THE EUROPEAN AEROSPACE
COST ENGINEERING WORKING GROUP (EACE)

A CAPABILITY IMPROVEMENT MODEL FOR COST MANAGEMENT

A White Paper on

The EACE Cost Engineering Capability Improvement Model (CECIM)

A product of the EACE Capability Model Sub-Group

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A Capability Improvement Model For Cost Management:
The EACE Cost Engineering Capability Improvement Model (CECIM)

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FOREWORD

Inaugurated by the European Space Agency (ESA) and the European space industry organisation, Eurospace, the first meeting of EACE, the European Aerospace Cost Engineering Working Group, was held at the European Space Agency Technology Centre, Noordwijk, in January 1999. The following aims and objectives were ratified at that time:

- To promote the function of Cost Engineering to the benefit of the Aerospace sector.
- To provide a forum for the exchange of experience, information and ideas relating to Cost Engineering activities.
- To stimulate and contribute to improvement in the tools, databases, and methodologies applied in the Cost Engineering process.
- To maintain cognisance of industry approaches to cost reduction trade-offs, including technology application, manufacturing processes etc.
- To identify training opportunities relating to Cost Engineering.

There was a consensus within the Working Group that Cost Management did not receive, within Europe, the recognition that benefits other disciplines. Three main reasons for this were cited:

- Within 'Technology' companies, Cost Management and Cost Engineering are considered less important than mainstream value-adding activities like design.
- Lack of formal identity for Cost Engineering. Despite the existence of professional institutions such as the Association Of Cost Engineers, Cost Engineering is not perceived to be a profession. Engineers see Cost Engineers as accountants, accountants see us as engineers.
- Lack of formally recognised training and qualifications.

It became apparent at the third Working Group meeting at ESRIN, Rome, in November, 1999 that the objectives of the Working Group were not being advanced expeditiously. Subsequent to this workshop, a small group reached the conclusion that the development of a Capability Improvement Model would go some way to establishing the reputation of the Working Group.

Work performed by the Software Engineering Institute (SEI) at Carnegie Mellon University in the United States had previously outlined a framework for development of such a model and this resulted in the creation of the Systems Engineering Maturity Model [1] that is now widely used by industry and government as a measure of organisational competence and process maturity within the Systems Engineering discipline.

At the fourth Working Group meeting, held at DASA, Bremen, in February 2000 [2], the authors proposed that a Sub-Group should be established with the objective of developing a Capability Improvement Model for Cost Engineering and volunteers were sought to participate in model development. The ultimate composition of the Sub-Group was as follows:

Emmanuel Adjari	Astrium (France)
Martin Dunkley	Airbus UK
Peter Fray	MoD Defence Procurement Agency
Giancarlo Filippazzo	Agenzia Spaziale Italiana
David Greves	European Space Agency
John Henson	Westland Helicopters Ltd
Dave Lewis	Cost Engineering Solutions Ltd
Hugh Pickerin	Anglian Enterprises Ltd
Bennie Schreiber	European Space Agency
Ian Taylor	British Aerospace Military A/C

I. A Definition Of Cost Engineering

In embarking on the development of the model it was important to have an understanding of the roles and responsibilities associated with the Cost Management/Cost Engineering domain. A brainstorming session previously conducted by EACE had arrived at the following scope definition and this was used as a basic reference for the work of the Sub-Group:

- Cost Estimation
- Scheduling
- Risk Analysis
- Cost Control
- Development of Cost Models
- Data Collection
- Cost Management/Engineering Process Evaluation
- Tools Evaluation and Development
- Cost Estimating Methods & Processes Development
- Validation of Input Data
- Analysis of Supplier Proposals
- Cost Reduction and Improvement
- Value Analysis
- Design to Cost
- Definition of Costing Requirements
- Economic Appraisal
- Preparation and Evaluation of Business Plans
- Benchmarking
- Cost as an Independent Variable (CAIV)
- Participation in IPPT (Integrated Product/Process Team)
- Support to/Participation in Cost Negotiations
- Achievement of Value for Money (from suppliers)
- Communicate Findings

II. Model Architecture

The CECIM model developed by the European Aerospace Cost Engineering Working Group (EACE) adopts a similar approach to the Software Engineering Institute 'Systems Engineering Capability Maturity Model' (SE-MM) developed at Carnegie Mellon University [1]. The architecture segregates Cost Engineering Process Areas (on the process side) from Generic Practices (on the capability side), which relate to increasing process capability. This architecture, which separates process-specific characteristics from the capability-related characteristics, is chosen to enable organisations to establish a process and then evaluate the effectiveness of that process on a continuing basis. Within the process side of the EACE CECIM, nineteen Process Areas have been defined to date, whilst the capability side retains the six levels of process implementation of the SEI SE-MM as follows:

- Not Performed
- Performed Informally
- Process Planned and Tracked
- Process Well Defined
- Quantitatively Controlled
- Continuously Improving

The model architecture, as shown in Figure 1, enables the use of a consistent appraisal methodology across the Process Areas. It clearly distinguishes essential, basic Cost Engineering process elements (the Process Side) from process management-focused elements (the Capability Side).

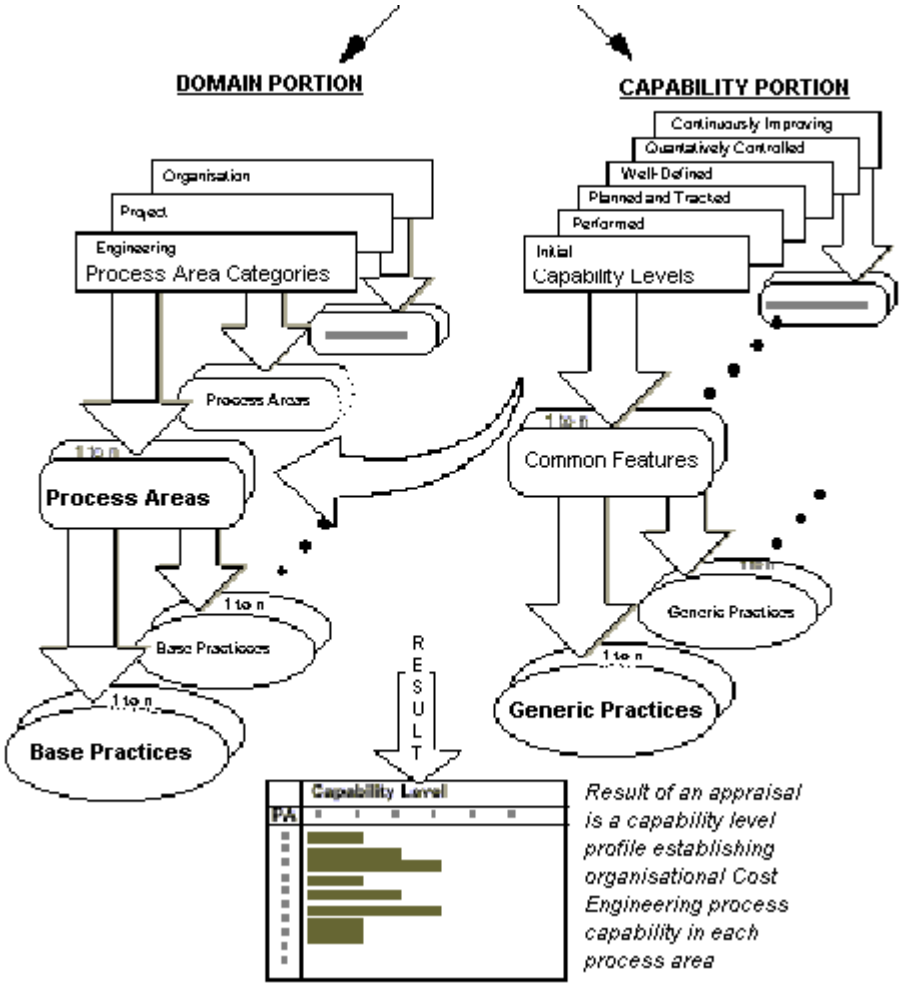
III. Model Capability Side

There are six capability maturity levels on the capability side of the model. These levels, which are shown in Figure 2, are arranged in a hierarchical fashion and build one upon the other.

Organisations should consider using the CECIM to identify and prioritise process improvement projects, remembering that all candidate improvements should be satisfy the primary aim of supporting their strategic objectives. An organisation that uses the CECIM should prioritise the process areas relative to their strategic objectives and aim for improvement in the highest priority process areas first. It may be too expensive for most organisations to aim for Levels 4 or 5.

Assigned to each capability level are common features or groupings of generic practices appropriate to the capability level. Generic practices are a series of activities applying to the management and measurement of the process. These are used during appraisal to determine the capability of the process. The capability levels are described overleaf:

Figure 1: Cost Engineering Maturity Model Architecture



Level 0: The Not Performed Level

There is a general failure to perform the Base Practices in the Process Area. This is likely to occur within an organisation that is new to Cost Management/Cost Engineering disciplines or new to the specific Process Area. Organisational objectives may be achieved, but without evidence of consistency, or recognition of the causal factors. Products resulting from the process are not easily identifiable.

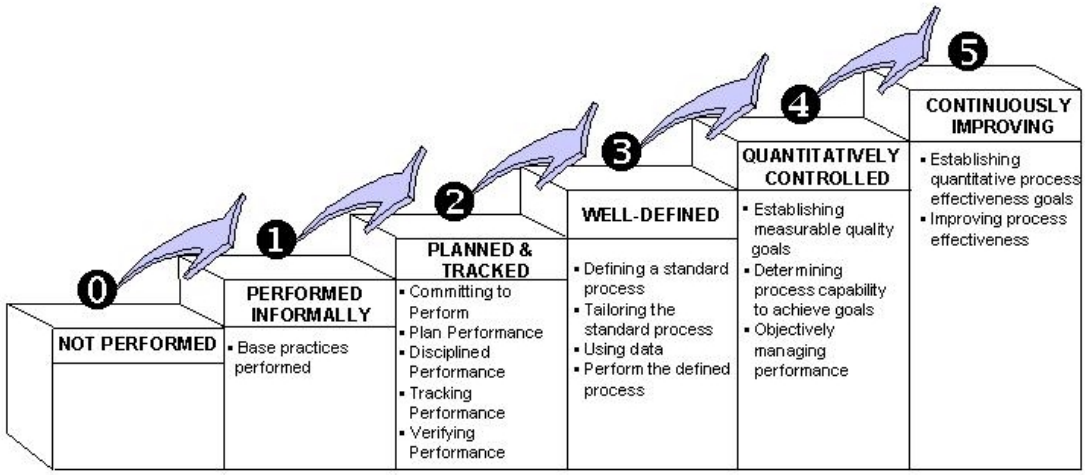
Level 1: The Performed Informally Level

At this level the Base Practices are normally performed. However, consistent planning and tracking of the performance is missing. Performance tends to depend on individual knowledge and effort. The quality of work products relies on individuals' perception. Experience of the individual seems to be the key factor: processes do not seem to be repeatable.

Level 2: The Planned And Tracked Level

At this level planning and tracking have been introduced and performance according to specified procedures can be verified. The work products conform to standards that provide for implementation of corrective action when variances in the standard of the work products are indicated. The organisation will use measurements to track the Process Area performance, which enables the management of activities based on actual performance. The primary distinction between this level and the Level 1 activity is that the performance of the process is planned and managed. Therefore it is repeatable but not necessarily across the enterprise. Common features and generic practices for the Planned and Tracked Level are summarised overleaf:

Figure 2: Capability Levels



i. PLAN PERFORMANCE:
- Allocate adequate resources.
- Assign responsibilities.
- Document the process.
- Plan the process.
- Ensure training.
- Provide appropriate tools.

ii. DISCIPLINE PERFORMANCE:
- Use plans, standards, and procedures.
- Do configuration management.

iii. TRACK PERFORMANCE:
- Track the status of the process area against the plan using measurement.
- Take corrective action, when the progress varies significantly from that planned.

iv. VERIFY PERFORMANCE:
- Verify compliance of the process with applicable standards and/or procedures.
- Verify compliance of work products with the applicable standards and/or requirements through audit.

Level 3: The Well Defined Level

At this level the Base Practices are performed throughout the organisation using approved, tailored standards and documented processes. The primary distinction from Level 2 is that the process is planned and managed *throughout* the organisation using accepted standard processes. Data from using the process are gathered systematically and used to determine whether or not the process should be modified or improved. Common features and associated generic practices for Level 3 are shown right:

i. DEFINE A STANDARD PROCESS:
- Standardise the process.
- Document a standard process or family of processes for the organisation.

ii. TAILOR THE STANDARD PROCESS:
- Tailor the enterprise's standard process family to create a well-defined process that addresses the particular needs of a specific programme.
- Perform the Defined Process.
- Use a well-defined process.
- Perform defect reviews.
- Use well-defined data.

Level 4: The Quantitatively Controlled Level

At this level, measured goals are established for each defined process and the associated work products. Detailed measures on performance are collected and analysed.

This enables a quantitative understanding of the process and improves the ability to predict performance. The primary distinction between this level and Level 3 is that the defined process is quantitatively understood and controlled. The common features and generic practices for Level 4 are shown below:

i. ESTABLISH MEASURABLE QUALITY GOALS:
- Establish quality goals.

ii. MANAGE PERFORMANCE OBJECTIVELY:
- Determine process capability.
- Use process capability. Take corrective action, when the process is not performing within its capability.

