AACE INTERNATIONAL RECOMMENDED PRACTICE

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COST ESTIMATE CLASSIFICATION SYSTEM - AS APPLIED IN ENGINEERING, PROCUREMENT, AND CONSTRUCTION FOR THE ROAD AND RAIL TRANSPORTATION INFRASTRUCTURE INDUSTRIES

AACE INTERNATIONAL

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TCM Framework: 7.3 – Cost Estimating and Budgeting

Rev. August 7, 2020

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Any terms found in AACE Recommended Practice 10S-90, *Cost Engineering Terminology*, supersede terms defined in other AACE work products, including but not limited to, other recommended practices, the *Total Cost Management Framework*, and *Skills & Knowledge of Cost Engineering*.

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1. PURPOSE

As a recommended practice (RP) of AACE International, the *Cost Estimate Classification System* provides guidelines for applying the general principles of estimate classification to project cost estimates (i.e., cost estimates that are used to evaluate, approve, and/or fund projects). The *Cost Estimate Classification System* maps the phases and stages of project cost estimating together with a generic project scope definition maturity and quality matrix, which can be applied across a wide variety of industries and scope content.

This recommended practice provides guidelines for applying the principles of estimate classification specifically to project estimates for engineering, procurement, and construction (EPC) work for the road and rail transportation infrastructure industries. It supplements the generic cost estimate classification RP 17R-97 [1] by providing:

- A section that further defines classification concepts as they apply to the road and rail transportation infrastructure industries.
- A chart that maps the extent and maturity of estimate input information (project definition deliverables) against the class of estimate.

As with the generic RP, the intent of this document is to improve communications among all the stakeholders involved with preparing, evaluating, and using project cost estimates specifically for the road and rail transportation infrastructure industries.

The overall purpose of this recommended practice is to provide the road and rail transportation infrastructure industries with a project definition deliverable maturity matrix which is not provided in 17R-97. It also provides an approximate representation of the relationship of specific design input data and design deliverable maturity to the estimate accuracy and methodology used to produce the cost estimate. The estimate accuracy range is driven by many other variables and risks, so the maturity and quality of the scope definition available at the time of the estimate is not the sole determinate of accuracy; risk analysis is required for that purpose.

This document is intended to provide a guideline, not a standard. It is understood that each enterprise may have its own project and estimating processes, terminology, and may classify estimates in other ways. This guideline provides a generic and generally acceptable classification system for the road and rail transportation infrastructure industries that can be used as a basis to compare against. This recommended practice should allow each user to better assess, define, and communicate their own processes and standards in the light of generally-accepted cost engineering practice.

2. INTRODUCTION

For the purposes of this document, the term *road and rail transportation infrastructure industries* is assumed to include facilities for major roads, highways, railroads, transit rail and similar facilities for transporting people and goods in the infrastructure industries. Rail may be primarily for freight, people (transit) or both including specialized systems such as metros, light rail, high speed, monorails and people movers. Projects may create new assets or modify existing assets but exclude maintenance work. These are generally considered civil works projects. This includes the right-of-way (ROW) and access site preparation and civil work (excavation, drainage, causeway, etc.), structures (e.g., over and underpasses, bridges, crossings, monorail structure, walkways, etc.), electrical for lighting and for power (if electric driven), road surfaces, guides, rail components and rolling stock, safety, signaling and signage, telecommunications, and other ancillary facilities.

This RP excludes some specialized scope elements. These specialized elements are commonly part of an overall road or rail investment program, but their estimates are often based on unique deliverables using unique data and methods, estimated by specialty firms or subcontractors, and often phased (i.e., these elements may have a different estimate class). The specialized elements may include, but are not limited to the following:

- Major long-span bridges and viaducts (e.g., major river crossings, canyon crossings, etc.); however elevated structure for urban monorail or people movers is included.
- Major tunnels.
- Major buildings such as toll stations, rail stations, rail maintenance, offsite fabrication (e.g., rail welding facilities), fueling and remote operations and control facilities.
- Specialized systems such as hyperloop and traction/cable funiculars and cable car.
- Major system power generation, transmission and substations are also excluded but distributed traction substations and power lines/rail for electric trains are included.

