US CENSUS BUREAU
Business Case Analysis

for implementation of

21st Century MAF/TIGER Enhancements

to support the
2010 Census

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21ˢᵗ Century MAF/TIGER Enhancements

The MAF/TIGER system is an aging national resource. It has been used for 15 years to support the various censuses and household surveys managed by the U.S. Census Bureau. It also has provided the "data" foundation of the burgeoning geographic information system (GIS) industry in the United States. These many and varied uses have been possible because the geographic information in the TIGER data base, along with the statistical data from the Census Bureau's various programs, have been available in a low cost, unrestricted, copyright-free environment under the terms of OMB Circular A-130.

To meet the address and geographic accuracy requirements of the 2010 Census, and to provide the address and map quality expected by local/tribal governments that want to work in geographic partnership with the U.S. Census Bureau, the federal government needs to fund, and the Census Bureau needs to implement, the 21ˢᵗ Century MAF/TIGER Enhancements initiative proposed in this "Business Case Analysis," starting in fiscal year 2002. Funding this initiative is a sound business decision because the savings that will be realized, even from the limited set of 2010 Census activities already examined, exceed the costs associated with implementing the full set of activities envisioned for the Selected Alternative. Implementing this initiative also is consistent with the recommendations made by the National Research Council in its First Interim Report, "Designing the 2010 Census."

Current Situation: Although the existing MAF/TIGER system has been able to meet most of the U.S. Census Bureau's geographic support requirements up through Census 2000, operational managers throughout the Census Bureau have expressed the belief that the agency **cannot** get through the 2010 Census without significant enhancements to the system. As currently designed and implemented, the MAF/TIGER system:

- **Impedes** the Census Bureau's ability to improve the **accuracy and quality** of its Master Address File (MAF) and integral TIGER data base.

- **Restricts** the Census Bureau in its resolve to adopt **an integrated address list update/ geographic update/data collection instrument** that will operate on portable/hand-held computers equipped with GPS capabilities.

- **Limits** the Census Bureau's **efforts** to make use of satellite/air photo imagery, Global Positioning System (GPS) locational technology, and high quality local/tribal files **to correct map errors** and **correctly locate every address**.

- **Precludes** Census Bureau staff from adopting **modern database practices** and using **rapid application development tools** to implement new activities.

- **Constrains** Census Bureau staff in their efforts to continue/establish **more effective geographic partnerships** with state, local, and tribal governments, other federal agencies, and private sector firms.

- **Diminishes** the Census Bureau's ability to provide geographic products and geocoding services of the highest possible **quality**.

Approach Envisioned: The U.S. Census Bureau needs to enhance the capabilities of the MAF/TIGER system beyond the level achieved for Census 2000, to prepare for significantly more automation of difficult and error-prone 2010 Census field activities, and to eliminate clerically-intensive address and map update operations. The enhancements proposed in this initiative will allow the Census Bureau to:

- Use contractors that have image processing expertise to **enhance the accuracy of street and other map feature locations** in the TIGER data base, **and the locations for each MAF address**.

- **Update** the MAF/TIGER **address and street information directly using GPS**-equipped portable (hand-held) computers and other satellite locational technologies, as well as from high quality files offered by local and tribal governments.

- Use contractors with image processing expertise to **implement automated feature change detection methods** that will efficiently identify areas where the TIGER data base needs to add new streets and the MAF needs to add new addresses.

- Use COTS database, GIS, and applications software products to **modernize the** MAF/TIGER **processing environment,** to **implement web-based** MAF/TIGER **update** and product generation operations, and to benefit from new **"rapid application development"** software techniques.

- **Extend and expand geographic partnership programs** that update the MAF/TIGER data base while there still is time to build on the experience and good will gained during similar programs for Census 2000.

- **Implement ongoing evaluation and corrective processes** for the MAF/TIGER data base that will guide expenditures of resources for updating address and street information beyond the corrections emanating from Census 2000 and assure the performance of the "national geocoding system" that Census Bureau customers expect and desire.

- **Implement** a MAF/TIGER system **business process re-engineering** program, in addition to the extensive requirements gathering process already completed.

- **Continue** to exercise **priority control** over MAF/TIGER updating activities and address list/map product generation activities.

Title of Initiative: DEC-1   21st Century MAF/TIGER Enhancements

I.   Business Need

- *Why are MAF/TIGER enhancements important to the U.S. Census Bureau at this time?*

The mission of the U.S. Census Bureau is to be the preeminent collector and provider of timely, relevant, and quality data about the people and economy of the United States. The Census Bureau's goal is to provide the best mix of timeliness, relevancy, quality, and cost for the data it collects and the services it provides. To do this, the Census Bureau must implement strategies to assure that what its customers want dictate what it does; strive for improved productivity to achieve lower costs, greater timeliness, and higher quality; improve public perception and cooperation by giving attention to the public's needs and concerns; and strengthen relationships with its employees. Implementing the activities outlined in the four Objectives of the 21st Century MAF/TIGER Enhancements initiative will allow the U.S. Census Bureau to better serve its mission and to better meet its goal.

Implementing the four Objectives will enhance the capabilities of the MAF/TIGER system beyond those achieved for Census 2000, offer levels of accuracy and services that were desired but could not be provided, and adopt Global Positioning System (GPS) locational technologies to resolve the most vexing issues still confronting field staff (see Appendix E). In no other program at the Census Bureau has the use of automation been more far-reaching or more successful than in the MAF/TIGER activity. The enhancements proposed in this initiative will keep the MAF/TIGER system at the forefront of the Census Bureau's infrastructure and operational support activities.

This "Business Case Analysis" proposes a sound strategy to meet the geographic support needs of the 2010 Census. In meeting these needs, the MAF/TIGER System also will meet most needs of the other censuses and household surveys that are managed by the U.S. Census Bureau, as well as the need to make greater use of administrative records in ways that will enhance the Census Bureau's comprehensive estimates and projections activities. In adopting these proposals, the Census Bureau will realize cost savings in the 2010 Census in excess of what it will cost to implement the proposed enhancement activities. These savings will accrue from using more efficient and effective technologies available today but not yet implemented in the MAF/TIGER system.

Implementing the full set of Objectives envisioned in the Selected Alternative of this "Business Case Analysis" is a multi-year effort that must be started in fiscal year 2002:

- To assure accuracy and quality in the address list and related map information that will be needed to support the 2010 Census and related testing program;

- To demonstrate the value of GPS-equipped portable (hand-held) computers that will guide and increase the effectiveness of 2010 Census data collection and address/ geographic update operations;

- To assure availability of a new computer processing environment, based on commercial off-the-shelf (COTS) software products, in time to support the testing activities planned in preparation for the 2010 Census;

- To be successful in continuing geographic partnerships with local and tribal governments while there still is time to benefit from the learning and experience gained in the geographic preparations for Census 2000;

- To implement an enhanced national geocoding system that will deal as effectively with "rural-style" addresses as the current system deals with city-style addresses.

Delaying the start of implementation activities beyond fiscal year 2002 will jeopardize starting/continuing preparations for all these activities.

- *What is the required performance or expected results?*

Although the MAF/TIGER system was able to meet most U.S. Census Bureau geographic requirements defined in advance of Census 2000, implementing this initiative will allow the Census Bureau to overcome significant limitations identified during Census 2000, the American Community Survey demonstration program, and the Census 2000 Supplementary Survey. Implementing the activities associated with the Selected Alternative also will allow the Census Bureau to demonstrate technologies that will foster greater automation of 2010 Census field activities, and to launch the Census Bureau's statistical programs into the 21st Century. Appendix D documents the requirements that exist today for the MAF/TIGER system, and shows which of these requirements the existing MAF/TIGER system fails to meet, in total or in part.

Specifically the U.S. Census Bureau expects the MAF/TIGER system to:

1. Correctly locate every street/road, every other map feature used for orientation during field data collection operations (streams, lakes, railroads, and the like) and every structure (address) in the United States, Puerto Rico, and the Island Areas.

    - Having correct locations for all addresses, streets, and other map features will allow the Census Bureau to use new technologies, such as GPS-equipped portable or hand-held computers, and to automate and integrate 2010 Census field data collection and address list/geographic update operations. Adoption of this new technology will:

        -- Eliminate the most vexing problems that still confront field staff as they perform address list and map update/verification activities, as they perform questionnaire delivery and enumeration activities in areas without city-style addresses, and as they attempt to make return/follow-up visits to housing units that have not responded during the mailback phase of a decennial census or a household survey. (Appendix E summarizes the geographic and address problems reported by observers of Census 2000 field operations.)

-- Save money by replacing the current paper maps, paper address lists, and enumerator-administered paper questionnaires, as required by the Government Paperwork Elimination Act (GPEA) and recommended by the National Research Council in its <u>First Interim Report</u> entitled, "Designing the 2010 Census."

-- Reduce the number of processing steps required to implement MAF/TIGER updates, which will avoid processing errors that accumulate and compound as needed revisions are passed from operation to operation.

- Using files provided by local/tribal government partners, whenever possible, to correct the locations of streets and other map features, and to correctly locate each structure. Using these files has the double benefit of saving money (when compared with purchasing corrected location information derived from satellite imagery or GPS-based activities) and achieving high levels of local/tribal government satisfaction.

- Having all structures (addresses) and map features in their correct location will make the 2010 Census field data collection activities more effective and accurate, and will facilitate partnerships that use address and geographic (street and boundary) information from state, local, and tribal partners, as envisioned under Public Law 103-430 and Executive Order 12906 (the latter activities will be coordinated in conjunction with the Federal Geographic Data Committee).

- Using contractors with expertise in satellite imagery/air photo interpretation to correct the locations of all existing structures (addresses), streets, and other map features that are not corrected using local/tribal files will avoid unnecessary federal government hiring/training/human resource management costs, take advantage of technical expertise and processing systems that exist in the private sector, and speed identification of new structures and new streets (change detection), so each can be accurately associated with the full set of geographic entities in which it belongs.

2. Replace the existing MAF/TIGER data base (that uses an in-house system developed during the 1980s), along with the applications software designed around it, with a modern processing environment based on COTS software products.

- Having a modern database structure will enable the use of web-based MAF/TIGER updating approaches and product generation activities.

- Using COTS software will enable more effective file transfers from (and back to) the portable computers that will be used in 2010 Census field operations, as well as from (and back to) the address and geographic data bases provided by local/tribal government partners. These improvements are needed to support multiple cycles of field and local/tribal review activities.

3. Extend and expand the highly successful geographic partnerships begun in conjunction with Census 2000 to take advantage of the training and experience that now exists among local/tribal staff who contributed address and street updates. The program expansion needs to include a "rolling LUCA" program, computer-based updates of governmental unit boundaries and the boundaries for other geographic areas, support for conversion to, and U.S. Postal Service adoption of, E-911 addressing systems, and active recruiting of more local/tribal governments into the ranks of active participation.

4. Implement a comprehensive national geocoding system that includes a plan for periodic MAF/TIGER evaluation and corrective activities that will guide planning for cost effective geocoding and coverage improvement operations before the MAF/TIGER data base is used to support 2010 Census operations.

5. Beyond preparing for a more efficient and accurate 2010 Census, in the post-Census 2000 period, the MAF/TIGER system must provide extensive geocoding services to other Census Bureau programs, such as helping the Administrative Records program to operate more effectively, helping the intercensal estimates program eliminate the current bias against small towns and rural areas, helping the Economic Census programs identify the communities with the greatest participation in the new "service economy," and so forth.

II.   Users/Stakeholders

- *Who will be affected by this decision?*

The primary users of the MAF/TIGER data base are the U.S. Census Bureau's data collection and data analysis organizations, including the 2010 Census. Of additional significance are all state, local, and tribal governments that desire to work in partnership with the Census Bureau to improve the MAF/TIGER data base. Beyond the direct users, other agencies and organizations that will be affected by (and benefit from) a decision to implement the Selected Alternative include:

- The agencies that are members of the Federal Geographic Data Committee;

- The state, local, and tribal governments that participate in the activities of the National States Geographic Information Council;

- The governments that are members of the National Association of Counties, the National League of Cities, the National Association of Towns and Townships, the International City/County Management Association, the U.S. Conference of Mayors, the National Congress of American Indians, and so forth;

- All customers for statistical and geographic data from Census 2000, the American Community Survey, the Economic Census, the various monthly household surveys, and so forth.

Additional stakeholders include other U.S. Census Bureau program initiatives that are not dependent on these 21st Century MAF/TIGER Enhancements, but that are likely to benefit from them, including:

- The American Community Survey and Census Long Form Transitional Database that will replace the long-form component of the 2010 Census. The American Community Survey will require improved address list completeness throughout the coming decade, especially in small towns and predominantly rural areas, and improved address/street locations to implement more effective computer-based data collection techniques. The American Community Survey coverage program is designed to supplement the other sources of address information for such areas;

- The initiative and to identify the many new businesses that comprise the burgeoning service-sector of the United States economy, and to correctly identify the communities in which each is located;

- The Next Generation Information Products initiative and its requirement to achieve fully integrated data tabulations and related geographic information; and

- The initiative for expanded uses of Administrative Records to better support the American Community Survey and other Census Bureau programs, while at the same time improving the quality and timeliness of intercensal statistical estimates, projections, and data tabulations.

