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CENSUS TECHNOLOGY: RECENT DEVELOPMENTS AND IMPLICATIONS ON CENSUS METHODOLOGY

Use of Hand Held Computers in the United States 2010 Decennial Census of Population and Housing: Lessons Learned So Far

Submitted by the United States of America *****

This meeting is organised jointly with Eurostat.

Summary

The Bureau of the Conference of European Statisticians (CES), at its meeting held in Washington, D.C. (United States) on 19-20 October 2006, approved the renewed terms of reference for the Steering Group on Population and Housing Censuses and the plan for future CES activities on population and housing censuses. The CES Bureau also agreed that the Steering Group would coordinate the work on the diverse types of meetings.

The present paper was prepared on request by the Steering Group on Population and Housing Censuses, for presentation and discussion at the Joint UNECE/Eurostat Meeting on Population and Housing Censuses in Astana (Kazakhstan), 4-6 June 2007. The paper provides substantive basis for the discussion in the session of the meeting dedicated to "Census technology: recent developments and implications on census methodology".

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* This paper has been prepared by US Census Bureau at the invitation of the secretariat. This document has been submitted late in order to include information on the latest progress in this work.

ABSTRACT

1.   For the first time, the United States will conduct portions of the field operations for the 2010 Census using hand held computers. At peak it is anticipated more than 500,000 temporary field staff will use a hand held computers to conduct census field activities and enumeration. In preparation for the 2010 Census the United States Census Bureau has conducted several tests and evaluations on the use of hand held computers in field activities. This paper shares some of the describes many of the lessons the U.S. Census learned while transforming activities that were previously conducted on paper into automated hand held computer activities.

I.   BACKGROUND

2.   Every ten years, the U.S. Census Bureau conducts the Decennial Census of Population and Housing to collect constitutionally mandated critical information about every person in the United States as of April 1st of the census year. The next U.S. Decennial Census will occur in 2010. The information collected includes ownership status of the household; relationship of individuals within the household; and age, sex, Hispanic origin, and race of each person in the household.

3.   In advance of the actual Census enumeration, the U.S. Census conducts several field activities to ensure having a complete inventory of housing units. Without a complete inventory of housing units, the Census Bureau cannot provide a complete count. To ensure a complete housing unit universe, census temporary workers canvass the entire United States to validate the completeness and accuracy of the universe, and to geo locate each housing unit in the universe. The canvassing occurs in the year prior to the Census. Then, in March of the census year, the U.S. Census Bureau delivers census questionnaires to every household in the universe. Upon receipt of the questionnaires, households are expected to answer the questionnaire and mail it back to the Census Bureau. A few weeks later households who have not mailed a completed questionnaire are visited by temporary census workers known as an "enumerators". The enumerators conduct an in-person interview to capture census information. This activity, known as Nonresponse Followup or "NRFU", is the largest field activity conducted by the U.S. Census Bureau. During the six to eight week period of this operation the U.S. Census Bureau employs an estimated 500,000 field personnel to contact approximately 40 million households that did not return the census form.

4.   During the 2000 Census enumerators conducted canvassing activities using paper maps and paper address lists and conducted the Nonresponse Followup operation using paper questionnaires, paper address lists, and paper maps. Upon completion of the field activities field staff returned paper materials to their local census office where the materials were checked in and validated and then shipped to large data processing centers. At the data processing centers thousands of temporary data entry workers data captured information from paper listings, questionnaires and maps. During the 2000 Census, data capture centers processed more than 1.5 billion pieces of paper. The cost associated with printing and processing and subsequent storage of more than 1.5 billion pieces of paper from the 2000 Census was a great expense to the U.S. Census Bureau.   .

5.   Shortly after the 2000 Census the U.S. Census began its exploration of automating some of its decennial census activities. At the same time advances in technology, including advances in mobile communications and the prevalence of lower cost more widely available mobile computing technology, created an opportunity for the U.S. Census to consider automating the 2010 Census. Conducting operations on the hand held computer in 2010 will not only eliminate the need to print and ship millions of pieces of paper, it also eliminates time, effort, and cost associated with the data capture of these items

6.   Early evaluations in 2002 and 2003 examined the feasibility of using maps and conducting an interview on a hand held computer. These feasibility studies were somewhat limited in scope, and were conducted with a small number of users. Positive results from these evaluations lead the U.S. Census to continue the evaluation of using hand held computers in two larger-scale census site tests in 2004 and 2006. The site tests examined the effects of using hand held computers with a broader user group for an actual census field operation.   In the site tests hundreds of users conducted Census operations within a Census test site. The magnitude of these tests enabled methodologists, field operations planners and statisticians to better understand the impact that the introduction of hand held computers had on the entire census taking process. During these evaluations U.S. Census staff not only examined how the introduction of hand held computers impacted enumeration, they examined how it impacted the hiring process, training process, the design of temporary Census offices and so on.

