

Management Challenges of the 2010 U.S. Census

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This article gives an insider's perspective on the approaches used to manage the 2010 United States Census of Population and Housing during its operational phase and meet the challenges faced (in particular, difficulties faced in automating data collection). Six management lessons learned are presented: (1) the exchange and integration of information is key; (2) decision makers must stay abreast of information and be ready to make quick decisions, even if based on incomplete information; (3) formal program management processes proved valuable but to get full value they must be in place early; (4) care, consistency, and accountability in applying existing project management and systems engineering best practices must be taken in managing contracts; (5) there is a need for integration of technology with business and operational needs focusing on the insertion, acquisition, testing, and deployment of technology; and (6) the U.S. Census Bureau should carefully determine where its expertise lies and focus its resources there.

Key words: Program management; risk management; software development; data collection.

1. Introduction

The U.S. Census, begun in 1790, is the longest continuously administered periodic census in the world. Managing the 2010 Census over its 15-year life cycle (1998–2013) is a huge undertaking, ranging from planning and supervising the research necessary to determine the design, to software development and testing, to major procurements of hardware and services, to managing large-scale field tests, to actually carrying out the census, and finally to dissemination of its results. This article focuses on the management challenges faced by the senior executives in charge of the decennial census program during the 2008–2010 period, during which final testing was completed and all field operations were carried out. Despite testing including a “dress rehearsal”, major and unanticipated problems were encountered in field implementation of software systems. This article describes how the

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U.S. Census Bureau reacted to those problems, implementing a major replan of field automation and related activities that included a reduction in scope of a major contract accomplished partly through shifting software development to a new contractor, improved management practices, increased testing, and strong contingency planning. Also discussed are two decisions about processes avoided that is, “roads not taken”: Why the U.S. Census Bureau did not use Internet data collection in 2010 and why it did not make extensive use of administrative records. A general overview of the organization and administration of the 2010 census can be found in Weinberg and Thompson (2011) and is not repeated here.

This article attempts to organize events during the immediate pre-and post-census period (2008 through 2010) in a coherent narrative within a broader management context. That context does not include its place in U.S. society. Thus I deliberately ignore such activities as the paid advertising campaign and other aspects of Census outreach like organizational partnerships. While hard scientific evidence is sparse, as a senior executive participating in real time in the process, I hope that my perspective and the implications I draw for future censuses are more than just idiosyncratic, though inevitably others involved will have different perspectives and draw different conclusions.

The political context of taking a census is also important, but was less so for the 2010 Census than for the 1990 and 2000 Censuses. According to the U.S. Constitution, the Census must be taken every ten years “in such Manner as [Congress] shall by Law direct.” For the 2000 Census, the design was the subject of heated debate and lawsuits, with planning proceeding on two tracks, and the final design determined by a January 1999 decision of the U.S. Supreme Court ruling out the use of sampling for nonresponse follow-up (less than a year ahead of the beginning of operations). Also controversial was the issue of whether to adjust the counts for under-counted (and over-counted) persons, ruled out by the Secretary of Commerce in late 2000, based on a technical recommendation by U.S. Census Bureau staff, just before the population counts by State were released (those counts are used to “apportion” seats in the lower legislative chamber – the House of Representatives). In contrast, most of the political discussions about the 2010 Census took place without the intense controversy that was part of the previous two decades’ debate. I attribute that lack of rancor to two particular events – the Supreme Court’s January 1999 ruling and a 2002 decision by Census Bureau Director Kincannon to rule out adjustment of future censuses for the purposes of apportionment and redistricting (redrawing the lines for legislative districts).

Because of the scope of the decennial census, the U.S. Census Bureau includes a separate organizational unit (called a directorate, each with subsidiary divisions) devoted to the conduct of that program, which also includes administration of the American Community Survey. The Associate Director for Decennial Census reports to the Director of the Census Bureau (a political appointee) through the Deputy Director (a career official acting as Chief Operating Officer). That Associate Director is assisted by an Assistant Director, who supervises several division chiefs, the most central of whom for the purpose of managing the decennial census is the Chief of the Decennial Management Division. The Decennial Management Division provided overall direction for program planning and coordination of the decennial census; assigned functional responsibility to divisions; determined program priorities; and developed budget requirements, schedules, and a cost and progress reporting and control system. It also ran the census risk management, issues

management, and change control processes (among others) and chaired the Census Integration Group of division chiefs. See below for more discussion of these roles.

2. Setting the Stage

In brief, the goals of the 2010 Census were to improve accuracy, reduce risk, and contain costs, when compared to Census 2000. Balancing cost, risk, and quality was at the heart of all program design and management decisions. To accomplish all three goals, the 2010 Census was conceived as a “reengineered” census (this description is adapted from Weinberg and Thompson 2011). The U.S. Census Bureau attempted to make three major changes in census-taking between 2000 and 2010 and was fully successful in two of those changes, but only partly successful in the third.

2.1. *Change Number 1 – Eliminating the Long Form*

The first major change was to eliminate the long form – roughly 50 questions asked only of a sample of the population (1-in-6 households in 2000); the long form had been part of the decennial census from 1940 to 2000. This was accomplished by launching the American Community Survey (ACS), a random sample survey of the population fielded every month. By accumulating data from five consecutive years, estimates are provided from this survey for geographic areas as small as block groups (typically a few hundred housing units), as well as for small population groups such as Native Hawaiians and Other Pacific Islanders. Since this is an ongoing survey, long form-equivalent information is now available starting in 2010 *every* year (for the prior five-year period) for *every* size of geography, instead of just once a decade. The actual 2010 Census form asked only ten (chiefly demographic) questions of the first person in the household and seven about each other person.

2.2. *Change Number 2 – Updating the Address and Map Databases*

The second change was to update the geographic framework of the census – both the Master Address File (MAF) and the Topologically Integrated Geographic Encoding and Referencing (TIGER) spatial (map) digital database. The MAF is the framework for the entire census and was typically updated only just before each census; it identifies all living quarters and links each to a spatial location with a specific geocode in the Census Bureau’s TIGER database. During the March to July 2009 Address Canvassing operation, the existing address and street locations in the MAF and post-2000 updates to those addresses supplied by the U.S. Postal Service, Census Bureau field representatives, and participating state, local, and tribal governments were verified, and latitude and longitude of each unit were added by using handheld devices equipped with Global Positioning System (GPS) hardware and software (the handhelds also handled personnel functions such as timekeeping). Further updates to the MAF were made during the 2010 Census itself, as enumerators identified missed units, and as local governments provided lists of new construction (there were several other sources of updates as well).

