Automating the Census 2000 Accuracy and Coverage Evaluation Field Operations

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I. Introduction

The Census Bureau implemented an extensive set of field data collection operations to measure the net undercount of the Census 2000 person and housing enumeration. The results of this survey, the Accuracy and Coverage Evaluation (A.C.E.), are being considered for correcting the census count for official statistical uses. The use of A.C.E. corrected census counts for Congressional apportionment was ruled unconstitutional in February 1999 by the Supreme Court. The possibility of using the corrected counts for other purposes was left open. As a consequence the Census Bureau redesigned the A.C.E. not long before field operations began.

Computer Assisted Personal Interviewing (CAPI) was used for the largest A.C.E. operation, Person Interview (PI), which was done in the summer of 2000. This independent re-enumeration of 315,000 dwellings in 11,802 sample clusters in all fifty states, DC and Puerto Rico was the largest CAPI survey ever undertaken by the Census Bureau. It required more than 6500 field staff, each with a laptop computer that was used for interviewing, quality control, supervisory functions, and Email. The field staff was hired and supervised by twelve A.C.E. regional offices (ACEROs), who in turn were directed and supported by Headquarters (HQ) project management and automation staffs.

To be used for correcting the census count, A.C.E. had to meet high standards of data quality, minimize nonresponse, detect and correct interviewer falsification, and accomplish all activities within a very tight and volatile schedule, integrated within the overall census schedule. Coverage estimates had to be produced by an absolute deadline. Further, the survey design of the A.C.E. required that it be conducted independently of census enumeration activities, i.e., that the census enumeration not affect that of A.C.E. and vice versa. This independence requirement imposed very constraining rules that limited the A.C.E. field managers in utilizing field staff, scheduling field work, and accessing general Census 2000 resources such as those for payroll and personnel.

II. General A.C.E. Automation Requirements

To manage A.C.E. field work we needed:

- **User-friendly software** to accommodate many users who had little or no experience using automated tools or with survey interviewing.
- **An automated control system (ACE2000)** that could track cases and manage the field staff for both large-scale paper and pencil interviewing (PAPI) and large CAPI operations from twelve sites. The system had to be flexible enough to adapt to different kinds of management, with as many checks and edits as possible, standardized functionality and the ability to identify and reassign problem cases quickly.
- **Integrated QA functions** - Quality Assurance (QA) functions that were integrated into both the operational flow and automated systems allowing accurate timely quality checks. The ability to target and to add QA cases were central. The system had to provide information to target interviewers for more QA. It had to allow specific cases to be added to QA.

III. Challenges

We had to overcome enormous challenges:

- **Timing** - Could we hire a large staff and get a great deal of work into the field quickly, for operations for which the starting date, the location of the work and the size of the workload were not known until shortly before an operation was to begin? We had no experience with this type of work flow.
- **Support** - Could we provide sufficient, timely support for automation, hardware and subject matter given the scale and timing of the operations and the fact that the majority of our HQ support staff, field staff and regional support staff were new hires?
- **Size** - Could the control system function given the large number of interactive end users and

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large number of "jobs" to be run and the load put on it? Could the telecommunications system handle the volume of transmissions and users?

- **Inexperienced staff** - Could we create a system that was sufficiently user friendly and forgiving of human error?
- **Training** - Could we train a large field and office staff, most of whom had no previous interviewing or computer experience, to produce the quantity and quality of work we required within the prescribed schedule?
- **Independence** - Could we build in sufficient controls to handle the various independence requirements while allowing sufficient supervisory discretion?
- **Ability to communicate with other systems** - The ACE2000 had to be able to communicate with the census control system, recruiting & payroll system, and other independent systems daily. Could this be accomplished?
- **Hardware Control** - Could we deploy and ensure the return of thousands of laptops dispersed around the country?

IV. Risk Reduction

The addition of a telephone interview phase was both the most important and the most successful strategy used to reduce risk. While independence rules prohibited us from being in the field at the same time as the census non-response follow up operation (NRFU), we could telephone households in urban areas, who mailed back their census form and included their telephone number.

