Planning the 2010 Census: Second Interim Report

Daniel L. Cork, Michael L. Cohen, and Benjamin F. King, Editors, Panel on Reseach on Future Census Methods, National Research Council

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PLANNING THE 2010 CENSUS

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Panel on Research on Future Census Methods

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Committee on National Statistics

Division of Behavioral and Social Sciences and Education

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Acknowledgments

THE PANEL ON RESEARCH ON FUTURE CENSUS METHODS of the Committee on National Statistics (CNSTAT) is pleased to submit this second interim report and wishes to thank the many people who have contributed to the panel's work and helped make possible the preparation of this interim report.

We thank the staff of the U.S. Census Bureau, under the leadership of director C. Louis Kincannon, deputy director Hermann Habermann, and former acting director William Barron, for their professionalism and their cooperation with the panel. In particular, we appreciate the commitment of Preston Jay Waite, associate director for decennial census, to working with the panel even during the difficult transition period between closing one decennial census and starting another. We thank Rajendra Singh, the panel's lead liaison with the Census Bureau, for his attention to the panel's needs. In addition, the work of the panel has been greatly facilitated by its work in smaller, working groups. Each of the panel's working groups has a designated liaison inside the bureau; they have been uniformly helpful and supportive, and we look forward to continued interaction over the panel's remaining year of service. These primary sources of contact include: Robert Marx and Linda Pike (Address List Development); Tracy Wessler and Andrea Brinson (Computing Systems and Technical Infrastructure); Jon Clark (Coverage Evaluation and Statistical Infrastructure); and Fay Nash (Enumeration Methods). The panel has also benefited from its interaction with other talented members of the Census Bureau staff,

including Nancy Gordon, Howard Hogan, Donna Kostanich, Alfredo Navarro, Jim Treat, Alan Tupek, and Frank Vitrano.

The tragic death of Charles H. "Chip" Alexander, Jr., in early September 2002 was an incalculable loss for the entire research community surrounding the decennial census and its related programs. The chief statistical methodologist for the American Community Survey (ACS), Chip was also the panel's designated liaison on ACS matters. One true pleasure of service on this panel was the opportunity for interaction with someone of Chip's great knowledge and good humor, and we join his friends and colleagues in mourning his loss.

Our panel colleague Joseph Salvo, of the New York City Department of City Planning, ably chaired a working group to evaluate the Local Update of Census Addresses (LUCA) program from the local government perspective. Jointly sponsored by this panel and our sister panel, the Panel to Review the 2000 Census, LUCA working group members drew from their firsthand expertise in documenting their LUCA experience in case study form. We thank the members of this group—Abby Hughes, Terry Jackson, Tim Koss, and Harry Wolfe—and working group consultant Patricia Becker for their efforts, a solid reference work for our panel and the entire research community. In particular, we thank working group member Shoreh Elhami, of the Delaware County (Ohio) Auditor's Office, for her continuing consultation with the panel on census and geography matters.

In April 2001 the panel opened its first examination of the proposed MAF/TIGER Enhancements Program by inviting a distinguished set of discussants to share their opinions on the proposed plans. In addition to Shoreh Elhami, this roster of discussants included: Rick Ayers (ESRI), Donald Cooke (Geographic Data Technology, Inc.), Michel Lettre (State of Maryland), and Sarah Nusser (Department of Statistics, Iowa State University). We thank them for their time and their talents.

Logistical arrangements for panel activities were made with great skill by Agnes Gaskin, senior project assistant. Research assistant Marisa Gerstein deserves thanks for her help with maintaining an archive of materials related to both this panel and the Panel to Review the 2000 Census. Former CNSTAT staff member Carrie Muntean, now stationed with the U.S. Foreign Service, did exemplary work for both panels and, in particular, with the LUCA Working Group.

CNSTAT consultant Meyer Zitter's zeal in collecting information for both panels is greatly appreciated. Finally, virtually all of the activities of the Committee on National Statistics benefit greatly from the involvement and advice of Constance Citro, senior program officer. Given her role as study director of our sister Panel to Review the 2000 Census, we have drawn quite heavily from her wisdom and benefit from her contributions.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the Report Review Committee of the National Research Council (NRC). The purpose of this independent review is to provide candid and critical comments that will assist the institution in making the published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process.

We thank the following individuals for their participation in the review of this report: Margo J. Anderson, Department of History, University of Wisconsin, Milwaukee; Lawrence Brown, Department of Statistics, University of Pennsylvania; Barbara Everitt Bryant, University of Michigan Business School; Stephen Fienberg, Department of Statistics, Carnegie Mellon University; D. Bruce Petrie, Canadian Institute for Health Information; and Kenneth Wachter, Department of Demography, University of California, Berkeley.

Although the reviewers listed above provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of the report was overseen by Robert Hauser, Center for Demography, University of Wisconsin. Appointed by the National Research Council, he was responsible for making certain that an independent examination of the report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring panel and the institution.

Benjamin F. King, *Chair*
Panel on Research on Future Census Methods

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Acronyms

ACE	Accuracy and Coverage Evaluation
ACF	Address Control File
ACS	American Community Survey
ALMI	Automated Listing and Mapping Instrument
BAS	Boundary and Annexation Survey
BSA	basic street address
C2SS	Census 2000 Supplementary Survey
CATI	computer-assisted telephone interviewing
CAUS	Community Address Updating System
CIFU	coverage improvement follow-up
CIO	chief information officer
CMM	Capability Maturity Model
CNSTAT	Committee on National Statistics
COTS	commercial off-the-shelf
CPS	Current Population Survey
DADS	Data Access and Dissemination System
DCS 2000	Data Capture System 2000
DEX	digital exchange
DMAF	Decennial Master Address File
DSF	Delivery Sequence File
FEAF	Federal Enterprise Architecture Framework
FIPS	Federal Information Processing Standards

GBF/DIME	Geographic Base File/Dual Independent Map Encoding
GIS	geographic information systems
GPS	global positioning system
GQ	group quarters
GSS	Geographic Support System
IDC/IQA	Internet Data Collection/Internet Questionnaire Assistance
IDEF0	Integration Definition for Function Modeling
IRS	Internal Revenue Service
IT	information technology
IVR	interactive voice response
LUCA	Local Update of Census Addresses
MAF	Master Address File
MAF/TIGER	Master Address File/Topologically Integrated Geographic Encoding and Referencing System
MAFGOR	MAF Geocoding Office Resolution
MCD	mobile computing device
MIS 2000	Management Information System 2000
MTAIP	MAF/TIGER Accuracy Improvement Project
MTEP	MAF/TIGER Enhancements Program
NRC	National Research Council
NRFU	nonresponse follow-up
OCS 2000	Operations Control System 2000
OMB	Office of Management and Budget
PALS	Program for Address List Supplementation
PAMS/ADAMS	Pre-Appointment Management System/Automated Decennial Administrative Management System
RFP	request for proposals
SS01	2001 Supplementary Survey
SS02	2002 Supplementary Survey
TIGER	Topologically Integrated Geographic Encoding and Referencing System
TMU	Targeted Map Update
TQA/CEFU	Telephone Questionnaire Assistance/Coverage Edit Follow-Up
USGS	United States Geological Survey
USPS	United States Postal Service

Executive Summary

THE PANEL ON RESEARCH ON FUTURE CENSUS METHODS has a broad charge to review the early planning process for the 2010 census. Its work includes observing the operation of the 2000 census, deriving lessons for 2010, and advising on effective evaluations and tests. This is the panel's third report; we have previously issued an interim report (National Research Council, 2000) offering suggestions on the Census Bureau's evaluation plan for 2000 and a letter report (National Research Council, 2001c) commenting on the bureau's proposed general structure for the 2010 census. The panel is expected to finish its work by the end of 2003, at which time it will issue a final report.

EMERGING STRUCTURE OF THE 2010 CENSUS

The Census Bureau's current plans for the 2010 census are predicated on the completion of three major initiatives:

1. *MAF/TIGER Enhancements Program.* A specific set of improvements has been proposed to improve the Census Bureau's address list (Master Address File, or MAF) and geographic database (Topologically Integrated Geographic Encoding and Referencing System, or TIGER).

2. *American Community Survey (ACS).* The decennial census long form will be replaced by a continuous survey, thus permitting a short-form-only census in 2010. The ACS covers the same social, economic, and demographic data as the census long form but will provide estimates in a more timely manner.

3. *Early Integrated Planning.* The Census Bureau hopes that early attention to planning will make census tests leading up to 2010 more informative and useful.

The Census Bureau's emerging 2010 census plan also includes development of mobile computing devices for use in nonresponse follow-up work and use of multiple response modes (mail, Internet, and telephone).

IMPORTANCE OF INTEGRATION

Of the three legs of the Census Bureau's 2010 census strategy, the panel considers early integrated planning as perhaps the one most crucial to a successful 2010 census—and, in some respects, the hardest to accomplish. In an earlier report, we recommended that:

> **The Census Bureau should produce a "business plan" that provides an overall framework for development of the 2010 census. Such a plan should include: (1) a clear statement of objectives, (2) an approximate timeline for completion of tasks, (3) a cost-benefit analysis of the various components of the plan, and (4) a fuller explanation of how intra-Bureau efforts will be coordinated. In assessing the costs and benefits (both monetary and nonmonetary) of a reengineered 2010 census, attention should be given to potential effects of new processes on census coverage and differential undercount and their measurement.**

Clear articulation of such a plan, backed by empirical evidence from evaluation studies and census tests, and with careful attention to both costs and benefits, would help greatly in developing the design of the 2010 census.

This interim report is neither intended to be an exhaustive assessment of the Census Bureau's plans for the 2010 census nor a comprehensive checklist of problem areas for which a solution would ensure a quality 2010 census. It concentrates primarily on two areas in which the Census Bureau has been particularly active and in which information has been most available to the panel: modernization of the bureau's geographic resources and efforts to model and develop the technical infrastructure of the census. This report also offers initial comment on the American Community Survey. In assessing these major initiatives, we have tried to suggest areas in which it is particularly important that the Census Bureau demonstrate how the initiatives support each other in an integrated fashion.

The panel's discussions with the Census Bureau on several topics of interest, including strategies for coverage measurement, refining residence rules, and new enumeration methods, are still developing. Thus we defer detailed discussion of these topics to the final report.

REAL REENGINEERING: BUSINESS PROCESS AND TECHNICAL INFRASTRUCTURE

The operations of the 2000 census were carried out, supported, or monitored by various software programs, the computer systems on which those software programs operated, and the telecommunication systems that connected the computer systems. The totality of these programs, and potentially other programs/systems carrying out many other functions, is referred to as the technical infrastructure of the census.

The computer systems that supported the 2000 census were principally implemented using customized in-house software programs. Collectively, the 2000 census technical infrastructure was functional but developed at high cost and high risk, without adequate time for development and testing to ensure that systems were capable of meeting functional needs.

In order to develop an improved technical infrastructure for the 2010 census, a necessary first step is to reengineer an appropriate logical infrastructure or business process model. In addition to improving the bureau's computer systems, articulating a logical architecture for the 2010 census is important in order to develop a more complete

understanding of how the 2010 census will operate and to provide a basis for comparing alternative design features.

The panel is strongly impressed by a Census Bureau pilot study that developed a logical architecture for the 2000 census and subsequently adapted part of that architecture to reflect a limited set of 2010 census assumptions. The modeling language (IDEF0) and the software tool (System Architect) used to support this work are both sound. We therefore strongly encourage the Census Bureau to continue its infrastructure reengineering activities and recommend that the bureau proceed as quickly as possible to develop alternative business process models for the 2010 census as a total system (Recommendation TI–1).

Reengineering a comprehensive technical infrastructure supportive of the 2010 census business process model will require considerable resources and close collaboration among all Census Bureau units. It will also require a strong coordinator, whom we refer to as the system architect for the decennial census, along with a dedicated full-time staff (Recommendation TI–2). Finally, such an enterprise will not be successfully undertaken without strong commitment and ongoing support from the highest management levels at the Census Bureau.

MODERNIZING GEOGRAPHIC RESOURCES

Though the extent of inaccuracy in the TIGER database is unknown, evidence suggests that roads, boundaries, and other geographic features are misplaced with sufficient frequency that TIGER is in need of a comprehensive update. Hence, the panel supports the TIGER realignment portion of the MAF/TIGER Enhancements Program. That said, the plausibility of the Census Bureau's ambitious realignment timetable would be bolstered considerably through development of a detailed work plan (including some notion of the order in which counties will be initially updated), specification of the desired positional accuracy of the realigned TIGER file as well as the local and tribal geographic files used to carry out realignment, and specification of the change-detection program to add updates in later years. The panel also supports the Census Bureau's efforts to implement a modern processing environment for its geographic resources using commercial off-the-shelf software.

Though the panel is satisfied that the enhancements program may substantially improve TIGER, it is our view that the program falls seriously short in enhancing the MAF. In part due to as-yet unspecified plans for local partnerships and the Community Address Updating System (CAUS), there is no comprehensive plan to improve the MAF by adding new addresses, screening for duplicates, and generally ensuring that housing unit rosters are as complete and accurate as possible.

The Census Bureau's current strategy shows signs of repeating costly errors from the 2000 experience. The Census Bureau argues that the combination of three activities will result in an up-to-date address list for the 2010 census: twice-yearly updates based on the U.S. Postal Service's Delivery Sequence File (DSF), CAUS, and implementation of a program akin to the Local Update of Census Addresses (LUCA) used in the 2000 census. Specifically, the DSF updates are intended to provide address coverage in urban areas with city-style addresses, and CAUS is intended to provide coverage in rural areas; these would be supplemented by local review. However, during construction of the 2000 census MAF, the Census Bureau argued that a similar combination—DSF updates coupled with LUCA—would provide sufficient address updates. But the bureau later expressed doubts and conducted a costly complete block canvass of addresses.

Evaluation work on the contributions of DSF and other sources to the 2000 MAF has not been completed, so it has not been demonstrated that the DSF is better poised to be a backbone source of addresses in 2010 than it was in 2000. Meanwhile, CAUS raises concerns because of the not-yet-secured funding for the ACS; since CAUS relies on a fully fielded ACS, its budgetary viability is uncertain. It is also unclear how CAUS field staff would be targeted to particular geographic areas and to what extent CAUS address listing duties might detract from their work in following up with ACS respondents.

We are assuming that the Census Bureau hopes to avoid a complete block canvass prior to the 2010 census, given the cost of that operation and the fact that it was treated as a last resort in 2000. However, it is difficult to see how a full block canvass can be averted without a clearer plan for CAUS and without evidence that the combination of DSF and LUCA leading up to 2010 can overcome the last-minute doubts that arose in the late 1990s.

Accordingly, the panel recommends that the Census Bureau provide clearer details on how the MAF/TIGER Enhancements Program and other geographic programs will add missing addresses, remove duplicate addresses, and generally correct the MAF (Recommendation MAF–1). In support thereof, the bureau should complete and improve evaluation work on address list development issues (Recommendation MAF–4). The panel further recommends that the Census Bureau would benefit from vesting responsibility for coordinating MAF improvement and research in one office, since this responsibility is currently diffused over several divisions of the Census Bureau (Recommendation MAF–2). Finally, the panel suggests that the bureau promptly develop and describe plans for local geographic partnerships (Recommendation MAF–3).

AMERICAN COMMUNITY SURVEY

The American Community Survey (ACS) is a major household survey anticipated to include 250,000 housing units each month. Relative to other national household surveys, the large sample size of the ACS should allow it to provide small-area information—population characteristic profiles for counties, cities, and other local areas. However, in order to approximate the sample size of the census long form, ACS estimates for smaller geographic and population groups would be based on 3- or 5-year moving averages. While the census long form can only provide these small area profiles in once-per-decade snapshots, the ACS collects information continuously throughout the decade. In the census context, the prime advantage of a full-fledged ACS is the resulting prospect of a short-form-only census.

The most basic question the panel faces regarding the ACS is whether it is a satisfactory replacement for the census long form. We recognize that significant estimation and weighting challenges must be addressed and that more research is needed on the relative quality of ACS and long-form estimates, with particular focus on measurement error and error from nonresponse and imputation (Recommendation ACS–1). The Census Bureau must do significant work in informing data users and stakeholders of the features and the problems of working with moving average-based estimates (Recommendation ACS–3). The Census Bureau must also complete evaluations comparing 2000

census long-form data with data from the ACS test sites, from the Census 2000 Supplementary Survey (a prototype ACS), and from the Supplementary Surveys conducted in 2001 and 2002. Making these data available (protecting confidentiality) to the wider research community could help greatly in building the research base for the ACS (Recommendation ACS–2).

We do not see any looming flaw so large in magnitude that full ACS implementation should be set aside. We therefore encourage full congressional funding of the ACS. It is important, though, that Congress recognize that funding of the ACS should be viewed as a long-term commitment. Cuts in funding in subsequent years (and with them reductions in sample size) will impair the overall quality of the survey, with first and most pronounced impact on the ability to produce estimates for small geographic areas and population groups.

However, given that funding for the ACS is not yet secured, the Census Bureau must begin contingency planning to be prepared in the event that full funding is not provided (Recommendation ACS–4).

PLANS FOR TESTING

The Census Bureau plans to conduct at least four major census tests prior to 2010 in order to try out new procedures and finalize program plans. In 2003, a national sample has been asked to participate in a test of possible response modes (e.g., mail, Internet, and telephone) and of rewordings of the questions on race and Hispanic origin. This 2003 test is being administered by mail and does not involve an active field deployment of enumerators to conduct follow-up questioning. A 2004 Census Field Test will cover a wider range of census operations, including field follow-up, in already-determined sites in Georgia and New York. The 2004 field test should be the first major test of the Census Bureau's plans for using mobile computing devices. In 2006, an as-yet unspecified test will focus on general and reengineered data capture, information, and management systems. Finally, a full-fledged dress rehearsal will be conducted in 2008; the Census Bureau hopes that, by avoiding a late-decade crush in designing census plans as occurred in 2000, the 2008 exercise will be a true rehearsal rather than a late experimental test. These major test initiatives will be supplemented by

a variety of other small-scale feasibility studies and analytic work over the course of the decade.

The Census Bureau shared plans for the 2003 census test with the panel at its September 2002 meeting and in subsequent discussions. However, the plans were shared with us too late for us to suggest and for the Census Bureau to effect any meaningful change in the 2003 test plan. Plans for 2004 and 2006 are still under development, and the panel looks forward to continued work with the Census Bureau on those plans.

ASSESSING THE OVERALL STRATEGY

A major conclusion of the panel is that discussion of the 2010 census design needs to be more fully informed by the evaluation of various trade-offs—the costs and benefits of various reasonable approaches in order to make wise decisions. For example, there are costs and benefits associated with the following decisions:

1. How accurate will ACS information be relative to long-form information?

2. How inaccurate is the TIGER database at present? What accuracy will result from various approaches to its enhancement, and at what cost per unit of enhanced accuracy? Of what magnitude are the cost reductions that may result from a geographically correct TIGER system, such as more accurate routing of nonresponse follow-up enumerators?

3. With respect to nonresponse follow-up and the use of various types of personal computing devices, what benefits would offset their respective costs?

4. What cost reductions (monetary and nonmonetary) will result from greater use of the Internet and other high technology means of enumeration, and what are the costs of greater use of these enumeration modes?

These and other fundamental questions need to be addressed so that decision makers can make informed selection among the various design options.

To date, the plan for the 2010 census has been presented to the panel with little supporting analysis. In part, this is attributable to the Census Bureau's need to devote more time and resources than expected to the intensive, specialized evaluation studies that surrounded the Accuracy and Coverage Evaluation (ACE) and the debate over statistical adjustment of 2000 census results. Whatever the reason for the delays, we are concerned that the selection of design options may have been hampered by a failure to fully exploit the existing information that is available from various management information and monitoring systems used to support the 2000 census.

The panel's recommendation in its letter report that contingency planning should be factored into census planning remains valid. This is particularly true with regard to the still-uncertain budgetary prospects of the ACS. But the possibility exists that budget fortunes leading to 2010 may not be as generous as in the 2000 cycle, and contingency plans must be adapted for various levels of budget support.

The Census Bureau should complete the remaining items on its planned evaluation list as expeditiously as possible. That done, the Census Bureau must subsequently take stock of what it has learned from the evaluation studies, flesh out the 2010 census plan with empirical support, and fill gaps in knowledge through further analysis of 2000 census operational data or through census tests.

— 1 —
Introduction

EVERY 10 YEARS, THE U.S. CENSUS BUREAU faces a job of almost bewildering complexity: counting an ever-increasing, ever-moving, ever-diversifying population and accurately tabulating it by location so that election districts and other mechanisms of democratic government can be recalibrated to better reflect their constituencies. American citizens' most recent involvement with the census was simply returning a form in 2000, and their next expected involvement is doing the same 7 years from now in 2010. For the average citizen, then, it may seem strange to read now about plans for the seemingly far-off 2010 census.

In truth, the complexity of the task demands early long-term planning. Any project to execute fundamental changes in the way a census is conducted demands even earlier planning still. The 2000 census is not yet over by some metrics—data products from 2000 are still being issued on a flow basis, and the Census Bureau's program of internal evaluations regarding 2000 census operations is far from complete. However, plans for the 2010 census are well under way. Indeed, the years 2002 and 2003 are not an unusual time to be discussing the 2010 census; it is closer to the truth to say that they are the deadline for effecting real change in the way the 2010 census is administered.

In 1999, the Census Bureau requested that the Committee on National Statistics (CNSTAT) convene a Panel on Research on Future Census Methods to assist the early planning efforts for the 2010 census. This report is the panel's third published comment on the emerging plans for the 2010 census. In the remainder of this section, we describe the scope of this report. To clarify the discussion, we briefly outline the major parameters of the developing plans for the 2010 census, as envisioned by the Census Bureau, with particular attention to the contrast between the 2000 census and the developing plans for 2010. We then describe the panel and its charge, and provide an overview of the remainder of the report.

THE "THREE-LEGGED STOOL" APPROACH TO THE 2010 CENSUS

By many accounts, the planning process for the 2000 census was fraught with risk and ultimately chaotic. As summarized in National Research Council (2001a), the Census Bureau initially developed a plan in 1996 that would have used statistical sampling during the process of following up with households that failed to file a mail return. Sample-based methods were also to be used to adjust final population counts for all purposes—including congressional reapportionment and redistricting—to reflect census undercount. This proposed plan touched off conflict that ultimately resulted in a January 1999 ruling by the U.S. Supreme Court forbidding the use of sampling to generate numbers for congressional reapportionment.[1] The decision forced the bureau to completely overhaul the census plan little more than a year from April 1, 2000, the census target date. Unanticipated difficulties also impacted parts of the census process. Between January and May 1999, when census field staff conducted an extensive canvass of the entire address list, concern arose that the list contained coverage gaps. During the actual conduct of the census, further evaluation of the address list suggested that the list had sizable levels of duplicate housing unit addresses, leading to an ad hoc operation to screen potential duplicates for further examination and possible reinstatement into the census (Nash, 2000).

[1] *Department of Commerce v. U.S. House of Representatives*, 525 U.S. 316 (1999).

The 2000 census was ultimately successful in meeting its statutory deadlines for providing data for reapportionment and redistricting, but the process by which it developed leaves considerable room for improvement. The final design for the 2000 census was only put into place an inadvisably short time before the census had to go into the field. Looking ahead to 2010, both the bureau and outside observers hope to avoid the risks and bruising consequences of late-formed plans, while at the same time keeping the escalating costs of conducting a census of the complex U.S. population in check.