The key new geographic activity undertaken for the 2010 Census was to update the maps (that is, TIGER) with the assistance of a contractor to align all the street centerlines and some geographic features (such as waterways) in every U.S. county, and in Puerto Rico

and all Island Areas, with GPS coordinates to 7.6-meter accuracy (the U.S. Census covers Puerto Rico and the Island Areas of American Samoa, the Commonwealth of the Northern Marianas Islands, Guam, and the U.S. Virgin Islands). By making TIGER align with physical reality, users can link the data spatially to the correct location, reduce geocoding errors substantially, and enable future updating with similarly aligned data files from local jurisdictions. The 2009 Address Canvassing operation obtained GPS coordinates for approximately 86.1 percent of the housing units (the residual received “manual” map spots, collected electronically). Since housing units were both added and removed by later operations, 86.5 percent of the final 133,341,676 housing units in the 2010 Census have GPS coordinates; there were also 166,827 group quarters (such as nursing homes and prisons) included in the Census.

Once the address file was ready, the country was divided geographically into collection blocks. Roughly 90 percent of housing units were in dense-enough areas that they received their census form by mail and were asked to mail it back. Roughly 90 percent of the remainder (9 percent of the total) had their form hand-delivered and were also asked to mail it back. The remaining 1 percent of housing units (and all group quarters) did not receive a questionnaire but were visited by an enumerator (enumerators also visited those in the first two groups who did not mail back their questionnaire). In 2010, only 74 percent of occupied housing units were enumerated by mail returned to a scanning center. The remaining 26 percent, plus all vacant housing units, had to be visited in person to complete the enumeration in the Non-Response Follow-Up operation. Figure 1 shows the 2010 Census work flow for its key operations.

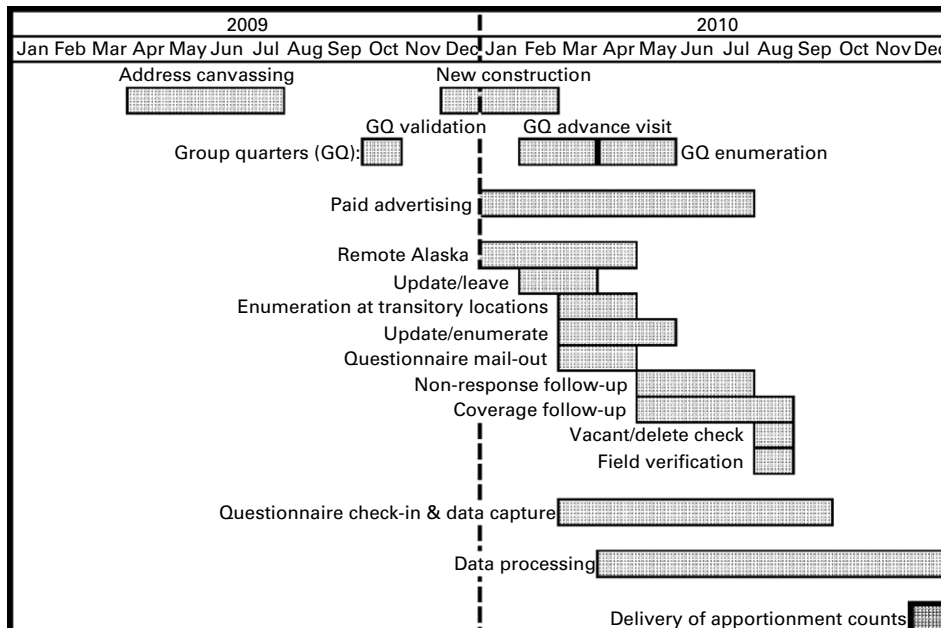


Fig. 1. 2010 Census Key Operations, 2009–2010. Note: Excludes Census Coverage Measurement activities. Source: U.S. Census Bureau. 2010 Census Operational Plan. Version 3.0, July 2010

2.3. *Change Number 3 – Automating Data Collection*

The third major change to census-taking was to build on the first two changes in order to more fully automate the data collection process. By mid-decade, this had become a plan to fully automate three key 2010 Census operations (Address Canvassing, the Non-Response Follow-Up person interview, and the Census Coverage Measurement personal interview – part of the decennial census's quality assessment) using hand-held computers. While automated processing of the actual census forms has been around for quite a while (for example, for the 1960 Census the Census Bureau invented a method for reading responses into a computer from microfilm: Film Optical Sensing Device for Input to Computers or FOSDIC), the intention was to push technology to the field. After assessment of the results of testing off-the-shelf handheld computers and Census Bureau-designed data collection software and systems, census planners decided to acquire both custom-built hand-held hardware and associated software via contracting. Problems encountered with the contractor-developed software in the 2007 Dress Rehearsal for the Address Canvassing operation led to the Secretary of Commerce approving a Census Bureau plan to revert to a paper-based response data collection for Non-Response Follow-Up, the same methodology that had been used for several decades. This change added to the cost of the 2010 Census but was adopted to reduce the risk of an unsuccessful census.

It is this third part of the reengineering that led to many of the management challenges, and thus it is on that part that the discussion in the penultimate section below is focused. At its peak, the Census Bureau used approximately 600,000 enumerators. Very few problems were encountered in that aspect of the census, so the management of that part of the operation is not discussed further.

3. **The Use of Contractors**

Because of the cyclical nature of decennial census work and its concomitant cyclical funding (roughly two-thirds of the 15-year life-cycle cost was spent in just 2009 and 2010; see Figure 2), and because of rapidly evolving technology, it is necessary to supplement the permanent headquarters and field staffs and the existing enterprise systems of the Census Bureau with both temporary employees and contractors, and to use contractor-provided solutions. To carry out the 2010 Census, the Census Bureau awarded seven major contracts, as summarized in Table 1. Each large contract was managed by a Project Management Office – a team of technical professionals (some of whom were also contractors), supervised by and supplemented with Census Bureau program and acquisition professionals. Training in project management and contract surveillance is encouraged and valued (and often required) – each of the chief project managers for the major contracts had a Master's Certificate in Project Management, a Project Management professional certification, or both, as well as U.S. government certification.

