Limiting factors of estimation accuracy and project risk

Limiting factors of estimation accuracy and project risk

COCOMO Forum - 23 October 2002
University of Southern California

Terry Woodings

Associate Professor, Murdoch University
Visiting Senior Fellow, University of Western Australia

terry@ee.uwa.edu.au

Topics

1 Introduction and aims of the research
2 Integration of teaching risk & project estimation
3 Partitioning and reducing the variation
4 Some statistical aspects
5 Sources of the data
6 Results and analysis
7 Some useful outcomes

Can we measure the software process?

Or does any useful measurement get lost in the noise of:

- **User fickleness**
- **Staff variation**
- **Communication problems**
- **Office politics**
- **Poor management ?**

Process improvement

The opposite of Quality is variation and inconsistency

To improve performance we must:

- Stabilise the process
- Implement a new strategy
- Measure size & direction of change
- Evaluate the optimum approach

Significant problems in estimating project effort and duration

Note previous comments on the relationship between risk and variance of the estimate.

There are several classifications [1] of the sources of bias and error of estimates.

Major areas are:

- Knowledge and definition of requirements
- Large variation in staff abilities (productivity)
- Changes in technological environment
- Managers do not adhere to process
- Shifting point of aim (project creep)
- End point of project is negotiated

These problems can be contained but not eliminated.

Aims of the research

Recent experiments have been designed to quantify the impact of the various sources of variation.

The aim is to partition the difference between Estimated and Actual effort into a series of issues that can be tackled individually.

Clearly, some areas give greater improvements in accuracy for less effort.

Assumptions of the work

1 There is a reasonably stable statement of requirements

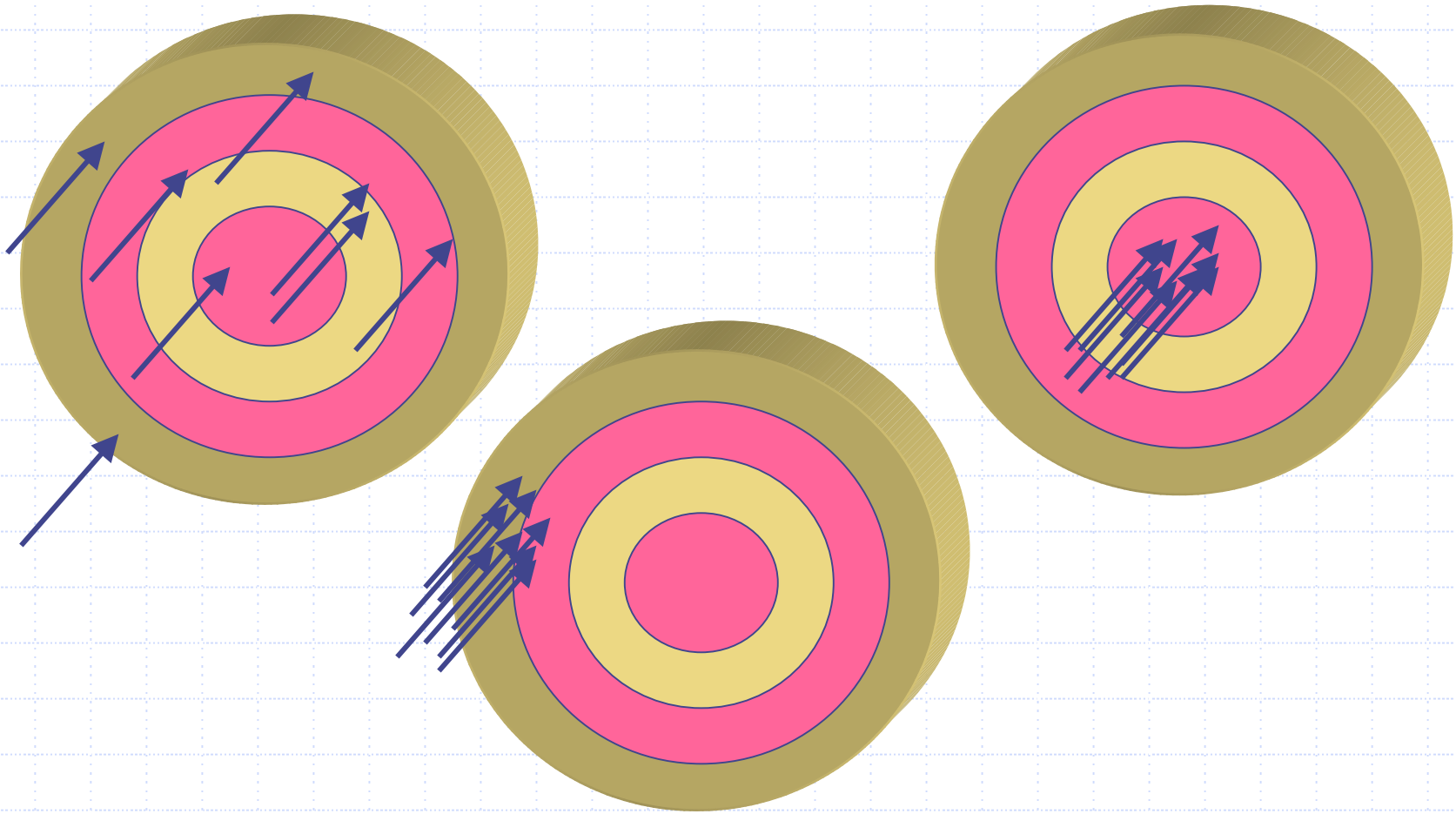
2 The primary objective is completion of some deliverable within given quality constraints

