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STATISTICS DIRECTORATE**

Joint ECE/Eurostat/OECD meeting on the management of statistical information systems
(Geneva, 17-19 February 2003)

Topic I: Measures for the improvement of quality at the IT management level

USE OF CAPABILITY AND MATURITY MODEL U.S. BUREAU OF THE CENSUS

Invited paper

Submitted by the Bureau of the Census, United States¹

I. BACKGROUND

1. The U.S. Census Bureau is the primary source of basic statistics about the population and economy of the United States. These statistics assist federal, state and local governments, the general public, and the private sector in the development and evaluation of social and economic activities. Major Census programs include the periodic censuses, current surveys, and a wide range of reimbursable work for other federal agencies. The programs cover a broad spectrum of demographic and economic statistics.

2. To fulfill the critical and continually expanding mission of data requirements from Census customers, and to reduce growth in operating costs, Census has become increasingly reliant upon information technology (IT) to improve the timeliness and quality of statistical products. Since most of the statistical products are generated by software developed internally at Census, improving the overall capability of software projects is a major goal of the Census IT Governing Board. The IT Governing Board recognized that there were some problems with Census software development and maintenance efforts, including:

- A reliance on heroes and key individuals who are almost solely responsible for a project's success or failure,
- A retirement rate so high that it is difficult to retain knowledge of Census software processes and practices,

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- Insufficient planning and management of budget and resource spending on software projects, and
- An inability to provide adequate documentation to demonstrate compliance with Government policies and requirements for software projects.

3. In the search to overcome some of these issues and problems, the IT Governing Board turned to the industry-accepted framework developed by the Software Engineering Institute (SEI) at Carnegie Mellon University. In August 2000, the Census IT Governing Board initiated the Capability Maturity Model (CMM) Pilot Program to begin a thorough investigation into the possibility of implementing a repeatable software process as described by the SEI's CMM for Software (SW-CMM). The IT Governing Board believed that implementing the SW-CMM would enable Census to create an improved and well-documented process at the corporate level to increase the quality of the Census Bureau's software.

II. CMM OVERVIEW

4. The SW-CMM was developed by the SEI as a model for judging the maturity of the software processes of an organization, and for identifying the key practices that are required to increase the maturity of those processes. The five levels of the CMM are organized to progress a project's software process from an immature, unrepeatable process to a mature, optimized process. Implementing the CMM can significantly improve the software development process, which promotes better management of software development and maintenance efforts. The five levels of the SW-CMM and their associated Key Process Areas (KPA's) are illustrated in Figure 1. Essentially, Level 1 can be described as chaotic, therefore, there are no KPA's at this level. Level 2 focuses on incorporating project management into software projects, Level 3 focuses on incorporating the same software project processes across the whole organization, Level 4 focuses on collecting and analyzing software project metrics, and Level 5 focuses on constant process improvement based on the implementation of Levels 2 through 4.

