**ORGANIC**

project that is routine for a company... it is in a well understood domain of application, or it is being done by a team that works well together. A project of this type will run smoothly, few hitches anticipated. This is the "easy" end

**EMBEDDED**

A project that will be difficult for a company. Perhaps it is in a domain of application that is fully novel (in 1965, build a software system to control a rocket that will fly men to the moon and back), or perhaps it is an area in which the company has little experience (Boeing writing Nuclear Power Plant control systems). Perhaps the teams available are freshly formed and inexperienced together.

Embedded projects also tend to suffer from the inherent complexity coming from specific, special hardware requirements. They tend to be very large efforts. Tight execution constraints complicate the development. Regulations from some authority may put constratins on the project as well.

**SEMI-DETACHED**

The middle of the difficulty spectrum. Projects here are somewhat complex but somethng the company has experience dealing with. Teams available are accustomed to managing systems in the domain of application. Teams may be composed of both experienced and inexperienced people. The overall project is not massive or huge, nor is it simple and

# Estimating SIZE

◦ other methods

FUNCTION POINTS is one method that has been researched, for example. Like COCOMO, the methods of Function Points has been developed from empirical evidence. Many projects were examined with respect to the characteristics discussed here, and the sizes of the final products examined, and a model produced to fit the data.

Functions Points methods works best with business-type information processing applications, since those are the projects that were examined to produce the model. It is also not as widely known, used, or trusted for estimating SIZE as COCOMO is for estimating EFFORT. We give it here just as an example.

5 items determine the ultimate complexity of an application... take the weighted sum of these counts to get the # of function points in a system.

| characteristic | weight |
|---|---|
| number of inputs | 4 |
| number of outputs | 5 |
| number of inquiries | 4 |
| number of files | 10 |
| number of interfaces | 7 |

inputs, outputs: groups count as one item (screenful, file)
inquiries: interactive "cases" or transactions a system must be able to deal with
interfaces: hook-up to other systems (OS, payroll system, company DB, etc.)

Once the # function points FP is calculated (from requirements), other data is used to estimate module/system SIZE. For various languages, data was obtained on how many lines of code are usually needed to implement one function point...

For example, let's say Ada programs tend to require 70 DSI per FP.

A system with FP=124 would have SIZE = FP * 70 = 124*70 = 8680

SO, the estimate for SIZE in this case is 8.68 KDSI

# Example of Intermediate COCOMO

From section 3.1.5 in Jalote...

Consider a database system needed for an office automation project.
The requirements document shows 4 modules needed.

Sizes are estimated as follows:

| | |
|---|---|
| data entry | 0.6 KDSI |
| data update | 0.6 KDSI |
| query | 0.8 KDSI |
| report gen | 1.0 KDSI |
| system SIZE | 3.0 KDSI |

- **How can SIZE be estimated in the first place?**

The project is judged to be ORGANIC (so a=3.2, b=1.05 )

The manager rates project details as follows:

| characteristic | level | EAF |
|---|---|---|
| complexity | high | 1.15 |
| storage | high | 1.06 |
| experience | low | 1.13 |
| programmer capabilities | low | 1.17 |

All others: nominal (1.0)

Person Months for the project:

$$PM = (1.15*1.06*1.13*1.17) * 3.2 * (3.0)^{1.05}$$
$$PM = 1.61 * 3.2 * 3.17$$
$$PM = 16.33$$

> 16 person months estimated

- How many people shoud we hire for this effort?

# Practice problem

◦ SOLUTION

For the following project description, generate estimates for total effort, project duration, and number of people needed using the intermediate COCOMO model.

CADCO, Inc., wants to produce a system that will perform computer-aided design for the home construction industry. They are a new company, and though they want to be the best in CAD systems, they are still, overall, a bit inexperienced. This project, then, for CADCO (at this time in their history) would be considered ◦ WHAT TYPE?

Initial analysis of the problem leads to requirements calling for 3 major modules, with the following sizes:

| | |
|---|---|
| screen drawing | 2.00 KDSI |
| object-base management | 3.50 KDSI |
| algebra/numerical methods | 1.75 KDSI |

The programmers that CADCO hired to start are among the best in the business, but most have never used C++ before, which will be the language of implementation. The system must run fairly fast, since users will be impatient if drawing takes too long. CADCO also would like to make their market as large as possible, which means the package should run on slower PCs as well as faster ones. Many models will accumulate over time; the house simulation routines and solid modeling routines will require a great deal of memory to operate efficiently. For the project, then, these effort adjustment factors are estimated:

| | |
|---|---|
| data base size | high |
| product complexity | very high |
| main storage | very high |
| execution time constraints | high |
| programmer capability | very high |
| programming language experience | very low |

all other characteristics rated nominal

# Solution

## What Project Type? SEMI-DETACHED

| | |
|---|---|
| screen drawing | 2.00 KDSI |
| object-base management | 3.50 KDSI |
| algebra/numerical methods | 1.75 KDSI |
| total SIZE | 7.25 KDSI |

**Effort** $PM = EAF * 3.0 * (SIZE)^{1.12}$

> 40 person-months

$PM = (1.05*1.30*1.21*1.11*0.70*1.14) * 3.0 * (7.25)^{1.12}$
$PM = 1.46 * 3.0 * 9.19$
$PM = 40.25$

**Project Duration** $D = 2.5 * (PM)^{0.35}$

> 9 calendar months

$D = 2.5 * (40.25)^{0.35}$
$D = 2.5 * 3.64$
$D = 9.10$

**Staffing** $P = PM/D$

4 or 5 people needed

$P = 40.25 / 9.10$
$P = 4.42$