the second objective, three methodologies were developed for use by the technician in monitoring compliance to the quality assurance requirements in the processing office: administrative analysis, independent investigation, and personal observation.

The administrative analysis technique's basic approach was the review of management status and progress reports and quality assurance summary reports to identify potential operational difficulties.

The independent investigations allowed the technicians the freedom to initiate their own analyses, using whatever

data was available, to confirm suspicions concerning potential quality assurance problems, to answer questions posed by management, or to check operations of interest.

The personal observation technique was useful in providing the technician with information and insights into the conduct of operations and quality assurance procedures. The quality assurance technician was expected to observe each processing unit frequently, especially during training and start-up of an operation.

Limitation—Most of the information in this report is based on oral as well as documented reports from the quality assurance technicians. However, many observations were confirmed from the problem referrals generated by the processing office management.

Results—From the quality assurance technicians' prospective, the Processing Office Quality Assurance Program was successful in monitoring the operations' compliance of quality assurance requirements. Factors that contributed to this perception were the close relationship that developed between the quality assurance technician and Quality Assurance Section Chief in the processing offices; the quality assurance technicians' unrestricted freedom and access to operations and information in the processing office; the support and understanding of upper management of the quality assurance technicians' responsibilities; and the simple presence and independence of the quality assurance technician at the processing office was a constant reminder that the quality assurance plans were important and an integral part of data processing. Each quality assurance technician encountered different experiences during their assignment and below are some highlights of their observations related to the operations' performance and the quality assurance programs.

1. The automated record keeping system, designed to provide and summarize quality and production data on the various quality assurance operations, was a valuable tool. It helped supervisors identify problems and improve performance, despite the initial operational and software problems.

2. Rotation of personnel between verification and production was a quality requirement intended to breakdown barriers within the operational unit and to eliminate backlog. However, the implementation was not fully explained until late into the process. Some operations rotated by row or by day of the week. The rotation concept was not supported for some operations.

3. There was initial confusion on whether the quality assurance technicians were to be involved in the keying operations. All keying operations were being monitored from headquarters. However, Jeffersonville keying quality was significantly lower than for the other processing offices. The quality assurance technician was asked by the processing office manager to look into the reasons for the high batch failure rates for one of the keying operations. The quality assurance technician concluded the factors that contributed were:

   - For rejected work units, only errors identified in the sample were repaired and there was no reveiw of the entire batch for errors. This process was intended to give the keyers additional information on the type and reason for their mistakes, as well as correcting the batches of all errors.
   - Failure of the keying management to use any of the quality control reports;
   - Lack of communication between headquarters and processing office on the quality assurance plan for keying.

   In late August, the Quality Assurance Unit chief and the decennial keying supervisor went to the Kansas City Processing Office to observe their keying operations. They were favorably impressed. After that visit the keying supervisor implemented the use of quality circles and began a new emphasis on quality as well as production. The keying quality began to improve steadily from that point and the relationship between the quality assurance unit and keying management staff became more agreeable.

4. Quality Assurance technicians spent a fair amount of time providing reasons for quality assurance and explaining that the documentation was not to identify blame, but an attempt to improve the overall process and the census as a whole.

5. Most of the operations' quality assurance requirements were implemented very well. However, several operations experienced difficulties. A couple of operations had difficulty qualifying clerks due to lack of availability of test desks. Telephone operations had problems sufficiently monitoring telephone calls, partly due to the unexpected volume of telephone calls. Another problem for some operations were due to the complexity of the quality assurance procedures. There was resistance to the use of quality circles due to lack of management being convinced of the benefits versus the impact on production.

Many of the quality assurance technicians had initial concerns about being accepted by the processing office staff and about not having extensive processing or quality assurance experience. The fear of being an outsider was eliminated for the most part because the processing office's management treated them as part of the team. The quality assurance technician, in exchange, kept the management staff informed of problems and tried to address all problems first at the processing office level before they were formally documented and sent to headquarters.

The recruitment and training of the quality assurance technicians were not implemented as planned. Initially, all quality assurance technicians were to be hired from outside the Census Bureau on a temporary appointment. They were to be hired to help monitor the printing of census questionnaires prior to being assigned to the processing offices. Their qualifications were to include significant training in statistics. Both of these requirements presented barriers for recruitment. The results were that only six quality assurance technicians of the seven needed were eventually placed. Only two were hired from outside the Bureau and four were reassigned from other areas of the Census Bureau. No quality assurance technician was assigned to the Jacksonville Processing Office. For this office, headquarters' analysts rotated to perform the quality assurance technician duties.

Conclusions—In general, the Processing Office Quality Assurance Technician Program accomplished all three of it's objectives. The implementation of the quality assurance programs within the processing offices was monitored, problems were identified, and referred to the processing offices management for resolution.

The quality assurance technicians felt that most of the quality assurance requirements were implemented properly. However, most of the quality assurance requirements that caused difficulties could have been minimized by clarification of procedures, enhanced training of supervisors on procedures and record keeping, and a consensus of agreement between processing offices and headquarters management on such quality concepts as rotation of personnel, use of quality circles, feedback, qualification of workers, and administrative action.

The quality assurance technicians felt that the automated record keeping system was a valuable tool for monitoring the operation and helped the supervisors to provide feedback. Efforts should continue to expand and refine both the software and analysis techniques to assist in isolating potential processing problems.

There were difficulties in filling the quality assurance technician position with qualified people on a temporary basis. Administrative ways should be developed to attract the necessary applicants if technicians are used in the future. It is imperative that such analysts are hired early to assist in the planning process to enable them to be trained thoroughly prior to being assigned to the processing offices.

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Printing

Introduction and Background—For the 1990 decennial census, approximately 107 million enumerator-administered

questionnaires and 112 million questionnaire mailing packages (along with approximately 90 million casing cards)[1] were produced at about 20 contractor sites. The contracts for the production of the questionnaires and mailing packages contained strict/ concise printing requirements that necessitated the use of equipment such as measuring microscopes, densitometers, rub-testers, and similar equipment to measure compliance with the contracts. The quality assurance technician program was developed to handle the arduous task of monitoring the contractors' adherence to the quality assurance requirements as specified in the government contracts. The program consisted of quality assurance technicians (hereafter referred to as technicians) who were trained in the classroom at Census Bureau headquarters and the Government Printing Office and on-the-job by experienced Census Bureau headquarters staff.

The technicians were to perform the following tasks: 1) verify the selection and inspection of the quality assurance samples, 2) detect and observe the corrective action taken on defective material, 3) ensure recordkeeping of the quality assurance data, and 4) investigate problems and report observations conflicting with the quality assurance requirements. The technicians monitored the contractors' adherence to the quality assurance requirements in conjunction with staff from the Government Printing Office and Census Bureau headquarters. The technicians performed these tasks by on-site monitoring of the production of the questionnaire packages.

Methodology—On-site monitoring began in April 1989 and ended in March 1990. There were 2 months in this time period where there was no production of questionnaires. The technicians were trained to perform the monitoring tasks in the classroom by the Government Printing Office and Census Bureau headquarters staff and on-the-job by experienced Census Bureau headquarters staff. The classroom training consisted of an overview of the procedures for monitoring the production of the questionnaire packages, technical training on how to calibrate and operate the equipment used to inspect the questionnaire packages, and the protocol for reporting inconsistencies and problems. The on-the-job training involved accompaniment and guidance from Census Bureau staff on how the technicians were to verify that the: 1) quality assurance samples were selected at the specified intervals and correctly identified, 2) specified visual and mechanical measurements were done, 3) expanded searches, clean-outs, adjustments, and reinspections were correctly performed when defects were detected, and 4) quality assurance recordkeeping forms were correctly completed and entered into the automated data collection software provided by the Census Bureau. The technicians also were required to investigate, report, and obtain resolutions for problems that occurred, and complete and mail quality assurance recordkeeping forms designed to report the observations of and measurements taken by the technicians to Census Bureau headquarters staff. (See forms in appendix B.)

Limitations—The reliability of the evaluation of the quality assurance technician program was affected by and dependent upon the following:

1. The late hiring of long-term technicians.
2. The potentially varying levels or degrees of classroom training the technicians received.
3. The accuracy of data relating to the length of time the technicians were working on printing related activities and the accuracy of quality assurance records on the number and length of trips each technician took.
4. The calibration and accuracy of the equipment used to inspect the questionnaire packages.
5. The accuracy of the quality assurance recordkeeping forms completed by the technicians.

Results—

Qualifications—The quality assurance technician program was not implemented *prior* to the pre-production of the enumerator-administered questionnaires and questionnaire mailing packages because no technicians had been hired. Initially, the technicians were intended to be hired from ''outside'' the Census Bureau. However, the qualifications were unrealistic relative to the type of people wanted for the job and the time frame the Census Bureau had to hire them. Thus, no one was hired. For this reason, four staff members from four of the Census Bureau processing offices were detailed to headquarters to serve as short-term technicians. Eventually, the qualifications were modified. After approximately 60 days, hiring of long-term technicians began. By the time all prior-to-production questionnaire packages (packages created by the contractor to demonstrate it's ability to produce the questionnaire packages per Census Bureau specifications) were produced, all but one long-term technician had been hired.

The quality assurance technician program consisted of a total of nine technicians. Of the nine, four were short-term and five were long-term. One of the five long-term technicians left the program before it was completed.

Training—The technicians were not all trained at the same time because they were hired over a period of 6 months. Two of the technicians received classroom training at Census Bureau headquarters, eight received classroom training from the Government Printing Office, and all received on-the-job training from experienced Census Bureau headquarters staff. The classroom training at Census Bureau headquarters lasted about 2 1/ 2 days and consisted of an overview and discussion of the procedures

[1]Address cards for every address in the mailout/ mailback areas that the United States Postal Service reviewed for accuracy and completeness.

for monitoring the production of the questionnaire packages. The topics included such things as how the questionnaires are printed, what the quality assurance requirements are, and the role and responsibility of the technicians. The classroom training at the Government Printing Office was technical, lasted approximately 1 week, and covered the calibration and operation of the equipment (measuring microscopes, densitometers, rub-testers, etc.) used to inspect the questionnaire packages. The on-the-job training, lasting about 2 days for each technician, involved the accompaniment and guidance from an experienced printing Census Bureau headquarters staff person on implementing what was taught in the classroom training sessions. This occurred at the contractor sites.

The classroom training for most of the long-term technicians was more comprehensive than the classroom training received by the short-term technicians. The long-term technicians experienced more hands-on training and more clarification of what was expected of them. The difference in training for the short-term and long-term technicians may have been the result of time constraints and the fact that this was a first attempt at this type of training. Regardless, all three types of training were deemed necessary and very valuable.

Monitoring—The technicians monitored production of the questionnaire packages at approximately 20 contractor sites over a period of 9 months of actual production. The first 2 months were monitored by the short-term technicians and the remaining 7 months were monitored by the long-term technicians. Experienced staff from the Government Printing Office and Census Bureau headquarters monitored the sites throughout production, especially between the time short-term technicians left and the long-term technicians arrived and were trained. Monitoring by the technicians, the Government Printing Office, and Census Bureau headquarters staff was done concurrently throughout the 9 months of production.

There was 100 percent coverage for the contractor sites where prior-to-production questionnaire packages were produced. For the actual production of the questionnaire packages, about half of the contractor sites were monitored at least 50 percent of production time, and four were monitored 100 percent of production time. The maximum number of sites operating during the same week was 14. The sites monitored most were sites where several problems were detected or expected, and sites where critical production phases such as imaging, inserting, packaging, and shipping occurred. The least monitored sites were sites where the envelopes were produced.

The technicians monitored a contractor site for approximately a week at a time. Most of the time the technicians went from one contractor site to another before coming back to Census Bureau headquarters to ''check in.'' The monitoring varied by shifts and hours. Monitoring the 20 contractor sites throughout the entire production of the questionnaire packages, to the extent it was accomplished, would have been virtually impossible without the technicians. There were too many sites for the Government Printing Office and Census Bureau headquarters staff to effectively monitor. There was some attempt made to rotate the technicians across sites.

While at the contractor sites, the technicians used the government contracts, quality assurance specifications, measuring devices, quality assurance samples and quality assurance recordkeeping forms completed by the contractors to ensure the contractors adhered to the quality assurance requirements. The technicians performed independent inspections of the printed materials and re-measured attributes that the contractors inspected. The readings of the technicians and contractors did not have to exactly match, but they had to be within a specified tolerance. All measurements, observations, and discrepancies were documented on quality assurance recordkeeping forms and investigated. The technicians completed their quality assurance recordkeeping forms and mailed them to Census Bureau headquarters each day. The technicians were to complete quality assurance recordkeeping forms for each shift observed. Most of the time, the technicians completed at least two quality assurance recordkeeping forms each day (one for each shift observed). Occasionally, no quality assurance recordkeeping forms would be completed for a given day. In addition to completing the quality assurance recordkeeping forms, the technicians called Census Bureau headquarters to keep headquarters abreast of what was happening at the contractor sites.

Throughout the entire quality assurance technician program, approximately 4.0 percent of the recordkeeping forms completed by the technicians contained re-measured attributes that were out of tolerance. The discrepancies consisted of out-of-tolerance image sizes, poor type quality, out-of-tolerance glue on the envelopes, out-of-tolerance trimming, missing staples, out-of-register ink, improperly stitched questionnaires, incorrectly measured questionnaire binding, and packages containing improper contents. No discrepancies were detected for the imaging of the questionnaires. Most of the discrepancies were detected for the construction of the envelopes (approximately 9.4 percent), the least monitored operation.

In addition to the discrepancies noted above, the following observations were reported: 1) the contractors incorrectly completed the quality assurance forms, 2) the quality assurance samples were incorrectly identified, 3) the quality assurance data were not entered promptly into the computer, and 4) the spoiled materials were incorrectly shredded. These observations were reported for almost all stages of production of the questionnaire packages at one point or another, but not all the time.

The technicians also monitored the end of the production of the casing cards. They were not required to complete quality assurance recordkeeping forms, but were required to call Census Bureau headquarters daily to report the status of the production of the casing cards. Since the technicians did not monitor this operation for any significant length of time, no inference can be made on the impact of the technicians' presence.

Conclusions—The quality assurance technician program was very useful for monitoring the production of the questionnaire packages for the 1990 decennial census. The presence of the technicians at the contractor sites had a positive impact on the quality of the materials produced. This was evidenced by the small number of discrepancies between the measurements of the contractors and technicians. Generally, the discrepancies led to immediate investigation and inspection of possibly defective materials.

