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Configuration Management for Transportation Management Systems
Establishing and Maintaining System Integrity

TMC PFS Projects

Final Subject Presentation

Slide 1: Title Slide

Configuration Management for Transportation Management Systems
Establishing and Maintaining System Integrity

Slide 2: Presentation Outline

- What is CM?
- Benefits of CM
- CM Process
- Recommendations for use in TMSs
- Resources

Speaker Notes:

The presentation is structured in 5 main components:

1. What is CM? - High-level overview of what CM is – what is the overall objective of CM and how is it "done", in general?
2. Benefits of CM - Focuses on the benefits realized by transportation agencies that are already using CM.
3. CM Process - Detailed description of the processes that make-up CM.
4. Recommendations for use in TMSs - Specific recommendations for applying CM within TMSs
5. Resources - Describes key transportation-oriented resources to support use of CM

Slide 3: What is Configuration Management? Why is It Important to My Agency and System?

Speaker Notes:

Let's begin by describing CM, and, more importantly, describing why it is important in designing, developing, and operating transportation management systems.

Slide 4: Configuration Management

"A management process for establishing and maintaining consistency of a product's performance, functional, and physical attributes with its requirements, design, and operational information throughout its life."

— EIA Standard 649

Speaker Notes:

This is the definition contained in the Electronics Industry Association (EIA) standard on CM.

In the case of transportation management systems – the term "product" should be thought of as a transportation management system.

The bottom line of this definition is that CM is about effectively managing change in large-scale complex systems.

Note that this includes hardware, software, and communications.

Slide 5: Purposes of CM

There are two fundamental purposes of configuration management (CM):

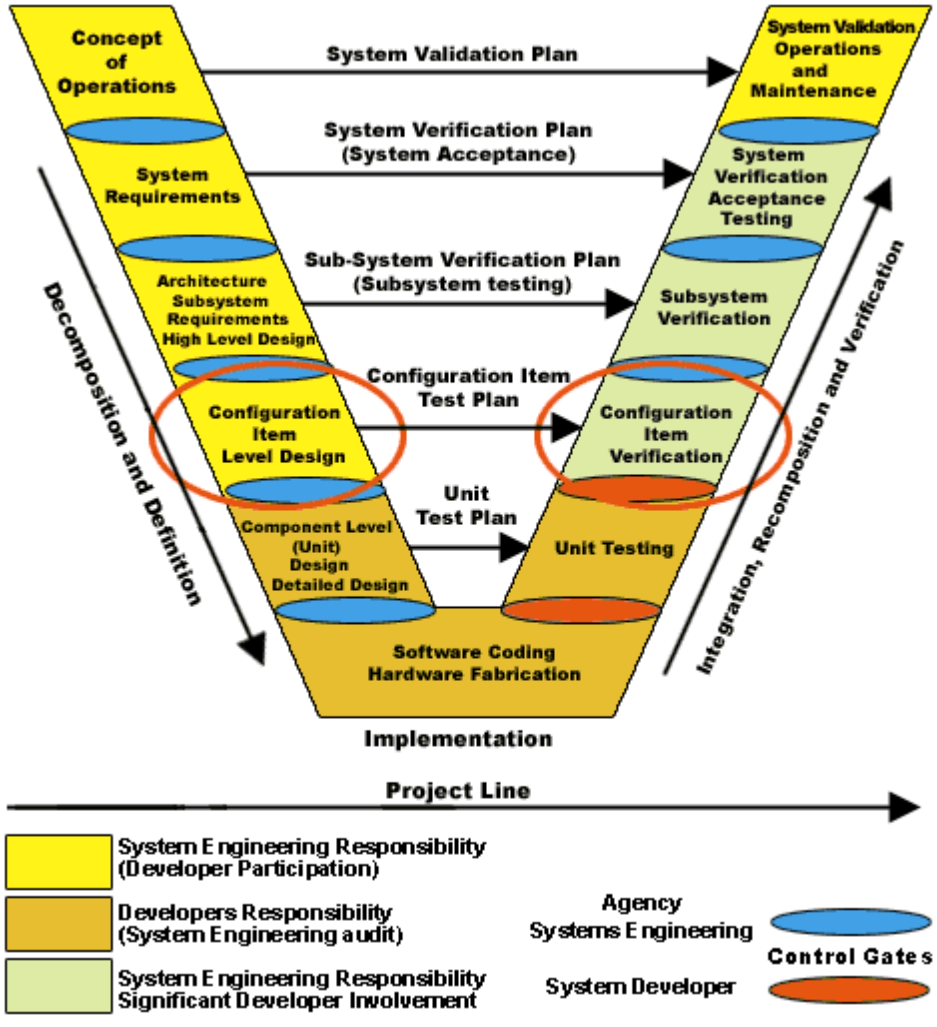
1. Establish system integrity
2. Maintain system integrity