In the early planning stages, the Census Bureau identified four basic goals for the 2010 census (Waite, 2002):

1. increase the relevance and timeliness of census long-form data;
2. reduce operational risk;
3. increase coverage, accuracy, and quality of census data; and
4. contain costs.

Based on those goals, the Census Bureau developed a general strategy for the 2010 census even as 2000 census returns were still being processed. As first described to the panel at its December 2000 meeting, the Census Bureau's general strategy for 2010 was likened to a "three-legged stool." Specifically, the general strategy is predicated on three major initiatives:

- *Modernization of the Census Bureau's geographic resources.* Specifically, the bureau's Master Address File (MAF) and its geographic database (Topologically Integrated Geographic Encoding and Referencing System, or TIGER) will be updated so that they will be consistent with coordinates derived using global positioning systems (GPS). The intent is to save field time and costs.
- *Implementation of the American Community Survey (ACS).* This proposed sample survey will collect data on the same social, economic, and demographic variables included in the current census long form, but will do so on a rolling continuous-time basis. Like earlier censuses, the census long form was administered to a sample of households in 2000 (1-in-6) while most households received a short form. However, full ACS implementation

will permit the 2010 census to be conducted using only the short form. Accordingly, it is hoped that this change will facilitate easier collection of information through the Internet and simplify data capture from census forms returned by mail.

- *Early integrated planning.* To the extent possible, census plans will be finalized as early as possible to facilitate effective testing in the years leading up to the census. It is hoped that this early planning will make the pre-2010 census tests more useful and informative as well as forestall a costly end-of-the-decade crunch in finalizing census operational plans.

An immediate adjunct to this three-pronged strategy is the incorporation of new technology in the census process. In particular, the Census Bureau's emerging 2010 census plans take advantage of a short-form-only census by including the following additional components:

- *Multiple response modes.* Simplifying to a short form would make completion of the census form easier and quicker—and more tractable for administering to respondents electronically. Hence, it is anticipated that the mailout-mailback component of the census would be heavily augmented with enumeration through use of the Internet and possibly interactive voice response via the telephone.

- *Mobile computing devices (MCDs).*[2] Nonresponse field work will make use of hand-held computing devices for communication of assignments, computer-assisted interviewing, and data capture. Making use of an enhanced MAF/TIGER database, the Census Bureau also anticipates that MCDs equipped with GPS receivers

[2]The Census Bureau uses the terminology "mobile computing devices"—or, more frequently, the acronym "MCD"—to describe the small computers planned for 2010 field data collection. However, the choice of MCD as a label is confusing given the acronym's long-standing meaning to data users accustomed to census geography. In that context, it stands for "minor civil division," the subcounty (township) divisions that are functioning governmental units in several midwestern and northeastern states. Though current plans and goals seem to favor a hand-held computing device on the order of current Palm Pilots, the alternative terminology "hand-held computing device" (HCD) may be too prescriptive. Hence, "portable computing device" (PCD) would likely be a better term, but we adhere to the MCD terminology for consistency with Census Bureau usage.

will allow interviewers conducting nonresponse follow-up to pinpoint the location of their assigned housing units and, possibly, to optimize their navigation from one assignment to another.

Final specifications and detailed plans for the above design remain to be developed; so too do complete plans for addressing other operational challenges and traditionally vexing problems in the coming census. These include:

- collection of census data from group quarters;
- enumeration of various hard-to-enumerate populations;
- use of administrative records either for nonresponse follow-up or address list improvement;
- forms of data dissemination;
- question wording, specifically with regard to the nature and content of questions on race and Hispanic origin; and
- plans for coverage measurement and evaluation.

Planning Milestones of the 2010 Census

The Census Bureau plans to conduct at least four major census tests prior to 2010 in order to try out new procedures and finalize program plans. The chronology of these tests and other milestones in the planning process for 2010 are shown in Table 1-1. In 2003, a national sample will be asked to participate in a test of possible response modes (e.g., mail, Internet, and telephone) and of rewordings of the questions on race and Hispanic origin. The 2003 test will be administered only by mail and will not involve an active field deployment of enumerators to conduct follow-up questioning. The 2004 Census Field Test will cover a wider range of census operations, including field follow-up, in predetermined sites in Georgia, New York, and Illinois.[3] The 2004 field

[3]Under budget totals consistent with the Bush administration's requests for fiscal year 2004, the Census Bureau would scale back the 2004 test to omit the Illinois site (Lowenthal, 2003b). The 2004 and other census tests will be discussed in greater detail in a later chapter.

Table 1-1 Planned Testing and Development Cycle for the 2010 Decennial Census, Assuming Short-Form-Only Census

Year	Census Activity
2002	Begin planning and develop methods for 2004 Census Field Test
2003	Conduct 2003 National Census Test, a survey administered by mail but offering multiple response modes (mail, telephone, Internet) and rewording of race and Hispanic origin questions
2004	Conduct Census Field Test, emphasizing use of mobile computing devices, in selected sites in New York, Illinois, and Georgia; Conduct Overseas Enumeration Test in France, Kuwait, and Mexico
2005	Analyze results and refine methodology
2006	Conduct Census Test, involving prototype technical systems
2007	Analyze results and refine and integrate systems and methods
2008	Dress rehearsal
2009	Begin to implement operations
2010	Conduct census

SOURCES: Waite (2002); U.S. Census Bureau, Public Information Office (2003b).

test should be the first major test of the bureau's plans for using mobile computing devices. In January 2003, the Census Bureau announced an Overseas Enumeration Test to be fielded in 2004, a test intended to gauge the response of U.S. citizens living in France, Kuwait, and Mexico to outreach and marketing efforts (U.S. Census Bureau, Public Information Office, 2003b). In 2006, an as-yet unspecified test will focus on general and reengineered technical systems. Finally, a full-fledged dress rehearsal will be conducted in 2008. It is hoped that avoiding a late-decade crush in designing census plans will make the 2008 exercise a true rehearsal rather than a late experimental test, as was the case with the 2000 census dress rehearsal.[4]

[4]In spring 1998, debate over the use of sampling methods in nonresponse follow-up led to the dress rehearsals for the 2000 census being cast as a comparison of basic designs. The original sampling-based framework was tested in Sacramento, California; a traditional census with a post-enumeration coverage survey was tested in Columbia, South Carolina; and a hybrid approach was fielded in Menominee County, Wisconsin.

CHARGE AND BRIEF HISTORY OF THE PANEL

The Panel on Research on Future Census Methods has a broad charge to review the plans for acquisition, analysis, and evaluation of research data needed to begin planning for the 2010 decennial census. The panel is charged to suggest improvements and preferred approaches, as well as to suggest priorities for analyzing census experimental and tracking data. Having been formed during the buildup to the 2000 census, a major role of the panel was to observe the implementation of the 2000 census, examining census accuracy and evaluating research program results, in order to determine appropriate lessons for the 2010 census.

Because of its early formation, this panel is unusual in the experience of previous National Research Council panels regarding the decennial census. This early start has been crucial for giving advice on the broad shape of the 2010 census, but it has presented unique challenges. Since its inception, the panel underwent two nearly year-long periods of relative dormancy due to the demands of carrying out the 2000 census. The first hiatus arose in 2000 due to heavy demand on the Census Bureau and its senior staff during the active follow-up and processing of the 2000 census. The second hiatus occurred during the summer and fall of 2001 as the Census Bureau engaged in intensive research over the question of whether to statistically adjust census data for estimated undercount.[5]

However, the work of the panel continued during these hiatus periods in the absence of formal panel meetings. Members of the panel joined members of its sister CNSTAT panel—the Panel to Review the 2000 Census—to visit census operations centers and local census offices during the conduct of the 2000 census. In addition, both panels

[5]As referenced earlier, the U.S. Supreme Court ruled in January 1999 that sampling methods could not be used in deriving the tallies used to reapportion the U.S. House of Representatives. This ruling left adjustment of census data for other purposes as an open question. Confronted with inconsistencies that the Census Bureau felt it could not resolve to its satisfaction in time to meet a legally mandated deadline for delivery of data to the states, the Census Bureau decided in March 2001 that it would not adjust the data used for redistricting. After still more research, the Census Bureau decided in October 2001 that it would not adjust 2000 census data for other nonredistricting purposes. National Research Council (2001a) provides additional information on the 2000 census adjustment debate and decisions.

jointly established a working group to evaluate the Local Update of Census Addresses (LUCA) program, by which state, local, and tribal governments could review address lists or population counts for their areas and suggest revisions. The Working Group on LUCA completed its report to both panels in early 2001 (Working Group on LUCA, 2001).

Previous and Future Reports of the Panel

This second interim report is the third report issued by the panel. In February 2000, the panel issued its first interim report, *Designing the 2010 Census* (National Research Council, 2000), based on early information gleaned from the panel's first two meetings. In December 2000, the panel heard the Census Bureau's first presentation of its preliminary 2010 census strategy and offered early feedback on the general strategy in a letter report to acting census director William Barron in February 2001 (National Research Council, 2001c). The Panel on Research on Future Census Methods will complete its work by the end of 2003, at which time it will issue a fourth and final report.

THE IMPORTANCE OF INTEGRATION

Though it covers a wide range of the topics under the panel's charge, this interim report is neither intended to be an exhaustive assessment of the Census Bureau's plans for the 2010 census nor a comprehensive checklist of problem areas whose solution would ensure a quality 2010 census. Instead, the primary focus of the report is to underscore the importance of one of the three major initiatives of the 2010 census plan envisioned by the Census Bureau: early integrated planning.

The panel wrote in its letter report (National Research Council, 2001c) that it "generally agrees with the Census Bureau on the goals of the two major initiatives of the current 2010 census strategy—the ACS and the MAF/TIGER upgrade—and strongly agrees on the importance of early planning." However, the three-pronged strategy for 2010 "appears to lack an overall framework." Put another way, the panel was concerned that the Census Bureau's planning for 2010 was commendably early but suffered from lack of attention to integration. It was unclear how the various pieces of the proposed plan interact and sup-

port each other. For example, it was unclear whether updated MAF/TIGER extracts would be available to support the sample selection and data collection processes of the ACS, or whether they would be available in time to support effective testing of mobile computing devices in the various census tests prior to 2010. The panel wrote that the Census Bureau's plan stressed the importance of integration but instead suggested "compartmentalized thinking, without due attention to how efforts across divisions within the Census Bureau will be coordinated and synthesized." Consequently, we urged that the bureau develop

> a "business plan"—that is, a clear statement of objectives and how they will be accomplished, when various steps in the census process must be completed, how much those steps will cost (in terms of both monetary and nonmonetary resources, including those that must be diverted from other areas to complete tasks in a timely fashion), the degree to which the steps will interact, and what benefits will accrue through each step. A critical feature of such a "business plan" for the 2010 census is a full enumeration of the costs and benefits—either monetary or nonmonetary—associated with each component of the census strategy. An example of a nonmonetary benefit is the improvement in quality of short-form data and timeliness of long-form data if the long form is replaced by the ACS.

Then, as now, the panel remains convinced that integration is key to development of a strong plan for the 2010 census. A primary goal of this interim report is to build on the recommendations from the letter report and—in the course of providing an initial assessment of 2010 census programs—suggest areas in which greater attention to integration of programs and efforts is needed.

Structure of This Report

In Chapter 2, we examine one segment of 2010 census planning in which the notion of integration is solidly established and under way. Since 2000, the Census Bureau has sponsored a pilot project to document the logical architecture of the decennial census—essentially, to map all activities and their information dependencies involved in the

census process from the initial development of address lists through to final data outputs. This mapping of the logical architecture is a major step toward developing the business plan we suggested in our letter report. More importantly, establishment of the logical architecture—beginning with an "as-was" model of the activities and their information dependencies involved in the 2000 census—allows for the model to be adjusted to reflect new assumptions. Revised "to-be" models can then be compared against each other to solidify plans for the 2010 census process. This information then becomes an important resource for specifying and assembling the actual physical technical infrastructure of the census and the myriad computer information systems that must work in sync to achieve census goals.

In subsequent chapters of this report, we then turn to the other two major initiatives envisioned in the Census Bureau's 2010 strategy, noting our concerns that it is not yet clear how these two broad-stroke initiatives will achieve desired goals either on their own or in concert with each other. In Chapter 3, we examine the bureau's proposed MAF/TIGER Enhancements Program. The basic objectives of the MAF/TIGER Enhancements are laudable and worthy of praise. However, in terms of furthering the Census Bureau's overall goal of accurate enumeration in 2010, the panel is worried that the bureau's current plans do not put sufficient weight on the MAF part of the program. In other words, the current Enhancements Program does not clearly document how addresses will be added to the Master Address File and from which sources, and—more importantly—does not clearly tie in to efforts to ensure that the MAF is free of duplicates and has full coverage of addresses in multiunit structures.

The American Community Survey, which we describe in Chapter 4, is a new potential source of fine-level data on the American populace on a much more timely basis than the once-a-decade snapshots currently afforded by the decennial census. The concept of continuous sample-based estimation is one of great statistical import and could surely be the basis for a report in its own right; the treatment in this report is decidedly not intended as our complete statement on the ACS. Our message on the ACS is much the same as our message regarding the MAF/TIGER Enhancements Program. The potential merit of the ACS is indisputable, and we support its implementation. But a compelling case has not been made for how the ACS fits into the broader goals

of the census. The clear objective of the ACS is to supplant a long-form component of the 2010 decennial census, but it remains to be fully demonstrated that the survey can actually meet all the needs that census long-form data currently satisfy. Does the increased currency of ACS data offset increases in variability inherent in the data as those figures are used by census stakeholders? We briefly outline challenges that remain in building a case for ACS estimation and look forward to continued work on the topic.

Included within the early integrated planning component of the Census Bureau's 2010 strategy is the goal of maximizing the benefit of early, comprehensive testing of revised census processes over the course of the decade. Major census tests are planned in 2003, 2004, and 2006, with a dress rehearsal to be held in 2008. In Chapter 5, we comment on the shape of the 2003 test as it was presented to the panel. As yet, the plans for the 2004 and 2006 tests are sufficiently unclear to the panel that our ability to provide precise comment is limited; in the chapter, we sketch some desired features for the upcoming tests.

We close this discussion in Chapter 6 by suggesting areas of strong interest to the panel that cut across divisions of the Census Bureau and deserve attention in the coming months. We find much in the extant planning for the 2010 census that is encouraging, and we are confident that—with continuing efforts to describe how all the various pieces fit and work together—the Census Bureau's particularly early start on laying the foundation for the 2010 census will ultimately serve it well.

— 2 —
Real Reengineering: Technical Infrastructure and Business Process

CONDUCTING A DECENNIAL CENSUS of the United States presents massive logistical challenges on many levels. It has been said that the fielding of the 2000 census—complete with over 860,000 short-term employees serving as enumerators—constituted the "largest peacetime civilian mobilization" in American history (U.S. Department of Commerce, Office of Inspector General, 2000:3). Impressive as well is the extent of computing and information networks that underlie the census—systems to track personnel hires and fires, monitor caseload, capture and synthesize data, generate maps, and so on—which must function not only at Census Bureau headquarters but also at regional offices, data collection centers, and over 500 temporary local census offices.

Specifically, the 2000 census relied on 10 major systems (U.S. Census Bureau, 2000):

- *Geographic Support System (GSS)*: facility for deriving extracts from MAF/TIGER as necessary and printing enumerator maps;

- *Pre-Appointment Management System/Automated Decennial Administrative Management System (PAMS/ADAMS)*: support for the hiring, processing, and payment of temporary employees, as well as administrative data archiving;
- *Operations Control System (OCS 2000)*: caseload management system to define and track enumerator assignments, as well as to monitor duplicate and missing addresses;
- *Data Capture System (DCS 2000)*: check-in and scanning of completed questionnaires;
- *Telephone Questionnaire Assistance/Coverage Edit Follow-Up (TQA/CEFU)*: support for respondents requiring assistance or additional forms, as well as follow-up data collection from respondents by phone;
- *Internet Data Collection/Internet Questionnaire Assistance (IDC/IQA)*: support and management of limited-scale Internet response to short-form questionnaires;
- *Accuracy and Coverage Evaluation (ACE)*: support for follow-up survey to assess possible undercount and, possibly, adjust census counts accordingly;
- *Management Information System (MIS 2000)*: senior management planning and information tracking, including schedule and budget;
- *Headquarters (HQ) Processing*: analysis and processing of final data, including production of reapportionment and redistricting population counts, as well as other data products; and
- *Data Access and Dissemination System (DADS)*: system for dissemination of census data to the public, most notably through the American FactFinder Internet site.[1]

[1]http://factfinder.census.gov [6/1/03].

In the end, this network of information systems supported achievement of the desired results. "Operationally, most agree that this decennial census was a success—participation was higher than anticipated … and operations concluded on time," notes one assessment. However, the assessment continues, the means by which it was achieved—including the patchwork of information systems—led to other descriptions: "costly, complex, and high risk" (U.S. Department of Commerce, Office of Inspector General, 2002:iii).[2]

The Census Bureau's generic label for its current plan for the 2010 census is that it is a "reengineering plan" (Waite, 2002). One interpretation of the term "reengineering" is that it means a marked departure from past practice—that the plan for 2010 is not intended to follow the 2000 census script merely with minor embellishment. The boldness of the Census Bureau's proposals for MAF/TIGER modernization and the American Community Survey suggests that the bureau is not taking "reengineering" lightly, and that is commendable.

A more meaningful interpretation of reengineering suggests a serious systemic analysis and evaluation of the entire decennial census process, with a particular eye toward effectively implementing changes, enhancing efficiency, and establishing organization-wide coordination on major initiatives. It is on this score that the panel critiqued the bureau's initial presentation of its 2010 census strategy, noting that the bureau's plans lacked an overarching framework.

Though not as well publicized as the Census Bureau's major proposed initiatives for the 2010 census, a pilot project within the Census Bureau has made great strides toward creating a base for true reengineering in the best sense of the term. This pilot project is a move toward establishing an enterprise architecture for the 2010 census, first by

[2]An example of the "high risk" nature of system operations: In late 1999, the Commerce Department's Office of Inspector General reviewed one of the constituent information systems of the 2000 census—the PAMS/ADAMS system to track personnel hiring and payroll. Based on interactions with the Census Bureau, the report concluded that the Census Bureau "did not follow a well-managed software development system" in creating PAMS/ADAMS, but the bureau was confident that the system would be able to support decennial census operations given "extensive operational use" of the system since the 1998 dress rehearsal. By January 2000, further review led the bureau to conclude that the PAMS/ADAMS might *not* be fully capable to support decennial needs and undertook "extensive software modifications" less than 3 months before Census Day (U.S. Department of Commerce, Office of Inspector General, 2000:i–ii).

mapping all the activities and information dependencies associated with the 2000 census and then by using that resulting structure as a model to test alternatives for 2010. In this chapter, we examine this effort in more detail.

TOWARD A "BUSINESS PROCESS" OF THE DECENNIAL CENSUS

Past experience with reengineering and upgrading information technology operations within corporations and government agencies suggests that the most prudent and productive approach is to proceed in well-thought-out stages or steps.

- *Define a "logical architecture" or "business process" model.* A first step is to articulate the set of activities and functions currently performed by the organization and the informational dependencies among them. This model of activities and functions is called a logical architecture. It may also be called a business process model because it defines the ways in which operations are carried out to accomplish the intended objectives of an organization. In the census context, the current business process would be the information flows and tasks associated with the 2000 census. We will explain the nature of logical architecture or business process models in greater detail in the following section.

- *Reengineer the logical architecture.* The completed logical architecture may be viewed as an "as-was" model; again, in this case, the as-was model would describe the activities of the 2000 census. Using the as-was model as a base, the next step is to produce one or more "to-be" models. That is, new assumptions and objectives are identified and the as-was logical architecture model is adjusted as necessary to find the optimal way to structure functions under the new demands. Different to-be models can then be compared against each other in order to reach a final architecture model.

- *Construct the physical technical infrastructure using the reengineered logical architecture as a guide.* The finished logical architecture/business process model is then used as template and specification for a new physical technical infrastructure—the

> actual network of hardware and software systems assembled to carry out the organization's work.

Any other approach—such as failing to map business functions in terms of overall objectives or rushing to make decisions on technical infrastructure too early—serves only to allow the organization to make more mistakes, albeit (probably) faster than before.

The Census Bureau has begun the task of reengineering the decennial census infrastructure in this manner because it fits into the objective of early planning and testing envisioned as part of its broad strategy for the 2010 census and because it brings the Census Bureau and the Department of Commerce into fuller compliance with the Information Technology Management Reform Act of 1996 (also known as the Clinger-Cohen Act).[3] This act forced federal agencies to reexamine their information technology (IT) structures, requiring greater attention to how IT furthers the agency goals and attention to modeling current and modernized IT structures as a business process. The Chief Information Officers (CIO) Council, created by executive order, subsequently developed the Federal Enterprise Architecture Framework (FEAF), a set of minimum standards for description of IT programs and modernizations.

Baseline: Logical Architecture of the 2000 Census

The Census Bureau contracted with the Centech Group, an IT company based in Arlington, Virginia, to develop its baseline for infrastructure reengineering: namely, a business process model of the operational flows underlying the 2000 census. Lockheed Martin was subsequently brought in as a subcontractor. The result of this first stage of work is a map of the logical architecture of the 2000 census, and it is summarized in a report (Centech Group, Inc., 2002a). A more detailed companion volume examines each logical segment of the model in greater detail (Centech Group, Inc., 2002b).

[3]The Information Technology Management Reform Act of 1996 is part of Public Law 104-106. Among other provisions, the act also encourages the use of commercial off-the-shelf (COTS) products relative to software systems built within government agencies.

Logical Architecture: What It Is and What It Is Not

The logical architecture models developed by the Census Bureau under this contract adhere to the Integration Definition for Function Modeling (IDEF0) language, a method that has been adopted as a federal standard for representing organizational functions and flows.[4] IDEF0 models use simple graphical structures to organize information. Functions (activities) of an enterprise are rendered as boxes; arrows connect the boxes, representing information constraints. For large enterprise models, a high-level diagram is typically produced as a guide or road map for the analyst; smaller pieces are then indexed based on this high-level map, available in full detail on separate pages.

A logical architecture model is a blueprint of the workflow of a particular enterprise. It describes the nature of information that must be passed from point to point at various phases of the operation and, in doing so, highlights information interfaces—points of connection both within the system and with external entities. A logical architecture model thus defines the baseline capability that must be present when a physical technical infrastructure is constructed. A logical architecture model may also convey a rough sense of where, geographically or organizationally, groups of activities should be clustered.

To better understand what a logical architecture model of the decennial census is, it is also important to remember what it is *not*. The main purpose of an IDEF0-based logical architecture model is to emphasize process and function. To that end, a logical architecture model effectively disregards two variables that are of some natural concern. First, it does not attempt to assign completion times to any function or process. Hence, the model describes forward information flow through a business process but is not meant in any way as a timeline or schedule of the process. Individual segments of the model may be completely distinct in terms of their actual execution time, or they may just as likely overlap extensively. In addition, IDEF0 models do not consider existing organizational boundaries; logical segments are partitioned strictly based on function and purpose, without respect to internal work divisions that may already exist within an enterprise.