Although the classroom training for all the technicians was not consistent, it was comprehensive. It also allowed the technicians to ask not only Census Bureau headquarters staff questions, but staff from the Government Printing Office as well. During on-the-job training, each technician was observed by experienced Census Bureau headquarters staff and their ability to serve as a technician was verified.

As a result of the evaluation of the quality assurance technician program, the following are recommended:

1. The quality assurance technician program should be used for the 2000 Census. However, the program should be implemented *prior* to the pre-production of the questionnaire packages. This would eliminate the need to hire short-term technicians until long-term technicians could be hired.
2. Since the basic qualifications to serve as a technician required the ability to master the materials needed to monitor the production of the questionnaire packages and function independently, an attempt should be made to obtain personnel from current Census Bureau staff to perform as technicians for as long as needed. The staff would be familiar with Census Bureau procedures, a hiring process would not be needed, and the staff would already be on board. After their function as technicians ends, they could go back to their original offices. This would help to ensure that all technicians would be hired before the pre-production of the questionnaire packages and allow for consistent and concurrent training of the technicians.
3. There should be regularly scheduled quality circle-type meetings with the technicians and Census Bureau headquarters staff. This would provide the opportunity for the technicians to interact and share information with each other as well as with headquarters staff. The technicians also would be able to ask questions and express any concerns they may have.
4. The technicians should be rotated between different contractor sites. This would allow them to gain experience in monitoring a variety of production processes and interacting with more than one contractor.

Reference—

[1] Green, Somonica L., DSSD 1990 Decennial Census Memorandum Series # M-56, ‘‘Evaluation of the Quality Assurance Technician Program for the Production of the 1990 Decennial Census Questionnaire Packages.’’ U.S. Department of Commerce, Bureau of the Census. August 1993.

APPENDIX A.
Glossary

Address Control File (ACF)—The Census Bureau's residential address file used to generate the addresses for the mailout and enumerator delivery of the questionnaires before Census Day. During the questionnaire processing operation, the ACF is used in identifying nonresponse problems.

Address Control File Browse—The software system for locating missing questionnaire identification numbers by accessing the ACF with address information on the form.

Address Register—A book used by enumerators in a census that contains the street address and related information for every housing unit and special place listed and/ or enumerated during the census.

Address Register Area (ARA)—A geographic area established for data collection purposes, usually consisting of several neighboring blocks.

Automated Recordkeeping System (ARS)—The system used to record quality assurance information from clerical census operations. This system produced quality reports which summarize quality assurance data and are used to advise unit supervisory clerks of quality problems in their unit.

Batch—Another term for a work unit of questionnaires. In some operations, a batch consists of a box of approximately 450 short forms or 100 long forms. Boxes of questionnaires to repair or markup can also be referred to as batches. (See Work Unit.)

Call Monitoring—The practice of the supervisors and lead clerks in the Telephone Unit of listening to some of the calls between the telephone clerks and the respondents to ensure that the clerks are handling the calls in an effective and proper manner.

Camera Unit—The name given to the consolidation of four boxes of questionnaires (also referred to as a CU), grouped to facilitate filming of the questionnaires.

Camera Unit Identification Number (CUID)—A number assigned to each camera unit for the purpose of controlling the movement of questionnaire data through FACT 90 processing and edit followup.

Casing Cards—Address cards for every address in the mailout/ mailback areas that the United States Postal Service reviewed for accuracy and completeness.

Census—A complete count of each of the component parts of a given population (or universe) such as people, housing units, farms, businesses, governments, etc. In a more general sense, a census can be a combination of complete count and sample data as is the case with the 1990 Decennial Census of Population and Housing.

Census Data—Data aggregated from the individual census questionnaires and published in a format (printed reports, computer tapes, CD-ROMS, and microfiche) which can be used in a program decision-making process, planning as well as for academic, genealogical, and private research.

Check-In—The logging in of questionnaires into the computer to indicate they are part of the processing flow. The check-in results are used to inform the Census Bureau which respondents are accounted for and which addresses require nonresponse followup.

Check-Out—The logging out of the questionnaires in the processing offices which need to be returned to the district offices for enumerator followup.

Collection Control File (CCF)—An automated system used in a field data collection office for management and control of field operations. Part of the Collection Control System for the 1990 decennial census.

Collection Control System (CCS)—The complete set of automated programs used to meet collection, administrative, personnel, and management control requirements in a field data collection office for the 1990 decennial census.

Control and Tracking System (CATS)—Computer software used to control and track the movement of camera units (or batches) through the data capture processing flow.

Data Capture—The conversion of data from a written document into a computer readable format. In the case of the 1990 Decennial Census, the questionnaire data are first converted to microfilmed data before being converted to computer readable data by FOSDIC.

Data Entry Clerk—A clerk specially skilled in using a computer terminal to transfer written information from census documents to a computer file. Also referred to as a keyer.

Decennial Census—A census that is taken every 10 years.

Decennial Operations Division (DOD)—The Headquarter-based, Census Bureau division responsible for overseeing Processing Offices and operations for the 1990 Decennial Census. (Later known as Decennial Management Division.)

Decennial Statistical Studies Division (DSSD)—The headquarters-based Census Bureau division responsible for overseeing and establishing guidelines for the Quality Assurance units in the processing offices. (Formerly known as Statistical Support Division (STSD).)

Deliverability Check Card—Was completed for search addresses where the basis street addresses was not found on the address control file. These cards were sent to the appropriate United States Postal Service (USPS) station for their assistance in determining whether the search addresses were: 1) deliverable as addressed, 2) deliverable with corrections, or 3) undeliverable.

District Office (DO)—Approximately 450 temporary offices established throughout the United States to coordinate enumerator canvassing activities for the 1990 Decennial Census operations.

Enumerator—A temporary census worker responsible for collecting information by canvassing an assigned area.

Fail—(See Failed Tolerance.)

Failed Tolerance—A negative result that is an unacceptable variation from the standard of weight count, film density, keying accuracy, batch size, etc.

Followup—The means used to obtain complete and accurate questionnaire data after previous attempts were unsuccessful. (See Telephone Followup and Non-response Followup)

FOSDIC—An acronym which stands for Film Optical Sensing Device for Input to Computers.

Geocode—A code which identifies the location of a living quarters and includes the district office code, the ARA number, the block number and in some cases the map spot number.

Group Quarters—A residential structure providing housing for nine or more unrelated persons using common dining facilities.

Headquarters (HQ)—The Census Bureau, located in Suitland, Maryland in the Washington, DC area.

Housing Questions—Those questions preceded by an ''H'' which pertain to the housing unit occupied by the respondent and other household members. (See Population Questions.)

Housing Unit—A house, structure, living quarters, etc. occupied by a single household or if vacant intended for occupancy as separate living quarters.

Hundred-Percent Questionnaire—Another name for the short form questionnaire since all of the questions are also asked on the long form questionnaire and are therefore asked of 100 percent of the population. (See short form.)

Imaging—Mailing package production process in which information such as variable respondent addresses, an interleaved 2 of 5 bar code, a census identification number, a binary coded decimal code, variable return addresses with corresponding postnet bar codes, and synchronization control numbers are encoded on each questionnaire.

Industry and Occupation (I&O)—The industry and occupation reported for the current or most recent job activity in response to questions on the 1990 Decennial Census long form questionnaire items 28 and 29.

Interview—The conversation conducted by a telephone clerk or enumerator with a respondent from whom census information is sought.

Jeffersonville, IN Office—One of the seven Processing Offices for the 1990 Decennial Census. In addition, a permanent Census Bureau office, called the Data Preparation Division (DPD), which handles most of the test census processing and current survey requirements between the decennial censuses. Also, for the current census operations, will be responsible for duplicating the microfilm produced by all the processing offices.

Keyer—(See Data Entry Clerk)

List/ Enumerate (L/ E)—Enumerators canvassed a geographic area, listed each residential address, annotated maps, and collected a questionnaire *from* or *enumerated the household* for housing units in more sparsely populated areas.

Long Form—A more detailed questionnaire which is distributed to about one out of every six households. In addition to the standard short form questions, the long form contains 26 more population questions per person and 19 more housing questions. A sample of the population is used to lighten the reporting burden of census respondents and to enable the Census Bureau to publish more detailed data than would be possible from the short form.

Long Form Keying—The operation which is responsible for entering all write-in entries on the long form. Also referred to as write-in keying.

Machine Error—A mechanical problem with the questionnaire such as mutilation, tears, food spills, damaged index marks, etc., which results in FOSDIC being unable to read data from that questionnaire. An ''M'' flag is printed on the Repair Diary to indicate a machine failure.

Mailout/ Mailback—The method for the data collection where questionnaires are mailed out to the respondents, and respondents mail their completed forms back to the address on the return envelop (either the local district office or a processing office).

Map Spot—The indication of a living quarters on a census map.

Map Spot Number—A unique 4-digit number for each map spot. This number is the last four digits in the geocoded section of the questionnaires.

Markup Unit—The unit responsible for correcting content or coverage errors noted by the computer edit and identifying those forms which require telephone followup or a personal visit to accurately complete the questionnaire.

Microfilm Access Device (MAD)—A machine used in the Search/ Match operations to review questionnaire images on microfilm and to print copies.

NonResponse Followup—The practice of sending an enumerator to collect the data from a household that has failed to complete its questionnaire within a certain time.

Original Keyer—A term used in data entry operations to distinguish the keyer, whose work has been verified, from the verifying clerk and other clerks in the unit.

Pass—1) The positive result in checking, verifying or editing a work unit to see if it is within tolerance. 2) In the Split Unit, the activity of wanding or keying identification numbers of questionnaire in a box or sorted pile to identify the result of the computer edit for each questionnaire.

Place-of-Work (POW)—The address location of the plant, office, store, or other establishment where the respondent worked the previous week.

Population Questions—Items on the questionnaire that ask for information about a member of the household. (See Housing Questions.)

Precanvass—An update of the tape address register (TAR) addresses done by census enumerators who compared physical locations of housing units with what they found in the address listings and made the necessary changes.

Prelist (1988)—One of two early precensus operations (see TAR) undertaken for the initial creation of address files for later incorporation into the address control file (ACF). The 1988 Prelist was conducted in suburban areas, small cities, towns, and some rural areas.

Procedure—The document containing a set of guidelines describing in detail how the various aspects of the processing operations are to be conducted in the various units in the processing offices.

Processing Office (PO)—There were seven offices established to handle the processing workload for the 1990 Decennial Census. The processing offices are:

Albany, NY
Austin, TX
Baltimore, MD
Jacksonville, FL
Jeffersonville, IN
Kansas City, MO
San Diego, CA

Quality Assurance (QA)—Quality assurance consists of monitoring, evaluating, verifying, and reporting on the work performed within the production units. The purpose of quality assurance is to identify performance problems and their causes, to propose solutions to these problems, and to communicate this information to the supervisors who will decide what corrective action needs to be taken.

Quality Control (QC)—Is the regulatory process through which we measure actual quality performance, compare it with standards, and act on the difference.

Quality Control Clerk—(See Verification Clerk.)

Question—An item on a questionnaire designed to elicit information from a respondent abut his/ her household and housing unit.

Questionnaire—For the 1990 Decennial Census, the form containing questions designed to collect population and housing data from the American public.

Questionnaire Data—The information about the household and housing unit recorded on the questionnaire.

Regional Census Center—A temporary office established during the census to manage and support the district offices activities.

Regional Office—A permanent office used to manage and support the collection of data for ongoing programs.

Register—Address register.

Reinterview—A quality control procedure to verify that enumerators collected accurate information.

Rekey—To reenter all data from a work unit because it failed tolerance. (See Repair definition 3.)

Repair—1) In edit review, one of four categories that, along with markup, indicate questionnaires that have been rejected by the computer edit. 2) To insert or correct data from a work unit because it failed tolerance. (See Rekey.)

Repair Unit—The unit responsible for fixing questionnaires that have been rejected by the computer edit because of machine errors, identification errors, and coverage inconsistencies.

Report—1) A document providing production or quality statistics. 2) A problem referral. 3) The title and classification of four types of census forms (Advance Census Report, Individual Census Report, Military Census Report, and Shipboard Census Report).

Respondent—The person who provides the questionnaire data by filling out the form or by answering questions from an enumerator or telephone clerk.

REX—Research, Evaluation, and Experimental Program.

Sample Questionnaire—(See Long Form.)

SAS—A software package used for Statistical Analysis developed by the SAS Institute Inc., Cary, North Carolina.

Search/ Match—The Search/ Match Coverage Improvement operation was conducted to help ensure that all persons were enumerated at their usual residence. Search/ Match was designed to improve both within household and whole household coverage.

Short Form—One of two types of questionnaires used to collect data for the 1990 Decennial Census. The short forms contain seven population and seven housing questions and are distributed to approximately five out of every six households. (See Long Form.)

Split—The separation of questionnaires after the computer edit into those that passed and those that failed the edit. Those that passed are the accepts and the Post Enumeration Survey accepts. Those that failed are the repairs and the markups.

Split Unit—The unit which separates questionnaires into four categories (accept, post enumeration survey accept, repair, or markup) by wanding or keying the questionnaire identification number.

Soundx Algorithm—An automated method of quality assurance verification for alpha/ numeric fields in which two versions of the same field entry are compared to determine whether or not the two entries refer to the same information despite minor differences (spelling, spacing, etc.). The number of character (keystroke) differences allowed depends on the length of the field. The soundx method of verification was developed by the Decennial Management Division.

Tape Address Register (TAR)—Computer tapes containing geocoded addresses for the address register areas within the most populated urban areas of the United States.

Tape Address Register area—An area where the initial address list is a purchased vendor file.

Telephone Assistance—A public service provided by the processing offices to aid respondents who require assistance in completing their questionnaires. This type of assistance is also provided by the district offices.

Telephone Followup—The processing office operation in which clerks conduct followup enumeration by telephone for the Type 1, mail return questionnaires that could not be fixed in the Markup Unit.

Tolerance—Leeway for variation from a standard which is set to determine whether a batch must be rekeyed or fixed because it had more errors than the tolerance allowed.

Type 1 District Office (DO)—There were 103 Type 1 District Offices that covered central city areas in the larger cities. Each Type 1 DO covered around 175,000 housing units.

Type 2 District Office (DO)—There were 197 Type 2 District Offices that covered cities and suburban areas. Each Type 2 DO covered around 260,000 housing units.

Type 2A District Office (DO)—There were 79 Type 2A District Offices that covered cities, suburban, rural, and seasonal areas in the south and midwest. Each Type 2A DO covered around 270,000 housing units.