Speaker Notes:

A system with integrity is one that is available and functional.

- A system with integrity is one in which all components are well defined and documented.
- A system with integrity is one in which a working baseline is always available to implement and provide transportation management services.
- A system with integrity is one that can be readily integrated with other regional intelligent transportation systems (ITS).
- A system with integrity is one with a high degree of traceability – allowing one to easily identify how system functions are provided technically.

Slide 6: CM is an Integral Part of the Systems Engineering Process



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Speaker Notes:

It is important to keep in mind that CM does not exist in isolation. It is an important and integral component of the systems engineering process. This means that CM begins when the system concept is formulated and then "follows through" for the entire system life-cycle.

This diagram is the "Vee Diagram" used by FHWA in systems engineering courses and documents. This diagram illustrates the top-down nature of systems engineering in which system development begins by defining a concept of operations, and then specific requirements are developed to drive design. As the system takes shape, and specific configuration items are established, the process seeks to ensure that the system can evolve and grow effectively.

In terms of change management, note the prominent role of "configuration items" in this process.

Slide 7: Why CM?

With almost 20 years experience in the design, implementation, modification and expansion of our system, the benefits of being quickly able to recover from problems by returning to an earlier working state are enormous.

Speaker Notes:

This testimonial from a DOT official clearly illustrates why CM is important – it protects an agency's investment in a transportation management system and ensures that the system will be available to fulfill its role.

These systems are in a constant state of change – problems will occur and a working, BASELINE system must always be available.

Slide 8: Benefits

- Enables efficient system changes, upgrades and deployments
- Thorough, complete documentation
- Rapid recovery from failure
- Saves operating and maintenance costs over life of system

Speaker Notes:

CM is in some ways like insurance – it protects you from catastrophic problems:

One problem that has been discovered as these systems change is that groups within an agency often work independently of each other, conducting changes without consulting one another and documenting the changes improperly. If the entire system is to undergo a major change or upgrade, this can present a significant problem. Contractors or agency personnel will often have to devote significant effort to retracing the steps taken in minor changes to the system to understand the current status. This obviously requires major outlays of time and money. CM provides a methodology for identifying, tracking changes to, updating information on, and verifying the status of all items within a system.

A proper CM Program will ensure that documentation (requirements, design, test and acceptance documentation) for items is accurate and consistent with the actual physical design of the item. In many cases, without CM, the documentation exists but is not consistent with the item itself. For this reason, contractors and agency staff will frequently be forced to develop documentation reflecting the actual status of the item before they can proceed with a change.

Some of the other benefits of CM that will hopefully never be needed are its provisions for disaster recovery. Because a CM Program should ensure that an accurate up-to-date baseline of the system exists, the re-engineering process should be far less costly. Without CM and the associated baselining process, entire subsystems will require redesign at a much higher cost and the recovery process will be greatly lengthened, if even feasible.

Once a CM program is in place, operations and maintenance is more efficient due to the improved understanding and documentation of the system – this saves time and money.

Slide 9: CM in Transportation

- As transportation management systems grow in scope and complexity, more and more agencies are incorporating CM practices.
- There is a need to accelerate use of CM
    - 27% of signal systems use CM
    - 62% of freeway management systems use CM.
        - Source: NCHRP Synthesis 294 (2001)

Speaker Notes:

TMSs continue to become larger and more complicated (not to mention a larger and larger investment on the part of DOT's) – this leads to a bigger need for CM and a more reasonable motivation for the investment in CM.

