

**International Infrastructure Project
Cost Estimating Work Breakdown
Paul Hewitt, International Project Estimating Limited**

Introduction

Construction Cost Estimating Work Breakdown Structure (WBS)

The term WBS has become a common term in all fields related to Cost Engineering including Construction Cost Estimating, Scheduling and Project Cost Control. A well defined WBS is the backbone of good Construction Estimating Software and can take several forms including the breakdown of items within an estimate, the layout of groups within a schedule or the rollup of accounts within a cost report. It usually starts with a client's desire to breakdown a tender into definable pay items, followed by the project manager's wish to schedule activities of work in a logically and efficient manner and the contract cost control engineer's goal to track and forecast costs. In each case a properly organized WBS is required.

The Phases of a Civil & Infrastructure Project

The cycle of developing, designing, constructing and maintaining Civil & Infrastructure projects includes many phases and participants. The projects usually originate with a developer or government body who formulate a concept design and budget. If the project is approved it then moves on to preliminary design and a more detailed budget is estimated. Depending on the financing options available, the project may go out as a traditional Detailed Design and Bid Build project or proposals may be solicited for Design Build or Design Build and Finance options.

Participants within the Project Cycle

The life of a major international infrastructure project can involve many participants and span across many years. These projects involve developers, government agencies, engineers, contractors, operators, environmentalists and community stake holders. It is essential for the success of a project that all participants within the project cycle communicate and transfer data efficiently and consistently.

Lack of a Standard Industry Wide Work Breakdown Structure (WBS)

The dilemma that the international construction industry faces today is that there has been no common work breakdown upon which to communicate and transfer data between project participants. Traditional agencies like state and provincial highway authorities have all developed their own tender breakdowns, many of which that have been around long before the creation of electronic data transfer. Construction estimators have tended to follow the layout of the bids as provided by the government agencies. The scheduler commonly ignores the estimate breakdown because it does not logically adapt well to the

sequence of work activities. The cost control engineer has to rollup the project costs into a corporate chart of accounts that even creates more inconsistency.

Current Standard Work Breakdown Structures

Many standard project work breakdown structures have been created over the years. The CSI (Construction Specifications Institute) format in North America and the SMM7 (Standard Method of Measurement) format in Great Britain are the most common and have been in existence for over 40 years. These originated as breakdowns for commercial building construction and quantity survey but both have evolved over the years to include other forms of construction. The State of California USA (DOT) Department of Transportation and the Province of Ontario Canada (MTO) Ministry of Transportation are examples of transportation government agencies whom have standardized tender breakdowns. The CSI (Construction Specifications Institute), the most popular Work Breakdown in North America, recently introduced an expanded version of their MasterFormat™ in 2004 [1]. This work breakdown was expanded from the tradition 16 divisions of work covering building construction to include 50 divisions of work covering civil site work as well as process equipment.

A Proposed Standard for an International Infrastructure Project Work Breakdown

None of the current breakdowns, including CSI, fully cover the complete civil infrastructure project cycle including; development, engineering, construction, operations, maintenance and risk mitigation. The current CSI MasterFormat™ 2004 Edition [1] comes closest to covering all the scope of work found in the construction of Building Facilities and Site Work. It falls short in addressing the unique requirements of estimators, schedulers and cost engineers in identifying all phases of work included in major Infrastructure work such as Build Own and Transfer (BOT) projects. This Standard Work Breakdown attempts to format the project into a multi-level WBS suited to estimate, schedule, track cost and measure performance on international infrastructure projects. The breakdown is also designed to facilitate the data transfer of a standard work breakdown between common estimating, scheduling and cost control software applications.

The International Infrastructure Project Work Breakdown Structure (WBS)

The following paragraphs outline the various sub-projects and phases within the Civil Infrastructure WBS.

The Sub-Projects within a Civil Infrastructure Project Life Cycle

Traditional work breakdown structures in the past have only identified the Construction Divisions within a project. This proposed work breakdown includes all phases within the life span of the project cycle, including Development, Engineering, Operations, Maintenance, Transfer and Risk.

1	Project Capital Cost	1.1	Overhead
		1.2	Construction
		1.3	Equipment
		1.4	Engineering & Design
		1.5	Capital Cost Escalation
		1.6	Capital Cost Risk
2	Project Development	2.1	Proposal
		2.2	Financial Close
		2.3	Development Overhead
		2.4	Development Escalation
		2.5	Development Risk
3	Operations & Maintenance	3.1	Operations
		3.2	Maintenance
		3.3	Transfer
		3.4	O & M Escalation
		3.5	O&M Risk

Project Capital Cost

The Project Capital Costs are normally the initial cost of the project, also referred to as the initial investment for the project. It is within this phase that the project is designed and built. Traditional work breakdowns have only included direct construction divisions. This WBS includes Site & Head Office Overheads, Construction Equipment as well as Rolling Stock and Engineering.

