COPSEMO Summary

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Abstract

*The **CO**COMO **P**hase **S**chedule and **E**ffort **MO**DEL (COPSEMO) is a model and tool for distributing schedule and effort across the MBASE/RUP phases. COPSEMO also uses a different schedule estimation calculation than COCOMO II's simple one: COPSEMO's schedule estimation uses a more complex calculation for the low effort situations, those below 64 person-months. At this time, there are no other COPSEMO "drivers" besides COCOMO II's calculated effort.*

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1. Introduction

The evolution of COPSEMO has its roots in several activities undertaken by the Center for Software Engineering: COCOMO II, and Focused Workshops.

1.1. Another step in the evolution of COCOMO II

The COCOMO II Model Manual provides the primary motive for this extension of COCOMO II. "As COCOMO II evolves, it will have a more extensive schedule estimation model, reflecting the different classes of process model a project can use; the effects of reusable and COTS software; and the effects of applications composition capabilities."

1.2. COCOMO II Schedule

The COCOMO II schedule, as presently implemented (COCOMO II.2000) reflects a waterfall process model, and not any of the currently accepted alternatives such as iterative, spiral or evolutionary. In addition, it has been observed that the COCOMO II's duration calculation seems unreasonable for small projects, those with effort under two person years.

1.3. CSE Focused Workshops

The CORADMO model, discussed elsewhere, needed to account for more phases than just the Waterfall had to offer in Preliminary Design and Detailed-Design, Code and Test (which are covered by COCOMO II's effort and schedule estimates). This lead to the need for "Anchor Points", and subsequently the MBASE/RUP designations of Elaboration and Construction for the same phases for which COCOMO II estimates apply.

The CORADMO model itself had its roots in the results of a 1997 CSE Focused Workshop on Rapid Application Development[1]. RAD is taken to mean application of any of a number of techniques or strategies to reduce software development cycle time. The initial CORADMO implementation subsumed the pre-cursor to COPSEMO, which was call COPSEMO.

The need for a stand-alone model to handle distribution of the effort and schedule to the different phases, and also to activities, was highlighted in a second Focused Workshop, this one on Estimation of Cost, Schedule and Process. This second workshop lead to breaking COPSEMO out of CORADMO and renaming it. At the same time, it strengthened the anchoring of the processes at the MBASE/RUP milestones. In addition, it provided the identification of activities associated with the phases, detailed work-breakdown structures for both Waterfall and MBASE/RUP development life cycles, and the default values for the distribution of effort and schedule to the different life cycles.

1.4. COCOMO II Constructive Phase Schedule & Effort Model

In an effort to overcome these shortfalls, an extension has been developed: the COCOMO II Phase Schedule & Effort Model (COPSEMO).

2. Improving the Classic COCOMO Model for Schedule

The classic COCOMO model has deficiencies in several areas: a waterfall predilection, and small-effort projects.

[1] B. Boehm, S. Chulani, and A. Egyed, "Knowledge Summary: USC-CSE Focused Workshop on Rapid Application Development," USC-CSE Technical Report, June 1997.

2.1. Duration Calculation

The COCOMO II schedule, as presently implemented (in COCOMO II.2000) reflects a waterfall process model and its duration calculation seems unreasonable for small projects, those with effort under two person years.

2.1.1 COCOMO II Duration Calculation

The COCOMO II duration calculation is based on an equation that has demonstrated historical accuracy, at least for large projects.

$$\text{Months} \sim 3\sqrt[3]{\text{Person-Months}}$$

This model component completely breaks down at very low efforts (16 person-months of effort) and is very questionable below a few person-years of effort.

2.1.2 COPSEMO Duration Calculation

COCOMO's effort and schedule estimates are only for the MBASE/RUP Elaboration and Construction (the phases between LCO and IOC anchor points or milestones). Inception corresponds to the COCOMO's "Requirements" activity, which is actually an additional (fixed percentage) effort, beyond the effort calculated by COCOMO.

Another important difference of COPSEMO's schedule estimation from COCOMO II's simple schedule estimation is the use of a more complex calculation for the low effort situations. The initial COCOMO II baseline schedule equation is

TDEV= (3.67 * PMbar^(0.28 + 0.2 * (B-0.91)) * SCED%/100

where *TDEV* is the calendar time in months from the determination of a product's requirements baseline to the completion of an acceptance activity certifying that the product satisfies its requirements. *PMbar* is the estimated person-months excluding the SCED effort multiplier, *B* is the sum of project scale factors (discussed in the next chapter) and SCED% is the compression / expansion percentage in the SCED effort multiplier.

