# 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

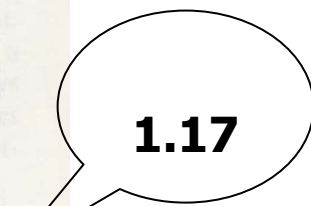
- MODP Modern Programming Practices
- TOOL Use of Software Tools
- SCED Required Development Schedule

# 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"

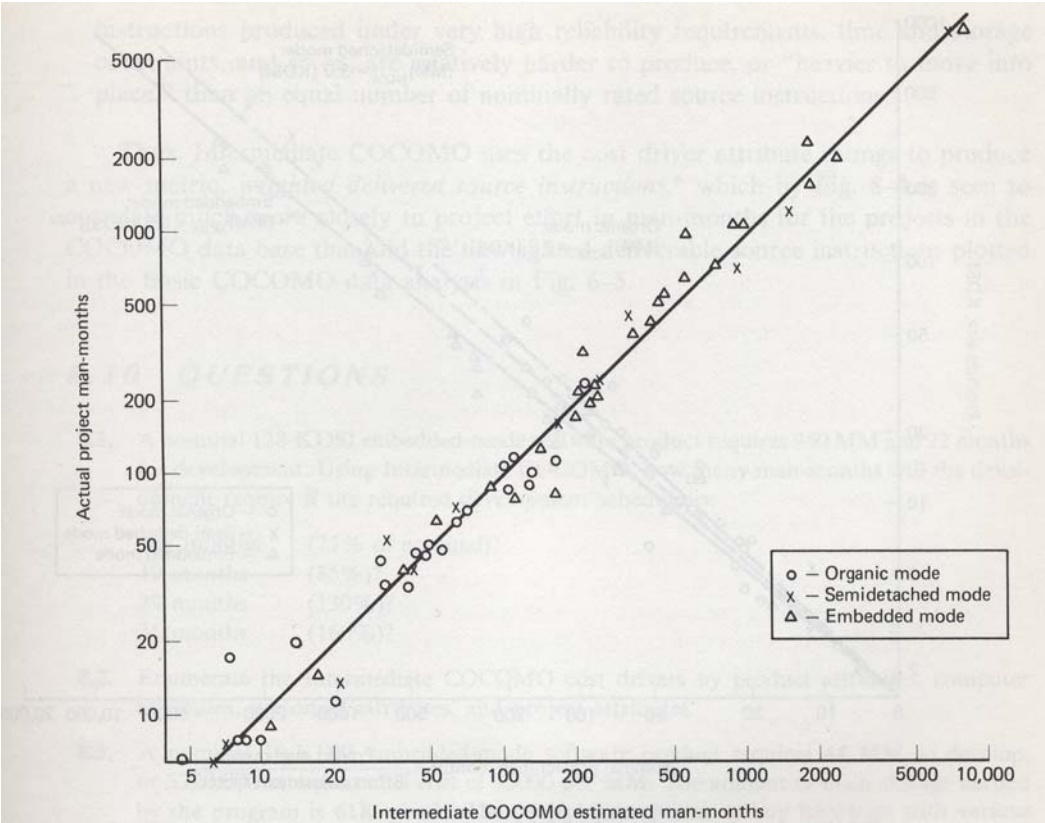



**FIGURE 8-3** Intermediate COCOMO estimates vs. project actuals

# 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