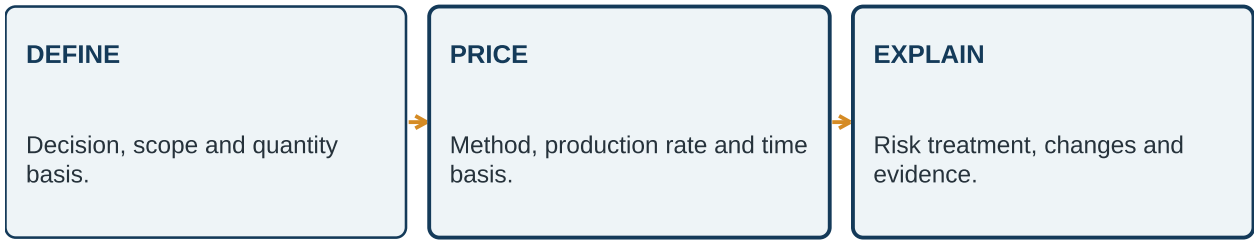
PE

PROFESSIONAL ENGINEERING CONTINUING EDUCATION

Construction Cost Estimating

Scope, Quantities, Uncertainty & Contingency

Self-Paced Course Study Guide



A practical estimating framework connects defined scope to quantities, pricing, uncertainty and documented decisions.

COURSE	CREDIT / CATEGORY	INSTRUCTOR
ENG-016	2 CEH / PDH · Pertinent to Engineering · Construction & Project Delivery	John W. Adcox, Jr., Ed.D., CPC

Superior Learning, LLC d/b/a BuilderCE

CONSTRUCTION COST ESTIMATING

2 CEH

PERTINENT

ENGINEERING

Course overview

Construction cost estimating is not a single arithmetic exercise. It is a structured decision-support process that connects the current definition of a project to quantities, pricing assumptions, production expectations, market conditions, uncertainty, and risk. A technically competent estimate allows a reviewer to understand what is included, what is excluded, how quantities were derived, where prices came from, which assumptions materially affect the result, and how the estimate should be interpreted at the current stage of project development.

This two-hour course is designed for professional engineers and construction professionals who prepare, review, rely on, or administer project cost estimates. It emphasizes the engineering judgment behind estimate classification, basis-of-estimate documentation, scope decomposition, quantity development, pricing methods, labor/material/equipment/subcontractor cost build-up, contingency, escalation, reconciliation, and construction-change evaluation. Examples are intentionally multidisciplinary and include civil/site, transportation, building, utility, and general construction contexts.

The course does not teach a proprietary estimating software system and does not treat a single database, unit-price book, bid tabulation, or contractor quote as authoritative for every project. Instead, the learner is shown how to select and document methods that are proportionate to the estimate purpose, project-definition maturity, available data, and consequence of error.

Course Purpose

Provide engineers and construction professionals with a practical framework for developing and evaluating estimates that are traceable to scope, appropriate to the maturity of project definition, transparent about assumptions and uncertainty, and useful for planning, design, procurement, change management, and project-control decisions.

Learning Objectives

Upon completion, the learner should be able to:

1. Explain how estimate purpose and project-definition maturity affect estimating method, level of detail, and expected uncertainty.
2. Develop a defensible basis of estimate that documents scope, exclusions, assumptions, data sources, methodology, pricing date, location, and key risks.
3. Organize project scope using a work breakdown structure, bid/pay items, assemblies, or other logical structures and identify the quantities and cost components required for an estimate.
4. Distinguish parametric, historical bid-based, unit-price, assembly, and cost-based estimating approaches and recognize when each is appropriate.
5. Evaluate labor, material, equipment, subcontractor, indirect, overhead, escalation, market, and location considerations without confusing numeric precision with estimate accuracy.
6. Apply contingency and risk concepts without using contingency as a substitute for incomplete scope definition or unsupported pricing.
7. Review and reconcile estimates, investigate material variances, and identify common estimating weaknesses such as omitted scope, inconsistent quantities, stale pricing, unsupported production rates, double counting, and untraceable assumptions.
8. Evaluate a construction change estimate using contemporaneous scope, quantity, price, productivity, schedule, and documentation information.

Study plan and navigation

MODULE	MINUTES	FOCUS
1	20	Estimate purpose, classification and basis
2	25	Scope, WBS and quantity basis
3	25	Pricing methods and cost build-up
4	25	Uncertainty, contingency, escalation and risk
5	15	Estimate evaluation, reconciliation and changes
6	10	Applied estimating scenarios

Planned instructional time: 120 minutes, exclusive of the final examination. Individual study time may vary.

How to complete this course

Read all modules in this course. No separate module acknowledgement is required. When you have finished reading, select Continue at the bottom of the BuilderCE lesson page to begin the 10-question final examination. If you are reading the PDF, return to that webpage first. A score of at least 70% is required to pass.

Worked quantity and productivity calculation · Principal sources

The modules follow the same logic an estimator or reviewer should use on a real project: first establish why the estimate exists, then define the scope structure, develop quantities and pricing, address uncertainty and time, and finally review and reconcile the result. The course uses simplified numerical examples to illustrate judgment. Those examples are not intended to replace project-specific design information, owner procedures, contract requirements, procurement rules, accounting practices, or professional standards.

MODULE 1 | 20 MINUTES

Estimate Purpose, Classification & Basis of Estimate

1.1 Start With the Decision, Not the Spreadsheet

A cost estimate has value only in relation to a decision. A planning estimate used to compare alternatives is not the same product as a pre-bid engineer's estimate used to support procurement, and neither should be expected to contain the same level of definition as a contractor's detailed construction estimate. Before building line items, the estimator should be able to answer a short set of questions:

- What decision will this estimate support?
- What project information exists today?
- What project information is still developing?
- Who will use the estimate?
- At what date are prices expressed?
- What organizational or contractual rules govern the estimate?
- How will uncertainty be communicated?
- What level of review is proportionate to the decision?

The first failure mode in estimating is often not a mathematical error. It is a purpose error: using a number developed for one purpose as if it were suitable for another. A preliminary budget may be

reasonable for selecting among corridor alternatives, yet inappropriate as a definitive funding commitment. A contractor's internal bid model may be useful for the contractor's decision-making but may include strategic pricing choices that are not appropriate for an owner's independent estimate. A historical unit price may be a useful starting point, yet misleading if the current project has different access, quantity, schedule, location, specification, or market conditions.

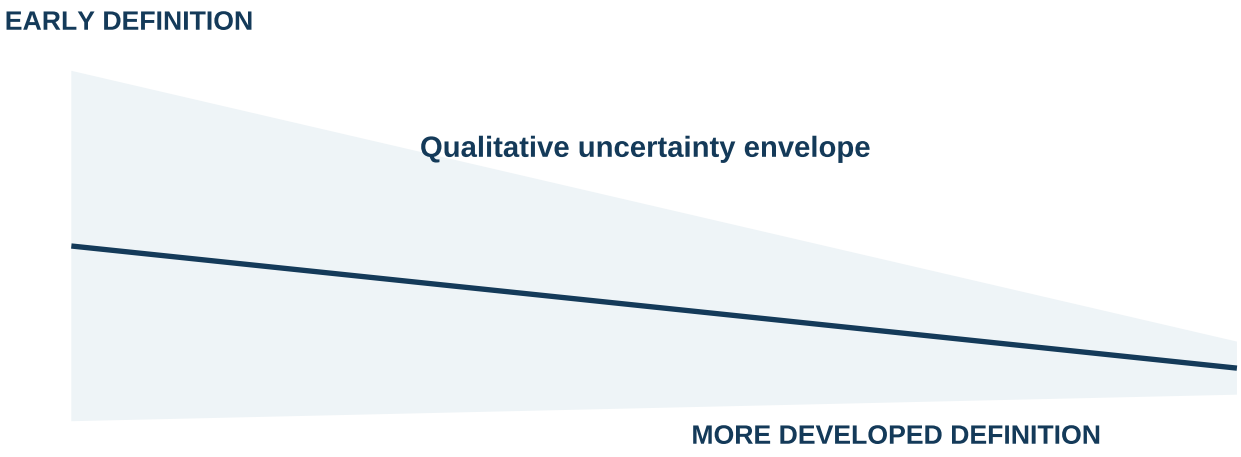
Professional estimating therefore begins with context. The estimate should state its purpose and the decision date so that later users are less likely to detach the total from the conditions under which it was prepared.

1.2 Classification Communicates Project Definition

AACE International's cost-estimate classification framework uses the maturity of project definition as the primary characteristic for classifying project estimates. The familiar Class 5 through Class 1 terminology runs generally from low definition to high definition. The point of classification is not to promise that every Class 3 estimate will fall within a universal accuracy band. The point is to communicate the maturity of defining information and the estimating approach appropriate to that maturity. AACE's industry-specific recommended practices make clear that the defining deliverables differ by industry, and that risk and other variables influence actual estimate outcomes. [1][2][3]

For a building project, maturity may be expressed through program requirements, schematic design, system selections, site information, architectural and engineering drawings, and specifications. For a roadway project, maturity may involve alignment, typical sections, earthwork, drainage, structures, utilities, traffic control, right-of-way, environmental commitments, and bid-item definition. In both cases, the estimator should classify the estimate based on what is actually defined, not merely the nominal design percentage printed on a schedule.

This distinction matters because "30 percent design" can describe very different levels of maturity on two projects. One may have stable alignment, geotechnical information, utility coordination, and a developed quantity model. Another may have unresolved major interfaces. A responsible estimate should disclose those differences rather than hide them behind a shared percentage-complete label.



Class 5 → Class 1: increasing maturity; industry-specific application.

Qualitative relationship between project-definition maturity and estimate uncertainty. Class communicates maturity and purpose; it does not guarantee an accuracy range.

1.3 Expected Uncertainty Is Not the Same as Sloppiness

Early estimates generally have more uncertainty because more project-defining information remains open. That uncertainty should not be confused with poor professional practice. A well-prepared early estimate can be highly useful when it clearly states its assumptions, captures the known scope, and

communicates uncertainty. Conversely, a detailed spreadsheet can be weak if its quantities are not traceable, its pricing is stale, or its scope definition is inconsistent.

An estimator should resist "precision theater" - the appearance of confidence created by many decimal places, hundreds of line items, or a narrowly stated total. Numerical precision reflects how the calculation is displayed. Estimate accuracy reflects how closely the estimate represents the eventual cost outcome for the defined scope and conditions. These are different concepts.

