PROGRAMME CONTROLS - COST

Performance Measurement Procedure

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1 Purpose & Scope

The purpose of this document is to outline the steps required to establish and perform Programme- and Contract-level performance measurement on Crossrail.

The performance measures described focus on the achievement of scope, cost and time targets and do not deal with measures concerning pure contract management, environment, health and safety, quality and other wider project information.

The key steps required to establish and monitor Earned Value and Productivity measures are defined along with associated responsibilities. Note that Productivity is measured at Contract level only.

2 Terms & Definitions

Definitions of key words are given in section 4, acronyms are defined below:

AC	Actual Cost
ACWP	Actual Cost of Work Performed
AFC	Anticipated Final Cost
BCWP	Budgeted Cost of Work Performed
BCWS	Budgets Cost of Work Scheduled
CCB	Current Control Budget
CE	Compensation Event
CPI	Cost Performance Index
CV	Cost Variance
EPPR	Engineering Progress & Performance Report
EV	Earned Value
EVA	Earned Value Analysis
ICE	Implemented Compensation Event
OCI	Optimised Contractor Involvement
PV	Planned Value
SPI	Schedule Performance Index
SV	Schedule Variance
WBS	Work Breakdown Structure
ES	Earned Schedule
SV(t)	Schedule Variance Time
SPI(t)	Earned Schedule Performance Index

3 Responsibilities

The majority of the required performance measures are collected through established information collected within data systems. However, for Earned Value and Productivity, a level of agreement is required between Contractor and Client to agree:

- The time profile and breakdown of budgeted cost against work scope

- What is measured and how
- The method for 'earning' completed work
- What Manhours are considered against what Indicative Units.

3.1 Contract Performance Measures

The Project Manager is responsible for establishing how Earned Value (EV) and Productivity will be measured at Contract level in discussion with the Contractor. The Contractor will submit this information for acceptance within 4 weeks of the starting date, as part of establishing the Baseline Accepted Programme as detailed in the Works Information Volume 2B – Part 14 – Management & Administration **[Ref 1]**.

As part of the periodic reporting:

- The Contractor is responsible for reporting performance in line with the agreed methods for EV and Productivity
- The Project Manager is responsible for assessing the Contractor's reported performance and implementing revisions for inclusion in the period reports as deemed appropriate.

3.2 Programme Performance Measures

The measurement of EV at Programme level is calculated from that reported and assessed at Contract level (section 4.2.2) so the applicable responsibilities are as defined in Section 3.1.

4 Proposed Performance Measures

4.1 Summary

The aim of the performance measurement regime is to provide a comprehensive, consistent, timely and reliable view of the programme's performance that predicts performance, and triggers management action to positively influence the outcome.

The regime includes, but is not limited to, EV and includes other meaningful indicators of performance. EV is one indicator of performance and its use and context in performance measurement will require active communication across the programme organisations and stakeholders.

The full list of potential performance measures is given below:

Earned Value	
Budgeted Cost of Work Scheduled (BCWS)	Measure of the budget of the planned works. Also known as Planned Value (PV)
Budgeted Cost of Work Performed (BCWP)	Measure of the progress achieved. Also known as Earned Value (EV)
Actual Cost of Work Performed (ACWP)	Measure of the actual cost incurred to achieve the Earned Value. Also known as Actual Costs (AC)
Cost Performance Index (CPI)	CPI = BCWP/ACWP, a measure of cost performance
Schedule Performance Index (SPI)	SPI = BCWP/BCWS, a measure of schedule performance
Earned Schedule (ES)	ES = C+I Where: C = Count of periods where BCWP=>BCWS I = (BCWP-$BCWS_c$)/($BCWS_{c+1}$-$BCWS_c$)