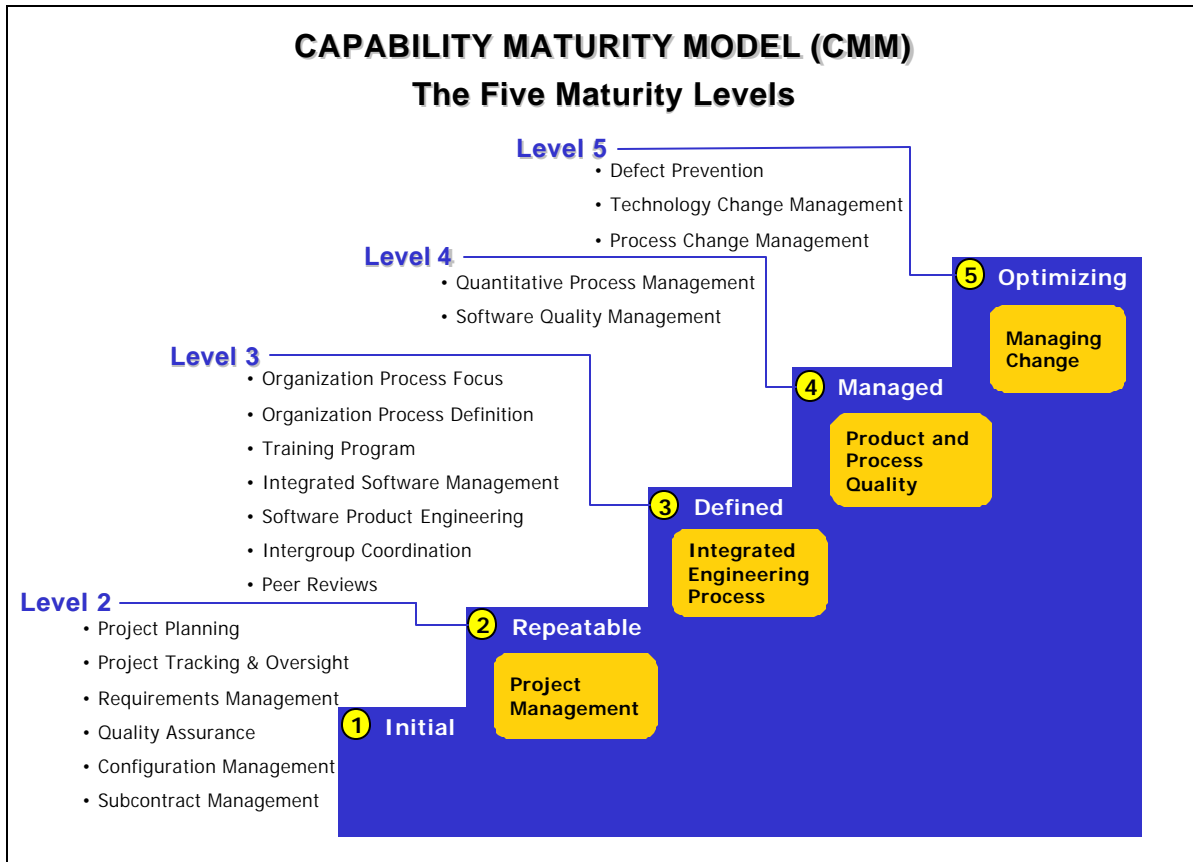


Figure 1

III. SCOPE

5. The CMM Pilot Program focused on Level 2 KPAs. However, when the pilot projects began to see some successes and feel the benefits of process improvement, the program and project leaders began investigating the possibility of implementing Level 3. Moving from a single project focus to a whole organization perspective is especially difficult given the Census Bureau's current culture. There are eight directorates at Census who develop and maintain software, and, in general, each directorate operates like an individual company with its own processes and procedures. Organizing a Census-wide effort for software development and maintenance process improvement is a large and difficult undertaking. However, the Census Bureau is moving forward towards that goal.

6. In March 2002, the IT Governing Board established and signed the Census Software Development and Maintenance Policy, which identified their expectations regarding the operation of every Census software project. The pilot program and the policy have helped to build momentum for a process improvement program for the Census Bureau at a corporate level.

7. This paper describes how we implemented the CMM Pilot Program, the results of the Pilot Program, the resulting enthusiasm for CMM, and the planned future of CMM at the Census Bureau.

IV. CMM PILOT PROGRAM SUMMARY

8. In order to evaluate the effectiveness of CMM on a representative cross section of the Census Bureau, the program included projects in three directorates of the Census Bureau – the Economic

Directorate, the Field Directorate, and the Demographic Directorate. Since August 2000, the three pilot project teams have made steady progress toward CMM Level 2 compliance. These projects were:

- Economic Directorate - Services Monthly and Annual Sample Maintenance (SMASM)
- Field Directorate - American Time Use Survey (ATUS) Blaise Authoring
- Demographic Directorate - Current Population Survey (CPS) March Supplement Report Processing

9. The CMM Program Team consisted of 10 members who managed the CMM Pilot Program and provided support to the pilot projects. The CMM Program Team included a CMM project manager and documentation specialist for each pilot project, a quality assurance leader who monitored all three pilot projects, a senior management advisor, and contracted consultants who were experienced in implementing CMM practices. Each pilot project included a project manager and various technical staff. Altogether, there were a total of 40 people involved with executing the pilot projects and program.