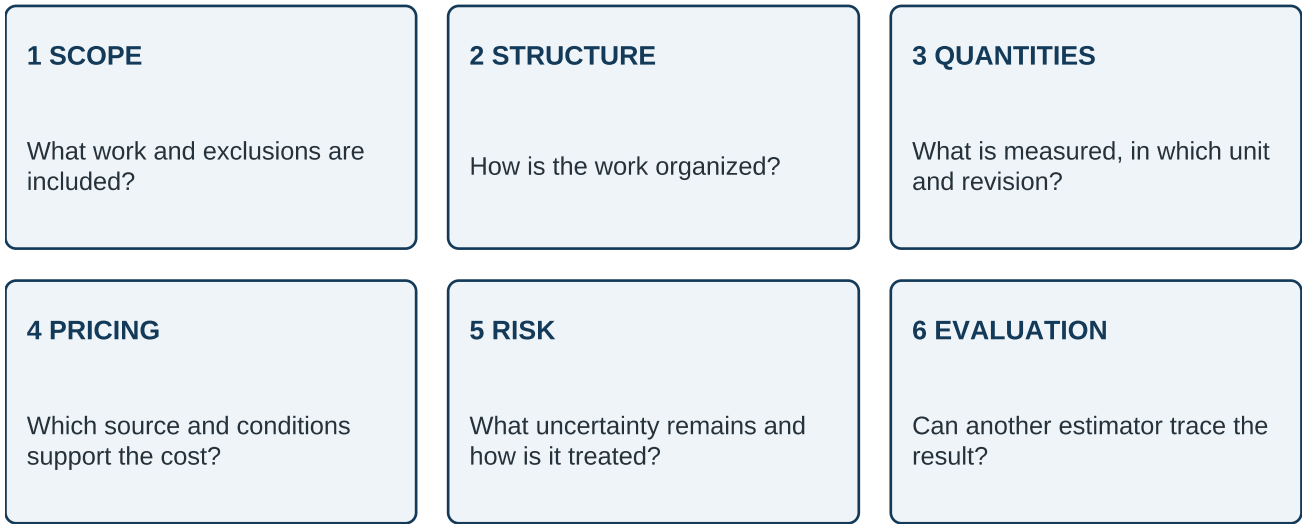
A planning estimate of $42.3 million may be less honest than a range or an estimate with a clearly stated contingency and uncertainty narrative if the project is still materially undefined. Similarly, rounding a unit price to the cent does not make an uncertain production assumption precise.

1.4 The Basis of Estimate Is the Estimate's Operating Manual

The basis of estimate (BOE) is the narrative and supporting record that explains what the estimate represents and how it was produced. It is often the most important part of the estimate for a future reviewer. A well-structured BOE commonly addresses:

estimate purpose and class or stage; project description and scope basis; drawing/specification/design-criteria references; estimate date and pricing date; location and site conditions; quantity source and measurement rules; estimating methods used; labor, material, equipment, and subcontractor assumptions; productivity or crew assumptions where applicable; quotations and historical data sources; freight, taxes, duties, and other applicable pricing elements; temporary work and general conditions; indirect costs; escalation basis; contingency/risk basis; exclusions; owner-furnished or third-party scope; major interfaces and known unresolved items; review status and estimate ownership.

The BOE should be proportionate to the estimate. A short planning estimate may need only a concise narrative, while a large capital estimate may require a formal document with attachments, source logs, quote files, and risk-analysis outputs. The principle is traceability: another qualified reviewer should be able to understand the estimate without relying on undocumented memory.



Basis-of-estimate traceability connects scope, structure, quantity, pricing, residual risk and an independently traceable result.

1.5 Assumptions and Exclusions Are Different

An assumption is a condition temporarily accepted for estimating because the project has not yet fully defined it. An exclusion is work intentionally left outside the estimate. Confusing the two creates risk.

Example: "Assume existing electrical service has sufficient capacity" is an assumption. If later study shows a service upgrade is required, the estimate should change. "Utility-company off-site upgrades are excluded" is an exclusion. The estimate may remain internally correct even though the total project funding requirement must address that excluded cost elsewhere.

Strong BOEs make assumptions testable. Instead of writing "normal site conditions," describe the specific estimating assumption: normal weekday access, no contaminated soil handling, no rock excavation, two work fronts available, standard local trucking distance, or another relevant condition. Specific assumptions can be verified or replaced as design develops.

1.6 Establish the Estimate's Perspective

An owner's engineer's estimate and a contractor's bid estimate may legitimately treat some elements differently. The owner's estimate may seek a reasonable prediction of competitive construction cost for a defined bid package. The contractor must decide how to price the work, account for internal overhead, allocate risk, cover bond/insurance needs, and pursue its business strategy. The same project can therefore support different estimating perspectives.

FHWA's current Central Federal Lands Engineer's Estimate Manual treats the engineer's estimate as a critical project-development tool that supports probable construction cost, scope decisions, and bid evaluation. It directs estimators to document the basis, assumptions, calculations, contingencies, and uncertainties and to review unit prices at milestones. [4] This is a useful model even outside federal highway work: the estimate should be collaborative, documented, current, and updated as project definition changes.

1.7 Estimate Governance: Ownership, Review, and Issue Status

An estimate should have a clearly identified owner. "Owner" in this context means the individual or team responsible for the estimate product, not necessarily the project owner. That responsibility includes controlling the working file, coordinating inputs, documenting assumptions, incorporating review comments, and identifying which version is authorized for use.

A practical estimate-governance record includes:

estimate title and project identifier; issue date and pricing date; estimate stage/classification; preparer(s); checker/reviewer(s); source design revision; approved scope baseline; major external inputs such as quotes or geotechnical information; revision history; approval or issue status.

The issue status should be unmistakable. A draft estimate used for internal design discussion should not be easily confused with an estimate released to support funding or procurement. Labels such as "Working Draft," "Design Review," "Budget Issue," or "Issued for Procurement Support" are useful when paired with organizational definitions.

Governance matters because estimate files often outlive the meeting in which their limitations were explained. Months later, a single PDF or spreadsheet may be forwarded to a stakeholder who never heard the original discussion. If the file itself does not state purpose, stage, pricing date, and key assumptions, the chance of misuse increases.

1.8 Classification Example: Same Project, Different Estimate Products

Consider a municipal water-treatment expansion. At the feasibility stage, the team knows the target treatment capacity and approximate site constraints but has not selected the final process train. A parametric estimate based on capacity and comparable facilities may be appropriate, supplemented by site and utility allowances.

Later, preliminary process selection identifies major equipment, building footprints, electrical demand, piping corridors, and site-development needs. The estimating team can now use assemblies, preliminary quantities, vendor budget quotes, and discipline-specific allowances.

At design development, quantities become measurable, major equipment quotations are refreshed, temporary construction requirements are better understood, and indirect costs can be modeled in more detail.

The project is the same, but the estimate should evolve because the decision and definition have evolved. Carrying the feasibility estimate forward merely by escalating the old total would discard new

information. Conversely, developing a detailed crew estimate at feasibility may consume effort without improving decision quality because the basic design is still unresolved.

The classification framework helps teams communicate this evolution. It should not be used mechanically. The estimator should explain which defining deliverables actually support the classification.

1.9 Mini Basis-of-Estimate Example

A concise BOE for an early roadway estimate might state:

Purpose: compare two alignment alternatives for programming.

Pricing date: third quarter 2026 dollars.

Scope basis: concept alignment dated August 18, 2026; preliminary typical sections; conceptual drainage; utility inventory not verified by subsurface investigation.

Method: historical bid-based unit prices for recurring roadway items; parametric allowances for drainage and traffic control; cost-based check for major earthwork.

Quantities: planning-level earthwork and pavement quantities generated from concept surfaces; bridge length from preliminary geometry; utility relocation allowance based on comparable projects.

Escalation: excluded from the base comparison because both alternatives are expressed in the same current-dollar basis; program escalation will be added after alternative selection.

Contingency: applied according to agency planning-estimate policy, reflecting unresolved drainage, utilities, geotechnical conditions, and access.

Major exclusions: right-of-way acquisition, owner program management, financing costs.

Open items: verify utility conflicts, geotechnical conditions, environmental mitigation, and bridge-foundation concept before next milestone.

This short narrative dramatically improves the usefulness of the estimate. It tells the next reviewer what the number means and which assumptions should be attacked first.

1.10 Avoiding "Estimate Drift"

Estimate drift occurs when the estimate continues to change without clear control over why. Causes include informal scope additions, inconsistent design revisions, quote updates inserted into one section but not another, and changes to global factors without reconciliation.

A disciplined estimate update should begin from a known prior version. Before updating, freeze or archive that version. Then identify the new design inputs and update only the affected accounts. The reconciliation should show the movement. If the new estimate is rebuilt from scratch, preserve a mapping so the project can still understand the causes of change.

This approach is especially important when the estimate is linked to a funding commitment. Decision-makers need to know whether a higher estimate reflects market escalation, project growth, risk discovery, or a correction. Those drivers lead to different management responses.

MODULE 2 | 25 MINUTES

Scope Development, Work Breakdown Structure & Quantity Basis

2.1 Scope Must Become Estimable

Drawings and specifications communicate design intent, but an estimate requires the estimator to translate that intent into measurable, priceable work. That translation is where many omissions occur. The estimator must identify not only primary installed components but also supporting activities: excavation, temporary access, testing, demolition, protection, traffic control, bypass pumping, shoring,

dewatering, permits, mobilization, restoration, temporary facilities, commissioning, disposal, and interfaces with other packages.

The estimating process should therefore include a deliberate scope-development pass before quantities are finalized. Read the project from multiple viewpoints:

1. Physical systems: What will exist when the project is complete?
2. Construction sequence: What temporary or enabling work is needed to build it?
3. Contract boundaries: Which party owns each interface?
4. Measurement/payment: How will work be bid, paid, or controlled?
5. Site constraints: What conditions affect means, methods, access, productivity, or cost?
6. Risk/open items: Which scope elements remain unresolved?

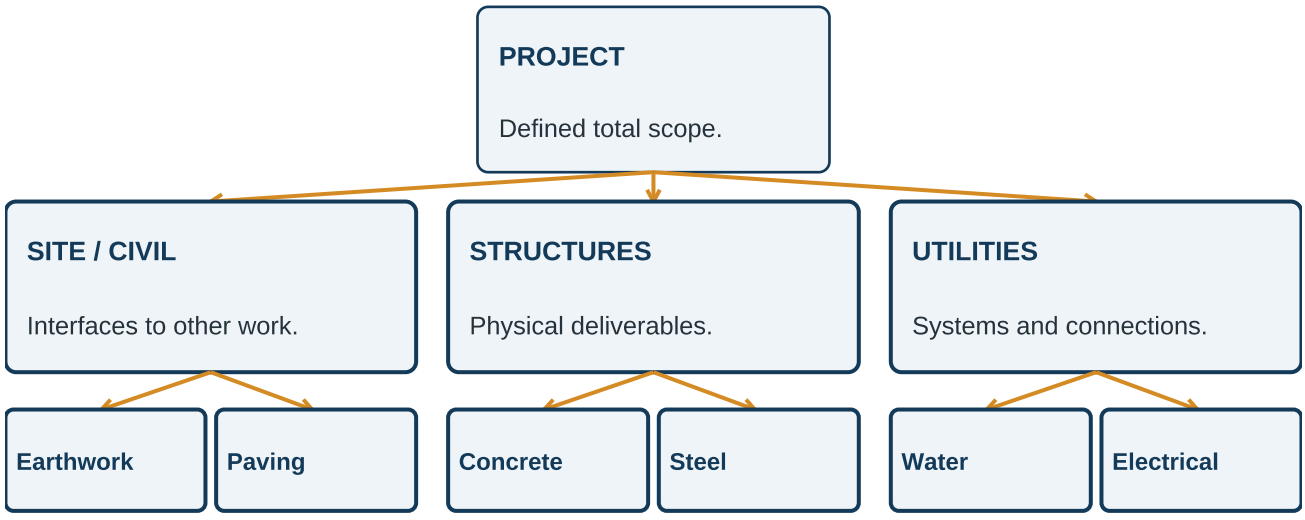
An estimator who looks only at finished permanent work may miss significant temporary and indirect costs. An estimator who looks only at bid items may miss owner-furnished work or cross-package interfaces that still affect the total program budget.