III. Current Approach (Baseline)

- *What is the U.S. Census Bureau doing now?*

The current MAF/TIGER system provides the geographic information infrastructure and application systems required to produce basic maps, address lists and geographic reference files, and to provide geocoding services and associated processing systems needed to meet the shared geographic requirements of all U.S. Census Bureau programs. When a specific Census Bureau program or activity requires MAF/TIGER services unique to its program (a special map type, more frequent boundary updates, more frequent address list updates, a special address or geographic file extract, and so forth) that program pays for the additional MAF/TIGER updates/applications software/products required. The chart appearing as Appendix A shows the cost of the Selected Alternative for the 21st Century MAF/TIGER Enhancements initiative, by Objective, for the 10-year cycle during which it will support the specific needs of the 2010 Census.

To support the shared geographic needs of the U.S. Census Bureau, and meet the geographic requirements identified in advance of the 1990 census and Census 2000, the Census Bureau developed a functionally integrated set of computer files and applications software known as the MAF/TIGER system. The current MAF/TIGER data base requires large volumes of information from many external sources to establish and maintain a current and accurate housing unit address list, current and accurate geographic

boundaries for all governments, current, address ranges to facilitate geocoding various files, and other map information.

The funds provided to the Geographic Support base program allow the U.S. Census Bureau to periodically update the inventory of housing unit addresses and related geographic information included in the MAF/TIGER data base for areas with city-style (house number/street name address) using the Delivery Sequence Files provided by the U.S. Postal Service.

However, the funds provided to the Geographic Support base program do **not** allow the Census Bureau to develop automated methods to deal with the types of addresses most commonly used for mail delivery in rural areas (rural route and box addresses, P.O. Box addresses, and General Delivery addresses); do **not** allow the MAF/TIGER data base to provide the levels of accuracy required to meet many current, and even more emerging, geographic support needs; do **not** allow the Census Bureau to correct address deficiencies that impede geocoding and matching addresses that are not city-style; and do **not** allow the Census Bureau to resolve the locational difficulties associated with competing field operations across the entire United States and the associated Island Areas.

If approved and funded, the activities associated with implementing the American Community Survey coverage program will begin to fill the gap in updating the MAF/TIGER data base with new addresses and roads in small towns and predominantly rural areas. This will support American Community Survey sample frame update requirements as well as the address list update requirements of the 2010 Census in areas without city-style addresses. These updates, along with the updates derived periodically from the U.S. Postal Service's Delivery Sequence File (DSF), will meet the Census Bureau's minimal needs for basic address lists, updated maps, geographic reference files, and geocoding services required by the periodic censuses, household surveys, intercensal population estimates, and research and development activities. However, the lack of a national geocoding system that provides block-level assignment of all addresses, city-style and other, is a significant liability.

Specifically, the Geographic Support base program:

- Updates the MAF/TIGER data base with city-style address for new housing units and commercial structures, some new streets, and revised boundary information for some governments. The U.S. Census Bureau accepts and processes updates provided voluntarily by local/tribal governments, those provided as a byproduct of Census Bureau field operations conducted in support of other programs, and through periodic matches with the U.S. Postal Service's DSF.

  However, it does **not** allow the Census Bureau to expand these efforts to the most expansive, and difficult-to-update, predominately rural areas.

- Maintains all existing in-house developed MAF/TIGER processing systems (data base and applications software) and the current separate databases for the MAF,

TIGER, GEOCAT, production control system, progress reporting system, problem referral system, and so forth. As staff expertise and funding permit, it will allow the Census Bureau to migrate additional portions of the MAF/TIGER system and its related applications software from the current Compaq (DEC) Alpha (open VMS) platform to more effective UNIX and NT platforms.

However, it does **not** allow the Census Bureau to undertake a major system-wide conversion to a COTS-based modern processing environment.

- Continues to support the minimal level of geographic partnerships with state, local, and tribal agencies that existed before Census 2000, such as a Boundary and Annexation Survey of American Indian areas, counties, incorporated places having at least a specified minimum population, and selected minor civil divisions. In addition, it allows the Census Bureau to continue accepting voluntary, ad hoc contributions of geospatial files from state, local and tribal governments, and will process these files as time and available resources permit.

    However, it does **not** allow the Census Bureau to initiate new geographic partnership activities or to actively encourage new partners.

- Maintains minimal quality control by reviewing samples of each output product to ensure that products adhere to specifications. These activities focus quality control only on assuring that the products generated from, and the geocoding services provided by, the MAF/TIGER system maintain existing quality levels.

    However, it does **not** allow the Census Bureau to make geocoding quality improvements beyond the incorporation of Census 2000 address data into the MAF/TIGER data base to provide improved and expanded address range geocoding coverage.

- *What performance gap or other problems is the U.S. Census Bureau having with this approach?*

    - The current TIGER data base is an amalgam of street, road, and other map feature information collected over more than thirty years from a wide variety of sources of varying accuracy and quality. (Examples are the Metropolitan Map Series of the late '60s that relied on taped-together paper copies of U.S. Geological Survey (USGS) maps of early-'60s/late-'50s vintage; the USGS 1:100,000-scale scanned map files from the mid-'80s; local/tribal and contractor-supplied updates from sources of unmeasured accuracy and quality; and updates sketched on paper maps by staff recording their perceptions of location while performing various field operations associated with the 1970, 1980 and 1990 censuses, and Census 2000).

        The result is a data set that (mostly) correctly represents the **relative** location of streets (and their associated addresses) and other map features (rivers, lakes, railroads, and the like), but that has highly variable (and almost totally

undocumented/undocumentable) locational accuracy. In one study of location accuracy done in 1999 (see Appendix F), the following disturbing results were documented:

-- The locations of specific streets in high-growth areas of Maricopa County, AZ varied in location error from a low of 120 feet to a high of about 500 feet; nearly a football field's amount of displacement, on average.

-- Locations from more controlled TIGER update activities, such as USGS-based operations and operations using local/tribal paper maps, generally had location errors of less than 150 feet.

-- Updates from less controlled activities, such as LUCA field verification and Address Listing, produced location errors exceeding 1,200 feet; more than four football fields of displacement.

- In three other studies done in 1998 (see Appendix G) reports were prepared that evaluate the prospects and methods for using GPS and digital orthophoto imagery to correct MAF/TIGER location errors. These studies have been supplemented with analyses of satellite image methods, as documented in the Booz-Allen & Hamilton MAF/TIGER Modernization Study (see Appendix D).

- The address ranges in the TIGER data base reflect updates from a similar amalgam of operations over more than 30 years. These address ranges are being revised to reflect the field-based observations of addresses included in Census 2000 through a process known as AARP (the Automated Address Range Program). The AARP process replaces old TIGER address range/block number relationship information with MAF-derived address/block number relationship information.

- The current funding level for the Geographic Support base program is not adequate to implement the additional automation, accuracy, and timeliness expectations of the MAF/TIGER system for the 2010 Census. This "Business Case Analysis" shows that "what makes sense for 2010" includes implementing the currently unfunded Objectives described below. To supplement the "Business Case Analysis," the U.S. Census Bureau contracted with Booz-Allen & Hamilton to prepare a needs assessment and requirements overview. Their findings support the strategy outlined in this "Business Case Analysis." (Appendix D provides a copy of their report entitled, Master Address File (MAF)/TIGER Modernization Study.)

The 21st Century MAF/TIGER Enhancements initiative identifies four Objectives the U.S. Census Bureau needs to implement to assure modernization of the MAF/TIGER system in time to meet the needs of the 2010 Census and its associated testing activities.

-- **Objective One:** Correctly locate every street and other map feature in the TIGER data base, each MAF address, and implement an effective automated feature change detection methodology. Accomplishing this Objective for the entire United States will require 8 years at the requested funding levels, after which a reduced funding level will support ongoing change detection activities.

-- **Objective Two:** Implement a modern processing environment for the MAF/TIGER system that will support rapid application development, allow extensive use of COTS software, and reduce staff training time. Achieving this Objective will require 5 years at the requested funding level, after which the new processing environment will be the only one used.

-- **Objective Three:** Expand and encourage geographic partnership programs with state, local, and tribal governments willing to help update the MAF/TIGER data base. The expansion needs to include a "rolling" LUCA program to maintain a current address list and updated street information for use by the 2010 Census as well as the various household surveys managed by the Census Bureau. It also needs to include implementing web-based updates of the addresses, streets, governmental unit boundaries, and other geographic entity boundaries used in Census Bureau activities. This Objective continues at a constant funding level once initiated.

-- **Objective Four:** Implement a comprehensive plan for periodic MAF/TIGER evaluation and corrective activities that will guide planning for cost effective ongoing coverage and geocoding improvement operations. This Objective continues at a constant funding level once initiated.

- *What is the future impact of NOT changing direction at this time?*

  Objective One:

  - NOT investing in correction of street, address, and other map feature locations will diminish the ability of the MAF/TIGER system to provide geographic products and services that meet the accuracy expectations of the 2010 Census field data collection staff and the U.S. Census Bureau's data product customers.

    -- The Census Bureau's field staff have reported (see Appendix E) extensive difficulties in completing address list updating and verification tasks, and in finding addresses and streets that required follow-up visits in Census 2000, the American Community Survey demonstration activities, and the Census 2000 Supplementary Survey.

    -- The local/tribal governments that participated in the Census 2000 geographic partnership programs, and many potential customers for TIGER geographic products, have told the Census Bureau that they will not consider future partnership/use without substantial improvements in location accuracy.

These deficiencies also will substantially reduce the use of the Census Bureau's geographic products by other federal agencies, local/tribal governments, and the private sector, leading to a reduced incentive for them to provide address and street update information to the Census Bureau.

- NOT investing in the identification and correct location of new housing units (addresses) and streets/roads in small towns and rural areas will result in an "urban bias" to the MAF/TIGER data base and will not provide the complete, uniform coverage required of U.S. Census Bureau data products.

- NOT incorporating high quality address and map updates from local/tribal partners will result in continued, and increasing, dissatisfaction with the geographic programs, processes, and products of the U.S. Census Bureau by partners who have tried hard to work cooperatively with the Census Bureau on both geographic and other aspects of the agency's statistical programs.

- NOT investing in new technologies to improve accuracy and find new structures will preclude adoption of portable, GPS-equipped computers for field data collection activities and continue the Census Bureau's reliance on labor-intensive, paper-based, interactive MAF/TIGER data base updating activities.

Objective Two:

- NOT investing in development of a new MAF/TIGER processing environment based on COTS software will:

  -- Result in continued dependence on the now outdated "homegrown" TIGER data base software system of the 1980s.

  -- Preclude efforts to allow more than one person (update clerk, computer programmer, or data analyst) to have access to a given MAF/TIGER partition at the same time.

  -- Continue the pattern of long lead times now experienced for development of new software applications to update and use the MAF/TIGER data base.

  -- Continue the long lead times now experienced for training new computer programming and MAF/TIGER update staff to a level where they can be productive.

  -- Preclude the hiring of computer programming staff and otherwise talented contractors that know COTS databases and applications; COTS tools that might be applicable to rapid development of new geographic processing systems and applications.

-- Present a significant impediment to the development of a paperless address list and geographic update system for Census Bureau field staff and local/tribal partners.

-- Present a significant impediment to the development of a web-based MAF/TIGER update system for use by local/tribal governments.

Objective Three:

- NOT extending the U.S. Census Bureau's investment in the training and experience achieved through Census 2000 geographic partnerships with local/ tribal governments across America will risk losing the staff expertise these partners now have in place and their confidence that the Census Bureau is serious about the value of their participation.

- NOT expanding the U.S. Census Bureau's geographic partnership efforts also will ignore the opportunity to improve the accuracy and inventory of addresses, streets, and boundaries in the MAF/TIGER data base using high quality information that those governments already have available. Ignoring this good information not only deprives the Census Bureau of greater accuracy, it also risks a decrease in the public's confidence in the Census Bureau's ability to maintain constructive partnerships.

  It is difficult to quantify the benefits of satisfied partners in state, local, and tribal offices across the United States. Nonetheless, the Census Bureau anticipates substantial benefits from expanding existing geographic partnership programs, based on the very positive feedback from Census 2000 geographic partnership activities.

- NOT expanding programs that provide opportunities for local/tribal partners to share automated address and map updates will result in the U.S. Census Bureau increasing its reliance on labor-intensive, expensive field operations, and related interactive MAF/TIGER data base updating activities.

Objective Four:

- NOT implementing new quality metrics will diminish the ability of the MAF/TIGER system to provide the highest possible quality in the geographic products and services prepared to support the U.S. Census Bureau's data collection activities and for the Census Bureau's data product customers.

- NOT identifying areas that have geocoding deficiencies, and not taking corrective action once such areas are identified, will preclude the ability to develop a true national geocoding system that can provide additional geocoding services, such as direct address matching, CATI contact, or field work.