Better than expected mail response to the census, provided more units with phones than expected. This enabled us to complete 29.5 %[2] of our Person Interview workload by telephone (90,386 cases). Field supervisors did most of the interviewing during the telephone phase, so it also served as a training period. This reduced the hiring needs for the next phase allowing us to use fewer interviewers and to make smaller assignments. This phase also served as a shakedown of the Person Interview software and enabled a "gradual" buildup to full scale.

Eliminating operations or eliminating automation for operations that would have depleted our automation development resources also reduced risk factors.
1) Originally we were required to trace movers. We attempted to interview census day residents of the sample unit who had moved out since census day even if we already had a good Person Interview proxy interview about that household. There was no clear evidence that these interviews improved the accuracy of our data.
2) We intended to automate the Person Follow Up Interview (PFU) phase of A.C.E. for the 2000 Census. The complexity of the software required combined with limited time led us to abandon our efforts.

"Early Warning Reports" provided a way to track the progress of the processing or census operation that fed into the A.C.E. operation. Because the size, geographic distribution and timing of receipt of the workload for three of the four major A.C.E. operations was unknown until immediately before the work was actually received in the ACEROs, planning staffing and scheduling training were difficult. Staff had to be available as soon as work arrived but not be trained so far in advance that they forgot their training by the time they started working.

V. Independence

The survey design also required independence between certain A.C.E. operations. We had a number of reports and interactive safeguards to maintain independence.
1) In order to ensure independence between the A.C.E. and the census, the ACE2000 did not allow cases to be released for personal visit until census NRFU was virtually done in that area. NRFU progress was extracted daily from the census control system in order to update the Early Warning Reports.
2) We provided a report indicating which clusters an employee had worked in previously on either A.C.E. or census operations. A similar report showed which A.C.E. employee(s) had worked in specific clusters. Assignment screens contained pop-up boxes warning that the person to whom the cluster was being assigned had previously worked in that cluster.
3) Safeguards to keep the QA operations independent from the operation being QA'd were included in the system.

VI. The Person Interview Instrument

Person Interview was designed to collect data from households to match to data from census questionnaires for corresponding dwellings. The interview consisted of establishing a household census day resident roster for a sample housing unit, a current roster if there were inmovers since census day and demographic characteristics for each person.

Checks on data quality were built into the instrument. Cases with insufficient information remained on the laptop until the interviewer indicated that were sure they could not get the missing information.

Other features of the instrument include:
1) **A separate interview for single person households**;

[2] Without Puerto Rico. Combined phone percent 28.7 %

2) **Two separate proxy interviews**; one for interviews with proxy respondents for *current residents*, and one for interviews with proxy respondents for *census day residents;*
3) **A separate full Spanish language translation**. The instrument recorded which language was used. While the Spanish version was designed to be used primarily in Puerto Rico it was also used extensively elsewhere. One locality had more than 30 % of their Person Interview interviews completed using the Spanish version and nearly 40 % of all census data collection areas had at least one.

VII. Person Interview Quality Assurance (PIQA)

We used an automated PIQA instrument that would identify possible falsification and collect replacement information for cases for which falsification was suspected. A 5% sample of all cases was randomly selected for QA. In addition, the ACERO had the ability to add Person Interview cases to QA. This was done to make the QA effort more efficient and effective in identifying falsification. A case targeted for QA was more likely to have been falsified than a case randomly selected for QA. HQ staff monitored QA very closely.

The most important features of the ACE2000 QA software were the three targeting reports and the ability to add cases to QA immediately.
1) **The Respondents Name Report.** The QA staff reviewed each case for unlikely respondent names such as Marilyn Monroe or Mickey Mouse. Cases of this type were added to QA.
2) **The Outlier reports** indicated whether or not an interviewer was an "outlier" for certain performance characteristics. The variables checked included percent of cases without a phone number and percent of cases vacant or not a housing unit. This report was used to identify interviewers who might be falsifying data.
3) **The Not Enough QA Cases report** indicated the QA status of each Person Interview interviewer. If less than 4% of their work was in QA, cases were added to QA. This was an important aid in early identification of possible falsification.
4) **The Add QA Cases screen** was used to add cases to QA. Cases added were usually of the same type as the suspicious case(s). For example, if an interviewer had an unusual number of vacant units, some of his/her "vacants" would be added to QA.