Level 5: The Continuously Improving Level

This is the highest achievement level of process capability. The organisation has established quantitative, as well as qualitative, performance targets based on its strategic goals. Continuous process improvement towards achievement of these goals using timely, quantitative performance feedback has been established. Further improvements are achieved by pilot testing of new ideas and tools improvement. The primary distinction from Level 4 is that the processes undergo continuous refinement and improvement, based on a quantitative understanding of the impact of changes to the process. Common features and generic practices for Level 5 are shown right:

i. IMPROVE ORGANISATIONAL CAPABILITY:
- Establish process effectiveness goals. Based on the strategic goals of the organisation.
- Improve the standard process continuously. By changing the organisation's standard process family to increase its effectiveness.

ii. IMPROVE PROCESS EFFECTIVENESS:
- Perform causal analysis of process defects.
- Eliminate defect causes.
- Improve the defined process continuously by changing the defined process to increase its effectiveness.

Table 1: Cost Engineering Process Areas

PA 01: Cost Estimating	PA 11: Ensure Process Quality
PA 02: Cost Modelling	PA 12: Design to Cost & CAIV
PA 03: Cost Control & Analysis	PA 13: Supply Chain Management
PA 04: VA / VE & Cost Reduction	PA 14: Knowledge Management
PA 05: Planning	PA 15: Capital Asset & Resource Mgt
PA 06: Risk Management	PA 16: Business Analysis
PA 07: Competences Management	PA 17: Business Case Development
PA 08: Define the Process	PA18: Audit
PA 09: Improve the Process	PA19: Cost Allocation
PA 10: Integrate Disciplines	

III. MODEL PROCESS SIDE

Each Process Area (PA) is a set of related Cost Engineering process characteristics, which, when performed collectively, facilitate the overall Cost Engineering function. The PAs are composed of Base Practices (BPs), which are defined as activities that are essential to the achievement of the purpose of the Process Area. The PAs are shown in Table 1. A detailed description of each PA along with a listing of its associated Base Practices is shown at Appendix A.

Within the Sub-Group, some discussion has taken place regarding the application of the model to project life cycles.

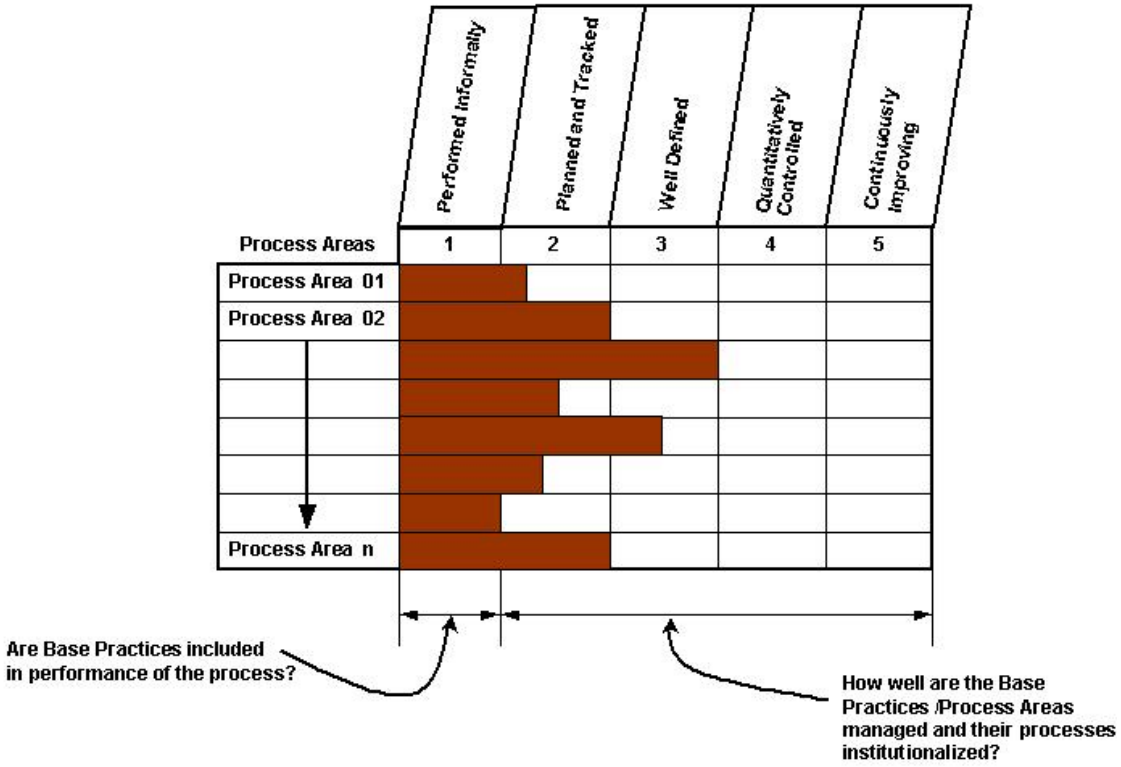
Clearly life cycles can vary by industry (e.g. the aircraft industry life cycle is significantly different to that of the consumer electronics industry, both in terms of product life and time-to-market). The life cycles can also vary by perspective, however, for instance the customer will focus on the acquisition life cycle, the contractor will be concerned with the development life cycle, whilst the focus of the end-user will tend to concentrate on the operational life cycle.

IV. DEPLOYMENT FOR ORGANISATIONAL APPRAISAL

The first step in developing a profile of the organisation's capability is to determine whether all the Base Practices are implemented. The second step is to assess how well the Base Practices are implemented and managed. To do this we need to look at each Base Practice in the context of the common features and the generic practices. Consideration of both the Base Practices (from the Domain Process Areas) and the generic practices (from the generic Capability definitions) thus results in a process capability profile that can determine the current level of implementation. We can then select improvement activities that can lead to attainment of the level that the enterprise targets. The use of the model for organisational appraisal is illustrated in Figure 3.

Following consideration, EACE have concluded that the CECIM Process Area guidelines will be capable of

Figure 3: CECIM Enterprise Appraisal



application during any phase of a system life cycle. Appropriate life cycle definitions already exist and these can be determined from the relevant industry standards.

V. Next Steps

Planned next steps for the model are to implement improvements based on operational experience. To this end, EACE are seeking to open dialogue with organisations that would be interested in piloting the deployment of the model with a view to reporting back to the Sub-Group before the end of 2001.

In addition, EACE intend to circulate other organisations with an interest in Cost Management and Engineering matters with the intent of securing further input and comment on the model and, finally, obtaining full ratification of the model, leading to general recognition and ultimate adoption as a recognised standard.

VI. Summary

The Capability Maturity Model establishes characteristics essential to a good Cost Management and Engineering process. The major benefit to the organisation is that the CECIM should enable improvement of the Cost Engineering process without necessarily driving changes in culture. This supports the objective of the provision of a methodology and tool for application in the achievement of organisational imperatives by ensuring optimisation of cost, schedule, and performance within the enterprise.

The development of the CECIM has served to confirm the scope and identity of the Cost Management and Engineering domain and thus helps to serve the needs of the Cost practitioner and of the individual EACE participant.

It is felt that the Process Area and Base Practice definitions that have been established during CECIM development form a valuable contribution to the knowledge base of EACE and a potential foundation for a “Book Of Knowledge” for the European Cost Management and Engineering community. This in itself could prove a suitable subject for investigation by a future EACE Sub-Group.

VII. Contact Points

Correspondence, particularly comments leading to future improvement of the CECIM are welcome. In particular,

EACE are keen to solicit enquiries from practitioners, Cost Management and Engineering related organisations, government agencies, institutions and corporations who may be interested in participating in the future development of the CECIM, or to collaborate with EACE on piloting CECIM implementation.

We look forward to hearing from you.

Dave Lewis: admin@costeng-solutions.com
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VIII. FOOTNOTES

In 2004, work commenced to develop a modified assessment methodology using the requirements defined in emerging standard ISO/IEC 15504 'Information Technology – Process Assessment': the appendix to this document forms the basis of a compliant Process Reference Framework within the meaning of ISO/IEC 15504, whilst the details of the model Capability dimension are being updated in parallel to correspond to the ISO/IEC 15504 definitions. None of these factors in any way reduces the validity of the existing definitions of the Domain and Capability dimensions as described herein and it is envisaged that organisations will elect to use either the method outlined herein or the 15504-compliant extension depending on the context and constraints associated with the purpose for which CECIM is being used.

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† Member, EACE Steering Group, ††Chairman, EACE.

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ACRONYMS

ACWP	Actual Cost Of Work Performed
BCWP	Budgeted Cost Of Work Peformed
BCWS	Budgeted Cost Of Work Scheduled
BOE	Basis Of Estimate
BOM	Bill Of Material
BP	Base Practice
CAIV	Cost as an Independent Variable
CBA	Cost Benefit Analysis
CBS	Cost Breakdown Structure
CER	Cost Estimating Relationship
CMM	Capability Maturity Model
CPA	Critical Path Analysis
CPI	Cost Performance Index
DTC	Design to Cost
EBS	Estimating Breakdown Structure
EVA	Earned Value Analysis
FAST	Function Analysis System Technique
FCAC	Forecast Cost At Completion
ITT	Invitation To Tender
OBS	Organisation Breakdown Structure
MOD	Ministry of Defence
PA	Process Area
PBS	Product Breakdown Structure
PERT	Programme Evaluation & Review Technique
PT	Product Tree
QMAC	Questionnaire on Methods & Allocation Of Costs
R & D	Research & Development
RFQ	Request For Quotation
ROI	Return On Investment
ROM	Rough Order Of Magnitude
SOW	Statement Of Work
SPI	Schedule Performance Index
SPS	Specialist Procurement Services (MOD)
SWOT	Strength, Weakness, Opportunity, Threat
VA/VE	Value Analysis, Value Engineering
WBS	Work Breakdown Structure
WIP	Work In Progress
WPD	Work Package Description

Appendix A: CECIM Process Area and Base Practice Descriptions

Process Area 01: Cost Estimating

Process Area Description

The purpose of COST ESTIMATING is to establish the costs of performing the envisaged work, as a basis for negotiation and subsequent engagement. The Process Area relates specifically to the activities that are performed prior to engagement, typically during proposal preparation.

Cost Estimating requires that a detailed analysis of the scope of work (both explicit and implicit) is performed and that the project objectives are clearly identified. Cost Estimating includes estimation of the cost of the Typical Product Outputs, the resources required, consideration of lessons learned, risk assessment, currency exposure consideration, and presentation of costs estimates to senior management for review and approval. It is important to fully understand the class of estimate required and tailor the process accordingly before commencing any estimate.

Base Practices

01. Understand Customer Needs
02. Classes of Estimate
03. Develop Metrics
04. Create WBS, OBS & PBS
05. Generate Target Costs
06. Establish Preliminary Programme Plan
07. Generate Make/Buy Plan
08. Obtain Material Costs
09. Generate Detailed Estimates for In-House Work
10. Agree Foreign Exchange Rates
11. Compilation of Works Cost
12. Calculate Contingency
13. Utilisation of Learning Curve
14. Issue Definitive Estimate
15. Cost Justification

Base Practice Descriptions

Base Practice 01: Understand Customer Needs

Description:
Analyse request from customer, internal or external, including all requirements, specifications etc associated with the request. Contact relevant people to ensure clear understanding and documenting of the needs, statement of work etc. Prior to commencing any estimating activity, establish and agree the level or class of estimate (see BP02) and ensure that all parties are aware of the commercial considerations (e.g. tender requirements, customer's contract pricing instructions).

Typical Work Outputs:

- Basis of Estimate (BOE)
- Hardware and Verification Matrix
- Preliminary Design and Development Plan
- Industrial Plan
- Contract pricing instructions (e.g. Fixed, Firm-Fixed etc.).

Note: The level to which the customer requirements can be determined will identify inputs to the "weak points" in risk identification (PA06/BP01) and determine the confidence level in the estimate being generated (PA01/BP02).

The pricing conditions will determine the level of escalation or de-escalation to be included in the works cost generated in BP11. For Fixed Price contracts a VoP (Variation Of Price) formula may be included in the requirements, alternatively, the organisation may be invited to develop the VoP basis for the recovery of escalation. For Firm-Fixed price contracts, the organisation will need to ensure that escalation is included in the works cost.

Base Practice 02: Classes of Estimate

Description:
Ensure that both customer (Internal and External) and estimator have a clear understanding of the class of estimate

required. At this stage it is essential to ensure that the class of estimate required is compatible with the level of information available. Whatever means are used to describe classes of estimate it is essential that the definition is fully understood by all parties and the appropriate level is agreed prior to commencing an estimate.

Typical Work Outputs:

- Definition of Class of Estimate

Note: The "class of estimate" will be an input to the risk identification process (PA06/BP01). Classes of estimate can be defined by number, e.g. class 1, 2, and 3 etc or descriptor, e.g. Rough Order of Magnitude (ROM), budgetary, fixed and firm, etc or percentage, e.g. ± 10% etc.