The TDEV calculations mean that the calculated schedule is related, approximately, to three times the cube root of the effort. For low-effort situations, especially below twenty-seven (27) person months, this yields a very pessimistic and unlikely duration of nine (9) months applying three (3) FSP people. Therefore, a new baseline schedule equation for efforts below 16 months has been chosen which is based on the square root of the effort, yielding equal FSPs and schedule months. A linear interpolation is used between the high-end applicability of 64 person months (which corresponds to a schedule of 14.4 months for a 100KSLOC EHART using 1998 average driver values), and the low end point of 16 person months.

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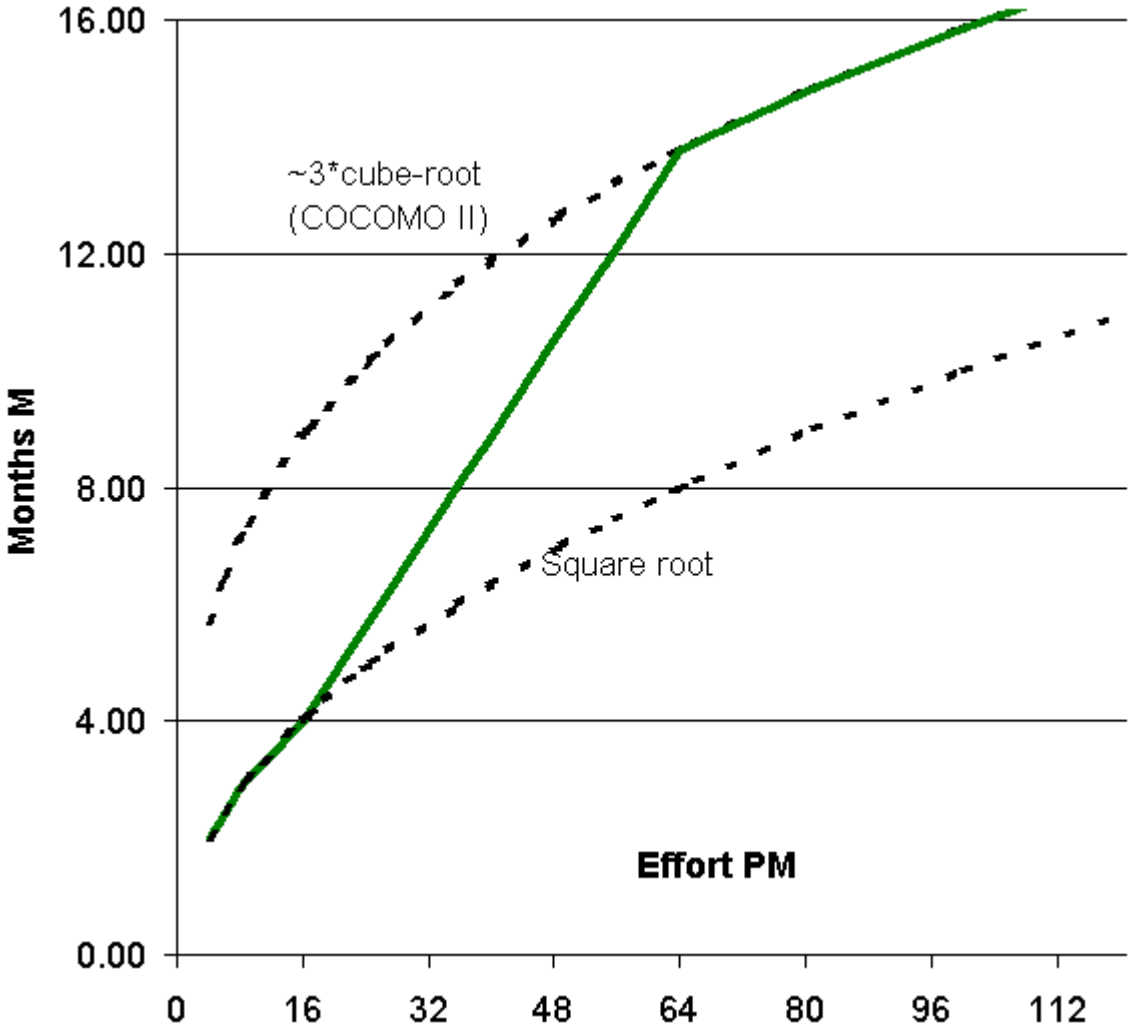

Figure 1. COCOMO II Schedule Estimate vs. COPSEMO Schedule Estimate

2.2. Process Model

The COPSEMO model is based on the lifecycle anchoring concepts discussed by Boehm[2]. The anchor points are defined as Life Cycle Objectives (LCO), Life Cycle Architecture (LCA), and Initial Operational Capability (IOC). An augmented illustration based on one from the Rational Corporation[3], Figure 2, shows the phases around the anchor points.