While these elements are not included in the RP, one must define the rail/road project's interfaces with these elements. The defining deliverables of some of those excluded project scopes are covered in other RPs; for instance:

- Buildings of all types: 56R-09 [2]
- Power transmission lines: 96R-18 [3]
- Substations: 18R-97 [4]

See Professional Guidance Document 01, *Guide to Cost Estimate Classification* [5].

These varied scope elements are usually sub-projects in a program. Each sub-project will have its own estimate within the overall project for which the classification should be determined using its respective classification RP. At a program level, the classification of the combined estimates will usually be rated by the classification of the least defined major scope element on the principle that a system is only as strong as its weakest link and the project risks have considerable dependencies between projects.

Road and rail projects often involve utility (e.g., power, water, gas, etc.) relocation and modification and consideration of this scope is included here. The location, condition and means of working with or on existing underground utilities are a particularly significant source of uncertainty in urban areas. The scope also considers potential effects of vibration, noise, settlement and other factors on facilities and structures near the road or rail right-of-way. However, projects to remove, modify or otherwise build major facilities or structures are assumed to be separate estimates. The same is true for major utilities relocated or modified as *pre-work*. For example, if a 30-inch gas pipeline was re-routed through a new boring prior to road construction by the utility operator, that would be estimated as a pipeline project. In any case, this interaction of scope adds complexity and is a source of uncertainty.

Road and rail transportation is considered an element of the infrastructure industry. The Construction Industry Institute has provided a good definition of infrastructure in its *Project Definition Rating Index for Infrastructure Projects* as follows [6]:

"A capital project that provides transportation, transmission, distribution, collection or other capabilities supporting commerce or interaction of goods, services, or people. Infrastructure projects generally impact multiple jurisdictions, stakeholder groups and/or a wide area. They are characterized as projects with a primary purpose that is integral to the effective operation of a system. These collective capabilities provide a service that is made up of nodes and vectors into a grid or system."

Using this definition, road and rail transportation are the vector or linear scope elements that connects buildings, industrial plants, storage and loading facilities, or other nodal facilities, which may include major bridges and stations at its terminations or intermediate points. The major bridge, tunnel, station and other facility nodes are integral elements of road and rail project scope; however, because their design and execution (and often contractors) differs greatly from the road and rail itself (including key plans and deliverables) they are excluded here other than interfaces. Road and rail projects are often executed as part of a program that also involves node project scope or existing system operational changes (or considerations for integrated system testing and startup). Even in early planning, work breakdown structures will usually segregate the main vector and node project elements allowing the classification specification for estimates for each element.

As the infrastructure definition states, a distinguishing feature of these projects is that they often traverse wide areas cross country which puts an emphasis on the definition of routing, land ownership, terrain and environmental conditions, and establishing right-of-way, etc. The route often intersects, interferes with, and/or is in conjunction with other vector utilities (e.g., power lines, pipelines, other rail, other roads, etc.). Associated scope definition challenges include defining stakeholder, permitting, and regulatory requirements. Road and rail infrastructure are regulated industries and often government-owned, although sometimes in partnership with private owners or privatized altogether. Often funding is provided by multiple government agencies which adds definition and decision-making challenges (e.g., local, state, province, federal, international, etc.). Environmental concerns are paramount, which greatly impacts planning and decision-making. Both road and track installation typically require specialized equipment and contractors for key elements.

Typical road transportation scope or asset elements include:

- Embankments.
- Cuts.
- Pavement layers.
- Drainage and culverts.
- Retaining/shoring structures.

- Noise barriers.
- Safety structures.
- Support structures (under/overpasses, minor bridges and walkways).
- Stripping, signage, signals and lighting.

Typical main installation elements include:

- Earthworks (land clearing, top soil removal, embankment and cut sections).
- Paving (with specialized equipment).
- Underground and surface drainage.
- Utility relocation and modification.
- Road and structure foundations including retaining/shoring features.
- Tunneling, rock blasting.
- Structural steel and/or concrete.
- Lighting electrical, signal electrical and controls.
- Various specialty items (sound barriers, guardrail, fence, speed control systems, smart systems, etc.).

