

William L. Nicholls II, U.S. Bureau of the Census

The U.S. Census Bureau is engaged in a program to develop, test, and implement computer-assisted telephone interviewing (CATI) for use in the Bureau's data collection activities. This paper: (1) briefly reviews the capabilities and potential benefits of CATI data collection; (2) summarizes the Bureau's progress toward adoption of this new data collection method; (3) describes unusual priorities and special requirements of CATI system design for Bureau applications; and (4) examines cost considerations and limitations.

1. Capabilities and Potential Benefits

Computer-assisted telephone interviewing, and its acronym CATI, refer to the use of interactive computer systems for on-line telephone interviewing and associated field work activities. In common applications, an interviewer sits before a video display terminal (VDT) wearing a telephone headset. The survey questions are displayed for the interviewer and read to the respondent. Responses are entered directly into the computer by depressing keys on the VDT keyboard. Precoded and numeric answers may be edit checked for range and consistency errors before moving to the next question. Text or verbatim answers are entered in full within prespecified field length requirements.

Advanced CATI systems perform a variety of functions in addition to on-line interviewing and editing: (1) they accept input data about the case from records or prior interviews which may be displayed, used in edit checks, or control item sequences during the current interview; (2) they manage the sample and provide on-line review and daily printed summaries of the sampling status of each case; (3) they schedule telephone calls and callbacks based on the outcomes of prior attempts including appointments made; (4) they determine when a case is completed, otherwise resolved, needs further callbacks, or requires supervisory review; (5) they provide hardcopy or on-line review of completed cases for computer-assisted coding of verbatim responses; and (6) they prepare output files for further processing or tabulation.

Computer-assisted telephone interviewing has a number of potential benefits for Census Bureau data collection.

It should improve data quality by elimination of out-of-range entries and skip pattern errors, by tailoring questions to each respondent's situation based on prior responses, by performing edit checks and reconciling apparent inconsistencies on-line, and by closer monitoring and management of interviewer performance.

It should contribute to more timely estimates by elimination of a separate data entry step, by replacement of clerical editing and coding with automated or computer-assisted coding of machine-readable entries, and by

transmitting completed cases to processing centers shortly after interviewing via communication lines.

It also should improve estimates through enhanced data quality, by permitting use of prior data in current interviews, by reduction of the interviewer's contributions to variance, and by improved opportunities for systematic measurement and control of other forms of nonsampling bias and error.

Since the Census Bureau has only recently begun studies comparing the costs and benefits of CATI with those of current data collection methods, the above remain potential rather than demonstrated advantages of CATI in Bureau surveys and censuses. However, the rapid growth of CATI in the private sector and reports of similar benefits by others provide encouragement that many of these gains will be realized. [2, 3, 4, 6, 7, 9, 11, 12]

2. Progress and Plans

The Census Bureau established its CATI Project in 1981 to accomplish three primary objectives: (1) to develop an advanced CATI system suitable for the Bureau's specialized needs; (2) to conduct field tests evaluating the performance and cost-effectiveness of this system in comparison with current data collection methods; and (3) to assist in the implementation of production CATI data collection.

In the Project's first year, the design and capabilities of CATI systems at academic and private research agencies were reviewed, cooperative work in CATI development was undertaken with the Berkeley and Michigan Survey Research Centers, and first requirements for the Census CATI System were prepared. In the second year, an initial prototype system was designed which performed successfully in a 7,500 case field test described more fully below. In the third year, now concluding, the prototype system has been enhanced to accommodate more complex surveys; and a second field test of 10,000 cases is being conducted. Although system enhancement and field testing will continue at least through 1986, first production software will be ready for installation by the fall of 1984.

Both design and field testing have thus far been conducted from a research and development facility located at Bureau headquarters in Suitland, Maryland, utilizing a minicomputer accommodating up to 30 interviewing stations. Current plans are to establish an initial production site outside headquarters within the next 12 to 18 months. If future tests prove successful and cost-effective, additional production sites will be established in several locations across the nation. The number, size, and location of production sites for current programs remains to be determined.