3 There is a well-defined, measurable development process

4 There are procedures to ensure compliance with the process

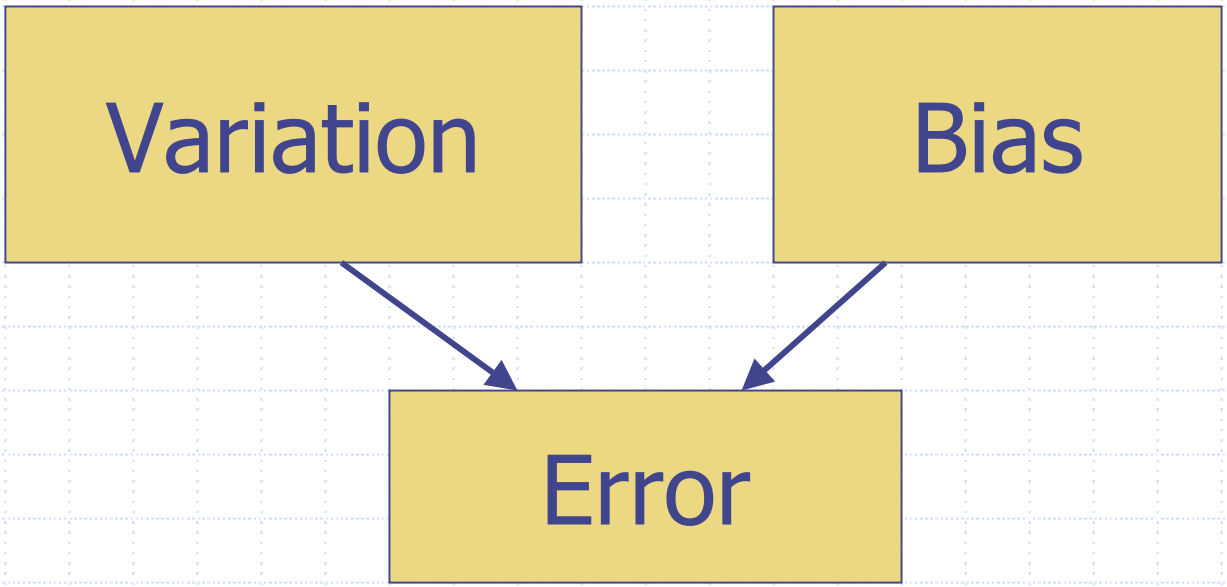
5 All information on the project is openly available (no political or hidden agendas)