VIII. Maximizing Response

After check in, incomplete cases were sent for supervisory review and supervisory action. At this point the supervisor could immediately assign the case to a different interviewer, accept the noninterview or flag the case to go into a two week post Person Interview nonresponse conversion operation (NRCO). The strongest interviewers were selected to work on NRCO. 97.9 percent of the 10,111 NRCO cases were converted. NRCO interviews had to meet the same standards for completeness as any other interview.

Cost and progress reports were sent daily to field supervisory staff laptops. They used these to monitor and manage their staff during all A.C.E. operations.

IX. Software

Controlling software changes: A Configuration Control Board was established prior to the start of field operations to evaluate proposed changes to A.C.E. software. The group made decisions about proposed software changes, identifying the steps and schedule required for implementing the decisions.

ACE2000 Software Testing: A two-stage testing process was used. Testing staff conducted initial testing of the software and its conformance to specifications. Once it passed this stage, it was released to another testing group for additional testing on a system with the same hardware configuration as that used in the regions.

Testing included three phases: functionality testing, load testing, and Graphical User Interface (GUI) stress testing.
1) **Functionality testing** checked that the software functioned as intended.
2) **Load testing** tested the ability of the system to accommodate the workload. The test included a workload larger than expected in production.
3) **GUI interface testing** for speed and stress on the system was the final test. This test involved activities performed routinely several times a day, such as making assignments and resolving cases requiring supervisory review. This testing was conducted with automated testing tools. Integration testing was also conducted for the interface between the ACE2000 and the laptop software components.

Laptop Software: The laptop software components included the automated instruments, organizing software, telecommunications software and security software**.** Organizing software allowed interviewers to organize and manage their cases. Using a modem to transmit, the laptop sent completed cases to HQ and received newly assigned cases. The software allowed the cases to move rapidly to and from the interviewer while tracking each case. All organizing, training and instrument software was available in both English and Spanish. The interviewer could change the language easily.

The primary physical security was accomplished through the distribution procedure for the laptops, the assignment

of a telecommunication user license number to each interviewer, and requiring a login password to access the laptop software. The license was checked during every transmission, and if the license was not correct, the system disconnected. The case data was protected by encryption using Secret Agent software, password protection, and other methods. The encryption/decryption used was more complex than for other census surveys. The security worked flawlessly.

Extensive path testing of the PI and PIQA instruments was conducted. Data output was reviewed at all stages of the process. After any changes the path testing was repeated. Prior to the final full systems tests, a series of mini-pretests was conducted to ensure that the laptop organizing software and the instruments were working in harmony.

Telecommunications were accomplished using NT-based software known as CONNECT:Remote. It provided for automatic software distribution, and an automatic re-dial feature. It also provided a safe file transfer process with four levels of security.

The telecommunications system was designed with redundancy and fault tolerance features. These included a split-site configuration, multiple servers, multiple NT communication servers, and multiple 800# access. The phone lines were load balanced. Log files were maintained on the server and the laptop.

Case Notes: One of the most important features of both the laptop software and the ACE2000 was always keeping interviewer notes with a case. The supervisor had the ability to add notes to a case in supervisory review. PI notes were available in PIQA.

Staff Information: The ability to hire and pay staff efficiently was critical. The ACE2000 staffing functions were some of the most difficult to implement. Personal information (such as SSN) was extracted from the recruiting/payroll system, eliminating the need to key the data. In addition, staff from a preceding A.C.E. operation was moved to the next operation without requiring re-keying. Payroll information was imported daily from the payroll system.

