Introduction to Configuration Management

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In this presentation, we discuss preliminary results of our project (funded by NSF) to develop innovative, high-quality educational materials in Configuration Management (CM). Specifically, we describe our efforts at developing a CM Overview Module and an accompanying Teacher's Guide for use as part of regularly scheduled courses in the engineering and business curricula. These materials incorporate effective educational practices to improve student learning in both curricula.

In what follows, we first define CM and discuss why it is important for students to know about CM. We then briefly describe the overview module that has been developed for CM instruction.

Product changes result from several issues such as design maturation and optimization, cost reduction initiatives, additional requirements, and/or other continuous improvement activities. These changes must be dispositioned continually. As the pace of change increases in complex global markets, many companies are realizing the need to place their product and processes under formal change control. These dynamic operating environments require efficient change management systems that provide the ability to accommodate changes and retain clear, concise, and valid requirements. In manufacturing, as a typical product progresses through its life cycle starting with its conceptual design, a large number of changes may be made in terms of refinements to component parts, part suppliers used, assembly methods employed, testing protocols applied, and maintenance procedures prescribed. As a result, a comprehensive and robust change management methodology must include CM.

A robust CM process requires a formal methodology for managing product and process related information to provide structure and speed to formal review, costing, approval and adoption of changes. In other words, "Configuration Management is the discipline of identifying the components of a continuously evolving system (taking into account relevant system interfaces) for the purpose of controlling changes to these components and maintaining integrity and traceability throughout the system life cycle." Doing CM well can have a significant influence on reducing costs and improving productivity especially for organizations that are operating as virtual global teams that rely on timely and correct information to make decisions.

Organizations that realize the importance of CM are using software-driven approaches to the task of coordinating the enormous quantity of detailed information involved in product information management. Properly implemented, a CM system provides, in a nearly paperless environment, the ability to plan, identify, control and account for the status of a product's configuration and its logistic support at any point in time, the ability to insure that appropriate review and approval processes are followed in processing proposed changes, and the ability to estimate the costs of change.

CM is used routinely in the defense and aerospace industries, and there are numerous commercial software systems designed specifically to support these applications. While there are also a considerable number of commercial software systems available that are designed to support more general manufacturing implementations of CM, these systems have not been widely adopted across the manufacturing sector. In most manufacturing firms, particularly small and mid-sized organizations, the myriad details of product design and manufacture are typically handled, stored and accessed on an ad-hoc basis by a few indispensable individuals. Unfortunately, informal systems are prone to error, which at the very least waste resources and can sometimes be life-threatening to consumers.

Why are CM systems not yet widely implemented in the general manufacturing sector? A major reason for this may be lack of information and education regarding CM and its benefits among manufacturing personnel. This is especially true for recent college graduates joining these firms as entry-level manufacturing engineers or managers, since there is little or no formal education or training in CM in university coursework at the present time.

Certainly, professional development education programs are available to provide corporate managers and operating personnel with an understanding of the benefits of CM and the key steps in implementing these systems. For example, the Institute of Configuration Management (ICM), established in 1981 and headquartered in Scottsdale, Arizona, offers a comprehensive array of coursework in CM. However, as noted above, within university academic environments, there is little or no coverage of CM in the typical baccalaureate-level engineering or management coursework. Indeed, the authors know of no examples of regularly offered undergraduate course work which provide more than a brief overview of CM. In part, this lack of coverage may be the result of limited educational materials for faculty members to use as resources. Academic journals provide references to CM under topics such as quality-assurance and management of design, but there are very few textbooks that are explicitly dedicated to CM. Moreover, since commercially available CM software is expensive and not easily adaptable to student use with personal computers and/or a university network server, it is also very difficult to demonstrate the operation of CM systems in an academic setting. Thus, today's engineering and management graduates do not leave their universities with an understanding of CM, its benefits, and how such systems operate.

The CM Overview Module developed in our project provides 1-2 weeks of undergraduate college-level coursework, and is organized around four topics as follows:

- *Importance of CM.* This topic uses several examples from industry to illustrate the importance of CM and the results a firm can hope to achieve by implementing CM. A demonstration of the use of CM software to monitor progress of a request for change as it moves through a typical organization is also presented.
- *Need for CM.* This topic includes a brief history of the development of CM and typical industry practices without CM that have resulted in high costs, wastage, etc. This background serves as the motivation for the need for a technique such as CM and an appreciation for benefits that could result.

- *Components of CM.* The ICM has identified four components of a CM implementation: Configuration Identification, Configuration Change Control, Configuration Status Accounting, and Configuration Audits. This topic discusses each of these issues in detail.
- *Case Studies.* Case studies serve as valuable educational tools to convey some of the issues in the above topics. Cases involve role playing with students playing the roles of managers in different departments of a firm. With the professor acting as the Chief Executive, students develop an understanding of the relationship between the different departments of an organization and how decisions must be made in a coordinated fashion to ensure a firm's success.

The accompanying Teacher's Guide provides a bibliography documenting sources for material presented in the CM Overview Module, and a reading list on CM-related topics. The guide also describes possible supplemental reading and project assignments for engineering and business students.

Both the module and Teacher's Guide will be made available to potential users in print form (word-processing files), through the World Wide Web, and possibly as a CD-ROM (supplied at production cost).

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Bibliography

1) BS 6488, "Code of Practice for Configuration Management of Computer-Based Systems," British Standards Institute (BSI), 1984.
2) Blanchard, Benjamin and Walter Fabrycky, Systems Engineering and Analysis, Third Edition, 1998.
3) Buckley, Fletcher J., Implementing Configuration Management: Hardware, Software, and Firmware, Second Edition, IEEE Computer Society Press, Los Alamitos, CA, 1996.
4) ICM Course I: CMII-Based Business Process Infrastructure, Revision W, Institute of Configuration Management, Scottsdale, AZ, 1998.
5) Monahan, Ray E., Engineering Documentation Control Practices and Procedures, Marcel Dekker, New York, NY, 1995.
6) Watts, Frank B. Engineering Documentation Control Handbook: Configuration Management for Industry, Noyes Publications, Westwood, NJ, 1993.

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