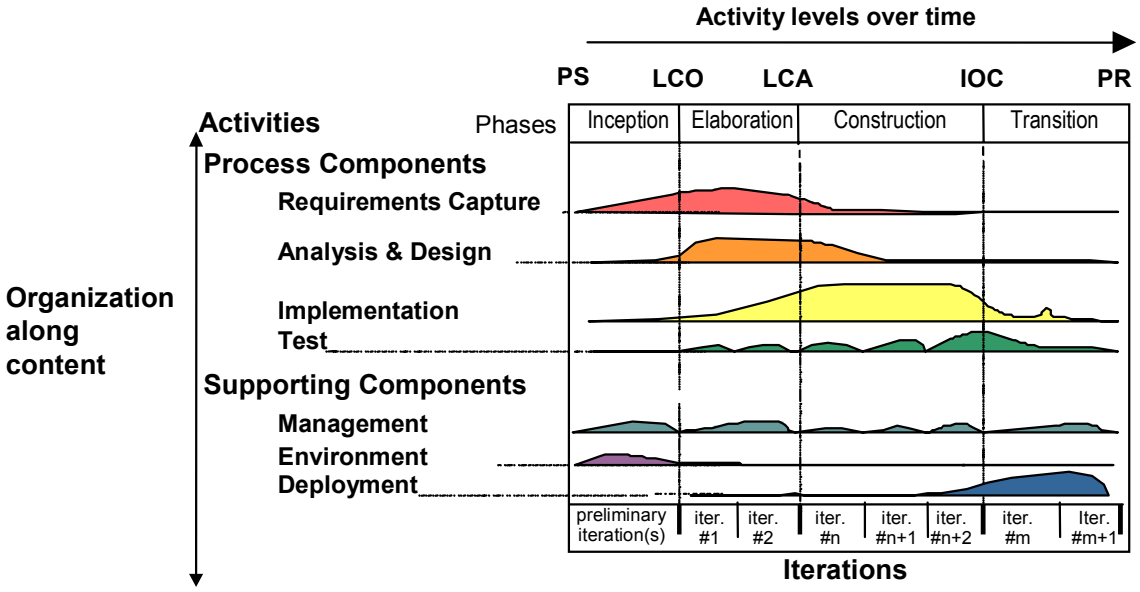

Figure 2. A modern lifecycle model with anchor points

[2] Barry W. Boehm, "Anchoring the Software Process," *IEEE Software,* 13, 4, July 1996, pp. 73-82.

3 Rational Corp., "Rational Objectory Process 4.1 – Your UML Process", available at http://www.rational.com/support/techpapers/toratobjprcs/.

2.3. Anchor Points, Phases and Activities

The diagram shows various activities, and implies iterations and the relative effort and duration of typical cycles within an iteration. The following table provides some more detail on the relative proportion of the activities, and some details.

COCOMO II Submodel Usage	Early Design	Post-Architecture		Maintenance
	LCO	LCA		IOC
Activities / Phase	**Inception**	**Elaboration**	**Construction**	**Transition**
Requirements Capture	Some usually	Most, peaks here	Minor	None
Analysis & Design	A little	Majority, mostly constant effort	Some	Some, for repair during ODT&E
Implementation	Practically none	Some, usually for risk reduction	Bulk; mostly constant effort	Some, for repair during ODT&E
Test	None	Some, for prototypes	Most for unit test, integration test and qualification test.	Some, for repaired code.

Table 1. Phases, Anchor Points, and relative amount and kind of Activities

3. Model Overview

The COPSEMO model assumes that data is available from a COCOMO II model.

3.1. COCOMO II Constructive Phase Schedule & Effort Model (COPSEMO)

The COPSEMO part of the model currently has no drivers, per se. The model does allow for the specification of the percentages of effort and schedule to be applied to the different phases: Inception, Elaboration and Construction. The predicted effort and schedule from a COCOMO II run correspond to the sum of the Elaboration and Construction phases' effort and schedule, respectively. The percentages of effort and schedule Elaboration and Construction phases thus total 100% and are used to distribute the sum accordingly. The percentages of effort and schedule for the Inception phase are also applied to the COCOMO II run's effort and schedule, respectively. Thus, the sum of the effort or schedule for three phases can actually total more than 100% of the COCOMO II run's effort and schedule.

4. Implementation Models

There are three implementations of the COPSEMO model at this time. The logical implementation model shows how the various input and models interrelate. The physical implementation model shows how the logical implementation model has been realized in spreadsheet models. These three models are shown below.