A. Program Objectives

10. The major objective of the CMM Pilot Program was to implement five of the six CMM Level 2 KPAs.² The program team made a concerted effort to cover as much of the five CMM Level 2 KPAs as possible across the three pilot projects, however, all aspects were not accomplished, nor were they intended to be. Specifically, the CMM Pilot Program Team sought to accommodate the different needs of each project by focusing on different KPAs as they related to their individual project objectives:

- The SMASM project focused on adequately documenting the requirements of the system.
- The ATUS project focused on defining a standard software development life cycle geared toward getting buy-in from their sponsors.
- The CPS project focused on developing a formal change control process for the existing software.

B. Program Methodology

11. The basic approach to the CMM Pilot Program included the following steps:

- (i) Provided formal training for pilot project participants on CMM;
- (ii) Analyzed the CMM framework and develop an analysis document to help guide the incorporation of CMM into all three pilot projects;
- (iii) Researched how other federal agencies have successfully implemented CMM;
- (iv) Planned the CMM Program by leveraging existing project management standards;
- (v) Hired consultants with CMM expertise;
- (vi) Tracked the CMM Program to the Program Plan;
- (vii) Worked directly with the Pilot Projects in a consulting capacity;
- (viii) Evaluated the CMM effort by conducting lessons learned sessions on a regular basis and by taking a survey of pilot participants. Results were also gathered from Software Quality Assurance audits and informal CMM self-assessments that were performed on all of the pilot projects.

C. Program Major Milestones

12. The CMM Pilot Program major milestones appear in Figure 2.

² The Software Subcontract Management KPA was not applicable to any of the pilot projects and, therefore, was out of scope for this program.

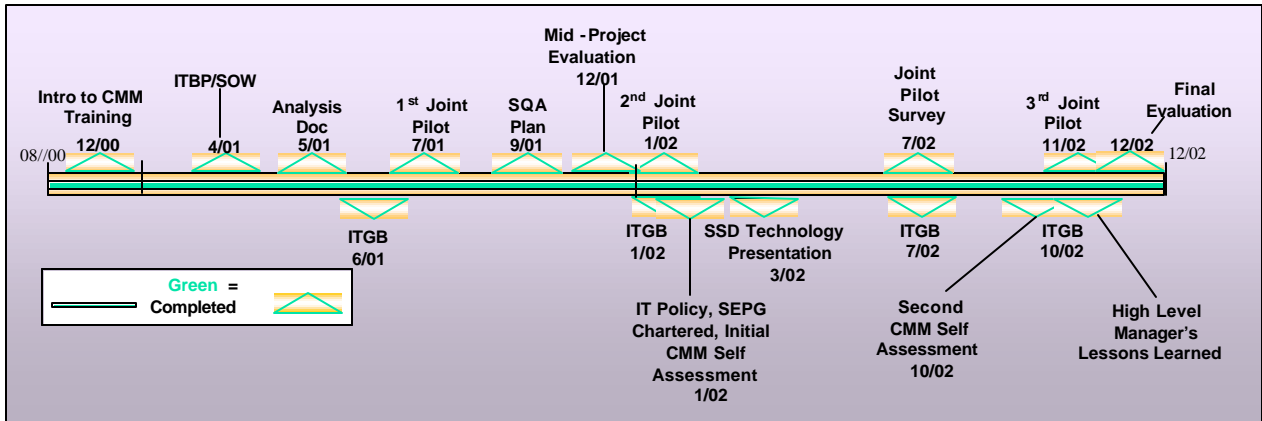


Figure 2

V. CONCLUSIONS

13. The CMM Pilot Program employed several mechanisms for evaluating the success of the program: Multiple joint pilot lessons learned sessions, a CMM Pilot Program survey, two quality audits per project and multiple CMM self-assessments. This section provides a summarized evaluation of the program based on participant feedback, and overall conclusions about the CMM framework and CMM compliance.