[4]Specifically, IDEF0 was released as a standard in 1993 in Federal Information Processing Standards (FIPS) Publication 183.

Finally, since the concepts may be confused, it is important to emphasize that a logical architecture is not equivalent to a physical computing or technical architecture. Properly executed, a logical architecture does not define the specific computing platform to be used or the specific database structure that may be employed, and it certainly does not presume to dictate the specific variables or records to be saved in particular databases. However, the logical architecture can provide a template for the physical trappings; the diagrammed flows and constraints of the model give shape to and provide baseline specifications for the types of activity that physical systems must be able to perform. Moreover, a logical architecture documents work but should be invariant to specific operational decisions—whether certain data are input at one computer or at twenty or, in the context of the census, whether operations take place in 500 local census offices or 600.

Follow-up Work

After defining operational flows, the Census Bureau's next step was to select a computer-assisted architecture modeling package. Ultimately, the bureau chose to use System Architect, a package developed by Popkin Software, Inc., as an initial base for its modeling efforts. Beginning in February 2002, the diagrams and logical flows captured in the logical architecture model of the 2000 census were rendered in System Architect, to support a pilot reengineering exercise.

Reengineering Exercise

Between August and October 2002, Census Bureau staff performed a logical architecture reengineering exercise, again contracting with the Centech Group, which issued the final results in a report (Centech Group, Inc., 2002c).

To keep the exercise manageable, given the Census Bureau's newness to the process, reengineering activities were narrowed in scope to focus on the data collection through data processing steps of the census process. Candidate areas for retooling were proposed and considered for inclusion in the exercise. Ultimately, the exercise concentrated on adapting the as-was model of the 2000 census to reflect three areas of change:

- *Localized control of follow-up procedures:* assignments for nonresponse follow-up would be made dynamically, based on regular updates of response status for all housing units during census conduct and on the progress of individual enumerators.

- *Centralizing data capture and formatting for all response modes:* ensure that data provided to headquarters is in uniform format regardless of response type (mail, telephone, Internet).

- *Redistribution of "undeliverable as addressed" questionnaires:* adapt sorting and screening processes to streamline handling of questionnaires returned by the U.S. Postal Service, for easier identification of vacant housing units.

Architecturally, adapting the as-was 2000 census model to reflect these operations included many changes in follow-up information processing as well as the addition of data centers[5] to perform processing and formatting tasks.

As part of the exercise, Census Bureau staff developed a list of sixteen architectural principles to guide the logical architecture as the three selected changes were incorporated into a to-be design. As the contractor report notes, individual architectural principles may, by design, oppose each other—"optimization for one principle may cause noncompliance with another principle." The hope is to find alternative architectural flows that best balance the opposing demands of the entire set of principles (Centech Group, Inc., 2002c).

For instance, two of the architectural principles are: "consider the needs of the respondent" and "facilitate counting everyone once, only once, and in the right place." These principles can be weighed against each other by the degree to which they contribute to overall goals. They can also be used to evaluate competing "to-be" logical architecture models. For instance, a higher number of response modes available to respondents under one plan might be considered evidence in its favor with respect to the "consider the needs of the respondent" principle. In the reengineering exercise, Census Bureau staff identified

[5]Here, "data center" refers to a designated point to handle sorting and reformatting tasks. Use of the term should not be confused with the Census Bureau's current state data centers, which are part of the bureau's existing apparatus for data and analysis outreach to users.

a number of such measures (quantitative and qualitative), which serve as evaluation criteria to compare the baseline as-was model (the 2000 census structure) with the proposed initiatives for the 2010 census.

ASSESSMENT

The panel enthusiastically endorses and supports the work that the Census Bureau has performed on its pilot logical architecture project and strongly urges its continuance.

Completion of the first phase alone—development of a logical architecture model for the 2000 decennial census—is a major accomplishment and deserves recognition for its potential utility. As the contractor's report notes, the Census Bureau has traditionally put "little emphasis on assessment of the entire 'end-to-end' decennial census process" (Centech Group, Inc., 2002a:vii). Hence, the bureau's efforts with this model of the 2000 census are indeed very encouraging.

The reengineering exercise was, understandably, very limited in scope, but it demonstrates that the Census Bureau is now poised to make fuller use of the modeling techniques in formalizing a logical architecture for the 2010 census. The logical model for the 2010 census can then be translated and operationalized in assembling the physical, technical infrastructure for 2010. The panel is comfortable with the bureau's selection of its modeling product and paradigm (System Architect and IDEF0, respectively), which appears to be quite sound.

> **Recommendation TI–1: Having completed a logical architecture model for the 2000 census and having conducted a limited-scope experiment to refit part of the model to reflect "2010 assumptions," the Census Bureau should continue and extend its logical architecture modeling activities. If necessary to gain experience with modeling functionality, additional small-scale experiments should be conducted to apply 2010-design ideas to parts of the architecture model that were not addressed in the first exercise. However, the Census Bureau should proceed as quickly as possible to construct alternative reengineered business process models for the 2010 census as a total system. The most promising model should be**

used to develop a final design and to assemble a physical technical infrastructure.

EXTENDING THE PILOT WORK: THE NEED FOR INSTITUTIONAL COMMITMENT

The Census Bureau's emerging plans for the 2010 census are laden with new initiatives and new technologies: a parallel data process in the ACS; more extensive ties to an updated MAF/TIGER system; data capture and transmissions from MCDs; Internet transactions; use of administrative records systems; and in-time collection and archiving of information for immediate use in quality control and quality assurance. Each of these activities will require care when incorporated into a logical architecture for the 2010 census.

Constructing an extensively reconfigured logical architecture—and, more importantly, using the resulting model as a template for building the actual physical infrastructure for the 2010 census—is an arduous task. And though the effort of using a completely realized logical architecture to build the physical technical architecture will ultimately reduce operational risk in census conduct, the architecture-building process is not without risks of its own. In terms of general recommendations as the Census Bureau continues with its architecture work, the panel's suggestions are generally consistent with an earlier National Research Council panel on which members of the current panel also served. The earlier panel was charged to advise the Internal Revenue Service on the modernization of its internal systems (National Research Council, 1996), a task similar in certain respects to reconfiguring the decennial census. Accordingly, our lead recommendations are similar: first, successful reengineering efforts typically require active "champions" at the highest management levels, and the bureau must seek champions for its architecture construction process. Second, in order to conduct a successful reengineering process, the Census Bureau will need to bolster its technical expertise in enterprise modeling.

Management "Champions"

The major technological enhancements envisioned under the Census Bureau's proposed plan for the 2010 census are distinctive not only

for their range but also for the manner in which they cut across long-standing organizational divisions within the Census Bureau. For example, MCDs with GPS receivers are a field data collection tool, and so many requirements for the devices will have to be driven by field personnel needs; however, they are of limited use if the positional accuracy of TIGER is not improved. Additionally, computer-assisted questionnaires contained on the devices would benefit from cognitive and usability testing.

The approach of enterprise or logical architecture modeling is to concentrate on function and information flow rather than preexisting work conditions, though indeed the finished result of modeling may suggest more efficient ways to structure operational workload. However, experience in carrying out similar infrastructure remodelings suggests that it will be vitally important to have strong support at the highest levels of management at the bureau—in effect, to have influential "champions" of architecture reengineering. These people can effectively convey the importance of the task and encourage all divisions to "buy in" to modeling activities, and then coordinate and integrate the emerging system.

Establishing a System Architect

The development of an adequate business process model for the 2010 census will require a serious effort that must be well staffed and well supported. Although top-level management support and commitment are necessary, it is our view that authority for coordinating and developing that model should be vested in one person—a system architect for the 2010 decennial census. We recommend that such a position be created as soon as possible and that a well-qualified candidate be hired to fill the job.

> **Recommendation TI–2: The Census Bureau should create and staff the position of system architect for the decennial census, conducting a search of persons with expertise in modeling business processes and conducting reengineering activities. The system architect must have the authority to work with and coordinate efforts among the organizational divisions within the Census Bureau**

and should serve as a champion of the idea and the importance of architecture reengineering at the highest levels of management within the bureau.

The system architect should be supported by a full-time staff of reasonable size; this is important in order to achieve necessary expertise in a modeling methodology that is new to the Census Bureau. The system architect and related staff have a primary role as information gatherers, tapping expertise of other Census staff to build and revise architecture models. But an important role is also outreach, in a sense—helping to build commitment to architectural principles by informing other parts of the Census Bureau of modeling results and demonstrating their usefulness.

CHALLENGES IN TRANSITION FROM LOGICAL TO PHYSICAL INFRASTRUCTURE

A business process or logical architecture model will define the activities and the informational interfaces/dependencies required to carry out the 2010 census. Between now and the dress rehearsal in 2008 (with an opportunity to do related testing in 2006), an integrated information system—a physical technical infrastructure—must be put into place to support those activities and satisfy their informational requirements. In preparation for the refinement of the 2010 logical architecture and the transition to a physical infrastructure, we offer some further comments based on past experience with reconfiguring information systems, and we will revisit the architecture efforts in our final report. We raise these points—some of them cautionary in nature—not to deter the Census Bureau from proceeding with architecture modeling efforts but merely to emphasize the difficulty and the importance of the task.

Changing Architecture and Methods Simultaneously

Reengineering the Census Bureau's information systems is a very large and complex project in its own right. However, it is made vastly harder because the Census Bureau will be reengineering a very large and complex integrated system *at the same time* as it attempts to make

substantial changes in the tools and methods it plans to use—for instance, the migration of the MAF/TIGER system to a commercial off-the-shelf database system, the development (in the ACS) of a complete data system parallel to the census, and the implementation of new response modes. The added difficulty involved in developing new methods simultaneously with new architecture argues ever more strongly for a strong, coordinated system architect for the census, since synchronizing efforts will be key to successful implementation.

For example, one part of the proposed MAF/TIGER Enhancements Program—which we treat in detail in the next chapter—is the conversion of the existing MAF and TIGER databases to a modern database environment. One cited goal of this single objective of the Enhancements Program is implementation of pilot projects to improve the Census Bureau's Capability Maturity Model (CMM) score, a measure of an organization's maturity in software engineering (Franz, 2002). This is certainly a laudable goal. However, in isolation, the time and investment it takes organizations to move up one CMM level is around 2 to 3 years, and this progress is slowed further by attempting broader systemic engineering at the same time. Allowing one of these paths—improving software engineering capability or designing system architecture—to proceed in isolation from the other could be a critical and costly error, if time and resources elapse without both contributing jointly to census objectives.

Potential Pitfall: Locking in Physical Infrastructure Too Early

A major danger in making the transition from retooled logical infrastructure to completed physical infrastructure is a rush to judgment—a rush to finalize physical structures too early. Moore's Law—the adage that computing power tends to double roughly every 18 months—is well known; the rate of change in the computer technology world is indeed astounding. Thus, in settling on the purchase of a particular computer or software package, the Census Bureau runs the same risk faced by millions of personal computer buyers in the past several years: namely, instant obsolescence, as the capabilities of the chosen product are bested shortly thereafter by the next generation of product.

The selection of MCDs is a particular area in which the Census Bureau should remain cognizant of the dangers of deciding on physical form too early. At present, small-scale tests of basic skills are being conducted—navigation using a map displayed on a palm-sized screen, administering a computerized questionnaire on a small computing device, and so forth. It is important that the Census Bureau conduct prototype testing of this nature, to get some sense of current capabilities and form factors; however, it is likely to be a mistake to draw final conclusions on qualities like desired MCD weight, size, and memory capacity based on early test results. MCDs are, essentially, relatively simple computing devices with reliable storage and test input facilities; additional features that may be desired include: a color display with good resolution, a GPS latitude-longitude acquisition device, electronic communication facilities such as a landline modem, and perhaps encryption and decryption capabilities. However, the most important product of early MCD testing is not so much a checklist of desired features but a clearly articulated plan of the workflows and information flows that must be satisfied by MCDs, as they fit into the broader infrastructure.

It would be a mistake to make assumptions at an early stage that unnecessarily limit the functionality or constrain the human factors of these devices. Given the rate of technological development, it is not unreasonable that a tablet-size MCD with a full-blown operating system, adequate memory, a 20 gigabyte hard drive, a GPS receiver, a modem, encryption facilities, and an 8-inch full-color screen display will be available in the market by 2007 at a price of $500 or less in the quantities required by the bureau. So to prototype systems and to put too much emphasis on usability tests using devices of considerably less capability—rather than using early testing to further refine the basic logical and informational requirements that the final device must satisfy—is probably too conservative and will result in the acquisition and use of devices that will be less effective than necessary.

Enterprise Architecture as Learning Tool and Guide to Organizational Change

The end goal of business process or logical architecture reengineering is the production of a smoothly functioning finished physical architecture—an amalgam of software, computer systems, and telecom-

munications systems. Given this purpose, it is perhaps too easy to cast the effort as purely technical and technological, a highly inaccurate impression. We strongly encourage the Census Bureau to take full advantage of the exercise of architecture reengineering. That is, we urge the Census Bureau to view the effort not merely as the means to reengineer its computer systems but also as a key information tool to reengineer its own organization and operations.

IDEF0 logical architecture models emphasize function and process, independent of extant labor and institutional boundaries within the organization. Large organizations that develop rigid internal divisions over time can benefit from—and find refreshing—the basic exercise of stepping back and specifying the most basic flows of information, without regard to which division performs a given function or to which directorate it may report. For the Census Bureau, this logical architecture modeling represents a "new, and very different, perspective on decennial census operations," one "based on logical groupings of functions [and highlighting] the commonality across similar processes that were developed independently for different operations" (Centech Group, Inc., 2002a:vii). Accordingly, this new approach represents a potential step away from the "compartmentalized thinking" the panel warned against in its letter report (National Research Council, 2001c).

By these comments, we do not suggest the need for wholesale change in the way the Census Bureau is currently structured. What we do suggest is that the Census Bureau could benefit greatly from the development of a task-based project management approach. The analysis of information flows in architecture models may suggest logical clusterings of activities—or redundancy in activities—and provide clues for how parts of the bureau may best be mobilized to carry out the task.

— 3 —
Modernizing Geographic Resources

A BASIC TENET OF SURVEY RESEARCH is that the development of a sampling frame—a listing of all units eligible for inclusion in the sample from which the sample is drawn—is crucially important to the quality of the survey. Systematic biases or flaws in the frame may induce serious errors of inference based on the survey results. Accordingly, when considering a decennial census—a survey of grand scale—it is difficult to overemphasize the importance of the underlying sampling frame. The quality of the address list to which questionnaires are mailed can lead to the omission or duplication of people or of entire housing units and can hinder the goal of counting each resident once and only once within the precise geographic boundaries in which they belong. Hence, this panel stated in its first interim report that "the address list may be the most important factor in determining the overall accuracy of a decennial census" (National Research Council, 2000:35).

The "three-legged stool" strategy outlined by the Census Bureau in describing the early plans for the 2010 census includes attention to modernizing the Census Bureau's primary geographic resources:

- the Master Address File (MAF), the source of addresses not only for the decennial census, but also for the Census Bureau's numerous survey programs; and

- the Topologically Integrated Geographic Encoding and Referencing System (TIGER), a database describing the myriad geographic boundaries that partition the United States.

The specific set of activities that the Census Bureau has described to achieve this modernization is known as the MAF/TIGER Enhancements Program (MTEP). In terms of its spirit and nominal goal, the MAF/TIGER Enhancements Program may be of paramount importance in terms of its potential impact on the quality of the 2010 census.

In this chapter, we review the MAF/TIGER Enhancements Program. As we will describe in detail, we support completion of the Enhancements Program, which should provide some necessary improvements to the TIGER database. However, we are concerned that the Enhancements Package does little to enhance—to improve—the MAF. More generally, the Census Bureau's strategy for dealing with the MAF shows signs of repeating costly and chaotic processes from MAF construction in the 2000 census.

OVERVIEW: CURRENT STATE OF MAF AND TIGER

Before we discuss the specific enhancements program that has been initiated by the Census Bureau, it is useful to first briefly review the nature and status of the two geographic systems addressed by the package—to get a sense of exactly what is in need of enhancement.

The Master Address File

Purpose and Scope

The Census Bureau's Master Address File (MAF) is, in essence, precisely what the name implies; it is the Census Bureau's complete inventory of known living quarters in the United States and its island areas. The MAF contains a mailing address for those living quarters, if one

exists. For housing units or living quarters without mail addresses, descriptive addresses (e.g., "white house with brown shutters on left") may be coded.

The MAF also includes an intricate set of flags and indicators that indicate sources from which the address was obtained and the time when it entered the MAF. In principle, the MAF is a constantly evolving and continually updated resource; the "snapshot" of the MAF that is extracted and used to conduct the decennial census is called the Decennial Master Address File, or DMAF.

Construction of the 2000 Census Master Address File

The concept of a continuously maintained MAF is a relatively new one; in the 1990 and earlier censuses, address lists were compiled from multiple sources prior to the census (most recently from commercial vendors) and were not retained after the census was complete. Following the 1990 census, the idea of maintaining the address list—to support not only the decennial census but also the Census Bureau's other survey programs—took hold. In part, writes Nash (2000:1), "a major impetus for this change was the undercounts experienced in the 1990 and earlier decennial censuses, nearly a third of which was attributed to entirely missing housing units." An initial MAF was constructed using the city-style addresses[1] on the Address Control File (ACF) developed for the 1990 census (Hirschfeld, 2000).

To populate the MAF, the Census Bureau "devised a strategy of redundancy using a variety of sources for addresses," thus "[assuming] responsibility for developing a comprehensive, unduplicated file of addresses" (Nash, 2000:1). Most prominent of the update sources were two that were endorsed by one of our predecessor Committee on National Statistics (CNSTAT) panels on the decennial census (National Research Council, 1995:5), which recommended that the Census Bureau "develop cooperative arrangements with states and local governments to develop an improved master address file" and that the U.S.

[1]A city-style address is one that can be specified by a numeric identifier (e.g., 305) in combination with a street name (e.g., Park Avenue), possibly with a specific subunit or apartment identifier. By comparison, non-city-style addresses are those that cannot be mapped to particular streets in this fashion, such as "Rural Route, Box 7" or a post office box.

Postal Service be given "an expanded role" in census address list operations. Both these recommendations were significant in that they required legislative authority in order to operate within the prohibition on release of confidential data codified in U.S. Code Title 13, the legal authority for census operations.[2] Congress granted this authority in the Census Address List Improvement Act of 1994 (Public Law 103-430).

The Delivery Sequence File One provision of the Census Address List Improvement Act authorized the Census Bureau to enter into a data sharing arrangement with the U.S. Postal Service, under which the Postal Service would regularly share its Delivery Sequence File (DSF) with the Census Bureau.[3] The DSF is the Postal Service's master list of all delivery point addresses served by postal carriers.[4] The name of the file derives from the Postal Service-specific data coded for each record along with a standardized address and ZIP code: namely, codes that indicate how the address is served by mail delivery (e.g., carrier route and the sequential order in which the address is serviced on that route). The DSF record for a particular address also includes a code for delivery type that is meant to indicate whether the address is business or residential.

[2]In *Baldridge v. Shapiro*, 455 U.S. 345 (1982), the U.S. Supreme Court ruled that the Census Bureau's "address list … is part of the raw census data intended by Congress to be protected" under the confidentiality provisions of Title 13. Accordingly, the court concluded that the bureau's address list is not subject to disclosure under the Freedom of Information Act or under the discovery process in civil court proceedings.

[3]Specifically, the legislation text indicates that "the Postal Service shall provide to the Secretary of Commerce for use by the Bureau of the Census such address information, address-related information, and point of postal delivery information, including postal delivery codes, as may be determined by the Secretary to be appropriate for any census or survey being conducted by the Bureau of the Census. The provision of such information under this subsection shall be in accordance with such mutually agreeable terms and conditions, including reimbursability, as the Postal Service and the Secretary of Commerce shall deem appropriate."

[4]The list does not include general delivery addresses. Additional information on the DSF and commercial programs under which private companies are able to match their own address lists against the DSF can be found on the Postal Service Web site at http://www.usps.com/ncsc/addressservices/addressqualityservices/deliverysequence.htm.

Because the census is conducted largely through mailed questionnaires—most of which are subsequently mailed back—the U.S. Postal Service is a crucially important conduit in the census process. Moreover, the Postal Service is a constant presence in the field, servicing existing and emerging routes on a daily basis. For these reasons, securing access to the DSF was a major accomplishment. The DSF is an undoubtedly vital source of address information, albeit an incomplete one for census purposes since the list of mail delivery addresses is only a subset of the complete list of housing units in the United States. Mail delivery listings may also be incomplete in distinguishing multiple housing units within the same structure.

The Postal Service began sharing the DSF with the Census Bureau in the mid-1990s. Currently, as part of the Census Bureau's ongoing Geographic Base Support Program, new versions of the DSF are shared with the Census Bureau twice per year and updates or "refreshes" to the MAF are made at those times.

Local Update of Census Addresses The Census Address List Improvement Act of 1994 also authorized the secretary of commerce and the Census Bureau to

> provide officials who are designated as census liaisons by a local unit of general purpose government with access to census address information for the purpose of verifying the accuracy of the address information of the bureau for census and survey purposes.

The act obligated the Census Bureau to "respond to each recommendation made by a census liaison concerning the accuracy of address information, including the determination (and reasons therefor) of the bureau regarding each such recommendation." Put another way, the act permitted the Census Bureau to share with a local or tribal government the address data it had on file for that locality, for their review and update.

To preserve Title 13 confidentiality, limits were placed on the information to be provided; the information to be disclosed to any particular locality was limited to address information and to the set of addresses for that area. Ultimately, the address information would only be shared

with local or tribal governments if they signed an agreement to hold the information as confidential and to dispose of it when finished with review.

In August 1996, the Census Bureau initiated a program to acquire address list information from local governments. The Program for Address List Supplementation (PALS) contacted local and tribal governments (along with regional planning agencies) and solicited whatever lists of city-style addresses that they maintained for their jurisdictions. However, the Census Bureau quickly concluded that the program was troubled; local address lists were not necessarily in computer-readable format, and then not formatted in such a way (including apartment and unit designators) as to match with the emerging coding system for MAF. More significantly, response by local governments to an open-ended query for local address lists—ideally coded to the appropriate census block—was low. The program was officially terminated in September 1997 (U.S. Census Bureau, Geography Division, 1999).

The Census Bureau's next attempt at local geographic partnerships followed closer to the spirit of the Address List Improvement Act by releasing parts of the Census Bureau's MAF for review rather than requesting entire address lists. The resulting program became known as the Local Update of Census Addresses (LUCA), though it is also occasionally referred to as the Address List Review Program. LUCA was conducted in two waves:

- *LUCA 98.* In 1998, local and tribal governments in areas with predominantly city-style addresses were given the opportunity to review the Census Bureau's address list. Census Bureau cartographers used blue lines to distinguish city-style address areas from non-city-style areas on the maps that defined eligibility for LUCA. Hence, LUCA 98 was said to target localities lying "inside the blue line."

- *LUCA 99.* In 1999, attention turned to areas outside the "blue line," those with non-city-style addresses.[5] Local and tribal governments were again offered the chance to review Census Bureau

[5]The "blue line" designating LUCA 98 and 99 areas was not constrained to follow borders of whole geographic locations, so many places and counties were eligible to participate in both waves of LUCA. In some localities, the blue line did not cleanly

materials, but this time the offer was to review block-level counts of housing units rather than actual addresses.

