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Report to the Ranking Minority Member, Subcommittee on Readiness, Committee on Armed Services, House of Representatives

August 2003

DOD PERSONNEL

Documentation of the Army's Civilian Workforce-Planning Model Needed to Enhance Credibility

GAO

Accountability ★ Integrity ★ Reliability

GAO-03-1046

DOD PERSONNEL

Documentation of the Army's Civilian Workforce-Planning Model Needed to Enhance Credibility

Why GAO Did This Study

Between fiscal years 1989 and 2002, the Department of Defense (DOD) reduced its civilian workforce by about 38 percent, with little attention to shaping or specifically sizing this workforce for the future. As a result, the civilian workforce is imbalanced in terms of the shape, skills, and experience needed by the department. DOD is taking steps to transform its civilian workforce. To assist with this transformation, the department is considering adopting an Army workforce-planning model, known as the Civilian Forecasting System (CIVFORS), which the Army uses to forecast its civilian workforce needs. Other federal agencies are also considering adopting this model. GAO was asked to review the adequacy of the steps the Army has taken to ensure the credibility of the model.

What GAO Recommends

To assure the reliability of Army civilian workforce projections and the appropriateness of the model for use DOD-wide and by other federal agencies, we recommend that the Secretary of Defense direct the Secretary of the Army to appropriately document the forecasting capability of the model.

Although DOD stated, in written comments on a draft of this report, it did not concur with GAO's recommendation, the Army is taking actions that, in effect, implement it.

What GAO Found

The Army has taken adequate steps to ensure that the historical personnel data used in the model are sufficiently reliable and that the information technology structure adequately and appropriately supports the model. For example, the Army has established adequate control measures (e.g., edit checks, expert review, etc.) to ensure that the historical data that goes into the model are sufficiently reliable. Moreover, it has taken adequate steps to ensure that the information technology support structure (i.e., the software and hardware used to interface with and house the model) would enable continuity of operations, functionality, and system modification and operations.

However, the Army has not demonstrated that it has taken adequate steps to ensure that the model's forecasting capability provides the basis for making accurate forecasts of the Army's civilian workforce. The Army's original certification of CIVFORS in 1987 was based on a formal documented verification and validation of the model structure that has not been formally updated since that time even though the Army has undertaken several model improvements. According to the Army's CIVFORS program manager, the Army has taken several steps, to include an independent review, peer reviews, and a comparison of forecasted data to actual data. However, documentation of these steps is incomplete and, therefore, does not provide adequate evidence to demonstrate the credibility of the forecast results. Without adequate documentation, the Army cannot show that it has taken sufficient steps to ensure the model's credibility in terms of its forecasting capability; consequently, there exists a risk that the forecasts it produces may be inaccurate or misleading. Furthermore, without documentation of CIVFORS's forecasting capability, it may be difficult for DOD and other federal organizations to accurately determine its suitability for their use.

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Abbreviations

CIVFORS	Civilian Forecasting System
DOD	Department of Defense
WASS	Workforce Analysis Support System

United States General Accounting Office
Washington, DC 20548

August 22, 2003

The Honorable Solomon P. Ortiz
Ranking Minority Member
Subcommittee on Readiness
Committee on Armed Services
House of Representatives

Dear Mr. Ortiz:

Between fiscal years 1989 and 2002, the Department of Defense (DOD) reduced its civilian workforce from 1,075,437 to 670,166—about a 38 percent reduction—with little attention to shaping or specifically sizing this workforce for the future. As a result, the civilian workforce is imbalanced in terms of the shape, skills, and experience needed by the department. DOD plans to downsize its civilian workforce by an additional 55,000 through fiscal year 2007. In addition, in April 2003, DOD submitted a proposal to Congress that would authorize DOD to establish a National Security Personnel System to transform its current civilian personnel system.[1] DOD is also exploring the feasibility of placing hundreds of thousands of civilians into essentially nonmilitary jobs that are currently performed by uniformed personnel. To assist in determining its future workforce, DOD will need reliable workforce planning tools, such as workforce projection models. According to DOD guidance, a model used to provide data for decision making should be accredited--that is, the model should be officially certified as acceptable for use for a specific purpose.