2.2 Work Breakdown Structures Reduce Omissions

A work breakdown structure (WBS) organizes the project into a hierarchy that can be estimated, reviewed, and reconciled. There is no single universal WBS. The structure should fit the project and the decisions the estimate supports.

A site-development estimate might divide work into demolition, earthwork, drainage, utilities, paving, landscaping, and site electrical. A building estimate might use substructure, superstructure, enclosure, interiors, mechanical, electrical, plumbing, fire protection, site work, and general conditions. A transportation estimate may align to bid items or major work features such as earthwork, pavement, structures, drainage, traffic control, signals, and utilities.

The WBS is more than a filing system. It is a completeness tool. It can expose boundaries where scope is missing or duplicated. If "site electrical" appears in both the building-electrical package and the site-utilities package, a reviewer should ask who owns conduit, duct bank, site lighting, controls, and utility-company coordination. If no package owns erosion control or maintenance of traffic, the omission becomes visible before bid.



Original scope-decomposition example: site/civil, structures and utilities. Interfaces need a defined owner to avoid omitted or duplicated cost.

A useful test is to ask whether every meaningful scope element has one primary home in the estimate. Some costs may be allocated across packages for management purposes, but the source logic should prevent double counting.

2.3 Match the Estimating Structure to the Design Structure

A common source of estimate drift is a mismatch between how the design is organized and how the estimate is organized. Suppose an estimate is arranged by building wing while the design team tracks changes by discipline. A mechanical change affecting all wings may be difficult to reconcile. Conversely, a discipline-based estimate may obscure phase or geographic constraints that drive construction cost.

There is no requirement that design and estimate structures be identical, but the mapping between them should be clear. For large projects, maintain a crosswalk. This supports milestone reconciliation: when a design package changes, the estimator can identify which estimate accounts require review.

2.4 Quantity Takeoff: Traceability Before Speed

Quantity takeoff converts project definition into measurable units. The estimating team should establish measurement rules so that quantities are consistent across estimators and milestones. For example:

- Is excavation measured bank volume, loose volume, or compacted fill volume?
- Are concrete quantities net in place or do they include waste?
- Is reinforcement measured from a takeoff or by an early-stage allowance?
- Are pipe lengths plan length or installed length with fittings/allowances?
- Are pavement areas measured to neat lines?
- Are demolition and restoration quantities separate?
- How are openings, laps, splices, and waste treated?
- Are temporary works quantified directly or included in crew rates/general conditions?

The answers depend on the estimate purpose and project stage. What matters is that the basis is consistent and documented.

Traceability does not require that every quantity be generated from sophisticated model-based takeoff. A hand calculation can be traceable if the source dimension, formula, units, and revision are retained. A BIM-derived quantity can be untraceable if the estimator cannot determine which model version or object filters produced it.

2.5 Unit Discipline Prevents Hidden Errors

Quantity errors often result from unit mismatches rather than complex mathematics. Common examples include:

square feet versus square yards; cubic feet versus cubic yards; linear feet versus stationing; tons versus cubic yards with an assumed density; each versus assemblies; gallons per minute versus total volume; hours per unit versus units per hour; nominal versus actual material dimensions.

Use explicit units in quantity sheets and unit-price databases. If a conversion factor is used, document it. Where density, shrink/swell, waste, or yield assumptions materially affect the quantity, treat the factor as an estimating assumption subject to review.

A useful internal rule is that every quantity should be capable of answering three questions: source, unit, revision. If any one of those is unclear, the quantity is not fully controlled.

2.6 Quantity Maturity Should Track Design Maturity

Early estimates may legitimately use allowances or parametric quantities where design information is incomplete. The mistake is carrying those allowances forward after better definition becomes available.

For example, a planning estimate may use a storm-drainage allowance based on site area and comparable projects. Once a drainage design identifies pipe sizes, structures, outfalls, treatment systems, and utility conflicts, the estimate should transition to a quantity-based model. Leaving the old allowance in place while also pricing the new quantities creates double counting.

At each milestone, ask which allowances should be replaced by measured scope. Maintain an allowance register if the project has many early-stage placeholders. Each allowance should have an owner, basis, amount, and trigger for retirement.

2.7 Interfaces: The Most Expensive Missing Line Item

Many costly omissions occur at interfaces rather than within well-defined systems. Examples include:

utility relocation between owner and utility company; equipment furnished by one party but installed by another; structural supports for mechanical/electrical systems; temporary bypass needed while permanent work is installed; testing, startup, commissioning, and training; demolition required to access new work; site restoration after utility or geotechnical work; traffic control supporting multiple work packages; environmental controls that span several scopes; controls integration between equipment vendors.

The estimator should actively search for these interfaces. One practical method is an "interface walk": review the WBS and ask what must happen before, during, and after each major work package. Another is to compare responsibility matrices and specifications against estimate accounts.

2.8 Avoid Double Counting

Double counting often enters an estimate when the same cost is included at more than one level. Typical examples:

waste included in both quantity and unit price; small tools included in labor burden and again as an indirect percentage; supervision included in crew rates and general conditions; freight included in vendor quotes and again as a separate allowance; subcontractor markup included in quoted price and again in a global markup; contingency applied at line-item level and again to the subtotal without recognizing the first allowance; escalation included in current unit prices and then reapplied globally.

A reviewer should understand where each cost component resides. A cost build-up matrix can help: list labor, material, equipment, subcontract, indirect, overhead/profit, escalation, and contingency treatment for each pricing source. The goal is not identical structure across every estimate method, but transparency.

2.9 Example - Early Site Estimate

A civil engineer is developing a planning estimate for a 25-acre industrial site. The concept plan identifies approximate building pads and roadway alignments, but final grading, stormwater, and utility routing are not developed.

A weak approach would create detailed-looking line items using assumed pipe diameters, inlet counts, and earthwork volumes unsupported by design. A stronger approach would:

classify the estimate as early-stage; use traceable site-area or comparable-project parameters where appropriate; quantify defined features such as approximate pavement area; use allowances for unresolved drainage and utility systems; document the assumed grading balance; identify off-site utility upgrades as an open interface; apply contingency/risk treatment consistent with the unresolved scope; define what information is required to replace each allowance at the next milestone.

The result may have fewer line items, but it more honestly represents the project definition.

2.10 A Controlled Quantity-Development Workflow

A repeatable quantity workflow improves both speed and auditability:

1. Receive and register the design source. Record drawing/model/specification revision.
2. Define measurement rules. Establish units, net/gross conventions, waste treatment, and rounding.
3. Assign quantity ownership. Clarify who is responsible for each discipline or WBS element.
4. Perform takeoff. Use the appropriate manual, CAD, model, or schedule-based method.
5. Run reasonableness checks. Compare high-level metrics and independent calculations.
6. Resolve interfaces. Reconcile overlaps between disciplines and packages.
7. Lock the milestone quantity set. Save the takeoff source used by the estimate.
8. Reconcile changes at the next milestone. Identify design growth versus correction.

This workflow avoids a common problem: the estimate spreadsheet updates continuously while the quantity source cannot be reconstructed. A reviewer sees the final number but cannot determine which design revision produced it.

2.11 Model-Based Takeoff: Powerful, Not Automatic

Digital models can accelerate quantity takeoff, but model quantity is not synonymous with construction quantity. Model objects may be incomplete, duplicated, temporary, non-costed, or defined at a level that does not match the estimate's measurement rules.

Before relying on model quantities, confirm:

model version and discipline; object inclusion/exclusion filters; whether linked models are duplicated; treatment of design options; whether demolition/existing conditions are modeled; object classification and units; whether temporary works are modeled; whether embedded components, openings, laps, waste, and accessories require separate treatment.

An estimator should understand the data path from model to estimate. Automated quantity export can reduce transcription error while simultaneously making a bad filter propagate faster. Control is therefore more important, not less.

2.12 Quantity Reasonableness Metrics

High-level metrics are useful as checks. Examples include:

earthwork cubic yards per acre or roadway station; concrete volume per square foot of structure; reinforcing steel pounds per cubic yard of concrete; piping length per process area; ductwork or electrical distribution metrics per building area; pavement tons per lane-mile; drainage structures per mile.

These metrics are not design standards and should not replace takeoff. They are diagnostic tools. If the current quantity differs materially from comparable projects, investigate. The answer may be legitimate: a tall retaining wall, unusual soil, heavier loading, or complex utilities. The purpose of the metric is to trigger the question.

2.13 Allowance Register

For projects with many unresolved items, maintain an allowance register separate from the estimate line-item detail. Useful fields include:

allowance ID; description; responsible discipline; amount or quantity; basis; reason an allowance is needed; design information required to retire it; target milestone; status.

Example:

A-014 - Temporary bypass pumping

Basis: preliminary allowance based on comparable utility rehabilitation work.

Reason: flow data and bypass routing not yet developed.

Retirement trigger: approved bypass concept and estimated pumping capacity/length.

Target: 60 percent design.

The register makes unresolved definition visible. It also prevents allowances from silently becoming permanent line items that no one revisits.

2.14 Constructability as a Quantity Issue

Constructability is often discussed as a pricing or productivity issue, but it can also change quantities. Examples include:

temporary retaining systems needed because open cut is not feasible; working slabs or crane pads; temporary drainage or dewatering; traffic-control devices and temporary pavement; access roads;

additional excavation for safe slopes; shoring or trench boxes; temporary supports; protection or relocation of existing facilities.

If the design drawings focus only on permanent work, these quantities may be missing. Collaboration between design and construction-experienced reviewers helps expose them.

2.15 Scope Freeze Is Usually Partial, Not Absolute

Project teams sometimes speak of "scope freeze" as a single event. In reality, different systems may mature at different rates. Structural foundations may be well defined while interiors or utilities remain open. The estimate should reflect this uneven maturity.

A useful technique is to rate definition by major WBS element. This avoids applying a single assumption to the whole project. A highly defined civil package may deserve detailed quantities and lower uncertainty, while an unresolved utility interface may retain an allowance and higher risk treatment.

This element-level view also improves review efficiency because the team can focus on the least mature high-cost areas.

MODULE 3 | 25 MINUTES

Pricing Methods & Cost Build-Up

3.1 Choose the Method That Fits the Information

Estimating methods exist on a continuum. Early in project development, the estimator may rely on parametric relationships or historical analogies. As definition improves, unit-price, assembly, or detailed cost-based methods become practical. The correct method is the one that is sufficiently reliable and transparent for the decision being made with the information available.