4.1. Logical COCOMO II Phase Effort and Schedule Extension

Figure 3 shows a conceptual logical block diagram for implementation of the COPSEMO Model. It assumes that the regular COCOMO II implementation is extended with phase distributions which are potential driven by language level (e.g., 3GL or 4GL), experience, etc. The phase distributions extension allocates the baseline effort and schedule by phase.

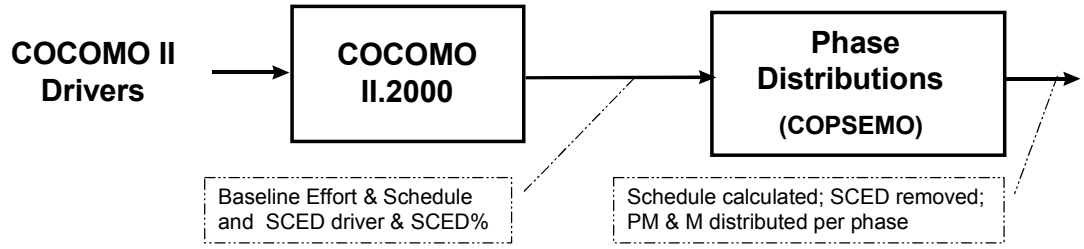

Figure 3. Logical Implementation Model

4.2. Physical COCOMO II RAD Extension

Figure 4 shows the shows the current implementation strategy for the COCOMO II COPSEMO extension. The left box represents the COCOMO II.2000 model as implemented by COCOMO II.exe, identified as "COCOMO II.2000" in its "About USC-COCOMO II" dialog box. Also part of the COCOMO II implementation suite is a spreadsheet called COCOMO_charts.xls. It is designed to import two CSV files that can be exported from COCOMOII.exe and make their information available in spreadsheet form (it also generates many useful charts and graphs of the data). The baseline effort and schedule as well as the values for all the drivers are acquired the COPSEMO Extension by links to the COCOMO_charts.xls spreadsheet. The COPSEMO Extension, which is actually implemented as COPSEMO.xls, distributes the effort (with no SCED impact), and schedule.

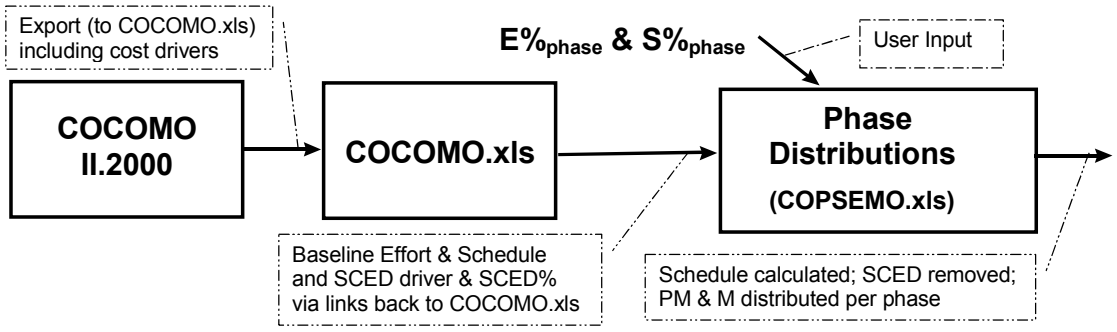

Figure 4. Physical Implementation Model

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4.3. Stand-alone Spreadsheet Implementation

Figure 5 contains a stand-alone implementation of the COPSEMO extension.

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Step **NOTE: BOLD** implies a required value. ***Italic*** implies an optional value

1.0 ..... f Currently implemented only for projects (not modules)
Get COCOMO II.2000 data and adjustments

2.0 ***Project: 5KNomNomNom*** **TotalSize= 5,000** **PM_C= 17.3** **M_C= 9.08**
(automatically from COCOMO_charts.xls) **SCED_R= N** **SCEDinc: 0%** **SCEDV= 1.00** P_C= 1.9013
Work hours per months (non-overhead or "billable"; COCOMO-II.2000 default= 152)= **152**