Type 3 District Office (DO)—There were 70 Type 3 District Offices that covered the more rural areas of the west and far north. Each Type 3 DO covered around 215,000 housing units.

Update/ Leave (UL)—Enumerators delivered decennial census forms for return by mail and at the same time updated the census mailing list in selected *rural areas.*

Urban Update/ Leave (UU/ L)—Enumerators delivered decennial census forms for return by mail and at the same time updated census mail list in preidentified census blocks consisting entirely of *public housing* developments.

Verification—The process of checking a clerk's work to determine whether the work is of acceptable quality to go on to the next stage of processing.

Verification Clerk—The clerk who is responsible for verification of a random selection of work. Also referred to as quality control clerk.

Work Unit—A generic term used to describe a tray, batch, box or camera unit of questionnaires, or a rolling bin of such items.

Work Unit Identification—A number assigned to each work unit.

Write-in Entry—An entry or respondent answer handwritten in the dotted-line areas of the questionnaire.

Write-in Keying—(See Long Form Keying.)

APPENDIX B.
1990 Decennial Census Forms

CENSUS '90

OFFICIAL 1990 U.S. CENSUS FORM

Thank you for taking time to complete and return this census questionnaire. It's important to you, your community, and the Nation.

The law requires answers but guarantees privacy.

By law (Title 13, U.S. Code), you're required to answer the census questions to the best of your knowledge. However, the same law guarantees that your census form remains confidential. For 72 years--or until the year 2062--only Census Bureau employees can see your form. No one else--no other government body, no police department, no court system or welfare agency--is permitted to see this confidential information under any circumstances.

How to get started--and get help.

Start by listing on the next page the names of all the people who live in your home. Please answer all questions with a black lead pencil. You'll find detailed instructions for answering the census in the enclosed guide. If you need additional help, call the toll-free telephone number to the left, near your address.

Please answer and return your form promptly.

Complete your form and return it by April 1, 1990 in the postage-paid envelope provided. Avoid the inconvenience of having a census taker visit your home.

Again, thank you for answering the 1990 Census.
Remember: Return the completed form by April 1, 1990.

Para personas de habla hispana –
(For Spanish-speaking persons)

Si usted desea un cuestionario del censo en español, llame sin cargo alguno al siguiente número: **1-800-CUENTAN**
(o sea 1-800-283-6826)

U.S. Department of Commerce
BUREAU OF THE CENSUS

FORM **D-1**

OMB No. 0607-0628
Approval Expires 07/31/91

Page 1

The 1990 census must count every person at his or her "usual residence." This means the place where the person lives and sleeps most of the time.

1a. List on the numbered lines below the name of each person living here on Sunday, April 1, including all persons staying here who have no other home. If EVERYONE at this address is staying here temporarily and usually lives somewhere else, follow the instructions given in question 1b below.

Include	Do NOT include
• Everyone who usually lives here such as family members, housemates and roommates, foster children, roomers, boarders, and live-in employees	• Persons who usually live somewhere else
• Persons who are temporarily away on a business trip, on vacation, or in a general hospital	• Persons who are away in an institution such as a prison, mental hospital, or a nursing home
• College students who stay here while attending college	• College students who live somewhere else while attending college
• Persons in the Armed Forces who live here	• Persons in the Armed Forces who live somewhere else
• Newborn babies still in the hospital	
• Children in boarding schools below the college level	
• Persons who stay here most of the week while working even if they have a home somewhere else	• Persons who stay somewhere else most of the week while working
• Persons with no other home who are staying here on April 1	

Print last name, first name, and middle initial for each person. Begin on line 1 with the household member (or one of the household members) in whose name this house or apartment is owned, being bought, or rented. If there is no such person, start on line 1 with any adult household member.

	LAST	FIRST	INITIAL		LAST	FIRST	INITIAL
1				7			
2				8			
3				9			
4				10			
5				11			
6				12			

1b. If EVERYONE is staying here only temporarily and usually lives somewhere else, list the name of each person on the numbered lines above, fill this circle → ○ and print their usual address below. DO NOT PRINT THE ADDRESS LISTED ON THE FRONT COVER.

House number | Street or road/Rural route and box number | Apartment number

City | State | ZIP Code

County or foreign country | Names of nearest intersecting streets or roads

NOW PLEASE OPEN THE FLAP TO PAGE 2 AND ANSWER ALL QUESTIONS FOR THE FIRST 7 PEOPLE LISTED. USE A BLACK LEAD PENCIL ONLY.

PLEASE ALSO ANSWER HOUSING QUESTIONS ON PAGE 3 →

Please fill one column ➡ for each person listed in Question 1a on page 1.

	PERSON 1	PERSON 2
	Last name First name — Middle initial	Last name First name — Middle initial
2. How is this person related to PERSON 1? Fill ONE circle for each person. If **Other relative** of person in column 1, fill circle and print exact relationship, such as mother-in-law, grandparent, son-in-law, niece, cousin, and so on.	START in this column with the household member (or one of the members) in whose name the home is owned, being bought, or rented. If there is no such person, start in this column with any adult household member.	If a RELATIVE of Person 1: ○ Husband/wife ○ Brother/sister ○ Natural-born or adopted son/daughter ○ Father/mother ○ Grandchild ○ Other relative → ○ Stepson/ stepdaughter If NOT RELATED to Person 1: ○ Roomer, boarder, or foster child ○ Unmarried partner ○ Housemate, roommate ○ Other nonrelative
3. Sex Fill ONE circle for each person.	○ Male ○ Female	○ Male ○ Female
4. Race Fill ONE circle for the race that the person considers himself/herself to be. If **Indian (Amer.)**, print the name of the enrolled or principal tribe. → If **Other Asian or Pacific Islander (API)**, print one group, for example: Hmong, Fijian, Laotian, Thai, Tongan, Pakistani, Cambodian, and so on. → If **Other race**, print race. →	○ White ○ Black or Negro ○ Indian (Amer.) (Print the name of the enrolled or principal tribe.) → ○ Eskimo ○ Aleut Asian or Pacific Islander (API) ○ Chinese ○ Japanese ○ Filipino ○ Asian Indian ○ Hawaiian ○ Samoan ○ Korean ○ Guamanian ○ Vietnamese ○ Other API → ○ Other race (Print race) →	○ White ○ Black or Negro ○ Indian (Amer.) (Print the name of the enrolled or principal tribe.) → ○ Eskimo ○ Aleut Asian or Pacific Islander (API) ○ Chinese ○ Japanese ○ Filipino ○ Asian Indian ○ Hawaiian ○ Samoan ○ Korean ○ Guamanian ○ Vietnamese ○ Other API → ○ Other race (Print race) →
5. Age and year of birth **a.** Print each person's age at last birthday. Fill in the matching circle below each box. **b.** Print each person's year of birth and fill the matching circle below each box.	a. Age: 0 0 / 1 1 / 2 2 / 3 3 / 4 4 / 5 5 / 6 6 / 7 7 / 8 8 / 9 9 b. Year of birth: 1 ● 8 / 9 1 / 2 2 / 3 3 / 4 4 / 5 5 / 6 6 / 7 7 / 8 8 / 9 9	a. Age: 0 0 / 1 1 / 2 2 / 3 3 / 4 4 / 5 5 / 6 6 / 7 7 / 8 8 / 9 9 b. Year of birth: 1 ● 8 / 9 1 / 2 2 / 3 3 / 4 4 / 5 5 / 6 6 / 7 7 / 8 8 / 9 9
6. Marital status Fill ONE circle for each person.	○ Now married ○ Separated ○ Widowed ○ Never married ○ Divorced	○ Now married ○ Separated ○ Widowed ○ Never married ○ Divorced
7. Is this person of Spanish/Hispanic origin? Fill ONE circle for each person. If **Yes, other Spanish/Hispanic**, print one group. →	○ No (not Spanish/Hispanic) ○ Yes, Mexican, Mexican-Am., Chicano ○ Yes, Puerto Rican ○ Yes, Cuban ○ Yes, other Spanish/Hispanic (Print one group, for example: Argentinean, Colombian, Dominican, Nicaraguan, Salvadoran, Spaniard, and so on.) →	○ No (not Spanish/Hispanic) ○ Yes, Mexican, Mexican-Am., Chicano ○ Yes, Puerto Rican ○ Yes, Cuban ○ Yes, other Spanish/Hispanic (Print one group, for example: Argentinean, Colombian, Dominican, Nicaraguan, Salvadoran, Spaniard, and so on.) →
FOR CENSUS USE →	○ ○	○ ○

PERSON 7

Last name

First name — Middle initial

If a RELATIVE of Person 1:

- ○ Husband/wife
- ○ Natural-born or adopted son/daughter
- ○ Stepson/ stepdaughter
- ○ Brother/sister
- ○ Father/mother
- ○ Grandchild
- ○ Other relative

If NOT RELATED to Person 1:

- ○ Roomer, boarder, or foster child
- ○ Housemate, roommate
- ○ Unmarried partner
- ○ Other nonrelative

- ○ Male
- ○ Female

- ○ White
- ○ Black or Negro
- ○ Indian (Amer.) (Print the name of the enrolled or principal tribe.)
- ○ Eskimo
- ○ Aleut

Asian or Pacific Islander (API)

- ○ Chinese
- ○ Filipino
- ○ Hawaiian
- ○ Korean
- ○ Vietnamese
- ○ Japanese
- ○ Asian Indian
- ○ Samoan
- ○ Guamanian
- ○ Other API

- ○ Other race (Print race)

a. Age — b. Year of birth (1)

0 0 0 0 0 0 0 0 0 0
1 1 1 1 1 1 1 1 1 1
2 2 2 2 2 2 2 2 2 2
3 3 3 3 3 3 3 3 3 3
4 4 4 4 4 4 4 4 4 4
5 5 5 5 5 5 5 5 5 5
6 6 6 6 6 6 6 6 6 6
7 7 7 7 7 7 7 7 7 7
8 8 8 8 8 8 8 8 8 8
9 9 9 9 9 9 9 9 9 9

- ○ Now married
- ○ Widowed
- ○ Divorced
- ○ Separated
- ○ Never married

- ○ No (not Spanish/Hispanic)
- ○ Yes, Mexican, Mexican-Am., Chicano
- ○ Yes, Puerto Rican
- ○ Yes, Cuban
- ○ Yes, other Spanish/Hispanic (Print one group, for example: Argentinean, Colombian, Dominican, Nicaraguan, Salvadoran, Spaniard, and so on.)

NOW PLEASE ANSWER QUESTIONS H1a—H7b FOR YOUR HOUSEHOLD

H1a. Did you leave anyone out of your list of persons for Question 1a on page 1 because you were not sure if the person should be listed — for example, someone temporarily away on a business trip or vacation, a newborn baby still in the hospital, or a person who stays here once in a while and has no other home?

- ○ Yes, please print the name(s) and reason(s).
- ○ No

b. Did you include anyone in your list of persons for Question 1a on page 1 even though you were not sure that the person should be listed — for example, a visitor who is staying here temporarily or a person who usually lives somewhere else?

- ○ Yes, please print the name(s) and reason(s).
- ○ No

H2. Which best describes this building? Include all apartments, flats, etc., even if vacant.

- ○ A mobile home or trailer
- ○ A one-family house detached from any other house
- ○ A one-family house attached to one or more houses
- ○ A building with 2 apartments
- ○ A building with 3 or 4 apartments
- ○ A building with 5 to 9 apartments
- ○ A building with 10 to 19 apartments
- ○ A building with 20 to 49 apartments
- ○ A building with 50 or more apartments
- ○ Other

H3. How many rooms do you have in this house or apartment? Do NOT count bathrooms, porches, balconies, foyers, halls, or half-rooms.

- ○ 1 room
- ○ 2 rooms
- ○ 3 rooms
- ○ 4 rooms
- ○ 5 rooms
- ○ 6 rooms
- ○ 7 rooms
- ○ 8 rooms
- ○ 9 or more rooms

H4. Is this house or apartment —

- ○ Owned by you or someone in this household with a mortgage or loan?
- ○ Owned by you or someone in this household free and clear (without a mortgage)?
- ○ Rented for cash rent?
- ○ Occupied without payment of cash rent?

If this is a ONE-FAMILY HOUSE —

H5a. Is this house on ten or more acres?

- ○ Yes
- ○ No

b. Is there a business (such as a store or barber shop) or a medical office on this property?

- ○ Yes
- ○ No

Answer only if you or someone in this household OWNS OR IS BUYING this house or apartment —

H6. What is the value of this property; that is, how much do you think this house and lot or condominium unit would sell for if it were for sale?

- ○ Less than $10,000
- ○ $10,000 to $14,999
- ○ $15,000 to $19,999
- ○ $20,000 to $24,999
- ○ $25,000 to $29,999
- ○ $30,000 to $34,999
- ○ $35,000 to $39,999
- ○ $40,000 to $44,999
- ○ $45,000 to $49,999
- ○ $50,000 to $54,999
- ○ $55,000 to $59,999
- ○ $60,000 to $64,999
- ○ $65,000 to $69,999
- ○ $70,000 to $74,999
- ○ $75,000 to $79,999
- ○ $80,000 to $89,999
- ○ $90,000 to $99,999
- ○ $100,000 to $124,999
- ○ $125,000 to $149,999
- ○ $150,000 to $174,999
- ○ $175,000 to $199,999
- ○ $200,000 to $249,999
- ○ $250,000 to $299,999
- ○ $300,000 to $399,999
- ○ $400,000 to $499,999
- ○ $500,000 or more

Answer only if you PAY RENT for this house or apartment —

H7a. What is the monthly rent?

- ○ Less than $80
- ○ $80 to $99
- ○ $100 to $124
- ○ $125 to $149
- ○ $150 to $174
- ○ $175 to $199
- ○ $200 to $224
- ○ $225 to $249
- ○ $250 to $274
- ○ $275 to $299
- ○ $300 to $324
- ○ $325 to $349
- ○ $350 to $374
- ○ $375 to $399
- ○ $400 to $424
- ○ $425 to $449
- ○ $450 to $474
- ○ $475 to $499
- ○ $500 to $524
- ○ $525 to $549
- ○ $550 to $599
- ○ $600 to $649
- ○ $650 to $699
- ○ $700 to $749
- ○ $750 to $999
- ○ $1,000 or more

b. Does the monthly rent include any meals?

- ○ Yes
- ○ No

FOR CENSUS USE

A. Total persons

0 0
1 1
2 2
3 3
4 4
5 5
6 6
7 7
8 8
9 9

B. Type of unit

Occupied: ○ First form ○ Cont'n

Vacant: ○ Regular ○ Usual home elsewhere

C1. Vacancy status

- ○ For rent
- ○ For sale only
- ○ Rented or sold, not occupied
- ○ For seas/ rec/occ
- ○ For migrant workers
- ○ Other vacant

C2. Is this unit boarded up?