IV.   **Alternative Solutions**

- *What constraints or assumptions are applicable?*

   The U.S. Census Bureau needs to continue its leadership role in accomplishing these enhancements and managing the MAF/TIGER system because it is the **only** system that integrates all the disparate address and geographic information required to support Census Bureau operations, and it provides the **only** set of applications software that meets the Census Bureau's production volume requirements. Although many private sector geographic systems offer some of the address and/or map information and some of the applications software required to support the statistical programs for which the U.S. Census Bureau is responsible, none offer the comprehensive suite of the MAF/TIGER system, none offer the processing throughput to nationwide decentralized operations as does the MAF/TIGER system, none integrate information of as many different types as the MAF/TIGER system, and none offer the degree of priority control, flexibility, and responsiveness as a Census Bureau-managed MAF/TIGER system.

   Accomplishing the needed geographic infrastructure improvements will allow the organizations that depend on the MAF/TIGER system for their statistical data to benefit from applying new technology for data collection and geographic information updates, to use COTS software for rapid application development, and to benefit from new address and geographic data sources. These enhancements will result in significant savings to the 2010 Census and are likely to allow other statistical programs the U.S. Census Bureau manages to operate much more effectively.

   The U.S. Census Bureau needs to enhance the capabilities of its MAF/TIGER system beyond the level achieved for Census 2000 and prepare for significantly more automation of field operations in the 2010 Census. All alternatives considered in this "Business Case Analysis" represent realistic solutions to the Census Bureau's requirement to support the additional automation, accuracy, and timeliness expectations of the customers for a 21st Century MAF/TIGER. This document presents the costs, benefits, and a risk analysis for each alternative.

- *Under what conditions might the current approach remain viable?*

   The current approach, (simply continuing the Geographic Support base program at its current funding level, identified in this document as Rejected Alternative A), is no longer viable to meet the increased demands placed on the MAF/TIGER system and does not provide an acceptable alternative. The resources provided to the base program are not sufficient to overcome its shortcomings and meet the needs of the 2010 Census or any of the new intercensal uses envisioned by the U.S. Census Bureau. Cost and benefit analyses were not performed on this "status quo" alternative because the current program no longer meets the Census Bureau's strategic objectives and requirements for the highest possible quality geographic services and data products. The current approach may result in an actual degradation of quality due to increasing reluctance of more sophisticated local and tribal governments, as well as other federal agencies, to provide updated address and geographic information to the Census Bureau.

- *How would the alternative(s) affect other systems, activities, or operations (for example, network infrastructure)?*

  The proposed 21st Century MAF/TIGER Enhancements will change the roles and requirements for many activities throughout the U.S. Census Bureau. Once the 21st Century MAF/TIGER Enhancements initiative is approved, and the scope of the changes that are funded becomes known, the Census Bureau's Project Manager will need to perform a "business process re-engineering" study to determine all the changes and linkages involved. (Performing such a study now would impose undue, and potentially unproductive, burdens on many programs that might not be affected once funding decisions are made.) Types of activities that are candidates for change include the following:

  - The MAF/TIGER updating process needs to become "web-based" rather than the current approach of all applications needing to use a "live" file residing on a specific computer. Implementing a web-based MAF/TIGER update system likely will require funding to support development of a new MAF/TIGER processing environment. (Objective Two).

    -- Support for this Objective will allow staff in all regional offices, the National Processing Center, at Headquarters, and in local/tribal geographic partner offices that need to update MAF/TIGER information to have concurrent access to the "real/current" version of the data base. This will allow each of them to see all current information from all sources, rather that the current situation in which most individuals viewing the MAF/TIGER data base see only an archived copy of an earlier version. This will enable much more affective participation by local/tribal partners that have expressed great frustration at the regular receipt of "next step" maps and/or lists that do not show recently submitted changes from "previous step" activities. It also will eliminate much of the frustration experienced when multiple Census Bureau offices need to update or view MAF/TIGER information concurrently.

    -- Providing and using the web-based capability will require significant bandwidth on telecommunications lines, but will reduce the need for large disk farms in each decentralized location (for example, the regional offices) that requires access to the MAF/TIGER data base.

  - Once street and address locations are corrected (Objective One), Census Bureau staff can begin using GPS-equipped portable/hand-held computers to perform not only MAF/TIGER update activities, but also CAPI-style data collection activities, using the same device. This will require acquisition of and support for the portable computers, but will replace the paper-based operations now in use and the computer/printer/key station infrastructure needed to support the current process.

- *What alternative solutions are feasible?*

  The following pages (Exhibit 1) provide an outline description and flow diagram for each Objective in the Selected Alternative for the 21st Century MAF/TIGER Enhancements initiative. The fifth page of Exhibit 1 provides an overall MAF/TIGER System Architecture diagram.

  Appendix B and Appendix C provide outline descriptions and flow diagrams for each Objective in the two other alternatives considered viable, but rejected as part of this "Business Case Analysis."

  No outline descriptions or flow diagrams appear for Rejected Alternative A -- simply continuing the Geographic Support Base Program at its current funding level -- because the current level of funding does not allow the Census Bureau to meet any of the new requirements identified in the Booz-Allen & Hamilton MAF/TIGER Modernization Study. The deficiencies in the current system have been documented in earlier sections of this "Business Case Analysis," and also in Appendixes E and F.

  In addition, the U.S. Census Bureau did not prepare outline descriptions or flow diagrams for Rejected Alternative D -- privatization of the Nation's geographic base information as recommended by the National Performance Review in adopting the findings of the report, "Financing the NSDI: National Spatial Data Infrastructure" -- because it does not comply with the open access policies of OMB Circular A-130. That report proposes making activities, such as providing current and accurate map information a private sector-financed responsibility. The Census Bureau could not fully compare this alternative for the following reasons:

  - There is no information available in the report on how adopting this approach would affect costs.

  - This alternative does not comply with the open access requirements of OMB Circular A-130. What is likely if this approach were to be adopted is the following:

    -- If the private sector commits its funds to finance the acquisition and update of accurate map information, their goal, of necessity, will be making money from the project to repay their investors. The private sector can do this using two techniques that are not available to the U.S. Census Bureau -- copyright and license fees.

    -- License fees will need to be high to recover all costs and make a profit. Thus, every copy of every map, whether printed on paper or displayed on the screen of a portable computer, will need to require payment of a license fee to the private sector -- one fee for every field assignment area and every map copy sold or provided to a data user.

-- Copyright will prohibit the free redistribution of the map information essential to customers understanding the spatial relationships of the statistical data. Every copy of a map, and every TIGER/Line® file the Census Bureau prepares to accompany its statistical data products, will require payment of a royalty, which will need to become part of the cost of the product. Further, no customer could make even a xerographic copy of the map or a duplicate copy of the computer file without paying an additional royalty.

-- This approach would irrevocably disable the State Data Center/Census Information Center program because those organizations that now participate in partnership with the Census Bureau would need to pay a royalty on every copy of a map and on every copy of a computer file they made for one of their customers. Further, none of their customers could make even a xerographic copy of the map, or a duplicate copy of the computer file they received, without paying an additional royalty.

-- The U.S. Census Bureau already is criticized for "discriminating against low income communities" (as are many other federal agencies) by charging the very modest prices it (or a State Data Center/Census Information Center) charges for its current map, computer file, and related statistical data products. The approach recommended by the National Performance Review study would further favor the "rich" communities and groups and exclude the "needy," including many of the constituencies that are members of the Secretary of Commerce's 2000 Census Advisory Committee and the four Race and Ethnic Advisory Committees.

V.   Benefit/Cost Analysis

- *What are the lifecycle costs of each alternative and its associated objectives?*

The following tables (Exhibit 2) show the annual total cost of, and the annual cost associated with each Objective within, each viable alternative* considered as part of the 21st Century MAF/TIGER Enhancements initiative analysis process. The charts show the cost during the 5-year period covered by the FY 2002 budget initiative process. A comparison set of tables (Exhibit 3) show these same annual costs by Object Class. The chart appearing as Appendix A shows the annual total and "by Objective" costs of the Selected Alternative for the 10-year cycle during which the 21st Century MAF/TIGER Enhancements initiative will support the 2010 Census. The 10-year time frame shown on that chart also allows comparison of the "full cycle" initiative costs with the savings that will accrue in 2010 Census operations and related activities.

* No costs are listed for Rejected Alternative A -- simply continuing the Geographic Support base program at its current funding level -- because that alternative has been deemed not viable; it does not meet any of the new requirements identified by the Booz-Allen & Hamilton MAF/TIGER Modernization Study. In addition, no costs are listed for Rejected Alternative D -- privatization of the Nation's geographic base information -- because there was no information available in the report recommending this approach regarding what costs would accrue as a result, and because the privatization alternative does not comply with the open access requirements of OMB Circular A-130.

Exhibit 1 - One

Selected Alternative, Objective 1
Correct Locations of Streets/Other Map Features and Structures with Local/Tribal Files and Available Imagery

Objective One: Correct locations of streets and other maps features in the TIGER data base and ensure accurate housing unit locations for each MAF address; implement automated change detection methods.

1) Use local/tribal files, where available, to correct the location of streets and other map features in the TIGER data base that provide orientation to field staff (rivers, lakes, railroads, and the like), where available, insert (or correct) the locations of structures (addresses) in the MAF, and when provided, update both the TIGER data base and the MAF with more current information.

2) Contract to use off-the-shelf imagery (that is available at a modest price and that shows all streets/roads, other map features, and structures (addresses) that existed in the latter half of the '90s) to correct the locations of existing streets and other map features in the TIGER data base, correctly locate existing structures (addresses) in the MAF, and where the imagery shows streets and structures not in the MAF/TIGER data base, add the new information in areas where newer local/tribal files are not available.

3) Associate each structure point with the appropriate MAF ID for addresses in the MAF.

4) Insert the Public Land Survey System (PLSS) network into the TIGER data base from computer files, where available, or by manual digitizing.

5) Purchase information that identifies areas of growth/change (by automated comparison of new with older satellite images).

6) Conduct field checks to resolve situations that cannot be completed in the office operations.

U.S. Census Bureau Operations

Contractor Operations

Interactive review process for unmatched streets/features/structures

Field resolution

Automated matching of streets/other map features and structures

Interactive review and correction

Local/Tribal File

MAF/TIGER

Computer-assisted operation to reshape features from imagery, insert a point for each structure, and link that point to the appropriate MAF ID(s)

MAF units

TIGER features

Off-the-shelf imagery

Structure MAF/TIGER data

18

Exhibit 1 - Two

Selected Alternative, Objective 2
Complete Redesign of the MAF/TIGER Processing Environment
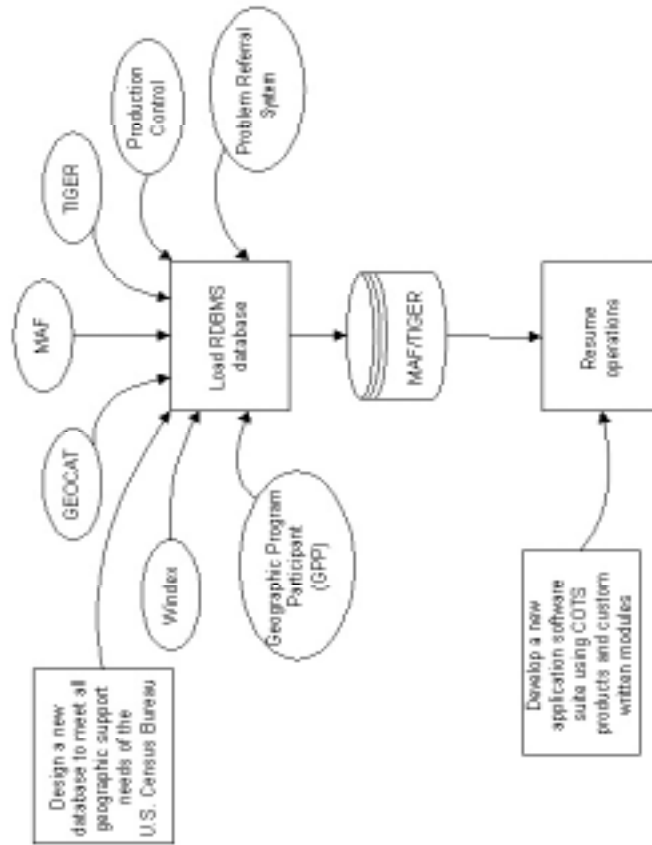
Objective Two: Develop a new processing environment for the MAF/TIGER System.

1) Develop a new design, using a COTS database, that will allow for fully integrating the geographic support information in the current MAF, TIGER, GEOCAT, GPP, Production Control, and related databases. The new database will be housed in a commercial RDBMS that has geospatial capabilities, and will be directly accessible by commercial off-the-shelf (COTS) software.

2) Develop a software architecture that utilizes COTS products to replace the in-house developed modules of the past, wherever possible. For those applications that must be custom developed, a rigorous component model of the new software architecture must be instituted to allow for evolutionary growth of the system over several years.

