

CS 350: Introduction to Software Engineering

Slide Set 3  
Estimating with Probe I  
C. M. Overstreet  
Old Dominion University  
Spring 2006

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Reading assignments

- Though Chapter 6 (PROBE)
- Text has many more examples than we're able to do in class!
  - And it's much easier to see how the plan data go onto the PSP forms

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Lecture Topics

- Planning overview
- Why estimate size?
- Size estimating principles
- The PROBE estimating method
- Size estimating proxies
- Estimating examples

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## Planning Overview

- Plans
  - allow you to make commitments that you can meet
  - provide the basis for agreeing on job scope, schedule, and resources
  - guide the work
  - facilitate progress tracking and reporting
  - help ensure that key tasks are not overlooked

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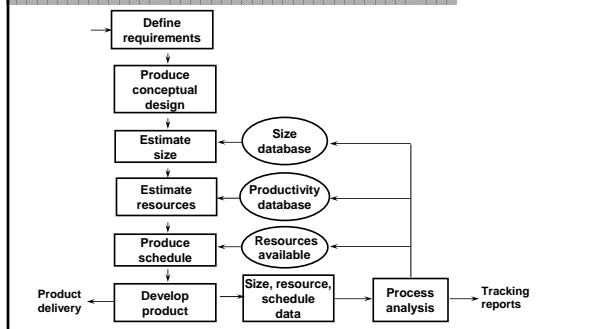
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## The Project Planning Framework



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## The Planning Process

- Before making the plan, you must have a requirement.
  - The better the requirement, the better the plan.
  - With ill-defined requirements, expect to make frequent plan updates.
- Plans are most accurate when based on size estimates and appropriate historical data.
- With a size estimate and historical data, you can
  - identify the data on the most similar prior work
  - base the resource estimate on these data

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## Size Estimating Principles - 1

- Estimating is an uncertain process.
  - No one knows how big the product will be.
  - The earlier the estimate, the less is known.
  - Estimates can be biased by business and other pressures.
- Estimating is an intuitive learning process.
  - Ability improves with experience and data.
  - Some people will be better at estimating than others.

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## Size Estimating Principles - 2

- Estimating is a skill.
  - Improvement will be gradual.
  - You may never get very good.
- The objective is to become consistent.
  - You will then understand the variability of your estimates.
  - You seek an even balance between under- and overestimates.

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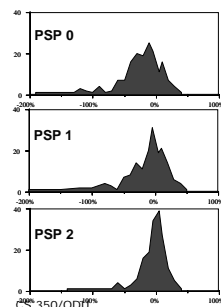
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## Balanced Estimates

- Majority are under-estimating
- Balance of over- and underestimates
- Much tighter balance around zero



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## Size Estimating Principles - 3

- The advantages of using defined estimating methods are that you
  - have known practices that you can improve
  - have a framework for gathering estimating data
  - can consistently use historical data to produce balanced estimates

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## Estimating with PROBE

- The PSP uses the PROBE method to estimate and plan projects.
- PROBE stands for PROxy Based Estimating.
- PROBE uses proxies to estimate program size and development time.
- A good proxy will help you to make accurate estimates.

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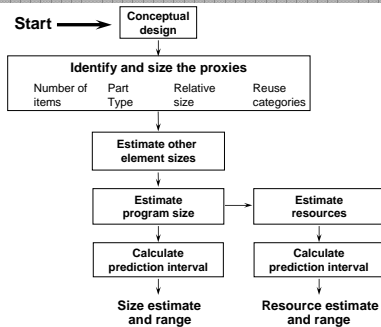
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## The PROBE Estimating Method



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## Conceptual Design - 1

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- The first estimating step is to make a conceptual design.
  - relate the requirements to the product
  - define the product elements that will produce the desired functions
  - estimate the size of what you plan to build
- For most projects, the conceptual design can be produced relatively quickly.
- For the PSP exercise programs, try to limit your conceptual design time to 10, or at most 20, minutes.

