

COCOMO

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First published in Boehm's 1981 book *Software Engineering Economics*^[1] as a model for estimating effort, cost, and schedule for software projects. It drew on a study of 63 projects at TRWAerospace where Boehm was Director of Software Research and Technology. The study examined projects ranging in size from 2,000 to 100,000 [lines of code](#), and programming languages ranging from [assembly](#) to [PL/I](#). These projects were based on the [waterfall model](#) of software development which was the prevalent software development process in 1981.

References to this model typically call it *COCOMO 81*. In 1995 *COCOMO II* was developed and finally published in 2000 in the book *Software Cost Estimation with COCOMO II*.^[2] COCOMO II is the successor of COCOMO 81 and is better suited for estimating modern software development projects. It provides more support for modern [software development processes](#) and an updated project database. The need for the new model came as software development technology moved from mainframe and overnight batch processing to desktop development, code reusability, and the use of off-the-shelf software components. This article refers to *COCOMO 81*.

COCOMO consists of a hierarchy of three increasingly detailed and accurate forms. The first level, *Basic COCOMO* is good for quick, early, rough order of magnitude estimates of software costs, but its accuracy is limited due to its lack of factors to account for difference in project attributes (*Cost Drivers*). *Intermediate COCOMO* takes these Cost Drivers into account and *Detailed COCOMO* additionally accounts for the influence of individual project phases.

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Basic COCOMO [\[edit\]](#)

Basic COCOMO compute software development effort (and cost) as a function of program size. Program size is expressed in estimated thousands of source lines of code ([SLOC](#), [KLOC](#)).

COCOMO applies to three classes of software projects:

- Organic projects - "small" teams with "good" experience working with "less than rigid" requirements
- Semi-detached projects - "medium" teams with mixed experience working with a mix of rigid and less than rigid requirements
- Embedded projects - developed within a set of "tight" constraints. It is also combination of organic and semi-detached projects.(hardware, software, operational, ...)

The basic COCOMO equations take the form

Effort Applied (E) = $a_b(KLOC)^{b_b}$ [person-months]
Development Time (D) = $c_b(Effort Applied)^{d_b}$ [months]
People required (P) = Effort Applied / Development Time[count]

where, **KLOC** is the estimated number of delivered lines (expressed in thousands) of code for project. The coefficients a_b , b_b , c_b and d_b are given in the following table:

Software project	a_b	b_b	c_b	d_b
Organic	2.4	1.05	2.5	0.38
Semi-detached	3.0	1.12	2.5	0.35
Embedded	3.6	1.20	2.5	0.32

Basic COCOMO is good for quick estimate of software costs. However it does not account for differences in hardware constraints, personnel quality and experience, use of modern tools and techniques, and so on.

Intermediate COCOMOs [\[edit\]](#)

Intermediate COCOMO computes software development effort as function of program size and a set of "cost drivers" that include subjective assessment of product, hardware, personnel and project attributes. This extension considers a set of four "cost drivers", each with a number of subsidiary attributes:-

- Product attributes
 - Required software reliability
 - Size of application database
 - Complexity of the product
- Hardware attributes
 - Run-time performance constraints
 - Memory constraints
 - Volatility of the virtual machine environment
 - Required turnabout time
- Personnel attributes
 - Analyst capability
 - Software engineering capability
 - Applications experience
 - Virtual machine experience
 - Programming language experience
- Project attributes
 - Use of software tools
 - Application of software engineering methods

- Required development schedule

Each of the 15 attributes receives a rating on a six-point scale that ranges from "very low" to "extra high" (in importance or value). An effort multiplier from the table below applies to the rating. The product of all effort multipliers results in an *effort adjustment factor (EAF)*. Typical values for EAF range from 0.9 to 1.4.

Cost Drivers	Ratings					
	Very Low	Low	Nominal	High	Very High	Extra High
Product attributes						
Required software reliability	0.75	0.88	1.00	1.15	1.40	
Size of application database		0.94	1.00	1.08	1.16	
Complexity of the product	0.70	0.85	1.00	1.15	1.30	1.65
Hardware attributes						
Run-time performance constraints			1.00	1.11	1.30	1.66
Memory constraints			1.00	1.06	1.21	1.56
Volatility of the virtual machine environment		0.87	1.00	1.15	1.30	
Required turnabout time		0.87	1.00	1.07	1.15	
Personnel attributes						
Analyst capability	1.46	1.19	1.00	0.86	0.71	
Applications experience	1.29	1.13	1.00	0.91	0.82	

Software engineer capability	1.42	1.17	1.00	0.86	0.70	
Virtual machine experience	1.21	1.10	1.00	0.90		
Programming language experience	1.14	1.07	1.00	0.95		
Project attributes						
Application of software engineering methods	1.24	1.10	1.00	0.91	0.82	
Use of software tools	1.24	1.10	1.00	0.91	0.83	
Required development schedule	1.23	1.08	1.00	1.04	1.10	

The Intermediate Cocomo formula now takes the form:

$$E = a_i (KLoC)^{b_i} \cdot EAF$$

where E is the effort applied in person-months, **KLoC** is the estimated number of thousands of delivered lines of code for the project, and **EAF** is the factor calculated above. The coefficient **a_i** and the exponent **b_i** are given in the next table.

Software project	a _i	b _i
Organic	3.2	1.05
Semi-detached	3.0	1.12
Embedded	2.8	1.20

The Development time **D** calculation uses **E** in the same way as in the Basic COCOMO.

Detailed COCOMO [\[edit\]](#)

Detailed COCOMO incorporates all characteristics of the intermediate version with an assessment of the cost driver's impact on each step (analysis, design, etc.) of the software engineering process.

The detailed model uses different effort multipliers for each cost driver attribute. These **Phase Sensitive** effort multipliers are each to determine the amount of effort required to complete each phase. In detailed cocomo, the whole software is divided in different modules and then we apply COCOMO in different modules to estimate effort and then sum the effort

In detailed COCOMO, the effort is calculated as function of program size and a set of cost drivers given according to each phase of software life cycle.

A Detailed project schedule is never static.

The five phases of detailed COCOMO are:-

- plan and requirement.
- system design.
- detailed design.
- module code and test.
- integration and test.

See also [\[edit\]](#)

- [Estimation in software engineering](#)
- [Comparison of development estimation software](#)
- [COSYSMO](#)
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Further reading [\[edit\]](#)

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