Constructive Cost Model COCOMO

Adapted from Allan Caine

Outline

- COCOMO in a Coconut-shell
- Complete Examples
- Intermediate COCOMO: Cost Drivers
- Advantages and Limitations of COCOMO

COCOMO in a Coconut-shell

$$E = a(KLOC)^{b}$$

- Where
  - E is the Effort in staff months
  - a and b are coefficients to be determined
  - KLOC is thousands of lines of code

The Constants

Mode	a	b
Organic	2.4	1.05
Semi-detached	3.0	1.12
Embedded	3.6	1.20

The Modes

- Organic
  - 2-50 KLOC, small, stable, little innovation
- Semi-detached
  - 50-300 KLOC, medium-sized, average abilities, medium time-constraints
- Embedded
  - > 300 KLOC, large project team, complex, innovative, severe constraints

Examples

- Suppose size is 200 KLOC,
  - Organic
    - $2.4(200)^{1.05} = 626$ staff-months
  - Semi-Detached
    - $3.0(200)^{1.12} = 1{,}133$ staff-months
  - Embedded
    - $3.6(200)^{1.20} = 2{,}077$ staff-months

Project Duration

$$TDEV = c(E)^{d}$$

- Where
  - TDEV is time for development
  - c and d are constants to be determined
  - E is the effort

Constants for TDEV

Mode	c	d
Organic	2.5	0.38
Semi-detached	2.5	0.35
Embedded	2.5	0.32

Example

- Picking up from the last example,
  - Organic
    - E = 626 staff months
    - TDEV = $2.5(626)^{0.38}$ = 29 months
  - Semi-detached
    - E = 1,133
    - TDEV = $2.5(1133)^{0.35}$ = 29 months
  - Embedded
    - E = 2077
    - TDEV = $2.5(2077)^{0.32}$ = 29 months

Average Staff Size

$$SS = \frac{E}{TDEV} = \frac{[\text{staff} \cancel{\text{ - months}}]}{\cancel{[\text{months}]}} = [\text{staff}]$$

Productivity

$$P = \frac{Size}{E} = \frac{[\text{KLOC}]}{[\text{staff - months}]} = \text{KLOC} \big/ \text{staff - month}$$

Complete Example, Organic

- Suppose an organic project has 7.5 KLOC,
  - Effort $2.4(7.5)^{1.05}$ = 20 staff–months
  - Development time $2.5(20)^{0.38}$ = 8 months
  - Average staff 20 / 8 = 2.5 staff
  - Productivity 7,500 LOC / 20 staff-months = 375 LOC / staff-month

Complete Example, Embedded

- Suppose an embedded project has 50 KLOC,
  - Effort $3.6(50)^{1.20}$ = 394 staff–months
  - Development time $2.5(394)^{0.32}$ = 17 months
  - Average staff 394 / 17 = 23 staff
  - Productivity 50,000 LOC / 394 staff-months = 127 LOC / staff-month

Comparison

Item	Organic	Embedded
Effort (staff-months)	20	394
Development Time	8	17
Average Staff	2.5	23
Productivity	375	127

Intermediate COCOMO

$$E = a(KLOC)^{b} \underbrace{\times C}_{\text{New}}$$

- Where
  - E is the effort
  - a and b are constants (as before)
  - KLOC is thousands of lines of code
  - C is the effort adjustment factor

Cost Drivers

- Intermediate COCOMO introduces Cost Drivers
- They are used because
  - they are statistically significant to the cost of the project; and
  - they are *not* correlated to the project size (KLOC).

Categories

- I. Product Attributes
- II. Computer Attributes
- III. Personnel Attributes
- IV. Project Attributes

I. Product Attributes

- RELY Required Software Reliability
- DATA Data Base Size
- CPLX Product Complexity

II. Computer Attributes

- TIME Execution Time Constraint
- STOR Main Storage Constraint
- VIRT Virtual Machine Volatility[1]
- TURN Computer Turnaround Time

[1]The hardware and software in combination.

III. Personnel Attributes

- ACAP Analyst Capability
- AEXP Application Experience
- PCAP Programming Capability
- VEXP Virtual Machine Experience[1]
- LEXP Programming Language Experience

[1]The hardware and software in combination.