Base Practice 03: Develop Metrics

Description:
Metrics should be established to assist in the introduction of estimating consistency. Accordingly, each activity that is subject to direct estimation within the scope of the estimating process should be analysed and metrics defined. Metrics form the basis of any Cost Estimating Relationships (CERs) that are developed. To ensure consistency, all metrics should be documented and circulated amongst those involved in the production of estimates. All metrics should be the subject of periodic review based on feedback from costs incurred and lessons learned. It is essential that any changes resulting from this review process be reflected in any models used.

Typical Work Outputs:

- Standard Metrics Definitions

Note: The CERs will be developed in PA02/BP04, Cost Modelling Data Analysis.

Base Practice 04: Create WBS, OBS & PBS

Description:
Once the statement of work, and thereby the scope of the activity, has been agreed between estimator and customer, it is essential to define the work content and construct the estimate according to a systematic framework. Typically this will involve the utilisation of one or more hierarchical structures in order to describe the task content, the deliverable elements or the division of responsibility, e.g. an agreed Work Breakdown Structure (WBS), Estimating Breakdown Structure (EBS), Product Breakdown Structure (PBS – "Product Tree"), etc.

The formats of the WBS, OBS and PBS will be influenced by the nature of the work that is to be performed and the work products that will be delivered. Other requirements that should be taken into account in defining the methodology to be applied in the design of the structures are those relating to the organisation's internal processes, e.g. those of Project Control, Project Office and Cost Accounting; those relating to customer and contractual requirements; constraints and conventions associated with the presentation of the information, e.g. layout, use of well-understood or preferred graphical or textual format.

Whatever format is used it is essential that the same framework is used to monitor collected costs during the Project or Product lifecycle and thereby enable direct comparison between estimate and incurred cost in any feedback loop.

Typical Work Outputs:

- Product Tree
- Work Breakdown Structure
- Estimating Breakdown Structure

Note: To ensure consistency between the estimating and planning processes (PA05/BP02), the same WBS should be used in both cases. When determining the WBS an input will be the "make/buy" policy (PA13/BP01) and co-contractor considerations.

In the event of a successful engagement, the WBS will form the basis, after revision as appropriate, for the collection and segregation of the associated costs (PA03/BP02).

On certain types of contract, for "cost visibility" the client may want to agree the WBS. This may also be necessary on certain types of institutional contracts both at the estimating and post award stages (PA18/BP03).

Base Practice 05: Generate Target Costs

Description:
It is vital that when targets are set they are realistic and achievable. Utilise customer and/or market intelligence or an externally-imposed target to establish the target price for the work that is to be performed. Perform budget allocation against the WBS, taking full life-cycle costs into account. Establish cost targets based on historic costs and trends, adjusted for factors including batch/lot sizes and multi-year buy arrangements, technological advances and maturity, source dependencies etc., to determine budget contributions. Determine appropriate contractual basis type for effort. Apply weighted factoring to determine cost targets.

Typical Work Outputs:

- Target Cost Register

Note: Target costs will be required to ensure "value for money" and to enable comparison between quotes (PA13/BP02). Target costs can be generated using individual CERs (PA02/BP05) or interpretation of knowledge assets (PA14/BP02).

Base Practice 06: Establish Preliminary Programme Plan

Description:
Each work package requires a preliminary plan, using either GANTT or PERT. These plans can be resourced and are used by the estimators to allocate the costs over time in order to determine forward load, to assess cash flow, to allocate payments to milestones and to ensure any conflicts on resource/facility limits are taken into account within the estimate. The schedule is also an important consideration in assessing schedule risk and subsequent commercial contingencies

Typical Work Outputs:

- Summary Schedule

Note: The planning data required should be an output from PA05/BP03.

Base Practice 07: Generate Make/Buy Plan

Description:
From the preliminary schedule and the make/buy plan the estimator will need to know which items are to be estimated as "in house" manufacture and which should be subcontracted as purchased items. It is important that this distinction is made as many enterprises apply different process additions to each element of an estimate.

Typical Work Outputs:

- Make/Buy Plan

Note: This is a parallel exercise with Supply Chain Management PA12/BP01, where the detailed analysis on make/buy strategy takes place.

Base Practice 08: Obtain Material Costs

Description:
A detailed schedule of all materials requirements must be created: the Bill of Material (BOM) or relevant engineering drawing(s) should provide the input for this activity where they are available. This schedule is the tool by which all materials costs, including bought-out and sub-contract items are collected. Separate costs should be identified for each listed item. Whenever possible, firm quotes should be obtained for all items. If quotes are not available and costs are extrapolated from previous similar items, or else estimated, this should be clearly identified and an appropriate provision in the form of contingency/risk should be identified and included in the estimate.

Typical Work Outputs:

- 3-point estimates for supply and sub-contract items

Note: This Base Practice applies to all items within the estimate that are to be sourced outside the local organisation for inclusion in the estimate. Estimates can either be generated by the suppliers (PA13/BP05) or by use of CERs, models, database etc (PA02/BP04 or PA14/BP02). Whichever method is employed, an assessment of the

suppliers' historical performance, using the Knowledge database PA 14, along with an assessment on the value of the CERs will be required as an input into the risk identification PA06/BP01. The 3-point estimate defines the minimum, maximum and most-likely cost for the item.

Base Practice 09: Generate Detailed Estimates For In-House Work

Description:
In the case of in-house work, each line item will also require an estimate of labour hours and these should include both the time to perform the work itself and the positioning time involved in preparing to perform the work. The method of carrying out the detailed labour estimate will vary from task to task depending on various factors. The most important of these factors will be the level of information available which will decide the method of estimate. Whatever method of estimate is chosen, it is crucial that a consistent approach is taken; this includes ensuring agreement at the outset of all standards that are to be applied, and communication of the standards to all stakeholders. For best practice, it should be assumed that work will be performed by appropriately-skilled personnel operating in correctly-equipped facilities under routine conditions (i.e., at a normal work-rate). Adjustments should then be applied to account for deviations from this scenario, by the use of learning allowances and contingencies.

Typical Work Outputs:

- 3-point estimates for internal work

Note: learning curve analysis can be carried out in the knowledge database PA14/BP02 or by appropriate industry standards. Utilisation of the learning curve is addressed in BP13. The method of estimating (standard) will be determined in PA08, Define Enterprise Cost Engineering process. The Cost Breakdown structure will be generated resulting from the Cost Allocation (PA19/BP03). The 3-point estimate defines the minimum, maximum and most-likely cost for the item.

Base Practice 10: Agree Foreign Exchange Rates

Description:
During the discussions on the customer requirements, foreign currency issues should have been identified and clarified. The customer may require all cost/price data to be submitted in a specified currency. Moreover, the customer may require the use of a fixed notional exchange rate relative to the local currency. Should either condition apply, it is essential that there is clear understanding of the exchange rates to be used in calculations. It is equally important that any raw material prices and sub-contract or vendor quotes are provided on the required basis or that conversion rates are established to provide compatibility with the requirements.

Typical Work Outputs:

- Exchange rates and protection requirements

Note: It may be appropriate to seek protection against currency exchange-rate fluctuation (e.g. 'hedging') and some provision for this may need to be included in the risk assessment or in the base estimate. Moreover, some form of insurance may be available to protect against bad debts on exports. Depending on the Cost Accounting methods that are applied within the organisation (PA19), these costs may be able to be included directly within the estimate. Alternatively they may be covered within the indirect costs.

Base Practice 11: Compilation of Works Cost

Description:
The works cost is the summation of all the elements of an estimate. Depending on the customer requirements and the Cost Accounting system employed, the Works Cost may include calculated provisions related to factors such as batch size, amortisation, estimating contingency and learning allowance, and any such cost elements should be clearly justified and all assumptions fully documented. The application of labour and process rates within the estimate must be well-defined in order to provide for traceability.

In presenting the Works Cost, the interpretation of the term must be clearly understood, since several models exist, e.g.:

1. Production cost including normal estimating allowances such as batch production, learning, scrap and rework.

2. Production cost plus technical risk contingencies.

3. As (2) above plus finance charges, packing insurance and transport costs (consistent with Incoterms), import/export duties, escalation and currency fluctuations.

Typical Work Outputs:

- Works Cost

Note: There must be a clear understanding of the difference between Works Cost and Ex-Works selling price.

Depending on the basis of the contract and the payment conditions, some jurisdictions and Cost Accounting Systems allow direct provision for financing charges related to the capital employed in performing the work (i.e. cost of money), this being a function of cash-flow analysis. Where this is the case, these costs are typically not included in the Works Cost. Cash-Flow analysis is addressed at PA17/BP02.

Escalation/de-escalation considerations will depend on the commercial requirements identified in PA01/BP01, Understand Customer Needs.

Care should be taken when summing 3-point estimates, since the minimum, maximum and most-likely works cost cannot be obtained by merely by summing the minimum, maximum and most-likely costs of the constituent elements.

Base Practice 12: Calculate Contingency

Description:
This will vary depending on the class of estimate and the definition. However, the main drivers for assessing the amount of contingency to add to the basic estimate will be the quality of the information and the input from the Risk Assessment.

Typical Work Outputs:

- Contingency to be included "in price"

Note: Resulting from the Risk Analysis (PA06), a detailed risk assessment will be furnished. A probability chart has been found to be an effective means of communicating the relationship between cost and risk in order to facilitate decision on the value of contingencies that should be held and the extent of risk that the organisation is prepared to sustain within the pricing strategy. The extent of customer oversight of contingencies and risks that are held within the price will vary according to the type of contract and the customer requirements. In some circumstances, formulaic arrangements may exist in order to determine the acceptable value of contingencies that may be held within the price, e.g. the Pricing and Forecasting Group of the Defence Procurement Agency (UK Ministry of Defence - previously SPS - Specialist Procurement Services) negotiates such arrangements with UK defence contractors.

Base Practice 13: Utilisation of Learning Curve

Description:
As described at BP09 the basic estimate should assume a fully trained, experienced operator who is familiar with the task. However, in reality, this is rarely the case, particularly at the start of a new contract. It is therefore necessary to make an allowance for the time taken to learn the job. The usual method of calculating learning is by applying learning curve theory to a notional settled down value. There are several methods of applying learning curves and each organisation will have their preferred options. Learning is normally only applied to labour hours, although some schools of thought advocate applying learning to material costs to allow for excessive scrap rates during the learning phase.

Typical Work Outputs:

- Learning Curve

Note: Output is to BP09. The concept of learning infers continuous improvement over successive production items. The curve is normally defined by the following equation:

$Y = bx^{-a}$

Where Y represents the time or cost of the xth unit, b the value, in hours or cost at constant economic conditions, of the first unit i.e. the time or cost of the first unit, x is the unit number within the series, and a is the exponent or slope of the curve (learning rate):

Learning Curve %	*Exponent(-a)*
95	*.0740*
90	*.1520*
85	*.2345*
80	*.3219*
75	*.4150*

Base Practice 14: Issue Definitive Estimate

Description:
Once the estimate is completed to the requirements of the customer as defined at BP01 the issue of the estimate should be controlled in the same way as any other technical document. To this end it is necessary to have a method for tracking any future changes to the technical or contractual elements that could impact the value of the estimate. The estimate should be revised and reissued as needed.

Typical Work Outputs:

- Definitive estimate, including works cost, contingency and cash analysis

Note: Document configuration issues are capability domain considerations.

Base Practice 15: Cost Justification

Description:
When complete the estimate will be approved by enterprise management. This approval should include a review of the target cost set in PA01/BP05 against the estimate generated in PA01/BP14. The assessment will include an analysis of lessons learned and historical data, risk contingency and planning, class of estimate, cost reductions including those resulting from VA/VE, forward load implications, cash flow and adherence to cost accounting requirements.

Typical Work Outputs:

- Cost justification analysis

Note: The cost justification brings together all aspects of the estimate for presentation and approval to organisational management. This Base Practice concerns the capability of the Cost Engineering function to present & justify the basis of the estimate and therefore the application of individual processes. Inputs to the justification will be an assessment of historical performance using the knowledge database (PA14/BP02), any potential cost improvements probably resulting from VA/VE considerations (PA04/BP04), input from the risk assessment (PA06/BP03), resource and capital considerations resulting from the assessment carried out in PA15 and a check on cost allocation issues from PA19.

Process Area 02: Cost Modelling

Process Area Description

The purpose of COST MODELLING is the provision of tools and processes to support the creation of consistent and robust estimates. This may include the application of parametric techniques or the use of a more-detailed, bottoms-up, method. In brief terms simple mathematical relationships are developed and as these increase in complexity they become a "model". A model is a series of equations, ground rules, assumptions, relationships, constants and variables that describe and define the condition being studied. The Cost Model is frequently deployed and accessed as a computer software implementation.

Base Practices

01. Preliminary Model Design
02. Identify System Information Requirements
03. Data Collection
04. Data Analysis
05. Develop Models
06. Calibrate and Validate Models
07. Model Maintenance

Base Practice Descriptions

Base Practice 01: Preliminary Model Design

Description:
This will be dependent upon customer requirements, and may take the form of flowcharts to represent the model structure and storyboards to depict the user interface screens. The problems that will invariably arise throughout the development process can be minimised by the use of a requirements specification (classification requirements, storage and data access) and an agreed statement of work. The use of such documents will also provide a clear foundation on which to proceed. The model inputs and outputs will need to be defined together with the transfer functions.