Process improvement as a two-stage process

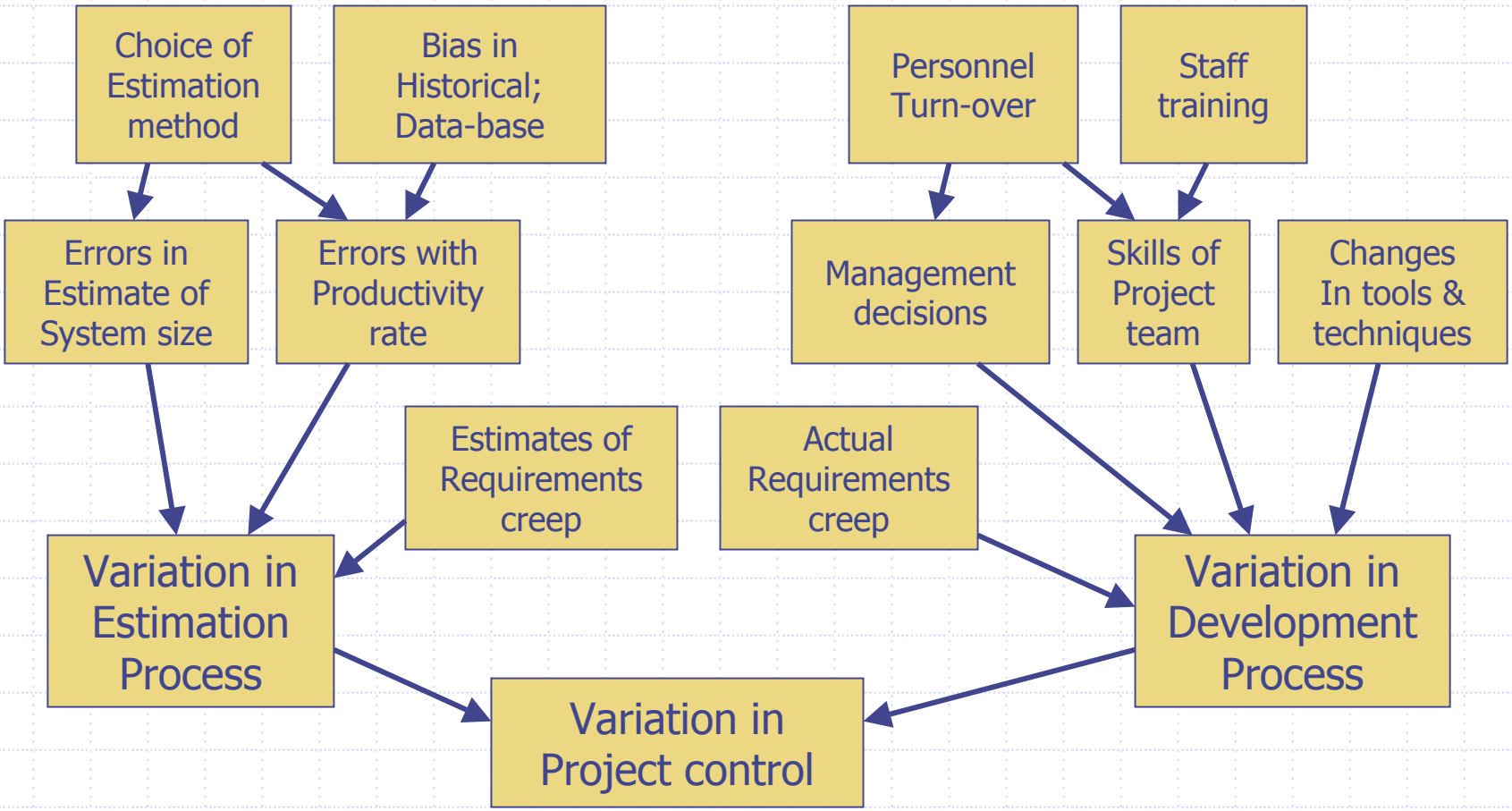


Variation versus Bias

Error can be divided into bias (due to the estimator) and variation (due to the process)



Sources of variation



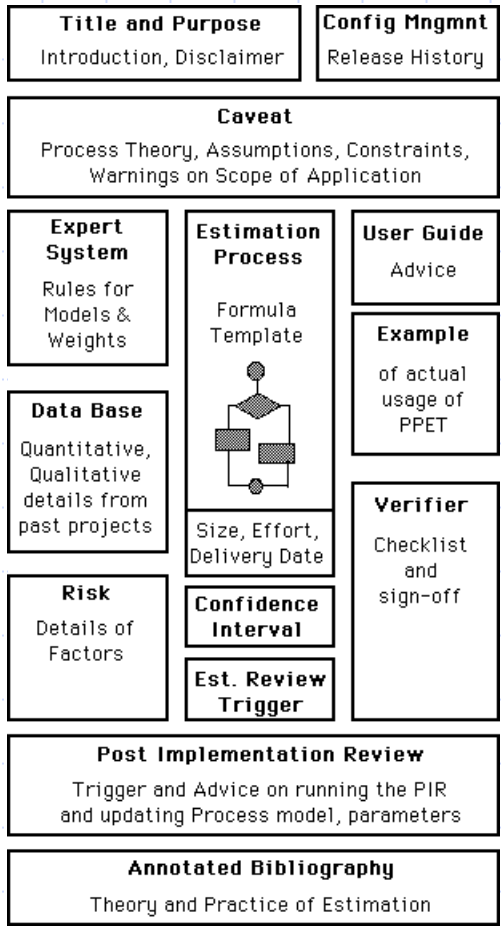
Sources of data

A series of exercises/experiments carried out in final-year software engineering classes at three West Australian universities over seven years.