- ○ Yes
- ○ No

D. Months vacant

- ○ Less than 1
- ○ 1 up to 2
- ○ 2 up to 6
- ○ 6 up to 12
- ○ 12 up to 24
- ○ 24 or more

E. Complete after

- ○ LR ○ TC ○ QA JIC 1
- ○ P/F ○ RE ○ I/T ○
- ○ MV ○ ED ○ EN
- ○ P0 ○ P3 ○ P6
- ○ P1 ○ P4 ○ IA JIC 2
- ○ P2 ○ P5 ○ SM ○

F. Cov.

- ○ 1b ○ 1a ○ 7 ○ H1

G. DO — ID

0 0 0 0 0 0 0 0 0 0 0
1 1 1 1 1 1 1 1 1 1 1
2 2 2 2 2 2 2 2 2 2 2
3 3 3 3 3 3 3 3 3 3 3
4 4 4 4 4 4 4 4 4 4 4
5 5 5 5 5 5 5 5 5 5 5
6 6 6 6 6 6 6 6 6 6 6
7 7 7 7 7 7 7 7 7 7 7
8 8 8 8 8 8 8 8 8 8 8
9 9 9 9 9 9 9 9 9 9 9

Please make sure you have . . .

1. **FILLED this form completely.**
2. **ANSWERED Question 1a** on page 1.
3. **ANSWERED Questions 2 through 7** for each person you listed in Question 1a.
4. **ANSWERED Questions H1a through H7b** on page 3.

Also . . .

5. **PRINT here the name** of a household member who filled the form, the date the form was completed, and the telephone number at which a person in this household can be called.

Name			Date
Telephone number →	Area code	Number	○ Day ○ Night

Then . . .

6. **FOLD the form the way it was sent to you.**
7. **MAIL it back by April 1,** or as close to that date as possible, in the envelope provided; no stamp is needed. When you insert your completed questionnaire, please make sure that the address of the U.S. Census Office can be seen through the window on the front of the envelope.

NOTE — If you have listed more than 7 persons in Question 1a, please make sure that you have filled the form for the first 7 people. Then mail back this form. A census taker will call to obtain the information for the other people.

Thank you very much.

The Census Bureau estimates that, for the average household, this form will take 14 minutes to complete, including the time for reviewing the instructions and answers. Comments about this estimate should be directed to the Associate Director for Management Services, Bureau of the Census, Washington, DC 20233, Attn: CEN-90, and to the Office of Management and Budget, Paperwork Reduction Project CEN-90, Washington, DC 20503. Please DO NOT RETURN your questionnaire to either of these addresses. Use the enclosed preaddressed envelope to return your completed questionnaire.

CENSUS '90

OFFICIAL 1990 U.S. CENSUS FORM

Thank you for taking time to complete and return this census questionnaire. It's important to you, your community, and the Nation.

The law requires answers but guarantees privacy.

By law (Title 13, U.S. Code), you're required to answer the census questions to the best of your knowledge. However, the same law guarantees that your census form remains confidential. For 72 years--or until the year 2062--only Census Bureau employees can see your form. No one else--no other government body, no police department, no court system or welfare agency--is permitted to see this confidential information under any circumstances.

How to get started–and get help.

Start by listing on the next page the names of all the people who live in your home. Please answer all questions with a black lead pencil. You'll find detailed instructions for answering the census in the enclosed guide. If you need additional help, call the toll-free telephone number to the left, near your address.

Please answer and return your form promptly.

Complete your form and return it by April 1, 1990 in the postage-paid envelope provided. Avoid the inconvenience of having a census taker visit your home.

Again, thank you for answering the 1990 Census.
Remember: Return the completed form by April 1, 1990.

Para personas de habla hispana –
(For Spanish-speaking persons)

Si usted desea un cuestionario del censo en español, llame sin cargo alguno al siguiente número: **1-800-CUENTAN**
(o sea 1-800-283-6826)

U.S. Department of Commerce
BUREAU OF THE CENSUS

FORM **D-2**

OMB No. 0607-0628
Approval Expires 07/31/91

Page 1

The 1990 census must count every person at his or her "usual residence." This means the place where the person lives and sleeps most of the time.

1a. List on the numbered lines below the name of each person living here on Sunday, April 1, including all persons staying here who have no other home. If EVERYONE at this address is staying here temporarily and usually lives somewhere else, follow the instructions given in question 1b below.

Include

- Everyone who usually lives here such as family members, housemates and roommates, foster children, roomers, boarders, and live-in employees
- Persons who are temporarily away on a business trip, on vacation, or in a general hospital
- College students who stay here while attending college
- Persons in the Armed Forces who live here
- Newborn babies still in the hospital
- Children in boarding schools below the college level
- Persons who stay here most of the week while working even if they have a home somewhere else
- Persons with no other home who are staying here on April 1

Do NOT include

- Persons who usually live somewhere else
- Persons who are away in an institution such as a prison, mental hospital, or a nursing home
- College students who live somewhere else while attending college
- Persons in the Armed Forces who live somewhere else
- Persons who stay somewhere else most of the week while working

Print last name, first name, and middle initial for each person. Begin on line 1 with the household member (or one of the household members) in whose name this house or apartment is owned, being bought, or rented. If there is no such person, start on line 1 with any adult household member.

	LAST	FIRST	INITIAL		LAST	FIRST	INITIAL
1				7			
2				8			
3				9			
4				10			
5				11			
6				12			

1b. If EVERYONE is staying here only temporarily and usually lives somewhere else, list the name of each person on the numbered lines above, fill this circle ⟶ ○ and print their usual address below. DO NOT PRINT THE ADDRESS LISTED ON THE FRONT COVER.

House number | Street or road/Rural route and box number | Apartment number

City | State | ZIP Code

County or foreign country | Names of nearest intersecting streets or roads

NOW PLEASE OPEN THE FLAP TO PAGE 2 AND ANSWER ALL QUESTIONS FOR THE FIRST 7 PEOPLE LISTED. USE A BLACK LEAD PENCIL ONLY.

PLEASE ALSO ANSWER HOUSING QUESTIONS ON PAGE 3 →

Please fill one column ➡ for each person listed in Question 1a on page 1.	PERSON 1	PERSON 2
	Last name First name Middle initial	Last name First name Middle initial
2. How is this person related to PERSON 1? Fill ONE circle for each person. If **Other relative** of person in column 1, fill circle and print exact relationship, such as mother-in-law, grandparent, son-in-law, niece, cousin, and so on.	START in this column with the household member (or one of the members) in whose name the home is owned, being bought, or rented. If there is no such person, start in this column with any adult household member.	If a RELATIVE of Person 1: ○ Husband/wife ○ Brother/sister ○ Natural-born or adopted son/daughter ○ Father/mother ○ Grandchild ○ Other relative → ○ Stepson/ stepdaughter If NOT RELATED to Person 1: ○ Roomer, boarder, or foster child ○ Unmarried partner ○ Housemate, roommate ○ Other nonrelative
3. Sex Fill ONE circle for each person.	○ Male ○ Female	○ Male ○ Female
4. Race Fill ONE circle for the race that the person considers himself/herself to be. If **Indian (Amer.)**, print the name of the enrolled or principal tribe. → If **Other Asian or Pacific Islander (API)**, print one group, for example: Hmong, Fijian, Laotian, Thai, Tongan, Pakistani, Cambodian, and so on. → If **Other race**, print race. →	○ White ○ Black or Negro ○ Indian (Amer.) (Print the name of the enrolled or principal tribe.) → ○ Eskimo ○ Aleut Asian or Pacific Islander (API) ○ Chinese ○ Japanese ○ Filipino ○ Asian Indian ○ Hawaiian ○ Samoan ○ Korean ○ Guamanian ○ Vietnamese ○ Other API → ○ Other race (Print race) →	○ White ○ Black or Negro ○ Indian (Amer.) (Print the name of the enrolled or principal tribe.) → ○ Eskimo ○ Aleut Asian or Pacific Islander (API) ○ Chinese ○ Japanese ○ Filipino ○ Asian Indian ○ Hawaiian ○ Samoan ○ Korean ○ Guamanian ○ Vietnamese ○ Other API → ○ Other race (Print race) →
5. Age and year of birth **a.** Print each person's age at last birthday. Fill in the matching circle below each box. **b.** Print each person's year of birth and fill the matching circle below each box.	a. Age 0 ○ 0 ○ 0 ○ 1 ○ 1 ○ 1 ○ 2 ○ 2 ○ 3 ○ 3 ○ 4 ○ 4 ○ 5 ○ 5 ○ 6 ○ 6 ○ 7 ○ 7 ○ 8 ○ 8 ○ 9 ○ 9 ○ b. Year of birth 1 ● 8 ○ 0 ○ 0 ○ 9 ○ 1 ○ 1 ○ 2 ○ 2 ○ 3 ○ 3 ○ 4 ○ 4 ○ 5 ○ 5 ○ 6 ○ 6 ○ 7 ○ 7 ○ 8 ○ 8 ○ 9 ○ 9 ○	a. Age 0 ○ 0 ○ 0 ○ 1 ○ 1 ○ 1 ○ 2 ○ 2 ○ 3 ○ 3 ○ 4 ○ 4 ○ 5 ○ 5 ○ 6 ○ 6 ○ 7 ○ 7 ○ 8 ○ 8 ○ 9 ○ 9 ○ b. Year of birth 1 ● 8 ○ 0 ○ 0 ○ 9 ○ 1 ○ 1 ○ 2 ○ 2 ○ 3 ○ 3 ○ 4 ○ 4 ○ 5 ○ 5 ○ 6 ○ 6 ○ 7 ○ 7 ○ 8 ○ 8 ○ 9 ○ 9 ○
6. Marital status Fill ONE circle for each person.	○ Now married ○ Separated ○ Widowed ○ Never married ○ Divorced	○ Now married ○ Separated ○ Widowed ○ Never married ○ Divorced
7. Is this person of Spanish/Hispanic origin? Fill ONE circle for each person. If **Yes, other Spanish/Hispanic**, print one group. →	○ No (not Spanish/Hispanic) ○ Yes, Mexican, Mexican-Am., Chicano ○ Yes, Puerto Rican ○ Yes, Cuban ○ Yes, other Spanish/Hispanic (Print one group, for example: Argentinean, Colombian, Dominican, Nicaraguan, Salvadoran, Spaniard, and so on.) →	○ No (not Spanish/Hispanic) ○ Yes, Mexican, Mexican-Am., Chicano ○ Yes, Puerto Rican ○ Yes, Cuban ○ Yes, other Spanish/Hispanic (Print one group, for example: Argentinean, Colombian, Dominican, Nicaraguan, Salvadoran, Spaniard, and so on.) →
FOR CENSUS USE →	○ ○	○ ○

PERSON 7

Last name

First name — Middle initial

If a RELATIVE of Person 1:

- ○ Husband/wife
- ○ Natural-born or adopted son/daughter
- ○ Stepson/ stepdaughter
- ○ Brother/sister
- ○ Father/mother
- ○ Grandchild
- ○ Other relative

If NOT RELATED to Person 1:

- ○ Roomer, boarder, or foster child
- ○ Housemate, roommate
- ○ Unmarried partner
- ○ Other nonrelative

- ○ Male
- ○ Female

- ○ White
- ○ Black or Negro
- ○ Indian (Amer.) (Print the name of the enrolled or principal tribe.)
- ○ Eskimo
- ○ Aleut

Asian or Pacific Islander (API)

- ○ Chinese
- ○ Filipino
- ○ Hawaiian
- ○ Korean
- ○ Vietnamese
- ○ Japanese
- ○ Asian Indian
- ○ Samoan
- ○ Guamanian
- ○ Other API
- ○ Other race (Print race)

a. Age — b. Year of birth

1 ● 8 ○ 0 ○ 0 ○

- ○ Now married
- ○ Widowed
- ○ Divorced
- ○ Separated
- ○ Never married

- ○ No (not Spanish/Hispanic)
- ○ Yes, Mexican, Mexican-Am., Chicano
- ○ Yes, Puerto Rican
- ○ Yes, Cuban
- ○ Yes, other Spanish/Hispanic (Print one group, for example: Argentinean, Colombian, Dominican, Nicaraguan, Salvadoran, Spaniard, and so on.)

NOW PLEASE ANSWER QUESTIONS H1a—H26 FOR THIS HOUSEHOLD

H1a. Did you leave anyone out of your list of persons for Question 1a on page 1 because you were not sure if the person should be listed — for example, someone temporarily away on a business trip or vacation, a newborn baby still in the hospital, or a person who stays here once in a while and has no other home?

○ Yes, please print the name(s) and reason(s).
○ No

b. Did you include anyone in your list of persons for Question 1a on page 1 even though you were not sure that the person should be listed — for example, a visitor who is staying here temporarily or a person who usually lives somewhere else?

○ Yes, please print the name(s) and reason(s).
○ No

H2. Which best describes this building? Include all apartments, flats, etc., even if vacant.

- ○ A mobile home or trailer
- ○ A one-family house detached from any other house
- ○ A one-family house attached to one or more houses
- ○ A building with 2 apartments
- ○ A building with 3 or 4 apartments
- ○ A building with 5 to 9 apartments
- ○ A building with 10 to 19 apartments
- ○ A building with 20 to 49 apartments
- ○ A building with 50 or more apartments
- ○ Other

H3. How many rooms do you have in this house or apartment? Do NOT count bathrooms, porches, balconies, foyers, halls, or half-rooms.

- ○ 1 room
- ○ 2 rooms
- ○ 3 rooms
- ○ 4 rooms
- ○ 5 rooms
- ○ 6 rooms
- ○ 7 rooms
- ○ 8 rooms
- ○ 9 or more rooms

H4. Is this house or apartment —

- ○ Owned by you or someone in this household with a mortgage or loan?
- ○ Owned by you or someone in this household free and clear (without a mortgage)?
- ○ Rented for cash rent?
- ○ Occupied without payment of cash rent?

If this is a ONE-FAMILY HOUSE —

H5a. Is this house on ten or more acres?

○ Yes ○ No

b. Is there a business (such as a store or barber shop) or a medical office on this property?

○ Yes ○ No

Answer only if you or someone in this household OWNS OR IS BUYING this house or apartment —

H6. What is the value of this property; that is, how much do you think this house and lot or condominium unit would sell for if it were for sale?