A. Pilot Participant Feedback

14. Lessons learned were gathered during the course of the pilot program by bringing all three pilot projects together approximately every six months and by administering an online survey to the pilot participants. The results gathered from the online CMM Pilot Program Survey were consistent with the feedback received during the various joint pilot meetings. That is, most of the new software process activities, such as developing a Software Development Plan and implementing a Software Configuration Control Board, were perceived to be effective by the project participants. Some practices, such as developing project plans, were perceived to be more important than others, such as the audits that evaluate and measure the quality of the project plans (see Figure 3).

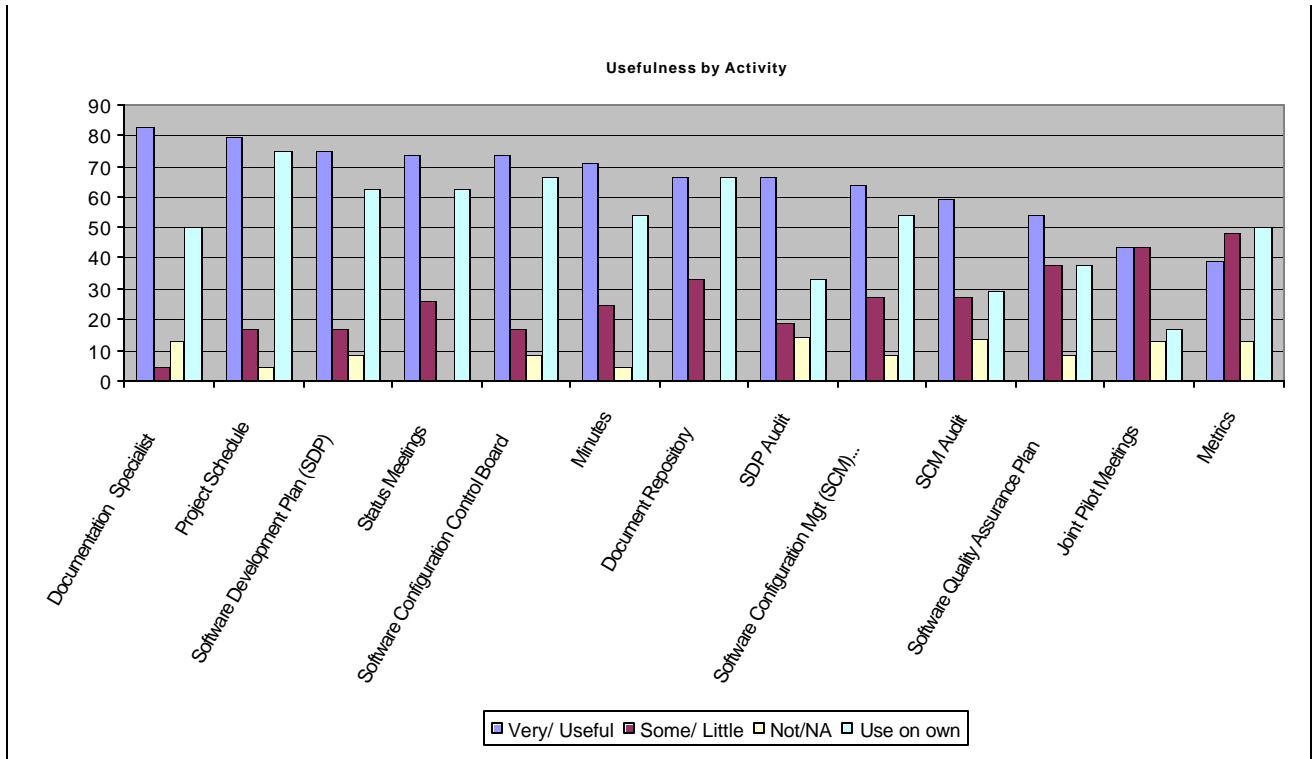


Figure 3

15. The survey responses also indicated that the pilot participants would continue to perform most of the software process activities after the pilot ended. Some other primary survey findings were:

- Lack of staff, time, and support from upper management are the primary obstacles to implementing CMM.
- 76% of the respondents would create project schedules on their own.
- More than 60% of the respondents would use a Software Configuration Control Board.
- Most respondents indicated they would need extensive documentation support on future projects.
- Respondents indicated a desire for additional training.