The CATI field test schedule is presented in Exhibit 1. Each test is being conducted for

the multiple purposes of: (1) system testing and shakedown; (2) gaining experience in CATI survey design and field operations; and (3) comparing CATI and current data collection methods in response rates, data quality, timeliness, and costs. The tests are being conducted on subsamples of Bureau surveys and censuses currently in progress or in conjunction with tests of other methods, such as random digit dialing and dual frame estimation. [1]

The first test of the Census CATI System was in telephone follow-up interviewing of persons not responding by mail to the National Survey of Natural and Social Scientists and Engineers. A total sample of approximately 138,000 persons was drawn from the 1980 Population Census; and three mailings of the questionnaire and a reminder letter after the initial mailing were completed to each selected person before telephone follow-up began. Telephone tracing through former residences and directory assistance was often necessary to obtain current addresses and telephone numbers. All telephone field procedures, including tracing routines, directory assistance calls, and refusal conversions, were on-line functions of the CATI system. Persons not reachable by telephone were subsampled for personal visit follow-up.

Telephone follow-up cases were randomly allocated to a CATI group at headquarters and to a comparison group at the Bureau's Data Preparation Division in Jeffersonville, Indiana, using paper-and-pencil methods. Comparative analyses of data quality and costs are not yet complete, but preliminary results indicate that the CATI group achieved a substantially higher response rate than the comparison group. If this difference is attributable to CATI, it apparently is a consequence of the efficiencies of computer-directed case management, call scheduling, tracing, and related field procedures rather than of on-line interviewing.

While encouraging, this initial result is not unambiguous, since the CATI and comparison groups also differed in interviewing experience, work schedules, length of training, supervision, and total work load. To measure the performance and costs of CATI in production interviewing, tests conducted from production sites (rather than from a headquarters experimental unit) and closer comparability of staff, training, work schedules, and supervision will be necessary. This may not be possible prior to the establishment of the first CATI production site planned in the next 12 to 18 months.

The initial field test did replicate previous reports of respondent and interviewer acceptance of CATI. [2, 7, 10] No evidence of respondent resistance to on-line entry of replies was apparent, and interviewer attitudes toward CATI were generally favorable.

Prior to completion of the pretest, an evaluation questionnaire was mailed to the 20 CATI interviewers remaining on the staff. One interviewer who resigned during training and two who left during the three months of field work could not be contacted without OMB

clearance and were not included. Of the 16 interviewers who responded, all replied positively to the question: "Did you like your job as a CATI interviewer?"; and all expressed an interest in working on future CATI surveys. Learning about and using the CATI terminals ranked first among things liked about the job, while dislikes focussed not on CATI per se but on familiar matters of pay rate, work hours, and physical facilities. All but one respondent reported that they became "totally confident and comfortable using the CATI terminals to conduct interviews" within two weeks or less. The importance of typing skills for CATI was reaffirmed by 81 percent of the interviewers who described typing skills as either important or very important to being a good CATI interviewer.

A second field test of the Census CATI System, currently in progress, closely resembles the first in general design. It consists of telephone follow-up to large farms not responding to repeated mailings for the 1982 Census of Agriculture. This test differs in the complexity of the on-line field procedures incorporated in the CATI system. These include: detailed procedures to identify farms receiving duplicate forms; clarification of unusual operations as falling inside or outside the scope of the Census; treatment of "have mailed" or "will mail" replies with additional follow-up when unverified; and state-by-state closeout including the rewording of requests for response as closeout approaches. The CATI questionnaire contains more than 1,000 distinct data items, of which only a small proportion are asked of any one farm. The Bureau's Jeffersonville facility will again serve as the non-CATI (or paper-and-pencil) comparison group.