TIGER

Production Control

Problem Referral System

MAF

Load RDBMS database

MAF/TIGER

Resume operations

GEOCAT

Windex

Geographic Program Participant (GPP)

Design a new database to meet all geographic support needs of the U.S. Census Bureau

Develop a new application software suite using COTS products and custom written modules

Exhibit 1 - Three

Selected Alternative, Objective 3
Expand/Encourage Geographic Partnership Programs to Update MAF/TIGER
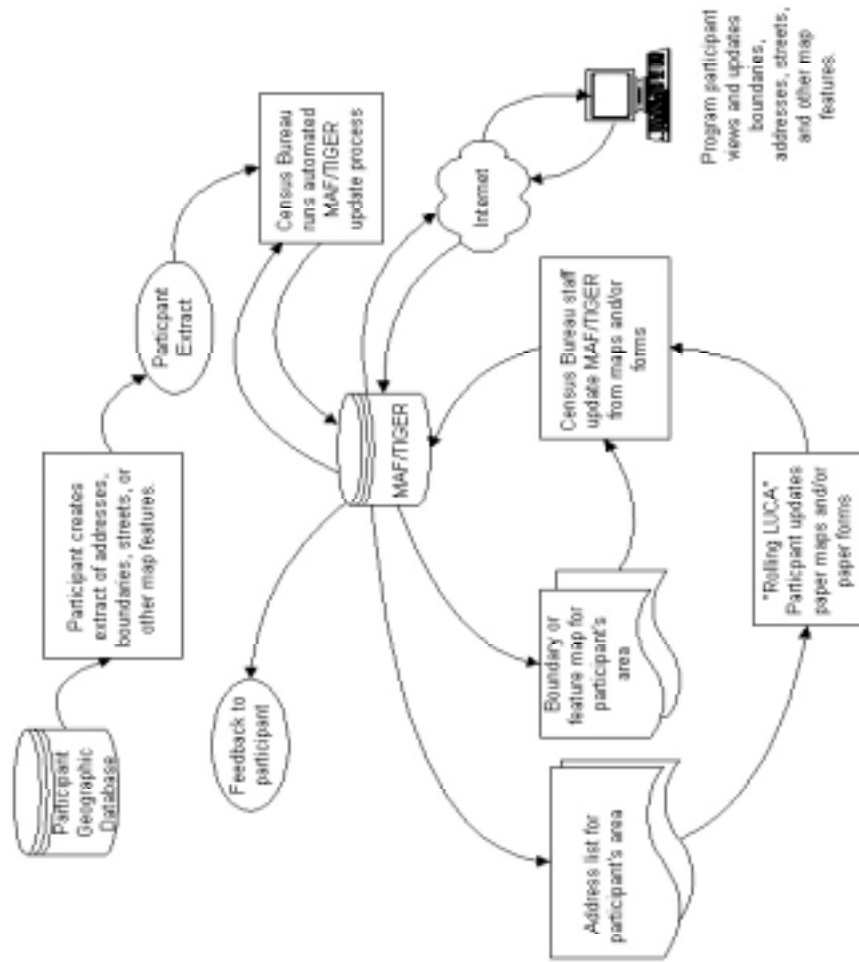
Diagram labels:
- Participant Geographic Database
- Participant creates extract of addresses, boundaries, streets, or other map features.
- Participant Extract
- Census Bureau runs automated MAF/TIGER update process
- Internet
- Program participant views and updates boundaries, addresses, streets, and other map features.
- MAF/TIGER
- Feedback to participant
- Census Bureau staff update MAF/TIGER from maps and/or forms
- Boundary or feature map for participant's area
- Address list for participant's area
- "Rolling LUCA" Participant updates paper maps and/or paper forms

Objective Three: Expand and encourage* geographic partnership programs with state, local, and tribal governments that continuously update the MAF/TIGER data base.

1) Institute a "rolling" Local Update of Census Addresses (LUCA) program to maintain a current address list for use in all U.S. Census Bureau censuses and household surveys.

2) Provide a web-based update process that will allow program partners to review and update (subject to Bureau validation) MAF/TIGER information across the Internet.

3) Solicit additional contributions of geospatial files from local and tribal governments to update the MAF/TIGER data base.

* This alternative assumes a continuation of normal Boundary and Annexation Survey operations and continued acceptance of voluntary contributions of geospatial files from local/tribal governments that already provide them.

Exhibit 1 - Four

Selected Alternative, Objective 4

Institute a Comprehensive Program for MAF/TIGER Evaluation and Repair

Objective Four: Implement a comprehensive plan for periodic MAF/TIGER evaluation and corrective activities that will guide planning for cost effective coverage and geocoding improvement operations.

1) Production applications will be expanded to allow for thorough error checking of work units for all output products and services. This will be accomplished by fully automated error checking software, where possible, automated error status reports, and by producing specialized data extracts for other quality assurance operations.

2) Integrated error checking will be extended to all processing operations associated with updating and using the MAF/TIGER data base, not just output products and services.

3) A full field evaluation program will be instituted to check the accuracy of the information in the MAF/TIGER data base, assess the accuracy of related geocoding activities, and specify necessary corrective activities.

4) Develop additional geocoding approaches that can be used to assign non-city-style addresses (and still ungeocoded city-style addresses) to the correct census block.

Diagram elements:

- QA results
- QA list request
- External data
- Priority/schedule
- Quality Metrics Database
- Clerical review, field work, partnership feedback, and other data sources
- QA evaluation/resolution
- List
- Request
- MAF/TIGER improvement operations
- Priority/schedule
- MAF/TIGER
- Files
- Problem Referral System
- Data from product/service QA
- User identified problems/errors
- MAF/TIGER product/service requests
- Products/Services
- Maps, GRFs, address list, TIGER/Line, geocoding, and so forth
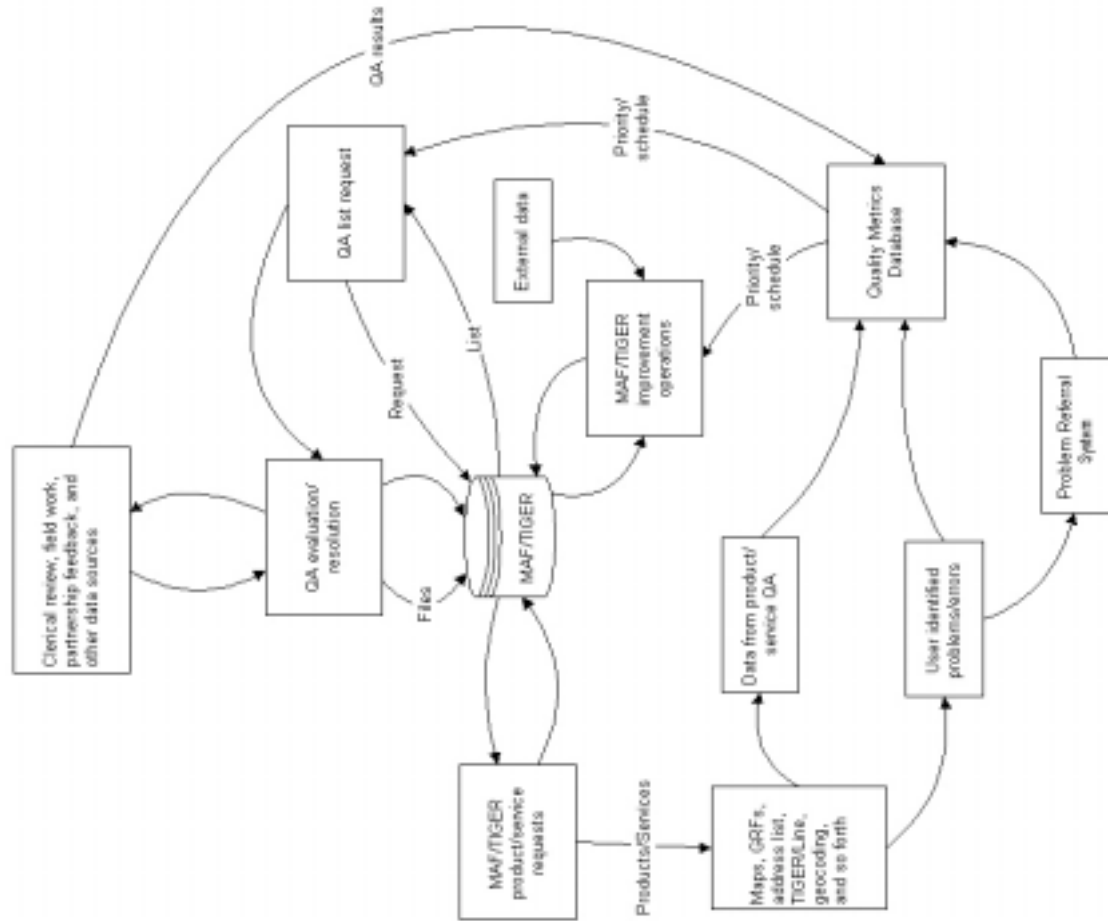
Exhibit 1 - Five
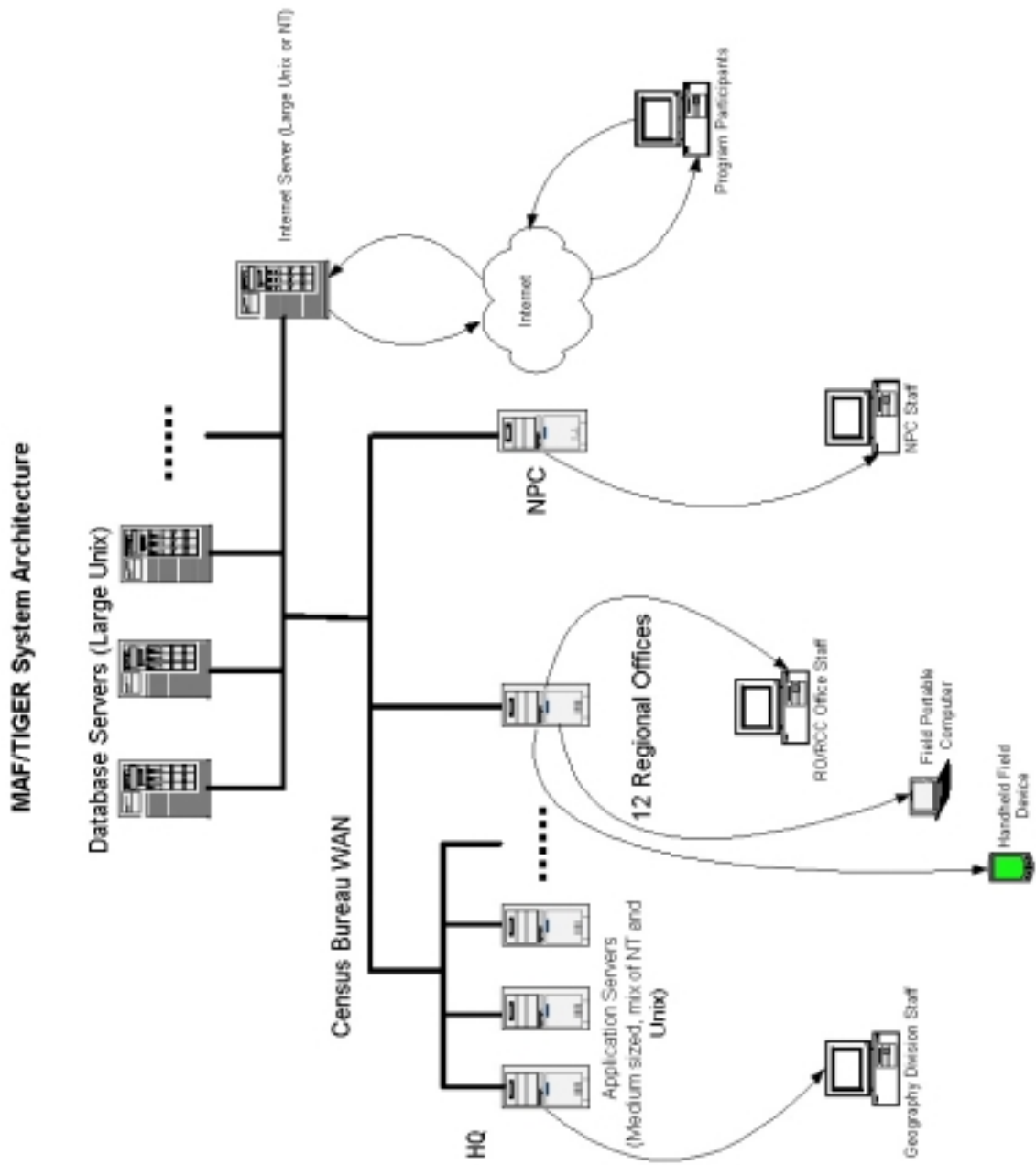

MAF/TIGER System Architecture

Exhibit 2: Estimated Costs for Enhancement Alternatives, by Objective

Estimated Cost of Selected Alternative, By Objective:

Fiscal Year	2002	2003	2004	2005	2006
Total Dollars (000's)	**$xxxxx**	**$ xxxxx**	**$ xxxxx**	**$ xxxxx**	**$ xxxxx**
Improve Address/Road Location Accuracy	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Implement New Processing Environment	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Enhance Geographic Partnership Options	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Expand Quality Metrics	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Estimated Full-Time Equivalents:	**xxxxx**	**xxxxx**	**xxxxx**	**xxxxx**	**xxxx**

Estimated Cost of Rejected Alternative B*, By Objective:

Fiscal Year	2002	2003	2004	2005	2006
Total Dollars (000's)	**$ xxxxx**	**$ xxxxx**	**$ xxxxx**	**$ xxxxx**	**$ xxxxx**
Improve Address/Road Location Accuracy	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Implement New Processing Environment	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Enhance Geographic Partnership Options	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Expand Quality Metrics	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Estimated Full-Time Equivalents:	**xxxxx**	**xxxxx**	**xxxxx**	**xxxxx**	**xxxx**

Estimated Cost of Rejected Alternative C*, By Objective:

Fiscal Year	2002	2003	2004	2005	2006
Total Dollars (000's)	**$ xxxxx**	**$ xxxxx**	**$ xxxxx**	**$ xxxxx**	**$ xxxxx**
Improve Address/Road Location Accuracy	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Implement New Processing Environment	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Enhance Geographic Partnership Options	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Expand Quality Metrics	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Estimated Full-Time Equivalents:	**xxxxx**	**xxxxx**	**xxxxx**	**xxxxx**	**xxxxx**

* No costs are listed for Rejected Alternative A -- simply continuing the Geographic Support base program at its current funding level -- because that alternative has been deemed not viable; it does not meet any of the new requirements identified by the Booz-Allen & Hamilton MAF/TIGER Modernization Study. In addition, no costs are listed for Rejected Alternative D -- privatization of the Nation's geographic base information -- because there was no information available in the report recommending this approach regarding what costs would accrue as a result, and because the privatization alternative does not comply with the open access requirements of OMB Circular A-130.

Exhibit 3: Estimated Costs for Enhancement Alternatives, by Object Class

Estimated Cost of Selected Alternative, By Major Object Class:

Fiscal Year	2002	2003	2004	2005	2006
Total Dollars (000's)	**$ xxxxx**	**$ xxxxx**	**$ xxxxx**	**$ xxxxx**	**$ xxxxx**
Hardware	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Software	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Telecommunications	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Contracts (IT activities)	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Contracts (programmatic activities)	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Labor and related	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx

Estimated Cost of Rejected Alternative B*, By Major Object Class:

Fiscal Year	2002	2003	2004	2005	2006
Total Dollars (000's)	**$ xxxxx**	**$ xxxxx**	**$ xxxxx**	**$ xxxxx**	**$ xxxxx**
Hardware	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Software	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Telecommunications	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Contracts (IT activities)	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Contracts (programmatic activities)	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Labor and related	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx

Estimated Cost of Rejected Alternative C*, By Major Object Class:

Fiscal Year	2002	2003	2004	2005	2006
Total Dollars (000's)	**$ xxxxx**	**$ xxxxx**	**$ xxxxx**	**$ xxxxx**	**$ xxxxx**
Hardware	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Software	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Telecommunications	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Contracts (IT activities)	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Contracts (programmatic activities)	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Labor and related	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx

*   No costs are listed for Rejected Alternative A -- simply continuing the Geographic Support base program at its current funding level -- because that alternative has been deemed not viable; it does not meet any of the new requirements identified by the Booz-Allen & Hamilton MAF/TIGER Modernization Study. In addition, no costs are listed for Rejected Alternative D -- privatization of the Nation's geographic base information -- because there was no information available in the report recommending this approach regarding what costs would accrue as a result, and because the privatization alternative does not comply with the open access requirements of OMB Circular A-130.

- *What benefits will be realized under the Selected Alternative and its associated objectives?*

The following chart (Exhibit 4) shows the benefits of the Selected Alternative, by Objective.

Exhibit 4: Benefits Associated with the Selected Alternative, by Objective

<u>Objective</u>	<u>Benefits</u>
1. Correctly locate every street and other map feature in the TIGER data base, each MAF address, and implement an effective automated feature change detection methodology.	Accurate coordinates will allow field staff to employ automated navigation technologies (GPS-equipped portable computers) to help them locate themselves and any street, structure, or address they are seeking, as recommended by the National Research Council in its <u>First Interim Report</u> entitled, "Designing the 2010 Census." Accurate coordinates will increase the U.S. Census Bureau's ability to incorporate more accurate address and geographic data from local/tribal partners and other sources both inside and outside the Census Bureau, as well as from administrative records sources. Assigning accurate coordinates to every structure will assist the U.S. Census Bureau in eliminating duplicate addresses.
2. Develop a new processing environment for the MAF/TIGER system.	Modernizing MAF/TIGER software will decrease future software development cycle times, which will allow faster development of new geographic update systems and faster implementation of new geographic support processes, such as a truly national geocoding system. Elimination of long lead times currently required for the development of new software applications to use the MAF/TIGER data base for new and improved products and services, thus assuring more timely delivery of all geographic products and services. Automation of address and map updates from local and tribal partners will reduce the U.S. Census Bureau's reliance on labor-intensive interactive MAF/TIGER data base updating activities. Independence from continued dependence on now outdated "homegrown" software systems of the 1980's.
1. and 2. Accurate address and map data in, plus a modern processing environment for, the MAF/TIGER system.	Replace the Address Listing operation with a Block Canvassing operation for areas that do not have predominately city-style address. Eliminate most paper map production activities through use of GPS-equipped portable/hand-held computers that will support both address list/geographic update activities and traditional data collection activities. Eliminate the labor-intensive, error-prone data keying and map digitizing operations associated with a paper map and paper questionnaire environment through use of the integrated portable computers. Greatly reduce the need for field verification activities associated with new addresses, duplicate addresses, and new streets because existence and accurate locations can be verified as entered on the integrated portable computers. Increased efficiency in field operations, such as Update/Leave, Update/Enumerate, and Nonresponse Follow-up, by using GPS-equipped portable computers to guide staff to the exact unit requiring attention.

3. Expand and encourage geographic partnership programs with state, local, and tribal governments to continuously update the MAF/TIGER data base.	Expansion of the U.S. Census Bureau's geographic partnership activities will increase the satisfaction of state, local, and tribal officials that offer their computer-readable address and geographic information, in accordance with Executive Order 12906 and the GPEA. Increased satisfaction and ease of operations involving field and regional staff in activities to update the address, street, and boundary information in the MAF/TIGER data base. Improved display capabilities, relevance, and timeliness of the U.S. Census Bureau's statistical data and geographic product dissemination program. Increased use of geographic files obtained from local/tribal partners will reduce the U.S. Census Bureau's reliance on labor-intensive MAF/TIGER data base updating activities. Improved accuracy in data tabulations for governmental units and other small areas.
4. Implement a comprehensive plan for periodic MAF/TIGER evaluation and corrective activities that will guide planning for cost effective coverage and geocoding improvement operations.	Increased quality of address and geographic products and services will allow the U.S. Census Bureau to support a fully integrated data collection and address list/geographic update instruments, thus eliminating paper products, as required by the GPEA. Increased geocoding coverage of the MAF/TIGER system will include non-city-style addresses and provide new software tools to improve the rate and quality of the associated geocoding services, especially in small towns and rural areas.

- *What is the projected return on investment and payback period, if applicable?*

    - **Return on investment**: The U.S. Census Bureau's cost analysis (Exhibit 5) of the proposal to implement the Selected Alternative of the 21st Century MAF/TIGER Enhancements initiative indicates that the Census Bureau will be able to realize cost savings in excess of initiative expenditures even if used only for the 2010 Census. Because the MAF/TIGER system is used in many other Census Bureau programs, the Census Bureau will be able to obtain a further positive return on the investment. Improving the appearance of Census Bureau maps used by local and tribal governments, and improving the ability of local/tribal governments to automatically match their address lists and maps with the MAF/TIGER data base, will increase public confidence in the quality of the resulting statistical data. Increased public confidence in the quality and value of Census Bureau geographic and data products also will increase the likelihood of constructive geographic partnerships.

    - **Payback period**: The greatest savings will be realized in fiscal years 2008-2010 by increased efficiency, reduction, or replacement/elimination of many large-scale field activities and data capture operations required for the 2010 Census. Some of these clerically intensive operations were implemented for Census 2000 because of the constraints the current MAF/TIGER system imposes on building and updating the address list and geographic database nationwide.

Exhibit 5: Benefits that Provide Quantifiable Cost Savings for the 2010 Census

Description of benefit	Potential Savings
Improved address list/map update operations	*$ xxxxx*
• Replacement of Address Listing with Block Canvassing.	$ **xxxxx**
• Elimination of paper map production through the use of a fully integrated data collection and address list/geographic update instruments.	$ **xxxxx**
• Elimination of clerically-intensive, data keying/scanning operations.	$ **xxxxx**
Computer-assisted field operations	*$ xxxxx*
• The reduction of decennial field activities for address list verification.	$ **xxxxx**
• Increased efficiency in field operations, such as update/leave, through the use of automated navigation technologies (GPS) to locate themselves and any structure address they are seeking.	$ **xxxxx**
• Increased efficiency in field nonresponse follow-up operation.	$ **xxxxx**
Improved processing environment	*$ xxxxx*
• Faster development of geographic product/service software and faster implementation of new geographic product/service delivery systems.	$ **xxxxx**
• Elimination of long lead times currently required for the development of new software applications that update/use MAF/TIGER.	$ **xxxxx**
Improved geographic boundary collection	**$ xxxxx**
• Increased use of geographic files obtained from local/partners will reduce the Census Bureau's reliance on labor-intensive updating activities.	$ xxxxx
Improved data tabulation capabilities.	*$ xxxxx*
• Increased geocoding coverage of the MAF/TIGER system will include non-city-style addresses and provide new tools to improve the rate and quality of geocoding services, especially in small towns and rural areas.	$ **xxxxx**
• Improved relevance and timeliness of statistical data and geographic product dissemination.	$ **xxxxx**
Total Life Cycle Savings from Implementing 21st Century MAF/TIGER Enhancements	**$ xxxxx**
Total Life Cycle Costs for 21st Century MAF/TIGER Enhancements	**$ xxxxx**
Net Monetary Benefit	**$ xxxxx**

• *How much confidence does the U.S. Census Bureau have in the cost (benefit) data?*

The U.S. Census Bureau has great confidence in the cost data (Exhibits 2 and 3) and benefit data (Exhibits 4 and 5), and is convinced that the expected benefits of this initiative merit the investment required to implement the Selected Alternative. (Note: No costs are listed for Rejected Alternative A (simply continuing the Geographic Support base program at its current funding level) or Rejected Alternative D (privatization of the Nation's geographic base information) because neither alternative has been deemed viable.)

VI. Risk Analysis

- *How does risk vary among the alternatives?*

    Selected Alternative: The major risks associated with the Selected Alternative are those associated with **not** investing in the 21st Century MAF/TIGER Enhancements initiative starting in FY 2002. These risks include:

    - Inability to fully automate the process for adding high quality address and map updates from local and tribal partners holding more current and accurate information in their system. This will result in continued dissatisfaction on the part of the partners who have tried hard to work cooperatively with the Census Bureau. It also will continue the Census Bureau's reliance on labor-intensive interactive MAF/TIGER data base updating activities.

    - Inability to move the MAF/TIGER processing environment to a modern processing environment based on COTS software. This will result in continued dependence on the now outdate "homegrown" software system of the 1980s. It also will require the long lead times currently observed for development of new software applications to update and use the MAF/TIGER data base.

    - Severely limit the ability of the MAF/TIGER data base to incorporate new addresses from administrative records sources and validate the locations of those addresses using new structure location information from satellites or detailed aerial photos. This will result in continued dependence on costly and labor-intensive field visits to validate MAF/TIGER information.

    - Inability to support the American Community Survey and other Census Bureau censuses and surveys to automate field address list and associated map update activities, and to integrate those activities with computer-based data collection operation. This will result in continued reliance on the labor and resource intensive paper maps and paper address lists currently inflicted on interviewers who already have their "questionnaire" automated. It also will preclude adoption of GPS technology to guide interviewers to their assignments, and require continued reliance on labor-intensive MAF/TIGER data base update operations separate from the on-site field visit.

    Rejected Viable Alternatives

    - Rejected Alternative B:

        -- This alternative would rely on a labor-intensive approach that involves a large field clerical operation to do the highly technical work needed to obtain GPS-derived anchor points, and a traditional, error prone approach to address list and map updating. This would require extensive training and staff skills not inherent in normal field data collections activities. It also would require that the U.S. Census Bureau invest in large amounts of computer and GPS hardware that will become obsolete fairly quickly.

        -- Prohibitively high costs.

-- Conversion of each component of the MAF/TIGER system to a COTS database without integrating some (or all) of them prolongs one of the problems of the existing system; lack of total integration.

