Census 2000 Evaluation R.1.c
November 27, 2002

Internet Questionnaire Assistance System Requirements Study

FINAL REPORT

This evaluation study reports the results of research and analysis undertaken by the U.S. Census Bureau. It is part of a broad program, the Census 2000 Testing, Experimentation, and Evaluation (TXE) Program, designed to assess Census 2000 and to inform 2010 Census planning. Findings from the Census 2000 TXE Program reports are integrated into topic reports that provide context and background for broader interpretation of results.

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PREFACE

Purpose of the System Requirements Study

The main objective of the System Requirements Study is to assess the efficacy of the requirements definition processes that were employed by the U.S. Census Bureau during the planning stages of the Census 2000 automated systems. Accordingly, the report's main focus is on the effectiveness of requirements methodologies, including processes for coordination, communication, and documentation, and their impact on overall system functionality. The report also addresses certain contract management issues and their effect on system development and/or operational considerations.

The System Requirements Study synthesizes the results from numerous interviews with a range of personnel--both U.S. Census Bureau staff and contractors--who were involved with the planning, development, operations, or management of Census 2000 systems. Our findings and recommendations in this report are qualitative in nature; they are based on the varied opinions and insights of those personnel who were interviewed. The intent is to use the results from this study to inform planning for similar future systems.

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EXECUTIVE SUMMARY

Internet Questionnaire Assistance and its companion system, Internet Data Collection, are Internet-based systems that were developed by the same team. While there is a technical linkage from an operational standpoint, for purposes of this report they will be treated as separate systems. This study presents information based on debriefings with Internet
Questionnaire Assistance system designers. A separate customer service survey evaluation will provide the user perspective of this system.

The overall objective of Internet Questionnaire Assistance was to provide information to the public to assist respondents with completing census questionnaires. This was accomplished through a user friendly interface which provided hyperlinks covering a variety of topics. Language assistance guides were an important feature of Internet Questionnaire Assistance and could be easily downloaded by non-English speaking respondents.

Internet Questionnaire Assistance was assessed by U.S. Census Bureau personnel as being very successful. One of the goals of the system was to lessen the burden on the Telephone Questionnaire Assistance operation. The Internet Questionnaire Assistance website received 23,864,598 hits between March 3, 2000 and April 19, 2000. The system was developed under a very aggressive schedule and deployed within 18 months. The short timeframe was due to an interruption of the planning effort that stemmed from high level concerns over the security implications of Internet Data Collection. Major results of the study include:

- Right system for the job. Internet Questionnaire Assistance was positively perceived by the personnel interviewed as "the right system for the job." It appeared to provide an effective means of disseminating Census 2000 information and foreign language assistance guides to the public through a user friendly interface. The few system shortcomings were all minor. Future versions of the system would benefit from enhancements such as email response or other feedback mechanisms.

- Security was essential. One major requirement and design issue was the need for the systems to provide strong levels of security against unauthorized intrusion; Internet Questionnaire Assistance succeeded in providing this protection.

- Dedicated personnel were a key factor. The success of the system was largely due to the involvement of a few highly talented and dedicated U.S. Census Bureau personnel. Contractor support (with the exception of penetration testing) did not play a role in the planning or development of the system.

These and other findings have led to the following key recommendations:

- **<u>System development methodology - establish agency-wide guidance</u>. There were no formal (i.e., agency endorsed) guidelines to indicate how the requirements definition process should be conducted. The requirements definition phase is an especially critical step in all generally accepted system development life-cycle methodologies in that it establishes the foundation for a system. Therefore, future systems development efforts would benefit from an agency-wide set of guidelines which outline the steps in the requirements definition process including methods for change control. It is recommended that the agency implement and adhere to such guidelines well in advance of future application development efforts. These guidelines must be flexible in order to minimize any adverse impacts on the design and development effort.**

- **<u>Time limitations - begin early planning for 2010</u>. Widespread Internet usage will place significant demands on the next generation questionnaire assistance system in 2010. Therefore, it is recommended that planning commence early and reflect an expectation of greater usage requirements.**

- **<u>Project oversight - use flexible project control structure</u>. The use of an oversight body to guide and monitor system development activities is considered a "best practice;" however, any project control structure should be flexible enough to encourage technical innovation.**

- **<u>Reliance on in-house expertise - assess staffing risks</u>. Historically, the agency has relied on in-house expertise to develop decennial systems. In the case of Internet Questionnaire Assistance, a single individual was the driving force behind the development effort. Given the nature, scope, and complexity of future systems, there are risks inherent in relying solely on in-house staff without supplementing these resources with external support.**

1. BACKGROUND

The Titan Systems Corporation, System Resources Division (Titan/SRD) was tasked by the Planning, Research, and Evaluation Division (PRED) of the U.S. Census Bureau to conduct system requirements studies for 12 automated systems used in the decennial census. This report is a study of the Internet Questionnaire Assistance (IQA) system. It addresses the extent to which the requirements definition process was successful in identifying the needed system functionality and offers one of several evaluation approaches for examining these automated systems. The report results are intended to assist in the planning of similar systems for the 2010 Census.