Federal government contracting fulfills multiple purposes. Often, it is used to purchase commodities or services that are readily available in the commercial sector, such as copy paper or transportation. This kind of contracting was used in the 2010 Census for such items as forms printing and telephone questionnaire assistance. A second type of contracting is to alleviate the need to hire permanent employees for temporary responsibilities. While temporary federal workers can be hired, and were indeed hired to

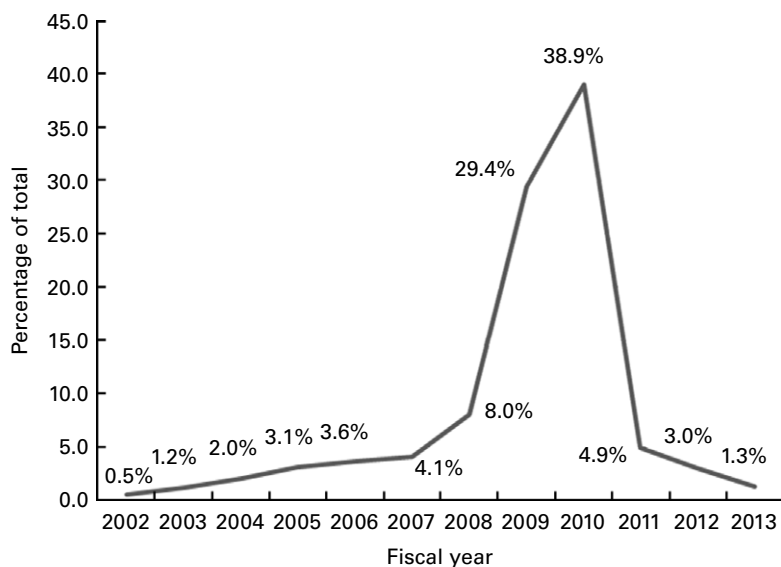


Fig. 2. Funding Cycle of the 2010 Census, Fiscal Years 2002–2013. Note: A Fiscal Year for the U.S. government runs from October 1 of the preceding calendar year to September 30 of the indicated year. Total estimated cost: \$12.6 billion (nominal U.S. dollars). For a distribution of total costs by key activity, see Brown et al. (2010), p. 36

carry out almost all short-term census field operations, it is difficult to hire, train, and retain some high-skilled workers that are needed for several years. This kind of contracting was used for the contract to update the digital map of the country. A third kind of contracting, and the one most difficult for the government to manage, is to acquire technologically advanced services for which existing government workers are not well-suited or for which corporate vendors have a comparative advantage. For the 2010 Census, this included contracts for software development, such as the Field Data Collection Automation and the Data Access and Dissemination System contracts, and for creative advertising services, part of the contract for an Integrated Communication Program.

Table 1. Major 2010 Census Contracts

Major contracts	Contract value
Decennial response integration system	\$1,019,512,000
Field data collection automation	\$801,525,000
Integrated communications program	\$361,966,000
MAF-TIGER accuracy improvement project	\$270,676,000
Data access and dissemination system	\$111,653,000
Printing (multiple awards)	\$75,973,000
Paper-based operations control system software development	\$30,771,000

Notes: All contracts of \$25 million or more included. These are rounded estimates as of 25 October 2011 and are subject to change. The Data Access and Dissemination System contract handles improvements to and maintenance of *American FactFinder*, the Census Bureau's main dissemination vehicle for more than just the decennial census data. That contract ends in September 2016.

While most of these large contracts awarded for the 2010 Census gave the Census Bureau few management challenges beyond some early funding issues and normal but intensive monitoring and modification as circumstances changed, two were particularly difficult to manage and are discussed at length below – the Field Data Collection Automation (FDCA) contract and the software development support contract for a Paper-Based Operations Control System awarded at the “last minute” when automated collection of information from nonrespondents was removed from the FDCA contract.

4. Management Initiatives

As part of the 2008 replan of the 2010 Census and in response to the perceived management problems that contributed to the difficulties with the FDCA contract, the Census Bureau worked closely with the Department of Commerce, the Office of Management and Budget, and oversight bodies to finalize quickly the long-planned management controls already under development for the decennial program. Consequent to the identification of the 2010 Census as a high-risk program by the U.S. Government Accountability Office (the investigative arm of the Congress) in March 2008, the decennial directorate developed a *2010 Census High-Risk Improvement Plan* briefed to the Department of Commerce, the Office of Management and Budget, and Congress. The plan focused on a range of challenges including program management, risk management, integration and testing.

4.1. Program Management Plan

The *2010 Census Program Management Plan* was first issued in March 2008 to codify procedures and inform decennial census staff and contractors, and oversight bodies, how decisions were to be made and issues were to be resolved regarding the 2010 Census. Key documented processes included risk management, schedule management, issue management, and change management.

Divisions are the key operational components of the Census Bureau – it is division staff who were charged with operational responsibility. Integration took place through cross-divisional (that is, integrated) operation and system teams, reporting to the primary governance group – the Census Integration Group of division chiefs chaired by the Chief of the Decennial Management Division. Census Bureau divisions involved in decennial census programs and operations were all responsible for resource management within their budgets established by Decennial Management Division. This included both resource balancing to ensure sufficient resources were applied to the highest priority operations and activities as well as succession planning to remove the unacceptable risk of having single points of failure in staffing plans. Division Chiefs were to make every effort to resolve issues escalated to them from the team leaders before raising the issue to the Census Integration Group. For the limited number of issues for which the Census Integration Group could not reach resolution, conflicts were escalated to the Decennial Leadership Group of more senior managers chaired by the Associate Director for Decennial Census. During the operational phase of the Census, the Decennial Leadership Group typically consisted of the Associate Directors for Decennial Census and Field Operations, the Assistant Director for Decennial Census, and the Chiefs of the Decennial Management and

Field Divisions. Of course, there were some issues escalated to the Director and Deputy Director for decision and, of these, a few escalated by the Director to the Under Secretary and Secretary of Commerce for decision. Figure 3 illustrates the decision-making roles of the various groups.

4.2. Decennial Census Integrated Schedule

The 2010 Census was organized as 44 interdependent operations with nearly 19,000 separate activities that are managed through an integrated schedule. This figure is actually an under-estimate as (1) activities prior to 2003 were not included in the final integrated schedule, and (2) teams and contractors had more detailed operation-specific schedules, only summarized in the integrated schedule. Of the 18,933 activities in the integrated schedule on 19 October 2011, 9,136 dealt with the 2003–2008 tests, and 9,797 dealt with the 2010 Census and its aftermath.

