Why Cocomo Works

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Apology

- I Inability to attend and participate actively - prior commitment

- II Have been a Cocomo critic for many years
  - did not question usefulness
  - believed it to be subjective, a self fulfilling prophecy
  - estimation tool should be objective
  - what resources are required to meet goals?

- Take this opportunity to publicly recant and confess the error in my thinking

- Talk will explain why
Start at the Beginning

• Why, despite 45 years effort and megabucks of investment does the software still suffer from so many **problems**
  - "...The methods of preparing programs for the EDSAC described in this book were developed with a view to **reducing to a minimum** the amount of **labour** required and hence of making it **feasible** to use the machine for problems that require only a few hours of computing time as well as for those requiring many hours..."

• Why is **major** process improvement so **difficult to achieve**?

• Process innovations have had **local** impact
  - subroutines
  - high level **languages**
  - **structured** programming
  - abstract **data types**
  - **modularisation**
  - formal methods
  - estimation, planning, management tools
  - programming **paradigms** eg.
  - **CASE**
  - environments
  - process modelling
  - process **improvement**
  - etc., etc.

• Impact on **global** industrial **capability** much less apparent

• Individually explainable, is there **global constraint**?

**Nature** of software evolution (development) **process**
Validated system ready for **installation** and **use**

Installation and operation closes major **feedback loop** - system contains implicit model of itself
More Complete Picture - The Global Process

- Humans drive system through interacting agencies, agents and activities that observe, interpret and communicate for enlightenment, planning, control

- Whether and how humans act or react is another matter

- Entire complex part of operational domain

Process a complex multi-agency, multi-agent, multi-level, multi-loop, feedback system

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1970s Evidence - OS/360 evolution

- note ripple followed by "oscillation"

1990s Evidence - Logica FW evolution

\[
S_{i+1} = S_i + \frac{E}{S_i^2}, \quad (1 \leq i \leq n-1), \quad E_i = \Delta S_i \cdot S_i^2 = (S_{i+1} - S_i)S_i^2 \quad \text{E}_p = \sum_{i=1}^{p-1} E_i/p-1
\]

- Note closeness of inverse square law fit

Ripples suggest feedback stabilisation
Characteristic Properties of Feedback Systems

- Possess global dynamics with **externally observable** behaviour largely determined by loop structure and characteristics.

- **Negative** feedback tends to **stabilise global behaviour**.

- **Positive** feedback tends to induce **growth** - may induce **instability**.

- **Composite effect** complex function of path characteristics.

- **Impact** of forward path changes on system with negative feedback is localised - externally observable impact **limited**.

- **Major** change of **system** behaviour requires changes to **feedback** mechanisms.

- Influence of **individual** loop mechanisms in multi-loop systems **difficult to isolate** - systems dynamics, not control theory.

Given their **intrinsic** feedback nature should these **properties** not hold for **software processes**?
The FEAST Hypothesis

• Phenomenology, exemplified by, but not limited to, OS/360 and Logica FW strongly supports this conclusion. Hence:

Postulate
• As complex feedback systems E-type software processes will evolve strong system dynamics, the global stability tendency of other feedback systems

Supporting comment
• As industrial processes evolve they develop positive and negative feedback controls to achieve stable growth and to control and direct processes - checks and balances

Three assertions
I The software evolution process for E-type systems constitutes a complex feedback system

II Where present, negative feedback is likely to constrain benefit derived from forward path changes, however promising changes are in themselves

III Major improvement requires process innovation to change system dynamics by modification of feedback mechanisms

Lemma
• Slow progress in process improvement may be due, at least in part, to lack of attention to feedback phenomena?

FEAST - an investigation
(Feedback, Evolution And Software Technology)
Strength of systems dynamics

- **FW data** provides strong support for hypothesis and laws of software evolution

- Fit on chart 5 based on **all** data points including **process start up**

- Excluding start up data, how many $E_i$ ($i =$ release sequence number) pairs are really **required** for estimating $E$?

![Logica FW System](image)

- Note **minimal impact** of decreasing numbers of data points used for estimating $E$ (chart 5) despite doubling of system size

- Mean absolute **error** and standard **deviation** of inverse square size prediction only some 70 and 60 modules respectively despite change in system size from under 1K to over 2K
Conclusion

- Just one indicator of speed of **system dynamics** build up (chart 5) and its **strength** thereafter (above chart)

- **Explains** power of Cocomo and asserts its realism

- Stuck with properties **imposed by dynamics** unless latter is **mastered** and an **appropriate technology** to change it can be **developed** and **applied**

- Future **significant improvement**, however defined, in planning and management capability requires manipulatable **model** of global software process as feedback system

- Insight and techniques stemming from **current studies** may provide basis for future Cocomo development to permit
  - more **objective** and **precise** estimation
  - **objective assessment** of resource requirement for a specific project
  - evaluation of of **organisational effectiveness**
  - identification of opportunities for **process improvement**
  - their **evaluation** before implementation

- **FEAST/1** a **preliminary investigation** laying the foundations of an international, multi-disciplinary collaborative investigation to develop **feedback based process improvement technology**

**FEAST/1**
• Two year EPSRC funding

• Three PIs, two RAs, 5 collaborators
  - BAe
  - ICL
  - Logica
  - MOD - CSS
  - MOD - DRA

• 1 October start

• Two Senior Visiting Fellows
  - Dr D E Perry, Lucid Technology
  - Professor W M Turski - U. of Warsaw

• Many international contacts from three FEAST workshops in 1994/5

• Preliminary results as exemplified by Logica FW data most encouraging, strongly supporting the feedback hypothesis, the presence and power of process dynamics and the Laws of Software Evolution


Outline project plan
Objectives

• Provide **objective evidence** of role and **impact** of feedback phenomena in software development processes

• **Identify** feedback **loops** and **controls**

• **Explore** practical implications for process **management** and **improvement**

• Provide **specific examples** of improvement opportunities revealed by feedback perspective

• Lay **foundations for further work** directed at significant and continuing improvement of industrial process

• Draw together beginnings of a (software) **process theory**

**Project**
Approach

- Analyse, measure, model industrial processes

*Black box*
- Build black and white box - system dynamics - models

- Formulate and test hypotheses explaining observations

- Produce and validate systems dynamics, and other, models

- Identify improvements for introduction to investigated processes

- Provide evidence that feedback perspective is significant in search for long term process improvement

- Generalise results to lay foundations for a theory of software evolution, the software process and software technology

- Establish a long range, multi disciplinary, international investigation of a difficult but potentially valuable technology

Lay foundations for systematic extension of theory and practice
Last three charts, 10 - 12, are for your information. Feel free to use them as is, modified, as information source or not at all. I suggest, but do not insist, that they appear in the printed version.
CORRECTION
A RECENT DILBERT STRIP
USED THE WORDS "ANT
FARM" TO DESCRIBE A
HABITAT FOR ANTS.

LAWYERS HAVE INFORMED
ME THAT "ANT FARM"
IS A TRADEMARK OF
"UNCLE MILTON INDUSTRIES,
INC." THEY DEMAND
A PUBLIC CLARIFICATION.

WHAT SHOULD WE
CALL A HABITAT
FOR WORTHLESS
AND DISGUSTING
LITTLE CREATURES?

LAW
SCHOOL.