Typical Work Outputs:

- Model Definition
- Preliminary Design

Base Practice 02: Identify System Information Requirements

Description:
This will be largely dictated by the customer requirements, which may also dictate the means by which the model is to be deployed and accessed. In terms of complexity and difficulty, software models that are required to be multi-user and those required to interface with external systems generally impose a greater challenge on the developer than independent stand-alone models. Where necessary, training in IT skills may be required and external consultation with IT specialist companies may be called for.

Typical Work Outputs:

- Requirement Specification.

Base Practice 03: Data Collection

Description:
There needs to be a systematic approach to data collection. The model being developed will dictate the nature of the data required. Data should be systematically collected from a number of sources such as manufacturing process information, material specifications, cost or financial charging systems, schedule, and quality requirements. Data mining techniques may be applied where large quantities of related data are available. The data will need to be sanitised, the nature of the data required being determined by the model.

Typical Work Outputs:

- Data for modelling
- Classifications of data
- Storage requirements

Note: These requirements are a necessary input to PA14 Knowledge Management

Base Practice 04: Data Analysis

Description:
The data collected will need to be organised by category, normalised and computed. The cost drivers will be identified and utilised to develop CERs. The CERs are developed on the basis of technical or physical characteristics of the products and systems and are used to identify the important parameters that have a significant impact on costs. Use statistical analysis, ensuring population count is large enough, to test the validity and sensitivity of the data.

Typical Work Outputs:

- CERs
- Categorised Data

Note: CERs are mathematical relationships that express cost as a function of one or more cost driving variables. These relationships can either be cost-cost variables (e.g. manufacture hours against quality hours) or cost-non cost variables (e.g. engineering hours against the number of drawings). CER development depends on an understanding of mathematical and statistical techniques, a subject too complex to discuss within the constraints of this paper.

Base Practice 05: Develop Models

Description:
While a SOW will provide the foundation upon which the model is to be based, it is essential to maintain frequent customer contact throughout the development process. Not only does this provide the customer with visibility of progress, it also provides them with the opportunity to request minor changes. Model development should follow a logical systems approach with version control and change documentation procedures in place. At pre-determined intervals (e.g. gate reviews) customer acceptance must be obtained before embarking on the next stage of development. In parallel with the development, it is important that the developers create clear documentation both to assist the user, and to provide for subsequent maintenance and update. Documentation may take the form of online help and / or hard copy documentation

Typical Work Outputs:

- Change Control Requirements
- Customer Acceptance

Note: Gate reviews will ensure timely availability of project deliverables and the existence and adequacy of future planning to assure completion of the model in accordance with requirements.

It is important for the analyst to remember that conditions change through technology or improvements within the enterprise; this will need consideration in the design.

Base Practice 06: Calibrate and Validate Models

Description:
Where possible, known and validated data should be used as an input to calibrate and validate the model's output. In circumstances where the model represents a known or familiar process, it may be easy to validate the output. It should be noted that the model will invariably give a slightly different result to actual values and thus it may be difficult to verify the accuracy of the model. Where significant differences occur it will be necessary to review the model and identify and correct any mistakes. In situations where there are many unknowns or the process is unfamiliar, it is recommended that comparisons be made against results generated using alternative methods of deriving an estimate. Close attention should be paid to determining any limitations to model fidelity and confirming the validity of responses over the full range of scenarios defined in the requirement. For models that are to be deployed as software applications, comprehensive User Acceptance Testing should be performed by many potential users, in order to gain user acceptance and provide additional confirmation of validity and robustness.

Typical Work Outputs:

- Calibrated model
- Validated model

Base Practice 07: Model Maintenance

Description:

Consideration should be given to the responsibility for future enhancements. The model owner (or developer) should be responsible for implementing any enhancements requested by the customer and resolving any problems with the model should they arise. In certain situations this may require some form of maintenance agreement being put in place. The customer has responsibility for ensuring that the data the model uses remains up to date and should ensure that adequate procedures are in place to review the data periodically. Feedback loop techniques are required to ensure timely update of data and procedures. In addition, provision should be made for routine re-evaluation of the on-going applicability for the defined purpose of the model.

Typical Work Outputs:

- Maintenance Agreement

Process Area 03: Cost Control & Analysis

Process Area Description

The purpose of COST CONTROL AND ANALYSIS is to monitor and control the costs against the baseline plan. The Cost Estimate generated in PA01 is validated and revised against the contract conditions. The baseline is then created.

On a periodic basis this baseline is compared against the actual value of work performed and the extent of remaining work in order to establish outturn costs. Cost Control and Analysis includes an update of the resources required, risk management, performance measurement using earned value techniques and evaluation of currency situations.

Base Practices

01. Establish Requirements
02. Confirm WBS
03. Revise Estimate
04. Establish Baseline
05. Collect Costs
06. Performance Measurement
07. Estimate to Completion
08. Assimilation of Lessons Learned

Base Practice Descriptions

Base Practice 01: Establish Requirements

Description:
The adequacy of the existing processes to control the work needs to be confirmed. This is achieved by review of the content of any applicable contract and examination of all internal (i.e. corporate/ divisional /departmental etc.) and external (i.e. customer-mandated) requirements. Methods of cost allocation and cost reporting should be reviewed to determine their adequacy. Examination of the extent, depth and frequency of cost information available through the established accounting, cost reporting and management information system(s) should be performed, in order to determine the capability of meeting the requirements. It may be necessary to consider the need for tailoring the standard cost collection or reporting approach in order to meet the requirements.

Typical Work Outputs:

- Project Plan
- Updated hardware/verification matrix
- Design and development plan
- Updated industrial plan.

Note: This is a similar exercise to Understand Customer Needs in PA01/BP01, the difference being that it is necessary to track all the changes made to the definition between submitting the estimate to the customer and receipt of go-ahead to commence the work.

Base Practice 02: Confirm WBS

Description:
Review the WBS created during the estimating phase (PA01/BP04) and implement revisions as necessary to provide improved resolution and appropriate visibility for control purposes. Adjust the WBS to account for any revisions to project scope, product tree or work distribution. The output will be used to create the Work Package codes against which actual costs will be collected.

Typical Work Outputs:

- Work Breakdown Structure Revisions
- Work Package Code Register

Note: The WBS generated for the original proposal (PA01/BP04) should be used as the basis. As far as possible a generic WBS should be implemented across all projects, to provide a systematic framework for comparison. This will enable easier capture and analysis of information within the Knowledge database PA14.

Base Practice 03: Revise Estimate

Description:
Confirm or revise as appropriate all contributory estimates generated (PA01), taking into account contingencies. Ensure the integrity and coherence of all sub-contract estimates. Re-

allocate estimates to align with any revisions that have been implemented to the WBS (BP02).

Typical Work Outputs:

- Revised internal and sub-contract estimates.
- Subcontract payment plan.

Note: This is a re-iteration of the activities carried out in PA01. Particular emphasis should be placed on those areas that have changed between the enterprise approved estimate (PA01/BP15) and contract award. Committing estimates should be sought from suppliers (PA13) to enable cash and milestone payment calculations to be finalised. There should be a complete re-assessment of the risks (PA06).

Base Practice 04: Establish Baseline

Description:
Once the estimates have been revised (BP03) it is necessary to establish the detailed and resourced schedule and then allocate resources against all activities in order to define the time-phased expenditure relative to the revised estimate. Any changes to the project timetable or activity durations that have been agreed should be taken into account. The resulting time-phased expenditure curve defines the cost Baseline (BCWS – Budget Cost of Work Scheduled). Cost collection against defined Work Package codes can commence when the Baseline has been established.

Typical Work Outputs:

- Budgeted Cost of Work Scheduled

Note: The budget at complete (BAC) is the total approved budget assigned to an element of work from inception to completion. It is synonymous with the sum of the time-phased budgeted cost of work scheduled (BCWS). The BCWS becomes the baseline, the strictly controlled, time phased, budget against which performance can be measured. This will be used for schedule performance evaluation in BP06.

Base Practice 05: Collect Costs

Description:
Collect and ratify all costs incurred against the project and ensure that these are coherent with the organisation breakdown structure and agreed method of cost allocation (e.g. overheads calculation and apportionment). Monitor and control expenditure in accordance with the established baseline.

Typical Work Outputs:

- Incurred Cost Reports
- Commitment analysis

Note: In performance measurement this metric is called the ACWP, (Actual Cost of Work Performed). This is the sum of all costs incurred and recorded in accomplishing the work performed, as shown in the general ledger accounts. This will be used to determine cost performance in BP06

Base Practice 06: Performance Measurement

Description:
Track work progress against the project plan relative to actual cost and baseline cost in order to determine the adequacy of performance relative to plan. Assess Earned Value (EV) of completed work. Monitor variances and predict likely outturns of project schedule and cost through projections based on observed trends.

Typical Work Outputs:

- Earned Value Analysis
- Cost Performance Index (CPI)
- Schedule Performance Index (SPI)

Note: Earned Value Analysis compares the value of the work that has been accomplished with the actual costs incurred and time taken to perform it. This is compared to the planned costs and duration predicted for the accomplishment. The metric BCWS defines the relationship between planned cost and duration. Implicit in this metric is the understanding that a defined work scope is represented by the BCWS, such that progress can be defined by reference to the extent of the work that should have been completed

within a given time relative to the portion of that work that was actually completed within this time. The progress metric is known as BCWP (Budget Cost of Work Performed). The associated actual costs are defined as ACWP (Actual Cost of Work Performed). Several analyses can be performed when these metrics are available.

The CV (Cost Variance) is the difference between the Budget Cost of Work Performed (BCWP) and the Actual Cost of Work Performed (ACWP):

$$CV = BCWP - ACWP$$

Where a positive variance indicates an 'under-run' (spent too little) and a negative variance indicates an 'over-run' (spent too much).

The CPI (Cost Performance Index) is a measure of cost efficiency or productivity, which is calculated as: -

$$CPI = BCWP / ACWP$$

Where a CPI>1 indicates that efficiency is better than planned, whilst a CPI<1 indicates efficiency is worse than planned.

The SPI (Schedule Performance Index) is a measure of schedule efficiency or productivity, which is calculated as follows: -

$$SPI = BCWP / BCWS$$

Where an SPI>1 indicates that efficiency is better than planned, whilst an SPI<1 indicates efficiency is worse than planned.

Base Practice 07: Estimate to Completion

Description:
Bottom up re-estimates of costs to complete should be compiled on a regular basis, taking into account performance, agreed changes and progress in order to validate the project cost outturn. The estimate to completion will include an update of the cost of sales (i.e. the value of payments by the customer for work done) and the cost of orders (i.e. the value of the work that the customer has agreed to pay for).

Typical Work Outputs:

- Estimate to Complete
- Estimate at Complete
- Cash Analysis
- Sales and orders forecast

Note: A verification of the estimate should be carried out periodically using bottom up techniques.

$$EAC = ACWP + ETC.$$

The ETC (Estimate To Complete) is the estimated cost to complete all remaining, authorised, work from Time Now to completion.

The Budget At Complete is the authorised value of the overall effort. An independent, synthetic estimate of the Forecast-At-Complete costs can be established using metrics:

$$FCAC = ACWP + (BAC-BCWP)$$

An independent synthetic estimate of the forecast completion date can be derived to compare against the results of the critical path analysis:

(BCWP-BCWS)/(BCWP/Elapsed months)

Base Practice 08: Assimilation of Lessons Learned

Description:
Cost and schedule performance information from prior projects should be utilised in performance assessment and forecasting. Ensure availability of normalised data from previous projects to support re-use of data.

Typical Work Outputs:

- Lessons Learned Analysis
- Project Close-Out Report

Note: Capture of required data is included in Knowledge Management PA14.

Process Area 04: VA / VE & Cost Reduction

Process Area Description

VA / VE (Value Analysis and Value Engineering) is a function oriented, systematic approach to the provision of value in a product, system or service. Often this improvement is focused on cost reduction, but other improvements such as customer quality and performance are important in the "value" equation.

VE is unique because it is based on function analysis, not only cost reduction. It requires the examination of the functions of a product or process. A technique often used is the Function Analysis System Technique (FAST), which defines a basic function and models its relationship with higher and lower level functions by determining how the functionality is delivered and testing the validity of the each function by asking why it is performed. Creative techniques are then used to define alternate means of performing the function at lowest cost without degrading quality or performance.

Base Practices

01. Gather Information
02. Consider Alternatives
03. Analyse Alternatives
04. Develop Proposals
05. Implementation

Base Practice Descriptions

Base Practice 01: Gather Information

Description:
Gather essential information so that the functions of the item or system can be analysed. What is it, what does it do, what does each function cost.

Typical Work Outputs:

- Function Analysis
- Breakdown of Function Costs

Base Practice 02: Consider Alternatives

Description:
Consider the alternatives that are capable of performing the basic functions. Use creative techniques like brainstorming and involve all team members.

Typical Work Outputs:

- Analysis of alternatives

Note: Brainstorming is employed in order to maximise creative output within a restricted time. All ideas are assumed to be equally valid and worthy of subsequent analysis. Within the session, judgement and criticism are prohibited to encourage maximum participation from all team members. The output of this analysis is to BP03.

Base Practice 03: Analyse Alternatives

Description:
Compare alternatives generated (BP02) with the requirements criteria. If they do not meet the criteria, they are dropped. The remainder are then ranked in order of feasibility and cost.