B. Audits

16. The Software Quality Assurance (SQA) Leader conducted audits on two processes for each pilot project team over the course of the CMM Pilot Program: (1) the planning and tracking process, and (2) the Software Configuration Management (SCM) process. For each audit, the SQA Leader studied the plans, examined documentation, and conducted an interview with the team. The SQA audit reports essentially answered the question, “Is there evidence that the team is executing the project according to their plan?” The possible answers were yes, no, and partially. Figure 4 shows the average of the three pilot project team audits for the two processes studied.

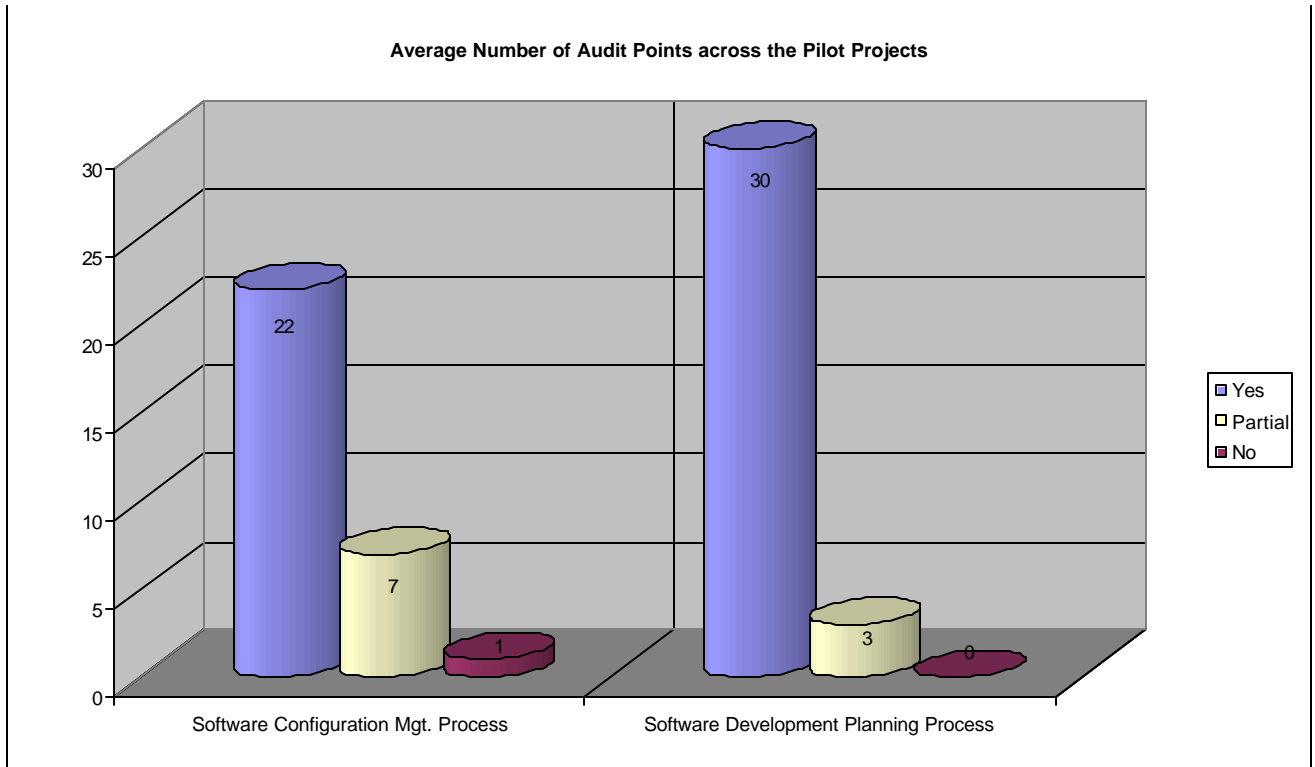


Figure 4

17. The SQA audits were a new activity for the pilot project teams to undertake. The audits helped the teams stay focused on following the plans they'd written and to appreciate the value of the plans as useful tools for managing the project and coordinating the team's efforts.