An integrated schedule was not put in place formally until May 2008, rather late in the census cycle (though parts of the program had their own schedules). This lack of early integration led to conflicts among the operations and consequently ad hoc resolution of those conflicts constrained by time pressures. Once the integrated schedule was in place, it was monitored and managed weekly through an alert process that included senior

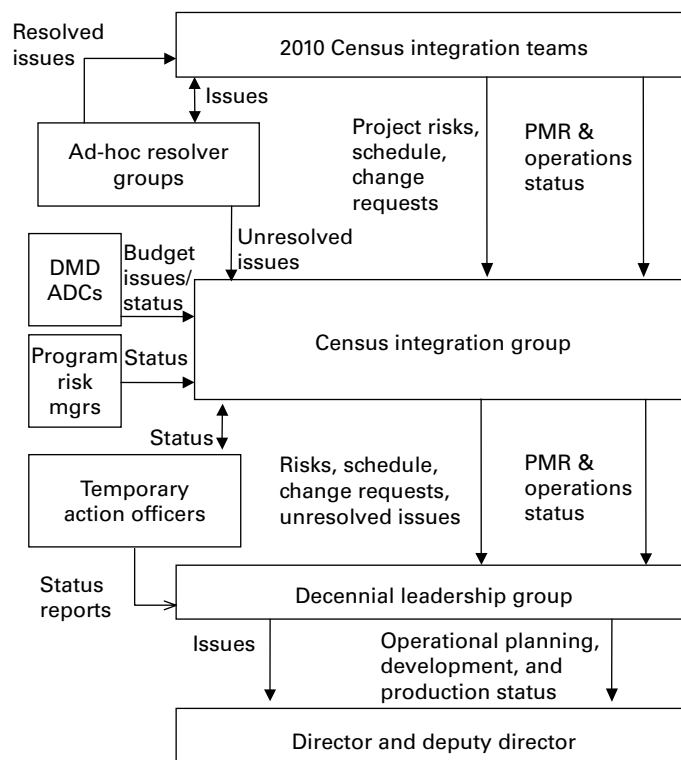


Fig. 3. 2010 Census Governance Structure. Note: DMD ADCs = Decennial Management Division Assistant Division Chiefs; PMR = Project Management Reviews. Source: U.S. Census Bureau. 2010 Census Program Management Plan. Version 5.0, December 2009

managers up to the Director. The “Schedule Alert Report” tracked the schedule at a high level – focusing on roughly 70 key schedule lines. Since the schedule was integrated, any delays in predecessor operations affected those key activities, and the causes of potential schedule issues could be tracked down and resolved.

4.3. Monthly Status Reports

Oversight for the Census Bureau is the responsibility of several organizations. In the direct chain of command, the Census Bureau’s Director reports to the Department of Commerce Under Secretary for Economic Affairs, who reports to the Secretary of Commerce, who reports to the President. In addition, both houses of the legislative branch have oversight responsibilities. Each of these oversight organizations has agents who attempt to gather the information necessary for effective oversight. Within the Department of Commerce, that function is served by the Office of the Inspector General; for the President it is the Office of Management and Budget (OMB); for the Congress, it is the Government Accountability Office (GAO).

Beginning as a result of GAO’s designation of the Census as high risk (rescinded in January 2011), Decennial Directorate senior management, along with senior field, administrative, and IT managers, began briefing the Commerce Department and OMB on a monthly basis, reporting on the status of the budget, schedule, risks, and issues affecting the 2010 Census, as well as recent accomplishments, upcoming activities, and the performance for each of the major decennial contracts (monthly briefings were discontinued in late 2010). Each *Monthly Status Report* was intended to present a comprehensive overview of 2010 Census activities, including Status of Key Issues; Recent Accomplishments; Upcoming Activities; Operational Update; Schedule Status; Program Budget/Costs; Program-Level Risks; an Overview (as a performance dashboard); Field Data Collection Program Integration; and Contract Performance for each major contract. The decennial leadership also briefed the Commerce Under Secretary for Economic Affairs weekly, and provided a weekly status report to the Secretary of Commerce. The Monthly Status Reports were used by OMB, GAO, and the Commerce Inspector General to monitor progress toward meeting milestones and metrics established in response to the designation as “high risk”; GAO and the Inspector General were provided with other documents (such as decision and informational memoranda) on a regular basis. The Monthly Status Reports were also shared with staff of the four relevant Congressional committees.

4.4. Risk Management Plan

A *risk* is a possible event or condition affecting the accomplishment of key program objectives that *may occur* in the course of a project. A realized risk (a possible event that has actually occurred) is an *issue*. The Decennial Directorate senior management team implemented a risk management plan in May 2008 that included the development of risk mitigation strategies (to avoid issues) and risk contingency plans (to deal with issues should they arise); these were managed through weekly meetings of a risk review board and documented on a risk register. High-level risks involve a large-scale threat to the 2010 Census; these were managed by a group of senior (division chief-level) managers as the

2010 Census Risk Review Board. For example, in version 37 of the risk register dated 12 July 2010, there were 25 program-level risks being managed. These included such risks as “H1N1 Influenza Affecting Regional Census Center and Local Census Office Activities”, and “Continued Operations of Critical Infrastructure During Disasters”.

In contrast, risks confined to a specific operation or system typically did not represent a serious threat to the overall success of the 2010 Census and were managed by the relevant team. (The Program Management Offices and all major contractors also maintained risk registers.) All of the high-level risks had *mitigation* plans and most had *contingency* plans associated with them (those that did not instead had plans in place to establish “rapid response” action teams should the need arise). The senior risk review board reviewed the lower-level risks as part of the quarterly Project Management Reviews of each team’s activities.

4.5. Contingency Funds

As a risk mitigation strategy that accompanied the Secretary of Commerce’s request for additional funding to mitigate the field automation problems described further below, Census Bureau management requested contingency funds as part of the Fiscal Year 2009–2011 budgets to address unanticipated events (e.g., the potential impact of the economy on census operations, natural disasters). These were appropriated by the Congress, but in the end, very few of those funds were needed and as a result \$1.87 billion of appropriated funds were returned to the Treasury after the key operations were completed.

4.6. Field Data Collection Automation Program Integration and Testing

As part of the replan to remedy the problems that surfaced during the testing of automated data collection, in May 2008 the Census Bureau established a new senior position reporting to the Associate Director for Decennial Census to ensure integration of the field data collection automation program across all decennial projects and contractors. The new executive’s responsibility was to oversee issues of architecture, scope, schedule, cost, risk, quality, and change management, and to coordinate the work of the new contractor brought on board to develop the software for the Paper-Based Operations Control System, as well as the internal staff working on related projects that were previously handled by the Field Data Collection Automation (FDCA) contractor (such as hosting the Decennial Applicant, Personnel, and Payroll System needed to pay salaries and expenses to enumerators on a weekly basis). The original FDCA contractor retained significant activities, such as supplying the software and hardware for the 2009 Address Canvassing operation, and supplying the office computing environment and telecommunications infrastructure for all 494 Local Census Offices.