- **Development of a Personal Project Estimation Tool**
- **Estimation of the Spelling Checker [2]**
- **Group projects of a multiple elevator controller**

Follow up within industry

Personal Project Estimation Tool (PPET)



Part of Estimation work-sheet

Have a look at the requirements for a spell checking system [Fenton, 1997] as specified by your tutor. The task is to estimate the amount of effort that would be needed to write the checker. Note that the standard dictionary of correct spellings is already complete and available but the personal dictionary will start as an empty file. Work together as a pair and agree upon each answer before filling in your own personal work sheet – which should be put in your portfolio.

.

2. How much effort would be required for your group to write such a system in Java? _____(person-hours)

3. On what date do you think your group could deliver it, if you started today? _____

8. The tutor will now provide a summary of the class' estimates. In the light of the figures, you may wish to update the figure you gave in question two to _____(person-days)

Part of Estimation work-sheet

Have a look at the requirements for a spell checking system [Fenton, 1997] as specified by your tutor. The task is to estimate the amount of effort that would be needed to write the checker. Note that the standard dictionary of correct spellings is already complete and available but the personal dictionary will start as an empty file. Work together as a pair and agree upon each answer before filling in your own personal work sheet – which should be put in your portfolio.

.

2. How much effort would be required for your group to write such a system in Java? _____(person-weeks)

3. On what date do you think your group could deliver it, if you started today? _____

8. The tutor will now provide a summary of the class' estimates. In the light of the figures, you may wish to update the figure you gave in question two to _____(person-days)

More of Estimation work-sheet

9. Assuming that all files in the Spelling Checker are of average complexity, produce a Function Point count:

   Total (raw or unadjusted Function Points) = _____

10. Suppose that you have data from the last four Java projects, your group produced:

A	40 FPs	45 Person-Days
B	60 FPs	75 Person-Days
C	90 FPs	115 Person-Days
D	160 FPs	215 Person-Days

Use this data to estimate how much effort it will take to produce the system based on your count from question nine: _____ (person-days)

Initial estimates (in days) by preferred time unit

Estimating Units	Mean	Standard Deviation
Hours	5.6	4.7
Days	6.7	6.9
Weeks	14.2	10.9
Months	69.4	47.5

Comparison of two estimation units

	person-hours	person-weeks
Mean (in person-days)	9.46	21.76
Standard Deviation (in person-days)	15.24	22.82

$t = 2.576$ on 31 df $p < 0.01$

Improvements due to education

Estimates of the spelling checker (in days)

	First exercise	After lectures	After project
Minimum	0.8	5	1
Maximum	180	180	115
Mean	35.3	39.7	51.4
Standard Deviation	46.3	42.7	34.5
Coefficient of Variation	1.31	1.08	0.67

Hypothesis

The hypothesis was that there would be substantial improvement possible in moving:

from 'guesstimates'

to group expert opinion (with Delphi methods)

to algorithmic methods (such as COCOMO)