7.   While U.S. Census Bureau technical staff were conducting evaluations and tests on the impact of using hand held computers for Census 2010 field operations, management and others were examining the business feasibility of automating field operations in the 2010 Census. These included evaluating the cost and effectiveness of automating various operations versus conducting them on paper, and determining what activities could be completed within the agency and what might require outsourcing. The U.S. Census conducted several years of market research to ensure that the scope and requirements necessary to automate field activities in the 2010 Census were in alignment with current technologies and market capabilities.

8.   After thorough consideration of evaluation results from both operational and business areas, the U.S. Census Bureau decided to conduct some 2010 field operations using hand held computers, and to leave some smaller and more complex operations to be done on paper. The U.S. Census Bureau also determined that there were not sufficient resources within the agency to create and integrate the systems required to support a partially automated field operations. Therefore it was elected to outsource; system design, software development, integration testing, telecommunication, maintenance, deployment, monitoring, and disposal services to support address updating, data collection, administrative, and management applications for regional and local offices during the 2010 Census. This outsorcing effort is know as the Field Data Collection Automation contract or FDCA.   After the decision to outsource was made, the U.S. Census Bureau worked with a third party to create an independent government cost estimate or IGCE. This estimate enabled the agency to have a better understanding of how much it would cost to design and develop the system required and helped evaluate submitted FDCA proposals. The IGCE also enabled the agency to request sufficient funds for the program from U.S. legislatures.

9.   In July of 2005 the U.S. Census Bureau issued a request for proposal for the Field Data Collection Automation contract, and then in late March 2006 the U.S. Census Bureau awarded the FDCA contract to the Harris Corporation. For the past year the U.S. Census Bureau has been working with the Harris Corporation to automate the NRFU and Address Canvassing operations, as part of the FDCA contract.

II.   LESSONS LEARNED

10.   Over the seven years that the U.S. Census Bureau has been evaluating and developing a hand held coputer solution for some of the census field operations, the agency has learned a great deal.   The remainder of this paper describes some of the U.S. Census Bureau's design choices and the resulting lessons learned. These lessons are drawn both from the agency's own development and evaluation from 2001 thru 2006 and from the work with Harris Corporation on the development of the 2010 Census.

A.   Lesson One: It takes time

11.   Converting the Nonresponse Followup (NRFU) questionnaire into a Computer Assisted Personal Interview (CAPI) instrument required input from methodologists, field operations designers, software developers, and usability experts. In 2000 a four page[1] paper NRFU questionnaire captured all of the responses, quality assurance information, and office remarks necessary for the operation.   For the 2010 Census the NRFU instrument contains over 100 screens, and there are multiple versions of the instrument including Spanish translations, and a separate versions for quality assurance activities. Automating a field operation also requires a system that can make assignments, track assignments and data, and transfer data to and from the enumerator – all in a secure environment. And any operation as large as the U.S. Census' NRFU operation requires many iterations of development and testing.   All of these factors add to the time needed to develop the system. The U.S. Census Bureau worked on the automation of the NRFU operation for the two site tests for over five years before it entered a contract with the Harris corporation, and it will work with the Harris Corporation for more than three more years before the 2010 NRFU operation goes live.

12.   In addition to the amount of time it takes to develop the system and instrument, automating an operation requires creativity and critical thinking because the introduction of automation adds rigidity to tasks that were previously very simple. Throughout the 2010 planning process the U.S. Census Bureau has discovered that automating an operation creates constraints that did not exist previously when paper was used. It takes time to dissect existing processes and determine new ways of working given the constraints of technology. For example enabling the reassignment of an enumeration case in a paper operation is as simple as instructing supervisors to transfer the paper questionnaire from one person to another, and then record that the case was reassigned. Enabling the same process in an automated operation takes months of planning, programming and testing.

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[1] During Census 2000 a sample of households answered a longer questionnaire. This questionnaire is no longer used in the decennial census or NRFU operation, and would not be meaningful in the comparison between the 2000 NRFU paper questionnaire and the 2010 NRFU instrument. Also, during the 2000 NRFU operation a continuation form was available for households containing more than 5 persons.