Productivity	
Indicative Installed Units	Selective measure of an installed unit that provides overall guidance to contract scope
Manhours	Number of manhours expended
Productivity	Manhours expended per installed unit
%Complete Construction	Percentage complete for construction works
%Complete Engineering	Percentage complete for engineering works
Schedule Performance	
Schedule Completion	Actual, forecast and movement of schedule completion dates
Float Erosion	Trending of level of programme float
Milestones Achieved	Completion of identified milestones against plan
Interface Management	Movement of controlled interface delivery deadlines
Cost Performance	
Baseline Budget [1]	The budget as established by the Programme and scrutinised by the Board (currently RP4.2)
Current Control Budget (CCB) [1]	The Baseline Budget as subsequently amended by approved change (including trends, change controls and ICEs) and budget transfers
Total of the Prices [1]	Sum of Total Prices plus allowances minus target for OCI plus approved change
Anticipated Final Cost (AFC) – Project level [1]	The aggregate of the contract level AFCs (being the initial Total of the Prices + ICEs + Resolved Trends + Risk Forecast) + Project Risk Forecast
Anticipated Final Cost (AFC) – Contract Level [1]	Initial Total of the Prices + ICEs + Resolved Trends + Risk Forecast. (NB: pre award the AFC = Current Approved Baseline Budget + Resolved Trends)
AFC Change Index	AFC (Contract/ Project/Programme Level) as a proportion of the Initial Total of the Prices at that level
Risk/Contingency Drawdown	Trending of levels of risk and contingency
Trends Resolved/ Unresolved	Number and value of trends resolved/ unresolved. Measures of the amount of change on the Contract
Contract Administration Performance	
Contracts Raised (Value & Number)	Value and number of contracts raised by the supply chain to deliver the works
CE Outstanding	Value and number of open Compensation Events
CE Index	Value of Compensation Events as a proportion of Initial Total of the Prices

This is a list of all Performance Measurement undertaken by Crossrail.

The procedures applicable to the schedule, cost and contract administration measures are defined elsewhere: Programme Schedule Management **[Ref 2]**; Cost Management & Forecasting **[Ref 3]**; Contract Administration Manual **[Ref 4]**; Reporting Procedures Handbook **[Ref 5]**. This document addresses EV and Productivity.

[1] Each of these will be profiled period-on-period

4.2 Earned Value

4.2.1 Contract-Level Earned Value

For Crossrail, the scope of works on a Project (comprising one or more Contracts) is modelled against a Work Breakdown Structure (WBS) which comprises Work Packages with one or more Activity Groups each of which has one or more Activities. Typically, a Work Package equates to a single Contract. Each Activity will typically map to many lower-level 'tasks' in the Contract schedule.

In order to establish EV on a Contract, the following must be identified (see APM EVA Guidelines, for example):

- A list of scope items, with a definition, known as the Earning Plan (section 6.1), of how progress is measured against that scope
- The CCB for each item of scope. As change is introduced to the Contract (through Implemented Compensation Events &/or transfers), the CCB must be updated for each item of scope
- A contract 'Performance Measurement Baseline' defined against the Contract's WBS integrating scope, schedule and CCB
- The actual cost incurred for each item of scope.

This will allow the following performance information to be calculated at contract level, for each period or cumulatively:

- Budgeted Cost of Work Scheduled ($BCWS_{CON}$) – Planned % Progress derived from CCB x CCB
- Budgeted Cost of Work Performed ($BCWP_{CON}$) or Earned Value – Actual % Progress x CCB
- Actual Cost of Work Performed ($ACWP_{CON}$)
- Cost Variance (CV_{CON}): $BCWP_{CON}$ - $ACWP_{CON}$
- Cost Performance Index (CPI_{CON}) : $BCWP_{CON}$ / $ACWP_{CON}$
- Schedule Variance (SV_{CON}): $BCWP_{CON}$ - $BCWS_{CON}$
- Earned Schedule Variance (SVt): ES – duration contract live (in periods)
- Schedule Performance Index (SPI_{CON}): $BCWP_{CON}$ / $BCWS_{CON}$.
- Earned Schedule Performance Index (SPIt): ES / duration contract live (in periods)

All of the above measures will be defined or derivable at Activity level for each Contract.

4.2.2 Programme-Level Earned Value

The Programme-level EV performance measures, for each period or cumulatively, are calculated from:

- Budgeted Cost of Work Scheduled ($BCWS_{PRG}$) – Sum of $BCWS_{CON}$ across all contracts
- Budgeted Cost of Work Performed ($BCWP_{PRG}$) – Sum of $BCWP_{CON}$ across all contracts
- Actual Cost of Work Performed ($ACWP_{PRG}$) – Sum of $ACWP_{CON}$ across all contracts
- Cost Variance (CV_{PRG}): $BCWP_{PRG}$ - $ACWP_{PRG}$
- Cost Performance Index (CPI_{PRG}) : $BCWP_{PRG}$ / $ACWP_{PRG}$

- Schedule Variance (SV_{PRG}): $BCWP_{PRG} – BCWS_{PRG}$
- Schedule Performance Index (SPI_{PRG}): $BCWP_{PRG} / BCWS_{PRG}$.