-- Not extending the Census Bureau's geographic partnership efforts will result in the Census Bureau ignoring opportunities to improve the accuracy and inventory of addresses, streets, and boundaries in the MAF/TIGER data base. Not extending them also will risk a decrease in the public's confidence in the Census Bureau's ability to maintain constructive geographic partnerships.

It is difficult to quantify the benefits of satisfied partners in state, local, and tribal offices across the United States. Nonetheless, the U.S. Census Bureau anticipates substantial benefits from expanding existing geographic partnership programs, based on the very positive feedback from Census 2000 geographic partnership activities.

-- Not implementing error checking processes on all sources of address and street information used for MAF/TIGER update activities will prolong the current need for extensive field verification operations before finally accepting (or rejecting) information from local/tribal, private sector, or other sources.

-- Not implementing a full field evaluation program, bolstered with a significant upgrade to the geocoding system, will prolong the current lack of comprehensive quality metrics for the MAF/TIGER data base.

- Rejected Alternative C:

-- Prohibitively high costs.

-- There is no known GIS that can perform all MAF/TIGER data base and related applications. Adapting a single commercial GIS to achieve all MAF/TIGER tasks is considered a greater risk than adapting a mixture of COTS database and applications systems.

-- Not extending the Census Bureau's geographic partnership efforts will result in the Census Bureau ignoring opportunities to improve the accuracy and inventory of addresses, streets, and boundaries in the MAF/TIGER data base. Not extending them also will risk a decrease in the public's confidence in the Census Bureau's ability to maintain constructive geographic partnerships.

It is difficult to quantify the benefits of satisfied partners in state, local, and tribal offices across the United States. Nonetheless, the U.S. Census Bureau anticipates substantial benefits from expanding existing geographic partnership programs, based on the very positive feedback from Census 2000 geographic partnership activities.

-- Not implementing a full field evaluation program, bolstered with a significant upgrade to the geocoding system, will prolong the current lack of comprehensive quality metrics for the MAF/TIGER data base.

Rejected Alternatives Deemed Not Viable

- Rejected Alternative A:

  The U.S. Census Bureau does not consider this alternative -- simply continuing the Geographic Support base program at its current funding level -- to be a viable alternative. The current funding level is not sufficient to overcome the shortcomings of the existing MAF/TIGER system, as documented throughout this "Business Case Analysis" and in Appendices D, E, F, and G.

- Rejected Alternative D:

  The U.S. Census Bureau does not consider this alternative -- privatization of the Nation's geographic base information -- to be viable because:

  -- The costs associated with adopting this approach are not documented in the report recommending it to the Federal Geographic Data Committee and the National Performance Review;

  -- The approach would impose unacceptable restrictions on the copying and redistribution of U.S. Census Bureau map and geographic products that are essential to understanding the statistical data the agency provides to the Nation;

  -- The U.S. Census Bureau cannot make the success of its data collection and data dissemination programs subject to the whims of the private sector; the Census Bureau must control its priority-setting system for MAF/TIGER updating and distribution of address and geographic information.

## VII.	Recommended Decision

- *Which alternative represents the best, risk-adjusted value for the taxpayer?*

  The Selected Alternative for the 21st Century MAF/TIGER Enhancements initiative represents the best, risk-adjusted value for the taxpayer. It provides a financially sound plan that aligns well with the U.S. Census Bureau's corporate goals and strategies. In addition, the Selected Alternative is highly consistent with the Census Bureau's "Strategic Plan." A high quality MAF/TIGER data base is, in fact, part of the Priority One Item: Census Modernization, and it is critical to a more efficient and less costly 2010 Census.

- *How does this alternative align with agency ("corporate") goals and strategies?*

  The key results of the U.S. Census Bureau's "Corporate Business Plan," listed below, are supported by the Objectives of the Selected Alternative for the 21st Century MAF/TIGER Enhancements initiative.

  - Cheaper and more effective ways to collect and disseminate data

  - Minimized burden on respondents

- Facilitated reporting

- Lower data collection costs and cost-effective systems

- Affordable system(s) for easy-to-use, accessible data

- Accurate geocoding and timely, efficient geographic products

- Quality work environment for Census Bureau employees (including field staff)

- *What key uncertainties remain with respect to the proposed solution?*

  The key uncertainties include:

  -- Availability of an appropriate level of funding in FY 2002 to allow completion of the full development/implementation cycle for the Selected Alternative, and to support the operational testing program for the 2010 Census.

  -- Availability of the high quality satellite, air photo, and local/tribal data required for this initiative to be fully successful.

  -- Unknown status of closely related U.S. Census Bureau program proposals.

VIII. Next steps

The critical next steps to implement the 21st Century MAF/TIGER Enhancements initiative are:

- *Initiative steps*

  - Approval by U.S. Department of Commerce management.

  - Approval by the OMB.

  - Inclusion in the President's FY 2002 budget.

- *Related activities*

  Once the initiative is approved, and its funding level becomes known, the following activities will occur:

  - Preparation (by the U.S. Census Bureau) of an operational plan that includes a detailed milestone schedule, a detailed budget, and performance measures for each funded Objective and related activities.

  - Development (by contractors) of prototype MAF/TIGER applications for activities, such as automated street and map feature repositioning, automated structure location recording, automated housing unit and street "change" detection, and so forth. This process will include a series of staged "hot-house" tests to evaluate the success of the planned methodologies and identification of "go/no go" decision points.

- Development (by contractors and U.S. Census Bureau staff) of a business process re-engineering study to determine exactly how the enhanced MAF/TIGER system will be integrated into all affected data collection, data processing, and data dissemination activities.

- Development (by the U.S. Census Bureau) of an integrated database design that incorporates all address and geographic information, and all functions currently housed in the MAF, TIGER, GEOCAT, the GPP, the production control system, the problem referral system, and the progress reporting system.

- Reviews and decisions (by the U.S. Census Bureau) about continuation of several current research activities, including existing CRADAs with the private sector.

- Expansion (by the U.S. Census Bureau) of external communication processes to assure broad understanding of initiative goals, including "town meetings" and expansion of geographic partnership programs with state, local, and tribal officials.

- Implementation (by the U.S. Census Bureau) of a national geocoding test to provide a benchmark for the current state of the MAF/TIGER data base.

- Development (by the U.S. Census Bureau) of a research and implementation program for assessing and improving the quality of the MAF/TIGER system and development of additional techniques needed to assure accurate geocoding of non-city-style addresses.

- Development (by the U.S. Census Bureau) of a procurement strategy for acquiring address and geographic data (corrected locations) from private sector vendors.

- *How will the U.S. Census Bureau measure performance and track the realization of benefits?*

  This project will be managed by a team of certified project managers using a performance-based management system. The goal of the performance measures is to ensure continual assessment of the outputs and outcomes, and to ensure timely, cost contained, quality performance.

  Performance Measures:

  - **Outputs**:

    -- Satisfaction increases for the state, local, and tribal partners that offer their computer-readable address and geographic information, in accordance with Executive Order 12906 and the GPEA;

    -- Quality of address and geographic products and services is able to support fully integrated data collection and address list/geographic update instruments, thus eliminating paper products, as required by the GPEA;

-- Housing unit coverage in the MAF is at least as complete, each year, as it was at the time of Census 2000 data tabulation, as documented by the Census 2000 Accuracy and Coverage Evaluation results.

- **Outcomes**:

  -- Improve the completeness and accuracy of the address and geographic information in the MAF/TIGER data base to increase the effectiveness of the resulting address and map (paper or computer-readable) products used in the U.S. Census Bureau's censuses and household surveys;

  -- Improve the display capabilities, relevance, and timeliness of the U.S. Census Bureau's statistical data and geographic product dissemination programs.

- *When and how will the U.S. Census Bureau update assumptions and analysis?*

  - **Objective Status**: In addition to updating this "Business Case Analysis" and its assumptions, by periodically evaluating the progress towards meeting the performance measures documented above, the U.S. Census Bureau's Project Manager will measure "planned versus actual" task completion dates by tracking the status of information in the Management Information System for 21st Century MAF/TIGER Enhancements activities.

  - **Objective Scheduling**: The U.S. Census Bureau has identified the work breakdown structure required for the Selected Alternative (see Exhibit 6). The Census Bureau's Project Manager will continue to build more detailed schedules, and update the related assumptions, using status information from its Management Information System.

  - **Objective Costs**: The U.S. Census Bureau has prepared cost estimates for the Selected Alternative of the 21st Century MAF/TIGER Enhancements initiative through fiscal year 2011 (and for the Rejected Alternatives that were considered viable, through 2006) using the GEOBUDGET cost model. This cost model was designed by the Census Bureau's Project Manager and implemented under a contract awarded to Booz-Allen & Hamilton. The Census Bureau's Project Manager will document any changes in the cost estimates for the Objectives comprising the 21st Century MAF/TIGER Enhancements initiative and related projects using this tool.

    Once approval and funding is allocated for 21st Century MAF/TIGER Enhancements activities, the U.S. Census Bureau's Project Manager will monitor monthly incurred costs for the various Objectives and related projects against the planned costs. (S)he will do this by evaluating the financial management reports provided by the agency's Core Financial System, and then by preparing spending variance reports.

Exhibit 6: Work Breakdown Structure for Selected Alternative

21st Century MAF/TIGER Enhancements Initiative

|	
01.01	**New Structure Identification/Coordinate Improvement/Housing Unit Spotting**
01.01A0010	Project Planning and Management
01.01A0020	MAF/TIGER conversion to interim structure
01.01A0030	Data source acquisition and management
01.01A0040	Contract hardware and satellite imagery file procurement
01.01A0050	Update MAF/TIGER from locally/tribally submitted files
01.01A0060	Adjust coordinates/update features in TIGER through digital exchange w/state/local/tribal
01.01A0070	Update MAF/TIGER in densely inhabited and high-growth areas
01.01A0080	Update MAF/TIGER in small towns
01.01A0090	Update MAF/TIGER in rural areas
01.01A0100	Contract to use satellite imagery to detect structure/feature changes
01.01A0110	Update MAF/TIGER annually as directed by automated change detection
01.01A0120	Adjust HU and street locations and addresses for new structures/resolve discrepancies
01.02	**Develop New Processing Environment for MAF/TIGER**
01.02A0010	Project Planning and Management
01.02A0020	Research commercial software for future processing environment
01.02A0030	Design new database structure for MAF/TIGER (includes creation of a prototype)
01.02A0040	Database design and conversion of applications software
01.02A0050	Obtain training for HQ and regional staff in the use of the new equipment and software
01.02A0060	Convert MAF/TIGER and related systems
01.02A0070	Full development of the modernized MAF/TIGER system
01.02A0080	Life cycle hardware replacement
01.03	**Expand Geographic Partnership Programs that Update MAF/TIGER**
01.03A0010	Project Planning and Management
01.03A0020	System analysis and design
01.03A0030	Set up website for local/tribal government access
01.03A0040	Process additional DSF matches each fiscal year
01.03A0050	Process administrative records files/take necessary corrective actions
01.03A0060	Process MAF/TIGER updates from all U.S. Census Bureau censuses/surveys
01.03A0070	Support 'rolling' address/feature and geocoding update program
01.03A0080	Continue local/tribal address list review and update program
01.03A0090	Enhance the digital exchange program with state/local/tribal partners
01.03A0100	Support FDGC cooperative grant program
01.03A0110	Geographic applications
01.04	**Implement Ongoing MAF/TIGER Evaluation Plan**
01.04A0010	Project Planning and Management
01.04A0020	Develop a process for evaluating the quality of MAF/TIGER update reference and geocoding improvement sources
01.04A0030	Test improved methodology for locating units within multi-unit structures
01.04A0040	Test quality evaluation/geocoding improvement program in limited number of sites
01.04A0050	Implement feature quality and geocoding improvement program nationwide (check about 250,000 cases-contract)
01.04A0060	Develop targeting concept using 'hot house' tests, including mail
01.04A0070	Investigate spatial data capture and quality concepts and approaches through 'hot house' tests
01.04A0080	Develop an integrated Quality Metrics Database

Appendix A

Funding the 21st Century MAF/TIGER Enhancements

Appendix B - One

Rejected Alternative B, Objective 1
Correct Locations of Streets/Other Map Features and Structures using Local/Tribal Files and GPS Operations

Objective One: Correct locations of streets and other maps features in the TIGER data base and ensure accurate housing unit locations for each MAF address; implement automated change detection methods.

1) Use local/tribal files, where available, to correct the location of streets and other map features in the TIGER data base that provide orientation to field staff (rivers, lakes, railroads, and the like), and where available, insert (or correct) the locations for all structures (addresses) in the MAF; and, when provided, update both the TIGER data base and the MAF with more current information. (Same as in Selected Alternative.)

2) Implement a specialized field operation to collect anchor points and the location of structures using GPS-equipped portable computers in areas where local/tribal files are not available.

3) Correct the locations of streets and other map features in the TIGER data base by conflation or rubber-sheeting to the anchor points or to the local/tribal files.

4) Insert structure locations collected in the field operation described above into the TIGER data base.

