‘Left-shift’ vs The Time Value of Money:
Unravelling the Business Case for Systems Engineering

Dr Michael Emes
Prof Alan Smith
Dr Ady James

UCL Centre for Systems Engineering
Most projects fail
Manifestations of project failure
Most projects fail: Evidence

Percentage cost overrun since approval

Delay

Cost overrun

Within time

50

40

30

20

10

0

10

20

30

40

50

60

70

80

90

100

Within cost

Delay (months) since approval

Key

BVRAAM = Beyond Visual Range Air-to-Air Missile
FJCA = Future Joint Combat Aircraft
NLAW = Next Generation Light Anti-Armour Weapon
PGB = Precision Guided Bomb
CIP = ComBAT, DBL Infrastructure and Platform BISA
LFATGW = Light Forces Anti-Tank Guided Weapon
GMLRS = Guided Multiple Launch Rocket System

Source: National Audit Office

NOTES
1 No over/underspend is reported on Typhoon as the information is commercially sensitive.
2 No time advance/delay is reported on Future Joint Combat Aircraft as the in-service date has not been approved.
Causes of Project Failure

- **Human factors**
  - Cognitive errors
  - Interpersonal failures
  - Barriers to effective decision making

- **Systemic factors**
  - The Bidding process
  - Judging project progress
  - Inappropriate contracts
Measuring Project Success

• Some combination of:
  – Quality performance (delighting the customer)
  – Schedule performance
  – Cost performance

• Quality is hard to quantify … focus on cost and time

• Net Present Value (NPV) can be used to quantify cost and schedule performance
  – This takes into account the size of the cash flows received, and the timing of them
The Time Value of Money

- A pound today is worth more than a pound tomorrow, since you could earn interest on the pound received today.

  - The time value of money is usually assumed to be constant, represented by a discount rate\(^1\), \(r\), or a discount factor, \(\delta = 1/(1 + r)\)

  - A safe pound is worth more than a risky pound. The discount rate applied to a project should reflect the risk inherent in that project

If there is more uncertainty about the future cash flows from a project, it should be given a higher discount rate

\(^1\)Discount rate is the rate at which future earnings are discounted relative to current earnings
Time Value of Money: Implications

Pay me now …

…I’ll pay you tomorrow
Net Present Value

- The most common measure of a project’s value is net present value (NPV):

1. Calculate expected cash flow each year for a number of years into the future (typically five, ten or fifteen years)
2. Apply a cumulative discount factor to future profits or losses to reflect the time value of money
3. Sum the discounted annual cash flow scores over the chosen number of years

\[ NPV = C_0 + \sum_{i=1}^{i=N} \frac{C_i}{(1 + r)^i} \]
Project Schedule and ‘Left Shift’

- What is left-shift
- Origins
- Usage
- Absolute or relative term?
Absolute Left Shift?

- How would you characterise the level of left shift of this project?

- What about this one?

Is it the peak or the mean of a distribution that identifies it as left-shifted?
Relative Left Shift

- Define an expected or *ideal* profile that assumes:
  - No additional unforeseen tasks
  - No unanticipated problems in executing tasks
  - No rework necessary of previously completed tasks
  - Uses readily available resources

- This ideal profile could have any shape, e.g. flat
Why is ‘left-shift’ relevant to SE?

Total Program Overrun
32 NASA Programs

Source: Gruhl (1992)

Definition Percent = \frac{\text{Definition $}}{\text{Target + Definition $}}

Program Overrun = \frac{\text{Actual + Definition $}}{\text{Target + Definition $}}

R^2 = 0.5206
When is left shift likely to be most useful?

- Finishing the project early is rewarded
- Finishing the project late is punished
- Problems encountered late are expensive
- NPV +ve project
- High discount rate
- Slow technological progress … or fast?
- Slow learning curves
A model for understanding the value of left-shift: Ideal
A model for understanding the value of left-shift: Actual
Model assumptions

- Prob. of unexpected problems
- Payment Schedule
- Cost of extra resources
- Discount Rate
Model results

**Key**

- **Actual**
- **Ideal/Expected**

**Graphs**

- **Effort**
- **Progress**
- **Cumulative Problems**
- **Cost**
- **Revenue**
- **Cumulative DCF**
Model results: Optimised average performance

- Optimum left shift from ideal/expected profile varied in the range 12% to 93% for the range of parameters considered.

- Largest left shifts are observed when:
  - Discount rates are high
  - Payment for the project is received based on progress
  - Cost of additional resources is low
  - Probability of unexpected problems is high
Model Results: Random Variations

Optimising the schedule for the expected or average conditions can lead to poor performance if conditions vary.

Expected NPV = £824m

Expected NPV = £769m
Conclusions

• Most projects fail

• Left shift is a useful principle, and can help to prevent project failure if used appropriately

• Some ways of quantifying left shift have been suggested

• The amount of left shift that can be justified varies from project to project and requires some thought
Further work

• We are continuing to developing our tools for managing complex projects

• We are planning to conduct a research project using these tools looking at:
  – The extent of Systems Engineering use in different industries
  – The value of Systems Engineering in different industries
  – What the barriers are to greater use of Systems Engineering, and
  – How these barriers can be overcome

• Two UCL MSc students have conducted research examining the value of SE/left shift in London Underground and Xerox (Kuldeep Gharatya and Matthew Nolepa)