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## Conceptual Design - 2

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- To make a conceptual design, identify the product functions and the program parts needed to produce them.
- In effect, you say: "If I had the following parts, I could build this product."
- Then, compare these parts to programs you have already written and estimate their sizes.
- Finally, combine the part estimates to give total size.
- If you do not understand the product well enough to make a conceptual design, you do not know enough to make a plan.

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## Size Estimating Proxies - 1

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- The basic issue
  - Good size measures are detailed.
  - It is generally hard to visualize product details early in a project.
- Alternatives
  - Wait to estimate until you have the detail.
  - Make your best guess.
  - Identify a suitable proxy.

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## Size Estimating Proxies - 2

- A good proxy should correlate closely to development costs.
- A good proxy should be easy to visualize early in development.
- It should also be a physical entity that can be measured.

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## Example: Building Costs

- Problem
  - The builder needs to know the floor area (in sq. ft.) to estimate the cost of construction.
  - Clients normally cannot describe their needs in square feet.
  - They usually can describe the type and number of rooms they want.
- Solution
  - Use rooms as a proxy for size.
  - Use historical (typical) data to translate from rooms to square feet.

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## Example: Customer Requirements

- Bedrooms: 1 large, 2 medium, and 1 small
- Bathrooms: 1 large and 2 medium
- Kitchen: 1 medium
- Living room: 1 large
- Dining room: 1 medium
- Family room: 1 large
- Utility: 1 medium

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## Historical Building Data

	Small	Medium	Large
Bedrooms	90	140	200
Bathrooms	25	60	120
Kitchens	100	130	160
Living rooms	150	250	400
Dining rooms	100	140	200
Family rooms	150	240	340
Utility	25	50	80

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## Proxy Calculation

Bedroom	1 large	=	1 x 200	=	200
Bedroom	2 medium	=	2 x 140	=	280
Bedroom	1 small	=	1 x 90	=	90
Bathroom	1 large	=	1 x 120	=	120
Bathroom	2 medium	=	2 x 60	=	120
Kitchen	1 medium	=	1 x 130	=	130
Living room	1 large	=	1 x 400	=	400
Dining room	1 medium	=	1 x 140	=	140
Family room	1 large	=	1 x 340	=	340
Utility	1 medium	=	1 x 50	=	50
Total (sq. ft.)					= 1870

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## Example: The Builder's Estimate

- The first estimation step provides the builder with the proxy data for room size.
- However, there are many other cost elements in home construction.
- Builders typically have extensive data to relate room size to the other building costs.
- With agreed initial plans, builders typically require detailed architectural specifications and estimates before quoting a price.

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## Example Product Proxies

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- Classes, functions, and procedures
- Product elements
  - database elements
  - screens, reports, scripts, files
  - book chapters

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## Classes as Proxies - 1

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- Correlation with development hours
  - Numbers of classes correlates reasonably well.
  - Class size correlates very closely.
  - Class size can be estimated using historical data.
  - The program size estimate is then calculated from the historical relationship between total class size and program size.
- With a good correlation, calculate program size from the relationship between class size and program size.

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## Classes as Proxies - 2

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- When classes are selected as application entities, they can be visualized early in development.
- Functions and procedures can often be estimated in the same way.
- Classes, functions, procedures, and their sizes can be automatically counted.

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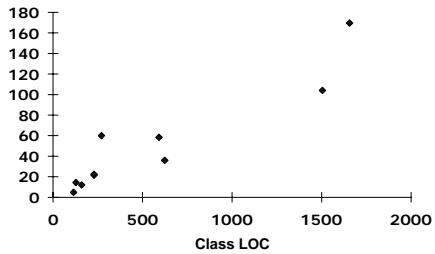
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## Class LOC Correlation With Development Hours



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## Estimating with Proxies

- Once you have selected a proxy, you must
  - obtain proxy data
  - organize the data for use in estimating
  - use the data to estimate the size of the proxies in the new program
- Combine the proxy estimates into the product estimate
- Make a resource estimate
- Produce a project plan
- The PROBE method shows you how to perform these steps.