METHOD	TYPICAL DEFINITION	RELATIVE EFFORT	GOOD FIT
Parametric	Low	Fast	Early alternatives
Historical bid	Low to medium	Fast	Comparable public work
Unit price	Medium	Moderate	Defined measurable work
Assembly	Medium to high	Moderate	Repeated systems
Cost-based / crew	High	Slower	Major or unusual items

No single method is inherently superior. A detailed crew build-up using unsupported production rates may be weaker than a well-normalized historical bid analysis. Conversely, a historical average may be misleading for a major, unusual, or market-sensitive item where current cost-based analysis is warranted.

3.2 Parametric Estimates

Parametric estimating uses a relationship between cost and a measurable project characteristic. Examples include cost per square foot of building area, cost per lane-mile, cost per gallon-per-day of treatment capacity, or cost per megawatt of installed capacity.

Parametric methods are useful for early alternatives and screening because they can quickly translate limited definition into a decision-scale estimate. Their weakness is that a single parameter may not capture project-specific complexity. A cost-per-square-foot benchmark may conceal major differences in structure, systems, site constraints, finish level, phasing, or location.

A defensible parametric estimate should document:

source projects or data set; relevant parameter definition; normalization for time and location; major scope differences; what the parameter includes and excludes; range or uncertainty appropriate to the maturity.

Do not treat a published benchmark as self-applying. The estimator remains responsible for deciding whether the benchmark is comparable.

3.3 Historical Bid-Based Estimates

Historical bid-based estimating uses prices from prior competitive bids or awarded work. It can be particularly useful for public-sector unit-price construction where agencies retain bid histories for recurring items.

Historical prices should be normalized rather than simply averaged. Consider:

bid date and inflation/escalation; quantity size; geographic location and haul distance; market competition; project access and traffic constraints; specification differences; season; project size and packaging; mobilization effects; whether the observed price was an outlier or strategically unbalanced.

FHWA's current CFL manual describes historical bid-based and cost-based estimating as common approaches and emphasizes adjusting information for project conditions. It generally uses historical bid-based estimating for minor items and cost-based analysis for major items, subject to project judgment. [4] The broader lesson is transferable: spend the most analytical effort on the items that materially drive the estimate.

3.4 Unit-Price Estimating

Unit-price estimating multiplies a measured quantity by an appropriate unit price. It is simple in form:

Estimated Cost = Quantity x Unit Price

The professional work lies in determining whether both inputs are valid. A unit price may represent:

a historical bid price; a published cost database; a vendor quote normalized to a unit; an internal cost history; a detailed cost build-up converted to a unit rate.

The estimator should document the source and whether the unit price already includes labor, equipment, material, subcontractor markup, freight, taxes, overhead, profit, or other elements. Unit prices from different sources may not be directly comparable.

3.5 Assembly Estimating

Assembly estimating groups related components into a functional unit. A building wall assembly might include framing, sheathing, insulation, membrane, exterior finish, accessories, and associated labor. A utility structure assembly might include excavation, bedding, structure, fittings, backfill, restoration, and testing.

Assemblies can be efficient when design repeats. They also reduce the chance that accessory components are forgotten. However, assembly assumptions must remain visible. If a typical assembly assumes shallow excavation but the current project has deep structures and groundwater, the assembly requires adjustment.

3.6 Cost-Based / Crew Estimating

Cost-based estimating develops the price from labor, equipment, material, subcontractor, and other cost components. For field work, a basic crew-based calculation links production to duration:

Crew Hours = Quantity / Production Rate

Labor Cost = Crew Hours x Loaded Labor Cost per Crew Hour

Equipment Cost = Crew Hours x Equipment Cost per Crew Hour

Material and subcontractor costs are then added, along with applicable indirects and markups.

The apparent simplicity hides significant judgment. Production rate is often the dominant assumption. Productivity can be affected by:

work geometry and repetition; crew skill and learning; access; congestion; traffic control; weather; shift restrictions; inspection/testing hold points; material delivery; equipment cycle time; site logistics; safety controls; rehandling; sequence and interfaces; planned overtime.

A production rate copied from a previous project should be treated as evidence, not a fact. Document why it is reasonable for current conditions.

3.7 Labor Cost

Labor cost may include base wage plus payroll taxes, insurance, benefits, fringe, union obligations, travel/per diem, small tools, supervision, and other burdens depending on organizational practice. An owner's engineer's estimate should not assume that every contractor organizes labor burden identically. The goal is to approximate a reasonable market cost basis for the intended estimate.

Avoid counting supervision twice. If foremen or general supervision are included in a crew, do not automatically add the same role again in general conditions unless the estimate clearly distinguishes working foremen from project supervision.

3.8 Material Cost

Material estimates should address current quote date, quantity, specification, waste, delivery, freight, taxes where applicable, storage, escalation, and market volatility. Vendor quotes should be reviewed for:

validity period; included/excluded freight; taxes; minimum order quantities; alternates; lead time; escalation clauses; packaging; installation exclusions; warranties/testing/startup; currency or commodity exposure where relevant.

A quote is not automatically a complete installed cost. It may cover only the supplied equipment or material.

3.9 Equipment Cost

Equipment may be owned or rented. Estimates can include ownership cost, operating cost, fuel, maintenance, mobilization, operator labor, attachments, standby, and utilization assumptions depending on the method.

The key is consistency between production and cost. If an excavator rate assumes productive operation for eight hours but the crew can work only five productive hours because of trucking or inspection constraints, the effective unit cost changes. Standby or low utilization can dominate equipment-intensive work.

3.10 Subcontractor and Vendor Quotes

Subcontractor quotes provide current market intelligence, but they must be normalized. Determine:

exact scope included; exclusions; assumed schedule; quantity basis; taxes and bonds; mobilization; escalation; insurance; temporary work; testing/commissioning; quote validity; commercial qualifications.

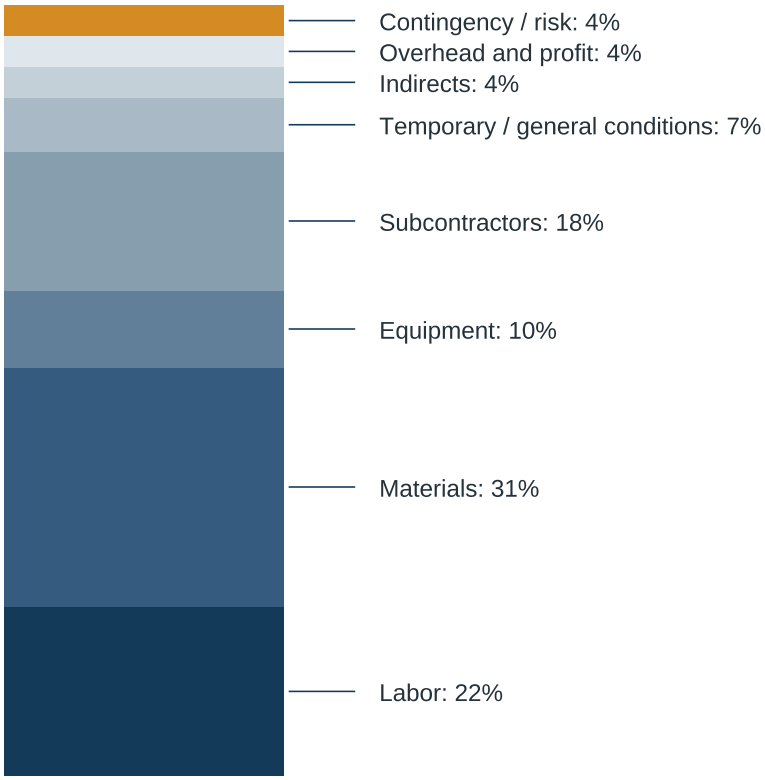
Quote comparison should be scope-normalized before price comparison. The lowest apparent quote may exclude major work carried by another bidder.

3.11 Indirect Costs, General Conditions, Overhead & Profit

Direct cost is associated with identifiable installed work. Indirect and project-level costs support the work but may not map neatly to a single pay item. Examples include project management, field supervision, temporary offices, utilities, security, cleanup, layout, quality control, safety administration, temporary access, small tools, bonds, insurance, permits, and project closeout.

Organizational conventions differ. The estimator should document where these costs are carried so they are not omitted or duplicated.

Illustrative composition only; percentages total 100%.



Illustrative estimate composition. Components are kept distinct; the 100% distribution is a teaching example, not a recommended estimating factor.

Overhead and profit treatment depends strongly on estimate perspective. An owner's estimate may include an allowance representing reasonable contractor overhead and profit. A contractor's bid strategy is a business decision. Neither should be confused with contingency for project uncertainty.

3.12 Market Conditions and Bid Climate

Market conditions can materially affect cost even when material and labor quantities are unchanged. Indicators include contractor backlog, major competing projects, skilled-labor availability, commodity volatility, financing conditions, material lead times, and number of expected bidders.

Market adjustment should be evidence-based. Avoid arbitrary "market factors" without explanation. If a project has only one qualified specialty supplier or unusually limited competition, document that risk and consider current quotes or scenario ranges.

3.13 Worked Cost-Based Example - Excavation and Haul

Assume an estimate includes 18,000 bank cubic yards of common excavation. The estimator expects a balanced excavation/embankment operation for part of the material and off-site disposal for 6,000 cubic yards. A simplified cost-based analysis for the exported material may include:

excavator and operator; loader/dozer support; truck fleet; spotter or labor support; fuel and operating cost; disposal/tipping fee; haul distance and cycle time; traffic/access constraints; supervision allocation.

Suppose the trucking cycle supports an effective production of 600 bank cubic yards per day. At 6,000 cubic yards, the exported portion requires approximately 10 production days. If the loaded crew/equipment cost is $14,000 per production day and disposal averages $9 per cubic yard, the conceptual exported-material cost is:

Crew/equipment: 10 days x $14,000/day = $140,000

Disposal: 6,000 CY x $9/CY = $54,000

Subtotal before applicable indirects/markups = $194,000

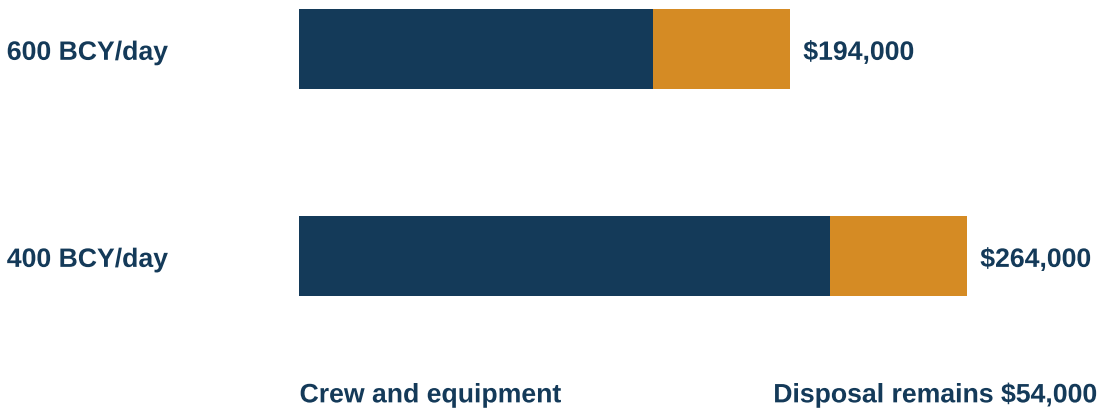
The arithmetic is easy. The engineering judgment is in the assumptions. If haul congestion reduces production to 400 cubic yards/day, duration becomes 15 days and crew/equipment cost rises to $210,000 before considering any schedule-level indirect impact. The estimator should therefore review haul route, loading balance, truck availability, and disposal hours.