- ○ Less than $10,000
- ○ $10,000 to $14,999
- ○ $15,000 to $19,999
- ○ $20,000 to $24,999
- ○ $25,000 to $29,999
- ○ $30,000 to $34,999
- ○ $35,000 to $39,999
- ○ $40,000 to $44,999
- ○ $45,000 to $49,999
- ○ $50,000 to $54,999
- ○ $55,000 to $59,999
- ○ $60,000 to $64,999
- ○ $65,000 to $69,999
- ○ $70,000 to $74,999
- ○ $75,000 to $79,999
- ○ $80,000 to $89,999
- ○ $90,000 to $99,999
- ○ $100,000 to $124,999
- ○ $125,000 to $149,999
- ○ $150,000 to $174,999
- ○ $175,000 to $199,999
- ○ $200,000 to $249,999
- ○ $250,000 to $299,999
- ○ $300,000 to $399,999
- ○ $400,000 to $499,999
- ○ $500,000 or more

Answer only if you PAY RENT for this house or apartment —

H7a. What is the monthly rent?

- ○ Less than $80
- ○ $80 to $99
- ○ $100 to $124
- ○ $125 to $149
- ○ $150 to $174
- ○ $175 to $199
- ○ $200 to $224
- ○ $225 to $249
- ○ $250 to $274
- ○ $275 to $299
- ○ $300 to $324
- ○ $325 to $349
- ○ $350 to $374
- ○ $375 to $399
- ○ $400 to $424
- ○ $425 to $449
- ○ $450 to $474
- ○ $475 to $499
- ○ $500 to $524
- ○ $525 to $549
- ○ $550 to $599
- ○ $600 to $649
- ○ $650 to $699
- ○ $700 to $749
- ○ $750 to $999
- ○ $1,000 or more

b. Does the monthly rent include any meals?

○ Yes ○ No

FOR CENSUS USE

A. Total persons

B. Type of unit

Occupied: ○ First form ○ Cont'n
Vacant: ○ Regular ○ Usual home elsewhere

C1. Vacancy status

- ○ For rent
- ○ For sale only
- ○ Rented or sold, not occupied
- ○ For seas/ rec/occ
- ○ For migrant workers
- ○ Other vacant

C2. Is this unit boarded up?

○ Yes ○ No

D. Months vacant

- ○ Less than 1
- ○ 1 up to 2
- ○ 2 up to 6
- ○ 6 up to 12
- ○ 12 up to 24
- ○ 24 or more

E. Complete after

○ LR ○ TC ○ QA JIC 1
○ P/F ○ RE ○ I/T ○
○ MV ○ ED ○ EN
○ P0 ○ P3 ○ P6
○ P1 ○ P4 ○ IA JIC 2
○ P2 ○ P5 ○ SM ○

F. Cov.

○ 1b ○ 1a ○ 7 ○ H1

G. DO — **ID**

PLEASE ALSO ANSWER THESE

H8. When did the person listed in column 1 on page 2 move into this house or apartment?

- ○ 1989 or 1990
- ○ 1985 to 1988
- ○ 1980 to 1984
- ○ 1970 to 1979
- ○ 1960 to 1969
- ○ 1959 or earlier

H9. How many bedrooms do you have; that is, how many bedrooms would you list if this house or apartment were on the market for sale or rent?

- ○ No bedroom
- ○ 1 bedroom
- ○ 2 bedrooms
- ○ 3 bedrooms
- ○ 4 bedrooms
- ○ 5 or more bedrooms

H10. Do you have COMPLETE plumbing facilities in this house or apartment; that is, 1) hot and cold piped water, 2) a flush toilet, and 3) a bathtub or shower?

- ○ Yes, have all three facilities
- ○ No

H11. Do you have COMPLETE kitchen facilities; that is, 1) a sink with piped water, 2) a range or cookstove, and 3) a refrigerator?

- ○ Yes
- ○ No

H12. Do you have a telephone in this house or apartment?

- ○ Yes
- ○ No

H13. How many automobiles, vans, and trucks of one-ton capacity or less are kept at home for use by members of your household?

- ○ None
- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5
- ○ 6
- ○ 7 or more

H14. Which FUEL is used MOST for heating this house or apartment?

- ○ Gas: from underground pipes serving the neighborhood
- ○ Gas: bottled, tank, or LP
- ○ Electricity
- ○ Fuel oil, kerosene, etc.
- ○ Coal or coke
- ○ Wood
- ○ Solar energy
- ○ Other fuel
- ○ No fuel used

H15. Do you get water from —

- ○ A public system such as a city water department, or private company?
- ○ An individual drilled well?
- ○ An individual dug well?
- ○ Some other source such as a spring, creek, river, cistern, etc.?

H16. Is this building connected to a public sewer?

- ○ Yes, connected to public sewer
- ○ No, connected to septic tank or cesspool
- ○ No, use other means

H17. About when was this building first built?

- ○ 1989 or 1990
- ○ 1985 to 1988
- ○ 1980 to 1984
- ○ 1970 to 1979
- ○ 1960 to 1969
- ○ 1950 to 1959
- ○ 1940 to 1949
- ○ 1939 or earlier
- ○ Don't know

H18. Is this house or apartment part of a condominium?

- ○ Yes
- ○ No

If you live in an apartment building, skip to H20.

H19a. Is this house on less than 1 acre?

- ○ Yes — *Skip to H20*
- ○ No

b. In 1989, what were the actual sales of all agricultural products from this property?

- ○ None
- ○ $1 to $999
- ○ $1,000 to $2,499
- ○ $2,500 to $4,999
- ○ $5,000 to $9,999
- ○ $10,000 or more

H20. What are the yearly costs of utilities and fuels for this house or apartment?
If you have lived here less than 1 year, estimate the yearly cost.

a. Electricity

$ .00
Yearly cost — Dollars

OR

- ○ Included in rent or in condominium fee
- ○ No charge or electricity not used

b. Gas

$ .00
Yearly cost — Dollars

OR

- ○ Included in rent or in condominium fee
- ○ No charge or gas not used

c. Water

$ .00
Yearly cost — Dollars

OR

- ○ Included in rent or in condominium fee
- ○ No charge

d. Oil, coal, kerosene, wood, etc.

$ .00
Yearly cost — Dollars

OR

- ○ Included in rent or in condominium fee
- ○ No charge or these fuels not used

QUESTIONS FOR YOUR HOUSEHOLD

INSTRUCTION:

Answer questions H21 TO H26, if this is a one-family house, a condominium, or a mobile home that someone in this household OWNS OR IS BUYING; otherwise, go to page 6.

H21. What were the real estate taxes on THIS property last year?

$ .00
Yearly amount — Dollars

OR

○ None

H22. What was the annual payment for fire, hazard, and flood insurance on THIS property?

$ .00
Yearly amount — Dollars

OR

○ None

H23a. Do you have a mortgage, deed of trust, contract to purchase, or similar debt on THIS property?

○ Yes, mortgage, deed of trust, or similar debt } *Go to H23b*
○ Yes, contract to purchase
○ No — *Skip to H24a*

b. How much is your regular monthly mortgage payment on THIS property? Include payment only on first mortgage or contract to purchase.

$ .00
Monthly amount — Dollars

OR

○ No regular payment required — *Skip to H24a*

c. Does your regular monthly mortgage payment include payments for real estate taxes on THIS property?

○ Yes, taxes included in payment
○ No, taxes paid separately or taxes not required

d. Does your regular monthly mortgage payment include payments for fire, hazard, or flood insurance on THIS property?

○ Yes, insurance included in payment
○ No, insurance paid separately or no insurance

H24a. Do you have a second or junior mortgage or a home equity loan on THIS property?

○ Yes
○ No — *Skip to H25*

b. How much is your regular monthly payment on all second or junior mortgages and all home equity loans?

$ .00
Monthly amount — Dollars

OR

○ No regular payment required

Answer ONLY if this is a CONDOMINIUM —

H25. What is the monthly condominium fee?

$ .00
Monthly amount — Dollars

Answer ONLY if this is a MOBILE HOME —

H26. What was the total cost for personal property taxes, site rent, registration fees, and license fees on this mobile home and its site last year? Exclude real estate taxes.

$ .00
Yearly amount — Dollars

Please turn to page 6.

PLEASE ANSWER THESE QUESTIONS

PERSON 1

Last name | First name | Middle initial

8. In what U.S. State or foreign country was this person born?

(Name of State or foreign country; or Puerto Rico, Guam, etc.)

9. Is this person a CITIZEN of the United States?

- ○ Yes, born in the United States — *Skip to 11*
- ○ Yes, born in Puerto Rico, Guam, the U.S. Virgin Islands, or Northern Marianas
- ○ Yes, born abroad of American parent or parents
- ○ Yes, U.S. citizen by naturalization
- ○ No, not a citizen of the United States

10. When did this person come to the United States to stay?

- ○ 1987 to 1990
- ○ 1985 or 1986
- ○ 1982 to 1984
- ○ 1980 or 1981
- ○ 1975 to 1979
- ○ 1970 to 1974
- ○ 1965 to 1969
- ○ 1960 to 1964
- ○ 1950 to 1959
- ○ Before 1950

11. At any time since February 1, 1990, has this person attended regular school or college?
Include only nursery school, kindergarten, elementary school, and schooling which leads to a high school diploma or a college degree.

- ○ No, has not attended since February 1
- ○ Yes, public school, public college
- ○ Yes, private school, private college

12. How much school has this person COMPLETED?
Fill ONE circle for the highest level COMPLETED or degree RECEIVED. If currently enrolled, mark the level of previous grade attended or highest degree received.

- ○ No school completed
- ○ Nursery school
- ○ Kindergarten
- ○ 1st, 2nd, 3rd, or 4th grade
- ○ 5th, 6th, 7th, or 8th grade
- ○ 9th grade
- ○ 10th grade
- ○ 11th grade
- ○ 12th grade, **NO DIPLOMA**
- ○ **HIGH SCHOOL GRADUATE** - high school DIPLOMA or the equivalent (For example: GED)
- ○ Some college but no degree
- ○ Associate degree in college - Occupational program
- ○ Associate degree in college - Academic program
- ○ Bachelor's degree (For example: BA, AB, BS)
- ○ Master's degree (For example: MA, MS, MEng, MEd, MSW, MBA)
- ○ Professional school degree (For example: MD, DDS, DVM, LLB, JD)
- ○ Doctorate degree (For example: PhD, EdD)

13. What is this person's ancestry or ethnic origin?
(See instruction guide for further information.)

(For example: German, Italian, Afro-Amer., Croatian, Cape Verdean, Dominican, Ecuadoran, Haitian, Cajun, French Canadian, Jamaican, Korean, Lebanese, Mexican, Nigerian, Irish, Polish, Slovak, Taiwanese, Thai, Ukrainian, etc.)

14a. Did this person live in this house or apartment 5 years ago (on April 1, 1985)?

- ○ Born after April 1, 1985 — *Go to questions for the next person*
- ○ Yes — *Skip to 15a*
- ○ No

b. Where did this person live 5 years ago (on April 1, 1985)?

(1) Name of U.S. State or foreign country

(If outside U.S., print answer above and skip to 15a.)

(2) Name of county in the U.S.

(3) Name of city or town in the U.S.

(4) Did this person live inside the city or town limits?

- ○ Yes
- ○ No, lived outside the city/town limits

15a. Does this person speak a language other than English at home?

- ○ Yes
- ○ No — *Skip to 16*

b. What is this language?

(For example: Chinese, Italian, Spanish, Vietnamese)

c. How well does this person speak English?

- ○ Very well
- ○ Well
- ○ Not well
- ○ Not at all

16. When was this person born?

- ○ Born before April 1, 1975 — *Go to 17a*
- ○ Born April 1, 1975 or later — *Go to questions for the next person*

17a. Has this person ever been on active-duty military service in the Armed Forces of the United States or ever been in the United States military Reserves or the National Guard? If service was in Reserves or National Guard only, see instruction guide.

- ○ Yes, now on active duty
- ○ Yes, on active duty in past, but not now
- ○ Yes, service in Reserves or National Guard only — *Skip to 18*
- ○ No — *Skip to 18*

b. Was active-duty military service during —
Fill a circle for each period in which this person served.

- ○ September 1980 or later
- ○ May 1975 to August 1980
- ○ Vietnam era (August 1964—April 1975)
- ○ February 1955—July 1964
- ○ Korean conflict (June 1950—January 1955)
- ○ World War II (September 1940—July 1947)
- ○ World War I (April 1917—November 1918)
- ○ Any other time

c. In total, how many years of active-duty military service has this person had?

Years

18. Does this person have a physical, mental, or other health condition that has lasted for 6 or more months and which —

a. Limits the kind or amount of work this person can do at a job?

- ○ Yes
- ○ No

b. Prevents this person from working at a job?

- ○ Yes
- ○ No

19. Because of a health condition that has lasted for 6 or more months, does this person have any difficulty —

a. Going outside the home alone, for example, to shop or visit a doctor's office?

- ○ Yes
- ○ No

b. Taking care of his or her own personal needs, such as bathing, dressing, or getting around inside the home?

- ○ Yes
- ○ No

If this person is a female —

20. How many babies has she ever had, not counting stillbirths? Do not count her stepchildren or children she has adopted.

None 1 2 3 4 5 6 7 8 9 10 11 12 or more

○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○

21a. Did this person work at any time LAST WEEK?

- ○ Yes — Fill this circle if this person worked full time or part time. (Count part-time work such as delivering papers, or helping without pay in a family business or farm. Also count active duty in the Armed Forces.)
- ○ No — Fill this circle if this person did not work, or did only own housework, school work, or volunteer work. — *Skip to 25*

b. How many hours did this person work LAST WEEK (at all jobs)? Subtract any time off; add overtime or extra hours worked.

Hours

22. At what location did this person work LAST WEEK?
If this person worked at more than one location, print where he or she worked most last week.

a. Address (Number and street)

(If the exact address is not known, give a description of the location such as the building name or the nearest street or intersection.)

b. Name of city, town, or post office

c. Is the work location inside the limits of that city or town?

- ○ Yes
- ○ No, outside the city/town limits

d. County

e. State

f. ZIP Code

FOR PERSON 1 ON PAGE 2

23a. How did this person usually get to work LAST WEEK? If this person usually used more than one method of transportation during the trip, fill the circle of the one used for most of the distance.

- ○ Car, truck, or van
- ○ Bus or trolley bus
- ○ Streetcar or trolley car
- ○ Subway or elevated
- ○ Railroad
- ○ Ferryboat
- ○ Taxicab
- ○ Motorcycle
- ○ Bicycle
- ○ Walked
- ○ Worked at home → *Skip to 28*
- ○ Other method

If "car, truck, or van" is marked in 23a, go to 23b. Otherwise, skip to 24a.

b. How many people, including this person, usually rode to work in the car, truck, or van LAST WEEK?