Given the complexity of TMS's – relatively few are currently using CM (see NCHRP 294 statistics). There is a need to accelerate use of CM in TMS – that is the goal of the handbook that has been developed and will be described next . . .

Slide 10: The Challenge

- Increase the use of CM practices to improve transportation management systems integrity.
- Use of CM must:

- Require reasonable levels of personnel and financial commitments
- Be tailored to the unique needs of transportation agencies

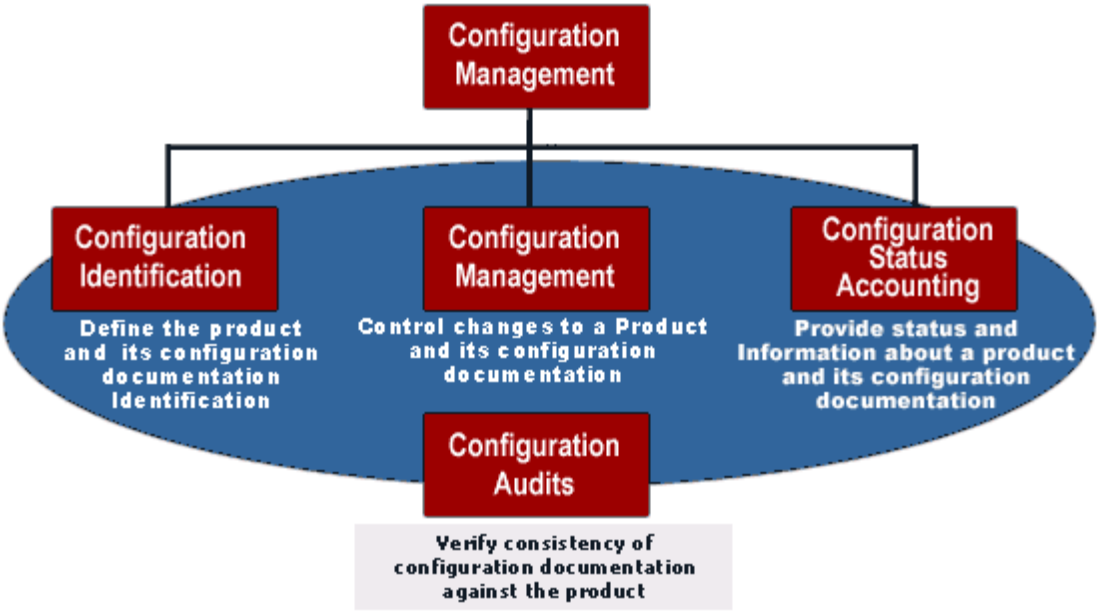
Speaker Notes:

As seen in the previous slide, despite the benefits of CM, it is not widely used in transportation management systems. The challenge for our community is to address this and increase the use of CM.

However, CM should not be used for CM's sake – a key challenge is to ensure:

- CM can be applied at different levels =- it is important to identify reasonable levels for TMS application (i.e. not too much money or staff commitment)
- CM needs to be appropriate to the needs of software/hardware systems that make-up TMSs.

Slide 11: CM Process



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Speaker Notes:

CM can be considered as an active process that continues throughout the life of a system – with certain elements of the process playing larger roles at different points in the lifecycle.

This graphic describes the basic elements of the CM process in very general terms – the next set of slides will consider each element in more detail.

Of particular note on this slide is that CM is not a high-tech or complex process – it really involves careful attention to detail.

Slide 12: CM Plan

CM Plan describes:

- How configuration management is accomplished
- How consistency is developed and maintained between system's configuration and records
- Resources, tools and opportunities to apply recommended CM practices

Speaker Notes:

Before entering into the CM Process as described in the previous slide, the accepted best practice is to develop a CM Plan.

Experience by DOT's indicates that an effective CM program MUST be founded on a sound, thorough CM plan.

