IMPROVING OPERATIONAL QUALITY AND PRODUCTIVITY FOR THE 1990 CENSUS

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I. BACKGROUND

After the 1980 census, we looked at the results of the analyses of various 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?

This paper will present a discussion of some of the techniques used for quality assurance in the 1990 census, how they differed from that used in 1980 and some examples and results of the process for selected operations.

In the early 1980s, we started to direct our quality control approach toward the Deming philosophy. We recognized the problems of relying on the inspection and repair method that was used in 1980 operations. This approach had not been completely successful. We decided that the Deming philosophy with its approach toward total quality improvement would better serve the Bureau of the Census.

We arrived at four major components to the philosophy, 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" for an operation as large as a Decennial Census is not easy. We needed 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 all 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 so that the system could be constantly improved. However, a system cannot constantly improve unless we provide the tools to the staffs and supervisors to do so. A major challenge was to design a system where we could measure the quality of the work, quantify error characteristics, and provide the information to management in a time frame where it could be used.

The integration of the responsibility for quality with production grew out of our 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. Quality the responsibility of the quality control area in another part of the organization. Top management always asked how things were going, but it was perceived in terms of quantity, not quality of work. Therefore, the weight within the organizational 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 in the organization.

To eliminate this antagonism, we made the production side responsible for quality. With this added responsibility, no one would be satisfied with just getting the job done. The job, now, had to be done well.

Quality assurance is different from quality control. It is difficult to get 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 part of the broader quality assurance concept.

The Bureau does a lot of the separate components of quality assurance, but integrating it under an

umbrella of quality assurance is a change in philosophy and management approach. This change has been one of the most difficult aspects of the new philosophy to implement during the 1990 Decennial Census.

II. QUALITY ASSURANCE FOR 1990

To support the new philosophy we made a concerted effort to design quality control plans integral to an overall quality assurance approach. We consulted and met with the sponsors and users of our specifications. We specified certain aspects to enable measurement of learning, continued performance improvement, and overall process quality. We 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, a unit of clerks, and of an individual.

We had to sell the new philosophy by educating both management and staff through the use of seminars on the Deming approach. Several pilot programs, outside the decennial area, were undertaken to show the effects of the new approach on the process. We tested the various aspects of the approach during the census test cycle.

To obtain both timely and accurate measurements of performance was one of our major goals. To achieve this we simplified any manual records and summaries, and we developed software to support the capture of quality data quickly. We also maintained an active quality control activity to measure the performance, both during training and during production.

Another goal of our 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.

We worked hard on specifying what was to be covered in training. We also thought it was important to make sure the trainees understood the job before they left the training room.

To achieve this goal we instituted practice work wherever possible and developed tests 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 two 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.

III. AREAS OF APPLICATION

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

A. Automation

The increase in the use of automation has made it possible to apply the new approach to areas that would have been impossible in 1980. With the placement of automation equipment at the field district office level, we can expect more consistent application of procedures.

Automation and the associated ability to control the materials by ID have permitted the census materials to be processed on a flow basis as they are received. This allows the processing in both the district offices and the processing offices to proceed. Productivity is enhanced in this way.

The increased use of automation has made it possible for the Bureau to improve the capture, analysis and dissemination of information on the status of the operations. For example, in the processing offices there was a computer assisted tracking system to monitor material work flow. Software and computer facilities also enabled the 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.

One of the basic properties for an effective quality assurance program is the speed with which feedback is given. Automation has provided a means by which we can turn around data and its interpretation rapidly. During processing of the 1980 census, it was not unusual for the manual recordkeeping to have a backlog of a couple of weeks, making the value of such data worthless.

Automation has also improved production because operations can be accomplished in much less time. Check-in of the mail returns is faster and better. We are generating listings to be used for nonresponse followup, not using the same address register over and over again.

B. 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. Some of the efforts to improve communication during the 1990 census planning cycle were:

1. Inter-Agency Working Groups

This phase was important during planning and implementing the 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 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. Once the various operations started, the working groups stayed intact. The emphasis then changed to monitoring the operation and resolving problems.

2. Internal Census Working Groups

Internal census working groups were developed to plan and design the best system possible for various operations for which the Bureau had sole responsibility. Their functions were similar to the inter-agency working groups.

3. Reduced Supervisor Ratio

We reduced the supervisory ratio. 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.