Telephone follow-up of mail nonresponse, which the first pretests performed, represents only one of several probable uses of CATI in Bureau surveys and censuses. Field tests now in design or planning, shown in Exhibit 1, illustrate a range of additional applications. They include:

1. Telephone interviews with households sampled by random digit dialing, including their use in dual-frame, telephone-personal, sampling designs to ensure coverage of nontelephone households.
2. Second and later visit telephone interviews with households previously interviewed in person. At present, second and later visit household telephone interviews are typically conducted by the Bureau from enumerator's homes.
3. Telephone interviews with business and other establishments. At present, the Bureau's establishment surveys typically employ mailed report forms with telephone follow-up to those not replying by mail.
4. Telephone prompting of mail returns, nonresponse follow-up, failed-edit follow-up, and reinterviewing for the decennial census. Uses of CATI for the 1990 Census currently are under consideration as part of a broader effort to automate decennial census activities and

EXHIBIT 1

CENSUS CATI SYSTEM CURRENT FIELD TEST SCHEDULE, JUNE 1983

Survey or Census	Use of CATI	Field Test			Status June 1983
		Start	End	Cases	
National Survey of Natural and Social Scientists and Engineers	Telephone follow-up of mail nonresponse	Aug. 82	Nov. 82	7,500	Complete
1982 Census of Agriculture	Telephone follow-up of mail nonresponse by large farms	May 83	Sep. 83	10,000	In progress
National Crime Survey -- CATI-RDD Test	First-visit household interviews Second interviews, same households	Jan. 84 Jul. 84	Mar. 84 Sep. 84	600 600	In design In design
National Crime Survey -- Current Sample	Second and later visit interviews with households previously interviewed in person	Apr. 84	Sep. 84	1,500	In design
Monthly Advanced Retail Trade Survey -- CATI Test	Telephone interviewing of business establishments for a test sample	Feb. 84	Unknown	Unknown	In design
Health Interview Survey -- CATI-RDD Test	Test of RDD-CATI interviewing for dual frame estimation	Jan. 85	Mar. 85	4,000	Proposed
Health Interview Survey -- Current Sample	Production RDD-CATI interviewing for dual frame estimation	Jan. 86	Dec. 86	Unknown	Proposed
1985 Pretest of 1990 Census	Telephone prompting and follow-up of mail nonresponse	Apr. 85	Jun. 85	Unknown	Proposed
1986 Pretest of 1990 Census	Telephone follow-up of failed-edit cases	Apr. 86	Jun. 86	Unknown	Proposed

may be first tried in the 1985 and 1986 pretests of the 1990 Census.

3. Special Requirements and Priorities of CATI System Design

The development of computer-assisted telephone interviewing, as a general technology, began in the private sector where it has found broad application in market research, polling, and related studies. [2, 3, 12] Commercial CATI systems frequently emphasize rapid setup and modification of CATI questionnaires, standardized sets of sampling and field procedures, and integrated coding and tabulation packages to permit analysis of results within minutes, hours, or a few days after the close of field work. University research centers have developed CATI systems for use in academic, policy, and governmental surveys, including pilot tests of CATI for Federally conducted surveys. [2, 6, 7, 8, 9, 10, 11] More than a dozen major CATI software packages now exist, which differ in their architecture, capabilities, flexibility, and hardware requirements.

The development of CATI for the Census Bureau has been guided by a number of special requirements and priorities which in combination will produce a CATI system differing in a number of significant respects from those in the private sector. This section of the paper describes some of these special requirements and provides illustrations of first solutions to these needs.

Several of these special requirements derive from the size and complexity of the Census Bureau's data collection activities. In

addition to the decennial Census of Population and Housing and the quinquennial Economic Census and Census of Agriculture, the Bureau presently conducts more than 50 annual, biannual, quarterly, and monthly surveys of households, housing units, business establishments, industrial firms, local governments, and other populations. Ten additional one-time surveys, field tests, and related data collection activities are currently in progress. Sample sizes of current surveys range up to 72,000 interviews per month with questionnaire mailings of much larger size. A CATI system for Bureau applications must accommodate unusually large case loads, for which networked CATI production sites in several locations across the nation appear mandatory. The Census CATI System also must prepare for highly complex interviews and a wide variety of question items, edits, and field procedures.

Additional special requirements of the Census CATI System follow from the Bureau's planned use of CATI in surveys employing varying combinations and sequences of mailed questionnaires, telephone interviews, and personal interviews. The mailed questionnaire remains the most efficient form of data collection for many establishment surveys and frequently the only feasible method of first-stage data collection from very large samples and populations. In such designs, the telephone and personal interview are second- or third-stage methods to ensure coverage of establishments, households, or persons not replying by mail. The personal visit interview also has a continually crucial role in household interview surveys, especially for

coverage of nontelephone households and for surveys which require personal contact to establish or maintain rapport for unusually long interviews or for extended series of interviews. Although CATI may be chosen as the sole data collection method for selected Bureau surveys for which it is uniquely suited, CATI frequently will be employed with other data collection methods chosen for their combined coverage and cost-effectiveness.