5) Insert the Public Land Survey System (PLSS) network into the TIGER data base from computer files, where available, or by manual digitizing. (Same as in Selected Alternative.)
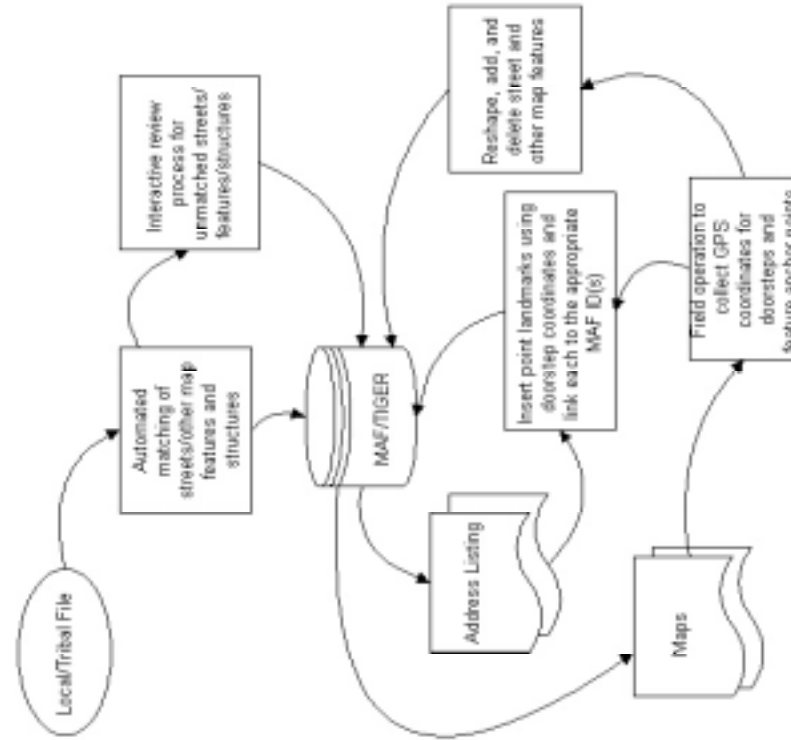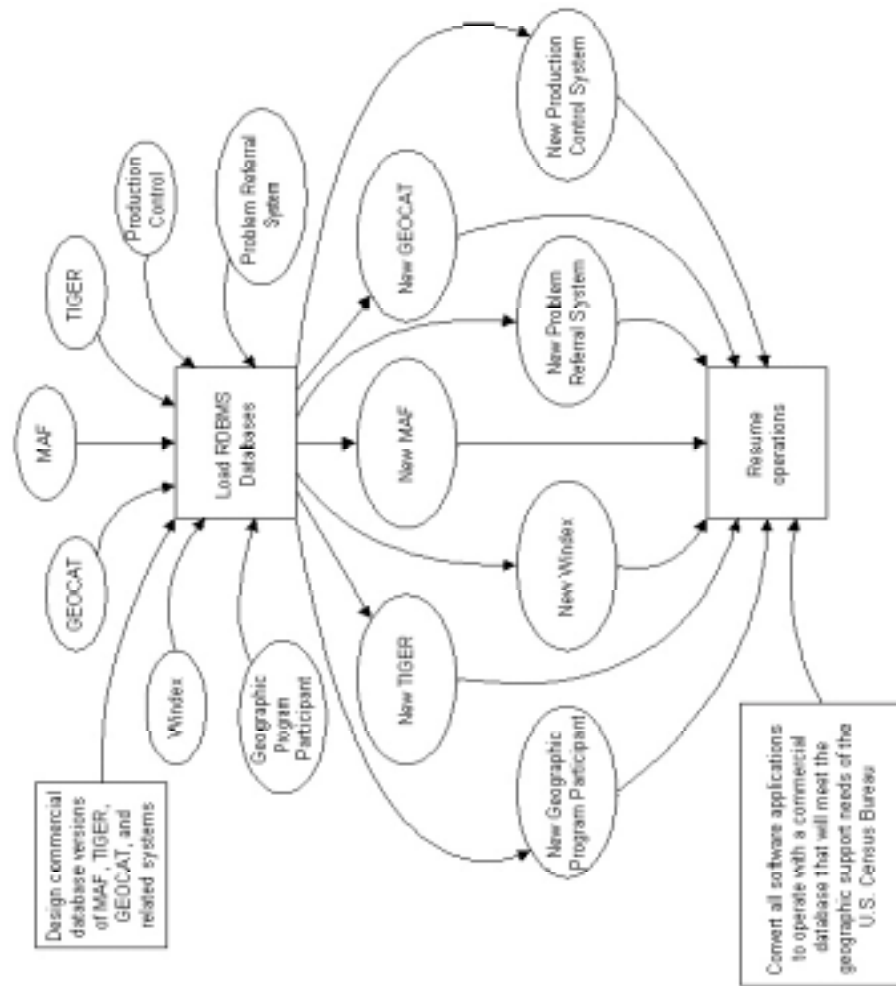
Appendix B - Two

Rejected Alternative B, Objective 2
Convert the Current MAF/TIGER Processing Environment to a Commercial Database

Objective Two: Develop a new processing environment for the MAF/TIGER System.

1) Transfer each of the geographic support databases from TIGER DB to a COTS database, preserving the exact structure and data content of each.

2) Convert existing applications software to access the MAF, TIGER, and related databases, in their new COTS database forms, using COTS software wherever possible.

Diagram nodes: MAF, TIGER, Production Control, Problem Referral System, GEOCAT, Winldex, Geographic Program Participant, Load RDBMS Databases, New GEOCAT, New Production Control System, New MAF, New Problem Referral System, New TIGER, New Winldex, New Geographic Program Participant, Resume operations

Design commercial database versions of MAF, TIGER, GEOCAT, and related systems

Convert all software applications to operate with a commercial database that will meet the geographic support needs of the U.S. Census Bureau
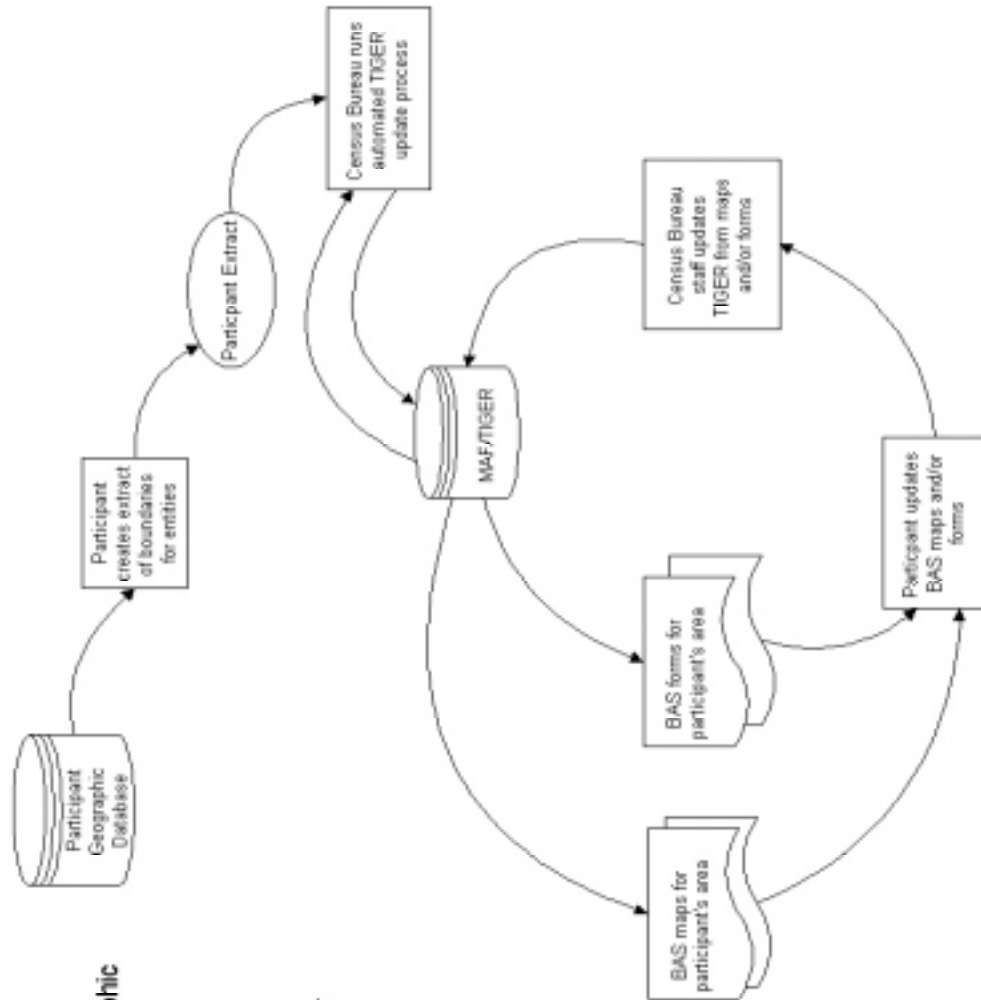
Appendix B - Three

Rejected Alternative B, Objective 3

Improve Existing Geographic Partnership Programs with Electronic Boundary Update Capability

Objective Three: Expand and encourage geographic partnership programs with state, local, and tribal governments that continuously update the MAF/TIGER data base.

1) Provide the capability to conduct an "electronic" BAS (automated update via an extract from a participant database) for those participants that wish to do so. Also, continue to provide the traditional paper map and paper form options.

2) Use the full range of follow-up and validation procedures when conducting a BAS of all legal geographic entities every year.

- Participant Geographic Database
- Participant creates extract of boundaries for entities
- Participant Extract
- Census Bureau runs automated TIGER update process
- MAF/TIGER
- Census Bureau staff updates TIGER from maps and/or forms
- BAS forms for participant's area
- BAS maps for participant's area
- Participant updates BAS maps and/or forms

Appendix B - Four

Rejected Alternative B, Objective 4
Improve Existing Quality Assurance Processes for MAF/TIGER Products and Services
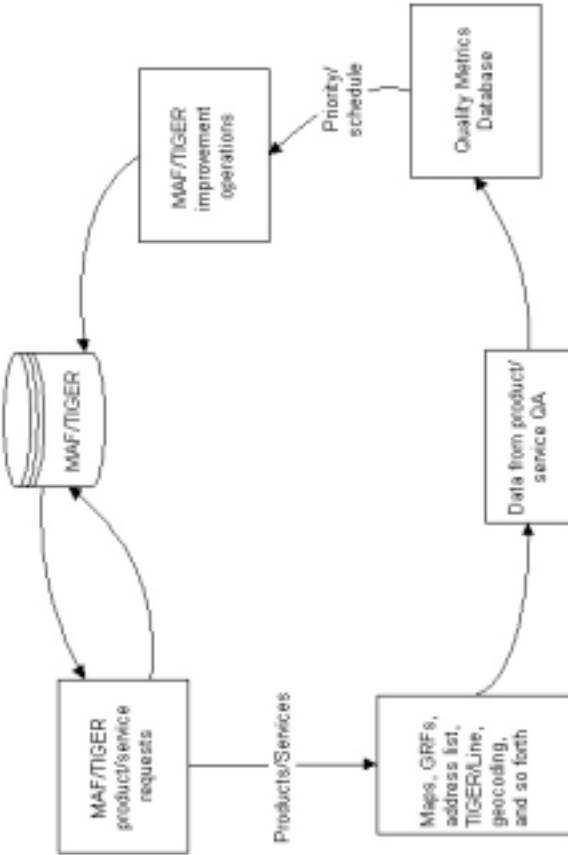
Objective Four: Implement a comprehensive plan for periodic MAF/TIGER evaluation and corrective activities that will guide planning for cost effective coverage and geocoding improvement operations.
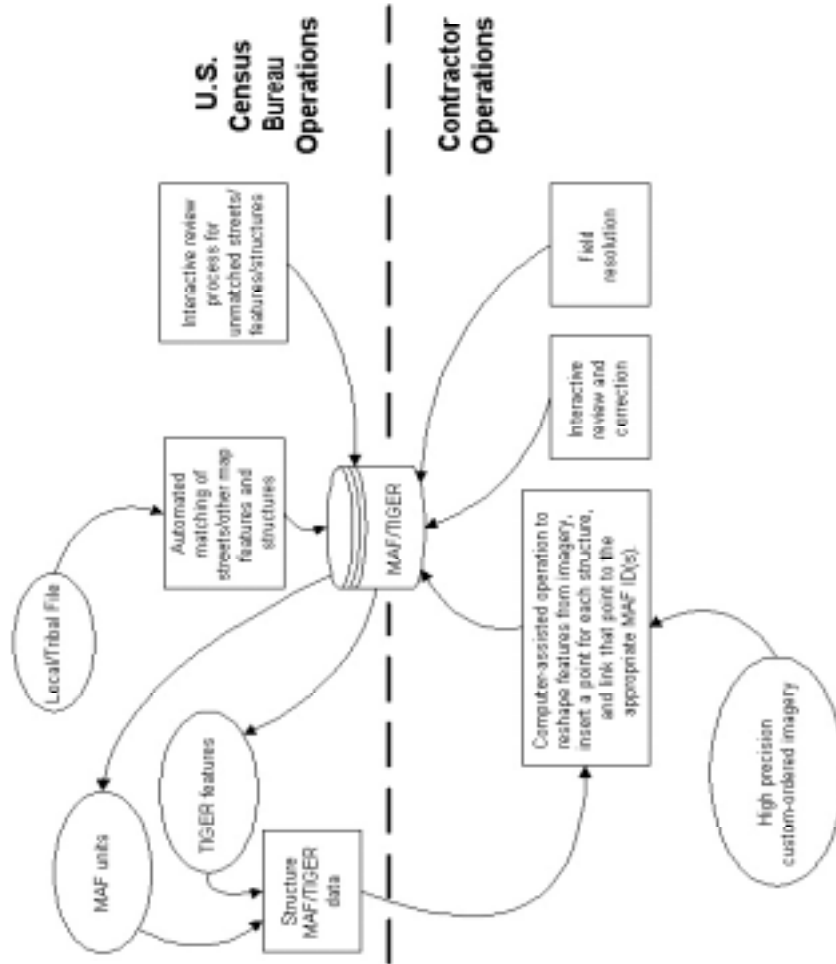
Production applications will be expanded to allow for thorough error checking of work units for all output products and services. This will be accomplished by fully automated error checking software, where possible, automated error status reports, and by producing specialized data extracts for other quality assurance operations. (Same as in Selected Alternative)

Appendix C - One

Rejected Alternative C, Objective 1
Correct Locations of Streets/Other Map Features and Structures with Local/Tribal Files and Current High Precision Imagery

Objective One: Correct locations of streets and other maps features in the TIGER data base and ensure accurate housing unit locations for each MAF address; implement automated change detection methods.