In a February 2003 testimony, the Chief of Staff of the Army stated that the Army has begun to transform its civilian personnel system. To assist with this transformation, the Army is using its workforce-planning model, known as the Civilian Forecasting System (CIVFORS), which forecasts future civilian workforce needs.[2] The Army is working closely with the

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[1] The system is proposed in the Transformation for the 21st Century Act of 2003. The act also proposes other wide-ranging changes, affecting civilian personnel pay and performance management, collective bargaining, rightsizing, and other human capital areas.

[2] The Civilian Forecasting System was adapted from an Army military forecasting model for civilian use in 1987.

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Office of the Secretary of Defense and the Office of Personnel Management to demonstrate the applicability of the model for use DOD-wide and in other federal agencies. According to Army guidance (Army Regulation 5-11 and Department of the Army Pamphlet 5-11), verification is one of the steps needed to ensure a model's suitability to perform its intended purpose. The verification process evaluates the extent to which a model has been developed using sound and established software engineering techniques, and it establishes whether the computer code correctly performs the intended functions. Army guidance also states that assessment of the correctness and forecasting capability is required.

In this report, we reviewed the adequacy of the steps the Army has taken to ensure the credibility of the model. In March 2003, we briefed your staff on our preliminary findings. To determine the Army's efforts to ensure the credibility of its model, we interviewed and obtained pertinent documentation from the Army's CIVFORS program manager. We also reviewed DOD and Army guidance relevant to the management of Army models and interviewed DOD officials to discuss their plans to adopt CIVFORS. We conducted our review from September 2002 to June 2003. More detailed information on our scope and methodology appears at the end of this report.

Results in Brief

The Army's steps were adequate to ensure that the historical personnel data used in the model are sufficiently reliable and that the information technology support structure[3] adequately and appropriately supports the model, but the Army has not documented its steps to ensure the credibility of the model's forecasting capability. The Army has established adequate control measures (e.g., edit checks, expert review, etc.) to ensure that the historical data that goes into the model are sufficiently reliable. Moreover, it has taken adequate steps to ensure that the information technology support structure would enable continuity of operations, functionality, and system modification and operations. However, the Army has not documented that it has taken adequate steps to ensure that the model's structure (including its forecasting capability and the appropriateness of its assumptions) provides the basis for making accurate forecasts of the Army's civilian workforce. The Army's original certification of CIVFORS in 1987 was based on a formal documented verification and validation of the model structure that has not been formally updated since that time, even

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[3] The software and hardware used to interface with and house the model.

though the Army has undertaken several model improvements. According to the Army's CIVFORS program manager, the Army has taken several steps, to include an independent review, peer reviews, and a comparison of forecasted data to actual data. However, documentation of these steps is incomplete and, therefore, does not provide adequate evidence to demonstrate the credibility of the forecast results. Without adequate documentation, the Army cannot show that it has taken sufficient steps to ensure the credibility of the model's forecasting capability; consequently, there exists a risk that the forecasts it produces may be inaccurate or misleading. Furthermore, without documentation of CIVFORS's forecasting capability, it may be difficult for DOD and other federal organizations to accurately determine its suitability for their use.

We are recommending that the Secretary of Defense direct the Secretary of the Army to appropriately document the Army's forecasting capability of the civilian workforce-planning model. Although DOD stated, in written comments on a draft of this report, it did not concur with our recommendation, the Army is taking actions that, in effect, implement it.

Background

According to an Army Human Resource official, the Army uses the workforce-planning model—CIVFORS—for human resources management. CIVFORS is a collection of software programs that anticipate future impacts on the workforce so that management can plan for changes instead of reacting to them. The model is used to evaluate a number of critical areas in civilian workforce planning, including projected recruitment of personnel, impact of organizational realignments, and changes in workforce trends (such as aging, retention, and projected personnel shortfalls). It is a life-cycle modeling and projection tool that models the most significant events that describe the life-cycle path of personnel, which includes accessions, promotions, reassignments, retirements, and voluntary and involuntary separations over a 7-year period.