The Census CATI System therefore must accommodate the rapid transmission of cases from and to other data collection methods. It must accept cases previously attempted by mail and route cases unreachable by telephone to personal interviewers, secondary sources of information, or other alternatives as needed. These capabilities are critical in maintaining high survey response rates and essential in censuses where each case must be accounted for. Use of CATI in combination with other data collection methods also requires methods of ensuring consistency of CATI output with data files prepared by key entry of mailed and personal interview report forms. Many of these capabilities have been developed in prototype for the current field test of the Census of Agriculture.

Unlike commercial and academic CATI systems, the Census CATI System has placed a relatively low priority on development of direct tabulation and analysis of CATI output files or their automatic reformatting for entry to standard statistical packages. Frequently, CATI output will constitute only a part of the sample to be tabulated. In addition, the Census Bureau routinely passes newly collected data through detailed computer editing, imputation, and weighting steps prior to tabulation. At present, these steps are more efficiently performed on large mainframes than on the minicomputers or microcomputers selected for CATI. The Census CATI System is not intended to perform the later stages of survey processing, tabulation, and analysis.

Special requirements also guided the selection of methods to enter and execute question items in the Census CATI System. While many commercial and academic CATI systems are designed for rapid input and revision of questions, the emphasis in the Census CATI System has been placed on: (1) freedom to chose among a broad range of question formats and edits; (2) protection of CATI surveys from unauthorized changes in wording and procedures; and (3) documentation facilitating informed review by content specialists, survey methods specialists, managers, client agencies, and the Office of Management and Budget.

The approach adopted is to enter question items and instructions in a user language, QISC, intended to be readable by professional staff without programmer training. 1/ Headquarters staff will prepare the QISC language setup file, containing the survey specifications and documentation. The QISC file is then translated to a programming source code (currently FORTRAN) and the source code compiled. Production sites will receive only the compiled version, or object file, downloaded from headquarters.

Trials in three surveys indicate that question items in the QISC user language are generally readable by Census Bureau content specialists, and survey statisticians following a few hours of instruction, at least when items are meaningfully named and annotated by the interspersed comments easily accommodated by the QISC language. To further simplify the review process, lineprinted copies containing only the displayed questions are readily produced. Additional refinements and simplifications of the user language are under consideration to further clarify complex question items, arithmetic operations, and atypical movements between items.

To accommodate both common and unusual interviewing situations in factual data collection, the CATI interviewers are being provided with a broad range of interviewer commands which permit departures from standard question sequences. These commands are accessed by terminal program functions keys. The interviewer commands permit an interviewer: (1) to back or jump back to previously answered questions and change their answers without erasing intervening entries; (2) to forward or jump forward after backup to the next appropriate question taking newly changed entries into account; (3) to enter interviewer notes to any question; (4) to omit sections of the interview when permitted and automatically prompt for them at a later time; (5) to interrupt an interview in mid-course, arrange a callback, and later resume the interview at an appropriate point; (6) to summon a supervisor for help or send a message to the supervisor; (7) and to display summaries of prior entries as needed.

A final Census Bureau requirement affecting CATI system design again derives from the Bureau's high priorities on thorough population coverage and high response rates. Through extensive field testing and experience, the Bureau has developed detailed procedures for each survey to distinguish in-scope and out-of-scope cases and to ensure high response rates by appropriate introductions, extensive callbacks, and special appeals to those who initially declined to participate.

These detailed, survey-specific procedures are not easily accommodated by a limited set of standardized opening and closing items, calling algorithms, and closeout routines. Instead a highly flexible CATI system is required which can meet complex and widely varying field work requirements appropriate to each survey. The approach followed thus far has been to employ the QISC user's language to include most field work steps as extensions of the interview. Work also is in progress to develop common modules for similar types of studies and to standardize the types of information passed between components of the CATI system rather than standardizing opening and closing items or calling procedures *per se*. Even with further advances in these and related areas, the Census CATI System is likely to remain one in which speed of survey setup and testing is sacrificed to addressing coverage and response rate issues in detail survey-by-survey.