To participate in LUCA, local and tribal governments were required to identify liaisons to handle the address list materials and to execute an oath of confidentiality. Materials were sent to the local and tribal governments, which had a specified time period to analyze them and submit any proposed changes. These changes were then reviewed by the Census Bureau, which often opted to reject part or all of the localities' suggested additions or deletions to the address list. An appeals process was set up under the auspices of the Office of Management and Budget (OMB), giving local and tribal governments a final opportunity if they found grounds to quarrel with the Census Bureau's judgments.

The Working Group on LUCA commissioned jointly by this panel and the Panel to Review the 2000 Census has conducted an extensive review of the LUCA process from the participant's (local government) perspective (Working Group on LUCA, 2001).

Block Canvass In the 1990 and earlier censuses, when address lists were not maintained from census to census but rather assembled before the decennial enumeration, a complete field canvass of the city-style addresses in designated mailout/mailback areas was a standard—but costly—operation. The Census Bureau had hoped to avoid a complete block canvass before the 2000 census; in introducing the Address List Improvement Act of 1994, U.S. Representative Thomas Sawyer expressed hope that "collection and verification of address information in primarily electronic format" from the Postal Service and local governments "will greatly reduce the amount of precensus field canvassing," activity that he indicated had proven "expensive and often inaccurate."[6] Rather than a complete block canvass, the Census Bureau planned to target specific areas with coverage gaps and focus field canvass activities on those areas.

In spring and summer 1997, as a continuous MAF began to take shape, optimism about the completeness of DSF updates gave way to

distinguish between city-style and non-city-style areas, causing frustration for some LUCA participants (Working Group on LUCA, 2001). The process for delineating city-style-address areas should be refined for future LUCA-type programs.

[6]Representative Sawyer's remarks can be found in the *Congressional Record* for the 103rd Congress, page H10618 (October 3, 1994).

doubts, which were compounded by the failure of PALS to obtain address information from local and tribal governments. Internal evaluations convinced the bureau that relying on DSF and LUCA alone could leave gaps in MAF coverage; in particular, the bureau was concerned that "the DSF file missed too many addresses for new construction and was not updated at the same rate across all areas of the country" (National Research Council, 1999:39).

Accordingly, the Census Bureau opted to change course and conduct a full canvass of addresses in mailout/mailback areas "in a manner similar to the traditional, blanket canvassing operations used in prior censuses." The bureau noted that the change would incur a large expense but—recognizing the bureau's concerns—a previous CNSTAT panel "strongly endorse[d] this change in plans" (National Research Council, 1999:25,39).

Plans for the complete block canvass overlapped with the emerging plans for the LUCA program. The bureau originally planned for LUCA 98 to obtain feedback in early 1998, so that resulting changes to the MAF would be ready for the block canvass in late 1999. However, delivery of MAF segments to most participating LUCA 98 localities was delayed. This led to a revised plan that LUCA 98 changes would be compared to the MAF after block canvassing was complete. Further delays led to abandonment of a reconciliation operation in which discrepancies between LUCA and block canvass observations would have been reviewed with localities; instead, localities received a list of accepted and rejected addresses in LUCA's "final determination" phase and were given 30 days to submit appeals to OMB's Census Address List Appeals Office (Working Group on LUCA, 2001).

The TIGER Database

Purpose and Scope

The TIGER database is, effectively, a cartographic resource that defines a complete digital map of the United States and its territories. It is intended to capture not only visible features—the centerlines of streets, rivers, and railroads, and the outlines of lakes, for instance—but the myriad political and administrative boundaries that may not correspond exactly with visible physical locales. Accordingly, the TIGER

database includes the political geography of 3,232 counties or county-level equivalents, over 30,000 county subdivisions or minor civil divisions, and over 20,000 named places, among other political units.

Of the many types of geography defined by the TIGER database, the most important are the boundaries of census blocks. Census blocks are the smallest unit of geography for which basic population data are tabulated in the census, and so it is these fine-resolution data at the block level that are aggregated to form political and other administrative boundaries. TIGER's primary function in census operations is *geocoding*, the matching of a given address or location to the census block in which it lies. Once a location has been matched to the correct census block, its location in higher-level geographic aggregates constructed from blocks is also known, and so census returns may be properly tabulated by geographic unit.

In addition to the geocoding function, the Census Bureau has relied on TIGER for three other major uses (O'Grady and Godwin, 2000; U.S. Census Bureau, 2001):

- *geographic structure and relational analysis:* how one geographic area relates to another, important for being able to aggregate small units like blocks into coherent higher-level aggregates;
- *geographic definitions:* serving as a repository for the current definitions of geography levels recognized by the Census Bureau; and
- *map production and dissemination:* printing the maps used by census enumerators to carry out their assignments.

The full TIGER database maintained by the Census Bureau contains point features along with linear features; in particular, points define the location of known housing units in areas without city-style addresses. However, most public exposure to the TIGER database comes via TIGER/Line files, a public excerpt of the TIGER database that contains only linear features such as roads, rails, and political boundaries (and, hence, not specific housing unit locations). The TIGER/Line files do contain complete street coverages with address ranges; it was the widespread availability of TIGER/Line files that facilitated the emergence and growth of the geographic information systems (GIS) industry.

The TIGER database is one part of a larger TIGER system, which includes the support structure of hardware and software necessary for maintaining the database. When TIGER was initially developed, the database was compiled in a unique and home-grown language defined by the Census Bureau; various software programs to update the database and to produce maps were similarly written to accommodate the custom, internal database language TIGER uses. As we will discuss, the proposed MAF/TIGER enhancements make changes in both the database and system senses, improving the content of the database as well as overhauling the support machinery around it.

How the TIGER Database Began

The TIGER database was developed by the Census Bureau, with assistance from the U.S. Geological Survey (USGS), to support the 1990 census. "TIGER began life as a patchwork quilt of data sources" (O'Grady and Godwin, 2000:6), two of which were primary. One of these sources was the GBF/DIME files used by the Census Bureau to do address matching to street segments in the 1980 census.[7] The GBF/DIME files foreshadowed TIGER in that they applied topological principles in piecing together points, lines, and polygons (Hirschfeld, 2000); they also began the move toward including more than streets and roads in census maps, adding features such as water, rail, and invisible boundaries. However, these files were limited in scope, covering the urban centers of 276 metropolitan areas—"less than 2 percent of the land area but 60 percent of the people in the United States" (Carbaugh and Marx, 1990). To complete the geographic coverage of the nation, the address reference information in the GBF/DIME files was merged with computer-coded versions of the water and transportation features defined by the USGS series of 1:100,000-scale topographic maps (Marx, 1986).

As O'Grady and Godwin (2000:4) note, "accuracy was crucial" when TIGER was first assembled "but only in a relational sense." "The coordinate information presented in the TIGER/Line files is provided for statistical analysis purposes only," wrote Carbaugh and Marx (1990); "it is only a graphic representation of ground truth."

[7]GBF/DIME stands for Geographic Base File/Dual Independent Map Encoding.

Put another way, the priority in early TIGER was to achieve basic functionality for census purposes, which meant favoring relational accuracy (describing how geographic features relate to each other, such as whether census blocks are adjacent) over positional or locational accuracy (precise location of geographic features relative to a chosen standard). Hence, O'Grady and Godwin (2000:5–6) recall that the Census Bureau drew on properties of the USGS maps in publishing the following positional accuracy statement in the documentation for TIGER/Line files released in 1995:

> The positional accuracy varies with the source materials used, but at best meets the established National Map Accuracy standards (approximately ±167 feet) where 1:100,000-scale maps from the USGS are the source. The Census Bureau cannot specify the accuracy of feature updates added by its field staff or of features derived from the GBF/DIME-Files or other map sources. Thus, the level of positional accuracy in the 1995 TIGER/Line files is not suitable for high-precision measurement applications such as engineering problems, property transfers, or other uses that might require highly accurate measurements of the [Earth's] surface.

In addition, the overall positional accuracy of early TIGER was limited by shortcomings in the GBF/DIME files, which were also oriented toward relational accuracy. In particular, Census Bureau enumerators and staff later found that "hydrographic features are not represented well" in TIGER database segments derived from the GBF/DIME files (Rosenson, 2001:1).

Updates to TIGER

Over the course of the 1990s, the TIGER database was updated using additional sources—each with unique (and often unknown) levels of positional accuracy. Among those sources are the following programs that are likely to continue during and after the MAF/TIGER Enhancements Program, although exactly how and when the resulting information will be incorporated—and how the programs might be restructured—is as yet unspecified:

- *Boundary and Annexation Survey (BAS):* an ongoing voluntary survey of local and tribal governments, in which TIGER-generated boundary maps are sent to governments for review and update

- *MAF Geocoding Office Resolution (MAFGOR):* a program in which city-style address records from the Postal Service Delivery Sequence File (DSF)—of which more will be said later—that can not be geocoded in TIGER are referred to census regional offices for review

- *Targeted Map Update (TMU):* a regular program in which census field staff update address ranges, add new streets, and update feature names in selected areas

Digital Exchange One TIGER update mechanism of particular interest is the Digital Exchange (DEX) system, in which local and tribal geographic database files are used to update TIGER features. Building and improving upon DEX's capabilities will be a major part of TIGER realignment in the Enhancements Program.

Developed in the late 1990s, the Census Bureau's DEX system is described in greater detail by Rosenson (2001). Given the unique structure of TIGER and its interface software, DEX does not work directly with the local and tribal geographic files but rather with a processed extract thereof known as an "exchange file." In particular, DEX is strictly limited to working with road features and the attributes associated with them, including ZIP codes. The exchange file derived from a local geographic file is a street centerline database coded using TIGER's structure. This exchange file is then matched to the TIGER file based on spatial location as well as on attribute information (e.g., street name), beginning with matches on the intersection points between named road features in each file.

After matching, one of the files is "rubber-sheeted"—meaning that its features are adjusted to better match attributes in the other file, with neighboring attributes being adjusted simultaneously, as necessary. As Rosenson (2001) notes, this "rubber-sheeting" can be done to either file but, at least in early DEX implementation, the process could introduce topological errors such as lines that cross each other without a system-

defined point marking their intersection. Thus, in order to preserve TIGER's topological structure, DEX manipulates the local "exchange file" to match certain TIGER features.

Though some DEX capability had been developed and selected local geographic files were obtained prior to the 2000 census, active TIGER updating using DEX was deferred during the actual conduct of the 2000 census.

The Need to Modernize

The development of TIGER is a milestone of which the Census Bureau should be extremely proud. A home-grown database management system constructed to manipulate an enormously complex network of visible and invisible boundaries, TIGER became an exemplar of what a geographic information system (GIS) can do. The example of TIGER—and, significantly, the public availability of TIGER/Line files, a full and fine-scale public atlas of the United States—touched off a commercial GIS revolution. Businesses and organizations of all sizes are continuing to learn the power of spatial data analysis, and the work of TIGER to bring together and make publicly available base geographic layers helped make that possible. TIGER is also rightly a source of pride because it successfully satisfied the operational demands of two decennial censuses. The coding system may be (in computer years) old and the structures arcane, but it is a rare in-house software product that can successfully cope with a production cycle of billions of printed maps and millions of addresses for geocoding in the way TIGER did in the 1990 and 2000 censuses.

But, as is the case with some revolutions, the first entrant ushers in tremendous change and then is unable to keep pace with the new world thus created; so it is with TIGER. Though the text-based TIGER/Line files are parsable by commercial GIS applications, modern database tools and the native TIGER database structure are not compatible. Hence, it has not been possible to directly update TIGER's street coverages using the GIS files updated and maintained by local and tribal governments. The Census Bureau's unique role in delineating census blocks—the base units that are aggregated to form most political districts—and ongoing programs such as the Boundary and Annexation Survey (BAS) give the Census Bureau advantages in defining the

invisible political boundaries that cross-cut the nation. But commercial GIS has made it possible for external companies and local and tribal governments to extend from a TIGER/Line base, realigning features when errors are found and making updates to street, rail, water, and other features to a degree that Census Bureau resources have not permitted in the past.

THE MAF/TIGER ENHANCEMENTS PACKAGE

The bureau has set forth five objectives as essential steps in a comprehensive MAF/TIGER modernization. They are spelled out with subtasks, as follows:

1. improve address/street location accuracy and implement automated change detection;

2. implement a modern processing environment;

3. expand and encourage geographic partnership options;

4. launch the Community Address Updating System (CAUS), which has also been known as the American Community Survey Coverage Program; and

5. implement periodic evaluation activities and expand quality metrics.

Objective One: Address/Street Location Accuracy

Objective One—the actual realignment of TIGER geographic features—is the centerpiece of the MTEP, enough so that it has acquired an acronym of its own. The contract to carry out Objective One—also known as the MAF/TIGER Accuracy Improvement Project (MTAIP)—was awarded to the Harris Corporation of Melbourne, Florida, in June 2002.

As described in documentation provided to the panel, the basic subtasks envisioned under Objective One are as follows:

1. correct (in TIGER) the location of every street and other map feature used by field staff and governmental partners for orientation, as well as the location of every boundary used for tabulation of decennial census and household survey data;

2. correct (in the MAF) the location of every housing unit and group quarters from which the decennial census and the household surveys collect data; and

3. implement an effective change detection methodology to document the location of every new street and living quarters, along with the street name and address for each.

Means of Updating Accuracy

As it has been explained to the panel, the basic idea of Objective One is to perform a single, extensive update of TIGER for each county based on an external source with, presumably, more current and accurately positioned feature information. These outside sources may include GIS files developed and maintained by local or tribal governments, commercial GIS files, or digital orthophotography/aerial photography. Once the TIGER data for a county is realigned, it is then poised for continual update through change detection—for instance, addition of features through comparison of TIGER to newer aerial photographs of a region. Through this strategy—extensive initial realignment, followed by change detection—the Census Bureau hopes to maintain TIGER so that its features are current to within 1 year.

Embodied in this general framework is great flexibility for the Census Bureau and its contractor to implement the TIGER update; at present, to the extent that plans have been shared with the panel, this great flexibility translates into very little specificity. The Request for Proposals (RFP) issued to solicit contractor bids to perform Objective One indicates the Census Bureau's strong preference to use local or tribal government GIS files as the update source.[8] However, the panel has not yet seen standards for the level of precision required of these local files, assessments of how many localities have GIS files that meet

[8]The RFP and other documents related to Objective One, the MAF/TIGER Accuracy Improvement project are archived at http://www.census.gov/geo/mod/maftiger.html.

that standard, or specifications for the measurement of local GIS file quality (e.g., comparison with sample field-collected GPS coordinates).

If local or tribal GIS files are not available, then alternative sources are to be used. For example, the Census Bureau has conducted experiments using subcontractors to perform updates based on digital orthophotographs and other image sources. However, it is as yet unclear which mechanism the Census Bureau and the Harris Corporation will favor in the absence of local files (or local files of insufficient quality) to perform the initial, global realignment.

Since it is unclear what exact source will be used for the initial realignment, it is even less clear what source will be used to update TIGER files in the change detection process, and with what frequency this will be done. As we will discuss later, effective communication between the Census Bureau and state, local, and tribal governments must be established in order to accomplish Objective One realignment and change detection.

Priorities

Franz (2002) described the following priority structure that the Census Bureau has identified for carrying out Objective One realignment:

1. *top priority:* linear feature realignment across all areas;
2. establishing/correcting structure locations in areas outside the 2000 census mailout/mailback area;
3. establishing/correcting structure locations inside the 2000 census mailout/mailback area;
4. establishing/correcting locations for residential structures over nonresidential structures, in carrying out the previous two steps.

Schedule

Under plans developed in 2002, the Census Bureau and the Harris Corporation are supposed to realign 250 counties during fiscal year 2003. To meet the goal of completing Objective One by 2008, the timetable for realignment of remaining counties is as follows: 600 in

fiscal year 2004;[9] 700 in 2005; 700 in 2006; 600 in 2007; and 382 in 2008. In principle, change detection to make further alterations is supposed to begin when counties are complete, so that 250 counties are slated for change detection in fiscal year 2004, 850 in fiscal 2005, and so forth, until all counties are handled using change detection methods in 2009.

A bar chart shared by the Census Bureau's Geography Division with the panel indicates the rough level of expected effort on each of the MTEP objectives for each fiscal year leading to the 2010 census. The chart bears out the centerpiece nature of Objective One: during the peak years of activity (2004–2008), the estimated level of effort devoted to Objective One exceeds that given the other objectives combined.

Objective Two: Modern Processing Environment

Objective Two of the Enhancements Program targets TIGER in the systems sense, modernizing the structure of the database. The current home-grown TIGER system suffers from key limitations, prominent among them, the inability to directly link with commercial GIS packages (and hence local and tribal GIS files maintained using those packages) and the limitation that only one module (county) of TIGER may be "checked out" for updating at any single time. Changes to the database structure also require that the suite of support software used to generate products from TIGER—for instance, simply to print maps for field enumeration—must also be reauthored and tested.

The Census Bureau's stated subtasks for Objective Two are as follows:

1. make maximum possible use of commercial off-the-shelf (COTS) and geographic information systems (GIS) tools to allow for rapid development of new applications;

2. customize the COTS/GIS tools to the minimum extent possible to avoid schedule and cost obstacles when the COTS/GIS vendors deploy new versions of their software.

[9]The figure of 600 counties is included in the detailed description of the Bush administration's budget request to Congress for fiscal year 2004.

Based on a chart provided to the panel, fiscal year 2003 is anticipated to be the peak year of Objective Two work, with some slight drop-off in fiscal 2004. Residual effort is expected in fiscal 2005 and 2006, with Objective Two not listed as an activity in 2007 or later years.

Objective Three: Geographic Partnerships

Objective Three acknowledges the crucial role of state, local, and tribal governments in maintaining geographic resources, not only for the TIGER realignment of Objective One but for continued update of the MAF, as in the LUCA program.

Subtasks of Objective Three identified by the Census Bureau are as follows:

1. devise and deploy new strategies to communicate more effectively with governments to increase the level at which they participate in MAF/TIGER review and update activities;

2. devise and deploy new ways in which to integrate more effectively the address list review, street update, and boundary reporting activities that now exist as separate programs;

3. establish new partnerships with other federal agencies and private-sector firms that have GIS and address files with information of value to an accurate and complete MAF/TIGER.

Based on a chart provided to the panel, fiscal year 2004 is anticipated to be the peak year of Objective Three work; the level of effort expected on this objective in each of the years 2003 and 2005 through 2010 are shown to be roughly equivalent.

Objective Four: Community Address Updating System

Briefly known as the ACS Coverage Program, the Community Address Updating System (CAUS) is the address list update component of the proposed American Community Survey (ACS). The basic idea of the program is to make use of the continued field presence that would be necessary to conduct the ACS, allowing ACS enumerators the opportunity to provide geographic updates. One hope is that the ACS enumerators might be particularly helpful in identifying geographic and

housing changes in rural areas, where local and tribal files might be less detailed (or unavailable).

The Census Bureau has identified the following subtasks for Objective Four:

1. focus on predominately rural areas in which the U.S. Postal Service's Delivery Sequence File (DSF) does not effectively identify the existence or location of new housing units;

2. provide address list (and street) updates beyond what can be identified through the current twice-yearly DSF "refresh" process to ensure a uniformly accurate sampling frame nationwide for the ACS and the other household surveys.

Through contractors, the Census Bureau has developed prototype Automated Listing and Mapping Instrument (ALMI) software, making use of a GPS receiver and a laptop computer. The ALMI system could permit ACS enumerators who encounter a new street that is undefined in TIGER to record a GPS trace as they drive along the street and to note location of houses along that street; these inputs could later be converted to TIGER.

Based on a chart provided to the panel, the anticipated level of effort that the Census Bureau expects to expend on Objective Four is roughly equivalent during each of the fiscal years 2003–2010.

Objective Five: Evaluation and Quality Metrics

Finally, Objective Five raises the issue of assessing progress and quality; subtasks identified by the Census Bureau for this Objective include:

1. provide quality metrics information that will guide (target) areas in need of corrective action beyond the changes identified in the change detection and CAUS activities;

2. document the progress being made to improve the accuracy and completeness of the street, address, and boundary information in MAF/TIGER; and

3. assure the availability of accurate and comprehensive metadata that meet federal standards about the information in MAF/TIGER.

Based on a chart provided to the panel, the anticipated level of effort that the Census Bureau expects to expend on Objective Five is roughly equivalent during each of the fiscal years 2003–2010.

ASSESSMENT OF GEOGRAPHIC MODERNIZATION EFFORTS

Locational Accuracy of TIGER

Problems with the positional accuracy of TIGER have been apparent to the Census Bureau and its users for some time; anecdotal experience of problems with TIGER representations developed from the experience of field enumerators during the 2000 census and from feedback from local and tribal governments who participated in LUCA (Working Group on LUCA, 2001). Quantitative evidence of TIGER discrepancies can be found in Liadis (2000), the report of a Census Bureau experiment that collected GPS position readings for approximately 6,700 "anchor points" spread across selected census tracts in eight counties. Distances could then be computed between these "ground truth" coordinates and the longitude/latitude combination coded in TIGER. The results show evidence of strong local variation, even across tracts within the same county. The distance between TIGER representation and ground truth varied with respect to the operation that introduced the point into TIGER. Somewhat ironically, more recent update programs—which added features by digitally inserting them as freehand drawings—accounted for the largest deviations from ground truth, while pre-1990 sources (e.g., GBF/DIME files) and programs involving direct use of local and tribal geographic files (e.g., DEX) generally came closest to true locations. The Census Bureau's Geography Division also conducted pilot experiments comparing—for small geographic samples—TIGER coordinates to a combination of GPS coordinates and commercially available cartographic databases (U.S. Census Bureau, Geography Division, 2000) and to digital orthophotos giving an aerial view of ground features (O'Grady, 2000).

Though the extent of TIGER inaccuracy may be unknown, there is enough extant evidence available that the panel decidedly concurs regarding the basic nature of the problem. Roads, boundaries, and other geographic features are sufficiently misplaced, and with enough regularity, that the TIGER database is in need of a comprehensive update; moreover, raw TIGER/Line files cannot be fully trusted for routine GIS and non-GIS-related tasks. Accordingly, the major motivation behind Objective One of the enhancements package is well taken.

Having concluded that locational error in TIGER is sufficiently clear as to require correction, it follows naturally that accomplishing the basic task envisioned under Objective One is essential to the modernization of the census. GPS coordinates collected by MCDs are only useful to the extent that they can be accurately placed onto base maps with streets and other key features. An accurately aligned TIGER, faithful to polygonal features such as municipal boundaries, can be passed along to localities and made available on the Internet, thereby allowing local and tribal entities the opportunity to report changes made to both linear (e.g., road and railroad) and polygonal features (e.g., administrative borders collected by the Boundary and Annexation Survey) in a more efficient and accurate way. If localities can readily utilize an aligned TIGER for geocoding their own address files, comparisons with (and updating of) the MAF can more closely resemble routine work.

Hence, the panel supports Objective One of the enhancements package and it is heartened by the general steps taken to accomplish the objective. In particular, the panel views the acquisition of an outside contractor as a sign of significant progress, rather than keeping TIGER updating as a purely in-house operation. As Census Bureau staff noted in an interview, it is indeed a "very major departure for us" to seek external help in retooling TIGER, but "we've come to the conclusion [that] we need to take advantage of [vendors'] expertise and understanding" (O'Hara and Caterinicchia, 2001).