This alternative is operationally identical to the Selected Alternative, but will use custom-ordered imagery (imagery that is very current, but very expensive) throughout the United States to improve the locations of streets currently in the TIGER data base, identify all new streets, correctly locate all structures (addresses) in the MAF, identify all new structures, and further correct/ update areas that were updated using local/tribal files.

U.S. Census Bureau Operations

Contractor Operations

Interactive review process for unmatched streets/ features/structures

Field resolution

Automated matching of streets/other map features and structures

Interactive review and correction

Local/Tribal File

MAF/TIGER

Computer-assisted operation to reshape features from imagery, insert a point for each structure, and link that point to the appropriate MAF ID(s)

MAF units

TIGER features

Structure MAF/TIGER data

High precision custom-ordered imagery

Appendix C - Two

Rejected Alternative C, Objective 2
Replace the Current MAF/TIGER Processing Environment with a Commercial GIS
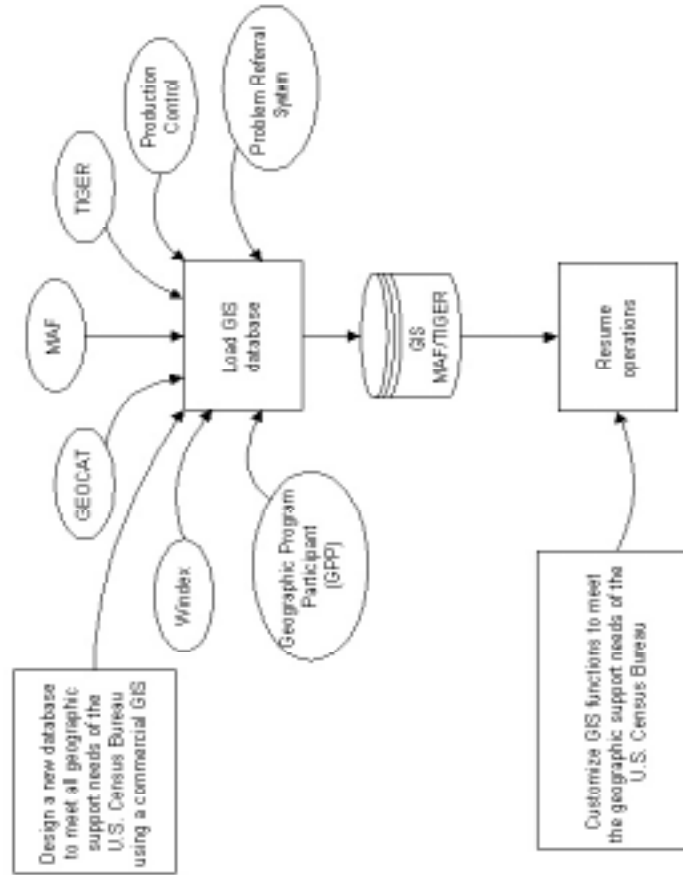
Objective Two: Develop a new processing environment for the MAF/TIGER System.

1) Develop a design for a new integrated geographic support database that will house the information in the current MAF, TIGER, GEOCAT, GPP, Production Control, and related databases. The database will be hosted in a commercial GIS.

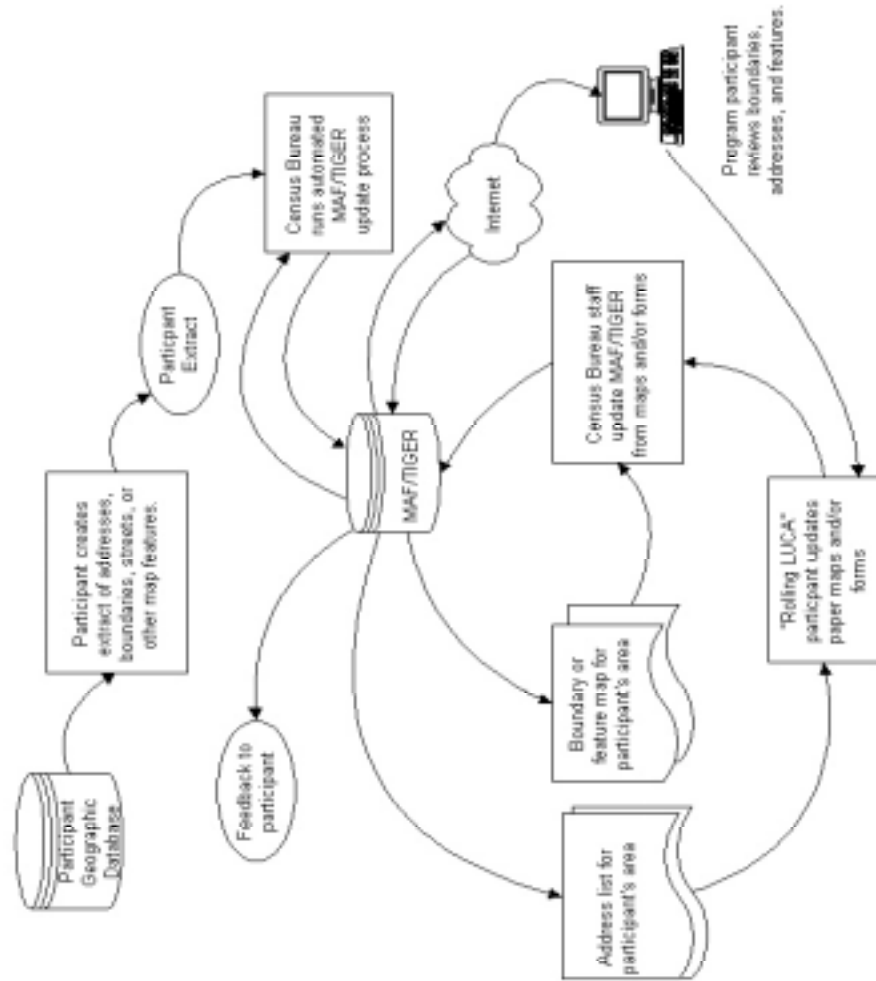2) Replace existing applications software with functions provided by the commercial GIS, customized where necessary.

Appendix C - Three

Rejected Alternative C, Objective 3

Improve Geographic Partnership Programs with Electronic File Submission, Internet-based Review, and Traditional Capabilities

Objective Three: Expand and encourage* geographic partnership programs with state, local, and tribal governments that continuously update the MAF/TIGER data base.

1) Institute a "rolling" Local Update of Census Addresses (LUCA) program to maintain a current address list for use in all U.S. Census Bureau censuses and surveys. (Same as in Selected Alternative.)

2) Provide a web-site that will allow program partners to review (but not update) MAF/TIGER information across the Internet.

3) Solicit additional contributions of geospatial files from local and tribal governments to update the MAF/TIGER data base. (Same as in Selected Alternative.)

* This alternative assumes a continuation of normal Boundary and Annexation Survey operations and continued acceptance of voluntary contributions of geospatial files from local/tribal governments that already provide them. (Same as in Selected Alternative.)

Flowchart elements: Participant Geographic Database; Participant creates extract of addresses, boundaries, streets, or other map features; Participant Extract; Census Bureau runs automated MAF/TIGER update process; MAF/TIGER; Feedback to participant; Internet; Census Bureau staff update MAF/TIGER from maps and/or forms; Boundary or feature map for participant's area; Address list for participant's area; "Rolling LUCA" participant updates paper maps and/or forms; Program participant reviews boundaries, addresses, and features.

Appendix C - Four

Rejected Alternative C, Objective 4
Improve Existing Quality Assurance Processes for MAF/TIGER Updates/Products/Services

Diagram elements: QA list request; External data; Quality Metrics Database; Priority/schedule; QA evaluation/resolution; MAF/TIGER improvement operations; MAF/TIGER; Request; List; Files; MAF/TIGER product/service requests; Data from product/service QA; Products/Services; Maps, GRF's, address list, TIGER/Line, geocoding, and so forth.

Objective Four: Implement a comprehensive plan for periodic MAF/TIGER evaluation and corrective activities that will guide planning for cost effective coverage and geocoding improvement operations.

1) Production applications will be expanded to allow for thorough error checking of work units for all output products. This will be accomplished by fully automated error checking software, where possible, automated error status reports, and by producing specialized data extracts for other quality assurance operations. (Same as in Selected Alternative.)

2) Integrated error checking will be extended to all MAF/TIGER processing operations, not just output products and services. (Same as in Selected Alternative.)
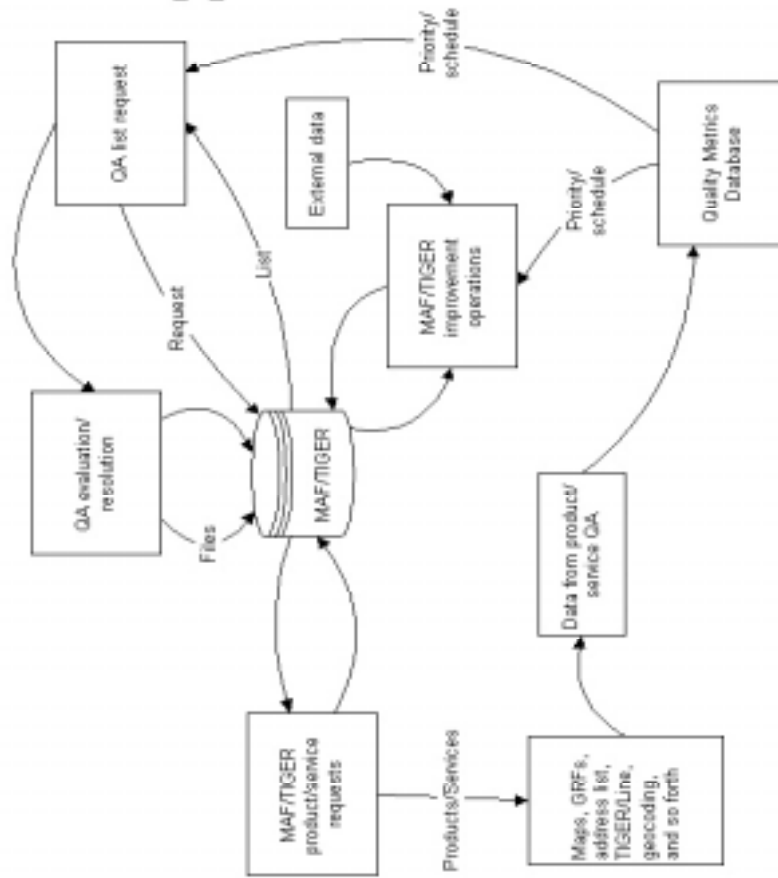
Appendix D

Master Address File (MAF)/TIGER
Modernization Study

Prepared by

Booz-Allen & Hamilton
for the
Geography Division
United States Census Bureau

Questions about specific aspects of this extensive study can be directed to
Robert Marx (301-457-2131) or Linda Pike (301-457-1017).

Appendix E

**Summary of Geographic and Address Problems:
Census 2000 Observation Reports**

Appendix F

GPS TIGER Accuracy Analysis Tools (GTAAT):
Evaluation and Test Results

Prepared by

John S. Liadis
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Appendix G

The Positional Accuracy of MAF/TIGER: Three Studies

Prepared by

Geospatial Research and Standards Staff
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U.S. Census Bureau