IV. Project Attributes

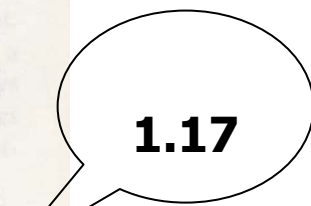
- MODP Modern Programming Practices
- TOOL Use of Software Tools
- SCED Required Development Schedule

Example

- Suppose the following assumptions are made:

TABLE 8–6 Cost Driver Ratings: Microprocessor Communications Software

Cost Driver	Situation	Rating	Effort Multiplier
RELY	Local use of system. No serious recovery problems	Nominal	1.00
DATA	20,000 bytes	Low	0.94
CPLX	Communications processing	Very high	1.30
TIME	Will use 70% of available time	High	1.11
STOR	45K of 64K store (70%)	High	1.06
VIRT	Based on commercial microprocessor hardware	Nominal	1.00
TURN	Two-hour average turnaround time	Nominal	1.00
ACAP	Good senior analysts	High	0.86
AEXP*	Three years	Nominal	1.00
PCAP	Good senior programmers	High	0.86
VEXP	Six months	Low	1.10
LEXP	Twelve months	Nominal	1.00
MODP	Most techniques in use over one year	High	0.91
TOOL	At basic minicomputer tool level	Low	1.10
SCED	Nine months	Nominal	1.00
	Effort adjustment factor (product of effort multipliers)		1.17



Example ..2

- So, the nominal amount of staff-months will be increased by 17% for organic, semi-detached, or embedded projects.
- Suppose it is estimated that a project will take 51 nominal staff-months at $5,000 / staff-month.
- The cost:
  - Nominally, $255,000 (51 X $5,000)
  - Adjusted, $298,350 (51 X $5,000 X 1.17)

The "Proof"

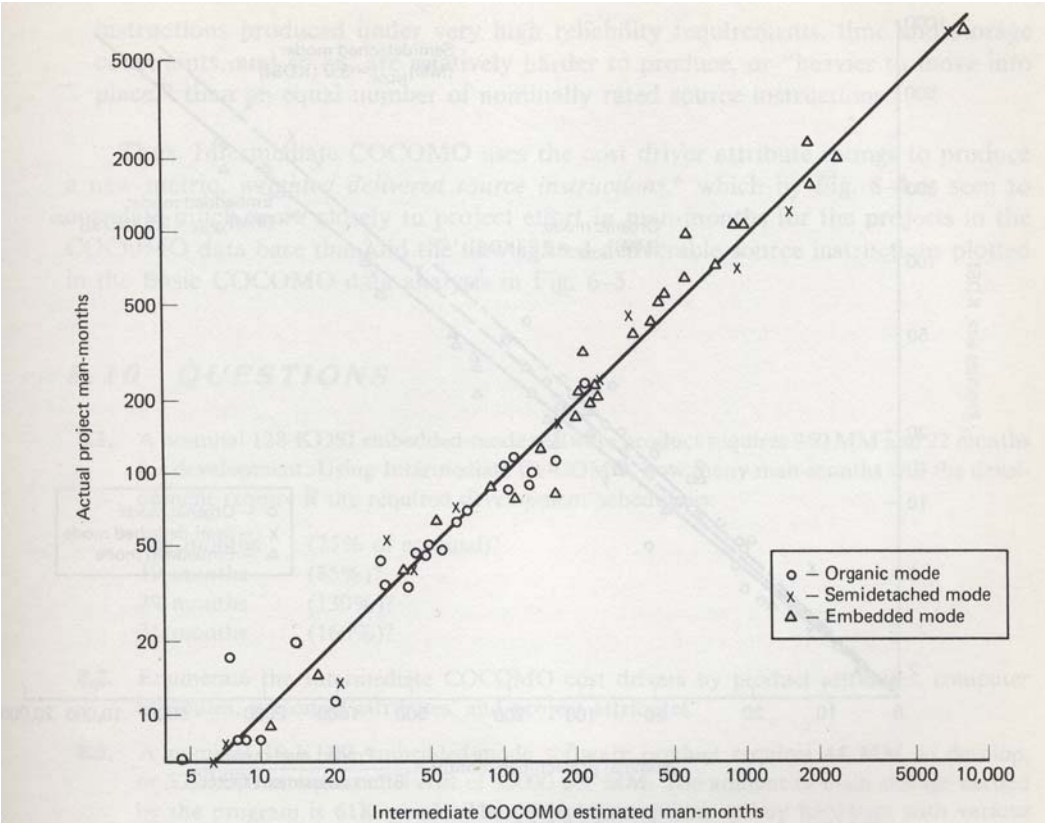


FIGURE 8-3 Intermediate COCOMO estimates vs. project actuals

Advantages

- Based on history
- Repeatable
- Unique adjustment factors
- Has different modes
- Works well on similar projects
- Highly calibrated
- Well-documented
- Easy to use

Limitations

- Ignores requirements volatility
- Ignores documentation
- Ignores customer's "skill"
- Oversimplifies security
- Ignores software safety
- Ignores personnel turnover
- Ignores many hardware issues
- Personnel experience may be obsolete
- Must know the cost drivers
- Must be able to predict project size

Final Word

- “The models are just there to help, not to make the management decisions for you.”

  -- Barry Boehm