1.1	Overhead	1.1.1	Site Indirect Costs
		1.1.2	Head Office Overhead
		1.1.3	Unallocated Costs
		1.1.4	Bonding & Insurance
1.2	Construction	1.2.1	Facilities
		1.2.2	Site Work
		1.2.3	Infrastructure
1.3	Equipment	1.3.1	Construction Equipment
		1.3.2	Operations Vehicles
		1.3.3	Transit Vehicles
1.4	Engineering & Design	1.4.1	Site Investigation
		1.4.2	Engineering Design
		1.4.3	Resident Engineering

Project Development

With the advent of the Build Own procurement model the activities and costs associated with the financial development of the project also have to be accounted for and tracked. On major Civil Infrastructure projects, separate entities called “Concessionaires” have evolved to take on this responsibility. The concessionaire is often a joint venture company comprised of the contractors involved with the project or can be a separate

entity on their own. The activities performed by the concessionaire have to be defined within the work breakdown structure. These activities are split into 3 distinct phases; the Proposal Phase during which time the proposal and financial models are prepared, the Financial Close phase, where the concessionaire negotiates with banks and financial institutions to procure financing for the project and the Operations phase, where the concessionaire manages or oversees the operation of the facility. On some international projects it may take several years to finalize all the legal agreements in order to get to financial close.

2.1	Proposal	61.10.00	Proposal Preparation
		61.20.00	Financial Modeling
2.2	Financial Close	61.30.00	Legal Due Diligence
		61.40.00	Financial Due Diligence
		61.50.00	Success Fees
2.3	Concessionaire Overhead	63.10.00	Management Salaries
		63.10.00	General Expenses
		63.10.00	Office Facilities
		63.10.00	Office Services
		63.10.00	Public Relations
		63.10.00	Travel & Subsistence
		63.10.00	Municipal Taxes

Operations and Maintenance

In addition to building and owning infrastructure facilities the concessionaire (developer) is normally required to operate and maintain the facility over an extended period of time. The concession period can extend for 20 to 30 years. At the end of the period that facility is then transferred back to the municipality or government agency. The WBS must include the ability to estimate, schedule and track these operations & maintenance activities over the concession period.

The staff involved with operating infrastructure facilities can include Management, Supervisors, System Controllers, Fare Collectors and Vehicle Operators. Energy Consumption can include electric power consumption for transit vehicles and fuel for buses. Consumables include tickets.

Maintenance can include such things as the cost of maintaining and cleaning buildings, repairing highway pavements, cutting and watering grass, replacing bridge bearings and maintaining ticket vending machines. Maintenance can also include the labor and parts required to operate transit vehicles over the concession period.

Transferring the facility back to the government includes demobilization costs such as cleanup costs, staff severance as well as audit fees required to transfer the assets.

3.1	Operations	3.1.1	Staff Salaries
		3.1.2	Overhead
		3.1.3	Energy

		3.1.4	Consumables
		3.1.5	Insurance & Bonding
3.2	Maintenance	3.2.1	Facility Maintenance
		3.2.2	Road & Site Work Maintenance
		3.2.3	Infrastructure Maintenance
		3.2.4	Rolling Stock Maintenance
		3.2.5	Service Vehicle Maintenance
3.3	Transfer	3.3.1	Demobilization
		3.3.2	Legal & Audit

The Construction Phase of Work Breakdown Structure

The Construction phase of the Capital Cost portion of the project is still where most of the detailed scheduling and cost control tasks are required. Most current WBS layouts have addressed the direct construction costs in detail. The following paragraphs describe how current breakdown structures have been adapted and revised to form part of the proposed Civil Infrastructure WBS.

Summary Levels within the Construction Cost Breakdown

The cost of construction has been summarized into definable levels that can be estimated, scheduled and procured. These sections are structured to help the estimator, scheduler or cost control engineer group the project into definable work packages. These work packages can also serve as subcontract procurement packages. The following table lists the main summary levels within the Construction Phase of an Infrastructure Project.