This example demonstrates sensitivity. The estimate is not merely "6,000 CY x a unit price." The unit price is an output of production and cost assumptions.

Worked estimate: distinguish quantity, productivity and risk

The excavation scope totals 18,000 bank cubic yards (BCY). This calculation addresses only the 6,000 BCY exported portion. The other 12,000 BCY is outside this subtotal. Assume an illustrative crew and equipment cost of $14,000 per day and disposal at $9 per BCY. These are teaching inputs, not current market quotations.

Export portion only: 6,000 BCY; values in thousands of dollars.



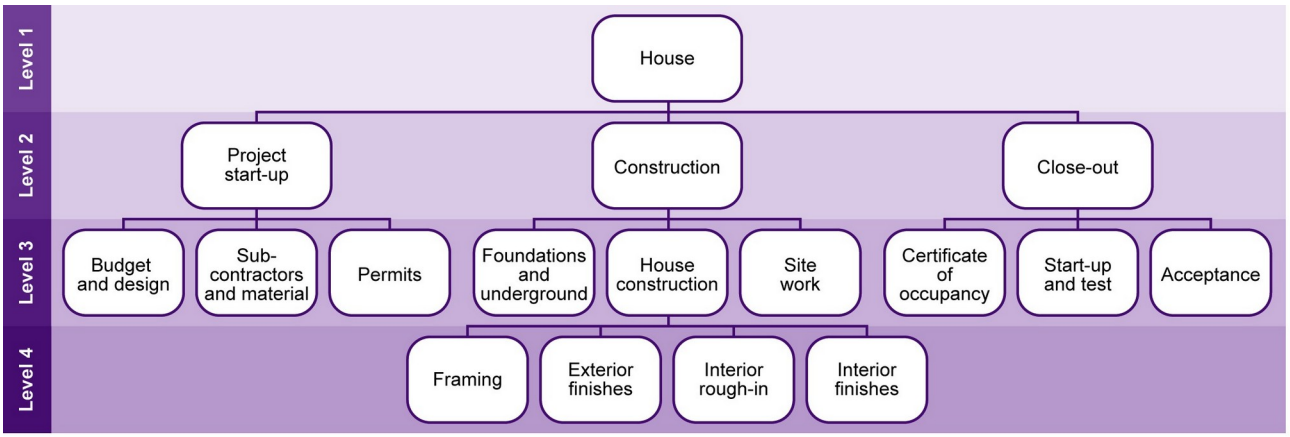
The export quantity and disposal rate remain fixed. Slower production increases time-dependent crew and equipment cost; it does not increase the disposal quantity.

EXPORT CALCULATION	600 BCY / DAY	400 BCY / DAY
Export quantity	6,000 BCY	6,000 BCY
Duration: quantity ÷ daily production	10 days	15 days
Crew / equipment: days × $14,000	$140,000	$210,000
Disposal: 6,000 × $9	$54,000	$54,000
Export subtotal	$194,000	$264,000
Implied export unit cost	$32.33 / BCY	$44.00 / BCY

The $70,000 difference is five additional crew/equipment days. The subtotal increases by approximately 36.1%: $70,000 ÷ $194,000. This is an identified productivity effect to analyze in the estimate basis; adding an arbitrary contingency percentage would not explain it. Verify the haul cycle, disposal operating

hours, loaded daily cost and acceptance of the material. Confirm whether actual haul and disposal quantities use bank, loose or compacted volume before applying unit prices. Indirects and markups are excluded, and the remaining excavation work still needs its own quantity and pricing basis.

Primary-source scope structure



Source: GAO. | GAO-20-195G

GAO-20-195G, Figure 7, printed page 57 (PDF page 69): original house work breakdown structure. Deliverables are organized before assigning cost.

GAO's house WBS separates project startup, construction and closeout, then decomposes the work into lower-level deliverables. It demonstrates a scope-organization task, separate from the export-production arithmetic above. Use the structure to assign work, identify interfaces and avoid omissions before rolling costs up.

Primary source:GAO Cost Estimating and Assessment Guide, Figure 7

3.14 Historical Price Normalization Example

Assume recent bid tabs show a drainage pipe item at $145/LF, $168/LF, and $210/LF. A simple average is $174/LF, but the projects differ:

Project A: 8,000 LF, open rural alignment, 2024 bid; Project B: 3,000 LF, suburban work, moderate utility conflicts, 2025 bid; Project C: 900 LF, urban night work, deep excavation, 2026 bid.

The current project includes 1,200 LF in a constrained urban corridor. The $145/LF rural price may deserve little weight. The $210/LF constrained price may be the most comparable even though it is the highest. The estimator can supplement this comparison with current quotes or a cost-based check.

Normalization can include mathematical index adjustment, but judgment remains necessary. Indexing a rural price to current dollars does not make it an urban-constrained price.

3.15 Quote Leveling

When multiple subcontractor or supplier quotes are available, prepare a quote-leveling sheet. Typical columns include:

bidder/vendor; base price; quantity; freight; tax; mobilization; bond/insurance; testing/startup; alternates; exclusions; schedule assumptions; validity; commercial qualifications; normalized total.

The normalization should be transparent. Do not alter a vendor quote and then present the adjusted number as if it were the quoted price. Retain the original quote and show estimating adjustments separately.

Quote leveling is especially important for equipment packages. One quote may include controls, startup, and freight while another excludes them. Bottom-line comparison without leveling can lead to a false conclusion.

3.16 Direct and Indirect Cost Boundaries

Organizations classify indirect costs differently. The estimate should follow the governing cost breakdown structure. What matters for review is that costs are neither missing nor duplicated.

Consider temporary power. One estimator may include temporary power in project general conditions. Another may allocate power to specific work packages. Either can work if consistently applied. Problems arise when the electrical package includes temporary distribution while general conditions also carry a full temporary-power allowance.

The same issue applies to:

field supervision; quality control; safety staff; cranes and hoists; temporary facilities; cleanup; survey/layout; security; traffic control; small tools.

The BOE should summarize major allocation rules.

3.17 Engineer's Estimate Versus Contractor Bid Strategy

An engineer's estimate should represent a reasonable expected construction price for the defined work according to the owner's procedure. A contractor's bid includes business strategy. That strategy may involve:

workload/backlog; desired margin; subcontractor relationships; owned equipment; pursuit strategy; risk appetite; cash-flow preferences; unbalanced item pricing within legal/contract limits.

For this reason, the engineer should not assume the contractor will price every item exactly at "cost plus a standard markup." The owner's estimate is an independent benchmark, not a prediction of each bidder's internal accounting.

This is also why bid analysis should focus on material variances and overall reasonableness rather than demanding line-by-line equality.

3.18 Data Quality Hierarchy

Pricing evidence can be thought of in tiers:

High relevance: current project-specific quote or recent comparable bid with known scope and conditions.

Moderate relevance: recent internal cost history or regional bid data requiring adjustment.

Lower relevance: national cost database, old project data, generic benchmark, or unsupported rule of thumb.

Lower-relevance data are not useless. They simply require more normalization and caution. A conceptual estimate may reasonably rely on lower-resolution sources when better information does not yet exist. As the project develops, the estimating team should replace generic sources with project-specific evidence.

Document data quality so reviewers understand where uncertainty resides.

MODULE 4 | 25 MINUTES

Uncertainty, Contingency, Escalation & Risk

4.1 Every Estimate Contains Uncertainty

Construction cost estimates are forecasts. Even a highly developed design has uncertainty related to market prices, contractor productivity, quantities, site conditions, logistics, schedule, and execution. Earlier estimates add uncertainty from incomplete project definition.

Useful uncertainty management begins by identifying sources rather than hiding them inside a single percentage. Common sources include:

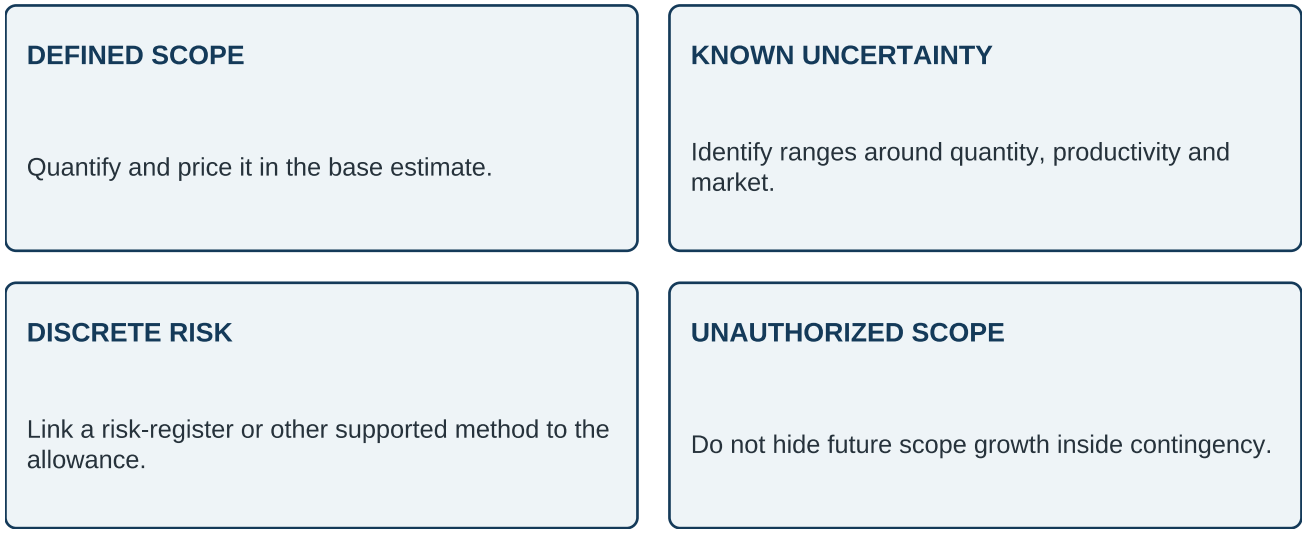
incomplete design; uncertain subsurface conditions; unknown utilities; environmental or permitting requirements; right-of-way/access; material price volatility; labor availability; production assumptions; procurement strategy; project phasing; weather/season; unusual temporary works; stakeholder requirements; market competition; schedule compression; unresolved interfaces.

The estimator should ask which uncertainties are already reflected in base quantities or unit prices and which remain outside them. This prevents double counting.

4.2 Base Estimate Versus Contingency

A base estimate should represent the cost of the defined scope using the selected estimating assumptions. Contingency is then used according to organizational policy and the estimate's risk framework to address residual uncertainty.

A weak practice is to intentionally underprice uncertain items and rely on a large global contingency to compensate. This destroys traceability. Another weak practice is to set contingency at a habitual percentage without considering project maturity or risk.



Known scope belongs in the base estimate. Contingency addresses documented residual uncertainty; unauthorized scope is handled separately.