4. Quality Circles

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

5. On-Site Observers

Another organization component established to improve operational performance was on site observers in both field and processing offices. These observers were referred to as quality assurance technicians (QA Tech). 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.

C. Organization

There have been several changes in the way the Bureau is organized for the 1990 census as opposed to the way it was organized for 1980. It is more decentralized in 1990. In 1980, the Bureau had three processing offices and for 1990 we have seven offices.

The within office structure is also different. The quality assurance area is integrated within the total organizational structure. A supervisor over a specific operation is now responsible for both production and quality. This is a major improvement over 1980 when there were separate areas responsible for production and quality.

D. Training

One of the components of the total quality assurance concept is the education and training of production staff. Our goal as management was to institute training on the job. The census created over 400,000 temporary jobs for more than two dozen major field and processing operations. The majority of the jobs were for 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 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.

As part of the Bureau's training to prepare to process the questionnaires a three 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 for the census.

E. Software Quality Assurance

In early 1987, the Bureau initiated a software quality assurance (SQA) effort. An interdivisional core group responsible for the design, monitoring, and evaluation of SQA for the 1990 census was established.

Software QA attempts to ensure that the finished product meets the user's requirements and matches the development specifications. Software QA spans the entire development life cycle including project initiation, design, implementation, testing, and maintenance. The purpose of monitoring software products at each development stage is early detection of errors or omissions. The earlier errors are detected, the easier and cheaper they are to correct.

F. 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 to meet this objective.

1. Pre-Operational Sampling

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

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 was also not feasible due to operational constraints.

2. 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. The other processing operations were dependently verified.

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 was used to identify areas of difficulty where additional training may be required.

3. 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 would also have interfered with the enumeration process.

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.

4. Reinterview

For the list/enumerate and nonresponse followup operations, the enumeration was conducted by census enumerators. To protect against census enumerators falsifying data during the field enumeration process, a sample of work was selected daily to be

reinterviewed. By comparing the reinterview responses to the original responses 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.

5. 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. A measure of the ability to perform was obtained by measuring the proportion of suppressed addresses returned as adds.

IV. SOME EXAMPLES AND RESULTS

A. Address List Development - Prelist

In 1988, addresses were obtained by Census enumerators in areas to be included in the mail-out portion of the census.

The coverage and content errors were identified through an independent sample selected prior to the actual start of the prelist operation. This operation was called advance listing. During the advance listing operation, enumerators canvassed the sampled blocks within the prelist address register areas and listed, as well as map spotted, a sample of addresses. During the prelist operation, each enumerator listed and map spotted all living quarters within his/her assigned geographic area. To identify possible coverage and address content errors, the field supervisor matched the sample addresses obtained during the advance listing operation to the addresses listed by the enumerators during the prelist operation. The match results were used to identify if additional training for the enumerator or release of the enumerator was necessary. In either case, the work was reassigned to another enumerator for recanvassing.

The listing error rate represents the proportion of addresses listed incorrectly by the enumerator due to either omission or content errors. The listing error rate for the 1988 Prelist was estimated to be 2.4 percent. This estimate represents an improvement over the 1988 Dress Rehearsal prelist listing error rate estimate of 11.0 percent. The 1988 listing error rate decreased over the duration of the operation showing the effect of the feedback and learning.

B. Data Entry - Prelist Keying

Data entry operations are perhaps the clearest example of the application of the new approach. For the Census, there are eighteen unique data entry operations lasting from two weeks to seven months.

The quality assurance program consisted of an automated system which selected a random sample of keyed records from each workunit; this sample was verified by another keyer. During the verification keying the system indicated any differences between the original keyer and verifier. It was the verifier's job to determine the correct entry. All of the differences by field type were maintained by the system in a quality assurance file. At the conclusion of verification, the system computed the estimated field error rate. If it was below a predetermined tolerance level the keyed data was accepted and the workunit passed. However, if the field error rate was above the tolerance level, the workunit was rejected and repaired by the original keyer, then reverified. Having the original keyer repair his/her own work served as a form of feedback since the keyer was able to learn from previous mistakes.

The purpose of repair was not, as it was in 1980, to significantly improve the overall quality of the data, but rather to protect against extremely bad workunits and to provide a means for feedback.