Typical Work Outputs:

- Retained alternatives
- Feasibility and cost analysis

Note: The input to this activity is from BP02. The refined alternatives are ranked in order of feasibility and cost and then provide the input to BP04.

Base Practice 04: Develop Proposals

Description:
The most promising alternatives are developed into proposals for review. The proposals are analysed for technical viability, estimated cost, accuracy, advantages and disadvantages.

Typical Work Outputs:

- Proposals for presentation

Note: The input to this activity is from BP03. The output from this activity is a formal proposal to the key stakeholders. Any presentation should be tailored to the audience but should include illustrations, drawings etc. All contributions from participants should be acknowledged along with any barriers.

Base Practice 05: Implementation

Description:
The developed alternatives are presented to a review panel. Following acceptance, implementation should commence with the creation of a detailed implementation plan. After implementation has commenced, the plan should be monitored to ensure realisation of the anticipated benefits.

Typical Work Outputs:

- Implementation Plan

Note: The implementation plan should be realistic (using base practices described in PA05 Planning), responsibilities should be well defined with key barriers to implementation identified in BP04 anticipated and mitigated by use of risk techniques described in PA06 (Risk Planning). Benefits should be measured using process techniques described in PA11(Ensure Quality).

Process Area 05: Planning

Process Area Description

The purpose of PLANNING is to provide a dynamic model to describe the anticipated behaviour of the project, in terms of what should be done and when it should be done, in order to accomplish the stated objectives. The model should be baselined at the outset and then updated during the period of performance in order to monitor and control the schedule.

Project planning involves a detailed consideration of all the activities needed to complete the project, estimates of how long each activity will take and definition of the relationships between the activities. The relationships order and constrain the activities and thus define establish how the project proceeds and how quickly it can be completed.

Base Practices

01. Establish Requirements
02. Confirm WBS
03. Preliminary Schedule
04. Critical Path Analysis
05. Set Target Schedules
06. Schedule Status
07. Lessons Learned

Base Practice Descriptions

Base Practice 01: Establish Requirements

Description:
Activity schedule planning requirements for a given engagement will depend on the complexity of the undertaking, the Work Breakdown, the number of people, disciplines/functions and organisations involved, the dependencies between their activities, the requirements of the customer and the methods of reporting and control that are to be applied. Where complex systems are being planned and where the work content will be distributed between separate organisations or locations, a nested or layered approach is frequently employed. In this case, the compatibility between planning and reporting tools and techniques employed by the participants should be investigated. Careful consideration must be given to the achievement of balance between the level of detail manifest within the plan and the requirement for flexibility to respond to future changes in scope or approach within the undertaking. An over-elaborate plan should be avoided, since this will prove difficult to maintain. Where there is a need to control and integrate the work of different organisations or sites, this can be achieved within the plan by the use of milestones to identify transactions and interfaces between the participating organisations: performance against the schedule requirements should be capable of being monitored and controlled effectively by the selection of milestones that align to key points in the progress of the project: these are likely to correspond to events with financial significance, e.g. payment triggers, or events with control significance, e.g. gate reviews. To provide benefit in performance measurement terms, it is important that the relationship between the activities presented in the schedule planning and those presented in the cost planning is clear.

Typical Work Outputs:

- Project Plan
- Schedule Architecture
- Hardware/Verification Matrix
- Design and Development Plan
- Industrial Plan

Note: This Activity is carried out concurrently (same exercise) with PA01/BP01, Understand Customer Needs during the proposal phase and with PA03/BP01, Establish Requirements, during the contract phase. The cost allocation is provided byPA19.

Base Practice 02: Confirm WBS

Description:
Review initial WBS and implement revisions as necessary to provide improved resolution and appropriate visibility for control purposes. Adjust for any revisions to project scope, product tree and work distribution.

Typical Work Outputs:

- Work Breakdown Structure Revisions
- Schedule architecture map to WBS, key control points and Work Package Codes

Note: This Activity is carried out concurrently (same exercise) with PA01/BP04, Create WBS, OBS, PBS (Product Tree), during the proposal phase & with PA03/BP02, confirm WBS post-award.

Base Practice 03: Preliminary Schedule

Description:
This requires detailed consideration of the activities required to complete the project. There is a need to determine realistic durations of the time needed to complete each activity and to evaluate the relationships between the activities. It is frequently helpful to adopt a top-down tiered approach, incorporating an increasing level of detail at each successive level. This assists in defining the durations of the phases of the lifecycle to be covered within the plan. External constraints should be taken into account, for example the availability of resources or facilities needed to perform the work. These relationships establish how the project will proceed and identify the duration of the project. Once the durations, logical relationships and constraints have been established, it may be necessary to rearrange the remaining elements of the work sequence in order to achieve the customer needs. Given an understanding of the effort involved in performing each defined work element, the schedule will assist in identification resource requirements to complete the project in accordance with customer needs.

Typical Work Outputs:

- Level 1, 2 and 3 schedule

Note: The preliminary Programme schedule is required in PA01/BP06, Cost Estimating, Determine Preliminary Programme Plan, and for the Risk Identification PA06/BP01.

Base Practice 04: Critical Path Analysis

Description:
Once the links between activities have been established, it is possible to calculate, for any activity, the earliest date on which it could start: this is accomplished by calculating the sum of the durations of all activities on each logical path leading to the start of the activity: the earliest start date is the shortest overall duration. Similarly, the latest start date is the longest possible duration. By calculating each logical path through from the start of the project to the end of the final activity, it is possible to determine the longest possible path from the first activity to the last activity: this is the critical path. By repeating the logic path tracing process in reverse, i.e. working from the final activity back to the start of the project, it is similarly possible to calculate the earliest and latest finish dates for each activity. The forward and backward analyses are known as the 'forward pass' and the 'backward pass' respectively. The information obtained thus enables the analyst to determine which activities must be started on time in order for the plan to be completed to schedule and which activities can be delayed without impacting the outturn. Moreover, it potentially enables the overall duration to be reduced by reducing durations, e.g. by making additional resources available in order to complete critical activities earlier. Risk mitigation action is also possible since the information provided by the Critical Path Analysis may identify means by which the sequence of activities can be rearranged to reduce the criticalities.

Typical Work Outputs:

- Preliminary critical path analysis
- Schedule optimisation

Base Practice 05: Set Target Schedules

Description:
Once BP04 is complete the schedule target can be set. This represents the schedule that must be achieved in order to complete the work by the target end-date and provides the baseline for schedule reporting.

Typical Work Outputs:

- Target Schedule

Note: Target dates are set for the original project plan so that as work progresses the current schedule and actual dates (BP06) can be compared to the original plan. The

target schedule will be used in PA03/BP04 to establish the BCWS.

Base Practice 06: Schedule Status

Description:
Once work is underway, the progress against the target schedule should be monitored and updated regularly. Any activity that has been started or finished since the previous update should be progressed as should all activities already underway. Where activity completion dates are expected to alter as a result of greater or lesser progress than expected, the schedule should be revised accordingly. Such alterations will lead to changes to the critical path and this must therefore be analysed in order to identify and resolve changes and impacts. Where there is a shortfall in progress, replanning, for example the allocation of additional resources, should be contemplated if the work is to be completed in accordance with the plan.

Typical Work Outputs:

- Updated Schedule Analysis and Critical Path

Note: The targets for comparison of the update are generated in BP05. The output from the analysis is required for performance measurement (PA03/BP06) and will impact the time at which future costs are incurred and the Estimate to Complete (PA03/BP07). The Critical Path Analysis should be compared against the independent forecast completion date generated in PA03/BP07, Cost analysis, Prepare Estimate to Completion

Base Practice 07: Lessons Learned

Description:
Cost and schedule performance information from prior projects should be utilised in all performance assessment and forecasting activity. It is therefore important to ensure that normalised data is available from previous projects to support re-use of data.

Typical Work Outputs:

- Lessons Learned Analysis
- Project close-out report

Note: Capture of required data is included in Knowledge Management PA14.

Process Area 06: Risk Management

Process Area Description

The purpose of RISK MANAGEMENT is to identify, assess, monitor and mitigate risks to ensure the success of the project. For Cost Engineering this Process Area is essential to the definition of the cost-risk trade-space and the prediction of outturn costs.

All projects have risks that are not easily recognisable and these must be identified and reflected within the estimating process. All potential risks, both known and unknown, need to be identified prior to engagement in order to plan and estimate successfully. Capitalisation of lessons learned and the application of brainstorming techniques are two of the means used to identify potential risks. Costs need to be identified both for reducing the probability of the risks happening and for reducing the gravity of the risks should appropriate triggers activate them.

Base Practices

01. Risk Identification
02. Risk Analysis
03. Financial Quantification
04. Risk Reduction Planning
05. Risk Monitoring and Control

Base Practice Descriptions

Base Practice 01: Risk Identification

Description:
A risk register should be compiled in order to capture all risks that may impact on project performance. Conventionally, all members of the project team and discipline specialists are involved in this activity. Risk capture may involve the performance of a SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis which should help to identify the risks and may identify means for reducing gravity or probability of risk realisation.

Typical Work Outputs:

- SWOT Analysis

Note: output is to BP02. The development of risk checklists is highly recommended. The SWOT analysis provides a structured analysis framework that can be applied to an individual project or to the overall business area to identify the following characteristics:

Strengths - i.e. what are the robust aspects of the undertaking?

Weaknesses - i.e. in what respects is the undertaking deficient?

Opportunities - i.e. what improvements could be made?

Threats - i.e. which issues, if not addressed, may undermine the success of the venture?

Each category contributes to the formulation of a strategy or plan that will be designed to exploit Opportunities and overcome Threats. In developing the strategy or plan, the intent should be to reduce reliance on Weak areas and maximise the utilisation of Strong areas.

Base Practice 02: Risk Analysis

Description:
Establish risk gravities and probabilities for each risk identified in BP01 and rank against thresholds in order to establish treatment priorities. The project team members should contribute to the determination of the threshold values. Risk avoidance and/or mitigation strategies should be developed and the use of cause and effect diagrams may be useful in this activity. For each risk identified, trigger events should be defined: these are the events that will initiate the actions to reduce the gravity of the risk.

Typical Work Outputs:

- Risk weighting and scattering diagram
- Cause and effect analysis

Note: Input from BP01, output to BP03. Cause and Effect Diagrams, also known as Fishbone diagrams, are not able to show complex cause and effect linkages. Tree Diagrams and

Relation Diagrams may be more suitable where this is necessary.

Base Practice 03: Financial Quantification

Description:
The cost impact of realising each risk and the associated avoidance and mitigation strategies should be determined. Ensure that the rationale for financial provisions is clear, delineating those risks that are not separately addressed (i.e. included in project general contingencies or margins) and those risks for which specific provision is required. Ensure that each risk path is unequivocal (i.e. does not include mutually exclusive risks) and that costs are uniquely identified (i.e. are not covered by separate provisions in different areas of the WBS).

Typical Work Outputs:

- Risk cost estimates
- Risk impact summary

Note: Input from BP02, output to BP04.

Base Practice 04: Risk Reduction Planning

Description:
It is important to quantify the programmatic impact of realising each identified risk versus the impacts of the associated avoidance and mitigation strategies. The interdependence of cost and schedule in outturn prediction must not be overlooked, i.e. an avoidance or mitigation strategy with low implementation costs can prove unacceptably expensive when it results in late delivery and associated penalties. Risk trigger dates should be identified and plans prepared by which mitigation and avoidance strategies are to be implemented. The costs associated with consequent schedule extensions should be identified and taken into account in formulating the risk strategy. Where the programmatic impact is favourable, the risk costs should be updated, where the programmatic impact is unacceptable, an alternative strategy should be established.

Typical Work Outputs:

- List of triggers
- Risk Plan

Note: Input is from BP03. The risk reduction and mitigation actions will impact on the schedule developed in PA05/BP03 Planning, preliminary schedule. The probability reduction actions (PRA) will need inclusion in the works cost generated in PA01/BP11 Estimating, Compilation of Works Cost. The Gravity Reduction Actions (GRA) will become part of the contingency generated in PA01/BP12. Risk triggers should be identified on the project plan (PA05/BP06) and included in the risk plan for monitoring in BP05.

Base Practice 05: Risk Monitoring and Control

Description:
Risk status should be routinely monitored and corrective action initiated in a timely manner. The risk condition of any activity will change as time proceeds and so the gravity and probability of identified risks should be subject to routine re-assessment. Previously-identified risks must be retired when their onset is no longer possible and due revisions made to the provisions held against their eventuality. When risks are realised, the cost and schedule provisions must be released in time to implement corrective action. To address new risks as they become apparent, means to capture them and implement appropriate revisions to cost and schedule should be established.

Typical Work Outputs:

- Updated Risk Plan

Note: The risk plan is output from BP04. Triggers are identified on the schedule maintained in PA05/BP06. The risk provisions included in the baseline determined in PA03/BP04 should be transferred to the budgets for individual work elements when the risk is triggered. Change Control measures should be in place to ensure that movements are recorded. On risk retirement, related provisions may be transferred to margins or returned to general provisions.

Process Area 07: Competences Management

Process Area Description

The purpose of COMPETENCES MANAGEMENT is to ensure that the necessary knowledge and skills are available to achieve the objectives of Cost Engineering within the organisation. The available knowledge and skill requirements (competences) need to be identified and compared to the organisations needs. Training, either internally or externally-sourced, may be used to remedy identified shortcomings.