IQA is an operation that allows respondents to obtain, via the Internet, information regarding the questions asked on the census questionnaire and job opportunities, or to request general information about the purpose of the census. An interdivisional team, consisting of representatives from eight divisions, had responsibility for developing IQA. IQA was designed as an electronic version of the Questionnaire Reference Book (QRB) with a fixed set of content. Assistance on specific Census 2000 forms is available by simply clicking on one of nine form numbers. There are also links for General Census 2000 Form Information and Frequently Asked Questions (FAQs). Both of these links are broken down into sub-categories to facilitate quick access via hyperlinks to the numerous Census 2000 documents and information that is available on-line.

IQA is available in the English language only; however, the site prominently displays a hyperlink for language assistance guides. These guides are available in more than 40 different languages for downloading. There are two separate language guide layouts - a two page guide (D-60A) corresponding to the Census 2000 short form questionnaire (D-1) and a 12 page guide (D-60B) corresponding to the Census 2000 long form questionnaire (D-2). Foreign language fact sheets are also available through IQA.

IQA supplemented the Telephone Questionnaire Assistance (TQA) system. The IQA website received 23,864,598 hits between March 3, 2000 and April 19, 2000[1]. The system was developed under a very aggressive schedule and deployed within 18 months. Since IQA is a collection of static web documents, it will remain operative indefinitely. The service resides behind a firewall for security protection.

[1] Web page hits are a relative measure of web traffic volume, not an accurate representation of the number of actual users. A web request may or may not be registered at the source server. Caching servers that speed up the web, hide hits and users from the serving source, so that the more volume a page/system generates, the less likely it is to register hits accurately. There are also other factors associated with user access that affect the accuracy of this number.

2. METHODOLOGY

The Titan/SRD Team interviewed key personnel for each of the Census 2000 automated systems using a structured approach centered around four fundamental areas. A set of questions under each of those areas was designed to explore: (1) the effectiveness of the requirements definition process; (2) how well the systems were aligned with business processes; (3) identification of any deficiencies in functionality or performance relative to actual operational needs; and (4) how effective the agency contract management activities were in regards to contractor performance. Contractors were not involved in the development of IQA.

The purpose of the system requirements study is to summarize the results of interviews with key personnel by system. A variety of related system documentation was reviewed in connection with the interviews. The assessments provided in Section 4., Results, reflect the opinions and insights of key personnel who were interviewed by the Titan/SRD Team in September 2000. Those personnel had varying levels of knowledge about the IQA system based on their involvement with system planning, development, implementation, or operational issues. Section 5., Recommendations, provides value added perspectives from the Titan/SRD Team that seek to illuminate issues for management consideration in the planning of future systems.

Quality assurance procedures were applied to the design, implementation, analysis, and preparation of this report. The procedures encompassed methodology, specification of project procedures and software, computer system design and review, development of clerical and computer procedures, and data analysis and report writing. A description of the procedures used is provided in the "Census 2000 Evaluation Program Quality Assurance Process."

Study participants reviewed the results of this system requirements study. Comments have been incorporated to the fullest possible extent.

3. LIMITS

The following limits may apply to this system requirements study:

- The perception of those persons participating in the interview process can significantly influence the quality of information gathered. For instance, if there is a lack of communication about the purpose of the review, less than optimal results will be obtained and the findings may lack depth. Each interview was prefaced with an explanation about its purpose in order to gain user understanding and commitment.

- In some cases, interviews were conducted several months, even years, after the participant had been involved in system development activities. This extended timeframe may cause certain issues to be overlooked or expressed in a different fashion (i.e., more positive or negative) than if the interviews had occurred just after system deployment.

- Each interview was completed within a one to two hour period, with some telephone followup to solicit clarification on interview results. Although a detailed questionnaire was devised to guide each interview and gather sufficient information for the study, it is not possible to review each aspect of a multi-year development cycle given the limited time available with each participant. Although this is a limitation, it is the opinion of the evaluators that sufficient information was gathered to support the objectives of the study.
    - Every effort was made to identify key personnel and operational customers who actively participated in development efforts. In the case of IQA, all government personnel who participated in the study are still with the Census Bureau. Since contractors were not involved in the development of the system, no contractor representatives were interviewed for this study.