The CM Plan is the document that will guide the CM Program of a particular group. Typical contents of a plan include items such as **personnel**, responsibilities, **resources**, **training requirements**, administrative meeting guidelines, definitions of procedures, tool use, organization configuration identification (CI) activities, **baselining**, configuration control, configuration status accounting, **naming conventions**, audits/reviews, and subcontractor/vendor CM requirements.

Plans typically are established at the outset of the CM Program and undergo changes as the system evolves and areas where the plan can be improved are identified. Contractors, in conjunction with the particular agency that will be using the CM Program, often develop the plans.

The benefit of the CM Plan is that it provides a central location for all CM Program information. The items selected for CI depend upon the scope of the effort. For example, CI may be constrained to software items or may be larger and include system level components ranging from software, hardware, firmware, documentation and perhaps the CM Plan. The plan serves as the primary resource for any questions pertaining to the CM Program. The primary benefit of the plan is that it clearly outlines how the CM Program is to be executed and will leave as little room for ambiguity as possible.

Slide 13: Configuration Identification

Configuration Identification is the basis where the configuration of items are:

- Defined
- Verified
- Products and documents labeled
- Changes are managed

Speaker Notes:

Configuration Identification is the process of documenting and labeling the items in the system. Depending on the scale of the particular CM Program, this may mean simply software versions or, in the case of a large Program, all hardware, software, documentation and the CM Plan itself. **The goal of Configuration Identification is to provide a unique identifier to each item to help track the changes to that item and to be able to understand its place in the system**. Often, Identification involves recording the identifier, maintenance history, relevant documents and other information that will simplify the change process in the future.

The benefits of configuration identification are to provide a means of unique identification of system components to support traceability and change management processes. Proper identification minimizes confusion over various versions of Configuration Items and facilitates the Change Control process by allowing items to be more easily tracked as they undergo change.

Slide 14: Change Control

Change Control is a process for managing product configuration changes and variances in order to assure system integrity.

Speaker Notes:

Change Control is the process of assessing the impact of a possible change to a system, determining the fate of the proposed change, executing the approved changes, and ensuring that the change is carried through to the proper documentation. Usually, a change is proposed by someone who is working with that particular part of the system that will be changed. Change requests are submitted to the relevant administrative body for review. This body is normally referred to as a **Change Control Board** (CCB). The CCB will review the proposed change, determine its effect on the overall system and decide whether or not to proceed with it. An important part of Change Control is ensuring that the change itself is documented and that the relevant Configuration Item's (CI) documentation now reflects that change.

The primary benefit of an effective Change Control procedure is that proposed changes are evaluated in terms of their impact on the entire system. Change Control allows the changes to be reviewed by personnel with a variety of interests and areas of specialty. This minimizes the negative impacts of changes on other components of the system. Change Control also ensures that the changes are properly implemented, and within schedule and cost constraints.

Slide 15: Configuration Status Accounting

Configuration Status Accounting is a set of activities associated with periodic reporting on the status of a configuration and the changes to that configuration.

Speaker Notes:

Configuration Status Accounting (CSA) is the **process of ensuring that all of the relevant information about an item – documentation and change history – is up to date and as detailed as necessary**. A primary goal of CSA is to repose CI information necessary to support existing and future change control efforts. A typical CSA system involves establishing and maintaining documentation for the entire life cycle of an object. Status Accounting is ideally carried out in conjunction with Change Control.

The primary benefit of CSA is that it provides a methodology for updating all relevant documentation to ensure that the most current configuration is reflected in the Configuration Identification database. CSA accounts for the current status of all proposed and approved changes. **The goal of CSA is to provide decision makers with the most up-to-date information possible**. Having the most recent information about a CI or changes implemented for a CI helps to reduce research efforts in future change control activities whether implementing a new change or rolling back a change that had a negative or unexpected impact.

Slide 16: Configuration Audits

Configuration Audits ensure that:

- Performance and functional requirements defined in configuration documentation have been achieved
- Design has been accurately documented

Speaker Notes:

Configuration Verification and Audit is the process of analyzing Configuration Items and their respective documentation to ensure that the documentation reflects the current situation. **Essentially, while Change Control ensures that change *is* being carried out in adherence with the CM Plan, Configuration Audits ensure that the change *was* appropriately carried out**. The most important goal of this process is to prevent lost time on future changes due to inaccurate documentation. If discrepancies are located between the documentation and the Item, the personnel carrying out the audit will prescribe a course of action for remedying the problem.