Competence improvement is not limited to the classroom but includes all aspects of skills enhancement and the building of knowledge.

Base Practices

01. Identify Needed Improvements in Skills and Knowledge
02. Evaluate and Select Appropriate Mode of Acquiring Knowledge and Skills
03. Prepare Training Manuals
04. Train Personnel
05. Maintain Records of Training and Experience

Base Practice Descriptions

Base Practice 01: Identify Needed Improvements in Skills and Knowledge

Description:
This Base Practice determines the improvements that are needed in skill and knowledge within the organisation. Skill and knowledge needs derive directly from organisational requirements. Current and future requirements are related to the organisational strategies and the requirements of the current workload. The extent to which the requirements can be met from within current establishment resources can be determined by the creation of a skills and knowledge matrix for existing personnel. Comparison of existing skills and knowledge assets with current and future requirements will thus enable the needed improvements to be defined. The ability of the organisation to deliver the needs from within the establishment will become apparent by examination of the capabilities that can be delivered by existing training programmes and the entry skills required to undertake the training. Project inputs can help to identify existing deficiencies, which may be remedied through training or acquisition of skills and knowledge by other means. Skills and knowledge improvements can also be achieved through the delivery of enhancements in Information Technology assets and the potential for making-good any deficits through such means should be investigated. Identification of skill and knowledge needs should also address how training delivery can be consolidated to achieve efficiencies of scale, and how training needs can be reduced by the implementation of common tools.

Typical Work Outputs:

- Training needs
- Skill and competence database.

Note: Additional training requirements for individuals can be identified through the appraisal process. Each project or function within the enterprise should maintain a training plan against its specific needs.

Base Practice 02: Evaluate and Select Appropriate Mode of Acquiring Knowledge and Skills

Description:
Project and organisation needs should be analysed since they may place constraints on the means by which current skills and knowledge can be augmented. In addition to conventional training courses, alternative means of skills transfer, such as the use of consultants, or acknowledged discipline experts may be appropriate.

Whilst it is likely that this activity will focus on improving the skill-base of the organisation, other means of skill and knowledge acquisition should not be overlooked, particularly when the cost of developing the necessary competence does not result in residual benefit to the organisation: under such circumstances there is a strong argument in favour of outsourcing to counter the skill deficit.

Typical Work Outputs:

- Study result on how to acquire knowledge
- Assessment of skill types
- Training Plan
- Alternate skill sources

Note: The organisational objectives, the availability of core skills internally and the deadlines for availability of the required skills will influence the costs of training programme delivery.

Base Practice 03: Prepare Training Materials

Description:
Where skills and knowledge are to be augmented through training delivery, it is important to address the design of training materials in a systematic manner. Thus, it may be appropriate to establish clear requirements to describe the scope of training, the means by which the training is to be delivered, the expected result of training and the means by which effectiveness are to be verified. Training materials may be developed within the organisation or else by an external contractor. In either case, procedures should be developed to evaluate and improve the effectiveness of any training, and this is likely to include provisions for initial pilots and review of training materials both by domain experts and by trainees from the pilot courses.

Typical Work Outputs:

- Course Description
- Training Material

Note: Course description should include intended audience, the training objective, training duration requirement, and the criteria to determine satisfactory completion of the training.

Base Practice 04: Train Personnel

Personnel should be trained to meet the requirements of the training plan using the materials developed in BP03

Typical Work Outputs:

- Trained Staff
- Analysis of course problems

Note: to ensure retention of knowledge, training should be provided on a Just-in-Time basis. It is important to ensure that the existing skill level of course candidates is carefully established to ensure that the training is appropriate. Incentives could be considered to improve uptake of training. Consideration should be given to Computer Based Training.

Base Practice 05: Maintain Records of Training and Experience

Description:
In order to maintain awareness of current capability, it is important that records are maintained to track the training that each employee has received. These records should inform recruitment activity and measures should exist to ensure the capture and validation of the skills and knowledge of new entrants and to update the records following termination.

Courseware material should be stored in a manner that facilitates future access and controls the configuration of training assets. Means of promoting the awareness of available training materials should be considered in order to encourage elective participation.

Typical Work Outputs:

- Training and competence records
- Configured training materials
- Record of revisions

Note: Records are kept of all employees training to aid the appraisal process and to inform the assignment of staff and managers. Lessons learned from the training sessions should be included in updates to course materials.

Process Area 08: Define Organisation's Cost Engineering Process

Process Area Description

The purpose of DEFINE ORGANISATION'S COST ENGINEERING PROCESS is to create and manage the standard Cost Engineering process, which can then be tailored to specific circumstances. This process involves defining, collecting and maintaining the process that meets the business objectives of the organisation as well as the needs of the client.

Base Practices

01. Establish Goals for the Organisation's Cost Engineering Process
02. Develop a Well-Defined Standard Cost Engineering Process
03. Define Guidelines for Tailoring the Standard Process for Special Situations

Base Practice Descriptions

Base Practice 01: Establish Goals for the Organisation's Cost Engineering Process

Description:
Internal and external drivers will impact the Cost Engineering process within the organisation. This must be recognised in order to establish the standard practice. The process goals should consider the financial, quality and human resource issues important to the success of the operation as well as the requirements of the client.

Typical Work Outputs:

- Goals of Cost Engineering Function
- Requirement of Standard Process

Note: The goals of the Cost Engineering function will be an input to the Knowledge database requirements (PA14/BP01) and will be used to define the required process BP02

Base Practice 02: Develop a Well-Defined Standard Cost Engineering Process

Description:
The organisation's standard Cost Engineering process is developed using the goals generated in BP01 and by reference to the organisational, national and international standards. New processes should be added as required. The organisation's standard Cost Engineering process should be documented and placed in the company procedure system

Typical Work Outputs:

- Standard Process
- Inputs to Training
- Inputs to Process Improvement

Note: Requirements may need to consider prevailing institutional or industry requirements (e.g. standard conditions of tender) and international standards e.g. ISO.

Base Practice 03: Define Guidelines for Tailoring the Standard Process for Special Situations

Description:
Since the organisation's standard Cost Engineering process may not be suitable for every situation, guidelines for tailoring it are needed. The guidelines should be designed to fit a variety of situations, whilst not allowing any undertaking to bypass standards that must be followed or substantial and important practices prescribed by the policy of the organisation.

Typical Work Outputs:

- Tailored Guidelines for new Standard Process

Note: Guidelines should be set to enable a tailored approach to the classes of estimate in PA 01/BP02, Cost Estimating Classes of estimate. The Base Practice will also determine when it is appropriate to apply alternative techniques to the estimating process (Cost Modelling PA02/BP07, DTC PA12/BP43). Tailoring may also take account of the skills and experience of the practitioners (PA07/BP04).

Process Area 09: Improve Organisation's Cost Engineering Process

Process Area Description

The purpose of IMPROVE THE ORGANISATION'S COST ENGINEERING PROCESS is to continuously improve the effectiveness and efficiency of the Cost Engineering process within the organisation. The requirement is to develop an understanding of the process in the context of the organisation's strategic goals, to analyse the performance of the process, and to undertake the planning and implementation of the required improvements to the process.

This area covers the continuing activities that measure and improve the performance of the Cost Engineering process within the organisation. The definition of the standard process is covered in PA08. Appraisal of the effectiveness of the current practices can be carried out using the CECIM in order identify the areas where improvement is needed.

Base Practices

01. Appraise Strengths and Weakness of Existing Process
02. Plan Improvements
03. Communicate Process Improvements to Affected Groups

Base Practice Descriptions

Base Practice 01: Appraise Strengths and Weakness of the Existing Process

Description:
Understanding the strengths and weaknesses of the processes currently being performed in the organisation is a key to establishing a baseline for improvement activities. Measurements of process performance and lessons learned should be considered in the appraisal. Appraisal can occur in many forms, and appraisal methods should be selected to match the culture and needs of the organisation.

Typical Work Outputs:

- Performance Analysis
- SWOT
- Maturity Profiles

Note: Use the EACE CECIM. For details of SWOT analysis see PA06/BP01.

Base Practice 02: Plan Improvements

Description:
Appraising the process provides momentum for change. This momentum must be harnessed by planning improvements that will provide the most payback for the organisation in relation to its strategic goals. The improvement plans provide a framework for taking advantage of the momentum gained in appraisal. The planning should include targets for improvement that will lead to high-payoff improvements in the process.

Typical Work Outputs:

- Process Improvement Plan
- Measurement metrics

Base Practice 03: Communicate Process Improvements to Affected Groups

Description:
Some process improvements may be useful to ongoing work, and these may be able to be incorporated into the current process depending upon the status of the work. Other parties, e.g. those responsible for training, quality assurance, measurement, etc., should be informed of the process improvements.

Typical Work Outputs:

- Schedule for Incorporating Changes
- Update of Training Plan

Note: It is important that the process improvements, rationale and expected benefits are effectively communicated to all players within the organisation including those disciplines that interface with the Cost Engineering function. The input to the training plan is for PA07/BP01.

Process Area 10: Integrate Disciplines

Process Area Description

The purpose of INTEGRATE DISCIPLINES is to identify the disciplines necessary for effective Cost Engineering to ensure that they can work together towards the organisation's objectives. These disciplines are likely to include Engineering, Finance, Commercial, Project Management, Manufacturing, Quality (and others). It is important that the disciplines are integrated into a co-operative environment. It is important to ensure that the right information gets to the team members in a timely manner.

Base Practices

01. Involve the Disciplines that are Essential to Successful Cost Engineering
02. Establish Methods for Interdisciplinary Co-Ordination
03. Develop and Communicate Goals
04. Communicate Results

Base Practice Descriptions

Base Practice 01: Involve the Disciplines that are Essential to Successful Cost Engineering

Description:
Efficient and effective systems result from a blending of the efforts of people from many disciplines. These people should be identified and involved in the processes that affect them, in time for effective collaboration.

Typical Work Outputs

- Listing of Disciplines
- Schedule for Integrating Disciplines

Note: The Cost Engineer must be cognisant with the concerns of all disciplines in generating his outputs and ensure their involvement. In PA03 (Cost Control & Analysis) the disciplines will be involved in the delivery of the work content and status reporting related to the estimates generated in PA01 (Cost Estimating). Engineering support will be needed to develop the cost models in PA02 & will also be involved in VA/VE (PA04).

Base Practice 02: Establish Methods for Interdisciplinary Co-Ordination

Description:
In addition to understanding the roles of the various disciplines and appreciating what information it is necessary to share, the Cost Engineer must understand how to share knowledge, i.e., the particular methods of getting information from an individual or group to others who need it. In addition, the Cost Engineer must recognise that other specialities may have their own processes that will need to be integrated with that of Cost Engineering.

Typical Work Outputs:

- Methods for Co-ordination

Base Practice 03: Develop and Communicate Goals

Description:
For the Cost Engineering process to proceed with reasonable smoothness, each stakeholder must know and work toward the same goals. These goals must be clearly developed and communicated to every member of the staff and other affected groups and individuals.

Typical Work Outputs:

- Developed Goals for Disciplines

Note: Examples of project objectives include cost/schedule, quality/cost, quality/schedule. Quality metrics are developed in PA11/BP03, Ensure Quality, analyse measurements.

Base Practice 04: Communicate Results

Description:
The results of interdisciplinary activities will include alternatives considered, the decisions made, and the rationale for the decisions. These results must be communicated promptly to affected groups and individuals.

Typical Work Outputs:

- Briefing to Disciplines

Process Area 11: Ensure Quality

Process Area Description

The purpose of ENSURE QUALITY is to address the quality of the Cost Engineering process. A high quality process can only be maintained if a mechanism exists to continuously measure, analyse and take corrective action.

Successful quality requires that the quality efforts be integrated throughout the disciplines and supporting processes. Quality variances that can be looked at include what the customer requires from analysis and reports, including the presentation of the reports.

Base Practices

01. Ensure Defined Process is Adhered-To
02. Measure the Quality of the Cost Engineering Process
03. Analyse Quality Measurements to Develop Recommendations for Quality Improvement
04. Initiate Activities that Address Identified Quality Issues or Quality Improvement Opportunities

Base Practice Descriptions

Base Practice 01: Ensure Defined Process is Adhered-To

Description:
Ensure that the execution follows the process defined for Cost Engineering. Compliance should be checked at regular intervals. Deviations from the defined process and the impact of the deviation should be recorded.

Typical Work Outputs:

- Recorded deviations from process
- Recorded impact of deviations

Note: there are several methods of monitoring the defined process. These include dedicated resources to observe all or some of the activities or taking samples of the work products.

Base Practice 02: Measure the Quality of the Cost Engineering Process

Description:
Measuring the characteristics of the work product provides an indication of the quality of the system. Measurements should be designed to assess whether the work outputs meet customer requirements. Measurements should also be designed to help isolate problems within the process. The process that is used to create a quality product is as important as the quality of the product. It is important to have a process that is checked by measurement so that problems are caught early, before the final work product is produced and found to not meet requirements. Therefore, having a process that is measured may lead to less waste and higher productivity.