C. CMM Self-Assessments

18. The purpose of conducting the self-assessments was to identify strengths and weaknesses in each of the pilot projects, and to establish a baseline by which the program could measure software process improvement against the SW-CMM for each of the projects. While no pilot project performed perfectly, all pilot projects gained an understanding of what improvements needed to be made and planned their project activities accordingly. Figure 5 shows the average percent compliance of the first and second set of self-assessments for each of the KPAs. Note: One pilot project has not conducted their final self-assessment as of the issue date of this document.

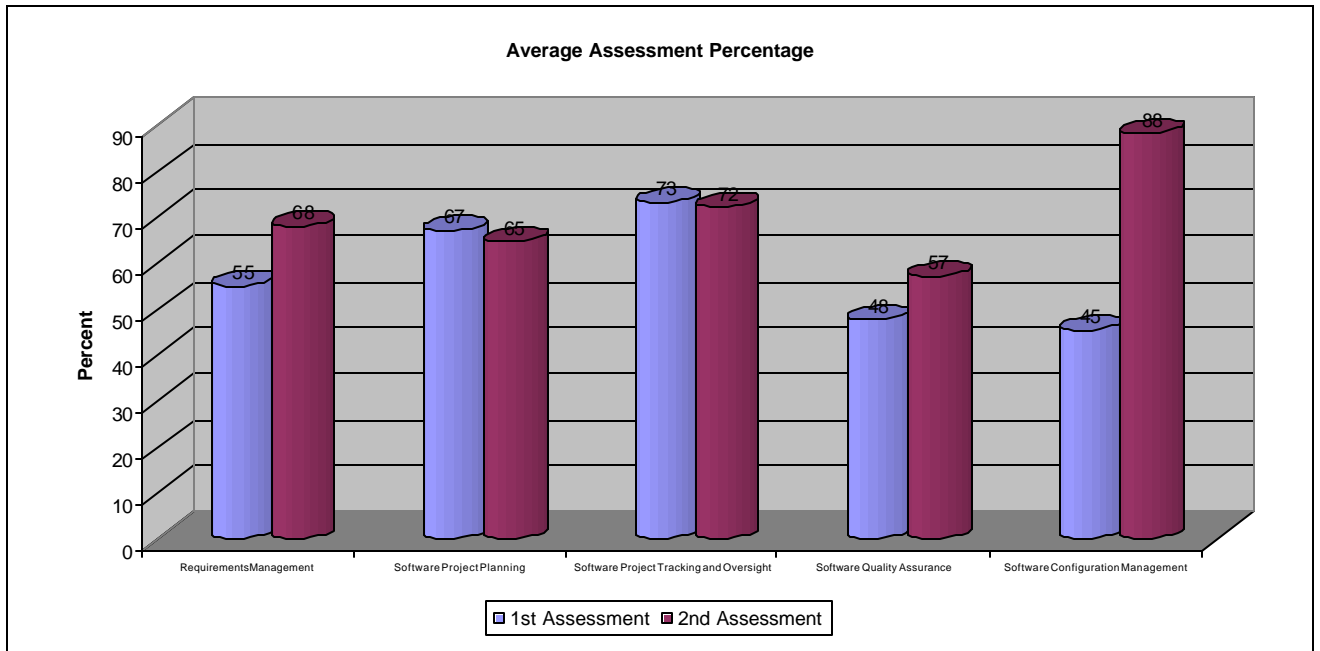


Figure 5

19. The biggest improvement for the pilot projects was in Software Configuration Management (SCM). It had the lowest score in the first assessment, but ended with the highest score. For the pilot project that scored a 92% compliance in this area, improvements in Software Configuration Management were their main objective, and they started with very little in terms of SCM best practice implementation. Another pilot project that already had SCM structures in place prior to the start of the CMM Pilot Program, concentrated on fulfilling the few SCM best practices that remained.

20. On average, all pilot projects made improvements in all of the KPAs of focus except two, Software Project Planning and Software Tracking and Oversight. One pilot project in particular actually scored slightly lower in the second self-assessment than they did in the initial assessment in these areas. This is also the same pilot project that transferred software planning and tracking responsibility from the CMM support team to the pilot project practitioners before the second assessment was conducted. The pilot project team admittedly did not keep project plans updated with changes as they occurred in the project, however, they recognized other improvements.