At that same time, the Associate Director also established a second new position – Decennial Chief Testing Officer – to serve as an independent point of accountability for an enhanced testing program that followed life-cycle software development principles and practices. His efforts were focused on new programs and on activities that the Census Bureau did not have the opportunity to test in the 2008 Dress Rehearsal. All planned and new testing requirements were documented in a program-level testing plan also shared

with the Government Accountability Office. Testing activities were organized into three components – operations, systems, and interfaces – and included developer, system, user, and regression (that is post-change) testing. The testing plans and metrics were reviewed by senior management at least biweekly and also as part of all quarterly Project Management Reviews; having such a consolidated plan allowed prioritization, identification of gaps, and schedule adjustments.

4.7. Additional Management Strategies

Additional changes in managerial practice since Census 2000 included creation of an information technology “enterprise architecture” compliant with statutory standards and federal government-wide guidelines for system design and development; thorough documentation of the 2010 Census goals, objectives, and strategies; and development of a detailed operational plan for each of the 44 census operations in a standardized format. A regular series of meetings allowed key individuals and groups to communicate quickly with one another about incipient problems and about hot issues. These meetings were supplemented with regular information postings on the electronic internal-use-only Census Operations Center.

5. Two Roads Not Taken in 2010: Internet Data Collection and an Administrative Records Census

The 2010 Census did not include any use of the Internet for household response, nor did it use administrative records extensively to “fill in” missing data or substitute for enumeration.

5.1. The Decision to Forego Internet Data Collection

The decision to avoid the Internet for self-response was based on research results from early in the decade, and on cost and security considerations (for more detail see Hill et al. 2011). Much research on Internet survey data collection has been conducted outside of the United States. However, research projects on Internet survey response rates may have limited relevance to the use of a Census Internet response mode option since a census environment, with its sizable advertising campaign and mandatory participation requirement, is different from a survey environment. The 2006 Canadian Census obtained an Internet response rate of 18.3 percent of the private occupied dwellings when given a choice of paper and Internet response options (Côté and Laroche 2009). Early indications are that Canada achieved a 54.4 percent Internet response rate to their 2011 Census (Ditchburn 2011). Yet both demographic and geographic characteristics and the relative availability of broadband Internet facilitating response differ markedly between Canada and the U.S.

Census 2000 also contained an experiment that studied the impact on response of providing mode choices. Offering a choice between Internet and mail increased the overall response rate by more than 2 percentage points compared to providing only a mail questionnaire (Schneider et al. 2005). Later in 2000, the Census Bureau also tested offering an Internet option for the American Community Survey (ACS). Contrary to the

Census 2000 experiment, offering a choice between Internet and mail decreased the response rate by 5.8 percentage points (Griffin et al. 2001). The differences are presumably due to the Census 2000 option being embedded within a widely-publicized national census, while the ACS was a new and then relatively unknown survey that was much longer than the Census 2000 short form.

In a 2003 Census test, several response option strategies were tested, including the use of Internet ‘push’ and ‘choice’ methods. The results indicated that households that were pushed to use the electronic modes were significantly *less* likely to respond (about 5.7 percentage points less; see Bouffard et al. 2004). For the choice panels offering Internet as a response option, the Internet response rate was less than seven percent. The results of a 2005 Census experiment showed that households who were encouraged to use the Internet at the replacement mailing also were significantly *less* likely to respond overall (about 3.7 percentage points less; see Bentley and Tancreto 2006).

As a result of these disappointing results, a decision not to use the Internet as a response option in 2010 was made in 2006. Because of continued increase in Internet use, this decision was revisited in 2008, but because of likely operational impacts, costs, and a concern that a last-minute security breach of an Internet response site would jeopardize the entire Census, the earlier decision was reaffirmed. Yet it is evident that survey response rates via the Internet continue to increase. Testing is already underway to determine the best way to incorporate Internet response options into both the ACS and the 2020 Census (see Hill et al. 2011 for early results of that testing); Internet collection of ACS responses is planned for 2013.

5.2. *The Decision to Limit the Use of Administrative Data*

Despite years (and even decades) of advocacy from outside groups to use administrative data extensively for decennial census-taking as a cost-reduction and potential quality-improvement measure, in 2010 the decennial census used such data almost exclusively in auxiliary roles. External advisory groups, most notably the Committee on National Statistics, part of the National Academy of Sciences (NAS), have consistently urged the Census Bureau to investigate the use of administrative records for census-taking (see Steffey and Bradburn 1994; Edmonston and Schultze 1995; Brown et al. 2010; Cook et al. 2011).

The Census Bureau did undertake an “Administrative Records Experiment” as part of Census 2000 (see Bye and Judson 2004 for results). Relying in part on the results of that experiment, the Census Bureau determined that the ability to do, and public acceptance of, an “administrative records census” were not high enough to undertake a large effort in 2010, but the use of such data was expanded in comparison to 2000. There were numerous uses of administrative data in the 2010 Census, most prominently its use for address list improvements. Three were actually used as part of the enumeration: identification of potential undercount cases for coverage follow-up, race coding for missing data, and the actual count of federally affiliated Americans overseas (part of the apportionment though not the resident population).

The most recent (and still ongoing) NAS panel (Cook et al. 2011) has once again urged a focus on administrative records research (pp. 22–23):

“We encourage the Bureau to be open to and use its matched records—census files, to explore the use of administrative data in a *supplementary* role to a wide variety of census operations. In particular, roles for administrative data as a supplementary resource to NRFU [Non-Response Follow-Up] operations should be explored. . . . Work on the administrative records matching study should contribute to the development of a business case for wider access to and use of administrative data, to inform final decisions on the use of the data. This business case includes both a utility side — a pure cost–benefit articulation — and an acceptability side. On the utility side, the administrative records simulation should permit cost modeling, for instance on the potential cost impact of resorting to records at different phases of NRFU. . . . By the acceptability side, we mean studying whether the respondent public, census stakeholders, and Congress (as the ultimate source of direction for conducting the census) will accept the wider use of administrative data in the census (and for which purposes).”

It is clear that to reduce costs substantially in the future a much greater use of administrative records will be necessary for the 2020 Census, and research is underway to determine the extent to which such data can accomplish the goal of counting everyone once, only once, and in the right location. For example, the Census Bureau is conducting a full match study of the 2010 census results to its administrative records research database. In effect, the research can be thought of as using administrative records to simulate the 2010 Census in order to thoroughly examine and document the coverage and quality of major governmental and commercial administrative record sets. Results are not yet available.