4. Cost Considerations and Limitations

Formal cost models for computer-assisted telephone interviewing are not yet available, but major cost implications may be identified by direction even when their magnitudes presently remain unspecified or vary by application. This permits a three-fold classification of cost implications into: (1) known additional costs; (2) known or anticipated savings; and (3) areas of uncertain cost consequences. Net cost effectiveness will be improved to the extent that known costs can be minimized and full advantage can be taken of potential savings.

Known additional costs include: (1) amortization and maintenance of computing hardware; (2) site preparation, rental, and furnishing; and (3) systems and operations support. The Bureau is currently assessing the costs of both minicomputer and multi-station microcomputer options for the Census CATI System. Both will be operational by the fall of 1984 and may be utilized in different applications. A micro-based system appears especially appropriate for the highly dispersed activities of the Decennial Census of Population and Housing.

Known cost savings include elimination of separate check-in and data entry steps and associated clerical activities. Additional cost savings are anticipated from increased efficiencies in: (1) sample management; (2) call scheduling and use of interviewer time; (3) post-interview editing and coding; and (4) survey management. Where CATI replaces personal visit interviewing, major savings also should be realized in interviewer hours and travel costs, offset only partially by increased telephone charges.

The direction of CATI's cost implications are uncertain in two areas. The first is field staff training and supervision. Although CATI requires an additional stage of interviewer training and employs a higher ratio of supervisors to interviewers than many paper-and-pencil methods, compensating efficiencies are likely from computer-aided instruction (CAI) of field staff, on-line supervisory functions to reduce clerical tasks, and the ability to monitor interviewer performance. To assess the effects of these new tools, an initial two-hour CAI interviewer training package has been prepared, on-line supervisory functions are in place, and both audio and visual monitoring capabilities will be available for the next field test.

A second area of uncertain cost consequences is in survey and questionnaire design. While the design of complex CATI surveys requires unusually detailed planning and a staff with an unusually broad range of skills, savings may be realized in such areas as forms design and printing. These savings should be greatest in surveys with large CATI samples, in surveys conducted wholly with CATI, and in revising the core areas or supplements of repeated surveys. When CATI is utilized for small subsamples of

one-time surveys which also require printed forms for multi-mode data collection, CATI design may constitute an added cost.

Groves, Berry, and Mathiowetz have observed that the principle limitations of CATI are the obverse of its principle strengths. [5] CATI's potential benefits largely derive from its ability to control and standardize data collection methods under strict, computer-enforced procedures established by the survey designer. There are correlative disadvantages.

First, CATI survey procedures, once committed to code, are not easily changed during interviewing. Question wordings, branching instructions, and item edits are easily revised; but the complex coding of calling algorithms, callback procedures, and criteria of completed interviews can not be modified quickly in mid-survey. If revised procedures are required as survey closeout approaches, they must be specified, developed, and tested in advance. Current CATI systems are less flexible than manual methods which can rely on the adaptability and judgment of survey staff to adjust priorities and procedures as knowledge of response rates and field costs accumulate.

Second, the design of a CATI survey typically requires more thorough and careful planning prior to the start of field work than does a paper-and-pencil survey. Since CATI procedures tend to be detailed, rigid, and difficult to revise, they must anticipate most problems likely to be encountered. Procedures for sampling, field work, coding, editing, and initial processing must be specified and reconciled in detail concurrent with questionnaire design if the goals of efficient field work and timely processing are to be met. Paper-and-pencil methods can more easily postpone decisions affecting the later stages of the survey process. They also are more adaptable when detailed procedures cannot be specified in advance with confidence, as in exploratory studies and pilot tests.