In the panel's assessment, the Census Bureau deserves generally high grades for Objective One and its determination to fix a major problem as well as the boldness of the approach. That said, concerns about the work remain, and the plausibility of the Census Bureau's ambitious realignment timetable would be bolstered considerably through attention to the following:

- a detailed work plan, including some notion of the order in which counties will be initially updated;
- specification of the desired positional accuracy standard of the realigned TIGER, coupled with specifications for the positional accuracy required of local and tribal GIS files; and
- specification of plans for the post-realignment change-detection program.

In addition, a subtle point raised in our earlier discussion of the Census Bureau's Digital Exchange (DEX) program deserves fuller explication. Given two GIS files (a local file and the TIGER data), a "rubber-sheeting" process manipulates certain matched features in one file to conform to the other, shifting related features automatically. The Census Bureau's early DEX system altered the local file to follow known features in TIGER to avoid topological bugs that may result otherwise—a justifiable choice, but one that intuitively runs counter to the basic purpose of updating the presumably misaligned TIGER based on presumably accurate local files. Additional detail on how the Harris Corporation's alignment tools handle topological gaps and address the conflation between local and TIGER files could strengthen confidence in the finished product.

A point of some contention between the panel and the Census Bureau has been the order in which Objective One realignment will be performed. Aside from indicating that jurisdictions involved in mid-decade census tests or dress rehearsals will be given priority, the Census Bureau has not given a clearer idea of how it expects the flow of county-by-county processing to proceed. The notion of ordering is understandably somewhat sensitive, since no locality would relish being last in the queue. However, the ambitious timetable laid out earlier in this chapter is unrealistic—at best—without some sense of ordering. The alternative—effectively starting 3,232 independent updating efforts simultaneously and hoping that 850 fall into realignment by the end of 2004—does not inspire much confidence. There is no right answer to the question of ordering—conceivable mechanisms include starting with urban counties or rural counties, starting with original GBF/DIME areas, sequencing by population, or sequencing by some assessment of how out of alignment TIGER is for an area. But provid-

ing some manner of structure to the task seems essential to measuring progress along the way to complete realignment and could add plausibility to the hypothesized timetable.

Modernizing the Toolset

Similarly, we applaud the Census Bureau's efforts to adopt GPS technologies and a modern processing environment using COTS products to achieve Objectives One and Two. This is already a long-term project and, to our knowledge, database requirements have yet to be finalized. Clearly a considerable effort is needed before the right combination of COTS products can be determined, and this needs to be carried out so that the system can be given a full-scale test prior to Census 2010.

With respect to Objective Two, the conversion to a modern database environment, the panel has two major points of concern. First, the difficulty of making the conversion work should not be underestimated. In early discussions with the panel, the conversion was characterized as a fairly easy step: a new database structure would be identified and new support software would be written (and tested, certified error free). Work on the TIGER database could then be suspended for a period of a few days, information ported over to the new structure, and the task would be done. All experience with such upgrades—particularly one that strives to raise the Census Bureau's Capability Maturity Model (CMM) score for software engineering at the same time that completely new systems are deployed—suggests that such a rosy scenario is misguidedly optimistic.

Second, the design of Objective Two and the new MAF/TIGER system should be coordinated with the broader technical architecture program described in Chapter 2 and should follow similar techniques. As with MCDs, it is more important to model the work and information flows that must be channeled in a modernized MAF/TIGER environment and to tailor the physical architecture accordingly, rather than lock into specific packages or programs too early. An architecture-based approach—coordinated with the rest of the Census Bureau—may add structure to the system of inputs and outputs to MAF and TIGER, including the information that is requested from state, local, and tribal governments.

Quality Metrics

Going further, we note that the Census Bureau has made significant steps toward establishing metrics to evaluate improvements in accuracy, as called for by Objective Five. Work with contractors has brought about an image-based rough assessment system that allows accuracy checks on incoming files, as well as progress on DEX evaluation of files on the basis of control points, and a soon-to-be installed system for quantifying and tracking MAF/TIGER errors over time. It is essential, in our view, that quality assessment through such metrics be an ongoing and well-timed process so that updating of the database achieves the apparent goal: information in MAF/TIGER maintained to a currency of 1 year or less at all times.

WEAKNESS: ENHANCING THE MAF

The MAF/TIGER Enhancements Program will make improvements to TIGER that are necessary, given known problems with TIGER accuracy. In other words, the MAF/TIGER Enhancements do show promise for enhancing TIGER. But, for the sake of census accuracy, a more important question is how the program will enhance the MAF—that is, how it will add new addresses, screen for duplicates, and generally ensure that address rosters are as complete and accurate as possible. It is on this score that the Enhancements Program falls seriously short, in our view, due to lack of development in Objectives Three and Four. More generally, the Census Bureau's current strategy shows relative inattention to MAF improvement and shows signs of repeating costly errors from the 2000 experience.

Alone, the magnitude of the Objective One task of realigning TIGER features—and the monetary cost associated with it—gives the Enhancements Program a TIGER-centric feel. But Objectives One, Two, and Five seem to speak to MAF largely as it inherits its quality from TIGER. Indeed, the Bush administration's fiscal year 2004 budget message to Congress described the geographic leg of the Census Bureau's 2010 strategy as a plan for "enhancing the Census Bureau's geographic database and associated address list." In line with our comments in opening this chapter, the MAF is too critical to the

quality of the census and other survey programs to be treated as an add-on or adjunct.

Current Plans for MAF Updates for 2010

The Census Bureau argues that the combination of three activities—"the ongoing MAF/TIGER updating using the Delivery Sequence File, CAUS, and enhancements included in the proposed MAF/TIGER modernization initiative"—"should result in an up-to-date address list for the entire United States" (U.S. Census Bureau, 2003a:11). More specifically, the update strategy is based on a rough urban/rural dichotomy:

- The Postal Service's DSF is intended to be the address update source "in areas where DSF addresses can be assigned a physical location, such as urban areas with city-style addresses" (U.S. Census Bureau, 2003a:9).

- "In rural areas with non-city-style addresses, this [DSF update] process cannot be used," and so the Census Bureau intends to update this segment through CAUS. The bureau indicates that the areas for which DSF updates cannot be used "encompass the majority of the Nation's land area and about 15 percent of the population" (U.S. Census Bureau, 2003a:9).

These update sources would be supplemented in the MAF/TIGER Enhancements Program, which we interpret to mean a successor to the 2000 census LUCA program under Objective Three.

The backbone of the Census Bureau's update strategy is the twice-yearly "refresh" that comes from the Postal Service's Delivery Sequence File. These regular updates are considered to be part of the bureau's Geographic Support Base Program, not the MAF/TIGER Enhancements Program. As we noted earlier, the DSF is undoubtedly an important source of address information, and we do not mean to imply in any way that its use is either wrong or inappropriate. However, reliance on the DSF as the principal source of address updates for (by the bureau's estimate) 85 percent of the household population raises concerns in at least three respects:

- *Historical precedent in the 2000 MAF-building process.* As we indicated earlier, DSF updates were also viewed by the Census Bureau as a centerpiece address source after the 1994 passage of legislation that enabled sharing with the Postal Service. However, the bureau perceived problems with the level of DSF coverage in fast-growth and new construction areas and, consequently, initiated a costly complete block canvass (National Research Council, 1999).

- *Effectiveness in 2000 unknown.* As we will discuss in considerable detail later in this chapter, evaluation work that would explain how the various sources that were merged to form the 2000 census MAF remains incomplete. Therefore, the effectiveness of DSF updates in providing valid census addresses (as well as duplicates) has not been empirically established. Worse, the Census Bureau's planned evaluation study on the DSF—F.1, "Impact of the Delivery Sequence File Deliveries on the Master Address File through Census 2000 Operations" (U.S. Census Bureau, 2002a)—was inexplicably cancelled in late 2002 (U.S. Census Bureau, 2003b).[10]

- *Limitation of DSF to mail delivery population.* Again, by definition, the DSF is intended to document mail delivery addresses, which is not equivalent to the complete list of housing units in the United States.

The Census Bureau's planned activity to update addresses in rural areas is CAUS, which—to briefly review—is an associated program of the American Community Survey (ACS). Under CAUS, ACS field representatives would list addresses (and update streets, using traces from a

[10]The planned evaluation was intended to "assess the impact of each of the [DSF updates performed prior to 2000] through Census 2000 operations by profiling the number and characteristics of housing units added to and deleted from the MAF following each delivery of the DSF" (U.S. Census Bureau, 2002a:C-56). Of its cancellation, all that is said is that "this evaluation will not be conducted. In late 2002, the Census 2000 Evaluation Program was refined and priorities reassessed due to resource constraints at the Census Bureau" (U.S. Census Bureau, 2003b:2). The bureau's planned "synthesis report" on address list development evaluations may comment on DSF contributions, but that report has not been completed.

GPS receiver) through a laptop computer–based tool known as the Automated Listing and Mapping Instrument (ALMI). However, general concerns raised by dependence on CAUS as an address update source include the following:

- *Linkage to ACS funding.* Full funding for the ACS has not yet been secured; consequently, the budgetary viability of CAUS is not known. Full implementation of CAUS must also await full-up mobilization of ACS support staff (and, presumably, more elapsed time as establishing ACS operations takes priority), which adds to the delay in the possible receipt of CAUS updates. Finally, the number of possible CAUS field personnel is obviously linked to the number of ACS enumerators; while it is hoped that budget commitments to ACS would not oscillate, CAUS effectiveness could also be impaired if ACS funding is not stable over the years.

- *ACS workload management.* It is unclear how much time and manpower ACS managers will commit to side work on address listing given the ambitious timetable of ACS data collection.

- *Unclear/unspecified mechanism for targeting areas for update.* The exact means by which CAUS representatives would be deployed to collect information in particular geographic areas are as yet unspecified. One such means is for enumerators to list new streets or developments they find by happenstance in carrying out their regular ACS work, but that is surely an unreliable means of covering the entire rural population. The draft ACS operations plan indicates that "ACS planners [will] use various methods for identifying where coverage is insufficient," including "work with community officials to acquire information about new addresses, new streets, and/or areas of significant growth" (U.S. Census Bureau, 2003a:10). But, again, the mechanics of this targeting are uncertain.

The third element in the address update strategy—a LUCA-type program—is a topic we will discuss in greater detail in a later section. But, for the purpose of the argument at hand, the major concern regarding a new local address review program is simply that no prototype plans have yet been developed.

We assume that the bureau hopes to avoid a complete block canvass prior to the 2010 census, given the cost of that operation and that it was treated as a last resort in 2000. However, in the absence of evidence that the combination of DSF and LUCA leading up to 2010 can overcome the last-minute doubts that arose in the late 1990s and without a clearer plan for CAUS—it is difficult to see how a full block canvass can be averted.

The Census Bureau needs to outline goals pertaining directly to MAF without particular regard to TIGER geography—for example, in the development of quality metrics and the identification of housing unit duplication. Overall milestones and tasks need to be specifically set for Objectives Three and Four, with particular regard to the ways in which activities in these objectives may work to control housing unit duplication and to more accurately identify and account for multi-unit housing structures. It also needs to expeditiously complete (and augment, as necessary) its evaluation work on the construction of the 2000 MAF, since that work is crucial to bolstering the case for the 2010 address update strategy.

Recommendation MAF–1: In articulating the MAF/TIGER Enhancements Program and defining its strategy for updating the MAF for the 2010 census, the Census Bureau should provide clearer details on how the MAF/TIGER Enhancements Program and other geographic programs will add missing addresses, remove duplicate addresses, and generally correct the Master Address File, independent of benefits derived from being cross-referenced to an updated TIGER database. In particular, the Census Bureau should use data from the 2000 census process to test the adequacy of the U.S. Postal Service's Delivery Sequence Files, the Community Address Updating System, and as-yet unspecified local partnership programs as primary contributors of new addresses.

Maintaining the MAF as a Housing Unit Inventory: Multi-Unit Structures and Duplication

An important first step in enhancing the MAF is an examination of the definition, identification, and systematic coding of housing units

(and, by extension, group quarters). For census purposes, the Master Address File's most fundamental purpose should be to serve as a complete register of housing units. The current MAF/TIGER Enhancements impart some benefit to MAF entries by virtue of their linkage to TIGER but do little to address two fundamental problems that hindered MAF's effectiveness as a housing unit roster in the 2000 census.

The first of these are multi-unit structures—physical buildings that contain more than one housing unit. Particularly problematic are small multi-unit structures, facilities, and homes with multiple residents but whose divisions into subhousing units is not obvious. A realigned TIGER database may offer a precise location for a structure—an aerial photograph may confirm a structure's existence or point to the construction of a new one—but that added precision is ultimately of little use if the address roster of subunits within the structure is unknown or inaccurate. Multi-unit structures pose problems conceptually (e.g., should a finished basement in a house that is sometimes offered for rent be counted as a unit?) and technically (e.g., do different data sources code an apartment as 3, 3A, or 3-A?), and deserve research during the intercensal decade.

A second problem that hindered MAF in the 2000 census was housing unit duplication. Duplication is an ever-present problem in a resource like the MAF, an amalgam of various sources. It was evidence of housing unit duplication that prompted an unplanned, ad hoc process—effective but risky—to filter potential duplicates during the actual conduct of the census in 2000 (Nash, 2000). It is possible that precise GPS coordinates may be useful in identifying some duplicates (e.g., structures at a street intersection that may be recorded on one street in one source and on the cross street in another source), but broader, more systemic sources of duplication should also be a research and evaluation focus leading up to 2010. As we will discuss later, identification of MAF input sources that contributed duplicate addresses will provide vital evidence in remedying duplication problems.

NEED FOR A MAF IMPROVEMENT COORDINATOR

In Chapter 2, we advocated the creation of a new position within the Census Bureau—a system architect for the decennial census—with the primary goal of integrating and coordinating effort on architecture remodeling. It is our view that improving the MAF is likewise an area that

would benefit greatly from refocused staff effort. At least four major divisions within the Census Bureau (Geography, Field, Decennial Management, and—with the ACS—Demographic Surveys) have a strong stake in the maintenance and use of the MAF. Given the legitimate (but sometimes competing) interests of the various divisions, it would be useful to vest responsibility for coordinating MAF improvement and research in one office with connections and the ability to work with all relevant divisions.

Recommendation MAF–2: The Census Bureau should designate a resident expert to oversee the development and maintenance of the MAF as a housing unit inventory, with a focus on improving methods to designate, list, and update units. The bureau should give high priority to discussion and research, within the bureau and with experts outside the bureau, on the following:

- **more effective means to define, list, and enumerate housing units and incorporate those changes into the housing unit inventory;**
- **more effective ways to define, list, and enumerate group quarters arrangements;**
- **sources of address duplication and possible remedies; and**
- **listing and enumeration in multi-unit structures.**

GEOGRAPHIC PARTNERSHIPS

To its credit, the Census Bureau has recognized the importance of partnerships with local and tribal governments by designating their creation and maintenance as Objective Three in the Enhancements Program. The Census Bureau's RFP for the TIGER realignment of Objective One makes this clear, noting that "the success of the Accuracy Improvement Project, and the continuous update of the information in MAF/TIGER, requires ongoing interaction between the Census Bureau and its federal, state, local, and tribal government geographic partners." To its detriment, though, the Census Bureau has not provided

clear indication of how partnerships would work. While the panel acknowledges that the funds available for expanding and encouraging geographic partnership options have been limited, the cryptic descriptions of Objective Three that we have received to this juncture do not make it clear how the Census Bureau intends to involve local and tribal partners in these programs.

A major stated role for local and tribal geographic partners is to contribute to Objective One—to share their current GIS files with the Census Bureau to support realignment. In this matter, and in past geographic interactions such as LUCA, the Census Bureau often has perceived "partnership" as a one-sided exchange: "partners" expend resources and turn information over to the bureau. The principal reward to a local or tribal government for entering into this kind of partnership is definitely not trivial: the prospect of a more accurate census count. The Census Bureau is not a fund-granting organization and hence can not directly subsidize local or tribal governments to improve and submit their geographical resources. That said, the Census Bureau should explore means of building partnerships that are true exchanges of information: for instance, giving census field and regional staff an increased role in interacting with local and tribal governments and collecting information updates. At the very least, steps should be taken to lessen the burden of partnership: conducting LUCA-like address list reviews in electronic form with submissions via the Internet and (as mentioned earlier) coordinating the various geographic data collection programs so that localities are not being asked for similar information in different formats by different divisions of the Census Bureau.

The Census Bureau needs to articulate a plan for communication with localities that takes advantage of existing structures, including the State Data Center Network, the Federal-State Cooperative Program for Population Estimates, State/Regional Councils of Governments, and other local governmental entities. The role of the Census Regional Office Geographic Coordinators relative to these entities and to Census Bureau headquarters needs to be spelled out.

The ability and willingness of different governments to join forces with the Census Bureau vary widely. It is inevitable that tensions will arise when local efforts are differentially expressed across different areas of the nation, whether such effort be devoted to mapping, to address listing, or to the nurturing of partnerships. Different areas should receive equal treatment in the spirit of fairness, yet local interest, fea-

sibility, and cost-effectiveness might well dictate otherwise. Moreover, geographic partnerships with local and tribal governments are useful to tap the knowledge and expertise of those closest to the field, but those partnerships are not a panacea. Variation in geographic information systems usage may impact the accuracy in local and tribal government geographic resources and could in cases introduce error when mixed with census resources.

In the interest of effectiveness, the successes and failures of prior LUCA programs should be analyzed in order to develop new community participation programs for 2010. Moreover, refined evaluation of the 2000 address file by type of enumeration area, by dwelling type, by the contribution of geographic update programs like LUCA, and by region of the country—highlighting areas of the country where eliciting local and tribal information may be most beneficial—is surely required if the Census Bureau is going to maintain the MAF in a cost-effective manner in the years leading to the 2010 census. The Census Bureau's future plans for LUCA and other partnerships programs should also include provision for evaluation of those very partnerships, not only to inform the effectiveness of local contributions from the census perspective but also to provide feedback to participating local and tribal governments.

Recommendation MAF–3: The Census Bureau and the Geography Division should move as expeditiously as possible to develop and describe plans for partnerships with state, local, and tribal governments in collecting address list and geographic information. Such plans should include a focus on adding incentive for localities to contribute data to the census effort, making it easier for localities and the bureau to exchange geographic information. Plans for partnerships should clearly define benchmark standards for local data to be submitted to the bureau.

THE KNOWLEDGE BASE FOR 2010: CURRENT AND FUTURE EVALUATION WORK

A recurrent theme in our preceding remarks is that there is a strong need for empirical evaluation of the construction of the MAF for the

2000 census. The foundation of the Census Bureau's evaluation studies along these lines is known as the MAF Extract. Related to the Decennial Master Address File—the "snapshot" of the MAF that was used to generate census mailing labels and to monitor mail response—the MAF Extract includes "flags" that indicate which of several sources contributed the address to the MAF. The MAF Extract also contains selected outcome measures, such as whether the address record was actually used in the 2000 census and whether it was tagged as a potential duplicate during the ad hoc duplicate screening program of early to mid-2000 (Nash, 2000).

The MAF Extract has certain liabilities, chief among them that the system of flags used to indicate the source of an address does not constitute a true history of the address on the MAF. Other than rough temporal ordering of the input sources themselves, it is usually impossible to determine which source first contributed the address. Still, the extract is critical to answering key questions about the MAF-building process, and the panel continues to urge that the data resource be tapped for as much information as possible.

Analyses of the extract should be conducted with respect to the type of enumeration area the address belonged to for the 2000 census (e.g., mailout/mailback or update/leave), as well as by geographic region of the nation. The main objective of analysis of the MAF Extract is not to highlight how different areas of the country may have fared under various programs in place at the time. Areas of the country do differ, but knowledge of how they respond and interact with census activities is essential knowledge for the planning of future census programs (see Question 6 below, for instance).

Some key questions to address through Census 2000 evaluations are the following:

1. Why were addresses included in the MAF but not in the 2000 census?

   This question provides perspective for the others on this list and is a good starting place.

2. How useful were the DSF updates in the identification of new units, especially in high-growth areas of the nation?

   The goal is to examine how much of the newest housing was picked up in a timely fashion by the U.S. Postal Service. An-

swers provide valuable clues about the effort the Census Bureau should put into other avenues (e.g., new construction program) as sources of information on new housing.

3. How effective were LUCA inputs relative to what was already known (or was promptly seen) in a DSF update? Of those contributions that can be determined as "unique," how many governments were represented and what kind of housing do these addresses represent?

   While LUCA must be conducted in 2010, the resources the Census Bureau chooses to expend on it can vary dramatically. Also, the answer to this question can inform strategies for the LUCA program in 2010.

4. What were the original sources of address records that were deleted as duplicates in the ad hoc duplicate identification and removal process conducted in 2000?

   Duplication that is tied to address listing anomalies can be rectified once the problems with duplicate addresses have been identified. Identifying the original contributing source of affected addresses is a prime means for doing that.

5. What were the original sources of addresses that were flagged as potential duplicates but later reinstated?

   This addresses the hypothesis that some addresses, originally considered as potential duplicates, were put back into the census in error. The Census Bureau already has an estimate of this number. By identifying the original sources of the addresses, the bureau will have valuable clues about what produced this problem and how to avoid it in the future.

6. What were the original sources of addresses for housing units where an interview was not obtained in nonresponse follow-up (NRFU)?

   One hypothesis regarding the shortfall of long-form data in the 2000 census has to do with NRFU enumerators encountering high levels of resistance from respondents who were being enumerated for the first time ever (some were there in 1990 but escaped detection). Where did the addresses of these

tough-to-enumerate units fall? (Of course, this is not the only hypothesis that could explain problematic long-form data; it is almost certainly not the most likely hypothesis, either. But it is an intriguing question that should be addressable using internal Census Bureau data on the MAF.)

7. What were the original sources of addresses for housing units when the housing unit was declared to be nonexistent or could not be found in NRFU?

   NRFU enumerators had the option of entering codes for "cannot locate," "duplicate," and "nonresidential," among others, as reasons for listing a unit as "nonexistent." Were these potential duplicates added back in? Were erroneous addresses brought in from LUCA that were not detected by the Census Bureau? Or were these addresses disproportionately from some other original source?

8. For cases where a unit was determined not to exist in coverage improvement follow-up (CIFU; the final follow-up stage during the actual fielding of the census), what was the original source of the address? How many addresses were erroneously kept in the census and then deleted when the bureau went out to check in CIFU?

The 1990 ACF, the initial 1997 DSF update, and block canvassing account for a very large percentage of all addresses in the 2000 census in mailout/mailback areas. In absolute terms, these sources will dominate any original sources in a volume analysis. Nonetheless, normalizations are possible so that the Census Bureau can more properly quantify the real contributions of various inputs to those addresses that were considered correct in the 2000 census. Most especially the effect, and perhaps differential effect, of LUCA programs needs immediate attention. In this last assessment, account should be made of the sometimes faulty nature of the LUCA program in the 1990s, timing and map accuracy problems among them.

Completed Evaluations

As part of the evaluation process for the 2000 census, an evaluation "topic report" on address list development was scheduled for release

in June 2003.[11] This report will synthesize the results of individual evaluation reports related to the general topic. It is expected that the detailed individual reports will be released in conjunction with the topic report. Consistent with its previous recommendations, the panel urges the Census Bureau to continue to make evaluations related to address list development a priority and to actively incorporate them into 2010 planning, including the census field test in 2004.