B.   Lesson Two: Don't automate questionnaires – automate data collection

13.   The automation of the NRFU and Address Canvassing operations has enabled the U.S. Census to add data quality components to data collection that were not previously available in a paper environment.   When using an automated questionnaire data capture is no longer reliant on the legibility of the enumerator's handwriting or spelling and many key fields such as address or processing id can be pre-filled to avoid transcription errors. Another feature of the automated questionnaire is the ability to embed skip patters within the questionnaire software to ensure that each enumerator is asking the appropriate questions.   Finally, the automated questionnaire can provide data input consistency checks to "double check" respondent answers as they are being collected. For example, in the 2004 Census Test the enumeration instrument performed consistency checks for age. If the age provided by the respondent was not the same as the age calculated by the instrument from the date of birth provided, the age edit check was invoked. During the age edit check, respondents were asked whether the age calculated by the HHC or the age given was correct.   The age edit was invoked for 22.83 per cent of the persons. Of those persons with a discrepancy, 76.43 per cent of the time the age calculated by the HHC was correct and 22.89 per cent of the time the age given was correct. Without an edit check asking the respondent to resolve a discrepancy between date of birth and age given, it is possible that post interview edits based on date of birth would have changed the correct age (age given) 22.89 per cent of the time.

14.   The use and capture of Global Positioning System (GPS) coordinates is another area where the U.S. Census is utilizing the technology of the hand held computer in ways that were not possible when operations were conducted using paper. For the 2010 Census, enumerators will capture GPS coordinates for housing units during the Address Canvassing operation using GPS receivers integrated in each hand held computer.   These coordinates are captured along with other information describing the housing unit. During the Nonresponse Followup activities, enumerators can use the coordinates of each housing unit along with a GPS marker on the map denoting the user's current location (or "you are here" indicator), to locate households requiring enumeration.   In early evaluations of navigation aids the U.S. Census found that the average amount of time it took for a field workers to locate a specific housing unit was reduced when they had access to an hand held map with GPS indicator. Additional findings during the 2004 Census test held that in the large majority of sampled cases (90.1%) GPS was considered helpful for locating a followup household

C.   Lesson Three: Don't underestimate the end user

15.   Initially, prior to conducting any evaluations and tests, the U.S. Census was concerned that introducing a hand held computer into the census taking process might create difficulties for enumerators, and as a result many people would be deterred from working on the census. However, in a survey conducted after the 2004 Census Test, evaluators found that most enumerators reported that they found conducting interviews with the hand held computer easy and that they liked using the hand held computer. In fact, the majority of the enumerators who responded and who also conducted Nonresponse Followup in Census 2000 reported that they preferred using the hand held computer versus using a paper questionnaire for collecting census data. Most of the Nonresponse Followup feedback questionnaire respondents reported that Nonresponse Followup respondents reacted favorably to the interview being done on computer

or had no reaction. Only 3.7 per cent responded that Nonresponse Followup respondents reacted unfavorably.

16.   In addition to the findings that most enumerators liked using the hand held computer the U.S. Census Bureau found that its own ability to recruit eligible enumerators was not impacted by the introduction of a hand held. As part of the 2004 Census Test, the U.S. examined how the introduction of a hand held device affected the ability to recruit and train temporary census enumerators. Consistent with the experiences with introducing laptop computer to the survey data collection in the 1990s it was discovered that the hand-held computer also did not appear to have an adverse affect on recruiting or retaining employees. Although the recruitment materials did not emphasize that hand-held computers would be used during the 2004 Census Test, participants in the debriefings indicated that, overall, the hand-held did not have an apparent impact on recruiting. While some older applicants were a little hesitant about using the hand-held computer, the debriefing participants suggested that recruits' comments about the hand-held were mostly positive. Comparison of 2000 and 2004 applicant characteristics indicated no differences in the agency's ability to recruit from the traditional applicant pools. The results of the Exit Survey revealed that the hand-held computer was not the stated reason that employees quit before their assignments were complete nor the major reason some refused additional work after finishing an assignment.

17.   With regards to training census enumerators, results from the Census 2004 and 2006 site tests indicate that the agency was able to teach new employees to use the hand-held computer to complete field activities. Following training, almost everyone reported they liked using the hand-held computer to collect data and most felt comfortable using it after the first day or first few interviews. It was also found that enumerators could be prepared to collect Global Positioning System (GPS) coordinates. Enumerators knew how to insert the GPS receiver and when to collect the coordinates. The agency was also successful in training temporary field staff to attach the modem[2] and electric cords and transmit collected data.

18.   While it was found that most enumerators are comfortable using the technology, it was seen the role of the field supervisor change. Previously U.S. field supervisors, known as "crew leaders", could successfully lead a staff without having technical skills themselves. However, the addition of a hand held computer has added additional duties that require facility/skills with computers both for the crew leader and for his assistants (know as "crew leader assistants"). In addition to the traditional responsibilities of a supervisor (e.g., training enumerators, monitoring performance, and motivating field staff), crew leaders now have the added role of learning, using, and training others on the functionality of the hand-held computer. Similarly, the hand-held computer did not change the crew leader assistant's major responsibilities, but their most critical tasks were now directly associated with the use of the hand-held computer. One of the most notable new challenges for the crew leader assistant regarding the hand-held computer was assisting new employees on its use. Both the crew leaders and crew leader assistants were required to provide computer and troubleshooting assistance to enumerators with hand-held computer problems during enumerator training and throughout production.