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## Organizing Proxy Data

- A common way to estimate is to
  - break the planned product into parts
  - relate these planned parts to parts you have already built
  - use the size of the previously built parts to estimate the sizes of the new parts
- To do this, you need size ranges for the types of parts you typically develop.
- For each product type, you also need size ranges to help judge the sizes of the new parts.

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## Example C++ Class Size Ranges

Type	LOC per item				
	VS	S	M	L	VL
Calculation	2.34	5.13	11.25	24.66	54.04
Data	2.60	4.79	8.84	16.31	30.09
I/O	9.01	12.06	16.15	21.62	28.93
Logic	7.55	10.98	15.98	23.25	33.83
Set-up	3.88	5.04	6.56	8.53	11.09
Text	3.75	8.00	17.07	36.41	77.66

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## Estimating Program Size

- Just as homes have square feet that are not in rooms, programs have code that is not in the program parts.
  - includes
  - declarations
  - other overhead functions
- The development job, however, must also produce this overhead code.
- The size of this additional overhead code is usually proportional to the size of the program's parts.

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## Estimating Development Time

- With sound estimating methods, actual program size will be closely related to estimated program size.
- The differences will be due to the overhead code and the estimating error.
- Actual development time is also often related to estimated program size.
- Again, with sound methods, the differences will be largely due to overhead activities and estimating error.

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## Statistically-Based Estimates

- PROBE uses historical data, linear regression, and the prediction interval to produce estimates of known accuracy.
- Regression provides the best fit, or minimum variance, of a line to these data.
- The variance of the data is used to determine the likely estimation error.
- The greater the variance, the larger the likely error.

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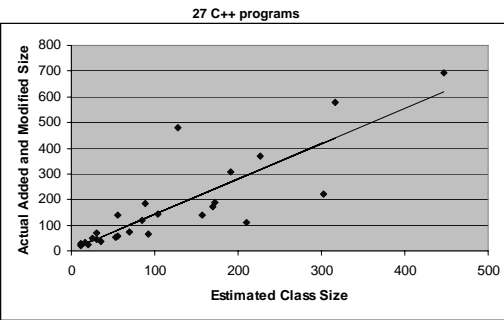
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## Regression Line for Program Size



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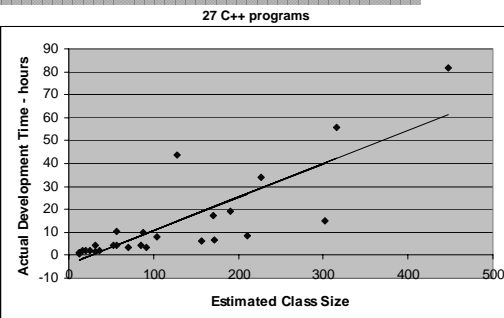
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## Regression Line for Development Time



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## Estimating Size and Time - 1

- To project a program's size or development time, find the equation for the regression line.
- Then use the regression formula to project size and time.
- E is the estimated proxy size.

$$y_k = \beta_0 + \beta_1 * x_k$$

$$\text{Added \& Modified \_ Size} = \beta_{0size} + \beta_{1size} * (E)$$

$$\text{Development \_ Time} = \beta_{0time} + \beta_{1time} * (E)$$

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## Estimating Size and Time - 2

- Calculate the regression parameters  $\beta_0$  and  $\beta_1$  from data on previously developed programs.
  - For x, use estimated proxy size (E).
  - For y, use the actual
    - added and modified size for the size estimate
    - total development time for the time estimate
- Calculate two sets of  $\beta_0$  and  $\beta_1$  regression parameters: one for size and the other for time.

