US Army Corps of Engineers

AD-A231 282

2

MISCELLANEOUS PAPER ITL-90-6

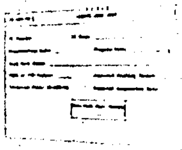
SOFTWARE DEVELOPMENT STANDARDS FOR PROJECT COST MANAGEMENT INFORMATION SYSTEM

by

Margaret B. Wright

Information Technology Laboratory

DEPARTMENT OF THE ARMY
Waterways Experiment Station, Corps of Engineers
Halls Ferry Road, Vicksburg, Mississippi 39180-6199



DTIC FILE COPY

US ARMY ENGINEER WATERWAYS EXPERIMENT STATION

DTIC
ELECTE
JAN 24 1991
S E D

December 1990

Final Report

Approved For Public Release; Distribution Unlimited

INFORMATION TECHNOLOGY LABORATORY

Prepared for DEPARTMENT OF THE ARMY
US Army Corps of Engineers
Washington, DC 20314-1000

Destroy this report when no longer needed. Do not return
it to the originator.

The findings in this report are not to be construed as an official
Department of the Army position unless so designated
by other authorized documents.

The contents of this report are not to be used for
advertising, publication, or promotional purposes.
Citation of trade names does not constitute an
official endorsement or approval of the use of
such commercial products.

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION
Unclassified

1b. RESTRICTIVE MARKINGS

2a. SECURITY CLASSIFICATION AUTHORITY

2b. DECLASSIFICATION / DOWNGRADING SCHEDULE

3. DISTRIBUTION / AVAILABILITY OF REPORT
Approved for public release; distribution unlimited.

4. PERFORMING ORGANIZATION REPORT NUMBER(S)
Miscellaneous Paper ITL-90-6

5. MONITORING ORGANIZATION REPORT NUMBER(S)

6a. NAME OF PERFORMING ORGANIZATION
USAEWES, Information
Technology Laboratory

6b. OFFICE SYMBOL *(If applicable)*
IM-CD-C

7a. NAME OF MONITORING ORGANIZATION

6c. ADDRESS *(City, State, and ZIP Code)*
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

7b. ADDRESS *(City, State, and ZIP Code)*

8a. NAME OF FUNDING / SPONSORING ORGANIZATION
US Army Corps of Engineers

8b. OFFICE SYMBOL *(If applicable)*

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER

8c. ADDRESS *(City, State, and ZIP Code)*
Washington, DC 20314-1000

10 SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.

11. TITLE *(Include Security Classification)*
Software Development Standards for Project Cost Management Information System

12. PERSONAL AUTHOR(S)
Wright, Margaret B.

13a. TYPE OF REPORT
Final report

13b. TIME COVERED
FROM ________ TO ______

14. DATE OF REPORT *(Year, Month, Day)*
December 1990

15. PAGE COUNT
21

16. SUPPLEMENTARY NOTATION
Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

17. COSATI CODES

FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS *(Continue on reverse if necessary and identify by block number)*
See reverse.

19. ABSTRACT *(Continue on reverse if necessary and identify by block number)*

Development of a large-scale software project requires the deployment of software standards. Department of Defense and Military Standards currently in use for software projects were developed for life-cycle software development efforts. Some modification to these standards was necessary for use in a prototyping environment. This paper reports the standards adapted for and being used by the Project Cost Management Information System.

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS

21. ABSTRACT SECURITY CLASSIFICATION
Unclassified

22a. NAME OF RESPONSIBLE INDIVIDUAL

22b TELEPHONE *(Include Area Code)*

22c OFFICE SYMBOL

Previous editions are obsolete

SECURITY CLASSIFICATION OF THIS PAGE
Unclassified

18. SUBJECT TERMS. (Continued).

Configuration management
Data dictionary
Data normalization
Fourth generation language
Prototyping
Quality assurance
Relational database management system
Software engineering
Software project development

Preface

This miscellaneous paper describes software development standards used for prototype development of a relational database management software project. The paper also provides information regarding the application of development standards to current development efforts. Funding for this paper was provided by the US Army Engineer Waterways Experiment Station (WES).

The Federal, Military, Army, and Department of Defense Standards cited were used to establish the necessary software development standards for the Project Cost Management Information System (PCMIS). Other references are listed following the main text.

The information in this paper was compiled at WES by Margaret B. Wright, Systems Modernization Unit (SMU), Computer Science Division (CSD), Information Technology Laboratory (ITL). Mr. Warren Bennett was Chief of SMU, Dr. Jerome Mahloch was Program Manager for PCMIS, Dr. Windell Ingram was Chief of CSD, and Dr. N. Radhakrishnan was Chief of ITL. The efforts of Bobbie Morrow, Information Management Division, who requested copies of the various Federal Standards, are gratefully acknowledged.