The panel has received access to a small number of individual topic evaluations that are not yet publicly available. These include: *Assessment of Field Verification* (Tenebaum, 2002); *The Address Listing Operation and its Impact on the Master Address File* (Ruhnke, 2002); *Block Canvassing Operation* (Burcham, 2002); *Evaluation of the Local Update of Census Addresses 99 (LUCA 99)* (Owens, 2002); and *List/Enumerate* (Zajac, 2002). Though they are not yet publicly available, we do wish to offer some comment on them to help guide future evaluation work.

Field Verification

In field verification, enumerators visited the locations of units with returned questionnaires lacking an assigned census ID number, to verify existence. These responses came from the Be Counted Program,[12] from Telephone Questionnaire Assistance, and other alternative response modes. Some 885,000 cases were subject to this verification step. About half of them were coded as valid; about a third of them were coded as deletes; the remainder as duplicates. Of particular interest: more than half of the addresses that had been deleted in two or more previous operations were coded as valid addresses. Tenebaum (2002:11) suggests "that the Bureau may need to conduct additional research into the source of the double deletes with a mail return to try to determine why they were deleted in two or more previous operations." We would like to see this research, with an emphasis on address histories and especially original sources, and with further detail on geographic locations and multi-unit dwellings. Some of the geographic detail is here by regional census office and by type of local

[11] As of the end of July 2003, the report had not yet been made publicly available.

[12] The Be Counted program allowed respondents who felt that they had been missed in the mailout of census forms to pick up a census form from public offices and submit it.

census office; some data are also available on the multi-unit addresses involved in field verification.

Address Listing Operation

The Address Listing Operation (Ruhnke, 2002)[13] appears to have been quite successful, if not efficient. It is noteworthy that among some 22 million addresses added to the MAF by this operation, 99 percent of them were deliverable to the DMAF and 43 percent of them matched to addresses identified as residential on or before the September 1998 DSF. However, the performance of Address Listing in handling multi-unit structures is hindered by a flaw in the definition of the MAF variable containing the number of separate housing units at a basic street address (BSA). Specifically, all non-city-style addresses—which constitute at least 14 percent of the cases added by address listing—are automatically considered single units. Although the evaluation report contains some geographic disaggregation (breakdowns by state), much of the report has little bearing on the questions we have listed above.

Block Canvassing Operation

The Block Canvassing Operation (Burcham, 2002) played a big role in improving the coverage of addresses on the MAF and in improving the associated geocoding, presumably at considerable expense. Block canvassing produced 6.4 million additions (some 30 percent of which were corrections or completions of addresses already on the MAF and some 35 percent of which were in multi-unit BSAs). Among the 6.4 million additions, 78 percent of them were valid addresses for the 2000 census. There were 5.1 million deletions (of which 48 percent were in multi-unit BSAs) and 24 percent of them turned out to be valid addresses for the 2000 census. Burcham (2002) provides some mention

[13]The Address Listing Operation was used to build an initial address list for geographic areas of the country that were to be enumerated using update/leave methodology. Between July 1998 and May 1999, census field staff went door-to-door in these designated areas, making a list of mailing addresses and locations as they went along. The results from this operation, Address Listing, were then used to assign work during the actual census. In 2000, census field enumerators visited these sites to leave census questionnaires and logged MAF updates they encountered (hence the update/leave terminology).

of particular areas—a large number of LUCA 98 deletes occurred in Cook County, Illinois, clustering of adds and deletes was found in Vermont, and there were many nonresidential deletes in Los Angeles, for example—where local information appears to resolve outlying results. These case studies provide useful lessons for future reference; a good deal of information is broken down by state. The report does touch on our Question 3 about LUCA but adds little information central to it.

LUCA 99

Reports by the Working Group on LUCA (2001) and the National Research Council (2001a) provide further insight into levels of LUCA *participation* by size of government and geographic location. However, only the Census Bureau evaluations can provide a picture of LUCA *effectiveness* by key variables.

Owens (2002) provides some information pertinent to Question 3, of which the following is perhaps of most interest to the panel. Participation rates were higher for larger governmental bodies; 2.2 million LUCA 99 addresses were subject to recanvass with about 76 percent being verified, 18 percent corrected, and 6 percent deleted; recanvassing itself added 328,000 addresses; some group quarters may have been added through LUCA 99 and the subsequent recanvassing; some of this information is broken down by state.

List/Enumerate

List/Enumerate (Zajac, 2002) added about 390,000 addresses to the MAF in sparsely populated areas of the country, more than 99 percent of which were included in the 2000 census; a rough estimate of cost per address is $50. A fair amount of information is broken down by state. Evaluation here does not provide many answers to questions posed earlier.

General Assessment

MAF evaluation work is required if the Census Bureau is to assess targeting methods for the ultimate goal: "to accurately identify local areas with potential MAF/TIGER coverage/quality problems," especially as it concerns the 2004 tests (Waite, 2002). In this vein, some of the

Census Bureau's forthcoming evaluation studies are of particular importance. One of these is the Housing Unit Coverage Study (Barrett et al., 2001) that deals with erroneous enumerations by MAF source; we suggest that the Census Bureau focus on erroneous enumerations by type (e.g., duplicates).

The evaluation reports provided to us generally give volumes and rates of adds/deletes that, when of interest, lack sufficient detail to be of use in guiding cost-effective strategies for targeting areas for coverage and address list improvement. Waite (2002) mentions the relative stability of the address list in the 2000 census as a tool for MAF targeting—we certainly endorse this thought, but we have not seen what is planned in this regard. Evaluations do not, as yet, yield much information on the added cost and benefit of programs. This information is surely crucial to the decision-making process during the present decade. Evaluations and presentations still fall short of alleviating our fear that the process of maintaining and updating the MAF in the near future becomes the default one of acquiring DSFs on some regular schedule, with augmentation from LUCA programs after field verification on a need-to-know basis. We have seen too few signs that cost and effectiveness of various address sources are understood on the basis of what transpired in the late 1990s. Such understanding remains an issue of the highest possible priority.

Recommendation MAF-4: Consistent with the panel's related recommendations on evaluation studies and the crucial importance of address list issues in conducting the census, the Census Bureau should:

1. **strive to fully exploit the information on address sources contained in the MAF Extract in completing 2000 census evaluations and assessing causes of duplicate and omitted housing units; and**
2. **build the capability for timely and accurate evaluation into the revised MAF/TIGER data architecture, including better ways to code address source histories and to output data sets for independent evaluation purposes.**

— 4 —
American Community Survey

PUT FORWARD AS A POTENTIAL REPLACEMENT for the decennial census long form in 2010, the American Community Survey (ACS) is a major household survey anticipated to include 250,000 housing units each month. The hope underlying the ACS is that, when fully operational, the survey will provide continuous information on demographic characteristics, social welfare participation, education and health status, commuting patterns, distribution and frequency of crime, and other important attributes of the population of the United States.

Until now, the equivalent of the ACS has only been conducted on a limited scale. Pilot data collection of the ACS began in selected test sites in 1996—a geographic base that reached 31 sites by 1999—and the resulting data have fed into reports of the feasibility of quality data collection.[1] In conjunction with the 2000 census, a larger-scale prototype

[1]Some of the 31 test sites are blocks of adjacent counties, but most are single county sites. Hence, in the dialogue that has emerged regarding the ACS, "31 test sites" and "31 counties" are used fairly interchangeably even though the test sites span 36 counties (U.S. Census Bureau, 2003a).

ACS began operations, involving 700,000 households per year. Data for this survey, known as the Census 2000 Supplementary Survey (C2SS), were first collected in 2000, and data collection continued at this level in 2001 and 2002.[2]

Original plans called for the ACS to begin full field implementation in 2003, a schedule that would support publication of small-area estimates in 2008. However, congressional stalemate on the budget for fiscal year 2003 delayed full implementation by at least 1 year; moreover, the fiscal year 2003 budget totals approved by Senate appropriators fell well short of the funds needed for full ACS deployment. Funding in support of full field implementation in 2004 and 2005 is unclear at this time.[3]

In this chapter, the panel offers its interim assessment on the ACS. As we will describe in detail, some benefits of the ACS are nearly indisputable, key among them the increased timeliness of the data relative to traditional long-form census estimates. But the new data resource brings with it new challenges in evaluation and estimation, and the Census Bureau needs to bolster the case for the ACS by providing stakeholders with information on the ways in which ACS information should be used in a variety of contexts. In order for the ACS to replace the long form, it must be demonstrated that the ACS can adequately meet all of the unique functions of long-form social and demographic data. The panel is supportive of full implementation of the ACS. However, we recognize that much remains to be done in articulating the strengths and the weaknesses—the challenges as well as the new opportunities—of the ACS as a replacement for the long form.

CONDUCTING THE ACS

When the ACS is fully fielded, it will use as its sampling frame the same Master Address File (MAF) used by the decennial census. The

[2]The Census Bureau refers to the latter two data collections as SS01 and SS02—the 2001 and 2002 Supplementary Surveys—respectively.

[3]Under the funding levels provided by the Bush administration's proposed budget for fiscal year 2004, questionnaire mailing for a full-scale ACS could begin during the fourth quarter (July–September) of 2004. Field work for follow-up would be deferred until after September 2004, pushing the considerable expense of field interviewing into the fiscal 2005 budget process. Prior to the fourth quarter mailing, data would continue to be collected in the 31 test sites and at the C2SS levels (Lowenthal, 2003a).

annual sample of housing units chosen for participation in the survey will be divided into monthly mailout panels, and each month's panel will be a systematic sample across the complete address list. Thus, it is intended that each month's sample will be a representative sample (approximately $\frac{1}{480}$) of the population of each area of the United States. However, this simplified version of the sample selection process will be complicated by alterations similar to practices currently used in the decennial census long form, including oversampling of small geographic areas.

The ACS is intended to be administered primarily via mailout/mailback. However, the proposed ACS techniques to follow up with households that do not return the mail form differ from decennial census practice. All mail nonrespondents will be initially followed up by computer-assisted telephone interviewing (CATI) during the month following questionnaire mailout, if there is an available phone number. After CATI follow-up, a random one-third of the remaining nonrespondents will be designated for follow-up by field enumerators. The precise nature of this sequential follow-up process remains to be determined; there are tentative plans to sample areas with low mail and telephone response rates at a higher fraction rather than a strict one-third random sample; this oversampling may help to make sample variances more comparable across areas.

The stagewise nature of ACS follow-up leads to another important design feature, which is that all of the information *collected* in a given month will be used as inputs for that month's estimates. That is, a particular month's estimates may include mailback responses from the present month's systematic sample of housing units but will also include completed telephone and personal interviews from 1 and 2 months prior, respectively. This design choice is advantageous in that it simplifies data processing and production load—there is no need to wait until month $t + 2$ for final resolution of all the housing units chosen in month t before processing responses already submitted. But it does raise complex methodological challenges, including the choice of weighting methods to address unit nonresponse.

While the size of this survey will make some direct small-area estimates possible, the estimates for areas under 65,000 population typically will be produced by aggregating information over either 3 or 5 years, depending on the size of the area. At this time, moving averages

are planned to be used for these aggregate-year estimates, though other possibilities could be considered in the future.

It is the need for a 5-year window to produce detailed small-area estimates that puts a firm constraint on the date of full ACS deployment. The initial plans for full deployment in 2003 would produce small-area estimates in 2008, allowing some time for the new ACS figures to gain acceptance as a long-form replacement. Hence, to match the long-form data production schedule of the 2000 census, the absolute deadline for full implementation of the ACS is 2007, which would permit the publishing of national estimates analogous to those from the long form in 2012.

STRENGTHS OF THE ACS

A great strength of the ACS relative to other national household surveys is its large sample size, which allows it to provide small-area information on the American population—population characteristic profiles for counties, cities, and other local areas. Over a 5-year period, the survey's sample size will approximate that of the census long form, supporting the production of estimates for small and nonstandard geographical areas, such as school districts and traffic analysis zones. In addition—and again given the large sample size—information will be available for population groups defined by factors other than geography, including racial and ethnic groups, age classes, occupational groups, and educational and health categories. (Tabulations can also be prepared for subpopulations with some combination of these characteristics.)

While the census long form can only provide these small area profiles in once-per-decade snapshots, the ACS collects information continuously throughout the decade. Therefore, the ACS has the important advantage of providing estimates of the intercensal dynamics of small-area changes in the many variables listed above. Such estimates have been almost nonexistent up to now and can provide important information for policy initiatives and public and private planning.

The increased timeliness of the ACS estimates relative to census long form estimates is a very substantial benefit. ACS data products are at most 3.5 years out of date when released; census long form data products are never less than 2 to 2.5 years out of date and can be as much as 12.5 years out of date. Presently, using census data to develop lower

bounds on the amount of year-to-year change that occurs for various estimates—for example, poverty rates—involves examining census-to-census differences and dividing by 10; this annual change may be measured directly under the ACS.

The ACS may eventually permit researchers to develop an integrated framework for more accurate small-area estimation, perhaps combining one or more waves of ACS data with results from administrative records, other household surveys, and the short-form decennial census. This broader perspective views the ACS as a supplement to the social and demographic information currently collected by existing surveys and administrative records systems. There are a variety of synergies that can be imagined between ACS and household surveys such as the Current Population Survey, jointly using each to improve the information collected by the other.

Relative to the decennial census, the prime advantage of a full-fledged ACS to the Census Bureau is the resulting prospect of a short-form-only census. Though the census long form was only administered to a 1-in-6 sample in the 2000 census, the operational burden is tremendous; completed long forms constitute a mountain of paper, and each form must be unstapled (running the risk of pages being mishandled) before processing.

There are also reasonable arguments that the ACS may provide more accurate information than the census long form. ACS data would be collected under more controlled circumstances by more experienced interviewers. Moreover, by spreading the demand on respondents to provide detailed personal and household information over the decade, the ACS may also be less susceptible to flaws and inaccuracies that may arise from nonresponse in a once-a-decade measurement. During the 2000 census, concern over the perceived intrusiveness of the long form questions was well publicized, leading to the conjecture—albeit one that has not been empirically documented—that this concern may have negatively impacted response rates on long form questions and, accordingly, hurt the accuracy of long-form data.

COSTS OF THE ACS

The great advantages of the ACS—timeliness and accuracy—must be offset against the costs of implementing the program. Given that it cannot "piggyback" on some of the infrastructure provided by the

decennial census, one might assume that the ACS could cost more than the marginal cost of the long form it is replacing. However, the Census Bureau has argued that operational efficiencies will make a short-form-only census complemented by ACS a less expensive option than a mixed long-and-short-form traditional census. In congressional testimony on May 13, 2003, Census Bureau director C. Louis Kincannon commented that "our current estimates indicate that three components of the 2010 Census [ACS, MAF/TIGER Enhancements, and early planning/testing] will cost approximately $11.2 billion. However, if we change course right now and revert to a traditional census, the cost will increase to more than $12 billion and perhaps much more."[4]

In its original presentation of its 2010 census strategy, the Census Bureau argued that most of the additional costs of ACS can be paid for through the associated greater efficiencies in the 2010 census. According to the bureau, these savings would result by eliminating the collection and processing of long-form information during the decennial census, through improvement of MAF/TIGER, and through use of hand-held data collection devices to facilitate field follow-up of mail nonrespondents. As the panel noted in its letter report (National Research Council, 2001c), we have not seen validation of this claim based on empirical evidence and suggest that a fuller cost-benefit analysis of the ACS would help bolster the case for the survey.

ACS INFORMATION AS A REPLACEMENT FOR LONG-FORM INFORMATION

Our basic theme in this report is the importance of integration within the census process, and in that spirit the panel urges the Census Bureau to make a stronger case for the ACS and its role in the broader census context.

At the most basic level, the case for the ACS as a replacement for the census long form is an easy one—the ACS's content is patterned on the long form, so the ACS will succeed in collecting the same set of data items as the long form. That information will, moreover, be collected

[4]The remarks are quoted from the director's prepared testimony before the U.S. House Subcommittee on Technology, Information Policy, Intergovernmental Relations, and the Census at a hearing on the ACS's potential to replace the census long form in 2010.

and released on a much more timely basis than the census long form—a significant benefit, and an improvement over the long form. But two basic questions remain to be fully answered in bolstering the case for the ACS.

First, is the ACS able to satisfy all of the needs currently addressed by long-form data? This larger question can in turn be divided into at least two aspects. The first stems from the fact that ACS estimates will—for all but the largest population or geographic groups—be based on averages across multiple years of data. Hence, the question arises: are there applications using the census long form for which substitution of a moving average-type estimate from the ACS would be inappropriate? The second subquestion is how well ACS estimates match other estimates of the same phenomena—not only how ACS findings compare with census long-form results but also how ACS estimates compare with other survey measures. (We will briefly discuss another aspect of the question—whether the ACS can provide specific breakdowns and analyses, to the same extent that the long form does—in a later section on the group quarters population.)

The second fundamental question of interest is: What is the quality of ACS estimates and data relative to the census long form? Specifically, what can be said about error—both bias and variance—in data collected through the ACS, and how does that compare with the census long form? It is also important to consider the level and possible patterning of ACS undercoverage, just as it is important to analyze the same with respect to the census long form.[5]

In the following sections, we offer some initial comments on these two basic questions. The panel recognizes that there are no absolutes in weighing the prospective ACS against the census long form—that all options involve trade-offs of both costs and benefits, and that the ACS cannot reasonably be expected to be better than the census long form in every respect (and vice versa). We are optimistic that increased Census Bureau attention to informing data users and stakeholders (whether long-term users of the long-form data or newcomers) about the unique

[5]For this discussion, we make the simplifying assumption that survey undercoverage, *relative to the census*, may be considered a component of nonresponse. (This is a simplifying assumption because some natural causes of survey undercoverage, like any incompleteness of the operational ACS address list, are of course not exclusively due to missing data.)

features and challenges of working with ACS data will build a stronger case for the survey.

ESTIMATION USING THE ACS

Adequacy of Moving Averages as Point Estimates

A basic concern regarding the American Community Survey as a replacement for the census long form is whether ACS estimates—-which, particularly for small areas or groups, would be moving averages of multiple years' data points—can take the place of fixed point-in-time estimates. Obviously, ACS estimates have one clear advantage in that those fixed point-in-time estimates could, for the census long form, refer to a point as much as 12 years ago. More to the point, though, the concern is whether fund allocation formulas or other public and private planning needs for demographic data can be addressed using a combination of data from multiple years. The Census Bureau has issued a draft report that attempts to address users' concerns about this shift (Alexander, 2002), and Zaslavsky and Schirm (1998, 2002) outline the advantages and disadvantages a locality may experience through use of either a moving average or a direct (census) estimate.

The crux of the debate on this point is that a moving average is a smoothed estimate; by averaging a particular time period's data observation with those within a particular time window, the resulting estimate is meant to follow the general trend of the series but not be as extreme as any of the individual points. The ramifications of this basic concept emerge when moving average estimates are entered into sensitive allocation formulas or compared against strict eligibility cutoffs. A smoothed estimate may mask or smooth over an individual year drop in level of need, thus keeping the locality eligible for benefits; conversely, it may also mask individual-year spikes in activity and thus disqualify an area from benefits. It is clear that the use of smoothed estimates is neither uniformly advantageous nor disadvantageous to a locality; what is not clear is how often major discrepancies may occur in practice.

One basic conceptual answer to this conundrum is to not use moving averages and instead use sample-based estimates from individual years. These estimates would be unbiased in terms of probability but

could be highly variable; this would affect aspects of formula grants such as "hold-harmless" provisions.[6]

A related worry that has been expressed about moving averages is that, by incorporating estimates from other time periods, the estimates for a given time period could be substantially biased and will not truly reflect the conditions for that given time period. The outstanding empirical question is assessing the bias that may result from averaging over 3 years of data compared to 5, and trying to weigh the magnitude of that bias against the bias associated with using a long-form estimate that is up to 12 years old. Intuitively, it is sensible that, when examining data series in which change is substantial between census years, moving average estimates would be preferable to seriously dated estimates. When there is little change through the decade, there should be little difference between the two estimates. However, since this is an empirical question, the Census Bureau should carry out research that helps to evaluate this trade-off.

The continuous measurement properties of the ACS give it unique advantages over the decennial snapshots available from the census long form, but they also raise a final, related point of concern regarding moving averages. That issue is assessing year-to-year change in a data series. It is incorrect to use annual estimates based on moving averages over several years when assessing change since some of the data are from overlapping time periods and hence identical. At the least, the results will yield incorrect estimates of the variance of the estimates of change. Therefore, users should be cautioned about this aspect of the use of moving averages. Along the same lines, moving averages present the same types of problems when they are used as dependent variables in various statistical models, in particular time series models, and in some regression models. Therefore, the Census Bureau could bolster the case for the ACS and potentially help relieve users' concerns if it would produce a user's guide that details the statistical uses for which moving averages are and are not intended, the problems they pose to users, and means to overcome them.

[6]A "hold-harmless" provision in a funding formula is one that limits the amount by which an allocation can change from one year to another; for instance, under a 70 percent hold-harmless level, a unit's allocation may only decrease by up to 30 percent. In a hold-harmless situation, an unusually volatile observation one year due to increased variability could mean that the unit's allocation may remain out of true alignment for several cycles due to the amount of allocation automatically carried over.

Though the prospect of using moving averages rather than long-form census estimates does raise legitimate concerns and will have impact on users, the panel judges that the benefit of more timely information collected by the ACS outweighs these concerns. That said, it is important that the Census Bureau strive to minimize the impact of the change and work to educate users and stakeholders about the nature of the change.

Comparing ACS/C2SS to the Census Long Form

Thus far, we have outlined from conceptual and theoretical perspectives the issues surrounding the adequacy of ACS estimates to replace the long form. It is also natural to address the question from a more pragmatic point of view: the ACS and the census long form purport to measure the same basic phenomena, but do the resulting data from both series actually tell the same story?

Comparisons of how the ACS or C2SS estimates match census long-form estimates implicitly treat the census long-form data as an effective "gold standard"—a questionable assumption at best, given that it discounts the various (and sometimes substantial) sources of error to which the long form is subject. First, the long-form data for small areas are subject to substantial sampling error. In addition, as mentioned above, the long form is also subject to nonresponse, and for some sample items, the amount of item nonresponse for the long form in the 2000 census was extremely high (National Research Council, 2001a).

Love (2002) has identified a number of sources of differences between the ACS (or C2SS) and long-form census estimates that complicate any direct comparison. These include: different reference dates; different modes of follow-up of nonresponse; different criteria used to decide if a response is acceptable; different edit and imputation techniques; different methods for data capture and processing; differences as to whether or not proxy interviews are accepted (they are not accepted by ACS but they are accepted for the decennial census); differences as to who is an eligible respondent; and different weighting procedures used to address nonresponse and sampling (e.g., the weighting of the long-form estimates to the 100 percent data). The reference period associated with a question item is of particular interest for ACS

estimates, since annual averages will be the average of responses corresponding to 12 different reference periods, depending on when the questionnaire was applied. There are also differences in the target population. For example, the ACS does not currently include group quarters in its survey, but the census does.