The most important benefit of Configuration Audits is that they verify that changes were carried out as approved by the relevant administrative body and that documentation about an item reflects the current configuration. By ensuring that changes are properly executed and all documentation is updated, Configuration Audits will facilitate future changes to the system.

Slides 17 and 18: Guiding Principals

1. Identify the context and environment in which CM is to be implemented and develop an appropriate CM Plan accordingly.
2. Define procedures describing how each configuration management process will be accomplished.
3. Conduct training so that all responsible individuals understand their roles and responsibilities and the procedures for implementing configuration management processes.
4. All items are assigned unique identifiers so that one item can be distinguished from other items.

5. Configuration documentation defines the functional, performance, and physical attributes of a system.
6. A baseline identifies an agreed-to description of the attributes of an item at a point in time and provides a known configuration to which changes are addressed.
7. Each change is uniquely identified.
8. Consider the technical, support, schedule, and cost impacts of a requested change before making a judgment as to whether or not it should be approved for implementation and incorporation in the item and its documentation.
9. Implement a change in accordance with documented direction approved by the appropriate level of authority.

Speaker Notes:

Guiding principles for CM in TMS presented in the text box are:

1. Identify the context and environment in which CM is to be implemented and develop an appropriate CM Plan accordingly.
2. Define procedures describing how each CM process will be accomplished.
3. Conduct training so that all responsible individuals understand their roles and responsibilities and the procedures for implementing configuration management processes.
4. All items are assigned unique identifiers so that one item can be distinguished from other items.
5. Configuration documentation defines the functional, performance, and physical attributes of a system.
6. A baseline identifies an agreed-to description of the attributes of an item at a point in time and provides a known configuration to which changes are addressed.
7. Each change is uniquely identified.
8. Consider the technical, support, schedule, and cost impacts of a requested change before making a judgment as to whether or not it should be approved for implementation and incorporation in the item and its documentation.
9. Implement a change in accordance with documented direction approved by the appropriate level of authority

Slide 19: Resources to Support the Use of Recommended CM Practices

Speaker Notes:

Now, we'll shift to describing key resources that can help transportation agencies implement CM in TMSs.

Slide 20: Configuration Management for Transportation Management Systems Handbook

Speaker Notes:

This section of the presentation will introduce the handbook.

Slide 21: Document Philosophy

- Relate national CM standards and guidance to transportation management systems
- Extensive use of examples of CM usage in transportation management systems
- Provide "pointers" to allow one to avoid reading document sequentially

Speaker Notes:

Let's begin by describing the philosophy of the researchers and the TMC PFS steering committee in developing this document.

First, there was no need to recreate generic CM guidance. EIA Standard 649 exists that provides an excellent introduction and description of "generic" CM.

What was needed was a document to relate the generic guidance specifically to the unique characteristics of transportation management systems. This document does this through extensive inclusion of transportation examples and experiences.

The document is intended to serve both as (a) an introduction to CM that can be read sequentially, and (b) as a reference document that can be referred to on an as-needed basis.

Slide 22: Handbook Foundation

EIA Standard 649 was used as the foundation for the document. Basic definitions and guidance were derived from the standard.

Speaker Notes:

Electronic Industries Alliance (EIA) Standard 649 *National Consensus Standard for Configuration Management* (ANSI/EIA-649-1998) is the definitive standard for CM – may easily be purchased at the EIA website http://www.eia.org

This standard served as the foundation for the handbook.

Slide 23: Handbook Features

- TMS-specific implementation guidance following the standard definitions
- Summary boxes of implementation guidance for quick access and review
- Transportation best practices based on concrete examples
- Numerous navigation boxes to help locate additional information

Speaker Notes:

Now we will highlight key features of the handbook

First – following standard definitions, specific implementation guidance for TMSs is provided. This guidance is always identified by the lighthouse icon.

Next, succinct summaries of implementation guidance are always provided – giving readers key "take-way" points.