Commander and Director of WES was COL Larry B. Fulton, EN, and Technical Director was Dr. Robert W. Whalin.

Accession For
NTIS GRA&I ☒
DTIC TAB □
Unannounced □
Justification

By
Distribution/
Availability Codes
Dist A-1 | Avail and/or Special

QUALITY INSPECTED 4

Contents

SOFTWARE DEVELOPMENT STANDARDS FOR PROJECT COST MANAGEMENT INFORMATION SYSTEM

Introduction

~~1.~~ The US Army Engineer Waterways Experiment Station (WES) Corporate Data Base Project (CDB) is using software engineering methods and a structured approach for development of management information systems. These software engineering methods are implemented on the Project Cost Management Information System (PCMIS) as part of the WES CDB. The standards used are based not only on the structured approach but also on Department of Defense ~~(DoD)~~ and Military standards. Modifications were made to typical life-cycle standards so they apply to a fourth generation language (4GL)* based information system being developed in a prototyping environment.

~~2.~~ Project standards encompass quality assurance, design analysis, development, documentation, testing, screen/report standards, and security. Configuration management (CM) standards are developed, but implementation has proven very difficult in a prototyping environment. CM implementation is planned after successful system testing. The use of standards provides consistency in reporting and is a valuable tool for the assurance of a quality product.

Background

3. The PCMIS project is being developed using a relational database management system (RDBMS). The final product is a series of user-interactive screens. These screens are engineered to provide program managers and principal investigators a timely means of managing their project funds and a user friendly interface to the Finance and Accounting portion of the Corps Engineers Management Information System (COEMIS). A prototyping approach is being used to develop and validate the screens.

4. PCMIS has enjoyed a high level of user involvement. This level of user involvement introduces a greater degree of success (based on user

* For convenience, special terms used in this paper are identified in the Glossary of Terms presented in Appendix A.

satisfaction) and some interesting challenges in the implementation of the usual design and development standards. Communication of requirements and specifications from the users to the design team was facilitated through the use of formal meetings between the design team and members of the user committee. Design requirements were translated by the design team into an online data dictionary. The development team receives the requirements in a standardized format. This documentation is also useful for design and database verification, quality assurance, integration testing, and for future maintenance of the system. This automated data dictionary is the baseline for system development and maintenance.

Quality Assurance Standards

5. Quality assurance (QA) standards are primarily based on DoD Standard (STD) 2168 Software Quality Program. (Department of Defense 1988b). They are expanded in the project QA plan to include project-specific guidelines. Reports are identified and formats are established. Quality assurance is provided to ensure compliance to explicit functional and performance requirements, explicit documented development standards, and implicit characteristics that are expected of PCMIS. Quality assurance encompasses procedures for the effective application of methods and tools, formal technical reviews, testing strategies and techniques, procedures for change control, procedures for assuring compliance to standards, and measurement and reporting mechanisms. It is a planned, systematic pattern of actions to provide adequate confidence that PCMIS conforms to established technical requirements.

6. Quality assurance guidelines are based on the following standards:

a. Defense System Software Quality Program
DoD-STD-2168 (Department of Defense 1988b).

b. Technical Review and Audits for Systems, Military Equipments, and Computer Software
(MIL)-STD-1521-B (Department of Defense 1985).

c. Quality Assurance Terms and Definitions
MIL-STD-109B (Department of Defense 1969).

d. Defense System Software Development
DoD-STD-2167A (Department of Defense 1988a).

e. Software Product Standards
DoD-STD-1703 (Department of Defense 1987).

7. The following reports, taken from the online data dictionary, are applicable to QA for the purpose of determining and monitoring quality of

requirements analysis, systems interface, software development, and data base design:

a. All (entity) relationships.

b. Function definition.

c. Function decomposition.

d. Functions implemented by modules.

e. Modules which implement a function.

f. Module definition.

g. Module summary.

h. Modules and the tables/columns used.

i. Function-module cross reference.

j. Tables, columns, and indexes.

k. Tables/columns which are used in a module.

Requirements analysis/design standards

8. Project requirement analysis started with formal user requirement meetings where user requirements were communicated to project design analysts. PCMIS analysts used Yourdan-DeMarco Software Engineering techniques to represent project data flows.