Typical Work Outputs:

- Process Quality Certification

Note: An example of measuring the work product quality is to carry out an analysis of the Estimate values throughout the project / product life cycle (Knowledge management PA14/BP02 and Cost analysis PA03/BP07)

Base Practice 03: Analyse Quality Measurements to Develop Recommendations for Quality Improvement

Description:
Careful examination of all of the available data on product, process, and project performance can reveal causes of problems. This information will then enable improvement of the process and product quality.

Typical Work Outputs:

- Analysis of Deviations
- Defect Reports
- Quality Trends
- Corrective Action Recommendations
- Cause and Effect Diagrams

Note: For cause and effect diagram information see PA06/BP02

Base Practice 04: Initiate Activities that Address Identified Quality Issues or Quality Improvement Opportunities

Description:

In order to continuously improve quality, specific actions must be planned and executed. Specific aspects of the process that jeopardise product or process quality need to be identified and corrected. This would include minimising cumbersome or bureaucratic systems.

Typical Work Outputs:

- Quality Improvement Plan
- Process Revisions
- Recommendations for Improving Process

Note: For effective implementation of the improvement activities, participation of the Cost Engineering and inter disciplinary teams should be encouraged. Use EACE CECIM.

Process Area 12: Design to Cost & CAIV

Process Area Description

The purpose of DTC/CAIV is to focus on Cost Performance trade offs in setting system Programme objectives. The process formalises the Cost and Performance trade offs that are needed to arrive at an affordable balance between cost, performance and schedule. The process requires the setting of realistic cost targets for systems and then managing the risks so that these objectives can be met. Cost can then be considered to be another system constraint on an equal footing with conventional performance parameters such as mass and thus worthy of similar analytical treatment within the system definition and development processes. DTC is intended to apply to all phases of the system life cycle to achieve the best balance between the cost of the various phases, performance and schedule.

Base Practices

01. Understand Mission Goals, Affordability, Engineering and Management Plans.
02. Identify Candidate Solutions
03. Cost/Performance/Risk Trade Studies
04. Refine Mission Requirement to Meet Cost Constraints.
05. Track Progress During Project Life Cycle

Base Practice Descriptions

Base Practice 01: Understand Mission Goals, Affordability, Engineering and Management Plans

Description:
In order to apply CAIV/DTC techniques, it is necessary to have a full understanding of the objectives: this enables segregation of the essential minimum requirements from the desirable attributes and thus defines the trade space in which the variables can be optimised. Cost budgeting is addressed in PA01/05. The implementation of Performance-Based Specifications assists in the process, by providing the maximum flexibility for the definition of appropriate configurations that meet the objectives, without the imposition of unnecessarily prescriptive constraints.

Typical Work Outputs:

- Trade Space Definition

Base Practice 02: Identify Candidate Solutions

Description:
In many circumstances, there may be a number of different schemes, configurations or technologies that could form the basis for the solution that is ultimately selected. Candidate configurations must therefore be identified at an early stage. Each candidate may require multiple trade studies to be performed at different levels of the product tree in order to establish the optimal configuration. Decision analysis techniques may prove useful at this stage in preparing a shortlist of candidate solutions.

Typical Work Outputs:

- Candidate Solutions Listing

Base Practice 03: Cost/Performance/Risk Trade Studies

Description:
Trade studies should be performed to determine the interdependencies between cost, performance, schedule and risk and thus identify the major system drivers and sensitivities: the overall lifecycle must be taken into account in determining system costs. Maximum use should be made of CERs in estimating costs. Trade studies should address the boundary conditions imposed by the system requirements and explore the impacts of providing different levels of functionality that meet or exceed the identified performance thresholds. Trade studies should address the relationships between the trade study elements at different levels within the product tree, since sub-optimal subsystem configurations may be necessary in order to achieve optimal system configuration: implicit in this process is therefore the need to allocate margins, requirements and budgets at subsystem level. It is essential to investigate the relationships in the margins beneath the required performance thresholds in order to identify areas in which minor relaxation of the performance requirements could result in major benefits in cost, schedule or risk reduction. Particular attention must be given to areas in which high rates of change are identified in

one trade element without commensurate changes in the other factors, since it is here that the maximum potential for optimisation exists. Where performance windows are specified, it is important to investigate each of the boundary cases, to avoid the definition of a point-solution that fails to satisfy all conditions.

Typical Work Outputs:

- Trade Studies

Note: CERs developed in PA02/BP04, Cost Modelling, Cost Analysis.

Base Practice 04: Refine Mission Requirement to Meet Cost Constraints

Description:
The results of the trade studies should be reviewed to identify candidate solutions that satisfy all imposed criteria. Where no candidates meet the requirements, it is necessary to identify the solutions that offer the closest matches. At this stage, it is necessary to establish how the requirements can be relaxed with minimum impact in order to enlarge the trade space. The trade study output should highlight those requirements where marginal reductions will yield maximum benefits.

Typical Work Outputs:

- Proposed Requirement Revisions

Base Practice 05: Track Progress During Project Life Cycle

Description:
During the project cycle, it is necessary to regularly revalidate the cost estimates for the overall mission or product life cycle, to confirm that the cost targets will be achieved. The elimination of early uncertainties may provide opportunities for reallocation of budget margins.

Typical Work Outputs:

- Revalidated Estimates
- Progress Reports

Note: Budget margins adjusted in PA03/BP07, Cost Analysis Estimate to complete

Process Area 13: Supply Chain Management

Process Area Description

The purpose of SUPPLY CHAIN MANAGEMENT is to manage and control all aspects of the supplier or sub-contractor interface. This commences in the proposal phase when the make/buy plan is developed against the internal strategy in order to determine which elements should be procured from outside sources. Quotes received from the outside sources are subject to value for money appraisal as part of the selection process. During the contract phase supplier prices are then baselined and paid against milestone achievement. All changes are agreed and negotiated.

Base Practices

01. Prepare Make/Buy Plan
02. Issue RFQs
03. Review Supplier Quotes
04. Select Supplier
05. Analyse and Negotiate Claims and Changes
06. Approve Invoices and Milestone Achievement
07. Close Out

Base Practice Descriptions

Base Practice 01: Prepare Make/Buy Plan

Description:
The WBS and requirements should be analysed and internal competences identified, in order to determine those activities for which a preference to create work products in-house exists. A gap analysis should be performed and all synergies with the organisation's strategy should be identified in order to inform the Make/Buy decisions. Capacity impacts should be reviewed to confirm that capacity is adequate for those work elements desired to be undertaken in-house. Potential external sources should be identified, and the possibility of establishing beneficial teaming agreements or virtual enterprise arrangements investigated.

Typical Work Outputs:

- Make/Buy Plan

Note: Input for the target costs will be provided from PA01/BP07, this is a parallel activity to PA01/BP08, Obtain Material Costs. The opportunity for the implementation of teaming and virtual enterprise arrangements may be influenced by pre-existing agreements made at organisational or project level.

Base Practice 02: Issue Requests For Quotation

Description:
RQP preparation should commence with the preparation of an RFQ plan and schedule. It is advisable to perform a requirements scrub to ensure that all essential and relevant provisions of customer-imposed requirements are mandated without inclusion of unnecessary or irrelevant requirements. Typical documentation within the RFQ package will include a performance-based specification, statement of work and contract terms and conditions and it is therefore necessary to ensure the availability of these items. Cost Engineering inputs will typically include participation in the development of the work breakdown structure, pricing instructions, evaluation criteria and weightings, schedule and payments plan, management requirements and performance tracking metrics. In parallel, supplier relationships and teaming arrangements should be developed.

Typical Work Outputs:

- RFQs Issued

Base Practice 03: Review Supplier Quotes

Description:
The adequacy of all responses should be reviewed prior to the performance of an integrated analysis of cost, resource allocation and schedule in accordance with the evaluation criteria and weightings generated in BP02. Cost analysis should be performed utilising appropriate metrics. Historic performance should be taken into account, both with respect to vendor-furnished and locally-held information. Potential vendors' should be short-listed in order of preference. The adequacy of vendor Cost Engineering processes needs to be

determined and requests for improvement or clarification may need to be compiled.

Typical Work Outputs:

- Supplier Responses Reviewed

Note: Use EACE CECIM to determine adequacy of vendor Cost Engineering processes. Target costs generated in PA01/BP05 may need adjustment to take account of any local considerations at the potential supplier based on the supplier historical performance. It may be opportune to hold a contingency between the targets set in PA01/BP05 and the targets imposed on the supplier as a provision to safeguard against poor performance: this should be addressed by revision of the risk plan in PA06.

Base Practice 05: Select Supplier

Description:
Best and Final Offer (BAFO) iterations may need to be performed in order to secure the best offer: this may occur pre- or post-award, depending on prevailing circumstances and commercial considerations. Responses to any BAFO activity and pre-award surveys may need to be undertaken. Measures may need to be taken to integrate the activities of the members of the supply-chain with those of the local organisation: included in this activity will be the implementation of measures to ensure that the vendor processes and those of any sub-tiers are compatible with those of the local organisation to the extent needed to ensure successful performance. The plans for control of the work will need to be revised to incorporate the cost/schedule baseline and milestones of the selected vendor.

Typical Work Outputs:

- Supplier Selection
- Supplier Cost/Schedule Baselines

Base Practice 06: Analyse and Negotiate Claims and Changes

Description:
In order to provide adequate control of the work, it is necessary for processes to be implemented to enable any changes to the baseline work scope to be tracked, to verify the validity of claims. When changes occur, it is necessary to have effective means of communicating the changes and ensuring a coherent response throughout the supply chain. In the event of changes being requested, means must exist to model the cost/schedule impacts prior to agreement. Thereafter, processes should provide for swift implementation of required adjustments to the cost and schedule baselines.

Typical Work Outputs:

- Performance Metrics

Base Practice 07: Approve Invoices and Milestone Achievement

Description:
Effective processes should exist to provide for prompt approval and disposition of claims and payments. Reconcile claims by determination of the adequacy of work performed and (where appropriate) the validity of incurred costs. Ensure that correct personnel are involved in the approval process. Ensure that the process provides for minimisation of delay between invoice/milestone claim receipt and payment approval.

Typical Work Outputs:

- Approved and verified milestones and payment claims

Note: Invoice payment and milestone achievement are required for performance analysis PA03/BP06.

Base Practice 08: Close Out

Description:

Determine at-complete metrics for cost and schedule performance, changes and claims. Ensure capitalisation of any residual risk or schedule margins. As appropriate, allocate provisions for retained payments, performance bonds and incentive payments.

Typical Work Outputs:

- Project Closure
- Supplier Metrics

Process Area 14: Knowledge Management

Process Area Description

The purpose of KNOWLEDGE MANAGEMENT is to capture and store all cost, programmatic and technical information of use to the Cost Engineering process and to enable its rapid retrieval. The information is required as background data in support of the estimates being generated, as templates for future estimates, and as aids in Lessons Learned and Risk Assessment exercises, in order to improve the whole costing process. The data required are all the source data required to justify the initial estimate.

Base Practices

01. Identify Strategic Knowledge Needs and Assets
02. Mobilise and Capitalise Assets
03. Identify and Implement Mechanisms for Knowledge Capture and Retention

Base Practice Descriptions

Base Practice 01: Identify Strategic Knowledge Needs and Assets

Description:
Identify the current means by which Cost Engineering know how and information are captured. Identify the Cost Engineering know how and information that are needed in order to capture internal (enterprise) and external (academic, institutional etc.) experience (e.g. methods, metrics) through which to capitalise and consolidate the Cost Engineering processes.

Typical Work Outputs:

- Knowledge Requirements
- Assets "catalogue"

Base Practice 02: Mobilise and Capitalise Assets

Description:
Identify and implement techniques by which the exploitation of current know-how and data that are routinely collected can be improved, e.g. by more efficient access, distribution or dissemination, accelerated or automated data processing, integration and consolidation of data sources, enhanced and extended analyses, hierarchical information management and storage. Foster the cultural changes that encourage the sharing of experiences and a mutually-supportive environment in which the individual is neither afraid to admit knowledge deficiencies nor motivated to conceal potential solutions.

Typical Work Outputs:

- Improved Knowledge Management techniques

Base Practice 03: Identify and Implement Mechanisms for Knowledge Capture and Retention

Description:
Relative to identified strategic knowledge needs that are not being currently satisfied, develop means by which deficiencies can be remedied e.g. through deployment of appropriate tools, design and implementation of specific processes e.g. to enable systematic capture of relevant data and information, identification of new information sources.

Typical Work Outputs:

- Knowledge Database

Note: Systematic exploitation and capitalisation of the organisation's knowledge assets is accomplished within those specific Process Areas that utilise the knowledge assets.

Process Area 15: Capital Asset & Resource Management

Process Area Description

The purpose of CAPITAL ASSET AND RESOURCE MANAGEMENT is to enable the organisation to predict and model the likely requirements for the future, compare against what exists and initiate recruitment or capital expenditure if there is a perceived shortfall.

It is likely that some form of probabilistic analysis will need to be carried out on future requirements using marketing or sales forecasts or related data.