21. Overall, two of the three pilot projects made significant advances in their software improvement efforts. One of the pilot projects improved by 76%, and the other improved by 25%, across all of the Level 2 KPAs from the initial assessment to the final assessment. It is anticipated that the third pilot project will also show significant improvements, however, the final assessment on this project has not yet been performed.

D. The CMM Framework

22. The Census Bureau believes that the CMM framework provides useful guidance. The CMM framework provided a structured framework to follow, the CMM Program Team provided the necessary translation of theory to practical implementation, and the pilot project team members worked hard to adopt new ways of approaching their business. This combination of effort at the project level, along with executive sponsorship and upper management support ensured the success of this program. Having support from the top is critical in adopting this type of major change in the way the Census Bureau does business.

23. There is a general realization and agreement that software development practices must be improved at the Census Bureau in order to survive future efforts and in particular, evaluations from external auditors.

As evidenced in the outcome of the CMM Pilot Program, it is clear that the Census Bureau is ready to embrace change by improving the way we manage and develop software. Several new software process improvement initiatives were spawned during the course of the CMM Pilot Program in different areas of Census, indicating a thirst for more knowledge and guidance in applying this knowledge throughout the Census Bureau.

E. CMM Compliance

24. The Census Bureau believes that CMM compliance is an excellent way to motivate efforts toward improved software development processes; however, CMM compliance, in and of itself, should not be the only motivation behind software process improvement. It is more practical for the Census Bureau to embrace this type of change by encouraging and supporting voluntary commitments of software process improvement. As senior staff retire, taking significant knowledge with them, there is a growing need for documentation. The CMM framework provides an industry accepted description of what documentation is needed. Fulfilling this need is a reasonable justification for committing to process improvement using the CMM. Conforming to CMM, per se, is not a reasonable justification for the cost and effort required to make these significant changes.

F. Future of CMM at the Census Bureau

25. Based on the Software Development and Maintenance Policy, upper IT management chartered the Census Software Engineering Process Group (SEPG) made up of the CMM Program Team, the pilot project managers, and other representatives across the Census Bureau. Since April 2002, the Census SEPG has been working toward a strategy for rolling out CMM practices across Census. This section describes the Census SEPG's initial recommendations for the necessary infrastructure for the Census Software Process Improvement (CSPI) Program.

G. The Census Software Process Improvement (CSPI) Program

26. The SEPG's vision is that all Census software projects will operate according to a scalable Census Software Process, which will help software managers and technical staff perform more effectively, leveraging leading software practices from both inside and outside of Census. The SEPG's mission is to promote the communication, education and integration of selected leading software practices throughout Census.

27. The SEPG will propose software policies and standards based on feedback from software projects and other SEPG partners. They will facilitate the development of Census Software Processes and offer consulting support. Other components of the CSPI Program are still being considered such as SQA support and a metrics program, however, the program will consist of training opportunities such as brown bag seminars and Census SEPG Conferences. Figure 6 shows the basic infrastructure being planned for the CSPI Program. Each numbered item in the infrastructure diagram is described below.