4. RESULTS

This section contains findings that relate to the effectiveness of the requirements definition process used during the development of IQA. The requirements process establishes the foundation for a system and, as such, must be designed to thoroughly consider all technical and functional aspects of development and operation of the system.

4.1 Requirements definition

Early efforts leading to the development of IQA can be traced back to 1996 when the Commerce Department was investigating Internet reporting and assistance options. By 1997, a group known as the Census 2000 Internet Questionnaire Team (C2IQT) was actively looking into the feasibility of using Internet technologies to support innovative business processes. However, in 1998, top level management concerns over the potential for security weaknesses in the Internet Data Collection (IDC) system led to a cessation of planning activities. Work resumed in October 1998, due to emphasis on e-government initiatives at the Commerce Department. The C2IQT was subsequently reformed as an interdivisional group known as the Internet Questionnaire Team (IQT).

The IQA requirements process benefited significantly from the involvement of a few talented people with technical skills and organizational knowledge as well as the Census Bureau's previous experience with web-based applications. Because time constraints precluded a traditional development cycle, an interdivisional team was put in place by the Decennial Management Division (DMD) to accomplish the project. The team consisted

of representatives from the following divisions:

- Computer Assisted Survey Research Office (CASRO)
- Decennial Management Division (DMD)
- Decennial Systems and Contracts Management Office (DSCMO)
- Decennial Statistical Studies Division (DSSD)
- Housing and Household Economic Statistics Division (HHES)
- Population Division (POP)
- Planning, Research, and Evaluation Division (PRED)
- Systems Support Division (SSD)

The team met on a frequent basis for one year to monitor status and progress and to address issues. Initially, it was thought IQA would be a major decennial system; however, owing to a lack of publicity, the scope of the system was diminished.

Requirements were continuously being "fed" to the developer right up to system deployment. The process lacked formal change control procedures. The developer was an in-house Information Technology (IT) specialist who also participated in the requirements definition process. Although there were planning and development meetings, there was no formal (i.e., agency endorsed) guideline to indicate how the requirements process should be conducted.

The system requirements definition and development processes were, by default, essentially a Rapid Applications Development (RAD) approach[2]. Time constraints and a lack of any systematized development methodology led to an accelerated, but effective, development effort that succeeded in bringing IQA (and IDC) on-line in time for Census 2000 despite the break in continuity resulting from the cessation of early planning efforts.

4.2 Requirements issues

4.2.1 Maximum accessibility was a primary goal

A requirement to maximize access to the website by the public was successfully met through a design which supported the use of several types and versions of Internet browser software. A further effort aimed at maximizing access to IQA was to provide the universal resource locator (URL) in the initial greeting of the TQA Interactive Voice Response (IVR) system. This feature may have served to direct some users to the IQA.

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[2] The RAD concept involves developing faster and higher quality applications through: (1) requirements gathering using workshops or focus groups; (2) prototyping and early, reiterative user testing of designs; and (3) a compressed development schedule that defers design improvements to the next product version. It also calls for reduced formality in reviews and other team communication. With IQA development revolving mostly around a single person, it is quite accurate to conclude that a RAD approach was applied by definition since resources and time were very limited.

An evaluation is being conducted on Census 2000 Internet usage that may provide insight into these issues; A.2.a, Census 2000 Operational Summary of Internet Questionnaire Assistance.

4.2.2 Penetration testing used to address security concerns

The security requirement for IQA was paramount from the outset given prior management level concerns about this issue. This was true for IDC as well, since from a security standpoint, both systems were essentially treated as one by decennial management. Accordingly, penetration testing was conducted by an outside contractor. This testing was designed to identify weaknesses in security that could result in unauthorized intrusion to IQA. The system withstood all attempts to breach security.

4.2.3 User interface appeared well designed

It is unclear the extent to which formatting standards were made available to the developer; however, the forms were reviewed by an in-house forms committee prior to implementation. The "look and feel" of the IQA user interface was professional in appearance. Access to IQA resources (documents, language guides, FAQ's) was available through convenient "point and click" hyperlinks. Navigation through various screens appeared to be well thought out and intuitive for users. An evaluation is being conducted on Census 2000 Internet usage that may provide insight into these issues; A.2.c, Census 2000 Internet Web Site and Questionnaire Customer Satisfaction Surveys.