In summary, CATI represents a new technology of great potential but like other data collection methods has its own unique advantages, disadvantages, costs, and requirements. Its advantages and cost-effectiveness should be greatest in repeated surveys, and in carefully planned and thoroughly pretested surveys and censuses with large samples, the types of data collection which constitute the greater part of the Census Bureau's work. Its use in smaller one-time surveys and special applications presents more operational problems and less confidence of cost-effectiveness, although the experience of CATI agencies in the private sector suggests that such applications also can be handled in a cost-effective and timely manner. The program of testing and development now in progress at the Census Bureau should contribute to a further specification of CATI's appropriate place among current data collection methods.

FOOTNOTES

1/ The abbreviation "QISC" stands for "Questionnaire Implementation Systems, Census." The original QIS CATI language was developed by UCLA Center for Computer-Based Behavioral Sciences. An enhanced QIS language, QISB, was later adopted for the CATI System designed by the Berkeley Survey Research Center. [11] QISC represents a further modification and extension of this language.

REFERENCES

- (1) Biemer, Paul P. "Optimal dual frame design: results of a simulation study." Paper presented at the 1983 Meetings of the American Statistical Association, Toronto, Canada. August 1983.
- (2) Cannell, Charles F.; Robert M. Groves; Lou J. Magilavy; Nancy A. Mathiowetz; and Peter V. Miller. "Comparison of CATI and nonCATI questionnaires." In Charles F. Cannell *et al.*, An Experimental Comparison of Telephone and Personal Health Surveys. Unpublished research report of the Survey Research Center, University of Michigan, prepared for the National Center for Health Statistics. Ann Arbor, Mich.; Survey Research Center, University of Michigan, April 1982. Volume 1, Section III, p. 43-70.
- (3) Dutka, Solomon, and Lester R. Frankel. "Sequential survey design through the use of computer assisted telephone interviewing." In American Statistical Association. Proceedings of the Section on Business and Economic Statistics, Houston, Texas, August 11-14, 1980. Washington, D.C.: American Statistical Association, 1980. p. 73-76.
- (4) Fink, James C. "Quality improvement and time savings attributed to CATI — reflections on 11 years experience." Paper presented at the 36th Annual AAPOR Conference, Buck Hill Falls, PA. Radnor, Pa.: Chilton Research Services, May 29, 1981.
- (5) Groves, Robert M.; Marianne Berry; and Nancy Mathiowetz. "Some impacts of computer-assisted telephone interviewing on survey methods. In American Statistical Association. Proceedings of the Section on Survey Research Methods, Houston, Texas, August 11-14, 1980. Washington, D.C.: American Statistical Association, 1980. p. 519-524.
- (6) House, Carole C., and Betsy A. Morton. "Measuring CATI effects on numerical data." Paper presented at the Meetings of the American Statistical Association, Toronto, Canada. August 1983.
- (7) Nicholls, William L., II. "Experiences with CATI in a large-scale survey." In American Statistical Association. Proceedings of the Section on Survey Research Methods, San Diego, California, August 14-17, 1978. Washington, D.C.: American Statistical Association, 1978 p. 9-17.
- (8) Nicholls, William L., II. "Progress toward computer-assisted telephone interviewing: a report to the ASA Census Advisory Committee," Unpublished Working Paper. Washington, D.C.: U.S. Census Bureau. September 1981.
- (9) Palit, Charles D. "A microcomputer based computer assisted interviewing system." In American Statistical Association. Proceedings of the Section on Survey Research Methods, Houston, Texas, August 11-14, 1980. Washington, D.C.: American Statistical Association, 1980. p. 516-518.
- (10) Rustemeyer, Anita, and Arnold Levin. Report on a telephone survey using computer assistance. Unpublished report. Washington, D.C.: U.S. Census Bureau, November 11, 1977.
- (11) Shanks, J. Merrill; George A. Lavender; and William L. Nicholls II. "Continuity and change in computer-assisted surveys — development of Berkeley SRC CATI." In American Statistical Association. Proceedings of the Section on Survey Research Methods, Houston, Texas, August 11-14, 1980. Washington, D.C.: American Statistical Association, 1980. p. 507-512.
- (12) Smith, Ronald, and Richard Smith. "Evaluation and enhancements of computer controlled telephone interviewing." In American Statistical Association. Proceedings of the Section on Survey Research Methods, Houston, Texas, August 11-14, 1980. Washington, D.C.: American Statistical Association, 1980. p. 513-515.