Concrete examples are used to identify transportation best practices of DOTs currently involved in CM. These sections are intended to go beyond high-level advice to provide specific actions that transportation professionals can take.

Given the scope and comprehensive nature of the handbook – navigation help is provided to point readers to background information on particular items when appropriate. This keeps readers from having to scan the document to find key pieces of information.

Slide 24: Handbook Chapters

1. Intro to CM & TMS
2. CM Current Practices
3. CM Processes
4. CM Plan
5. CM Baselines
6. Making it Work in Your Agency
7. CM & System Life Cycle

8. CM Tools
9. Resources to Support CM Programs

Speaker Notes:

This guidance document is structured in three key sections, as follows.

Section 1 – General Introduction to CM & Transportation Management Systems

This section provides general information describing CM and presents an overview of the current practices in CM and transportation management systems. As such, this section is well suited as an introduction to those new to this area or management personnel. The following chapters form Section 1.

- Chapter 1. Introduction
- Chapter 2. Configuration Management and Transportation Management Systems – Current Practices

Section 2 – Technical Guidance – CM & Transportation Management Systems

This section provides detailed information on how to implement CM in TMSs. It is intended for a technical audience of individuals who are responsible for implementing a CM program. The following chapters form Section 2.

- Chapter 3. Configuration Management Processes
- Chapter 4. Configuration Management Plan
- Chapter 5. Configuration Management Baselines

Section 3 – Guidance for Implementing a CM Program

This section provides guidance to implement or improve a CM program to support a transportation management system. This section goes beyond the technical details of CM to consider such issues as resources required to sustain a CM program, tools available to support CM, etc. This chapter is well suited for both technical personnel and management to consider in framing an agencies program. The following chapters form Section 3.

- Chapter 6. Configuration Management Program – Making it Work in Your Agency
- Chapter 7. Configuration Management and the System Lifecycle
- Chapter 8. Configuration Management Tools
- Chapter 9. Resources to Support Configuration Management Programs

Finally, the document concludes in Chapter 10 with a presentation and discussion of nine guiding principles for CM and transportation management systems.

Slide 25: Other CM Resources

Outreach Materials:

- CM Primer
- Fact sheet
- Tri-fold brochure
- Available from TMC Pooled Fund Study Web Site @ http://tmcpfs.ops.fhwa.dot.gov/projects.htm

FHWA 2-day Training Course: CM for Transportation Management Systems
http://www.nhi.fhwa.dot.gov

Speaker Notes:

Other outreach materials are available to supplement the handbook. These are shorter, more targeted documents intended to promote awareness of CM.

Configuration Management Primer - The intended audience of the primer is community leaders, executive managers, key interests that have the potential to allocate resources, influence local practices, or may manage programs or transportation management systems that should be incorporated into their programs, policies, procedures, or practices.

Project fact sheet - The intended audience of the fact sheet is any individual who is engaged with or responsible for the planning, design, implementation, management, operation or maintenance of transportation management systems.

Tri-fold Brochure –The intended audience of the brochure is executives, senior managers, and other key interests that have the potential to allocate resources, influence local practices, or the participation of their agency or staff.

These documents can be accessed on the FHWA Freeway Management and Traffic Operations web page at http://ops.fhwa.dot.gov/Travel/traffic/freetraffic.htm or through the ITS Electronic Document Library at www.its.dot.gov

Slide 26: Other CM Resources

- NCHRP Synthesis 294: CM for Transportation Management Systems
  www4.nationalacademies.org/trb/synthsis.nsf
- ITS Peer-to-Peer Program
  www.its.dot.gov/peer
- ITS Electronic Document Library
  www.its.dot.gov/itsweb/welcome.htm

Speaker Notes:

Other valuable resources include:

NCHRP Synthesis 294 documents the use of CM in transportation agencies as of 2001 – it also provides basic information on CM and its role in TMS.

NHI has prepared a 2-day course on CM in TMS – this is specifically intended for transportation professionals.

The ITS Peer-to-Peer Program can be used to help gain access to professionals experienced with CM in TMS.

Finally, the EDL is a great resource to search for documents closely related to your particular needs.