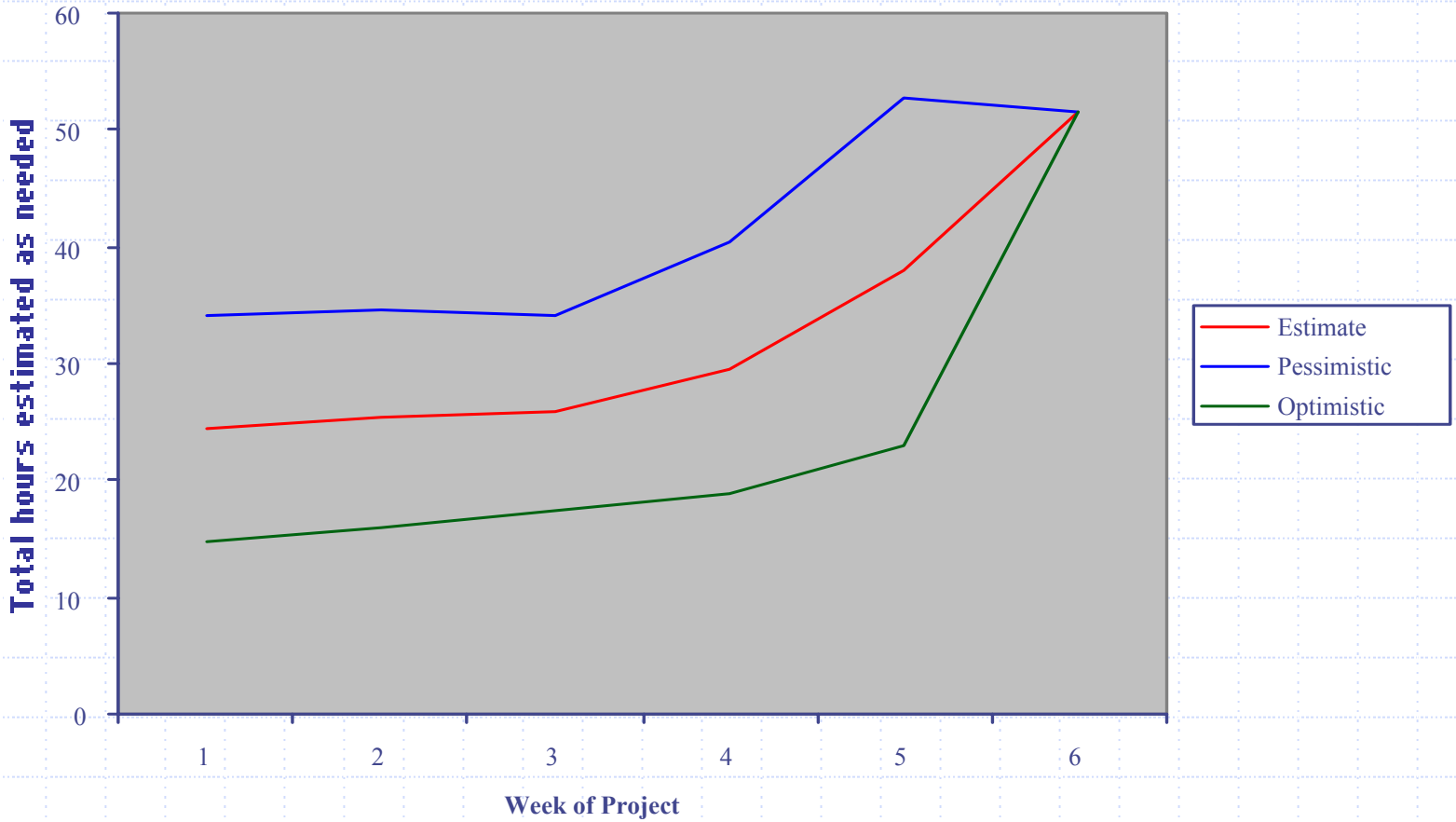
to estimation methods tailored to a particular organisation (calibrated with past project data)

and that size estimates in Function Points could be obtained consistently.

Reduction in variation due to choice of method & no of steps

	Mean	Standard Deviation	Coefficient of Variation
Duration (days)	13.06	15.12	1.157
Effort (person-days)	16.16	17.72	1.097
Delphi (person-days)	17.71	12.99	0.733
Analogy (person-days)	49.06	23.73	0.484
Size (Function Points)	42.61	16.22	0.381

Progressive accuracy of estimates



Partitioning the variation (error) in project estimates

Var(actual - estimate) = Var(actual) + Var(estimate)

iff the actual and estimate are independent variables

(actual – estimate)

= (actual – $\overline{\text{actual}}$) + ($\overline{\text{actual}}$ – $\overline{\text{estimate}}$) + ($\overline{\text{estimate}}$ – estimate)

Squaring both sides, summing over the n projects and dividing by n gives:

Mean Squared Error:

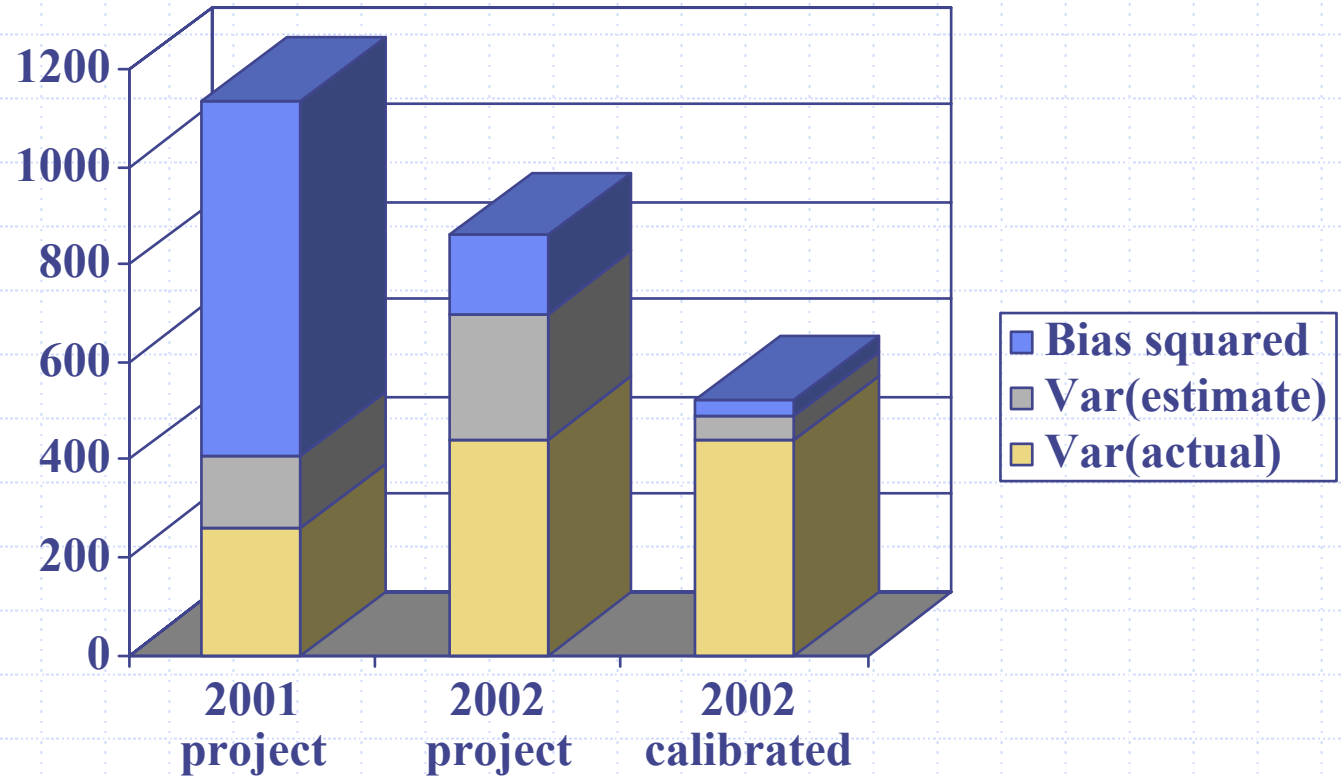
= Var(actual) + Bias squared + Var(estimate)

+ Cross-Product

Components of mean square error

	2001 project	2002 project	2002 calibrated
Mean Estimate	24.45	33.20	51.50
Mean Actual	51.50	45.84	45.84
Error or Bias	27.05	12.64	-5.66
Variance (estimate)	143.6	259.0	47.7
Variance (actual)	261.5	440.6	440.6
Bias squared	731.7	160.4	34.3
Cross Product	-165.0	4.7	2.0
Mean Square Error	971.8	864.5	524.6

Limiting factors to estimation accuracy



In Conclusion

These experiments have been used to:

1 demonstrate to students some issues in project estimation

2 illustrate to managers the sources and sizes of error in estimation

3 illustrate methods for process improvement experiments (PIEs)

4 obtain some measure of the relative size of sources of error - leading to a Theory of Constraints approach for the reduction of estimation error.

Acknowledgement

I would like to express my appreciation for the support, discussions and consideration given by Dr Gary Bundell, Dr Rachel Cardell-Oliver, Prof Geoff Roy and A/Prof Richard Thomas whose students, as well as my own, were involved in the various software engineering exercises.

References

[1] Putnam, L.H. and Myers, W. (1992) "Measures for Excellence", Yourdon Press

[2] Fenton, N.E. and Pfleeger, S.L. (1997) "*Software Metrics – A Rigorous & Practical Approach*", 2nd Edition, PWS Publishing

[3] Boehm, B.W. et al (2000) "*Software Cost Estimation with COCOMO II*", Prentice Hall.