6. Identifying the Automation Problem

The data capture (Decennial Response Integration System or DRIS) contract was awarded in October 2005 and the field automation (FDCA) contract was awarded in April 2006. Immediately upon award, both contractors had to replan their proposed work schedules and shrink the scope of software development to account for the fact that the government, when establishing the life cycle budget for the 2010 Census in 2000, had underestimated the funds needed in the early planning and preparatory years of both contracts. These replans added risk to both contracts in that early development work had to be pushed later into the decade and in retrospect should have alerted the decennial census program management offices to enhance their contract monitoring. However, the impact of delayed funding on the DRIS contract was smaller than on the FDCA contract since the 2010 Census was the second time that the DRIS contractor had provided data capture services to the census (and they had provided similar services to other countries in the interim) while the 2010 Census was both the first experience for the FDCA contractor with a census (much of its previous experience had been in the defense arena) and the first experience for the Census Bureau with a contract to automate field data collection. For example, the FDCA contractor’s proposal for “on-the-fly” self-designed management reports was an unacceptable solution for a workforce of newly hired and trained supervisors.

Another source of risk was the fact that the Census Bureau had not determined its final design or its program management and system engineering controls for the 2010 Census at

the time of the FDCA award in 2006, and all federal agencies operated in an environment with ever-changing Information Technology (IT) security requirements. At the urging of agency, departmental, and oversight acquisition professionals, the FDCA contractor in particular was to be held to less deterministic performance goals (“solution-based” contracting) and allowed the latitude to determine the best approaches to meeting the agency’s needs. The Census Bureau did provide high-level requirements but as detailed requirements were developed and a new schedule was adopted, any new information meant contractors had to quickly and accurately accommodate several rounds of changes, which increased cost and risk.

Yet another source of risk was the failure of the FDCA Program Management Office to establish aggressive contractor oversight and stringent change control early in the contract (passive oversight being a natural complement to the performance-oriented acquisition strategy). A lack of aggressive monitoring along with inadequate information exchange led to inadequate integration between the contractor and the agency staff who would be the customers of its products and software.

Potential risks became reality when there was noticeable under-performance on the first major field testing activity that used FDCA-supplied hardware and software – the Address Canvassing Dress Rehearsal in March-June of 2007. Despite a major reduction in requirements, and despite the delay in contract award and consequent replan to align schedule and budget which led to slower than desirable software development and inadequate testing, the FDCA-provided software mostly worked for many of the high-level requirements, albeit with significant performance and data problems. Identification of these software problems raised concerns within the agency about the contractor’s ability to refine the software to meet more detailed requirements for the control systems for all operations and also about its ability to complete the rest of its responsibilities to automate the Non-Response Follow-Up interview and the Census Coverage Measurement interview.

Concurrent with these problems, in March 2007, the associate director for the decennial census asked an independent Federally Funded Research and Development Center (FFRDC) contractor that had both project management expertise and familiarity with the 2010 Census planning process to conduct an independent assessment of the FDCA program. In its June 2007 report, the FFRDC contractor concluded that FDCA was at significant risk of cost and schedule overruns and potentially omission of essential requirements.

These concerns, coupled with Congress’s failure to approve a timely budget for the Census Bureau for Fiscal Year (FY) 2008 (beginning 1 October 2007) until 26 December 2007, and its decision not to provide an “anomaly” (albeit one not requested by the President) recognizing the increasing cost of the census in FY 2008 versus 2007 in the temporary funding bills (called continuing resolutions) covering the October-December period, led to the cancellation of many 2008 Dress Rehearsal activities. As a first step to reduce pressure on the FDCA contractor, activities related to the Census Coverage Measurement Program were removed from the contract in December 2007 and reassigned to Census Bureau staff while Census Bureau officials determined whether additional changes were needed. (The Census Bureau had automated that operation in-house in 2000.)

To determine the next steps, several major activities were undertaken starting in October 2007. Prior to that time, no “red flags” had been posted by the FDCA program management office nor were senior management officials fully aware of the potential issues with FDCA. First, a Census Bureau team was charged by the Decennial Management Division with developing the detailed requirements that the FDCA contractor would need its products and software to meet in order to successfully carry out the remaining tasks. This was, in effect, a repudiation of the original plan to use performance-based contracting. The FDCA contractor demanded these on very short notice. After negotiations, delivery of the detailed requirements for the 2009 Address Canvassing operation was completed in November 2007, with delivery of all remaining detailed requirements for the 2010 Census completed in January 2008. While a major effort, it was however the inevitable result of the specific research and development strategy adopted earlier in the decade which put off critical design decisions as long as possible in order to take full advantage of evolving technology and new research results.

Second, after receiving a new and unexpectedly large cost estimate from the FDCA contractor to fulfill the remaining January 2008 detailed requirements, a task force was established, led by a former Deputy Director of the Census Bureau, with daily oversight by a team of senior Department of Commerce officials, to determine the appropriate course of remediation to recommend to the Director and the Secretary of Commerce. The task force report was reviewed by an independent panel of experts who made individual recommendations to the Secretary of Commerce. As a result of those inputs, the Director of the Census Bureau and the Secretary decided to reduce the scope of the FDCA contract significantly, focusing the contractor’s resources on completing the automation of the Address Canvassing operation, completing the operations control system for all paper-based operations, and supplying the IT infrastructure for the 494 Local Census Offices. This was coupled with a decision to revert to the paper-based data collection approach used for Non-Response Follow-Up in the 2000 Census.

To implement the recommendations of the task force, the Census Director appointed a new Associate Director for Decennial Census, and the Directorate leadership created a “get-well” plan with short deadlines for certain key activities; components of this get-well plan were overseen by five “action officers”. As part of the replan, an “Integrated Product Team” brought together senior staff from all Census Bureau stakeholders to integrate all FDCA-related operational decisions, assisted by the FFRDC contractor. The team also identified personnel to “embed” (that is, co-locate) with the FDCA contractor to reduce communications difficulties. Shortly after these decisions were made, further assessment by the Decennial Directorate leadership based on input from the Integrated Product Team led in March 2008 to moving the development of the Paper-Based Operations Control System (PBOCS) for all operations after Group Quarters Validation to a new contractor. At that point it is worth noting that the first paper-based production operation that needed that control system (data collection in “Remote Alaska”) was scheduled to begin in January 2010. To get the additional funding that this alternative required, the Secretary and the Census Bureau Director testified before Congress.

To carry out the PBOCS development, the Decennial Directorate established a new software development project management team within an established division (the Decennial Systems and Processing Office), hired knowledgeable consultants with

extensive software development experience to advise the development team, and hired a contractor to provide the programmers needed to implement revised software requirements that replaced the ones supplied to FDCA in January 2008. Because of the critical nature of the work and the aggressive time frame for development, the plans included (1) close coordination with primary stakeholders (in particular the Field Division which managed the collection operation), (2) embedded security specialists, (3) “agile programming” with many short-cycle iterations, (4) frequent check-ins with stakeholders, and (5) one preproduction and three production software releases, each with enhanced functionality.