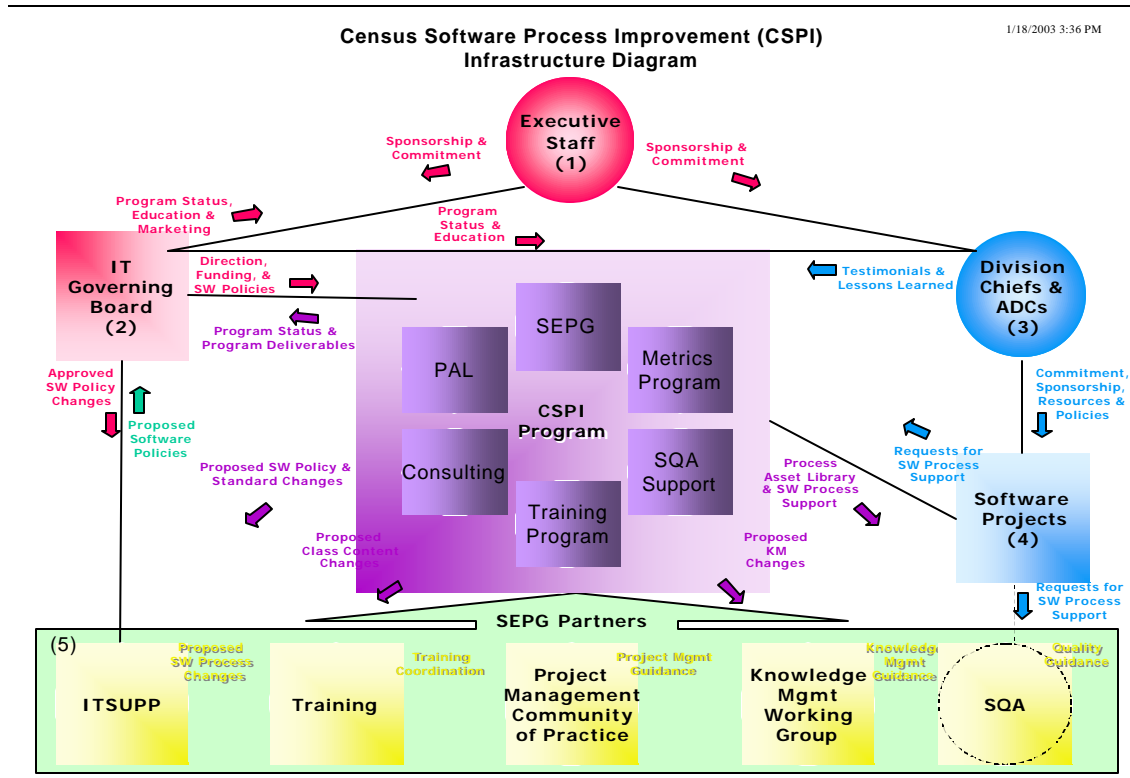


Figure 6

- (1) **Executive Staff**
The Executive Staff will require visibility of high-profile software projects, so that it can effectively mitigate Census risks. The Executive Staff will in return provide sponsorship and commitment to the CSPI program.
- (2) **IT Governing Board**
The IT Governing Board is a consulting and decision-making body, and a professional IT resource to the Census Executive Staff. The IT Governing Board will act as the Steering Committee for the CSPI Program. In that capacity, the IT Governing Board will be responsible for providing direction to the SEPG and ensuring that support for the Program is maintained. The IT Governing Board will require visibility into the activities of the SEPG and Census software projects. The IT Governing Board will establish and communicate Census software policies.
- (3) **Division Chiefs and ADCs**
Division Management consists of Census Division Chiefs and Assistant Division Chiefs (ADCs) who are responsible for the people and operations within their divisions. Division Management will require visibility of software projects within their divisions, so that they can effectively mitigate risks. Division Management tailors and communicates Census software policies to the needs of their divisions.
- (4) **Software Projects**
Software projects are undertakings requiring concerted effort and focusing on analyzing, specifying, designing, developing, testing, and/or maintaining software components and associated documentation of a system. A software project may be sub-task of a larger undertaking, such as a survey project. The software project team consists of individuals responsible for requirements development and maintenance (subject matter experts) as well as individuals responsible for

developing and/or maintaining the software (programmers or software engineers). Software project teams may require additional assistance from the SEPG, specifically in defining and/or improving their software processes. At a minimum, the SEPG will provide all software projects with access to the current Census process asset library (PAL), which will include:

- The Census Software Process and Definitions
- Descriptions of SEPG approved software life cycles
- Guidelines and criteria for tailoring the Census Software Process to a software project
- A library of software process-related documentation (e.g., templates)

(5) **SEPG Partners**

Several Census programs will contribute to the success of the CSPI Program and Census software projects. The SEPG will coordinate the activities of the CSPI Program with the “SEPG Partners” and leverage the assets and knowledge of these SEPG Partners, in order to maximize the return on investment on all programs within Census. The following SEPG partnerships are known at this time:

- IT Standards and Uniform Products Program (ITSUPP)
- Training
- Project Management (PM) Initiatives
- Knowledge Management (KM) Working Group
- Quality Assurance (QA) Initiatives