Verification and validation of models are important steps to building credible models because they provide the foundation for the accreditation process to ensure the suitability of the models for their intended purposes, as stated in Army guidance, Management of Army Models and

Simulations.[4] The verification process evaluates the extent to which a model has been developed using sound and established software engineering techniques, and it establishes whether the model's computer code correctly performs the intended functions. Model verification includes data verification, model documentation, and testing of the information technology structure that supports the model; model verification is contained in such documents as the programmer's manual, installation's manual, user's guide, analyst's manual, and trainer's manual. According to Army guidance, assessment of the correctness and forecasting capability of the model is also required, and it should be performed by a subject matter expert independent from the model developer; however, the developer is expected to conduct in-house verification and testing to assist in the overall model development process. Validation is the process of determining the extent to which the model adequately represents the real world.

Civilian Workforce-Planning Model's Data Reliability and Information Technology Structure Are Adequate, but Forecasting Ability Not Fully Established

The Army has taken steps to ensure the reliability of the historical personnel data used by the model and the adequacy of its information technology structure used to support the model, but it has not provided documentation that it has sufficiently tested and reviewed the most critical aspect of the model—its forecasting capability and the appropriateness of its assumptions. As a result, the forecasting credibility of the current version of the model is not sufficiently validated or documented. Without proper documentation of the abilities of the model, there is a risk that the forecasts it produces may be inaccurate or misleading and the suitability for use by other organizations may be difficult to determine.

Historical Personnel Data Reliability Is Adequate

The Army's review of the historical personnel data used to provide information for workforce planning was adequate to show that the data are sufficiently reliable for use in the workforce model. Data regarding personnel (such as date hired, education, age, grade level, and occupational series) are taken from the Army's Workforce Analysis

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[4] Headquarters, Department of the Army, Management of Army Models and Simulations, Army Regulation 5-11 (Washington, D.C., July 10, 1997). This regulation prescribes policy and guidance and assigns responsibilities for the management of Army models and simulations, including development and maintenance.

Support System (WASS).[5] CIVFORS uses the most recent 5 years of historical data to forecast the civilian workforce planning needs during the next 7 years.

According to Army guidance, to ensure that data are sufficiently reliable for use in the Army model, support documents should contain information about the overall characteristics of the database. Furthermore, the documents should show the intended range of appropriate uses for the model as well as constraints on its use. They should also include concise statements of the condition of the database for the purpose of indicating its stability. The Army provided most, but not all, of the documents referred to in Army guidance; we believe that the documents provided are key ones and are adequate to show that WASS data are sufficiently reliable for use in CIVFORS. In addition, the Army program manager for the CIVFORS workforce-planning model stated that the workforce data are checked by reviewing the arithmetic in the numerical algorithms to verify that there is no unexplained change in the size of the civilian personnel workforce contained in the database. Further, edit checks include matching social security numbers for personnel from one time period to another to account for actual personnel and personnel transactions processed. In addition, CIVFORS has automated checks for inappropriate numbers or characters. Such steps help to assure that the data contained in WASS accurately and completely reflect critical personnel aspects and transactions.

Information Technology Structure Is Adequate

The Army's procedures for validating the information technology support structure (the software and hardware used to interface with and house the model) were also sufficient. For example, the Army (1) adequately documented the information technology structure to allow for continuity of operations, (2) tested its functionality, and (3) provided expertise for system modification and operation. Procedures used by the Army include documenting the model's system description and hardware and software requirements, providing system and user manuals, planning for configuration management,[6] and conducting functionality tests to help

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[5] WASS enables analysis of data on Army civilians from 1974 to the present. It has analysis capabilities that range from frequency distribution to trend analysis.

[6] Configuration management is the control and documentation of changes made to system hardware, software, and documentation throughout the development and operational life of the system.

ensure the system's usability and operability over time and to demonstrate the adequacy of the information technology structure to support use of the workforce model.

Model's Forecasting Ability Is Not Fully Established

The Army's documentation cannot show that the forecasting ability of CIVFORS has been adequately evaluated and, therefore, we cannot fully assess the credibility of the model. According to Army guidance, validation is the process of determining the extent to which a model adequately represents the real world. According to the Army program manager, over a 7-year period, CIVFORS forecasts the anticipated impacts on the workforce based on the most significant events in the life-cycle path of personnel (to include accessions, promotions, reassignments, retirements, voluntary separations, and involuntary separations). Army guidance states that an independent, peer, and subject matter expert review of the model should be conducted. The Army guidance also suggests generally accepted methods, such as conducting a careful line-by-line examination of the model design and computer code and algorithms. The Army's program manager said this had been done for the original certification of CIVFORS in 1987. However, no formal document of the reviews has been prepared in the years since, even though the Army has undertaken several model improvements, such as (1) an expanded scope to include more dimensions in the modeling process; (2) a more integrated, streamlined process that involves fewer steps; and (3) greater flexibility, achieved by generalizing the formulas and parameters.