9. Analysis and design project guidelines are based on standard entity relationship (E/R) methodology. A fully attributed E/R diagram is the established baseline for documentation in the database dictionary. The relational database design is taken to third normal form and then "custom-fit" to project specifications based on performance, efficiency, code complexity, and designer experience considerations. This process is called data normalization.

10. The following reports are used for analysis/design baseline:

a. Interview minutes.

b. Data flow diagram.

c. Work flow diagram.

d. Entity relationship diagram.

e. Functional hierarchy.

f. Requirements list.

Documentation standards

11. Department of Defense Automated Information Systems Documentation Standards DoD STD 7935.1 (1986) forms the basis for documentation standards for PCMIS. This standard specifically provides guidelines for the development (and revision) of information systems. The Data Base Specification section applies to DBMS.

12. Specific guidelines are further established in the introduction of the PCMIS User's Manual. Standard key definitions are also included here and apply only to the specific production environment. The user's manual establishes a standard format for screen documentation and presentation.

13. The online database dictionary provides much of the project documentation with the dictionary employing standard software engineering documentation methods. Additional documentation guidelines are discussed in other individual sections of this paper and are subject specific.

Testing standards

14. Testing guidelines are documented in the PCMIS software Test Plan and based on the following standards:

a. Defense System Software Quality Program
DoD-STD-2168 (Department of Defense 1988b).

b. Technical Review and Audits for Systems, Equipments, and Computer Software
MIL-STD-1521-B (Department of Defense 1985).

c. Defense System Software Development
DoD-STD-2167A (Department of Defense 1988a).

d. Software Product Standards
DoD-STD-1703 (Department of Defense 1987).

These standards are modified to apply to prototyping. PCMIS testing guidelines cover the areas of field/screen testing, code design testing, user validation, and system test. The first three areas are at the unit/integration level of testing or lower. Acceptance testing is conducted by the users prior to production. Module (unit) testing is performed by the module programmer and includes the following:

a. Verification of all computations using nominal, singular, and extreme data values.

b. Verification of all data input options.

c. Verification of all data output options and formats, including error and information messages.

d. Exercise of all executable statements at least once.

e. Test of options at branch points.

System test includes a parallel test with the actual data and results from COEMIS fed to PCMIS. The resulting database will then be examined to prove the system.

15. Testing guidelines include: (a) recommendation of personnel requirements for the different levels of testing; (b) required facilities and hardware; and (c) required support software.

16. Several test reports and their formats are identified in the test plan as the standard for testing documentation. They include the following report forms (copies included in Appendix B).

- a. Module screen signoff checklist (for programmers).
- b. Software validation form (to report code problems).
- c. Software test matrix (match requirements to test).
- d. Test procedures (test description and data).
- e. Software evaluation report (for test evaluation).

The software validation form is used to report any problems with code, code walk-throughs, break sessions, and user validation. A section for comments and correction signoff is included.

Screen/report standards

17. Screen standards include guidelines for screen and menu layouts and screen security. A screen layout is set forth to spell out: the program identifier, border characteristics, and general layout for all screens. Specific placement of key fields, such as date, screen title, and screen code, is indicated in the screen layout.

18. Menu screen standards include placement of menu options and instructions to be included for menu options. Standard menu options are numeric, although entry of a specific alphanumeric screen code allows a user to skip through the normal menu paths.

19. Entry and display screen standards set forth guidelines for consistency in (a) function key definitions, (b) error messages, and (c) help messages. Error messages and help messages that are common throughout are standardized.

20. Context sensitive help is provided for each screen with programmer defined messages specific to all allowable function keys. Automatic help messages for unused function keys are turned off to prevent confusion and to present a clearer help screen. Help messages for each enterable field are also available, in the form of an online help facility. Field help is not automatically displayed, in an effort to prevent redundancy and improve system performance. A predefined function key is used to access field help messages.

21. Hardcopy reports follow similar layout guidelines for key fields. Guidelines are included for titles, headings, footers, and page numbers. Reports are no more than 132 characters in width. Repeating fields that are subordinate to a key field are indented. For example, a report may show

several work units, and the subunits associated with each work unit are indented below it.

Security standards

22. Security guidelines are established for access limitation, online availability, data integrity, backup/recovery, data retention, and historical data management in PCMIS Data Base Control and Security Issues Plan. The security plan identifies system constrain' and establishes baseline positions based upon user requirements.

23. Each user is assigned an individual username and password not echoed on the screen. This allows for unique identification of each person granted access. Unique user identification provides an audit trail and is used to perform access control. Classes of users are authorized to perform certain activities or to access certain data. All access for update, deletion, and commonly accessed queries are made through PCMIS menu. When a user logs on, his user class or type is determined and access privileges are established accordingly. Database queries only are allowed outside the PCMIS menu structure to allow managers flexibility in accessing their data.