3.0 Calculate Baseline values: PM_BS by adjusting work hours per months; M_BS by applying COPSEMO's M=f(PM) to PM_BS; and P_BS from PM_BS/M_BS.
Calculate Months_Base-Schedule (M_BS) as function of COCOMO II.2000 calculated effort (PM_CnoSCED)
If PM_C< 16 then M_BS = Sqrt(PM_CnoSCED); and therefore P=M
If 16<=PM_C<64 then M_BS=(Mof64-4)/48*PMnoSCED)+(4-16*(Mof64-4)/48)
If PM=>64 then M_BS =3.67*(PM_C^(0.28+0.2*(B_C-0.91)))*SCEDph/100
M_BS= =IF(PMnoSCED<16.001,SQRT(PMnoSCED),IF(PMnoSCED<64,((Maf64-4)/48*PMnoSCED)+(4-16*(Maf64-4)/48),3.67*POWER(PMnoSCED,(0.28+0.2*(B-0.91)))*SCEDph/100))
PM_BS= 17.3 M_BS= 4.26 P_BS= 4.055

4.0 Get Effort % & Schedule % per stage
Default values: *Italic*

	Inception		Elaboration		Construction		Transition		Total E&C	Total
Effort %	*6.0* **6.0**		*24.0* **24.0**		*76.0* **76.0**		*12* **12.0**		100.0	118.0
Schedule %	*12.5* **12.5**		*37.5* **37.5**		*62.5* **62.5**		*12.5* **12.5**		100.0	125.0
P/Ave(P)	0.48		0.64		1.22		0.96		1.00	Does not apply
	PM / M : P		PM / M : P		PM / M : P		PM / M : P		PM / M : P	PM / M : P-ave
PSE Distributed	1.04 / 0.53 : 1.95		4.14 / 1.60 : 2.60		13.12 / 2.66 : 4.93		2.07 / 0.53 : 3.89		**17.3 / 4.26** : 4.05	20.4 / 5.32 : 3.83

Ave(P) refers to the average number of persons on the project; it is the same as PM_BS/M_BS for the entire project,
and each stage's P/Ave(P) is the same as stage's Effort%/Schedule%.

5.0 Plot of P vs. M. "Input" values: **BOLD**

	Inception	Elaboration	Construction	Transition	Total E&C	Total
Effort %	**6.0**	**24.0**	**76.0**	12.0	100.0	106.0
Schedule %	**12.5**	**37.5**	**62.5**	12.5	100.0	112.5
P/Ave(P)	0.48	0.64	1.22	1.00	1.00	
	PM / M : P	PM / M : P	PM / M : P	PM / M : P	PM / M : P	PM / M : P-ave
PSE Distributed	1.04 / 0.53 : 1.95	4.14 / 1.60 : 2.60	13.12 / 2.66 : 4.93	2.07 / 0.53 : 3.89	**17.3 / 4.3** : 4.1	20.4 / 5.32 : 3.83

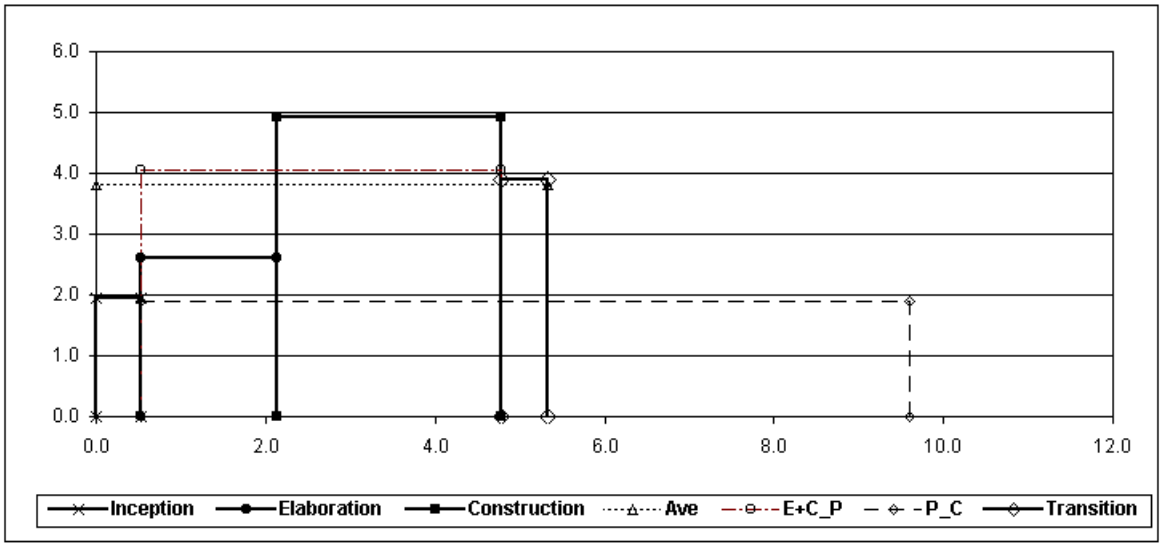

Figure 5. The COPSEMO extension