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[2] The 2004 Census Test used a hand held computer that required the user to attach a GPS and Modem. For the 2010 Census these items will be integrated into the hand held computer.

19.   Finally, various usability tests were conducted at many stages of the process. The experience is that these usability evaluations are very valuable for isolating end-user issues that would not otherwise be obvious to developers or methodologists. For the 2004 and 2006 Census tests, the usability expertise and test facilities within the Census Bureau were utilized to provide expert opinions and to conduct various usability tests in a laboratory environment. For 2010 development, the usability expertise of both the Census and the Harris Corporation and its subcontractors are being utilized to evaluate all 2010 software.

D.   Lesson Four: Automation can't replace interpersonal communication

20.   In 2000, Census crew leaders had to meet daily with their enumerators to provide them new work assignments and collected completed work. At times these in person meetings required extensive travel for supervisors and staff.   In the automated setting for the 2010 Census crew leaders can assign and un-assign work remotely and enumerators can log into the network to receive their assignments at any time. The remote assignment functionality of the hand held computer also enables the central processing system to remove assignments from an enumerator's workload when a completed questionnaire arrives at the Census Bureau. This eliminates the costs and respondent burden associated with duplicate enumeration attempts.

21.   Initially it seemed that the automated assignment functionality might reduce the need for a daily meeting between a crew leader and his enumerators. However the agency's experiences in the 2004 and 2006 Census site tests suggested that the daily meeting was necessary for a variety of other reasons.   Meeting daily enables crew leaders to monitor each person's intended work plan so that they can effectively redistribute work as needed.   The daily meetings also provide an opportunity to discuss performance expectations and provide feedback to staff. Crew leaders reported also felt enumerators were less motivated to perform and produce when they did not have to meet daily with. Finally, the daily meetings provide an opportunity for crew leaders to assist staff with basic technical problems, and they facilitate the exchange of problematic hand held computers when more severe technical problems occur. As a result of these findings, for the 2010 Census the agency will continue to improve the automated assignment process, and continue to develop methods for crew leaders to have visibility into the work that their enumerators perform, but it is expected that crew leaders will meet with enumerators in person daily to ensure team continuity and communication.

E.   Lesson Five: Hand Held Computers don't necessarily save as much office space as you might think

22.   One of the primary motivations for the automation of portions of the 2010 Census was to reduce costs associated with the printing, shipping, processing and storage required for paper field operations. The use of the hand-held computer in the field will eliminate the need for paper questionnaires, listings and maps for automated field operations and this will which significantly impact the amount of paper used in the 2010 Census. Given the reduction in paper usage, it is initially anticipated that the size of the temporary census offices could be smaller, and less expensive. However the findings from the 2004 Census Test indicated office space savings resulting from a reduction in paper storage requirements were off-set (to some extent) by space requirements for new hand-held computer support areas such as the Hand-held Computer Inventory room and on site help desk support.

F.   Lesson Six: Training presents new challenges and opportunities

23.   The transition to an automated field operation has presented many challenges for training developers at the U.S. Census. First and foremost the amount of training increased with an automated instrument as opposed to decreasing training as it was originally anticipated. The increase in training time is primarily related to the time required to explain device and instrument operation. The type of training administration has also changed with the introduction of automation. The format of U.S. Census enumerator training remains mostly lecture, but more in class and out of class exercise were added to the training in order to increase student proficiency with the software. Additionally, for the 2010 Census, students will be able to conduct some modules of the training independently by following along with a computer lead training module resident on the device.

24.   While technology has improved the types of training that can be developed, the development of training itself is also now tied to the development of the automated solution. Given the tight timelines of the Census testing and development, it is challenging to create classroom training materials and computer based training modules. Finally logistical issues were also encountered that have constrained the types of places training can be conducted. For 2010 automated training must occur in facilities with access to electrical outlets. Additionally, the introduction of using hand held computers during training created the need for trainers to bring additional materials (power strips, extension cords, and tape) to the training sites. While all of these things are manageable, they present challenges that were not present during the 2000 and the potential impact for 2010 is still being assessed.

III.   CONCLUSION

25.   While it has been a challenge to conduct some of the 2010 Census field operations on a hand held, the U.S. Census Bureau is confident that automating these larger field operations will improve the overall quality of the census. The lessons learned thus far from the evaluations and site tests have been invaluable, and the agency has already made several improvements to the process and operations as a result of these lessons. It is hoped that others will benefit from these findings as they explore conducting census activities using a hand held.

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