24. Online availability addresses the hours that PCMIS will be available to users and further states that maintenance is performed after normal working hours. Guidelines for user notice are established in the event the system must be down during working hours.

25. Guidelines to ensure database integrity are established. Database integrity checks are developed and run to verify database accuracy. It is the database administrator's responsibility to maintain database integrity in conformance to the E/R model. Database backup and recovery methods determine the backup interval and recommended procedures for recovery operations. Specific backup/recovery standards are tailored to the production environment. Other environment specific standards include reorganization of the database due to maintenance or performance requirements.

26. Data retention and archival of historical data are covered by Army Regulation AR 25-400-2 (Headquarters, Department of the Army, 1987). Regulations are used as required minimum and modified for upward reporting capability.

Database naming standards and conventions

27. The abbreviation standard adhered to for data element naming is AR 310-50 (Headquarters, Department of the Army, 1985). All applicable abbreviations included in the standard are used. Any words not included in the standard are constructed using the conventions described in the Headquarters, Department of the Army, 1 JUNE 1987 letter entitled "Data Element Naming Conventions." The data element naming conventions referred to in this letter apply to all Corps Information Systems Modernization Program projects.

Keyboard mapping standards

28. Keyboard mapping standards for PCMIS depends on the production machine. The development is taking place in an IBM block mode environment, therefore the keyboard mapping reflects this. Keyboard mapping varies depending on the communications protocol used. There is one set of keyboard symbols for developers using terminals with direct connections. A second set is used by members of the development team using a software emulation package and a hardware connection. A third set is used by people who dial into the system using a communications package such as Procomm.

29. Each software package maps the keyboard differently. During development, the standard being used is based on direct connection to the development machine. A decision concerning standard keyboard mapping must be made prior to production, after the production machine has been set up, and protocol software has been tested.

User Workstations

30. User workstations could be "dumb" terminals connected directly to the production machine, or PC's. Due to the large number of PC's currently in use on the WES campus, PCMIS is standardizing on PC's.

31. PC communications to the production machine will be via the WES network for the most part. VistaCom, a CDC product, is the communications/emulation package under consideration, because the production machine will be a CDC computer. One software communications package will be the standard established for all user interaction. This standard protocol will require specific user training, but will "travel" with the user regardless of the workstation type used to access the database.

References

Department of Defense. 1969 (Apr). "Quality Assurance Terms and Definitions," Military Standard MIL-STD-109B, Washington, DC.

__________. 1985 (Dec). "Technical Review and Audits for Systems, Equipments, and Computer Software," Military Standard MIL-STD-1521-B, Washington, DC.

__________. 1986. "Automated Information Systems Documentation Standards," DoD-STD-7935.1, Washington, DC.

__________. 1987 (Feb). "Software Product Standards," Department of Defense Standard DoD-STD-1703, Washington, DC.

__________. 1988a (Feb). "Defense System Software Development," Department of Defense Standard DoD-STD-2167A, Washington, DC.

__________. 1988b (Apr). "Defense System Software Quality Program," Department of Defense Standard DoD-STD-2168, Washington, DC.

Evans, Michael W., and Marciniak, John J. 1987. Software Quality Assurance and Management, Wiley, New York.

Headquarters, Department of the Army. 1985 (Nov). "Authorized Abbreviations and Brevity Codes," Army Regulation 310-50, Washington, DC.

__________. 1987 (Jan). "The Modern Army Recordkeeping System (MARKS)," Army Regulation 25-400-2, Washington, DC.

Pressman, Roger S. 1987. Software Engineering, A Practitioner's Approach, McGraw Hill, New York.

Appendix A: Glossary of Terms

1. Baseline is a specification or product that has been reviewed and agreed on and thereafter serves as the basis for further development. A baseline can be changed only through change control procedures (Evans 1987).

2. Data dictionary is: (a) a collection of the names of all data items used in a software system, together with relevant properties of those items, such as length and representation; (b) a set of definitions of the data flows, data elements, files, databases, and processes referred to in a data flow diagram (Evans 1987).

3. Data flow diagram is a graphic representation of a system, showing data characteristics, relationships, and logical flow of data as links between the software functional elements (Evans 1987).

4. Data normalization identifies redundant data that may exist in the logical data structure, determines unique keys needed to access data items, and helps to establish necessary relationships between data items. Three levels of normalization, called normal forms, can be achieved. Normalization is used to simplify the logical data structure (Pressman 1987).