1.2.1	Facilities	1.2.1.1	Buildings
		1.2.1.2	Building Services
1.2.2	Site Work	1.2.2.1	Existing Conditions
		1.2.2.2	Earthwork
		1.2.2.3	Paving
		1.2.2.4	Landscaping
		1.2.2.5	Site Improvements
		1.2.2.6	Utilities
		1.2.2.7	Traffic Control
1.2.3	Infrastructure	1.2.3.1	Walls
		1.2.3.2	Bridges
		1.2.3.3	Tunnels
		1.2.3.4	Rail
		1.2.3.5	Airfield
		1.2.3.6	Marine
		1.2.3.7	Dams

CSI MasterFormat™ 2004 Divisions of Work

It is under construction summary levels that the author has followed the basic divisions of work as defined by CSI MasterFormat™ 2004 [1]. In the 2004 version, the term “Building” construction was replaced with “Facilities” construction. Building Services that used to be classified under division 15 for Mechanical and division 16 for Electrical were shifted to divisions 20 through 29. New divisions were created covering Civil and Infrastructure from divisions 30 through 39. There are over 3,000 lines within this section of the WBS. We have included sample breakdowns of two of the main CSI divisions here for illustrative purposes. The Building divisions, that remained the same from the original CSI breakdown, and a new breakdown for the Earthworks level, included with the new CSI divisions for Site Work.

1.2.1.1 Buildings	02.00.00	Building Site Work
	03.00.00	Building Concrete
	04.00.00	Masonry
	05.00.00	Metals
	06.00.00	Wood & Plastics
	07.00.00	Thermal & Moisture Protection
	08.00.00	Openings
	09.00.00	Finishes
	10.00.00	Specialties
	11.00.00	Permanent Equipment
	12.00.00	Furnishings
	13.00.00	Special Construction
	14.00.00	Conveying Systems
	1.2.2.2 Earthwork	31.21.00
31.22.00		Grading Earth
31.23.00		Earth Excavation
31.24.00		Embankment Construction
31.25.00		Erosion Control
31.26.00		Sub-grade Preparation
31.27.00		Structural Excavation
31.28.00		Structural Backfill
31.33.00		Rock Stabilization
31.38.00		Soil Stabilization
31.39.00	Rock Excavation	
31.40.00	Shoring	

New Infrastructure Items and Activities

For Infrastructure work, where similar activities can be included in multiple items, the traditional CSI breakdown does not work for estimating and scheduling purposes. For example; if a Retaining Wall and a Bridge are to be constructed on the same project, they have to be estimated and scheduled separately, yet they both include similar CSI divisions of work such as excavation, setting and stripping formwork, and placing concrete. For this reason, the work breakdown structure must include different WBS codes for these similar activities in the various infrastructure summary levels. The proposed Infrastructure Break down includes the following classifications:

Walls, Bridges, Tunnels, Rail, Airfield, Marine, Dams

The following table illustrates the different breakdown required for a Wall as opposed to a Bridge, although each are performing essentially the same activities.

1.2.3.1.2	Cast in Place Walls	03.11.01	Foundation Preparation
		03.11.02	Footing Excavation
		03.11.03	Wall Backfill
		03.12.01	Mud Slab Concrete
		03.12.02	Mass Concrete
		03.12.03	Footing Concrete
		03.12.04	Wall Concrete
		03.13.01	Reinforcing Steel
		03.13.03	Dowels
1.2.3.2.1	Bridges	03.21.01	Foundation Preparation
		03.21.02	Footing Excavation
		03.21.03	Abutment Backfill
		03.22.01	Mud Slab Concrete
		03.22.02	Mass Concrete
		03.22.03	Footing Concrete
		03.22.05	Substructure Concrete
		03.22.06	Deck Concrete
		03.22.07	Approach Slab Concrete
		03.22.08	Barrier Wall Concrete
		03.22.09	Concrete Slope Paving
		03.23.01	Reinforcing Steel
		03.23.02	Welded Wire Fabric
		03.23.03	Dowels
		03.23.04	Stressing Systems
		03.24.04	Pre-cast Concrete Girders
		03.24.05	Structural Grouting

Conclusion

A comprehensive Work Breakdown Structure is essential for the proper communication of construction cost estimating and scheduling data between all participants in an International Infrastructure Project. The Work Breakdown must include all phases of the project life cycle, from conception, through development, engineering, construction, operations, maintenance and transfer. In order to accomplish this task, the WBS must also be available in formats compatible with the common software applications used to manage these projects.

References

1. MasterFormat™ 2004 Edition Numbers & Titles
Construction Specifications Institute (CSI)
99 Canal Center Plaza, Suite 300, Alexandria, VA USA 22314