- ○ Drove alone
- ○ 2 people
- ○ 3 people
- ○ 4 people
- ○ 5 people
- ○ 6 people
- ○ 7 to 9 people
- ○ 10 or more people

24a. What time did this person usually leave home to go to work LAST WEEK?

- ○ a.m.
- ○ p.m.

b. How many minutes did it usually take this person to get from home to work LAST WEEK?

Minutes — *Skip to 28*

25. Was this person TEMPORARILY absent or on layoff from a job or business LAST WEEK?

- ○ Yes, on layoff
- ○ Yes, on vacation, temporary illness, labor dispute, etc.
- ○ No

26a. Has this person been looking for work during the last 4 weeks?

- ○ Yes
- ○ No — *Skip to 27*

b. Could this person have taken a job LAST WEEK if one had been offered?

- ○ No, already has a job
- ○ No, temporarily ill
- ○ No, other reasons (in school, etc.)
- ○ Yes, could have taken a job

27. When did this person last work, even for a few days?

- ○ 1990
- ○ 1989
- ○ 1988
- ○ 1985 to 1987

Go to 28

- ○ 1980 to 1984
- ○ 1979 or earlier
- ○ Never worked

Skip to 32

28-30. CURRENT OR MOST RECENT JOB ACTIVITY. Describe clearly this person's chief job activity or business last week. If this person had more than one job, describe the one at which this person worked the most hours. If this person had no job or business last week, give information for his/her last job or business since 1985.

28. Industry or Employer

a. For whom did this person work? If now on active duty in the Armed Forces, fill this circle → ○ and print the branch of the Armed Forces.

(Name of company, business, or other employer)

b. What kind of business or industry was this? Describe the activity at location where employed.

(For example: hospital, newspaper publishing, mail order house, auto engine manufacturing, retail bakery)

c. Is this mainly — Fill ONE circle

- ○ Manufacturing
- ○ Wholesale trade
- ○ Retail trade
- ○ Other (agriculture, construction, service, government, etc.)

29. Occupation

a. What kind of work was this person doing?

(For example: registered nurse, personnel manager, supervisor of order department, gasoline engine assembler, cake icer)

b. What were this person's most important activities or duties?

(For example: patient care, directing hiring policies, supervising order clerks, assembling engines, icing cakes)

30. Was this person — Fill ONE circle

- ○ Employee of a PRIVATE FOR PROFIT company or business or of an individual, for wages, salary, or commissions
- ○ Employee of a PRIVATE NOT-FOR-PROFIT, tax-exempt, or charitable organization
- ○ Local GOVERNMENT employee (city, county, etc.)
- ○ State GOVERNMENT employee
- ○ Federal GOVERNMENT employee
- ○ SELF-EMPLOYED in own NOT INCORPORATED business, professional practice, or farm
- ○ SELF-EMPLOYED in own INCORPORATED business, professional practice, or farm
- ○ Working WITHOUT PAY in family business or farm

31a. Last year (1989), did this person work, even for a few days, at a paid job or in a business or farm?

- ○ Yes
- ○ No — *Skip to 32*

b. How many weeks did this person work in 1989? Count paid vacation, paid sick leave, and military service.

Weeks

c. During the weeks WORKED in 1989, how many hours did this person usually work each week?

Hours

32. INCOME IN 1989 — Fill the "Yes" circle below for each income source received during 1989. Otherwise, fill the "No" circle. If "Yes," enter the total amount received during 1989.

For income received jointly, see instruction guide. If exact amount is not known, please give best estimate.

If net income was a loss, write "Loss" above the dollar amount.

a. Wages, salary, commissions, bonuses, or tips from all jobs — Report amount before deductions for taxes, bonds, dues, or other items.

○ Yes → $ .00 Annual amount — Dollars
○ No

b. Self-employment income from own nonfarm business, including proprietorship and partnership — Report NET income after business expenses.

○ Yes → $ .00 Annual amount — Dollars
○ No

c. Farm self-employment income — Report NET income after operating expenses. Include earnings as a tenant farmer or sharecropper.

○ Yes → $ .00 Annual amount — Dollars
○ No

d. Interest, dividends, net rental income or royalty income, or income from estates and trusts — Report even small amounts credited to an account.

○ Yes → $ .00 Annual amount — Dollars
○ No

e. Social Security or Railroad Retirement

○ Yes → $ .00 Annual amount — Dollars
○ No

f. Supplemental Security Income (SSI), Aid to Families with Dependent Children (AFDC), or other public assistance or public welfare payments.

○ Yes → $ .00 Annual amount — Dollars
○ No

g. Retirement, survivor, or disability pensions — Do NOT include Social Security.

○ Yes → $ .00 Annual amount — Dollars
○ No

h. Any other sources of income received regularly such as Veterans' (VA) payments, unemployment compensation, child support, or alimony — Do NOT include lump-sum payments such as money from an inheritance or the sale of a home.

○ Yes → $ .00 Annual amount — Dollars
○ No

33. What was this person's total income in 1989? Add entries in questions 32a through 32h; subtract any losses. If total amount was a loss, write "Loss" above amount.

○ None OR $ .00 Annual amount — Dollars

Please turn the page and answer questions for Person 2 listed on page 1. If this is the last person listed in question 1a on page 1, go to the back of the form.

OMB No. 0607-0572: Approval Expires March 31, 1990

FORM **D-169** (7-17-87)

QUALITY CONTROL LISTING AND MATCHING RECORD

21st Decennial Census — 1990

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

a. District Office name | **b.** ARA number | **c.** Crew leader code

d. Advance lister code | **e.** Enumerator code | **f.** Is this the FIRST ARA assigned? ☐ Yes ☐ No

Ask the following question at each address. A line must be filled for each separate living quarters.

(16) **Are there any other living quarters, occupied or vacant, in this building or on this property?**

Block number (1)	Advance lister map spot number (2)	**What is the exact MAILING ADDRESS of this living quarters?** MAILING ADDRESS: House number (3)	Street name, rural route and box number, or PO box (4)	Apartment number, unit designation, or trailer (5)	City, State, and ZIP Code (6)	***FILL IF COLUMN (3) IS BLANK*** **What is the FULL name** *(last, first, middle initial)* **of the occupant?** (7)	Road name (8)	PHYSICAL LOCATION **How would you describe the location of this place?** *Example: Ylw hse ½ mi S of Sunset Dr* (9)	*Mark (X) if —* Vacant (10)	*Fill col. (13)* Special place (11)	Cluster (12)	Remarks *If "X" in col. (11), enter special place name/type. If "X" in col. (12), enter estimate of HU's in cluster.* (13)	MATCHING (14) *Mark (X) if —* Match (a)	No Match (b)	Enumerator map spot number (c)	RESULTS OF RECONCILIATION (15) Enumerator (a)	Advance lister (b)	Reasons for NO match (c) 1	2	3
					City / State / ZIP Code																
					City / State / ZIP Code																
					City / State / ZIP Code																
					City / State / ZIP Code																
					City / State / ZIP Code																
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					City / State / ZIP Code																
												Subtotal →									
												g. TOTAL from column (14b) →									

Copy distribution: WHITE — District Office **YELLOW** — Crew leader

FORM **D-169A** (7-20-87)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

SUMMARY OF ADVANCE LISTING AND MATCHING

21st Decennial Census — 1990

A. District Office name

B. ARA number

C. Crew leader code

D. Advance lister code

E. Enumerator code

F. Is this the first ARA assigned?

☐ Yes ☐ No

G. TOTAL from D-169, item g

(17) PRELIMINARY

a. First six listings qualifications

DECISION: ☐ Accept ☐ Reject
ACTION: ☐ OJT
Date of action _____

b. Second six listings qualifications

DECISION: ☐ Accept ☐ Reject
ACTION: ☐ OJT ☐ Release
Date of action _____

c. Process control

DECISION: ☐ Accept ☐ Reject
ACTION: ☐ OJT ☐ Release
Date of action _____

(18) FINAL

a. First six listings

DECISION: ☐ Accept ☐ Reject
ACTION: ☐ OJT
Date of action _____

b. Second six listings

DECISION: ☐ Accept ☐ Reject
ACTION: ☐ OJT ☐ Release
Date of action _____

c. Process control

DECISION: ☐ Accept ☐ Reject
ACTION: ☐ OJT ☐ Release
Date of action _____

(19) RESULTS OF RECANVASSING

	Total
a. Listings	
b. Adds	
c. Wrong block	

Notes

U.S. Department of Commerce
Bureau of the Census

Form D-802

Sheet ___ of ___ Sheets
ZIP CODE _____

PACKAGING VERIFICATION: MAIL/OUT MAIL BACK
QUALITY ASSURANCE RECORD
21st Decennial Census - 1990

Contractor	GPO Jacket Number	Form Type	Date	Shift	Machine Number

Pallet Number	Postal Classification (1)	Box Number(s) (2)	Beginning SEQ Number (3)	Ending SEQ Number (4)	Both SEQ Numbers Match The Packages (5)		Number of Packages (6)	Acceptable Weight		Actual Weight (9)	Explain Difference (10)
					Yes	No		Low (7)	High (8)		

U.S. Department of Commerce
Bureau of the Census

Form D-803

Sheet ___ of ___ Sheets
District Office _____

PACKAGING VERIFICATION: UPDATE LEAVE
QUALITY ASSURANCE RECORD
21st Decennial Census - 1990

Contractor	GPO Jacket Number	Form Type	Date	Shift	Machine Number

Pallet Number	ARA Number (1)	Beginning SEQ Number (2)	Ending SEQ Number (3)	Both SEQ Numbers Match The Packages (4)		Number of Packages (5)	Acceptable Weight		Actual Weight (8)	Explain Difference (9)
				Yes	No		Low (6)	High (7)		

Sheet _____ of _____ sheets

FORM **D-849** (6-12-89)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

SAMPLE FOSDIC QUESTIONNAIRE GATHERING, STITCHING, AND TRIMMING VERIFICATION QUALITY ASSURANCE RECORD

21st Decennial Census — 1990

A. Contractor name

B. GPO jacket number

C. Form number

D. Date *(Mo./day/Yr.)*

E. Shift

F. Machine number

Time (1)	Number inspected (2)	NUMBER IN ERROR DURING Inspection (3)	NUMBER IN ERROR DURING Expanded search (4)	Type of error *Enter code from right or specify.* (5)
a.m. p.m.				
a.m. p.m.				
a.m. p.m.				
a.m. p.m.				
a.m. p.m.				
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a.m. p.m.				
a.m. p.m.				
a.m. p.m.				
a.m. p.m.				
a.m. p.m.				

ERROR CODES FOR COLUMN (5)

GATHERING CODES

A = Missing pages

B = Unsequential pages

C = Other, specify

STITCHING CODES

D = Missing staple(s)

E = Misplaced staple(s)

F = Improperly applied (closed)

G = Other, specify

TRIMMING CODES

H = Improperly trimmed

I = Other, specify

IMAGE DEVIATION CODES

J = Skewed

K = Improperly positioned

L = Other, specify

Copy distribution: **WHITE** — Bureau of the Census **YELLOW** — Contractor

Sheet _____ of _____ sheets

FORM **D-851** (6-14-88)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

INSTRUCTION GUIDE AND MOTIVATIONAL INSERT PRINTING VERIFICATION QUALITY ASSURANCE RECORD

21st Decennial Census — 1990

A. Contractor name

B. GPO jacket number

C. Form number

D. Date *(Mo./day/Yr.)*

E. Shift

F. Press number

Time (1)	Number inspected (2)	NUMBER IN ERROR DURING Inspection (3)	NUMBER IN ERROR DURING Expanded search (4)	Type of error *Enter code from right or specify.* (5)
a.m. p.m.				
a.m. p.m.				
a.m. p.m.				
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a.m. p.m.				
a.m. p.m.				

ERROR CODES FOR COLUMN (5)

PRINTING CODES

A = Poor type of quality or uniformity

B = Misplaced or skewed image

C = Other, specify

FINISHING CODES

D = Improperly trimmed

E = Improperly folded

F = Improperly bound

G = Torn or damaged

H = Other, specify

Copy distribution: **WHITE** — Bureau of the Census **YELLOW** — Contractor

Sheet _____ of _____ sheets

FORM **D-852** (7-14-88)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

ENVELOPE PRINTING/CONSTRUCTION VERIFICATION QUALITY ASSURANCE RECORD

21st Decennial Census — 1990

A. Contractor name		
B. GPO jacket number	**C.** Form number	
D. Date *(Mo./Day/Yr.)*	**E.** Shift	**F.** Machine number

Time (1)	Number inspected (2)	NUMBER IN ERROR DURING: Inspection (3)	NUMBER IN ERROR DURING: Expanded search (4)	Type of error *Enter code from right or specify.* (5)
a.m. p.m.				
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a.m. p.m.				
a.m. p.m.				
a.m. p.m.				

ERROR CODES FOR COLUMN (5)

CODE PRINTING

A = Poor type of quality or uniformity

B = Misplaced or skewed image

C = Other, specify

FINISHING

D = Improperly trimmed

E = Improperly folded

F = No glue on return flap

G = Incorrect size of envelope

H = Incorrect size of window

I = Misplaced window

J = Torn or damaged

K = Other, specify

Copy distribution: **WHITE** — Bureau of the Census **YELLOW** — Contractor

Sheet _____ of _____ sheets

FORM **D-853** (11-17-88)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

SAMPLE PACKAGE ASSEMBLY VERIFICATION QUALITY ASSURANCE RECORD

21st Decennial Census — 1990

A. Contractor name

B. GPO jacket number

C. Form number

D. Date *(Mo./day/Yr.)*

E. Shift

F. Machine number

Time (1)	Number inspected (2)	NUMBER IN ERROR DURING Inspection (3)	NUMBER IN ERROR DURING Expanded search (4)	Type of error *Enter code from right or specify.* (5)
a.m. p.m.				
a.m. p.m.				
a.m. p.m.				
a.m. p.m.				
a.m. p.m.				
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a.m. p.m.				
a.m. p.m.				
a.m. p.m.				
a.m. p.m.				
a.m. p.m.				

ERROR CODES FOR COLUMN (5)

CODE

A = Address on the questionnaire is **not** visible through the window on the outgoing envelope.

B = Mailing package does **not** contain the proper contents.

C = Any material is torn or damaged.