Base Practices

01. Obtain Resource Requirements
02. Probabilistic Analysis on Future Projects
03. Manage Resource Requirements
04. Initiate Plan to Cover Shortfalls

Base Practice Descriptions

Base Practice 01: Obtain Resource Requirements

Description:
It is important to routinely capture all resource needs in order to sustain current and future work. The information needed should be systematically captured for all work in progress and prospects, through feedback from sources such as estimates at complete for work in progress and proposals for prospective work. Resource types should be identified in accordance with standard definitions (e.g. CBS and OBS categories). Needs should be time-phased to facilitate identification of conflicts and shortfalls. Means of segregating firm (i.e. work in progress) resourcing requirements from speculative requirements (prospects) should be adopted. Availability (capacity) should be projected, taking into account losses through maintenance and downtime, vacations, retirement, lifing and wastage factors. Deficiencies should be highlighted e.g. availability of skill types, requirements for special plant or facilities.

Typical Work Outputs:

- Resourcing Plan

Note: Inputs are from PA01/14, PA03/BP07 and PA05/BP06.

Base Practice 02: Probabilistic Analysis on Future Projects

Description:
Since it is not practical to provision fully against potential future resource requirements arising from projected future work, means of determining the probability of prospective work being realised should be established. The future resource requirement profile can then be analysed in-depth by applying different probability criteria, in order to initiate specialist acquisition activity or other appropriate strategies when appropriate. The resource model should be kept up-to-date so that the true cost of new work can be readily determined (e.g. to support bid/no-bid decisions) and future overhead bases determined with improved accuracy.

Typical Work Outputs:

- What-if Plans

Base Practice 03: Manage Resource Requirements

Description:
Resource needs are dynamic and depend on volume of work and throughput. During the project lifecycle, resource needs may deviate from the baseline due to slippages, changes or under/over prediction of efficiency. External influences can also affect resource needs e.g. reprioritisation, personnel changes, facility and plant availabilities. It is therefore important to monitor resource utilisation and re-forecast regularly, taking into account internal and external factors. The periodic revision of Estimates To Complete should provide visibility of the forecast resource needs. The updated resource plan must be promulgated to enable corrective action to be implemented and should be integrated with the overall resource planning model held at organisational level.

Typical Work Outputs:

- Updated Resource Plans

Note: This is a parallel activity to PA03/BP07.

Base Practice 04: Initiate Plan to Cover Shortfalls

Description:
Where the future plan shows resource shortfalls, including capital assets, it will be necessary to recruit resources, either permanent staff or short-term contract staff, and fund or hire the capital assets required to complete the project plan. Conversely, where the plan indicates that resource surpluses are likely, different types of action should be considered, ranging from means to exploit the surplus capacity or divestiture of unneeded capital equipment to short-term lay-offs and planned redundancies.

In addition, succession planning should be routinely implemented in order to establish the strategies that are to be followed in the event that key resources become unavailable.

Typical Work Outputs:

- Plan for covering resource shortfalls or surpluses
- Succession plan

Process Area 16: Business Analysis

Process Area Description

The purpose of BUSINESS ANALYSIS is to ensure systematic engagement of the organisations Cost Engineering capability in performing analyses, both to establish the economic health of the organisation and of proposed future undertakings, and to monitor the economic effectiveness with which assets are utilised and proposed assets are capitalised. The potential contribution of Cost Engineering methods, techniques and tools in these areas is frequently overlooked and this in itself represents an inefficient utilisation of corporate resource.

Base Practices

01. Monitor Efficiencies
02. Benefits Tracking and Analysis
03. Identify Profitable Business
04. Overheads forecasting

Base Practice Descriptions

Base Practice 01: Monitor Efficiencies

Description:
Compile and analyse metrics to identify yields and performance indices for labour and capital resources and perform comparisons across business and products. Ensure utilisation of metrics in costing activities.

Typical Work Outputs:

- Yields Analysis

Base Practice 02: Benefits Tracking and Analysis

Description:
Establish benefits metrics, perform cost benefit analyses (CBA) and return on investment (ROI) analyses.

Typical Work Outputs:

- Benefits Analysis

Base Practice 03: Identify Profitable Business

Description:
Analyse historic, current and projected work to establish strategic fit of new prospects. Perform margin and contributions analysis to grade ongoing and prospective work. Recommend profitable areas for expansion and identify areas for withdrawal.

Typical Work Outputs:

- Strategic Recommendations

Base Practice 04: Overheads Forecasting

Description:
Analyse business trends, e.g. product mix, to determine future capital asset and labour resource requirements. Forecast impacts on overheads and rate structures. Ensure utilisation in out year costing activities.

Typical Work Outputs:

- Out-Year Costing Guidelines

Note: Input into PA19/BP02, Cost Allocation, Establish indirect/direct allocation.

Process Area 17: Business Case Development

Process Area Description

The purpose of BUSINESS CASE DEVELOPMENT is to perform the necessary analyses and thus develop the detailed case for the undertaking of new business ventures. It includes the appraisal of sales volumes and revenue forecasts, definition of the means of financing the venture and the resulting cash flow projections, and culminates in definition of profitability and preparation of the Business Plan.

Base Practices

01. Market Analysis
02. Financing Scheme Analysis
03. Compilation of the Business Plan

Base Practice Descriptions

Base Practice 01: Market Analysis

Description:
In the business plan, all sources of revenues are generated by a perceived economical value to an end customer. The market analysis identifies these end customers and their needs and quantifies the resulting revenues. The market analysis should define the current market value of the product and the changes in value that will occur over time as a result of market penetration and saturation.

Typical Work Outputs:

- Market Analysis

Base Practice 02: Financing Scheme Analysis

Description:
Appropriate means of financing the undertaking must be established. Initial sources of funding may include use of loans from venture capital funds, government grants and incentives, bank loans or local capital. Finance may also be raised through the sale of equities. In most cases, the use of capital will incur financing costs of some description, and these must be taken into account in determining cash flow.

Typical Work Outputs:

- Cash Flow Plan

Base Practice 03: Compilation of the Business Plan

Description:
The business plan integrates the spend derived from the cost estimate, the funding scheme and the source of revenues established with the market analysis to derive the profitability of the business and its break-even point. Comprehensive forecasting must take into account expenditure, revenue and commitments.

Typical Work Outputs

- Business Plan

Note: Input from PA01/BP14, Cost Estimating Issue Definitive Estimate. Updated by PA03/BP07, Cost Control and Analysis Estimate to Completion

Process Area 18: Audit

Process Area Description

The purpose of AUDIT is to verify that estimating systems and processes operate in accordance with the agreements between client and supplier, in order to establish the correctness of the estimate and to establish a baseline to follow.

Base Practices

01. Agree Approach to Audit
02. Review Estimating Process
03. Carry Out Audit
04. Negotiate Findings
05. Implement Agreement

Base Practice Descriptions

Base Practice 01: Agree Approach to Audit

Description:
The auditing authority and the supplier have to jointly agree the approach to the investigation, also the information needed to carry out the task, and how the findings will be applied. The audit can be performed using the complete fully detailed estimate that can be tested by both parties before agreement of the content or else using a representative sample, from the supplier, with an agreement to apply the results to the whole task. This later approach involves preparing an independent estimate for comparison.

In some cases, the contract may provide for payment to be made on the basis of determination of ascertained costs. This involves investigation into the supplier's costs 'that have been properly incurred for the purpose of the contract' (i.e. have been reasonably and fairly incurred). In these cases the customer may apply for a reduction in the price to an amount that he believes is fair and reasonable. The auditor will require access to plans, estimates, cost records, and other supporting evidence such as invoices and details of the agreed cost allocation.

Typical Work Outputs

- Auditors Estimate
- Audit Approach

Note: Audits are normally carried out by institutional or defence agencies where fees (profits) are regulated by national or international agreements. Audits can be carried out pre-contract on the proposed estimate or post contract on incurred costs.

Base Practice 02: Review Estimating Process

Description:
The estimating system implemented by the supplier should be examined to establish confidence in the methodology. Estimates produced in a consistent and methodical manner in accordance with a well-documented process are more likely to be accurate. It is necessary for the auditors to visit the work area to understand the environment and processes by which work is carried out.

Typical Work Outputs:

- Supplier estimating process

Note: Use can be made of the EACE CMM

Base Practice 03: Carry Out Audit

Description:
The auditor will prepare a WBS followed by a detailed independent estimate for all items to be sampled. There is a need for the supplier to ensure that all estimates are capable of withstanding close scrutiny and so complete records of the rationales for all estimates together with supporting evidence should be maintained.

Where payment is to be made on a cost reimbursement basis, it is necessary for the auditor to understand the WBS, statement of work (SOW), Work Package (WP) descriptions, and other relevant documentation involved in work authorisation and scope definition. The auditor will need to review the methods of cost collection and cost coding.

In determining the validity of a supplier claim, the auditor will need to create an independent estimate of the cost of the work performed and compare this with the budgeted spends. Where significant (particularly adverse) variance is apparent, further investigation is warranted. Personnel time booking records are potential sources of abuse and manipulation and these should be investigated to verify that the records are up to date and relevant to the work that has been performed.

Samples should be taken from the WBS to verify that the rates used are consistent with the CBS and skill mix. Invoices should be examined to establish relevance to the contract in respect of quantities and the cost allocation.

Typical Work Outputs:

- Estimate for comparison on audit

Note: The auditors approach is to create an estimate in a similar way to PA01 Cost Estimating, the auditor will use his knowledge database to ascertain estimates against the WBS, he will then use the agreed published cost allocation (PA19/BP03) to calculate the estimate for negotiation with the supplier (BP04). For post contract costing the audit will normally concentrate on the cost recording & invoicing process (PA03)

Base Practice 04: Negotiate Findings

Description:
Record findings and decide strengths and weaknesses of the estimate, or recorded costs and how to approach the negotiation. The auditor should review his own strategy for the negotiation and list what he expects to achieve (the bottom line), what he could concede, and what he will not. It may be necessary to leave some contentious items for later wider or higher level discussions.

Typical Work Outputs:

- Final report

Base Practice 05: Implement Agreement

Description:
Decide the structure of the report and how to communicate the outcome of the negotiation. Ensure that all follow-up actions are executed punctually and thoroughly.

Typical Work Outputs

- Implementation plan

Process Area 19: Cost Allocation

Process Area Description

The purpose of COST ALLOCATION is to establish the basis to be used for preparing estimates within the organisation by unequivocal segregation and identification of prime costs and overheads. This is the means of determining rates within the organisation. In many organisations, the cost allocation system will be subject to external scrutiny and regulation. Even where this is not the case, it is valuable for the organisation to ensure that a clear and consistent method of cost allocation is established and communicated to those with an involvement in the estimating and cost management processes.

Base Practices

01. Decide Basis of Direct and Indirect Allocation
02. Establish Costs that are Compatible with Direct and Indirect Allocation
03. Publish Cost Allocation
04. Apply Cost Allocation to the Estimating Process

Base Practice Descriptions

Base Practice 01: Decide Basis of Direct and Indirect Allocation

Description:
Cost allocation is fundamental to the estimating process as it defines those activities that may be charged directly (and therefore require inclusion within the estimate as identified chargeable elements) and those which are charged indirectly (and therefore should not be included within the direct estimate). It also specifies how costs of the direct activities are to be charged to contracts. Direct costs are those costs that make up the prime cost of a product, i.e. the cost of all the labour, materials and expenses directly expended on producing the saleable product.

Typical Work Outputs:

- Direct/indirect allocation

Note: The term product includes reports, data, advice, services, specifications, prototypes, samples and other items in the normal range of the activities of the organisation.

Base Practice 02: Establish Costs that are Compatible with Direct and Indirect Allocation

Description:
There is a need to establish those items that are to be allocated as direct charges to a product or process and will therefore require production of an estimate. All other costs will be assumed to be recovered within overheads.

Typical Work Outputs:

- Cost Breakdown Structure

Note: The direct allocations are included as tasks in the estimate generated in PA01 and in costs allocated in PA03. These tasks will be costed by addition of the Prime & overhead rates.

Base Practice 03: Publish Cost Allocation

Description:
The rates may differ from one department of the organisation to another although the principles in their calculation will be the same. Providing the resulting rates are practical, consistently applied to products and do not significantly distort charges to contracts, they will usually be acceptable to an external customer with rights of oversight or regulation of the cost allocation process. In the estimating process, estimates will be prepared for those direct items that form part of the saleable output and their make-up will comprise labour, materials and expenses elements described as direct costs in the cost allocation. These items are usually listed in the schedule that defines the cost elements that are charged within the scope of the estimate. However some elements, although listed, may be of such small value or so difficult to assess (e.g. paint) that their costs are recovered in the overhead.

Typical Work Outputs:

- Cost allocation

- CBS

Note: Cost allocation is the basis for the application of rates to the estimating process. Where costs are subject to external regulation, the breakdown between direct and indirect costs within the organisation, the supporting computations and rationales and the specific values of the various direct and overhead rates are generally subject to review and approval by the regulating authority. Reciprocal arrangements frequently exist to enable approved rates within one jurisdiction to be applied within the domain of another jurisdiction without seeking additional approval. Two examples are the UK MoD QMAC (Questionnaire on Methods of Accounting) and the US DoD Disclosure Statement.

The declared cost structure and cost allocation will form the basis of determining allowable and disallowable costs within the audit PA18/BP04.

Base Practice 04: Apply Cost Allocation to the Estimating Process

Description:
The cost allocation methodology has to be implemented within the estimating process. This requires that methods for communication of the methodology and verification of the correct application of the methodology within cost estimates are implemented.

Typical Work Outputs:

- Implemented cost allocation

Note: Input to PA01 Cost Estimating & PA03 Cost Analysis.