4.2.3 Contingency

Contingency (both Project- and Programme-level) will only contribute to Contract- and Programme-level performance measures when it is drawn down into the Contract-level CCB. In other words, value is not earned, and actuals are not recorded against contingency unless it is drawn into this budget at contract level.

4.3 Productivity Measurement

The intention of Productivity measurement is to arrive at a single unit, or a small number of units of measurement of installation to understand how productive site manhours are at installing the scope of the contract.

In order to establish Productivity measurement on a Contract, the following must be identified:

- One or a small number of Indicative Units. These should be unit(s) of delivery which give an indication of whole contract progress. Where possible these should be one of the Activities identified for EV, as progress measurement agreements can be inherited from the Earning Plan. If this is not the case a separate progress measurement agreement must be achieved.
  An example Indicative Unit may be Segment Installation for tunnelling, in which case this would provide the Indicative Unit of installation and therefore it would not be necessary to measure other installation activities.
- Manhours associated with the Indicative Unit. It is important here to exclude manhours for one-off activities around mobilisation and demobilisation, and to exclude manhours for other workstreams not 'indicated' by the indicative measure. This requirement may influence which Indicative Measure is selected. To follow our example, manhours for the tunnel boring, ring installation, cleanout and services installation would be included in the Segment Installation manhours. Manhours associated with the construction of the portals or installation and removal of the TBM would be excluded.

This will allow the following information to be calculated:

- Planned Indicative Installed Units – Period on Period planned units to be installed derived from the project schedule
- Planned Manhours – Period on Period manhours planned to install the units derived from the project schedule
- Planned Productivity – Planned Manhours/Planned Units
- Actual Indicative Installed Units – Period on Period actual units installed
- Actual Indicative Manhours – Period on Period manhours expended installing the units
- Actual Productivity – Actual Manhours/Actual Units
- Productivity Index – Planned Productivity/Actual Productivity.

5 Progress Measurement Techniques

The following standard approaches to progress measurement have been agreed for the generic workscope listed:

Scope	Measurement Item	Measurement Technique
Indirects		Earn at Plan
Land and Property		Earn at Plan
Design	Drawings	Drawing Sign-off (EPPR Control System)
Procurement (of Contract)		No Value
Early Works (low value)		Earn at Plan
Preliminaries		Earn at Plan
Significant Works		
Tunnel	Segment Installation	Unit
	Cleanout	Linear Metre
	Walkways	Linear Metre
Shaft	Excavation	m^3
	Steelwork	See Steelwork
	Equipment	See 'Scope' Equipment
	Lining	Segment or m^2
Permanent Way	Track Slab	Linear Metre
	Floating Track Slab	Linear Metre
	Rail Installation	Linear Metre
	Switches and Crossings	Item
Signalling	Design	Milestones
	Software Development	Milestones
	Linear installation	Linear Metre
	Testing & Commissioning	Milestones
Depots	Civils	Quantities
	Track	Linear Metre
	Offices	Quantities
	Equipment	See 'Scope' Equipment
Portals	Wall	m^2
	Slabs	m^2
	Excavation	m^3

Scope	Measurement Item	Measurement Technique
Systems &IT	Software Development	Milestones
	Linear installation	Linear Metre
	Testing & Commissioning	Milestones
Equipment	Manufacture	Milestones
	Installation	Unit
Electrical Power	OLE	Linear Metre
	Substations	See 'Scope' Equipment
	Connection to Network	Item
Steelwork	Design	Milestones
	Manufacture	Tonnes
	Installation	Tonnes
Stations		
Station Box and Tunnel Enlargements	Wall	m^2
	Slabs	m^2
	Excavation	m^3
Platforms		Linear Metre or m^3
Ticket Halls	Gate line equipment	Item
	Rooms	Item or m^2
Lifts and Escalators	Equipment	See 'Scope' Equipment
Connecting Tunnels	Excavation	Linear Metre
	Lining	m^2
Control	Software Development	Milestones
	Linear installation	Linear Metre
	Equipment Manufacture	Milestones
	Testing & Commissioning	Milestones
Finishes	Surfaces	m^2
	Railing etc	Linear Metres
Commissioning		Milestones

Therefore the following main measurement techniques are proposed:

- Earn at Plan (aka Level of Effort) – BCWP is equal to BCWS, giving an SPI performance of 1.0, and directly relating progress to period on period planned spend. This is effective for level of effort type activities such as project management, where a resource plan is submitted, against which staff are mobilized. It can also be used when the scope of works involved is of a minor nature allowing attention to be placed elsewhere to maximize effectiveness
- Items, Units and Drawings – The completion of the Items, Units and Drawings are counted with a proportion of the total planned completion providing a %Progress. This is effective for large numbers of individual deliveries, such as Indicative Units and drawings
- Linear Metres – The measurement of completion of linear delivery from a start point. This can be used to measure any construction that occurs in a linear direction, such as track installation, and is effective as an Installed Units measure.
- m^2, m^3, Tonnes – The measurement of construction completion by the m^2, in the case of wall or floor coverings, m^3 in the case of, for example, excavations and tonnes in the case of steel, for example – the proportion of total planned completion providing % progress.
- Quantities – Where contracts are covering a wide range of non standard scopes, identification and measurement of a selection of items should be used, made up of Items and Units, m^2, m^3, Tonnes etc.
- Milestones – Where completion includes a number of different stages, then a milestone agreement should be reached with the Contractor. Prime examples of this is significant pieces of Equipment, where milestones may be identified for:
    - Placing of Purchasing Contract
    - Design, including intermediate completion
    - Manufacture
    - Delivery
    - Installation
    - Testing and Commissioning

In these cases the % attributed to the milestone should be in line with the value of the item in proportion to the whole. In some instances the later milestones may have an overstated % such that there is a concentration on completion.

6 Identify Performance Measures

6.1 Establish an Earning Plan

For each item of scope, in order to identify how EV will be measured, the following must be identified in an Earning Plan:

- Progress measurement technique
- Details of % progress attributed to individual stages or items
- Identification of Level 3 Schedule items describing start and finish of measurement
- Identification of any profile to be assigned to the measurement (flat, bell curve, back loaded etc.)

6.2 Productivity

For each Contract, an inspection of the installed units being measured should be undertaken to identify if any satisfy the following criteria:

- They are indicative of a wider scope
- Site Manhours can be directly attributed to their delivery.

6.2.1 Identify Indicative Units

In order to identify suitable Indicative Units the following should be taken into consideration:

- Indicative Units should require a significant number of other units for them to be completed
- Indicative Units may include the last unit in a chain of unit installations. However, in this case it should be noted that the measure will automatically be back end loaded
- The units as a whole should be a regularly repeated process. If all individual units are completed before moving onto the next, the selected Indicative Unit will not indicate overall progress.

6.2.2 Identify Manhours

It is advisable that only one Indicative Unit is selected per WBS item (Work Package, Activity Group, Activity item) such that all manhours recorded under that WBS can be rolled up against that measure. If more than one per WBS is utilised, then manhours must be split across a number of units.

6.2.3 Establish a Productivity Plan

Planned curves of Indicative Units, Manhours and therefore Productivity should be established. This should utilise the Contract's Baseline Accepted Programme to describe start and finish limits for the installation. Also, it is recommended that a non-linear productivity plan is used, such that there is an expected level of inefficiency at the start, when working practices are being established, and at the end, when snagging and finishing activities arise, with the majority of the most productive work during the middle of the run.

7 Measure EV & Productivity

7.1 Earning Value & ACWP

As work on the Contract progresses, assessment should be made each period on two aspects:

- The % Progress corresponding to the agreements made in the Earning Plan
- The actual cost of the works in accordance with the Earning Plan.

It is important to note that the Certified Cost (the costs approved for payment to the contractor) may be in advance of the ACWP. For instance where a contractor has been paid for materials purchased, he may not earn the ACWP of those materials until they are installed.

7.2 Productivity

As work progresses, assessment of the actual Indicative Units and Manhours should be made and compared with the corresponding planned values.

8 Recording & Reporting

Recording of actual performance will be provided through the introduction of a common cost system. The reporting of performance, along with the reporting timetable is covered in the Reporting Procedures Handbook **[Ref 5].**

9 Reference Documents

Ref:	Document Title	Document Number:
1.	Works Information Volume 2B – Part 14 – Management & Administration	CRL1-XRL-V3-XWI-CR001-50035 (Civils) CRL1-XRL-V3-XWI-CR001-50131 (Systems)
2.	Programme Schedule Management	CR-XRL-Z9-GPR-CR001-00006
3.	Cost Management & Forecasting	CR-XRL-Z9-GPR-CR001-00010
4.	Contract Administration Manual	CRL1-XRL-W-GML-CR001-50001
5.	Reporting Procedures Handbook	CR-XRL-Z9-GPR-CR001-00012
6.	APM EVA Guidelines, 2008	ISBN 978-1-903494-26-4

10 Standard Forms / Templates

Ref:	Document Title	Document Number:
1.	None	
2.		
3.		
4.		