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## Calculating Total Program Size

- Total program size includes added, modified, deleted, base, and reused code.
- When modifying an existing program, base code is the size of the unmodified existing program.
- When modifying programs, include their unmodified size in base code and not in reuse.
- While base code is a form of reuse, the PSP only counts unmodified code from the reuse library as reused.

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## Completing the Estimate - 1

- To complete the size estimate, calculate the
  - projected added and modified size with the size regression parameters
  - total program size, including added, modified, deleted, base, and reused code
  - estimated new reusable code to be added to the reuse library
- The completed estimate includes estimated development time calculated with the time regression parameters.

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## Completing the Estimate - 2

- With the size and time estimates, calculate the
  - 70% upper (UPI) and lower (LPI) prediction intervals for projected program size
  - 70% upper (UPI) and lower (LPI) prediction intervals for development time
- The prediction interval is covered later.

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## Completed Example - 1

- Base program (B) 695 LOC
- Deleted (D) 0 LOC
- Modified (M) 5 LOC
- Base additions (BA) 0 LOC
- Added parts (A)  $115+197+49 = 361$  LOC
- Reused parts (R) 169 LOC
  
- Estimated size  $E = BA + A + M = 366$  LOC

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## Completed Example -2

- Starting with  $E = 366$ , use the size regression parameters to calculate the projected size (P).
- $\beta_{0Size} = 62$  and  $\beta_{1Size} = 1.3$
- Projected size  $P = 62 + 1.3 * 366 = 538$  LOC
- Total size  $T = 538 + 695 - 5 * 169 = 1397$  LOC
- Estimated total new reusable = 49 LOC

\* Modified size is subtracted so it is not included twice.

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## Completed Example -3

- Starting with  $E = 366$ , use the time regression parameters to calculate development time.

$$Development\_Time = \beta_{0Time} + \beta_{1Time} * (E)$$

- $\beta_{0Time} = 108$  and  $\beta_{1Time} = 2.95$
- Development time =  $108 + 2.95 * 366 = 1186$  min.

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## Messages to Remember

- Accurate size estimates will help you to make better development plans.
- Estimating skill improves with practice.
- A defined and measured process provides a repeatable basis for improvement.
- To make accurate estimates, you must use historical data and follow sound methods.
- The PROBE method shows you how to do this.

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## Tutorial: Using PSP1

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- ### Tutorial Objectives
- After this tutorial, you will
    - understand the new elements of PSP1
    - know how to use the PSP1 process scripts and forms
    - be prepared to use PSP1 for program 3

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- ### PSP1 Objective
- The objective of PSP1 is to establish an orderly and repeatable procedure for developing software size estimates.

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## New Process Elements

- The new process elements are:
  - PROBE size estimating method and size estimating template
  - test report template
- The project plan summary has been expanded.
  - Summary section has been added with plan, actual, and to-date productivity
  - Program Size summary includes planned size for all size accounting types
  - All values except the Total Size under Actual in the Program Size Summary are now calculated.

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## PSP1 Project Plan Summary - 1

- The PSP1 Project Plan Summary includes a new summary section.
- The summary section includes plan, actual, and to-date productivity.
- The program size summary section has been expanded to report planned size for all size accounting types.
- All values except total actual size are calculated.

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## PSP1 Project Plan Summary - 2

- Plan, actual, and to-date productivity is included.
- It is the number of added and modified size units per hour.
- $Productivity = A\&M\ Size / Total\ Development\ Time * 60$

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## Test Report Template

- Use this form to record data on each of your tests.
  - what test was run
  - which test data were used
  - results that were obtained
- Helpful for
  - developing and recording test cases
  - performing regression testing

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## PROBE and the Size Estimating Template

- Starting with PSP1, the PROBE method is used for making size and time estimates.
- The Size Estimating Template is used to
  - record input to the PROBE method
  - calculate the estimated size and time
  - record actual size