In addition, there is insufficient documentation regarding tests performed, since 1987, in which CIVFORS's forecasts for prior years are compared against equivalent historical data (called an "out of sample" test) to measure the model's forecasting capability. Such testing, which is one method to validate a model's forecasting capability, would involve using the first 5 of the last 7 years of historical data to forecast the 2 subsequent years. The forecasts for the last 2 years could then be compared to the actual historical data. The Army, however, performed tests comparing patterns of forecasts against historical data (called "in sample" tests), showing that forecasts reflect the same patterns as the historical data used to develop them for a sample of three Army major commands. However, the draft document that was provided to us was inadequate to fully assess the sampling used by the Army and the value of the tests.

Finally, the Army could not provide adequate documentation of an independent or peer review of the model. The Army's CIVFORS program manager stated that the major commands served as peer reviewers by

conducting a comparison of their workforce data to WASS and CIVFORS workforce data. We believe that such assessments by users provide important information but do not constitute a peer review as defined in Army guidance. Also, the results of these assessments were not available for us to review. The program manager also stated that an independent subject matter expert reviewed the functional design and the code in 1999, but a formal report of the activities performed and the specific changes or modifications implemented during the review were not produced.

Documentation has often not been a priority for several reasons. According to the Army's CIVFORS program manager, lack of documentation is primarily due to limited funding, which was spent on implementing changes to CIVFORS and WASS rather than on the production of formal documents. Further, a shortage of staff (only one staff person—the program manager) and loss of documents during the attack on the Pentagon on September 11, 2001, also affected the amount of documentation the Army could provide us. The program manager also stated that some documentation was not needed because CIVFORS's design is predicated on proven methods in other Army active-duty, military manpower forecasting models. In addition, the program manager stated that the Army and contractors have primarily been adapting technology (upgrading from mainframe to personal computer to Web-based) to improve model functionality rather than creating new technology. However, without proper documentation of the abilities of the model, there exists a risk that the forecasts it produces may be inaccurate or misleading. Consequently, decisions about future workforce requirements may be questionable, and planning for the size, shape, and experience level of the future workforce may not adequately meet the Army's needs.

These issues may extend beyond the Army. In April 2002, DOD published a strategic plan for civilian personnel, which includes a goal to obtain management systems to support workforce planning. According to a DOD official responsible for civilian workforce planning tools, components within DOD have been requesting a modeling tool to assist them with civilian workforce planning. As a result, DOD has decided to test the Army's civilian forecasting model. In October 2002, DOD purchased hardware, installed modified software, and provided training to a small number of personnel. Recently, DOD obtained a historical database of civilian personnel data from the Defense Management Data Center and provided the database to the contractor to load into the model. Two agencies have volunteered to test the model: the Defense Logistics Agency and the Washington Headquarters Service. DOD is working to develop a test for these organizations using their own civilian personnel data to test

the model. At the end of the testing period, DOD will assess the model to obtain a better understanding of its logic and determine whether or not it should be implemented departmentwide.

Conclusions

As DOD continues to transform and downsize its civilian workforce, it is imperative that the department properly shape and size the workforce. One tool that could assist in this effort is CIVFORS—the Army's workforce planning model. However, proper documentation of the verification and validation of CIVFORS is needed before expanding its use. The Army has taken adequate steps to ensure that the historical personnel data used in the model are sufficiently reliable and the information technology structure appropriately supports the model; however, it has not fully documented that it has taken adequate steps to demonstrate the credibility of the model's forecasting capability. Further, a model should be fully scrutinized before each new application because a change in purpose, passage of time, or input data may invalidate some aspects of the existing model. Without sufficient documentation to demonstrate that adequate steps have been taken to ensure the credibility of the model's forecasting capabilities, decisions about the Army's future civilian workforce may be based on questionable data and other potential users cannot determine with certainty the model's suitability for their use.