Contingency should not be used to hide unauthorized scope growth. If a future building addition is not part of the approved project, it should not silently sit in contingency. Likewise, contractor overhead/profit should not be mislabeled as contingency.

4.3 Deterministic and Risk-Based Approaches

Organizations use different contingency methods. A deterministic method may apply a percentage based on project class, maturity, or risk category. A more developed risk-based approach may identify discrete risks, probability, consequence, and correlations and use quantitative analysis to estimate a reasonable contingency distribution.

This course does not prescribe one universal method. The important controls are:

use a method approved for the project/organization; document the method; avoid duplicate risk allowances; separate base-scope cost from risk treatment; update the risk basis as design and market conditions change; communicate whether the estimate is a point value, range, or probability-based output.

For large or high-consequence projects, a risk workshop can improve the estimate even before quantitative modeling. Engineers, construction staff, operations, procurement, environmental, utility, and

owner stakeholders often identify different uncertainties. The estimate should reflect that multidisciplinary view.

4.4 Quantity Uncertainty

Quantity uncertainty is often material before final design. One approach is to use an allowance quantity for unresolved scope. Another is to define a range. What should be avoided is pretending an uncertain quantity is exact.

Example: an early retaining-wall estimate may assume 20,000 square feet based on preliminary geometry. Instead of treating that value as final, the BOE can state the source geometry, identify geotechnical and alignment dependencies, and explain that the quantity will be updated after wall type and limits are confirmed.

When quantities become defined, remove early allowances and recalculate the risk treatment.

4.5 Productivity Uncertainty

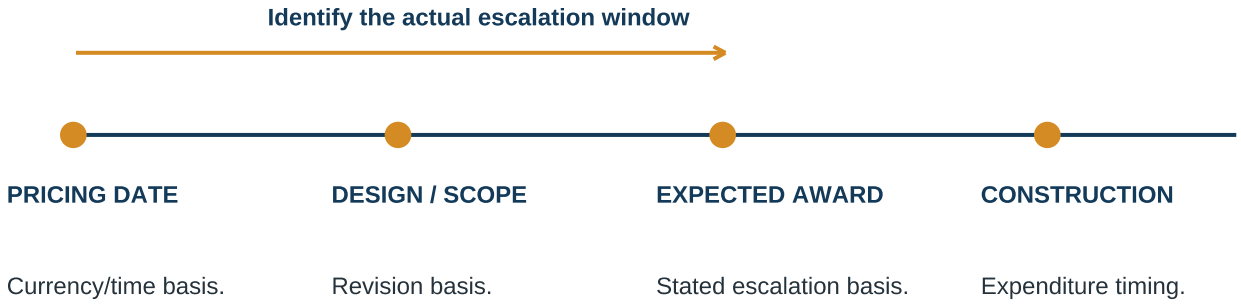
Productivity is a frequent hidden risk. A cost-based estimate may be highly sensitive to cycle time, crew balance, equipment utilization, access, and work hours. Scenario analysis can help.

For example, consider 40,000 cubic yards of excavation. If the assumed production is 1,000 cubic yards/day, the work requires 40 production days. If traffic, haul, or site constraints reduce effective production to 700 cubic yards/day, duration becomes approximately 57 days. That change affects labor/equipment cost and may extend project-level indirect costs.

The estimator should identify assumptions with this kind of leverage and prioritize them for review.

4.6 Escalation: State the Time Basis

Estimates are prepared at a pricing date, but construction may occur later. Escalation converts current pricing to a future time basis according to a documented method.



Make the pricing date and escalation window explicit. A time basis must be stated before applying an escalation factor.

The estimator should identify:

base pricing date; target date or expenditure period; index or forecast source; annual/periodic escalation assumption; whether compounding is used; whether different cost categories require different treatment; whether quoted prices already include escalation; whether schedule changes require re-escalation.

FHWA's December 2025 CFL manual instructs its estimators to develop estimates in current-year dollars and escalate to the proposed contract award date. [4] Other owners may use midpoint-of-construction, expenditure curves, or program-specific rules. Follow the governing procedure and state it.

4.7 Location Adjustment

Location affects labor rates, material freight, taxes, productivity, subcontractor availability, and market competition. Generic geographic cost indexes can help normalize benchmark data, but they should not substitute for project-specific market intelligence when major decisions are at stake.

If historical data are from a different region, document the adjustment method. A location factor derived from national averages may not capture a remote project with limited staging, long haul distances, or specialized labor.

4.8 Inflation, Escalation, and Market Volatility Are Related but Not Identical

"Inflation" is often used broadly. In estimating practice, separate concepts can matter:

broad economic inflation; construction-cost escalation; commodity-specific price movement; labor agreement changes; shortage premiums; temporary bid-market effects.

A single index may not capture all of them. For long-duration projects or volatile commodities, consider whether project-specific procurement timing or quotes should supplement a general escalation index.

4.9 Contingency Drawdown Through Design

It is reasonable for contingency to decrease as uncertainty is resolved, but the reduction should follow actual risk retirement rather than an automatic calendar. A project can become more defined while also discovering costly conditions. A milestone estimate may therefore have lower percentage contingency but a higher total cost.

This is why reconciliation matters. When contingency changes, explain which uncertainties were resolved, which new risks emerged, and whether scope moved into the base estimate.

4.10 Management Reserve and Scope Growth

Some programs use management reserve in addition to project contingency. Terminology varies. The estimator should follow organizational definitions and avoid treating different reserves as interchangeable.

A useful distinction is:

base estimate: defined scope at current assumptions; contingency: allowance for uncertainty/risk within the defined project, according to policy; management reserve/program reserve: separately controlled funds for broader program uncertainty, if applicable; future scope: work not currently authorized or included.

The BOE should explain which categories are in the published total.

4.11 Example - Material Volatility

A design estimate includes structural steel based on a current supplier quote valid for 30 days, but the anticipated bid date is nine months away. The estimator should not simply retain the quote as a future fixed price. The estimate could:

1. retain the current quote as the base source;
2. document the quote date and validity;
3. apply the project's approved escalation methodology to the future pricing date;
4. identify unusual commodity volatility as a risk if appropriate;
5. re-quote the material near the next milestone;
6. confirm whether freight/fabrication/erection are included.

This creates an audit trail and a revalidation plan rather than a false sense of certainty.

4.12 Sensitivity Analysis: Find the Assumptions That Matter

Sensitivity analysis asks how much the estimate changes when a key assumption changes. It can be simple and still be powerful.

For a unit-price item:

Cost = Quantity x Unit Price

A 10 percent change in quantity changes cost by 10 percent if the unit price remains fixed. But real projects may be nonlinear. Smaller quantities can increase unit price because mobilization is spread over fewer units; larger quantities can improve production until capacity constraints appear.

For a crew-based item:

Cost = (Quantity / Production Rate) x Daily Crew Cost

The estimate can be sensitive to both production and crew cost. Test realistic low/base/high cases for major items.

Sensitivity analysis should focus on high-value or high-uncertainty assumptions. There is little value in testing a small landscaping line if structural steel pricing or excavation productivity drives millions of dollars.

4.13 Simple Contingency Development Example

Assume a design-development estimate has a $50 million base construction cost. The team's risk review identifies:

utility conflict risk; incomplete geotechnical information; market volatility for electrical equipment; unresolved maintenance-of-traffic staging; moderate quantity uncertainty in site work.

The organization uses a structured deterministic method that assigns contingency based on project maturity and risk rating. The team documents a 12 percent contingency, or $6 million.

The important part is not the number 12 percent. The important controls are:

the base estimate contains currently defined scope; known scope is not intentionally omitted; the risk drivers are listed; the percentage follows the organization's method; the contingency is revisited when utilities, geotechnical data, and staging are resolved.

If the next milestone resolves most utility and geotechnical uncertainty, the contingency may decrease. If the project also adds scope, the total estimate can still increase. The reconciliation should make both movements visible.

4.14 Quantitative Risk Analysis - Conceptual View

For major programs, quantitative risk analysis may model cost and schedule uncertainty using probability distributions. Inputs can include ranges for quantities, unit costs, productivity, escalation, and discrete risk events. Simulation produces a distribution of possible outcomes rather than a single deterministic total.

This course does not teach Monte Carlo modeling, but engineers who review risk-based estimates should understand several principles:

output quality depends on input quality; correlated risks should not be treated as fully independent when they are not; risk events and base-estimate uncertainty must be separated to avoid double counting; selected funding confidence levels are policy/management decisions; the model should be documented and reproducible.

A sophisticated simulation cannot correct a weak scope baseline. The same traceability principles still apply.

4.15 Escalation Calculation Example

Assume a current-dollar estimate is $20 million at the pricing date. The project procedure calls for escalation to expected award 18 months later using an approved forecast of 4 percent annual compound escalation.

A simplified calculation is:

Future Cost = Current Cost x (1 + annual escalation)^(years)

Future Cost = $20,000,000 x (1.04)^1.5

This is approximately $21.21 million.

The exact method should follow the owner procedure. Some programs use monthly indices, annual midpoint conventions, expenditure curves, or separate escalation for major commodities. The example simply illustrates why the target date and compounding convention must be documented.

Also confirm the base pricing already embedded in quotations. If a vendor quote is firm through award, escalating that quoted component again may double count.

4.16 Risk Register Integration

A risk register becomes more useful to estimating when it includes enough information to link risks to cost accounts or assumptions. Fields can include:

risk description; cause; affected WBS element; probability; cost consequence; schedule consequence; mitigation; owner; status; whether reflected in base estimate or contingency analysis.

This avoids the common disconnect in which a project has a risk register and an estimate but no explicit relationship between them.

Example: "Unknown utility conflict" should identify the affected utility/site accounts. If investigation later resolves the conflict, the estimator can update both the risk register and the cost treatment.

4.17 Communicating a Range

Early estimates may be more useful when presented with a range or confidence narrative. However, ranges should not be invented casually. The basis should reflect classification guidance, historical performance, risk analysis, or organizational policy.

Avoid statements such as "estimate is accurate to plus or minus 10 percent" unless the organization has a defensible basis. AACE's classification materials caution that estimate class and project-definition maturity are only part of the accuracy story. Risk, complexity, technology, market, and estimating process matter. [1][2][3]

A better communication may be: "This planning estimate is based on concept-level definition. Major uncertainties are utilities, geotechnical conditions, and drainage scope. The program contingency reflects those uncertainties under the agency's planning-estimate procedure. The estimate will be rebaselined after preliminary design."

4.18 When Not to Apply a Global Percentage

Global percentages are convenient, but they can mask the actual source of cost. Consider "10 percent for difficult site." If the difficulty is primarily:

long haul distance; limited staging; night work; dewatering; contaminated soil; restricted crane access.

then pricing those impacts in the affected work may be more transparent than a single global percentage. The estimate can still carry contingency for residual uncertainty.

The rule is not "never use percentages." It is "use percentages deliberately and explain what they represent."

MODULE 5 | 15 MINUTES

Estimate Review, Reconciliation & Change Cost Evaluation

5.1 Review the Logic, Not Just the Math

Spreadsheet arithmetic is necessary but not sufficient. A technically correct formula can multiply the wrong quantity by the wrong price. Estimate review should test:

scope completeness; quantity traceability; unit consistency; pricing source and date; productivity assumptions; quote scope; indirect-cost treatment; escalation; contingency; exclusions; interfaces; version control; reconciliation to prior estimates.