Work on comparing the ACS (test sites) and C2SS estimates to census long-form estimates has been initiated by the Census Bureau. To date, what is known is that there are some large differences; generally, these differences can be explained by the amount of sampling error in the two surveys (U.S. General Accounting Office, 2002a). However, examination of complete-sample C2SS data suggests large differences for the number of housing units lacking complete plumbing facilities and for the number of unpaid family workers. Also, at the state level, a large number of C2SS estimates differed from the long-form estimates by at least 10 percent, including the number of workers commuting using public transportation, the number of households with income above $200,000, the number of housing units lacking complete plumbing facilities, and the number of renter-occupied units with gross monthly rent of $1,000 to $1,499.

The Census Bureau needs to complete this analysis, including the contribution of sampling variance, for all years of data collection, and attempt to identify the sources of differences other than sampling error. A priority of this analysis should be responses related to residency, but all responses should be examined.

QUALITY OF ACS ESTIMATES

The error associated with ACS data may be decomposed into sampling error (sample variance) and nonsampling error, the latter of which can be further separated into error due to nonresponse and measurement error due to various causes.

At the most basic level, sampling error in the ACS will be slightly larger than that for the long form because the total ACS sample size over a 5-year period will be slightly smaller than that for the census long form. On its own, this difference is unlikely to have a substantial impact on users. However, sampling error due to initial mail and CATI nonresponse is widely variable and could be appreciable in some small

areas.[7] As a result, the Census Bureau is considering raising the sampling rate for areas with high mail and telephone nonresponse to make this source of sampling error more comparable across areas.

It should be noted as we review these issues that, generally, these are concerns that are generic to all surveys, including the census long form. That is, these concerns are not raised as specific flaws of the ACS. They are, nonetheless, features of the ACS that must be measured and weighed, in deciding how best to use the data.

Estimating Nonresponse

Unit Nonresponse

One part of nonresponse in a survey program like the ACS is unit nonresponse—that is, a failure to obtain questionnaires and data from households selected for inclusion in the sample. One common combined measure of unit nonresponse and survey undercoverage is the sample completeness ratio, which is the sample-weighted estimate of the population count for a certain area divided by the census count for the area. The sample completeness ratio nationally for C2SS was 90.2 percent, while the comparable figure for the 1990 long form was 89.7 percent (U.S. Census Bureau, 2002b). These figures may appear close, but some care must be taken in interpreting them. For example, the long form accepts proxy responses while proxies are not permitted in the ACS or C2SS, and it is generally accepted that proxy responses are of lower quality than responses by household members.[8] So the programs, and these ratios, are not directly comparable. Still, the C2SS seems to be roughly equivalent to the long form with respect to unit nonresponse and survey undercoverage.

Another statistic that is often examined to assess the quality of survey data collection is the rate of mail questionnaire return. This is because—in the census context—information collected through self-response is typically considered to be of higher quality than in-

[7]See Salvo and Lobo (2002) for relevant discussion on this point.

[8]Nonresponse follow-up for long-form data was often concluded with the collection of short-form data only (that is, a higher premium was placed on gathering the basic short-form characteristics from as many nonrespondents as possible rather than insisting on a complete long-form return). Such forms are treated as long-form unit nonresponse.

formation collected through field enumeration (National Research Council, 1995). For the complete-sample C2SS, the mail return rate was 51.9 percent, somewhat lower than the 58 percent for the 2000 census long form (National Research Council, 2001b). (For the 2000 ACS in the Bronx County test site, the mail return rate was 36.4, compared to 55.8 for the long form in the 1990 census in Bronx County (Salvo and Lobo, 2002).) This difference could potentially contribute to a lowering of the quality of ACS information relative to census long-form information. However, this could possibly be addressed by improved field data collection.[9]

Further evidence for the relative accuracy of ACS data can be found in Salvo and Lobo (2002), in which a metric of acceptability is defined for long-form questionnaires. Applying this metric to data for Bronx County, New York (one of the thirty-one ACS test sites), they found that 49 percent of enumerator returns for the long form failed to achieve acceptability, whereas only 14 percent failed for the ACS. Moreover, the overall weighted survey response rate for the C2SS has been calculated as 95.4 percent, which is very high for a household survey. This rate includes responses across the different possible modes of administration (mail, CATI, interviewer) but does not factor in survey undercoverage; the panel hopes to obtain the comparable figure for the census long form in the near future.

Item Nonresponse and Invalid Response

Extant research based on item imputation rates for responding households measures not only item nonresponse, but also includes imputations for responses that fail edits. However, this complication is relatively infrequent and is consistently applied to both the C2SS and the census long form. As a result, we feel that it is reasonable to compare item imputation rates to measure the impact on data quality from item nonresponse. Item imputation rates for the C2SS were substantially lower than those for the decennial census for 100 percent

[9]As Salvo and Lobo (2002) demonstrate, there is substantial heterogeneity to the mail return rate and the other measures of nonresponse as a function of characteristics often associated with being difficult to count in the census. Therefore, it should be understood that both the ACS and the census long form are more and less successful in collecting quality data depending on the area of interest.

responses on both the short and long forms. For example, for age, the census imputation rate was 3.6 percent, whereas for the C2SS it was 2.4 percent. Salvo and Lobo (2002) report that the allocation rate (essentially the same as the item imputation rate) for the 2000 ACS in Bronx County was typically much higher in the 1990 long form than in the 2000 ACS, and, further, that this difference was strongly related to the lower quality of field data collection for census long-form information in comparison to the ACS. The U.S. General Accounting Office (2002a) reports on preliminary work carried out by the Census Bureau for long-form items in which the imputation rates were slightly higher than for the 2000 C2SS. The Census Bureau intends to extend the analysis of imputation rates to all long-form items in the near future. Since there was no content follow-up for the 2000 census long form, it is very reasonable to expect that the gap for long-form items will be even more pronounced than the observed difference for short-form items. We point out that there are other differences in administration between the ACS (C2SS) and the census long and short forms (e.g., the ACS uses CATI and CAPI) that complicate this comparison, some of which are discussed below. However, it seems correct to anticipate that the ACS data will be found to be subject to less item nonresponse for long-form information than the census.

Quality of Imputed Responses

Rates of unit and item nonresponse are only partially informative as measures of the ultimate error due to nonresponse. This is because the imputation and weighting routines that the Census Bureau uses to treat item and unit nonresponse (and survey undercoverage) can offset some of the information loss, depending on the extent to which the various assumptions used to support the imputation methods hold (e.g., responses missing at random). Therefore, measures of the quality of imputations are an important additional measure of the impact of item and unit nonresponse.

This impact could be measured using either a reinterview survey or through matching to a more reliable source of data (possibly administrative records or highly reliable household surveys). Both of these approaches are problematic. Reinterview surveys of appreciable sample size are expensive and require high-quality interviewing to elicit higher

quality responses than provided earlier. Matching studies are limited by the availability of higher quality, comparable information—a difficult standard to meet. The Census Bureau is in the process of carrying out a matching study comparing C2SS responses to those for the 2000 census short form, on the understanding that both sets of responses are subject to error.[10]

Some interesting work on responses to race and ethnicity questions has been carried out (Bennett and Griffin, 2002). A less satisfying variant of this analysis could still be carried out for small geographic aggregates, for example, comparing census and ACS frequencies and means for responses at the tract level, which would overcome the inability to match individual long-form responses. Some of this work is being conducted by the Census Bureau and is discussed below. Historically, there were matching studies of census responses to Internal Revenue Service (IRS) and Current Population Survey (CPS) data for earlier censuses (Bureau of the Census, 1964, 1975b),[11] and excellent reinterview studies were done in the 1970s and 1980s (Bureau of the Census, 1970, 1975a). Also, limited research on the quality of the imputations for 1990 were carried out by Thibaudeau (2002), but comparable work has not been carried out for 2000.

Measurement Error

Measurement error consists of differences between the response that was intended by the survey designers given a household's characteristics and the response that was actually captured. Possible contributors to measurement error include: misunderstanding of a question by the respondent, collecting data for the wrong time period, responding in the wrong units, transposing digits, making errors in capturing the response, intentional lying by either the respondent or the field enumerator, and so on.

[10]Due to the design of the C2SS—specifically, the provision that the same respondent would not receive both the census long form and the C2SS—this matching is only feasible for characteristics on the census short form.

[11]Confidentiality concerns in the 1980s and 1990s led the IRS to restrict access to data, even for statistical purposes, thus precluding further census matching studies in recent decades. More recently, the IRS has facilitated limited administrative records research by the Census Bureau using IRS data with appropriate safeguards.

It is reasonable to assume that, generally, the measurement error in ACS will be either comparable to, or very possibly somewhat less than, that for the census long form. The reason behind this argument follows from ACS design specifications: the ACS interviewing staff will be more experienced than short-term census enumerators, and ACS interviewers are forbidden to use proxy respondents.

One challenge in comparing measurement error between the ACS and the census long form is reconciling the different definitions of residence in the two systems.[12] These definitions are both valid and defensible, and each may have particular advantages in different contexts, but their basic differences complicate comparison. Moreover, the ACS stages data collection over 3 months, and this may induce error due to temporary vacancies and frequent moving. For analytic purposes, the moving time window of the ACS may present difficulties in interpreting quantities like income. Each interview's snapshot is intended to capture a respondent's income for the 12 months preceding the interview, as opposed to a fixed April-to-April reference frame; this may complicate time series comparisons.

TOPICS FOR FURTHER RESEARCH AND DESIGN CONSIDERATION

A substantial agenda of outstanding operational and methodological issues would have to be addressed in a fully operational ACS. Some of these issues should be tackled in the near future in order to generate the maximum benefits from use of the ACS as part of an integrated framework of estimates.

Voluntary versus Mandatory Response

The law governing conduct of the census imposes penalties on "whoever, being over eighteen years of age, refuses or willfully neglects

[12]The census attempts to capture "usual residence"—the location where respondents usually live or spend most of their time. By comparison, the ACS captures "current residence," the place where the respondent is at the time of the interview. More precisely, the ACS uses a "Two Month Rule"; any respondent at a sampled household unit who has been living at the location for more than 2 months is considered a current resident (U.S. Census Bureau, 2003a). This can create differences for migrant workers or "snowbird" retirees who live for lengthy periods in different areas of the country.

. . . to answer, to the best of his knowledge, any of the questions on any schedule submitted to him in connection with any census or survey" enabled in other parts of the census code (13 USC § 241(a)).[13] In addition, it is a crime to willingly give false answers to such censuses or surveys (13 USC § 241(b)). Accordingly, census mailings in 2000—as in previous years—prominently featured notices that "your response is required by law."

The Census Bureau has argued that the ACS is intended to replace the mandatory census long form and, hence, the ACS should be conducted on the same mandatory basis as the census. The General Accounting Office has concurred with the bureau that it has statutory authority to conduct the ACS and that it has the authority to require responses (U.S. General Accounting Office, 2002b). The distinction between voluntary and mandatory conduct is a significant one because it is believed that the "required by law" verbiage on census forms plays a role in raising response rates.

However, early congressional discussion of the nature and content of the ACS led individual members of Congress to suggest that the ACS be conducted on a voluntary basis. Accordingly, the Census Bureau is conducting part of the 2003 Supplementary Survey (the prototype ACS) on a voluntary basis; this test includes replacing "required by law" verbiage with a more generic appeal (U.S. Census Bureau, 2003a). The response rates, including item nonresponse rates, on the voluntary surveys will be compared with a control group receiving mandatory-response questionniares, as well as to the 2001 and 2002 Supplementary Surveys. The Census Bureau anticipates being able to report initial results of this test to Congress in August 2003, and the basic question of mandatory response is an important one to have settled early.

Interaction with Intercensal Population Estimates and Demographic Analysis Programs

One high-priority research area should be the development of models that combine information from other sources—household surveys, administrative records, census data, and so forth—with ACS information. One prominent example of this is the interplay of estimates from

[13]However, the census code does provide that respondents cannot be compelled to disclose their religious beliefs or affiliation (13 USC § 241(c)).

ACS and the population estimates program from the Census Bureau. At this point, it is planned that estimates from the ACS are to be controlled to postcensal population estimates. However, this should not be considered a one-way street. It is also possible for ACS to be used to provide the population estimates program with improved estimates of internal and external migration, fertility, household size, and vacancy status. The resulting improved population estimates could then be used as improved marginal totals to which to control ACS estimates. Further, the ACS also provides direct information on population size, and a joint estimate from population estimates and from the ACS is conceivable. The Census Bureau needs to carry out research on how the ACS can be used to improve intercensal population estimates. Furthermore, the Census Bureau needs to examine how existing household surveys could change their poststratification practices (controlling totals by age, race, and sex) given the collection of ACS data.

The potential for ACS to provide improved estimates of internal and external migration also suggests the importance of exploring the potential interactions between the ACS and population estimates derived by demographic analysis. Demographic analysis uses aggregate data on birth, death, immigration, and emigration to produce population estimates by age, sex, and race. Demographic analysis was a key benchmark used to evaluate coverage in the 2000 census, but it has significant limitations. First, estimates of immigration and emigration—particularly those of illegal immigration—are inherently difficult to produce with precision. Second, existing administrative records used to generate demographic analysis counts facilitate only the most basic racial comparisons—white and black—but do not permit direct estimation of Hispanics and other groups. The Census Bureau should consider ways in which the ACS might inform demographic analysis estimates, including more refined estimators of birth among the foreign-born population and of internal migration.

Other possibilities—for instance, using ACS and household survey information jointly in regression models to provide improved estimates of the frequency of crime or unemployment—could also be addressed as a research topic.[14] Another high-priority research area would

[14]The use of models that combine information from other sources has implications for the sample designs of the major household surveys and is a future research topic

be identification of better procedures for weighting and imputation, to address nonresponse and undercoverage in the ACS; the hope would be to develop procedures that are, in a sense, optimized for ACS survey data, and not simply borrowed from procedures used on the decennial census long form.

Group Quarters

The intent of the census long form is to provide information on characteristics of the entire population. This means not only the population residing in housing units but also those living in group quarters—such places as college dormitories, military barracks, prisons, and medical and nursing facilities. Nonresponse to the census long form and the need to impute for nonresponse may detract from the overall reliability of census long-form data, but those data do at least allow users to make some inference about the group quarters population. Accordingly, the complete elimination of the census long form—and the possible loss of data on the group quarters population—is an obvious concern of some census stakeholders.

In its draft operational plan, the Census Bureau has indicated that the ACS will be administered to a 2.5 percent sample from the bureau's group quarters roster (U.S. Census Bureau, 2003a). It remains to be determined how adequate this may be for monitoring this important population group, especially for small levels of geography.

SUMMARY AND ASSESSMENT

In 1995, a previous Committee on National Statistics (CNSTAT) panel related to the decennial census offered its comments on an idea "which the Census Bureau has recently been investigating:"

> to drop the long form from the census and substitute a continuous measurement survey—that is, a large monthly survey of perhaps 200,000 to 500,000 households. By averaging the results of the monthly surveys over a period of 3 to 5 years, more timely long-form-type data, accurate enough

of great potential interest. Use of these models and connections to external programs such as the ACS may permit other household surveys to reallocate sample to areas in which estimates are less reliable.

> for use in relatively small geographic areas, could be produced. . . .
>
> In its preliminary work, the Census Bureau has speculated that the costs of the new continuous measurement survey over a decade could be roughly offset by the cost savings from dropping the long form from the census and by other cost reductions that might be achieved in intercensal operations. . . .
>
> Although we believe that the proposed continuous measurement system deserves serious evaluation, we conclude that much work remains to develop credible estimates of its net costs and to answer many other fundamental questions about data quality, the use of small-area estimates based on cumulated data, how continuous measurement could be integrated with existing household surveys, and its advantages compared with other means of providing more frequent small-area estimates. In our judgment, it will not be possible to complete this work in time to consider the use of continuous measurement in place of the long form for the 2000 census (National Research Council, 1995:9).

Eight years later, faced with the task of offering advice on making the vision of continuous measurement a reality in the 2010 census, the similarity between the arguments then and now is uncanny. Similar, too, are the points of concern; the current panel is hard-pressed to improve upon the basic summary of concerns outlined by our predecessors. We are, however, much more sanguine that a compelling case can be made for the ACS and that it is a viable long-form replacement in the 2010 census.

In summary, the panel appreciates the enormous potential benefit of the ACS—of having a program for continuous measurement of social and demographic variables of key national interest. The ACS presents a unique source of timely information that could be extremely useful to public and private planning and that could be used to support more effective and targeted fund allocation. The potential benefits of the ACS are self-evident and require little salesmanship. However, what does require fuller justification is how these benefits offset the costs of

the program and, more fundamentally, how the program works as a true long-form replacement. The panel is optimistic that such a compelling case can be made, though it will take continued evaluation work and research.

> **Recommendation ACS–1: The Census Bureau should carry out more research to understand the differences between and relative quality of ACS estimates and long-form estimates, with particular attention to measurement error and error from nonresponse and imputation. The Census Bureau must work on ways to effectively communicate and articulate those findings to interested stakeholders, particularly potential end users of the data.**

The fact that the Census Bureau has not done more in comparing the data collected from the 31 ACS test sites, the C2SS, and the 2001 and 2002 Supplementary Surveys with the data collected by the 2000 census long form is disappointing. Such analyses would help assess the quality of ACS data and would be helpful in making the argument for transition from the long form to the ACS. This deficiency is probably due to limited analytic resources at the Census Bureau and creates an argument for "farming out" this analysis to outside researchers. Furthermore, since access to local information is very useful in interpreting the results, the Census Bureau should explore whether local experts might be interested in assisting in this effort.

> **Recommendation ACS–2: The Census Bureau should make ACS data available (protecting confidentiality) to analysts in the 31 ACS test sites to facilitate the comparison of ACS and census long-form estimates as a means of assessing the quality of ACS data as a replacement for census long-form data. Again, with appropriate safeguards, the Census Bureau should release ACS data to the broader research community for evaluation purposes.**

> **Recommendation ACS–3: The Census Bureau should issue a user's guide that details the statistical implications**

of the difference between point-in-time and moving average estimates for various uses.

Part of a fuller justification of the ACS necessarily involves a cost-benefit assessment: enumeration of all benefits and costs, measurement or postulation of the benefits and costs, and comparison with costs and benefits (including data collection and processing) of the status quo approach (the census long form). The panel acknowledges that it is difficult to put a price tag on the value of more timely data, but coming to terms with cost-benefit trade-offs is an important part of assessing the program. Estimates of the possible error in ACS and long-form estimates as a function of the datedness of the data need to be factored into any comparison. This can be done by adding them to estimates of mean squared error. Such comparisons will be somewhat approximate in several respects, but the resulting assessments will be more reflective of the relative utility of these two sets of estimates.

ACS Funding

The panel looks forward to further discussion on the methodological challenges associated with the ACS but, at this particular time, our most fundamental recommendations regarding the ACS must be very pragmatic in nature. In our letter report (National Research Council, 2001c), we strongly urged the Census Bureau to make contingency planning a focus of its planning efforts, with particular attention to the funding levels for the ACS. The difficulty of securing fiscal year 2003 funding for the anticipated full launch of the ACS underscores the importance of that recommendation.

Implementation of the ACS would allow the 2010 census to consist only of the short-form questionnaire, a design feature that is too critical and too wide-reaching to leave unresolved until late in the decade. The short-form-only census would facilitate broader Internet data collection and the use of MCDs to collect respondent data; it would reduce the data collection effort and simplify use of multilanguage forms. A late reemergence of the need for long-form data collection would remove any efficiencies the Census Bureau had developed from its streamlined design.

Funding for the ACS is, of course, not a decision of the Census Bureau but of Congress. Accordingly, in building a compelling case for the ACS, the Census Bureau needs to work in concert with congressional liaison. The importance of making a decision on general 2010 census structure within the next 2 years—early in the decade—must be emphasized; the role of the ACS in that structure must be articulated. Furthermore, it must be stressed that support for the ACS cannot be erratic; major changes in sample size over the course of the program could severely compromise use of the ACS as a vital component of a coordinated set of estimates. The panel is encouraged by statements in a recent hearing on the ACS that indicate that congressional authorizers are aware of the importance of making a clear decision regarding ACS funding. Specifically, at a May 13, 2003, hearing on the ACS, Representative Adam Putnam (R-FL), the chairman of the House Subcommittee on Technology, Information Policy, Intergovernmental Relations, and the Census, commented in his opening statement:

> I am also very aware that we are rapidly approaching the point where the Census Bureau needs to know one way or the other if there will be a long form in the 2010 census or will the ACS be the new survey tool. It's fundamental to a successful 2010 Census that we let the Census Bureau know as soon as possible how the Congress expects the Census to be conducted. I'm hopeful that we can continue to work together to resolve these final remaining issues, and that Congress can make a final determination on full funding for the ACS in the near future.

Given our panel's charge, the most basic question we face is whether the ACS is a satisfactory replacement for the census long form (and therefore something that should be the foundation of 2010 census planning as it has become). We recognize that significant estimation and weighting challenges must be addressed; the survey's costs, benefits, and uses must also be clearly articulated in order to convince users and stakeholders of the surveys' effectiveness. However, we do not see any looming flaw so large in magnitude that full ACS implementation should be set aside.

We therefore encourage full congressional funding of the ACS. It is important, though, that Congress recognize that funding of the ACS

should be viewed as a long-term commitment. As Representative Putnam noted in his comments, it is important that Congress send a clear signal (whatever it decides) regarding the ACS. The benefits of the ACS will be jeopardized if the survey program is faced with oscillating budget commitments; cuts in funding (and with them reductions in sample size) will impair the overall quality of the survey, with first and most pronounced impact on the ability to produce estimates for small geographic areas and population groups.

Contingency Planning

In the meantime, the Census Bureau must begin contingency planning to be prepared should support for the ACS not be forthcoming. Some possibilities include: reinstitution of the long form in 2010; implementation of a 1-year ACS (e.g., like the C2SS) to run simultaneously but not bundled with the census; greatly increasing the sample size and revising the content of the Current Population Survey; or greater use of administrative records supplemented with other survey data. The costs and benefits of these various approaches need to be developed and presented for review so that decisions on the ACS can be fully informed. Also, planning needs to be started on the most likely of these or other contingencies so that the bureau is well prepared.[15]

Recommendation ACS–4: The Census Bureau should identify the costs and benefits of various approaches to collecting characteristics information should support for the full ACS not be forthcoming. These costs and benefits should be presented for review so that decisions on the ACS and its alternatives can be fully informed.

[15]The Office of Inspector General of the Census Bureau's parent agency, the U.S. Department of Commerce, has expressed similar concerns. "If the Bureau does not receive sustained ACS funding throughout the decade, it may be unable to eliminate the long form for 2010"; consequently, the Census Bureau's planning for 2010 should "include a contingency plan for use of the long form" (U.S. Department of Commerce, Office of Inspector General, 2002:iv).

— 5 —
The 2003 and 2004 Census Tests

AN IMPORTANT PART OF PLANNING for the decennial census is testing—trying out new procedures and techniques in order to finalize the census design before the count begins. A regular feature of the census process since the 1940 census, the Census Bureau's program of intercensal tests has pursued several major directions (Bailar, 2000):

- major changes in census methodology (most notably the conversion to mailout/mailback as the dominant mode of census collection and the use of sampling);
- techniques to improve coverage and to better measure census coverage;
- optimal questionnaire wording and format;
- new technology; and
- improved census processing.