Recommendation for Executive Action

To assure the reliability of Army civilian workforce projections, as well as the appropriateness of the model for use DOD-wide and by other federal agencies, we recommend that the Secretary of Defense direct the Secretary of the Army to appropriately document the Army's forecasting capability of the model.

Agency Comments and Our Evaluation

Although DOD stated, in written comments on a draft of this report, that it did not concur with our recommendation, the Army is taking actions that, in effect, implement it. DOD's written comments are contained in appendix I.

Regarding our recommendation that the Secretary of Defense direct the Secretary of the Army to appropriately document the Army's forecasting capability of the model, DOD stated that the Army recognizes the need to fully document its verification and validation efforts. Further, DOD stated the staff of the Assistant Secretary of the Army, Manpower and Reserve Affairs, has begun developing a verification and validation plan to enable outside parties to assess the suitability and adaptability of the model for

their organizational use. This verification and validation process is scheduled for completion in September 2003. However, during our review, DOD did not provide information about the full scope of this verification and validation effort. We believe that as the Army undertakes its verification and validation effort, it should clearly document, as we recommended, its assumptions, procedures, and the results so that future users can replicate the tests to appropriately establish the model's validity for their purposes.

DOD also did not concur with our finding that the forecasting ability of the model has not been fully established. DOD stated that the ultimate test of a system is performance and that CIVFORS has been consistently generating Army projections with high standards of accuracy. We did not independently evaluate the model's accuracy. As our report makes clear, our basic point is that the model's forecasting ability has not been documented in accordance with Army guidance. We continue to believe that without adequate documentation, the Army cannot show that it has taken sufficient steps to ensure the model's credibility in terms of its forecasting capability. DOD also provided technical comments, which we incorporated where appropriate.

Scope and Methodology

We did not independently evaluate the model or the application of the steps; rather, we reviewed the adequacy of the steps that the Army program manager stated were taken to ensure the credibility of the model. To determine the adequacy of the steps the Army has taken to ensure the credibility of its civilian workforce-forecasting model, we discussed CIVFORS with the Army's CIVFORS program manager in the Army G-1 office, Civilian Personnel Policy Directorate, who has overall responsibility for the workforce analysis and the forecasting system. In addition, Army contractor officials who are responsible for providing technical, analytic, and management support to operate, maintain, and enhance the planning tool and model participated in several of our discussions with the program manager. We reviewed the following CIVFORS's documents regarding the information technology support structure: the Configuration Management Manual, the System's Specifications, the Design/Subsystem Documentation, the Operator's Manual, and the User's Manual. In addition, we reviewed the 1987 and draft 2002 test analysis report on the Civilian Forecasting System and other documentation provided by the Army to obtain information on how the model operates according to model assumptions. We also reviewed the DOD Defense Modeling and Simulation Office guidance on verification and validation of models, the Army regulation and pamphlet pertaining to the

management of Army models and simulations, and other literature regarding model credibility. We also interviewed DOD officials in the Civilian Personnel Management Service responsible for developing plans to adopt the Army's workforce forecasting model to discuss the status of their efforts.
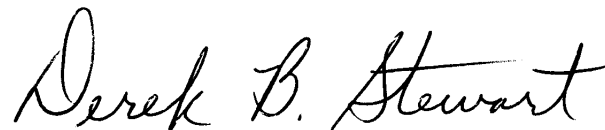
We conducted our review from September 2002 to June 2003 in accordance with generally accepted government auditing standards.

We are sending copies of this report to the appropriate congressional committees, the Secretary of Defense, the Under Secretary of Defense for Personnel and Readiness, and the Secretary of the Army. We will also make copies available to others upon request. In addition, the report will be available at no charge on the GAO Web site at http://www.gao.gov.

If you or your staff have any questions about this report, please contact me at (202) 512-5559. Key contributors to this report are listed in appendix II.