SCOPE Complete? Interfaces assigned?	**QUANTITY** Traceable to current design?
PRICE Current source and normalization?	**PRODUCTIVITY** Supportable under project conditions?
INDIRECTS Complete and not duplicated?	**RISK** Transparent and proportionate?
TIMING Pricing and escalation dates clear?	**GOVERNANCE** Version, decisions and approvals retained?

Eight complementary questions test the logic and evidence behind the total.

A reviewer should prioritize the largest cost drivers and highest-risk assumptions. This is consistent with the general Pareto principle: a small number of items often drive a large share of total cost. The exact distribution varies, but ranked review is more efficient than giving every minor line the same attention.

5.2 Independent Checks

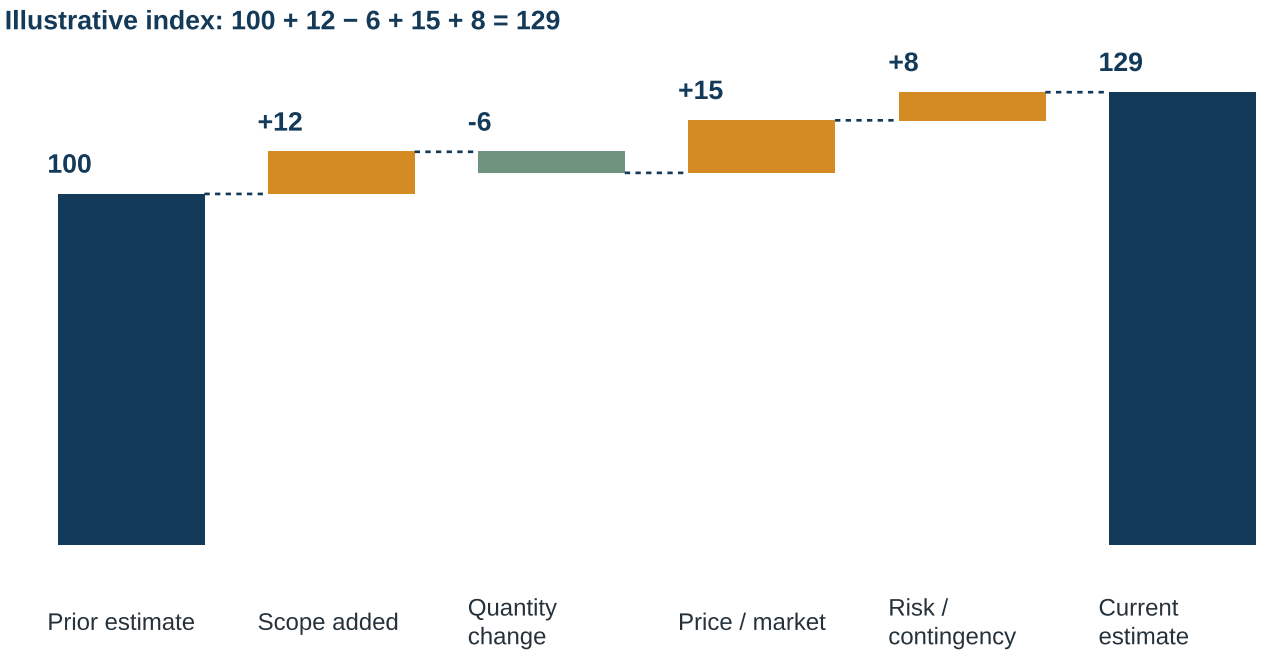
Useful independent checks include:

compare major quantities against design metrics; calculate cost per square foot, lane-mile, bed, gallon/day, or another high-level parameter; compare current unit prices with recent bids or quotes; independently build a major cost item; review crew productivity against schedule; compare indirect cost as a share of direct cost; verify that escalation and contingency are applied to the intended base; reconcile subtotal additions and markups.

A high-level benchmark should not override project-specific detail, but a major deviation should trigger investigation.

5.3 Estimate Reconciliation

Reconciliation explains why an estimate changed from one milestone or version to another. Simply stating "estimate increased 18%" is not enough. The change should be decomposed into causes.



An illustrative estimate index reconciles from 100 to 129 through separate scope, quantity, price/market and risk changes.

Typical reconciliation categories include:

scope added/removed; design development; quantity change; unit-price change; productivity/method change; market escalation; schedule change; indirect-cost change; contingency/risk change; estimate correction.

A reconciliation log reduces the risk that management interprets every increase as "estimating error." Sometimes the estimate changes because the project changed. Other times pricing or quantity assumptions were corrected. Both should be transparent.

5.4 Reconcile Quantities and Prices Separately

Suppose concrete cost rises from $4.0 million to $5.2 million. The reviewer should separate:

quantity change: 20,000 CY to 22,500 CY; unit-price change: $200/CY to $231/CY; scope/quality change: higher-strength mix or difficult placement; indirect/markup treatment change.

Without this separation, the team cannot determine whether the driver is design growth, market movement, or estimating methodology.

5.5 Bid Review and Reasonableness

An engineer's estimate can support bid evaluation, but procurement rules vary by owner. The estimate should remain independent and confidential where required. Bid comparison should consider:

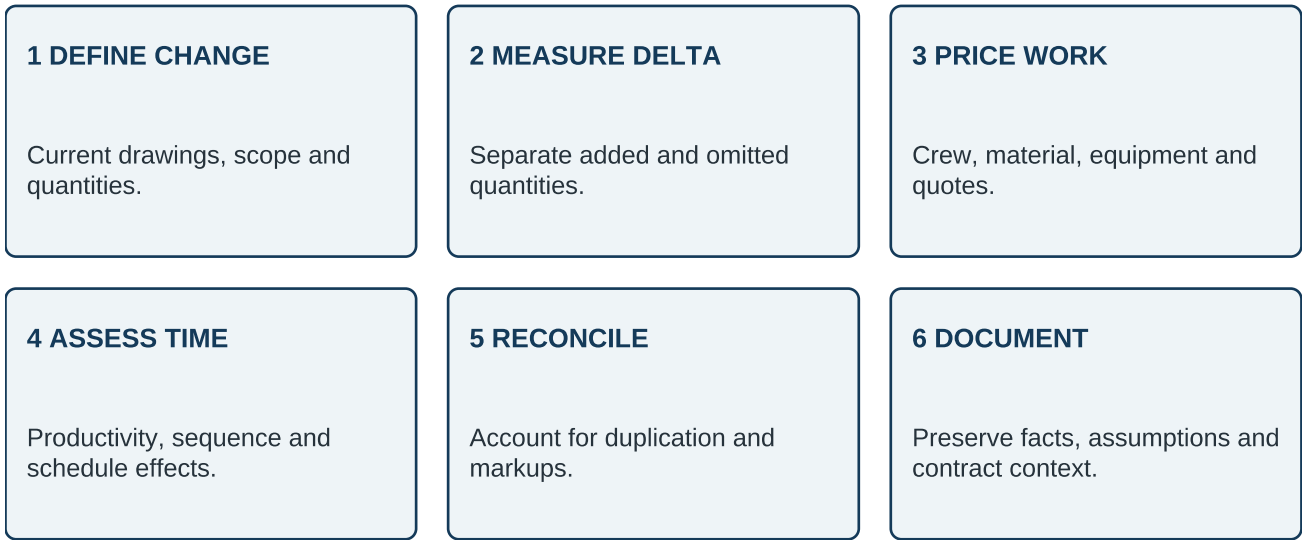
total bid; major item variance; unusual unit prices; unbalanced pricing; bidder scope interpretation; quantity sensitivities; market competition; estimate assumptions that may differ from bidder means/methods.

A large variance does not automatically mean the contractor is wrong or the engineer's estimate is wrong. It is a signal to investigate.

For example, a low unit price may reflect contractor-owned equipment, a favorable material source, strategic front-loading elsewhere, or a scope misunderstanding. A high unit price may reflect quantity risk, difficult access, mobilization embedded in the item, or limited competition.

5.6 Change Estimate Evaluation

Construction changes create special estimating challenges because the work may occur under existing contract conditions, with constrained sequence, reduced competition, disruption, or schedule effects. The cost evaluator should define the change clearly before pricing it.



Evaluate change quantities, cost and schedule effects, then reconcile and document them. Cost reasonableness remains distinct from contractual entitlement.

A practical workflow is:

1. Define the changed work and contractual direction.
2. Identify added, deleted, and modified quantities.
3. Establish reasonable labor, material, equipment, and subcontract costs.
4. Evaluate productivity and sequencing effects that are supportable.
5. Apply applicable markups according to contract requirements.
6. Consider schedule/indirect effects separately and document the basis.
7. Reconcile contractor proposal and independent estimate by scope and assumption.
8. Preserve negotiation/approval records.

The cost estimate should not decide legal entitlement by itself. Engineers and contract administrators should distinguish cost reasonableness from contractual entitlement. The project contract, governing law, and owner procedures control entitlement.

5.7 Contemporaneous Information Matters

Change estimates are strongest when developed near the time of the change. Preserve:

current plans/sketches; RFI responses/directives; quantity calculations; labor/equipment rates; supplier/subcontractor quotes; schedule fragment or time-impact support where used; daily records relevant to productivity; negotiation notes; approved modification.

Reconstructing a change months later from memory increases uncertainty and disputes.

5.8 Schedule and Productivity Effects

Not every change creates compensable delay or disruption, but schedule effects can be real. The estimator should avoid unsupported blanket factors. If a productivity adjustment is proposed, look for evidence such as:

changed sequence; restricted access; trade stacking; repeated mobilization; overtime; winter work; interrupted workflow; material handling changes; work in occupied areas.

The analysis should remain within the estimator's role and contract framework. When legal interpretation is involved, obtain appropriate contract/legal review.

5.9 Version Control

Every formal estimate should have a version identifier or date and enough metadata to distinguish it from prior versions. Retain:

input files; quote files; quantity backups; estimate export/report; BOE; reconciliation; review comments; approval/issue record.

Version control matters because estimates often circulate independently of their context. A reviewer should be able to determine which version supported a funding decision or procurement action.

5.10 Structured Review Meeting

For major milestone estimates, a structured review meeting is more effective than asking reviewers to "look over the spreadsheet." Provide the BOE and a review package that highlights:

total cost by major WBS; top cost drivers; changes from prior estimate; largest quantities; largest unit prices; major quotes; key production assumptions; allowances; contingency/risk basis; escalation; exclusions/open items.

Assign reviewers by expertise. Civil engineers can challenge earthwork/drainage quantities; electrical reviewers can challenge equipment and distribution; construction personnel can challenge productivity and temporary works; project management can challenge phasing and schedule; procurement can challenge market assumptions.

Record comments and dispositions. A comment log is part of estimate evidence, especially when a major assumption is challenged and consciously retained.

5.11 Material Variance Investigation

A material variance is not defined by one universal percentage. Significance depends on total project value, item value, risk, and decision context.