During the data entry operation a variety of computer-generated quality assurance reports were used by the data entry supervisors to provide additional feedback to the keyers. Some reports provided information on production both at the workunit and keyer levels, while other reports focused on the individual keyers, tracking both production and quality data. Error distribution reports allowed the supervisors to pinpoint sources of keyer difficulty. For each workunit that failed the quality assurance check, a report showing all differences was generated. This listing contained the keyer's and verifier's entries for each field on which they disagreed. Using these reports, the supervisors were able to identify sources of keyer error, and provide appropriate feedback to the keyers, as warranted.

The 1988 Prelist data entry operation keyed approximately 65,000 address registers containing approximately 29 million addresses and 174 million address fields. The estimated field error rate was 0.48 percent. This was a significant improvement over the 1988 Dress Rehearsal rate of 1.0 percent. The field error decreased significantly throughout the operation. The field error rate dropped from 1.06 percent during the first weeks of keying to 0.44 percent by the end of the operation. Similar results are being found for other data entry operations.

C. Questionnaire Printing

The design and development of the census questionnaires took place far in advance to allow time for testing of the content and of the various data collection methodologies.

Questionnaires underwent various printing and bindery processes. A formal quality assurance operation was performed by the contractor at each step of the production process to ensure that the forms met the quality standards required in the contract. The primary purpose of the quality assurance was to assure the legibility of the printed or personalized image, the correct assembly, the correct packaging of the census questionnaires and associated forms and the ability to scan the FOSDIC forms. The quality assurance for each process followed a similar format: sampling, inspection and testing, corrective action and clean-out of defective materials, and recording of quality assurance data. In addition, a Quality Improvement Program was established to monitor the implementation of the quality assurance requirements. Trained government observers were sent to all sites to monitor the contractors' adherence to the quality assurance program.

There was a learning process from contract to contract that allowed us to constantly improve the quality assurance/production process. One of the most important factors in obtaining a quality product was the ability to work together as a team. A joint effort by the Census Bureau and the Government Printing Office worked with the contractors to promote a common goal to produce the best product possible - if there was disagreement on how to reach that goal, we talked it out and developed a mutually acceptable plan.

Analytical data are not yet available; however, preliminary indications are that the printing process went well. As might be expected in a printing job for approximately 250 million forms, there were some problems but nothing of a systematic nature has been reported.

D. Reinterview

The purpose of the reinterview operation was to identify census enumerators who falsify data during the enumeration process and to provide the information to management so that the appropriate administrative action could be taken. The reinterview operation was implemented for both the Nonresponse Followup Operation and the List/Enumerate operation.

The reinterview program was designed to identify data falsification during the enumerator phase on these two operations. The program consisted of two components: (1) the selection of a random sample of completed cases from each enumerator's assignment during the early phase of the operation, and (2) the selection of a random sample of completed cases from each enumerator whose performance on specified indicators differed significantly from the average rates exhibited in their geographic area.

The reinterviewer's job was to contact the sample households either by telephone or by personal visit, verify that they had reached the correct sample address and conduct the reinterview and reconciliation (if needed). The reinterview consisted of obtaining the unit status and original household roster as of Census Day. If there were differences between the reinterview data and the original census data, the reinterviewer reconciled the differences and determined who was accountable for the differences. If the original enumerator was accountable, field supervisory staff researched the case to determine if actual data falsification had occurred - if it had, the enumerator was released and the data falsified cases re-enumerated.

A critical component of the reinterview program is the amount of time between the original interview and the reinterview. By reducing this time and identifying data falsifiers early reduces the amount of damage done and thereby decreases the amount of re-enumeration. Also, the more efficient the detection system the better it serves as a deterrent to enumerators.

During the 1988 dress rehearsal the average lagtime was 16 days - entirely too long to have an effective reinterview program. This was due mainly to the sample selection being within the district office and thereby susceptible to any other delays incurred within the office. To improve this for the decennial census, we moved the sample selection to the field - to be selected by field staff prior to the questionnaire reaching the district offices.

Preliminary results indicate that this design change was successful in reducing the lagtime to an average of four days - resulting in a more efficient program. Analytical data on the magnitude of data falsification is not available at this time.

These are a few examples of how the quality of the census has been improved. Over the next few years we will continue to analyze the data and report on the quality of the census. But we realize that there can be further improvements to the quality of the census operations, and we plan to use these data to help us identify additional areas of improvement.

1/ This paper reports the general results of research undertaken by Census Bureau staff. The views expressed are attributable to the authors and do not necessarily reflect those of the Census Bureau.