Sincerely yours,

Derek B. Stewart
Director, Defense Capabilities
 and Management

Appendix I: Comments from the Department of Defense

OFFICE OF THE UNDER SECRETARY OF DEFENSE
4000 DEFENSE PENTAGON
WASHINGTON, D.C. 20301-4000

AUG 8 2003

PERSONNEL AND
READINESS

Mr. Derek B. Stewart
Director, Defense Capabilities and Management Issues
U.S. General Accounting Office
441 G Street, N.W.
Washington, DC 20548

Dear Mr. Stewart:

This is the Department of Defense (DoD) response to the General Accounting Office (GAO) draft report, "DOD PERSONNEL: Greater Review and Documentation of the Army's Civilian Workforce-Planning Model Needed to Enhance Credibility," dated July 23, 2003, (GAO Code 350385 Prior Code 350198/GAO-03-1046). It is important to note that the genesis of this report was the GAO notice of the intent to review "DOD's Civilian Human Capital Strategic and Workforce Planning" on May 16, 2002; that GAO chose not to include DoD's reply in its March 2003 report, "DoD Actions Needed to Strengthen Civilian Human Capital Strategic Planning and Integration with Military Personnel and Sourcing Decisions;" and that GAO began another "Review of DOD's Strategic Workforce Planning for Civilians" on June 17, 2003. Specifically listed as an objective in this study was for GAO to determine "What actions have DoD and the military services taken to ensure the credibility of the workforce data and the analyses used in developing the civilian strategic workforce plans?" While the second study is ongoing, recommendations concerning the Civilian Forecasting System (CIVFORS) must now be considered premature.

We nonconcur with the recommendation that the Secretary of Defense direct the Secretary of the Army to appropriately document the Army's forecasting capability of the model. The Department of the Army recognizes the need to fully document Verification and Validation (V&V) for its CIVFORS model. The staff of the Assistant Secretary of the Army, Manpower and Reserve Affairs, has begun this process, scheduled for completion in September 2003.

We also nonconcur with the major finding of the report that the model's forecasting ability is not fully established. The ultimate test of the system is performance. Using Army analysts to produce specific Army products, the CIVFORS system has been consistently generating Army projections with high standards of accuracy. The Army offers the following comments to substantiate the system's abilities:

CIVFORS has been projecting Army civilian personnel strengths, gains and losses since Fiscal Year (FY) 1990. Data studies provided to GAO

documented deviation of total projected (CIVFORS forecast) Army end
strength within one percent of actual on-board strength totals for FY90
through FY01. In FY02 the model predicted projected end strength of
222,600; the actual Army end strength was 223,449. The difference
between the projected and actual was 849; this is a deviation of a little less
than four-tenths of one percent (0.4 percent). Established standards of
accuracy by most government and private sector organizations for
forecasting models is 2.5 to 5 percent deviation. The Army model has
consistently exceeded this standard during its entire operational life.

Documented evidence was provided to GAO to support the credibility of
the model forecasts in the analysis/evaluation of employee transaction
patterns. A specific example of behavior pattern forecasting was illustrated
by the Civil Service Retirement System (CSRS) retirement bubble analysis.
CIVFORS data predicted that the anticipated mass exodus of employees
covered by the CSRS retirement system would not materialize. This
conclusion, despite being in opposition to the established theory of the
personnel community, validated CIVFORS capability in the area of
employee gains and losses forecasting. In projections developed for FY02
retirements for Army Materiel Command, the model forecasted 1665;
actual retirements for FY02 were 1694, a deviation of 29 for a projection
accuracy of 98.3 percent.

For a complex mathematical procedure to consistently perform at a 99%
accuracy rate validates, by most conventional standards, the credibility of
the results. Consistently accurate results produced over a long period of
time can only be produced by a model whose conceptual design is founded
in mathematically sound theory and is executed by correctly programmed
automation code. It is statistically impossible for any system to generate 99
percent accurate forecasts for over 13 years operating with incorrect
mathematical algorithms and/or erroneous programming code.

We suggest that either this report be delayed until after September 30, 2003, to
allow the Army to complete its V&V process or that the information concerning Army
CIVFORS be included in the current review of "DOD's Strategic Workforce Planning for
Civilians."

Sincerely,

Charles S. Abell
Principal Deputy

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Appendix II: GAO Contact and Staff Acknowledgments

GAO Contact

Christine Fossett (202) 512-2956

Acknowledgments

In addition to the name above, David Dornisch, Barbara Johnson, Barbara Joyce, John Smale, Dale Wineholt, and Susan Woodward made significant contributions to this report.