D = Other, specify

Copy distribution: **WHITE** — Bureau of the Census **YELLOW** — Contractor

Sheet _____ of _____ sheets

FORM **D-854**
(10-5-88)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

ROLL-TO-ROLL QUESTIONNAIRE PRINTING VERIFICATION QUALITY ASSURANCE RECORD

21st Decennial Census – 1990

A. Contractor name

B. GPO jacket number

C. Form number

D. Date *(Mo./Day/Yr.)*

E. Shift

F. Press number

Roll number	MEASUREMENTS							ROLL STATUS – *Mark (X)*			Type of error *Enter code from right*
	Density readings		Circle wall thickness			Show-through					
	Low	High	Low	High	Difference column (5)–(4)	Low	High	Accept	Cleaned out	Reject	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)

ERROR CODES FOR COLUMN (12)

CODE PRINTING

A = Any measurement of the black ink density is out of tolerance.

B = Any measurement of the circle wall thickness is out of tolerance.

C = Any unprinted spot in the index areas or vertical bars is out of tolerance.

D = Any black mark/spot is out of tolerance.

E = Poor type quality or uniformity.

F = Image is misplaced or skewed.

G = Black and blue inks are out of register.

H = Any show-through measurement is out of tolerance.

I = Ink bleeds through.

J = Other, specify.

Copy distribution: **WHITE** – Bureau of the Census **YELLOW** – Contractor

Sheet _____ of _____ sheets

FORM **D-856**
(3-6-89)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

ADDRESSED 100 PERCENT (SHORT) QUESTIONNAIRE VERIFICATION QUALITY ASSURANCE RECORD

21st Decennial Census — 1990

A. Contractor name

B. GPO jacket number

C. Form number

D. Date (Mo./Day/Yr.)

E. Shift

F. Machine number

Count number	Number inspected	MEASUREMENTS								NUMBER IN ERROR DURING		Type of error
		Black ink density reading		Circle wall thickness			Show-through printing (low)	Rub-off personalization				
		Low	High	Low	High	Difference column (6)—(5)		Bar code (high)	BCD code (high)	Inspection	Expanded search	*Enter code from right*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)

ERROR CODES FOR COLUMN (13)

CODE PRINTING

- **A** = Any reading of the black ink density is out of tolerance.
- **B** = Any measurement of the circle wall thickness is out of tolerance.
- **C** = Any unprinted spot in the index areas or vertical bars is out of tolerance.
- **D** = Any black spot is out of tolerance.
- **E** = Poor type quality or uniformity.
- **F** = Image is misplaced or skewed.
- **G** = Black and blue inks are out of register.
- **H** = Any show-through measurement is out of tolerance.
- **I** = Ink bleeds through.
- **J** = Other, specify.

PERSONALIZATION

- **K** = Bar code not within specifications.
- **L** = BCD code not within specifications.
- **M** = Postnet bar code not within specifications.
- **N** = Misplaced or skewed image.
- **O** = Poor type quality or uniformity.
- **P** = Code numbers do not match.
- **Q** = Any show-through measurement is out of tolerance.
- **R** = Ink bleeds through.
- **S** = Fails the rub test (if applicable)
- **T** = Other, specify.

FINISHING

- **U** = Improperly trimmed.
- **V** = Improperly folded.
- **W** = Torn or damaged.
- **X** = Other, specify.

Copy distribution: **WHITE** — Bureau of the Census **YELLOW** — Contractor

Sheet _____ of _____ sheets

FORM **D-862**
(10-11-88)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

SAMPLE FOSDIC QUESTIONNAIRE SIGNATURE PRINTING VERIFICATION QUALITY ASSURANCE RECORD

21st Decennial Census — 1990

A. Contractor name		
B. GPO jacket number	**C.** Form number	**D.** Page(s)
E. Date (Mo./Day/Yr.)	**F.** Shift	**G.** Press number

Count number	Number inspected	MEASUREMENTS							NUMBER IN ERROR DURING		Type of error
		Black ink density reading		Circle wall thickness			Show-through		Inspection	Expanded search	*Enter code from right*
		Low	High	Low	High	Difference column (6)–(5)	Low	High			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)

ERROR CODES FOR COLUMN (12)

CODE PRINTING

- **A** = Any reading of the black ink density is out of tolerance.
- **B** = Any measurement of the circle wall thickness is out of tolerance.
- **C** = Any unprinted spot in the index areas or vertical bars is out of tolerance.
- **D** = Any black spot is out of tolerance.
- **E** = Poor type quality or uniformity.
- **F** = Image is misplaced or skewed.
- **G** = Black and blue inks are out of register.
- **H** = Any show-through measurement is out of tolerance.
- **I** = Ink bleeds through.
- **J** = Other, specify.

FINISHING

- **K** = Improperly trimmed.
- **L** = Improperly folded.
- **M** = Torn or damaged.
- **N** = Other, specify.

Copy distribution: **WHITE** — Bureau of the Census **YELLOW** — Contractor

Sheet _____ of _____ sheets

FORM D-863 (3-9-89)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

ADDRESSED SAMPLE QUESTIONNAIRE OUTSIDE LEAF VERIFICATION QUALITY ASSURANCE RECORD

21st Decennial Census — 1990

A. Contractor name		
B. GPO jacket number	C. Form number	D. Page(s)
E. Date (Mo./Day/Yr.)	F. Shift	G. Machine number

Count number (1)	Number inspected (2)	MEASUREMENTS: Black ink density reading Low (3)	Black ink density reading High (4)	Circle wall thickness Low (5)	Circle wall thickness High (6)	Difference column (6)—(5) (7)	Show-through Printing Low (8)	Show-through Printing High (9)	Show-through Personalization (10)	NUMBER IN ERROR DURING Inspection (11)	NUMBER IN ERROR DURING Expanded search (12)	Type of error *Enter code from right* (13)

ERROR CODES FOR COLUMN (13)

CODE PRINTING

- **A** = Any reading of the black ink density is out of tolerance.
- **B** = Any measurement of the circle wall thickness is out of tolerance.
- **C** = Any unprinted spot in the index areas or vertical bars is out of tolerance.
- **D** = Any black spot is out of tolerance.
- **E** = Poor type quality or uniformity.
- **F** = Image is misplaced or skewed.
- **G** = Black and blue inks are out of register.
- **H** = Any show-through measurement is out of tolerance.
- **I** = Ink bleeds through.
- **J** = Other, specify.

PERSONALIZATION

- **K** = Bar code not within specifications.
- **L** = BCD code not within specifications.
- **M** = Postnet bar code not within specifications.
- **N** = Misplaced or skewed image.
- **O** = Poor type quality or uniformity.
- **P** = Code numbers do not match.
- **Q** = Any show-through measurement is out of tolerance.
- **R** = Ink bleeds through.
- **S** = Fails the rub test (if applicable)
- **T** = Other, specify.

FINISHING

- **U** = Improperly trimmed.
- **V** = Improperly folded.
- **W** = Torn or damaged.
- **X** = Other, specify.

Copy distribution: **WHITE** — Bureau of the Census **YELLOW** — Contractor

FORM **D-877** (8-3-89)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

FOSDIC QUESTIONNAIRE ROLL-TO-FOLD PRINTING (COVER) QUALITY ASSURANCE RECORD

21st Decennial Census — 1990

1. Jacket number	**2.** Contractor's name
3. Site	**4.** Machine number
5. Government inspector's name	
6. Date	**7.** Shift

8. *MARK (X).*	Yes	No	NA
a. Sample correctly selected			
b. Sample correctly identified			
c. Expanded search correctly performed (if necessary)			
d. Defectives properly isolated and disposed of			
e. Census QA recordkeeping form correctly completed			
f. Census software data promptly and properly entered			

9. MEASUREMENT AND INSPECTION VERIFICATION

Measurement or inspection (a)	Equipment calibrated (b)		Correctly measured (c)		Correctly recorded (d)		VERIFICATION OF MEASUREMENT 1		2		3		4		5	
	Yes	No	Yes	No	Yes	No	Ctr. (e)	Gov't. (f)	Ctr. (g)	Gov't. (h)	Ctr. (i)	Gov't. (j)	Ctr. (k)	Gov't. (l)	Ctr. (m)	Gov't. (n)
Spots																
Hickeys																
Strikethrough																
Type quality																
Ink register																
Showthrough																
Density																
Circle wall																
Image size																
Image position																

▶ NOTE — Record the sample/box number (indicate range, if possible) of any defects not corrected by the contractor.

10. Comments

Copy distribution: **WHITE** — Census, STSD **YELLOW** — GPO **PINK** — Government inspector

FORM **D-878** (8-3-89)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

FOSDIC QUESTIONNAIRE ROLL-TO-FOLD PRINTING (INSIDE PAGES) QUALITY ASSURANCE RECORD

21st Decennial Census — 1990

1. Jacket number	**2.** Contractor's name
3. Site	**4.** Machine number
5. Government inspector's name	
6. Date	**7.** Shift

8. *MARK (X).*	Yes	No	NA
a. Sample correctly selected			
b. Sample correctly identified			
c. Expanded search correctly performed (if necessary)			
d. Defectives properly isolated and disposed of			
e. Census QA recordkeeping form correctly completed			
f. Census software data promptly and properly entered			

9. MEASUREMENT AND INSPECTION VERIFICATION

Measurement or inspection (a)	Equipment calibrated (b)		Correctly measured (c)		Correctly recorded (d)		VERIFICATION OF MEASUREMENT 1		2		3		4		5	
	Yes	No	Yes	No	Yes	No	Ctr. (e)	Gov't. (f)	Ctr. (g)	Gov't. (h)	Ctr. (i)	Gov't. (j)	Ctr. (k)	Gov't. (l)	Ctr. (m)	Gov't. (n)
Spots																
Hickeys																
Strikethrough																
Type quality																
Ink register																
Showthrough																
Density																
Circle wall																
Image size																
Trim size																
Folding positiion																
Image position and skewness																

▶ NOTE — Record the sample/box number (indicate range, if possible) of any defects not corrected by the contractor.

10. Comments

Copy distribution: **WHITE** — Census, STSD **YELLOW** — GPO **PINK** — Government inspector

FORM **D-879** (8-3-89)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

FOSDIC QUESTIONNAIRE ROLL-TO-FOLD PRINTING AND TRIMMING QUALITY ASSURANCE RECORD

21st Decennial Census — 1990

1. Jacket number	**2.** Contractor's name
3. Site	**4.** Machine number
5. Government inspector's name	
6. Date	**7.** Shift

8. *MARK (X).*	Yes	No	NA
a. Sample correctly selected			
b. Sample correctly identified			
c. Expanded search correctly performed (if necessary)			
d. Defectives properly isolated and disposed of			
e. Census QA recordkeeping form correctly completed			
f. Census software data promptly and properly entered			

9. MEASUREMENT AND INSPECTION VERIFICATION

Measurement or inspection (a)	Equipment calibrated (b)		Correctly measured (c)		Correctly recorded (d)		VERIFICATION OF MEASUREMENT 1		2		3		4		5	
	Yes	No	Yes	No	Yes	No	Ctr. (e)	Gov't. (f)	Ctr. (g)	Gov't. (h)	Ctr. (i)	Gov't. (j)	Ctr. (k)	Gov't. (l)	Ctr. (m)	Gov't. (n)
Spots																
Hickeys																
Strikethrough																
Type quality																
Ink register																
Showthrough																
Density																
Circle wall																
Image size																
Trim size																
Folding positiion																
Image position and skewness																

NOTE — Record the sample/box number (indicate range, if possible) of any defects not corrected by the contractor.

10. Comments

Copy distribution: **WHITE** — Census, STSD **YELLOW** — GPO **PINK** — Government inspector

FORM **D-880**
(8-23-89)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

MOTIVATIONAL INSERT AND INSTRUCTION GUIDE ROLL-TO-FOLD PRINTING AND TRIMMING QUALITY ASSURANCE RECORD

21st Decennial Census — 1990

1. Jacket number	**2.** Form number
3. Contractor's name	**4.** Site
5. Government inspector's name	
6. Date	**7.** Shift

8. *MARK (X).*

	Yes	No	NA
a. Sample correctly selected			
b. Sample correctly identified			
c. Expanded search correctly performed (if necessary)			
d. Defectives properly isolated and disposed of			
e. Census QA recordkeeping form correctly completed			

9. MEASUREMENT AND INSPECTION VERIFICATION

Inspection (a)	Correctly measured (b) Yes	Correctly measured (b) No	Correctly recorded (c) Yes	Correctly recorded (c) No	Comments (d)
Binding					
Type quality					
Ink register					
Trim size					
Folding position					
Image position and skewness					

NOTE — Record the sample/box number (indicate range, if possible) of any defects not corrected by the contractor.

10. Comments

Copy distribution: **WHITE** — Census, STSD **YELLOW** — GPO **PINK** — Government inspector

FORM **D-881** (8-23-89)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

ENVELOPE ROLL-TO-FOLD PRINTING AND TRIMMING QUALITY ASSURANCE RECORD

21st Decennial Census — 1990

1. Jacket number	**2.** Form number
3. Contractor's name	**4.** Site
5. Government inspector's name	
6. Date	**7.** Shift

8. *MARK (X).*	Yes	No	NA
a. Sample correctly selected			
b. Sample correctly identified			
c. Expanded search correctly performed (if necessary)			
d. Defectives properly isolated and disposed of			
e. Census QA recordkeeping form correctly completed			

9. MEASUREMENT AND INSPECTION VERIFICATION

Measurement or inspection (a)	Correctly measured (b) Yes	Correctly measured (b) No	Correctly recorded (c) Yes	Correctly recorded (c) No	Comments (d)
Type quality					
Ink register					
Glue					
Window size					
Window placement					
Envelope size					
Trim size					
Folding position					
Image position and skewness					

▶ NOTE — Record the sample/box number (indicate range, if possible) of any defects not corrected by the contractor.

10. Comments

Copy distribution: **WHITE** — Census, STSD **YELLOW** — GPO **PINK** — Government inspector

FORM **D-882**
(8-23-89)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

FOSDIC QUESTIONNAIRE GATHERING, STITCHING, AND TRIMMING QUALITY ASSURANCE RECORD

21st Decennial Census — 1990

1. Jacket number	**2.** Contractor's name
3. Site	**4.** Machine number
5. Government inspector's name	
6. Date	**7.** Shift

8. *MARK (X).*

	Yes	No	NA
a. Sample correctly selected			
b. Sample correctly identified			
c. Expanded search correctly performed (if necessary)			
d. Defectives properly isolated and disposed of			
e. Census QA recordkeeping form correctly completed			

9. MEASUREMENT AND INSPECTION VERIFICATION

Measurement or inspection (a)	Correctly measured (b)		Correctly recorded (c)		VERIFICATION OF MEASUREMENT									
					1		2		3		4		5	
	Yes	No	Yes	No	Ctr. (d)	Gov't. (e)	Ctr. (f)	Gov't. (g)	Ctr. (h)	Gov't. (i)	Ctr. (j)	Gov't. (k)	Ctr. (l)	Gov't. (m)
Gathering														
Stitching														
Trim size														
Image position and skewness														
Folding position														

▶ NOTE — Record the sample/box number (indicate range, if possible) of any defects not corrected by the contractor.