Typical main physical rail transportation scope or asset elements include:

- Track components (rails, fastenings, sleepers, switches and crossings, catch point, trap point, buffer stops).
- Ballast or slab track (if not ballast), and the railroad base (sub-ballast, sub base).
- Earthworks (land clearing, top soil removal, embankment and cut sections).
- Tunnel boring.
- Underground and surface drainage.
- Utility relocation and modification.
- Station boxes and platforms.
- Elevated structures for monorail or other transitways.
- Grade crossings and safety barriers.
- Overhead lines and structures if electric propulsion.
- Power distribution such as traction substations, and high and medium voltage cable if electric propulsion.
- Signaling and telecommunication systems including related facilities (e.g. ETCS – European Train Control System, GSM-R, antennas, facilities for signaling and telecom).
- Locomotives and rolling stock, trainsets and other vehicles.

In general, the more developed or urban the route, the more complex the installation will be. For urban areas, obstructions are frequent. Noise, vibration and dust will be an issue for nearby developments. Settlement may affect nearby foundations requiring monitoring and mitigation. In remote locations, difficult or environmentally sensitive terrain, installation has its own challenges. Before any installation work can begin in an area, appropriate land and ROW must be acquired which creates unique scheduling as well as cost challenges. Stakeholder management is usually complex.

For the purpose of estimate classification, the main scope definition deliverables start with planning the traffic capacity and loading, types of road and rail including technology; and establishing the routing including its elevation profiles, interchanges, crossings, and other elements including interferences with utilities and structures. Traffic planning capacity and loading provides an understanding of any specific technologies, which may include vehicle type and size consideration (i.e. low floor cars), stop locations, feeder service requirements, operational and public parking, etc. The route's land characteristics and the nature of developments drive the need for special design features and execution strategies. Stakeholder requirements need to be considered for each scope definition decision.

Often the early planning of alternatives is done as part of a long-term regional transportation and system operating strategy development that is periodically revised. Then, as defined by regional and/or national agency procedure, funding or grants for engineering and construction is obtained that requires further supporting scope definition. This long-term consultative planning, and often politicized approval and funding (given that funding is often from tax revenue), are somewhat unique features of transportation stage-gate processes and estimate classification concerns.

This guideline reflects generally-accepted cost engineering practices. This RP was based upon the guideline practices of multiple regional and national agencies as well as other published references and standards. [7] [8] [9] [10] Company and public standards were solicited and reviewed, and the practices were found to have significant commonalities (other than the stage number and estimate names). These classifications are also supported by empirical industry research of infrastructure cost growth and accuracy by phase. [11]

This RP applies to a variety of project delivery methods such as traditional design-bid-build (DBB), design-build (DB), construction management for fee (CM-fee), construction management at risk (CM-at risk), and private-public partnerships (PPP) contracting methods.

3. COST ESTIMATE CLASSIFICATION MATRIX FOR THE ROAD AND RAIL TRANSPORTATION INFRASTRUCTURE INDUSTRIES

A purpose of cost estimate classification is to align the estimating process with project stage-gate scope development and decision-making processes. For road and rail, the stage-gate process is usually heavily integrated with and driven by government long term planning, as well as funding processes. However, institutional stage-gate processes and the names of phases and estimates vary considerably; each user must compare the stages of the process governing their work and decide how the classification aligns with them. Examples of variations are shown later in Figure 2.

Table 1 provides a summary of the characteristics of the five estimate classes. The maturity level of project definition is the sole determining (i.e., primary) characteristic of class. In Table 1, the maturity is roughly indicated by a percentage of complete definition; however, it is the maturity of the defining deliverables that is the determinant, not the percent. The specific deliverables, and their maturity or status are provided in Table 3. The other characteristics are secondary and are generally correlated with the maturity level of project definition deliverables, as discussed in the generic RP [1]. The characteristics are typical but may vary depending on the circumstances.