From all indications, the Census Bureau is not eager to repeat the experience of the 2000 census, in which the lateness in reaching a general census design limited the effectiveness of operational testing. Under the heading "Lessons Learned from Census 2000," Waite (2002) emphasized the importance of effective testing: "If we want to achieve our Census 2010 Goals, operational testing of design infrastructure ***must start early*** in the decade and continue through the Dress Rehearsal." In particular, the census dress rehearsal—typically held 2 years prior to census deployment—should properly be a comprehensive run-through of census machinery to fine-tune the final census design. However, in 1998, the dress rehearsal had to serve as a feasibility test for three quite different general designs, involving different levels of sampling techniques (National Research Council, 2001a).

The Census Bureau's proposed plans for the 2010 census—particularly the elimination of the census long form—are sufficiently different from the plans for the 2000 census that all possible opportunities for testing design options must be fully exploited in order to finalize an effective design for 2010. As depicted in Table 1-1, milestones in the 2010 planning process include major census tests roughly every other year leading up to 2010.

The Census Bureau shared plans for the 2003 census test with the panel at its September 2002 meeting and in subsequent discussions. However, the plans were shared with us too late to allow us to suggest or for the bureau to effect any meaningful change in the 2003 test plan. Plans for 2004 and 2006 are still under development, and the panel looks forward to continued work with the Census Bureau on those plans. In this chapter, we offer comments on the 2003 test and initial comments on the 2004 test and will revisit the 2004 and 2006 tests in great detail in the final report.

2003 NATIONAL CENSUS TEST

As presented to the panel, the 2003 National Census Test will be a nationwide test involving 250,000 households. It is strictly a mailout test; no field enumerators will be used to conduct nonresponse follow-up, thus distinguishing this test from the proposed 2004 Census Field Test, which will have a follow-up component. Households selected for

inclusion in the test were set to be notified by an advance mailing in late January (U.S. Census Bureau, Public Information Office, 2003a).

The 2003 test focuses primarily on two issues:

- *Multiple Self-Response Modes.* Offering respondents the opportunity to respond by mailing the questionnaire back (the traditional method), filling out an Internet version of the questionnaire, or responding to the questionnaire via an automated TouchTone telephone system known as interactive voice response (IVR).

- *Race and Ethnicity Question Wording.* Altering the way in which the questions on race and Hispanic origin are presented, including the omission of the "some other race" category currently offered as an alternative under race.

Prior to the 2000 census, it was hoped that a second mailing of replacement questionnaires could be used to increase responses to the initial mailed questionnaire; however, logistical concerns dictated that it be dropped from the 2000 census plan. The 2003 census test is not directly a test of the use of targeted replacement questionnaires; however, the current plan is to use replacement questionnaires as part of the limited (not in-person) follow-up process. Hence it is thought that the test could yield some insight as to the effectiveness of replacement questionnaires in improving response.

Plans call for the test to consist of 16 experimental groups, in each of which the households will be sent a letter in advance of the actual questionnaire delivery. A control group will be eligible for a replacement questionnaire in nonresponse follow-up but will have the race and ethnicity questions as worded in the 2000 census. Eight treatment groups will be used in the response mode portion of the test; each group will vary on whether IVR or Internet response is mentioned on the initial questionnaire or encouraged in a reminder postcard. An additional seven treatment groups on race and ethnicity wording will round out the experimental groups. Each of these groups has slight variations on the wording of the questions: for example, whether "some other race" is allowed as a possible response or whether examples of possible Hispanic origin groups are listed in the question. A particularly subtle variation involves whether respondents are asked

"Is Person *x* Spanish/Hispanic/Latino?" versus the alternative "Is Person *x* of Spanish, Hispanic, or Latino origin?"

From a purely conceptual point of view, developing a test strategy for a new decennial census design should flow from and build upon the experience of the previous census. In this case, evaluations from the 2000 census would be used to identify problem areas—parts of the census process in which procedures may not have performed as expected or in which problems occurred—and tests would be devised to evaluate alternative routines. In this context, the selection of the preceding two topics for the first major census test leading up to the 2010 census is intriguing but somewhat confusing. That the Census Bureau should investigate the effectiveness of accommodating responses by phone and Internet is clear, but whether the issue merits a large resource-intensive test this early in the decade is a valid point of debate. With regard to both topics, it could be argued that resources might better be channeled into completing evaluations of the 2000 census that could guide more effective targeted testing. For example, one might naturally prefer to exploit data already in hand to answer key questions before launching a large-scale study: How many respondents submitted both Internet and paper responses? What was the level of item nonresponse in the limited number of Internet responses relative to mail responses? Is there evidence that the restrictive security measures surrounding the 2000 census Internet option deterred respondents from answering via the Internet? How many Internet respondents started to provide data but did not complete the instrument? How does the population that identified itself as "some other race" compare to other subgroups, and why is dropping the possible response "some other race" a useful or meaningful possibility?

Another consideration for timing the tests of Internet responses, in particular, is that this is an extremely dynamic area, with tremendous changes in the uptake of Internet-capable home computers, high-speed connections, and other technologies. It would be risky to predicate a test of methods for 2010 on any predictions that could be made now other than that current state-of-the-art technologies will be more widely dispersed and new technologies will have appeared. In fact, even without a test of Internet technologies, we probably could say more today about results that will be obtained in 2003 than we can about the relationship between those results and what will actually be found in

2010. Thus, data on Internet response collected in 2003 might contribute little to the planning process, relative to competing activities.

A primary concern for the panel was the design of the race and ethnicity component of the test. The plan for this portion involves seven treatment groups that—like the control and response mode treatment groups—are stratified only by their mail response rate in the 2000 census (specifically, they are grouped into "high" and "low" response groups based on a selected cutoff). The panel's concern is whether this design is sufficient to answer the primary questions of interest. The differences in the questions administered to the different treatment groups are often quite subtle—the distinction between being "Hispanic" versus "of Hispanic origin," for example. Hence it is unclear whether the sample design will generate enough coverage in Hispanic communities to facilitate conclusive comparisons—whether it will reach enough of a cross-section of the populace to gauge sensitivity to slight changes in question wording and whether it will reach a sufficiently heterogeneous mix of Hispanic nationalities and origins to decide whether including instructions or examples improves response.

To this end, there are two methods by which the effective number of respondents who are active on this question could be augmented. First, either through selection of test sites or through oversampling of blocks within test sites, the number of respondents who are likely to have relevant characteristics can be increased. Second, given that the two major treatment factors being examined—response mode and questionnaire wording—are likely to be relatively independent (orthogonal) in action, it seems reasonable to completely cross the two treatment factors in this experiment. By varying response mode and race/ethnicity wording for the complete sample, power to distinguish between alternatives may be gained relative to the current design using effectively separate experiments.

Also, the alternative race and Hispanic origin questionnaire wordings planned for the 2003 test are variations along three different factors: identification as "Hispanic" versus "of Hispanic origin," inclusion of "some other race" as a valid choice, and provision of examples of detailed Hispanic origin. The panel is concerned that these alternatives are relatively narrow and, as a result, may not provide sufficient information on question formats for use in 2010. It is also unclear that these particular selections are derived from an established research base. For

the purposes of a true experiment, our view that it may be useful to consider even more radical question alternatives, such as folding race and Hispanic origin into a single question in a "check one or more" format. Such an alternative may in fact not be tenable as a choice in 2010—it may force higher levels of imputation for groups who select Hispanic but no legally defined race category, and it may be counter to Office of Management and Budget guidelines on race and ethnicity categorization. But from a research perspective, such might be the best way to determine how people prefer to categorize themselves, and the results may inform strategies for analysis and tabulation of final census results.

2004 CENSUS FIELD TEST

In October 2002, the Census Bureau announced the selection of sites for the 2004 Census Field Test. The selected sites are Colquitt, Thomas, and Tift counties in Georgia; Lake County in Illinois; and a portion of northwestern Queens County in New York.[1] Original plans called for the 2004 test to involve approximately 450,000 housing units across the various sites; since the test involves a field work component, approximately 3,000 temporary jobs will be created to conduct the test (U.S. Census Bureau, Public Information Office, 2002).

As discussed at the panel's September 2002 meeting, still-developing plans for the 2004 test call for work on at least seven different topic areas. Test sites were selected to try to obtain a variety of geographic types (urban/suburban/rural) and racial groups (Waite, 2002). Though field work will be done in each of the test sites, and, in some respects, the activity will almost seem to be a census in miniature, the Census Bureau is not promising or even offering participating sites a population count at the end of the test.

[1]Under the fiscal year 2004 budget proposed by President Bush in January 2003, the Census Bureau would scale down the 2004 test to drop Lake County, Illinois, as a test site and to reduce the planned workload in Queens County, New York (Lowenthal, 2003b).

Mobile Computing Devices

A clear, primary thrust of the 2004 test is work with mobile computing devices (MCDs) for field work. To date, the Census Bureau's testing of MCDs have been small pilot tests of basic skills. For instance, small numbers of field staff with different levels of local familiarity were assigned to locate an assigned set of addresses on TIGER-based maps on a Pocket PC-class device in a pilot test in Gloucester County, Virginia. This test concentrated only on locating features using a small-screen map and not on using the computer to calculate a route to those features (U.S. Census Bureau, Mobile Computing Device Working Group, 2002).

The Census Bureau's hope is that the 2004 test will be a more comprehensive test of MCD capabilities, including use of global positioning system (GPS) receivers and computer-assisted personal interviewing software to administer short-form interviews in English or Spanish.

As we commented in Chapter 2, prototyping of MCDs in 2004 is very important for getting a sense of current capabilities, but it is more important to clarify the requirements and information flows associated with the devices. That said, we hope that sufficient information is gained about the process of MCD and GPS use during the 2004 test to inform final design decisions later in the decade.

Race and Hispanic Origin Questionnaire Wording

The Census Bureau also intends to follow up its work in the 2003 mailout-only test by including alternate wordings of the race and Hispanic origin census questions in the 2004 field test; these proposed wordings were discussed earlier. It is unclear whether the full range of alternatives will be worked into the 2004 test; given the panel's concern that the 2003 test alone is unlikely to provide definitive evidence in favor of any one of the subtle alternatives under consideration, we hope that the 2004 test is not used merely to test one "favored" alternative from the 2003 results.

Foreign Language Questionnaires

In the 2000 census, respondents requiring a questionnaire in a language other than English could request it from the Census Bureau,

from local census offices, or from follow-up enumerators. The 2004 test will be a first test for some proposed improvements, including test deployment of a dual language (English and Spanish) questionnaire. Delivery of the English/Spanish questionnaires is intended to be done in a targeted manner (e.g., based on high concentrations of Hispanic-origin responses in the 2000 census for a particular tract or block group).

Other 2004 Test Topics

Other topics have been identified for testing in 2004; however, the panel has not yet seen information on them—or, more precisely, how exactly the Census Bureau plans to test them—in fuller detail than bulleted lists of possible directions. Consequently, further comment on them awaits further interaction between the panel and the Census Bureau as plans continue to take shape. These general topics include:

- *Field-Based Coverage Improvement.* Strategies for reducing person duplication by clearer explication of residence rules and by better tracking of housing unit occupancy status during nonresponse follow-up.

- *Targeted Canvass to Update MAF.* Use of administrative records and the Census Bureau's housing unit estimates program to identify localities with potential MAF coverage problems and comparison of address canvasses in those areas with existing MAF coverage.

- *Contact Strategy for Self-Response.* Strategies for reminding and encouraging respondents to submit their questionnaires on their own (as opposed to having to be contacted by a field enumerator during nonresponse follow-up). One such strategy, a targeted mailing of a second questionnaire, is to be tested in both the 2003 Census Test and the 2004 Field Test.

- *Special Place/Group Quarters.* Development and testing of new definitions for group quarters and refinement of the techniques used to list group quarters for enumeration.

Counting Americans Overseas

Distinct from the 2004 Census Field Test, the Census Bureau has announced plans for another test program for 2004. The Overseas Enumeration Test would attempt to count American citizens residing in France, Kuwait, and Mexico. The test will rely on a publicity campaign to be mounted using English-language media in the three countries. Potential respondents would be urged to request that a questionnaire be mailed to them, to pick up a questionnaire at an embassy or consulate, to obtain a questionnaire from Census Bureau "partner organizations that serve Americans overseas," or to complete the questionnaire via the Internet (U.S. Census Bureau, Public Information Office, 2003b). The panel has not seen any more detailed information on this test, which is an apparent reaction to concerns raised in litigation shortly after the release of reapportionment totals.[2]

Timeline

Under the basic timetable presented in Waite (2002), active preparation for the 2004 Census Test will begin in April–June 2003 with the hiring and training of staff. Address canvassing and the authoring of initial test evaluations are scheduled for late 2003, as is questionnaire printing. Questionnaires are scheduled for mailout in early 2004, with the reference date (Census Day) set at April 1, 2004; questionnaire check-in, data capture, and nonresponse follow-up continue through July 2004. Processing of the results and continued drafting of evaluation reports are expected to continue through the rest of 2004 and extend into early 2005.

[2]Under the reapportionment counts issued by the Census Bureau in December 2000, North Carolina was allocated the 435th seat in the U.S. House of Representatives, as prioritized by the method of "equal proportions" used to reapportion the House. A fourth congressional district for Utah was ranked 436th, falling short of the additional seat by less than 1,000 people. Consequently, Utah challenged the reapportionment counts on the basis that the Census Bureau's limited overseas enumeration omitted Mormon missionaries and other private citizens who should have been tallied in the census. However, Utah's case was rejected by a federal appeals court, and the U.S. Supreme Court declined to take the case on appeal (Lowenthal, 2003a). Utah would subsequently challenge the Census Bureau's imputation strategy but lost that challenge in a U.S. Supreme Court ruling (*Utah v. Evans*, 526 U.S. 452, 2002).

— 6 —
Conclusions and Future Work

PLANNING FOR THE 2010 CENSUS is, to put it mildly, not easy. The Census Bureau is trying to launch two major initiatives in an increasingly tough fight for federal budget resources. Data products from the 2000 census are still being released, and virtually all of the formal evaluation studies for the 2000 census remain to be publicly released. The 2010 census planners must strive to keep pace with new opportunities in rapidly changing information technology; they must try to work to achieve design consensus with both Congress and the executive branch, even though three congressional elections and two presidential elections will take place between now and Census Day 2010. It is no easy task, but it is a vital one; decisions made in these early years of the decade will be crucial to the success of the 2010 census.

In this interim report, we have reviewed the major components of the Census Bureau's emerging plan for the 2010 census. There is much to like about this plan—-its earliness and its relative boldness—but major challenges remain. The panel looks forward to continued work on the issues raised here and will revisit them in its final report. The panel's interactions with the Census Bureau on several topics

of interest, including strategies for coverage measurement, refining residence rules, and new enumeration methods, are continuing, and so we defer detailed discussion of these topics to our final report as well. We close this interim report with some further principles and suggestions for 2010 census planning.

COSTS AND BENEFITS

A major conclusion of the panel is that discussion of the 2010 census design needs to be more fully informed by the evaluation of various trade-offs—the costs and benefits of various reasonable approaches in order to make wise decisions. For example, there are costs and benefits associated with the following issues:

1. How accurate will ACS information be relative to long-form information?

2. How inaccurate is the TIGER database at present? What accuracy will result from various approaches to its enhancement, and at what cost per unit of enhanced accuracy? Of what magnitude are the cost reductions that may result from a geographically correct TIGER system, such as more accurate routing of nonresponse follow-up enumerators?

3. With respect to nonresponse follow-up and the use of various types of personal computing devices, what benefits would offset their respective costs?

4. What cost reductions (monetary and nonmonetary) will result from greater use of the Internet and other high-technology means of enumeration, and what are the costs of greater use of these enumeration modes?

These and other fundamental questions need to be addressed so that decision makers can make informed selection among the various design options.

To expand on some of the preceding examples, the Census Bureau has not provided, to date, a full justification for the use of mobile computing devices (MCDs) to assist in nonresponse follow-up data collection, or for the use of Internet and interactive voice response (IVR) as

alternatives to initial data collection via mailback. The MCDs are likely to cost somewhere on the order of $250 million. Their potential benefits include automated data collection and transmission, higher quality data collection, easier identification of housing units, facilitated navigation from one housing unit to the next, and facilitated communication of assignments. While these are certainly important advantages, they need to be quantified to be able to analyze whether the advantages offset the costs, both monetary (perhaps on the order of $250 million for procurement) and nonmonetary (impacts on training the pool of enumerators). The use of the Internet and IVR as primary modes of initial data collection comes at a modest cost, but it is plausible that a great majority of those who would make use of these technologies would have been likely to reply to the mailed questionnaire. How much of an inroad these new technologies would make with hard-to-count populations remains an open question. The benefits must then be compared with the costs, among them the potential for duplicate enumerations.

PLANNING AND EVALUATION

To date, the plan for the 2010 census has been presented to the panel with little supporting analysis. In part, this is attributable to the Census Bureau's need to devote more time and resources than expected to the intensive, specialized evaluation studies that surrounded the Accuracy and Coverage Evaluation (ACE) and the debate over statistical adjustment of 2000 census results. Whatever the reason for the delays, though, we are concerned that the selection of design options may have been hampered by a failure to fully exploit the existing information that is available from various management information and monitoring systems used to support the 2000 census.

In its letter report (National Research Council, 2001c), the panel urged the Census Bureau to "give high priority to evaluation studies and data analyses that are important to building an overall 2010 census framework." We further suggested the following as priority issues of concern:

- the relative impact of various processes (such as the Local Update of Census Addresses [LUCA] and block canvassing) that were used to assemble the 2000 census MAF;

- the effect of local and tribal partnerships on the data collection process;
- comparison of estimates from the ACS and 2000 census long-form data, in sites where both are available;
- coverage of the population, disaggregated by demographic and geographic subgroups;
- the effectiveness of major automated systems for data collection, capture, and processing;
- the quality and completeness of long-form data collection; and
- the effectiveness of operations used to designate special places and enumerate the group quarters and homeless populations.

This remains a good list of topics for which evaluation information is critical.

In at least two major waves in early and late 2002, the Census Bureau reviewed its planned set of evaluation studies and—citing resource demands and the need to prioritize research—cancelled dozens of planned evaluations, reducing the total list of studies from 149 to 91 (with 18 planned evaluations converted to reports in the ACE/adjustment series) (U.S. Census Bureau, 2002a, 2003b). Agree or disagree with the particular items selected for cancellation—we have already cited the cancellation of evaluation F.1 on the Delivery Sequence File as one that is difficult to understand—this refocusing of the list has presumably made the formal evaluation workload tractable.

Accordingly, the Census Bureau should complete the remaining items on its planned evaluation list as expeditiously as possible; it must also complete and release its "synthesis reports" that are intended to draw conclusions from thematic blocks of evaluations. That done, the Census Bureau must subsequently do the following:

- *Take stock of what it has learned from the evaluation studies and flesh out the 2010 census plan with empirical support.* For example, the Census Bureau's strategy for updating the Master Address File must be grounded in (and, as necessary, changed to reflect) findings of the relative contribution of good, valid census

addresses from the Delivery Sequence File and other sources. Further examples: the case for mobile computing devices must reflect evaluation-based knowledge of enumerator problems in finding assignments, and logical architecture reengineering must try to correct problems encountered in the interaction of the 2000 census computer systems.

- *Fill gaps in knowledge through further analysis of 2000 census operational data or through census tests.*

In terms of general census planning, the panel's suggestion in its letter report that contingency planning should be factored into census planning remains valid. This is particularly true with regard to the still-uncertain budgetary prospects of the American Community Survey. But it is true more generally. Congress provided ample funding for the 2000 census and, as we have argued earlier, Congress must be aware that cuts in funding in the years leading up to 2010 could severely impact the quality of the American Community Survey and other census operations. But the possibility exists that budget fortunes leading to 2010 may not be as generous as in the 2000 cycle, and contingency plans must be adapted for various levels of budget support.

INTEGRATION

Finally, as we have reiterated several times in this report, integration of effort and integrated planning are keys to successful census planning. We have advocated the creation of two positions within the census hierarchy—a system architect and a MAF improvement coordinator—because they reflect two areas in which coordination is particularly critical. We hope that logical architecture modeling as described in Chapter 2 provides clues to other ways in which effort may be better integrated and internal organizations may be realigned.

Other prominent examples of substantive areas in which integration may be lacking include:

- insufficient efforts to develop requirements for the personal computing devices and to understand how these devices interact with headquarters with respect to acquiring up-to-date maps, assignments, navigation, and data transmission;

- redefinitions of group quarters, residency rules, and related concepts—based on 2000 census evaluations and experiences—that impact within-household undercoverage, and the relationship between these definitions in the census and the American Community Survey; and

- clear articulation of responsibility and activity in the Community Address Updating System (CAUS) of the ACS.

In our letter report (National Research Council, 2001c), we recommended the following:

> **The Census Bureau should produce a "business plan" that provides an overall framework for development of the 2010 census. Such a plan should include: (1) a clear statement of objectives, (2) an approximate timeline for completion of tasks, (3) a cost-benefit analysis of the various components of the plan, and (4) a fuller explanation of how intra-bureau efforts will be coordinated. In assessing the costs and benefits (both monetary and nonmonetary) of a reengineered 2010 census, attention should be given to potential effects of new processes on census coverage and differential undercount and their measurement.**

Clear articulation of such a plan, backed by empirical evidence from evaluation studies and census tests and with careful attention to both costs and benefits, would help greatly in building support for the 2010 census plan.

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Michael L. Cohen is a senior program officer for the Committee on National Statistics, currently serving as co-study director for the Panel on Research on Future Census Methods and staff to the Panel to Review the 2000 Census. He previously assisted the Panel on Estimates of Poverty for Small Geographic Areas. He also directed the Panel on Statistical Methods for Testing and Evaluating Defense Systems. Formerly, he was a mathematical statistician at the Energy Information Administration, an assistant professor in the School of Public Affairs at the University of Maryland, and a visiting lecturer in statistics at Princeton University. His general area of research is the use of statistics in public policy, with particular interest in census undercount, model validation, and robust estimation. He has been elected as a fellow of the American Statistical Association. He received a B.S. degree in mathematics from the University of Michigan and M.S. and Ph.D. degrees in statistics from Stanford University.

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Shoreh Elhami *(consultant)* is the geographic information systems (GIS) director for the Delaware County, Ohio, Auditor's DALIS (Delaware Appraisal Land Information System) Project. Elhami's involvement in census-related projects goes back to the 1990 census, when she became involved with the postcensus review process. From 1997 to 2000, as the county's census liaison, Elhami orchestrated all Census 2000 related activities. She has over 12 years of experience in the GIS field and is the principal architect of the DALIS Project's GIS system, which was the primary resource used for the Local Update of Census Addresses (LUCA) in the county. Under Elhami's direction, the DALIS Project has received Ohio's Best GIS Practices Award from the Ohio Geographically Referenced Information Program in 1998 and Environmental Systems Research Institute's Special Achievement Award in 2000. Elhami frequently speaks at national and international GIS conferences and is the past president of the Ohio Chapter of the Urban and Regional Information Systems Association. She served as a member of the LUCA Working Group jointly commissioned by the Panel to Review the 2000 Census and the Panel on Research on Future Census Methods. She is currently a member of the Mapping Science Committee of the National Research Council's Division on Earth and Life Sciences. She received an M.A. in city and regional planning from Ohio State University.

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