During the Census’s operational phase that began in early 2010, the development team also included representatives from three additional vendors who were responsible for monitoring their systems, diagnosing problems, and assisting with issues resolution, covering hardware, database software, and operating system software. In addition, the Census Bureau established an independent assessment team of senior IT executives and consultants, led by the Census Bureau’s Chief Information Officer (the Associate Director for Information Technology), to provide an ongoing independent and objective view of the status of the program and associated risks, and to propose mitigation strategies. When significant issues began to arise, the assessment team embedded some of its members into the development team and reported to the Associate Director and the Deputy Director weekly.

According to Mueller (2007), “Agile programming breaks down an application development project into small modularized pieces. Each piece, addressed one at a time in a very short time frame, adds to the application and represents a complete part of the functionality. You can deploy the partial application and expect people to accomplish some level of work with it, even if the application doesn’t do everything you intend it to do in the long run.” Further, “Each piece is an iteration that lasts from one to four weeks. As a result, you know immediately when a particular piece of an application proves troublesome. . . . The customer (user) is involved with the project at the outset, which means that the development team makes fewer wrong assumptions about how the user will interact with the application and the steps required to perform a particular task.”

Agile programming met the Census Bureau’s need – as Mueller notes, “managers often use agile programming techniques to rescue projects that are in trouble.” The choice of an iterative process was deliberate and was supplemented by an attempt to design program modules that allowed for reuse. However, because of “just-in-time” delivery, key software development activities such as load, performance, and interface testing, and integration with the overall technology infrastructure, were not adequately performed. For example, because of inadequate testing, every component of the technology infrastructure (including both hardware and software) required multiple changes after PBOCS was in production. These infrastructure changes were happening in parallel with the repair of defects and the delivery of new functionality.

Despite reassuring results from a few “Decennial Applications Load Tests” in late 2009 and early 2010 that involved testers from about 400 Local Census Offices (those that had opened by then), PBOCS continued to be unreliable and unstable. To improve the situation, the Associate Director established an Application Reliability and Infrastructure Stability workgroup and a PBOCS Performance workgroup to resolve technical, schedule,

requirements, performance, and user issues; these included members of all stakeholders as well as system performance specialists and vendor technology specialists. To help solve performance problems, substantial additional hardware was installed that significantly increased the capacity of the PBOCS environment. Even though performance monitoring software was also installed, due to lack of time PBOCS could not be sufficiently performance-tuned.

Determining why agile programming did not work well for PBOCS development is beyond this author's expertise. Contributors are however likely to include a failure to plan properly, an inadequate initial architecture, the relatively long (6-week) period between software iterations, the lengthy list of initial requirements that later had to be pared down in a relatively ad hoc rather than a thorough manner, and the failure to relate the PBOCS software architecture fully to the functional requirements and the Census Bureau's IT systems.

When the Non-Response Follow-Up (NRFU) operation (that is, enumeration of the 48.0 million housing units which did not respond by mail) began, PBOCS performance declined significantly and it could not produce either assignments or management reports quickly, particularly when users were permitted to access software for more than one operation. As noted by the GAO (U.S. Government Accountability Office 2010, p. 20), "despite efforts to upgrade its hardware and software, PBOCS continued to experience system outages, slow performance, and problems generating and maintaining timely progress reports." As noted in the report, according to the Census Bureau, these issues were due, in part, "to the compressed development and testing schedule, as well as to the inadequate performance and interface testing."

To actually accomplish the NRFU and subsequent field work, the Census Bureau implemented many workarounds, such as moving the printing of assignments to the PBOCS testing server, moving the NRFU shipping function to other software, restricting the number of users and hours of system availability (the latter to allow for software upgrades), offline batch report generation, and developing contingency software for certain operations (actually adopted for the later Field Verification operation). Nevertheless, the performance issues led to backlogs of many millions of paper questionnaires sitting at Local Census Offices waiting to be checked in before they could be shipped to the Paper Data Capture Centers (which in turn were operating below capacity due to the delays). These issues likely led to some inefficiencies (such as delay of quality assurance reinterviews) and extra costs throughout the system, with the most impact probably in the local offices.

In sum, the Census Bureau "muddled through" with less-than-perfect software mainly via the dedication of staff and contractors to mission success. Once the backlog problem was solved (a matter of weeks, not months), operations were completed on time and mostly under budget, the population counts by state were delivered to the President ten days early, and all deadlines for delivery of data needed for legislative redistricting were met.

7. Management Lessons Learned

While most of the discussion above has been linked to events, this section is more introspective and in consequence subjective, rather than solely evidence-based. With that

caveat, I nonetheless believe that there are six major lessons to be learned about management of a decennial census from the 2010 Census experience.

First and primary is that information and more importantly, *the exchange and integration of information, is key*. This is a major challenge given the stove-piped nature of the Census Bureau, the number of operations, and the number of systems supporting those operations. Issues can be identified early and mistakes rectified only if decision makers are aware and engaged. Daily briefings of the Census Integration Group of key managers on ongoing and upcoming operations at the height of the 2010 Census helped ensure that information flowed, anomalies were identified, and decisions were made expeditiously. To assist in keeping all participants informed, an electronic Census Operations Center was established. Some information on the site (e.g., “Key Issues”) was restricted to those with a need-to-know, but all Census Bureau staff could browse the site for much of the information needed to understand progress and plans. I recommend that the 2020 Census have a knowledge manager as a key position. The lack of a dedicated full-time knowledge manager in 2010 likely has led to insufficient documentation of lessons learned from the 2010 Census.

Second, *decision makers must stay abreast of information and be ready to make quick decisions, even if based on incomplete information*. Too many layers can delay decisions, so having daily briefings of senior management during the heart of the census cycle is invaluable. Also valuable is the presence of a contingency fund, even one controlled by OMB (as was the case for the 2010 Census). Since the Congress approved contingency funds as part of the budget, there was usually sufficient time to alert the Department of Commerce and OMB to the need to spend contingency funds on unexpected activities (such as universal fingerprinting of temporary employees, not part of the original budget request) and get approval reasonably quickly. This stands in contrast to the need for supplemental appropriations to complete the 1990 enumeration (because mail response did not meet initial expectations and the wages paid to enumerators did not sufficiently control staff turnover). Furthermore, since the Census Bureau showed it can use contingency funding responsibly, it is possible that Congress would approve its inclusion in the operational budgets for the 2020 Census, especially for hard-to-forecast operations, and I recommend that OMB allow the Census Bureau to do so. I also endorse GAO’s call for the Census Bureau to adopt better cost estimation procedures (see, for example U.S. Government Accountability Office 2008).