4.2.4 Difficulties encountered in preparing language assistance guides

Although this was not specified in the Statement of Work (SOW), the production of language assistance guides was initially planned to support 49 languages. Due to problems encountered with generating Portable Document Form (PDF) files by a supporting contractor, over 35 of the files were rendered unusable. Therefore Census Bureau personnel were required to scan these files into PDF images. This decreased the quality of the guides' on-line display. Nonetheless, the guides appeared to be a successful feature of IQA.

4.3 Alignment with business processes

This section contains findings that relate to how well IQA supported the specific business processes that were associated with the Census Bureau's need to provide Internet-based information services to the public. Designing IQA to fully support this objective built upon the Census Bureau’s previous experience with web-based applications.

4.3.1 Internet provides additional access to census information

The main goal of IQA was to provide information to the public about Census 2000. In

the past, this process of providing information was accomplished through Census Bureau call centers. The agents at these centers used the hardcopy Questionnaire Reference Book to field questions. For Census 2000, TQA provided a more efficient means of meeting this functionality by combining agent response with an automated instrument and automated telephone menu. IQA was a supplemental process which provided another avenue to allow a large segment of the public (i.e., those with access to the Internet) to gain immediate access to census information via the World Wide Web. From the outset, IQA was designed for English speaking persons only; however, the need to serve non-English speaking persons was also recognized. Accordingly, IQA provided a means to be responsive to the enumeration of this segment by making language assistance guides available.

4.3.2 System perceived as effective by study participants

IQA was perceived by those interviewed as being successful with respect to its ability to support census business processes and as the "right system for the job." Study participants have suggested that future versions of the system would benefit from enhancements such as email response and other feedback mechanisms.

4.4 System deficiencies

This section contains findings that relate to any specific shortcomings that were identified with respect to the system's ability to accomplish what it was supposed to do. Recognizing that 100 percent success is rarely achievable, especially in the case of a completely new system, it is still worthwhile to assess deficiencies in the spirit of constructively identifying "lessons learned." Such insights can greatly contribute to improvements in future system development activities.

4.4.1 Management metrics provided although not initially defined

The need for collecting system utilization metrics for management purposes (e.g., hit counts) was "conceptualized" but not fully defined up front. Nonetheless, system usage statistics were available on a daily basis and submitted to the Executive Information System (EIS) for management use. These statistics provided extensive data for analytical purposes.

4.4.2 Lack of IQA in Dress Rehearsal reduces management confidence

Since IQA was not included in the Census 2000 Dress Rehearsal because of time constraints and security issues, this contributed to a reduced confidence in the Census Bureau's ability to deploy web-based systems. Formal usability testing focused mainly on IDC, which was interactive, and not on IQA because it was a "read only" type of system. That is, it provided access to static web pages that simply replicated the QRB. Time constraints were also a factor that worked against any efforts to test the system.

4.5 Contract management practices

This section contains findings that relate to the effectiveness of contract administration activities. Unlike most Census 2000 systems which required extensive contractor support, IQA was "home grown." However, as previously mentioned, contractor support was used to generate PDF files for the language guides. Contractors were also used for penetration testing. These two support areas were not assessed as part of this study because they were not directly associated with the system development effort.

4.5.1 In-house resources responsible for primary development effort

All IQA/IDC system development and operations were performed "in-house" by Census Bureau personnel, except for penetration testing and PDF generation of language guides.

4.5.2 Contractors used to prepare language assistance guides

Contractor support was utilized to generate language assistance guides. Most of the PDF formatted files that were provided by the contractor were determined to be unreadable. The contractor's failure was problematic for the Census Bureau in that most of the needed files had to be scanned into PDF image format by Census Bureau personnel.

5. RECOMMENDATIONS

This section synthesizes the findings from above and highlights opportunities for improvement that may apply to the Census Bureau's future system development activities. The recommendations reflect insights from Titan/SRD analysts as well as opinions regarding "lessons learned" and internal "best practices" that were conveyed by Census Bureau personnel during interviews.

5.1 Reliance on in-house expertise

Historically, the Census Bureau has relied on in-house expertise to develop decennial systems. The success of IQA was due in large part to the expertise and dedication of a single person who had extensive knowledge of computer technology and census business processes. This individual wore several "hats" (designer/developer and content coordinator/programmer) and worked extremely long hours to support both the development and operation of the system. Because of time constraints imposed on the project, several other Census Bureau personnel were assigned to supporting roles as part of the overall management structure.