X. Hardware

Laptop Selection: We needed a laptop that met very specific conditions: weigh no more than 5.25 pounds, have a battery that was easy to change, have a screen that could be read in bright sunlight, could withstand (reasonable) extremes of hot and cold weather and would not die when the first raindrop splashed on the keyboard. The laptop had to be able to run DOS 6.22 and be Y2K compliant. Since A.C.E. interviews often were conducted while using battery power, standing at the doorstep of a respondent's home, aspects of a laptop that would be unimportant in an office setting were critical for us. We gave very high priority to the stability and comfort of the laptop while standing and conducting an interview. None of the laptops tested had good visibility in bright sunlight. Several were judged to be acceptable.

The HP OmniBook 900 laptop was chosen by an acquisition team. The team included members with expertise in hardware, programming, field procedures, telecommunications and acquisition. Experienced CAPI interviewers rated the laptops based on their usability in a field situation.

Testing of the laptops was conducted in three stages:
1) **Physical:** The functions and features of each laptop were evaluated using specific criteria and tests. Each laptop received a pass/fail for each test.
2) **Application:** Application testing evaluated the laptops in relation to technical characteristics using software that would be used in the field. Among the things tested were the visual and audible drain alert and battery life.
3) **Subsystem:** This testing was subjective and evaluated the laptops' usability while conducting mock interviews. These tests included: ease of use, accessibility of features, contrast adjustments, physical battery replacement, ease of reading screens in varied lighting conditions including bright sunlight.

Laptop control: The bureau contracted with a commercial vendor to perform four main functions:
1) acquire the laptops and peripheral hardware,
2) load the software,
3) pack and deploy the laptops to the field,
4) repair and replace broken items.

A decision was made as a result of early field tests to provide users with a "kit" that contained the laptop and all the necessary items related to the operation and control of the laptop. The kit concept proved to be an excellent strategy as it facilitated control.

A total of 9,055 kits was deployed. Census staff performed a QC of the kits before they left the vendor. Fewer than twenty defective kits were returned to the vendor for replacement. At the ACERO each kit was checked into an automated property control system and linked to the end user. Laptop losses were held to the surprisingly small number of ten. This excellent record was due mainly to a tight control and security process at all levels.

Overall our experience with the laptops was very successful.

- We were able to deploy, track and recover close to 100% of the laptops sent to the field.
- The interviewers mastered the use of the laptops with very few problems.
- The laptops were durable and functioned well. Fewer than 3% required repair by the vendor.
- The A.C.E. laptops with some upgrades are now being used by our permanent interviewing staff. The fact that we could use these laptops for other surveys was one of the factors in the decision to purchase the laptops rather than to lease them.

XI. Training

We set out to develop structured training programs for all staff for all operations. Our goal was to have homogeneous core training given across the nation despite the different levels of experience, or lack of experience, and different presentation styles of the trainers. The initial training for each office or field activity was designed to train supervisory staff who would in turn train their subordinates. These "train-the-trainer" sessions were the first step in a *cascaded training*.

Training had to introduce new office and field staff to census concepts and procedures as well as instruct them on the technical aspects of A.C.E. We needed interviewer training that would teach interviewers to use the laptop, to do a quality interview, to overcome respondent reluctance, to transmit data using the laptops and *that an only slightly more experienced staff member could deliver.*

The first automation training for each operation was generally given to ACERO management staff by HQ staff. In addition, the HQ staff trained all of the QA supervisors. QA required this increased attention in the context of the enormity of the task of launching and managing the PI.

Developing a hierarchical troubleshooting process, was imperative due to staffing constraints. Our goal was to solve problems in the field if at all possible. A problem that could not be solved in the field was referred to the ACERO. If the ACERO was unable to solve the problem, it was sent to HQ. Training on troubleshooting automation problems was available for all levels of A.C.E. staff.

We had a four day laptop troubleshooting training for ACERO and HQ support staff. It featured diagnostic flow charts. This training played a key role in the success of our automation support efforts. The Laptop Operations Guide was one of the most effective tools used for A.C.E. It gave step-by-step instructions for using and troubleshooting the laptop. The Laptop Operations Guide was given to each person who used a laptop.