10. Comments

Copy distribution: **WHITE** — Census, STSD **YELLOW** — GPO **PINK** — Government inspector

FORM **D-884**
(8-23-89)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

MAILING PACKAGE ASSEMBLY QUALITY ASSURANCE RECORD

21st Decennial Census — 1990

1. Jacket number	**2.** Contractor's name
3. Site	**4.** Machine number
5. Government inspector's name	
6. Date	**7.** Shift

8. *MARK (X).*	Yes	No	NA
a. Sample correctly selected			
b. Sample correctly identified			
c. Expanded search correctly performed (if necessary)			
d. Defectives properly isolated and disposed of			
e. Census QA recordkeeping form correctly completed			

9. MEASUREMENT AND INSPECTION VERIFICATION

Measurement or inspection (a)	Correctly measured (b)		Correctly recorded (c)		VERIFICATION OF MEASUREMENT									
					1		2		3		4		5	
	Yes	No	Yes	No	Ctr. (d)	Gov't. (e)	Ctr. (f)	Gov't. (g)	Ctr. (h)	Gov't. (i)	Ctr. (j)	Gov't. (k)	Ctr. (l)	Gov't. (m)
Address visible														
Improper contents														
Damaged materials														

▶ NOTE — Record the sample/box number (indicate range, if possible) of any defects not corrected by the contractor.

10. Comments

Copy distribution: **WHITE** — Census, STSD **YELLOW** — GPO **PINK** — Government inspector

FORM **D-885** (9-1-89)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

FOSDIC QUESTIONNAIRE ROLL-TO-FOLD PRINTING AND IMAGING QUALITY ASSURANCE RECORD

21st Decennial Census — 1990

1. Jacket number	**2.** Contractor's name
3. Site	**4.** Machine number
5. Government inspector's name	
6. Date	**7.** Shift

8. *MARK (X).*	Yes	No	NA
a. Sample correctly selected			
b. Sample correctly identified			
c. Expanded search correctly performed (if necessary)			
d. Defectives properly isolated and disposed of			
e. Census QA recordkeeping form correctly completed			
f. Census software data promptly and properly entered			

9. MEASUREMENT AND INSPECTION VERIFICATION

Measurement or inspection (a)	Equipment calibrated (b)		Correctly measured (c)		Correctly recorded (d)		VERIFICATION OF MEASUREMENT									
							1		2		3		4		5	
	Yes	No	Yes	No	Yes	No	Ctr. (e)	Gov't. (f)	Ctr. (g)	Gov't. (h)	Ctr. (i)	Gov't. (j)	Ctr. (k)	Gov't. (l)	Ctr. (m)	Gov't. (n)
A. Printing Spots																
Hickeys																
Strikethrough																
Type quality																
Ink register																
Showthrough																
Density																
Circle wall																
Image position																
B. Personalization Bar code																
BCD code																
Postnet bar code																
Image position and skewness																
Type quality																
Code numbers match																
Showthrough																
Strikethrough																
Rub-off and scuffing																
C. Finishing Trim size																
Folding position																
Image position and skewness																

NOTE — Record the sample/box number (indicate range, if possible) of any defects not corrected by the contractor.

Copy distribution: **WHITE** — Census, STSD **YELLOW** — GPO **PINK** — Government inspector

FORM **D-886** (9-1-89)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

FOSDIC QUESTIONNAIRE ROLL-TO-FOLD PRINTING AND IMAGING (COVER) QUALITY ASSURANCE RECORD

21st Decennial Census — 1990

1. Jacket number	**2.** Contractor's name
3. Site	**4.** Machine number
5. Government inspector's name	
6. Date	**7.** Shift

8. *MARK (X).*	Yes	No	NA
a. Sample correctly selected			
b. Sample correctly identified			
c. Expanded search correctly performed (if necessary)			
d. Defectives properly isolated and disposed of			
e. Census QA recordkeeping form correctly completed			
f. Census software data promptly and properly entered			

9. MEASUREMENT AND INSPECTION VERIFICATION

Measurement or inspection (a)	Equipment calibrated (b)		Correctly measured (c)		Correctly recorded (d)		VERIFICATION OF MEASUREMENT 1		2		3		4		5	
	Yes	No	Yes	No	Yes	No	Ctr. (e)	Gov't. (f)	Ctr. (g)	Gov't. (h)	Ctr. (i)	Gov't. (j)	Ctr. (k)	Gov't. (l)	Ctr. (m)	Gov't. (n)
A. Printing Spots																
Hickeys																
Strikethrough																
Type quality																
Ink register																
Showthrough																
Density																
Circle wall																
Image position																
B. Personalization Bar code																
BCD code																
Postnet bar code																
Image position and skewness																
Type quality																
Code numbers match																
Showthrough																
Strikethrough																

NOTE — Record the sample/box number (indicate range, if possible) of any defects not corrected by the contractor.

Copy distribution: **WHITE** — Census, STSD **YELLOW** — GPO **PINK** — Government inspector

FORM **D-887** (9-1-89)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

FOSDIC QUESTIONNAIRE ROLL-TO-ROLL PRINTING QUALITY ASSURANCE RECORD

21st Decennial Census — 1990

1. Jacket number	**2.** Contractor's name
3. Site	**4.** Machine number
5. Government inspector's name	
6. Date	**7.** Shift

8. *MARK (X).*	Yes	No	NA
a. Sample correctly selected			
b. Sample correctly identified			
c. Expanded search correctly performed (if necessary)			
d. Defectives properly isolated and disposed of			
e. Census QA recordkeeping form correctly completed			
f. Census software data promptly and properly entered			

9. MEASUREMENT AND INSPECTION VERIFICATION

Measurement or inspection (a)	Equipment calibrated (b)		Correctly measured (c)		Correctly recorded (d)		VERIFICATION OF MEASUREMENT 1		2		3		4		5	
	Yes	No	Yes	No	Yes	No	Ctr. (e)	Gov't. (f)	Ctr. (g)	Gov't. (h)	Ctr. (i)	Gov't. (j)	Ctr. (k)	Gov't. (l)	Ctr. (m)	Gov't. (n)
Spots																
Hickeys																
Strikethrough																
Type quality																
Ink register																
Showthrough																
Density																
Circle wall																
Image size																
Image position																
Trim size																

▶ NOTE — Record the sample/box number (indicate range, if possible) of any defects not corrected by the contractor.

10. Comments

Copy distribution: **WHITE** — Census, STSD **YELLOW** — GPO **PINK** — Government inspector

FORM **D-889**
(9-6-89)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

ADDITIONAL COMMENTS QUALITY ASSURANCE RECORD

21st Decennial Census — 1990

1. Jacket number	**2.** Contractor's name
3. Site	**4.** Machine number
5. Government inspector's name	
6. Date	**7.** Shift

8. Comments

Copy distribution: **WHITE** — Census, STSD **YELLOW** — GPO **PINK** — Government inspector

Sheet _____ of _____ sheets

FORM **D-1984** (1-10-90)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

MARKUP OPERATION QUALITY RECORD

21st Decennial Census — 1990

1. Batch ID

2. DATE

a. Production			**b.** Quality assurance		
Month	Day	Year	Month	Day	Year

3. Clerk ID

4. Verifier ID

5. Production time

6. WU size

7. NUMBER OF ITEMS *(d) + (f)* —

a. Verified

b. In error

8. Clerk in TOL ☐ Yes ☐ No

9. Clerk status

10. QA decision ☐ Pass ☐ Fail

Processing office

11. Batch type ☐ Long ☐ Short

12. Shift

Questionnaire ID (a)	Tally edit actions (b)	List of actions omitted (c)	TOTAL *Actions omitted* (d)	List of incorrect actions (e)	TOTAL *Incorrect actions* (f)	Error rate $\frac{(d) + (f)}{b}$ (g)
12. TOTAL →						

FORM **D-1986** (1-5-90)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

TELEPHONE FOLLOWUP MONITORING QUALITY REPORT

21st Decennial Census — 1990

1. Batch ID		
2. DATE		
a. Production (Month / Day / Year)	**b.** Quality assurance (Month / Day / Year)	
3. Clerk ID	**4.** Verifier ID	
5. Production time		
6. Work unit size	**7.** NUMBER OF ITEMS — **a.** Verified	**b.** In error
8. Clerk in TOL (Yes / No)	**9.** Clerk status	
Processing Office name	**10.** QA decision	**11.** Batch type / **12.** Shift

Call number (a)	Monitoring item (b)	Quality level *Mark (X)* (c) Poor	Fair	Satisfactory	Good	Excellent	Comments (d)	Date discussed with clerk (e) Month	Day
1	Proper introduction								
	Questions asked properly (probing)								
	Quality of speech								
2	Proper introduction								
	Questions asked properly (probing)								
	Quality of speech								
3	Proper introduction								
	Questions asked properly (probing)								
	Quality of speech								
4	Proper introduction								
	Questions asked properly (probing)								
	Quality of speech								
TOTAL →									

Copy distribution: **WHITE** — Supervisor **YELLOW** — QA Unit

*U.S. GPO: 1990-748-051/000107

FORM **D-1998** (1-5-90)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

TELEPHONE FOLLOWUP RESOLUTION QUALITY RECORD

21st Decennial Census — 1990

1. Batch ID					
2. DATE					
a. Production			**b.** Quality assurance		
Month	Day	Year	Month	Day	Year
3. Clerk ID			**4.** Verifier ID		
5. Production time					
6. Work unit size	**7.** NUMBER OF ITEMS —				
	a. Verified — col. (c)		**b.** In error — cols. (e) & (g)		
8. Clerk in TOL			**9.** Clerk status		
10. QA decision			**11.** Batch type		
Processing Office name			**12.** Shift		

QUESTIONNAIRE Type *Mark (X)* (a) Short	Long	ID number (b)	Number of edit actions (c)	List of edit actions unresolved (d)	TOTAL *(Sum of items listed in column d)* (e)	List of edit actions refused (f)	TOTAL *(Sum of items listed in column f)* (g)
13. TOTAL →							
KEYED TOTALS →							

Copy distribution: **WHITE** — Supervisor **YELLOW** — QA Unit

*U.S. GPO: 1990-748-051/000108

FORM **D-2011** (3-5-90)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

QUESTIONNAIRE REPAIR QUALITY RECORD

21st Decennial Census — 1990

1. Batch ID					
2. DATE					
a. Production			**b.** Quality assurance		
Month	Day	Year	Month	Day	Year
3. Clerk ID			**4.** Verifier ID		
5. Questionnaires in work unit			**6.** NUMBER OF ITEMS — **a.** Verified		**b.** In error
7. Clerk in TOL			**8.** Clerk status		
Processing Office name			**9.** QA decision ☐ Pass ☐ Fail		**10.** Batch type ☐ Short ☐ Long

Questionnaire ID (a)	Error flags *Mark (X)* (b) M	X	XP	A	G	Comments (c)
TOTAL →						

Copy distribution: **WHITE** — Supervisor **YELLOW** — QA unit

☆ U.S. GOVERNMENT PRINTING OFFICE: 1990–748-051/20005

FORM **D-2112** (4-17-90) — U.S. DEPARTMENT OF COMMERCE, BUREAU OF THE CENSUS

SEARCH/MATCH BATCH CONTROL RECORD

21st Decennial Census — 1990

1. Batch number

2. Number of forms in batch

3. Date created

4. Batch origin

☐ Geocoded in DO ☐ Split for clerical geocoding

☐ Not geocoded ☐ USPS check

A. FLOW CONTROL

	Geocoding (a)	ACF check (b)	CU/FN lookup (c)	Matching/ Transcription (d)
1. Production clerk initials				
2. Production date				
3. QC clerk initials				
4. QC date				
5. Number of forms verified				
6. Error type and number *(Enter number in appropriate column.)*				
a. Incorrect geocode				
b. Not geocoded when should have been				
c. Incorrect address match				
d. Exact address not found when matching address present found on ACF				
e. BSA not found when BSA present on ACF				
f. ID or Pop count incorrectly transcribed				
g. Correct address match but CU/FN incorrectly selected				
h. Persons incorrectly transcribed				
i. Persons not transcribed when should have been				

B. COUNT CONTROL

	Number of forms (a)	Remarks (b)
1. Geocoding/Browse unit		
a. Forms geocoded		
(1) Addresses on ACF		
(2) Addresses not on ACF		
b. Forms unable to geocode		
2. Matching/Transcription unit		
a. Forms transcribed		
b. Forms matched		

FORM **D-2291**
(8-22-89)

U.S. DEPARTMENT OF COMMERCE
BUREAU OF THE CENSUS

QUALITY ASSURANCE MONITORING RECORD FOR TELEPHONE ASSISTANCE

21st Decennial Census — 1990

A. Processing Office name

B. Unit number

C. Date

D. Shift

CLERK ID NUMBER _____ S/R

Call number (1)	What is the quality level of — (2)	MARK (X) Poor (3)	Fair (4)	Satisfactory (5)	Good (6)	Excellent (7)	Form completed by phone? Mark (X) one (8) Yes	No	Comments (9)	Date discussed with clerk (10) Month	Day
1	PROPER INTRODUCTION										
	QUESTIONS ANSWERED PROPERLY										
	SPEECH										
2	PROPER INTRODUCTION										
	QUESTIONS ANSWERED PROPERLY										
	SPEECH										
3	PROPER INTRODUCTION										
	QUESTIONS ANSWERED PROPERLY										
	SPEECH										
4	PROPER INTRODUCTION										
	QUESTIONS ANSWERED PROPERLY										
	SPEECH										

NOTE TO THE READER

This Census of Population and Housing Evaluation and Research Report is designed to inform the public about the quality assurance program approach and the results for the major decennial census operations. If you would like additional information on any of the topics presented in this publication, copies of the reference documents, or other information about the quality assurance program, please write to:

Mr. John H. Thompson
Chief, Decennial Statistical Studies Division
C/ O Quality Assurance REX Publication
Bureau of the Census
Washington, DC 20233

We welcome your questions and will provide any requested information, as available.