Recommendation: Extensive reliance on one individual, while it may have been very cost-effective and expedient, introduced significant risks for the Census Bureau. Had that person's availability come into question, IQA might not have been fully developed and could have led to a situation that posed negative publicity ramifications for the agency. It is recommended that the Census Bureau give careful consideration to contingency planning when selecting personnel for high profile system development and operational activities. This should include designation of back-up personnel for critical positions and cross-training of team members. Given the nature, scope, and complexity of future systems, it is recommended that the Census Bureau augment in-house experts with external resources.

5.2 Time limitations

The time constraints impacting this project stemmed from unusual circumstances that were beyond the control of the development team. There were only 18 months to develop and test the system, thereby necessitating deployment of IQA without the benefit of a formal dress rehearsal. This compressed development time essentially ruled out the possibility of acquiring contractor services and led to reliance on in-house resources for both development and operation of the system.

Recommendation: To the extent possible, compressed development schedules should be avoided in that they introduce additional technical, cost, and schedule risks for the Census Bureau. It is recommended that the Census Bureau initiate system planning and requirements definition efforts early on to allow sufficient time for application development, testing cycles, dress rehearsal, program documentation, and user training.

5.3 Requirements methodology

Due to the cessation of early system planning efforts, valuable time and continuity were lost with respect to system planning efforts. Nonetheless, the requirements team did an effective job in defining what the system needed to do. The essential functionality was provided and the user interface was designed to be compatible with various types of Internet browsers. However, the requirements were not prepared using any type of

standardized methodology and were not "frozen" to allow programming efforts to proceed without interruption. Typically, constantly changing requirements greatly increase the risk to a project; however, in the case of IQA this risk was reduced because of flexibility built into the design of the code.

Recommendation: Institute an agency-wide set of guidelines for the requirements definition process. This process is central to establishing a sound foundation for any system and would be a critical success factor with respect to any future Internet-based applications. Requirements should also be "frozen" at some point to allow developers to concentrate on writing code. Constant changes could have easily introduced software "bugs" that may have created an unstable application. Attempts at fixing bugs may inadvertently give rise to logic problems in other areas of the application that are connected through tie-ins or "hooks." Such connections can introduce instability into related modules in the application, which might not be immediately apparent without extensive regression testing.

5.4 System development life-cycle (SDLC) methodology

Due to a compressed development schedule, there was little time to formally address the steps in a typical SDLC. Many agencies have promulgated their own SDLC models to provide structure to the system development process.

Recommendation: It is recommended that the Census Bureau implement and promulgate an SDLC model through an agency directive. This model should be flexible enough so that it guides, but does not hamper, development efforts within the dynamic decennial environment. It is also suggested that staff receive training in the application and benefits of the SDLC methodology. This should contribute to a greater awareness of the importance of systematizing the life-cycle development process and help to avoid after-the-fact criticism from governmental oversight bodies.

5.5 Project oversight

IQA was a major undertaking for the Census Bureau that utilized unfamiliar technology. Since it was intended for public use, the success of this system was paramount. Moreover, the web-enabled system posed security issues associated with the access. An established group known as the Census Operational Managers (COM) worked in association with the IQT. The COM reviews many system development efforts and evaluates specific issues and/or recommendations that might impact census operations.

Recommendation: The COM worked together with the DMD to monitor the progress of IQA development efforts. In cases where major IT initiatives are undertaken, it is recommended that both DMD and the COM become involved early in the project life-cycle to ensure that the requirements definition process is performed according to a standardized methodology. This oversight will contribute to the development of a solid foundation for the system. Given the unprecedented nature of the IQA and the potential high risks associated with deploying new technologies, high level oversight and support was essential to address budgetary, contractual, and technical issues that may weigh on system development efforts. In general, the use of an oversight body is considered a "best practice;" however, reporting and administrative requirements for each program should be structured to minimize any adverse impacts on the design and development effort. Any project control structure should be flexible enough to encourage technical innovation.

5.6 Contractor support

The unreadable PDF files placed an additional burden on the Census Bureau. Personnel had to scan in printed copies of both short and long form guides for all files that had been rendered unusable.

Recommendation: A contractor's failure to produce a useable deliverable can have a negative, and indeed severe, impact on a project. The Census Bureau needs to take steps to minimize the potential for this type of situation. It is recommended that the Census Bureau give consideration to incorporating contractual provisions that require contractors to demonstrate their abilities to produce critical deliverables. If necessary, arrangements can be made to compensate contractors for these demonstrations. These costs might prove to be negligible when compared to the cost and consequences of project delays.

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