A laptop computer based training (CBT) module covering the use of the organizing software was installed on every laptop. Training cases and other laptop CBTs focusing on the interview process were installed on all laptops and used in all interviewer training. The training cases and CBTs could be refreshed and reused. Automation staff was expected to complete all of the interviewer training as well as technical training. Each staff member completed all training given to their subordinates as well as training geared specifically to their position.

Freezing Training Software: In order for training materials to be prepared, printed, packaged in kits and shipped to the ACEROs in time to train the trainers, laptop training software was frozen five months before the production software. The ACE2000 training software was frozen two months before the production software. This meant that the training software did not fully match the production software. The laptop training software differed from production software primarily in ways that were not apparent. The ACE2000 training software diverged from the production software in more visible ways.

XII. Support

A centralized support center provided automation support for all field operations for Census 2000. One team of support staff was dedicated to A.C.E. This team referred questions to the subject matter/operations or development staff, as appropriate. REMEDY was the software used to log, refer and track problems. This area was the focal point for all automation related communications between HQ and the ACEROs. HQ staff had access to the entire ACE2000 while the ACEROs had access only to the data for their region. This was critical in troubleshooting problems. HQ software contained additional functionality to permit support and to allow flexibility to react to unusual circumstances.

Support was also provided by three weekly teleconferences with ACERO staff. Each teleconference focused on different functional areas. Conferences held prior to the start of each operation facilitated communication and training of the ACERO staff.

Automation support clerks, who were to be the primary automation contact between the field staff and the ACERO, were one of the most difficult positions to fill. As a result, staffers with many different job titles were trained to handle laptop support and troubleshooting. This turned out to be a very successful approach due to very stable laptop software and excellent training packages.

Teamwork: All aspects of A.C.E. were designed, developed and monitored by cross-functional teams. Team leaders met weekly to report on progress and to

make needed decisions. The team concept worked extremely well. It allowed each functional area to be represented during the design process and insured that input, process and output met all of the users' needs. This also insured that the various automated systems were able to communicate effectively.

XIII. Lessons Learned and Recommendations

1) ***It is possible to train a very large and inexperienced staff to do quality CAPI interviews*** in a fairly short time frame. Careful attention to training materials, a smoothly functioning instrument and a gradual expansion of staff were key.

2) ***Major design requirements and decisions have to be made much earlier in the decade than many realize***. The larger and more automated a survey becomes the earlier the methods and materials must be locked down. For 2010 census automation, this will result in our locking into less than cutting edge hardware and software, but will also result in very robust survey tools and materials.

3) ***Monitoring of processes and progress by HQ staff is valuable*** and should be expanded.

4) ***Testing of all hardware and software should be extensive.*** We believe that thorough testing of the software was critical to our success.

5) ***Teamwork*** with effective, frequent and timely communication sounds cliched but we believe that the cross-functional teams were extremely effective. Early and frequent communication among all areas with program responsibilities is crucial to be sure that everyone is proceeding with the same vision.

6) ***All systems should be planned with the needs of the other systems in mind*** and we all need to be aware that changes to one system affect other systems.

7) ***Redundancy in resources is another key to minimizing risk.*** Every thing and every person should have a backup.

8) ***If something is not working consider simplifying or eliminating***. A good job with a paper instrument is better than a poor job with an automated instrument.

9) ***A core group of HQ automation support staff should be brought on board as early as possible and should continue with the project through completion***. They should participate in the software development and in support of the software during the early tests.

10) ***The availability of manuals and materials in Spanish was of significant help*** in certain areas. For 2010 we hope to incorporate more languages.

11) ***Laptop inventories need to be fully automated.*** This includes receipt, control, deployment, retrieval, disposition and creation of reports.

12) ***Production software should be frozen as early as possible*** to allow training software to most closely match the production software and to allow sufficient time for preparing materials and training.

XIV. References

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