5. Prototyping is the rapid development of a functional representation of a system capability that serves to provide a test bench on which system and user interface concepts can be tested prior to development (Evans 1987).

6. 4GL fourth generation language is a higher level language that uses a nonprocedural approach to translate requirements to implementation. Fourth generation tools automatically generate source code based on the developer's specification (Pressman 1987).

Appendix B: Examples of Project Cost Management Information System Test Plan Forms

1. Modu̇le screen signoff checklist. The checklist (Figure B1) is completed by the programmer/analyst during verification of the coded modules. The list is then validated and verified for test readiness by the analyst in charge of testing, and the records are maintained for audit purposes.

2. Software validation form. The software validation form (Figure B2) is used to report code problems. It is used for code design walk-throughs, code break sessions, and user validation. The developer is responsible for correcting the deficiency and returning the form to be filed in the software validation notebook.

3. Software test matrix. The software test matrix (Figure B3) will serves two purposes. When the appendix is delivered at the beginning of a test period, the matrix documents the modules to ' e tested and which of the tests from the test suite will be used to test functions implemented by each module. The matrix then will be used during the test to record the validation or exceptions to a test. A copy of the completed matrix will be included in the software evaluation report to verify any exceptions or corrections.

4. Test procedures. The software test procedure report (Figure B4) will be delivered as part of the Test Appendix. It will be prepared by the individual performing the test and used to record the immediate testing results. The beginning and ending test times will be noted.

5. Software evaluation report. The software evaluation report (Figure B5) will be completed by the tester and delivered to the test analyst no later than 3 days following a test period.

This checklist is filled out by the programmer/analyst during verification of each coded module. It is validated and verified for test readiness by the analyst in charge of testing. These work sheets are maintained for audit purposes.

SCREEN CODE: ________ DATE: __________
PROGRAMMER: ________ ANALYST: __________

TESTING STANDARDS

Software testing represents the ultimate review of specification, coding, and design. Test cases are constructed to zero in on areas where there is a high probability of finding errors. Field/Screen level testing will include:

All computations verified using nominal, singular, and extreme data values? __________

All data input options verified? __________

All data output options and formats, including error and information messages verified? __________

All executable statements exercised? __________

Options at branch points tested? __________

Entry of invalid data, escape sequences, and function keys? __________

Proper database storage verified where applicable? __________

SCREEN STANDARDS

Screen Standards have been developed for the PCMIS project. The programmer/developer is responsible for compliance with these standards.

Field identifiers clear? __________

Help messages clear? (use examples where possible) __________

Error messages clear? __________

All other screen standards including format satisfied? __________

Figure B1. Module/screen signoff checklist

I. Purpose

Use this form to record operational or functional defects observed in PCMIS software. This form may also be used to document suggestions for improvements or enhancements to PCMIS. Please observe the following guidelines:

- Always identify the screen/program module containing the defect or for which a suggestion is being made.
- Indicate if the defect/suggestion is related to the functional requirements being fulfilled by the screen/program module, the method in which the screen/program module operates, or is being used.
- Do not record multiple defects/suggestions on the same form. Use a new form for each defect observed or suggestion being made.

II. Review Identification

Name of Reviewer: ____________________ Date: __________

III. Software Identification

Screen/Program Module Code: _________

Title: ____

IV. Defect/Suggestion Classification

Functional: ___ Operational: ___

V. Description of Defect/Suggestion

VI. Person Assigned to for Resolution

VII. Resolution of Defect/Suggestion

VIII. Programmer Signature/Date Fixed

Figure B2. Software validation form

Test Date: ___________

Tested Module	Functional Requirements	Test Identification							

<u>Test Certification Signatures:</u>

Quality Assurance:
Programmer/Analyst:

Code Review/Design:
Programming Management:

Comments:

Figure B3. Software test matrix

a. Test XXXXXXXXX.

b. Test input requirements:

Beginning Time:

1.

2.

3.

4.

5.

6.

7.

8.

9.

10.

Ending Time: __________

c. Test output requirements:

1.

2.

3.

4.

5.

6.

7.

8.

9.

10.

d. Test output analysis method:

e. Uniquely identified acceptance criteria:

Figure B4. Test procedures

Review Identification:

Project:
Date:

Location:
Time:

Product Identification:

Module:
Material Identification:

Producer:

Brief Description:

Code Test:

Code Test Evaluation Participants:

Problems or Defects Encountered with Recommended Action:

User Validation Test:

User Validation Test Participants:

Problems or Defects Encountered with Recommended Action:

Figure B5. Software evaluation report