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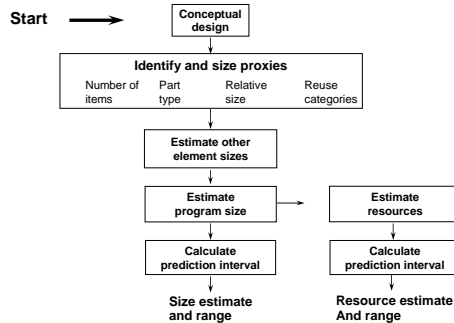
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## Steps in the PROBE Method




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## Conceptual Design

- Conceptual design relates the requirements to the parts needed to produce the program.
- The parts needed are
  - base parts – an existing part that will can be used but will require modifications.
  - added parts – new parts that need to be developed.
  - reused parts – an existing part that can be used as-is.

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## Identify and Size Proxies

- Added parts are new parts that must be developed and their size must be estimated.
- The size of an added part is determined by using a proxy.
  - Identify the part type, e.g. calculation, IO, etc.
  - Estimate the number of items, e.g. methods.
  - Estimate the relative size, i.e. very small, small, medium, large, or very large.
  - Find the size of an item of this part type and relative size in the relative size table.
  - Calculate the estimated size = size of an item \* number of items

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## Estimate Other Element Sizes

- Base parts are existing parts that will be changed by adding, deleting, or modifying.
- The size estimate of a base part is its actual size and an estimate of the additions, deletions, and modifications.
- Reused parts are parts that are used without modification.
- The size estimate of a reused part is its actual size.

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## Estimating Base Parts

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- During planning, enter each base part
  1. Record the name of the base part
  2. Enter the planned size of the base part
    - Enter the base size
    - Enter the estimated deleted, modified, and added size.

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## Estimating Added Parts

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- During planning, enter each added part
  1. Enter the part name.
  2. Select a part type.
  3. Enter the planned number of items
  4. Enter the planned relative size
  5. Enter the planned size.

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## Estimating Reused Parts

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- During planning, enter each reused part
  1. Enter the name of the reuse part
  2. Enter the planned size of the reuse part.

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## Estimate Projected Size and Time

- Projected size and time are calculated from estimated part size using historical data and PROBE method A, B, C, or D.
- The PROBE Calculation Worksheet automates these calculations.
- During planning, select a PROBE method
  1. Select a method for program size (A, B, C, or D)
  2. Select a method for time (A, B, C, or D)Method choice depends on how much data you have and how good it is. Will be discussed later

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## Selecting PROBE Methods

- The PROBE script includes guidelines for selecting methods.
- The parameters referenced in the script can be found at the bottom of the size estimating template.
- Method selection data
  1. method C
  2. method B
  3. method A
- Method data can be graphed
  4. method C and B
  5. method A

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## After Development

- During postmortem the actual size of parts is entered on the size estimating template.
- The actual size of the program is entered in Total, under Actual, in the Program Size Summary section of the project plan summary.

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## Recording Base Part Size

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- During postmortem, enter the size of each base part
  1. Measure and enter the actual base, deleted, modified, and added size.
  
- Note:
  - For a part not estimated, add it and enter zeros in plan.
  - For a part not used, enter zeros in actual.

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## Recording Added Part Size

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- During postmortem, enter the size of each added part.
  1. Measure and enter the actual number of items.
  2. Measure and enter the actual size.
  
- Note:
  - For a part not estimated, add it and enter zeros in plan,
  - For a part not used, enter zeros in actual.

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## Recording Reused Part Size

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- During postmortem, enter the size of each reuse part.
  1. Measure and enter the actual size of the reuse part.
  
- Note:
  - For a part not estimated, add it and enter zeros in plan.
  - For a part not used, enter zeros in actual.

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## Recording Total Actual Size

- During postmortem
  1. Measure and enter the actual total size.

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## Messages to Remember

- Estimating accuracy will fluctuate.
- Your estimates will have some bias.
- PROBE adjusts for bias using historical data.
- Engineering judgment is still required.
- If you software development skills are still developing, these estimates will likely be less accurate.

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