A practical variance review asks:

1. Is the quantity different?
2. Is the unit price different?
3. Did the scope definition change?
4. Did the pricing date or escalation change?
5. Did productivity assumptions change?
6. Did a quote expire or get replaced?
7. Did indirect cost allocation change?
8. Did contingency move into base scope?
9. Was a prior error corrected?

This sequence prevents the team from jumping immediately to "the market moved" or "design grew."

5.12 Bid Analysis Example

An engineer's estimate for a roadway project is $24.5 million. Three bids are:

Bidder A: $22.9 million; Bidder B: $24.0 million; Bidder C: $25.4 million.

The totals cluster around the estimate, but one major earthwork item in Bidder A is far below the engineer's unit price. The reviewer should inspect whether:

A has a favorable borrow/disposal source; mobilization or related costs appear in other items; quantity risk is being strategically priced; the estimate used conservative production; the bid contains an error or unusual imbalance.

The correct response depends on procurement rules and the full bid. Total agreement does not eliminate the need to review material unbalanced items.

5.13 Change Estimate Numerical Example

A change adds 450 linear feet of 12-inch utility pipe in a congested area. The independent estimate includes:

material: $95/LF = $42,750; installation crew/equipment: $160/LF = $72,000; bedding/backfill/restoration: $58/LF = $26,100; testing and traffic control allowance: $18,000; subtotal direct cost: $158,850.

Applicable contract markups and any schedule-related costs are evaluated separately according to the contract. The contractor proposal is $225,000.

The evaluator should not simply negotiate the contractor to the independent estimate midpoint. First reconcile assumptions:

- Does contractor material price include fittings not in the independent estimate?
- Is excavation deeper?
- Does the crew require night work?
- Is traffic control scope larger?
- Are restoration limits different?
- Is there documented disruption?
- Are markups correctly applied?

After scope normalization, the estimates may converge or the independent estimate may need revision. The independent estimate is a decision tool, not an infallible target.

5.14 Review for Double Counting

Before issue, run a specific double-counting review. Check:

general conditions versus crew inclusions; labor burden versus payroll adders; freight in quotes versus freight allowance; waste in quantities versus unit rates; subcontractor markup versus global markup; contingency embedded in allowances versus global contingency; escalation in quotes versus project escalation; bonds/insurance in quoted packages versus global factors; testing/commissioning in vendor scope versus separate estimate lines.

This review can be more valuable than checking minor arithmetic.

5.15 Estimate Audit Trail

A good estimate audit trail lets a reviewer move in both directions:

From total to evidence: total -> WBS -> line item -> quantity -> source/design -> price -> quote/history/build-up -> assumption.

From design change to total: design change -> affected quantities -> affected pricing -> risk/indirect effect -> estimate revision -> reconciliation.

If either direction is impossible, future updates become harder. Auditability is therefore not administrative overhead; it is a productivity tool for the next milestone.

5.16 Lessons From Estimate Misses

When an estimate materially misses the eventual outcome, perform a lessons-learned review. Classify the cause:

scope omission; scope growth after estimate; quantity error; price/data error; productivity error; market change; risk event; escalation assumption; schedule impact; contract/packaging strategy; arithmetic/model error.

Do not label every variance "estimator error." The purpose is to improve the process and historical data. If the cause was a scope interface, update checklists. If a production assumption was optimistic, update the cost database with context. If market conditions changed abruptly, improve source-refresh triggers.

Historical data become more valuable when accompanied by lessons and project metadata, not just final unit prices.

MODULE 6 | 10 MINUTES

Applied Estimating Scenarios

Scenario 1 - Roadway Concept Estimate With Incomplete Quantities

A transportation team is comparing two corridor alternatives. The preferred alignment has not been selected. Earthwork is approximate, drainage is conceptual, utilities are not fully investigated, and structures are identified only by approximate type and length.

Poor response: create detailed bid-item quantities from assumed design features and present a narrow point estimate with no BOE.

Stronger response:

identify the estimate as early-stage; use high-level quantities that can be supported; use parametric or historical relationships for unresolved components; normalize historical data for date/location/quantity; identify utilities, geotechnical conditions, right-of-way, and traffic control as material uncertainties; document allowances; use a risk/contingency approach consistent with project procedures; present the estimate as suitable for alternative comparison, not definitive procurement.

The engineering value is not in pretending the design exists. It is in making the estimate useful while clearly communicating what remains unresolved.

Scenario 2 - Design Development Causes a Large Increase

A building estimate increases from $68 million to $82 million between schematic and design-development milestones. Management asks why "estimating was wrong."

The reconciliation shows:

$5 million new program scope; $3 million higher MEP quantities after system definition; $2 million market escalation; $2 million revised site/utility work; $1 million higher general conditions from schedule extension; $1 million lower contingency because uncertainty was retired.

The total increase is $14 million, but the cause is not a single estimating miss. The reconciliation distinguishes authorized scope growth, design development, market movement, schedule, and risk transfer into the base estimate.

Engineering lesson: estimate performance should be evaluated against the scope and information available when the estimate was prepared.

Scenario 3 - Large Unit-Price Variance

A current estimate prices 10,000 tons of aggregate base at $62/ton while recent bid history averages $44/ton.

A strong reviewer does not immediately overwrite the current rate. Investigation finds:

the current project requires night work; the haul source is significantly farther away; quantity delivery is constrained by staging; the material specification differs; the recent bids were larger projects with better production efficiency.

The $62/ton rate may still require validation, but the variance has legitimate project-specific drivers. The reviewer should document them and, if practical, seek an independent quote or cost-based check.

Scenario 4 - Omitted Utility Interface

A site estimate includes trenching and site electrical distribution but assumes the utility company will complete transformer and primary service work. The utility's scope letter later reveals that the owner must fund duct-bank extension and off-site upgrades.

The issue is an interface failure. The estimator should:

1. add the newly defined owner scope;
2. update the BOE;
3. reconcile the estimate change as scope clarification;
4. retire any prior allowance that covered the interface;
5. update risk treatment for remaining utility uncertainty.

Scenario 5 - Construction Change

During construction, an unforeseen conflict requires relocating a 16-inch water main. The contractor proposes a lump-sum change including labor, equipment, material, traffic control, subcontracted testing, and extended supervision.

The owner's evaluator should develop an independent estimate using the changed quantities, current project conditions, reasonable crew/productivity assumptions, quotes where appropriate, and contract-defined markups. If the relocation affects the critical path, schedule/indirect effects should be evaluated with appropriate evidence rather than applying an unsupported percentage.

The evaluator should separate:

physical changed-work cost; schedule/indirect cost; contractual entitlement; negotiation position.

Applied Decision Framework

Across all five scenarios, the recurring questions are:

1. What is the estimate for?
2. What scope is actually defined?
3. What remains uncertain?
4. What quantities can be traced?
5. What price method best fits the information?
6. What time/location basis applies?
7. What risk treatment is justified?
8. Can a reviewer reproduce the reasoning?

An estimate that answers those questions is much more useful than one that simply produces a total.

Capstone Scenario - Estimate Development Across Three Milestones

A county plans a new operations facility with a maintenance building, administration space, fueling, site utilities, stormwater, and fleet parking. The project is estimated at three milestones.

Milestone A - Programming

Available information:

- target building area;
- approximate site;
- functional program;
- fleet count;
- no final building systems;
- no geotechnical report;
- conceptual site circulation.

Approach:

- parametric building benchmark normalized for region/date;
- site-development allowance based on area and comparable work;
- separate allowances for fueling and utility connection;
- higher contingency under agency policy;
- explicit exclusions for land acquisition and off-site utility upgrades.

Decision supported: confirm program affordability and compare sites.

Milestone B - Schematic Design

New information:

- structural concept;
- building footprint;
- preliminary MEP systems;
- grading concept;
- stormwater concept;
- utility routes;
- preliminary construction schedule.

Approach:

- replace building-area parameter with system/assembly estimates;
- measure pavement, major utility lengths, earthwork, and stormwater elements;
- obtain budget quotes for major equipment;
- build general conditions from schedule assumptions;
- update location and escalation;
- reduce or redirect allowances as design becomes defined;
- reconcile the estimate to Milestone A.

Decision supported: authorize design development and adjust project budget.

Milestone C - Design Development

New information:

- coordinated discipline drawings;
- equipment schedules;
- refined quantities;
- geotechnical recommendations;
- utility coordination;
- phasing;
- updated market quotes.

Approach:

- detailed quantity/unit-price and cost-based estimates for major work;
- quote leveling for major equipment/subcontracts;
- explicit temporary works and phasing costs;
- risk register linked to estimate;
- refined escalation to bid/award;
- formal independent review and reconciliation.

Decision supported: funding confirmation and procurement planning.

The key lesson is that the estimate did not merely "get more detailed." Its methodology, documentation, uncertainty treatment, and review effort evolved with the decision and project definition.

Capstone Review Questions

1. Which Milestone A allowances should be retired at Milestone B?
2. Which high-cost assumptions deserve independent checks at Milestone C?
3. How should a newly identified off-site utility upgrade appear in reconciliation?
4. If the construction schedule extends six months, which estimate components may change besides escalation?
5. Which evidence should be retained so the final estimate can be audited after bid?

Course Summary

Capstone takeaway: a strong estimate review considers scope, quantity, pricing, indirect cost, risk, timing, and documentation effects together rather than treating the final total as the only result.

Construction cost estimating is a professional judgment process supported by quantitative tools. Good estimates are:

purpose-driven - developed for a defined decision; maturity-aware - aligned to actual project definition; scope-complete - organized so interfaces and omissions can be found; quantity-traceable - source, units, and revision are controlled; method-appropriate - parametric, historical, unit-price, assembly, or cost-based methods are selected deliberately; pricing-current - date, market, location, quote, and productivity assumptions are documented; risk-transparent - contingency addresses uncertainty rather than hiding known scope; time-based - escalation and pricing dates are explicit; reviewable - major cost drivers and assumptions receive independent checks; reconciled - changes from prior versions are explained; governed - versions, approvals, and supporting records are retained.

The objective is not to eliminate uncertainty. It is to make uncertainty visible, proportionate, and manageable while providing decision-makers with the best support the available project information allows.

Principal references and source links

- [1] AACE Professional Guidance Document 01: Guide to Cost Estimate Classification Systems. Classification communicates project-definition maturity; the applicable industry framework matters. Open source
- [2] AACE RP 56R-08, Building and General Construction Industries, revision August 7, 2020. Open source
- [3] AACE RP 98R-18, Road and Rail Transportation Infrastructure Industries, revision August 7, 2020. Open source
- [4] FHWA Central Federal Lands, Engineer's Estimate Manual, December 2025. A federal-agency procedure and practical example; project requirements control applicability. Open source
- [5] FHWA estimates, bidding and progress payments resources. Open source
- [6] Florida Board of Professional Engineers, continuing-education provider guidance. Open source
- [7] GAO-20-195G, Cost Estimating and Assessment Guide, March 2020. Figure 7, printed page 57. Open source

Legacy instructional source: John W. Adcox, Jr., Quick Estimating Methods.

Public publisher and agency source information checked November 15, 2026. Technical examples support engineering judgment; use the governing project requirements, adopted code edition and applicable standard for implementation.

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