Third, *program management processes proved valuable but to get full value they must be in place early*. The processes systematized and implemented in 2008 when the program was in extremis proved valuable, both in the control and in the knowledge it gave senior managers at the Census Bureau, but also in the reassurance it gave oversight officials in the ability of the Census Bureau to keep its house in order and complete the census successfully. But unfortunately, they should have been in place during the research and testing phase. It is likely, though of course not certain, that had mature management controls, in particular an active risk management program and an integrated schedule under change control, been in place earlier in the process, such as when the key support contracts were put in place in 2005 and 2006, that some of the later management challenges faced by the Census Bureau might have been less severe.

The need for robust program management includes a wide range of activities, from issues management and change control, to acquisition strategies and risk management. Without arguing that the risk management process used in the 2010 Census was perfect, I believe it can be a springboard for instituting risk management for other major Census Bureau and indeed Department of Commerce programs. In commenting on the Census Bureau's briefing on its high-risk improvement plan (after singling out the risk management process in particular for praise), Clay Johnson III, then Deputy Director of OMB for Management wrote to senior Census Bureau officials to say "Again, I am very impressed with the path you are now on with regards to the Census. As you all said, it is not over till it's over and there are many risks to be managed to acceptable levels. But I'm betting on you." [Johnson 2008] That bet paid off – the Census Bureau returned \$1.87 billion in appropriated funds.

Fourth, *more care, consistency, and accountability in applying existing project management and systems engineering best practices must be taken* in managing contracts, especially of those contractors with little experience in working on a decennial census. In one corner was a contractor with little experience on Census projects, attempting to do something which had not ever been done before – automating three major census field operations. In another corner was a contractor, mostly doing what it had done before for the 2000 Census (capturing data). The former had major problems with costs and meeting the government's needs in a fluid environment, while the latter had few problems, finishing on time despite needing to adapt to changing needs (e.g., the need to capture enumerator-filled forms). Contractors need to become part of the census team, and not managed at arm's-length. A key lesson learned is that if you are doing large-scale contracting, then you need to have a highly skilled staff of contract managers, preferably with experience on a prior census, plus a mechanism for timely and effective communication, such as embedding senior staff with key contractors.

Much of the timeline for and problems with the PBOCS development mimicked what happened with FDCA software development both prior to the 2008 Dress Rehearsal and for the data capture contractor prior to the 1998 Dress Rehearsal for the 2000 Census. Systems need to be in place early for testing and they need time to mature – but it is essential to put in place comprehensive requirements including load testing and architecture configuration before the contractor starts writing code. The problems arose from a combination of contractor inexperience with the massive business of taking a census, the lack of early detailed requirements, and insufficient time to address issues as they arose. The major lesson that we relearn each decade is to award large and complex contracts early in the decade. Of course, that means making design decisions earlier also. Since responsible decision-making requires adequate testing and experimentation, sufficient funds must be made available for research and development early in each decennial census cycle, and decision-makers must be willing to accept potentially sub-optimal solutions to reduce risk, and resist the temptation to adopt the latest technology, untested in a census environment.

Fifth, *the Census Bureau needs integration of technology with business and operational needs focusing on the insertion, acquisition, testing, and deployment of technology*, based on a well-thought-out plan for purchasing what it can get from the

market at the latest possible moment while developing what it cannot. Whether it adopts private cloud computing or something else, the Census Bureau's Chief Information Officer needs to work closely with the Associate Director for Decennial Census in developing a viable and flexible enterprise IT platform based on standards and using best practices to securely host the decennial census while allowing adaptability to changed circumstances. Clear identification of roles and responsibilities coupled with an extensive and rigorous testing program for all hardware and software components and configuration management are all key ingredients for success. The first warning signs of trouble with data collection automation should not have been the 2007 Address Canvassing Dress Rehearsal. In fact, it is likely that the Census Bureau will abandon the practice of a formal Dress Rehearsal two years before a census, in the sense that the name suggests that no further changes to procedures will be made afterwards, and replace it with an end-to-end test of some kind. At the very least, software continues to change to correct problems and reflect changed requirements, as does the Internet (likely to be a major data collection mode in 2020), implying that flexibility will be important. In addition, the Census Bureau should strive to put its operational control system for the next census in production well before 2020 by implementing prototype systems for current multi-mode surveys like the American Community Survey early in the decade.

Nevertheless, I believe that it will never be the case that the Census Bureau can fully specify the detailed specifications of each operation planned for the 2020 Census more than five years ahead of its implementation, which would be required were it to follow IT "best practices" to minimize risk in software development. Tested, acceptable census methods will evolve, as do the cultural attitudes of society towards the government and towards the Census, as well as perhaps privacy concerns, and thus programmers will need to be flexible enough to adapt to those changes. For example, Internet and smart phone technology as of 2020 will not be the same as that of 2018, let alone 2015; yet the Census Bureau will be expected by the public and the Congress to take full advantage of Internet connectivity and smart phone capabilities in both carrying out and managing the 2020 Census. The next Census has to use the technology that exists and has been proven in the marketplace, yet remain flexible enough to adopt improvements as they come forward as late as 2019.

Sixth, since the human and knowledge capital to do a census is held by only one organization in the country, *the Census Bureau should carefully determine where its expertise lies and focus its resources there*, allowing others (such as contractors) to supply "commodity services" and products which require less program-specific knowledge, or can be accomplished under the direct supervision of knowledgeable staff. For example, it worked well to contract out (that is, no problems were encountered in) telephone questionnaire assistance and the purchase and placement of standard desktop computers; that should continue.

As mentioned above, these conclusions are subjective and thus need to be validated by others reflecting on their management experiences with the 2010 Census program. Yet I hope that some of the lessons learned from the 2010 Census will translate into a better 2020 Census. Of course, there remain unanswered questions that others might address.

These include:

- When during the decennial cycle should the Census Bureau move from an experimental research and planning mode into a more formal testing and management mode?
- Which of the many meetings and management processes were most useful and which were redundant and unnecessary?
- How should one organize the field data collection operation – in other words, are there cost efficiencies to be gained from radical change?
- Can one develop an up-front IT architecture that will guide the census throughout its 15-year life-cycle?
- How does one design an effective software testing structure for such a dynamic but delivery date-constrained and high-visibility environment?

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