Which activities make the biggest impact on project success?

Benefits of Systems Engineering

The quantitative studies overleaf looked at correlation of individual SE practices with business benefit. They were conducted independently on different continents, but with strong agreement:

- Integrated engineering planning done early (system-level, cross-disciplinary, whole lifecycle) makes the biggest difference. Other INCOSE work (see Guide Z11) underlines the benefit of PM and SE working together.
- Focusing on requirements (including scope management and mission / usage analysis) shows the next highest correlation with success.
- Then comes early definition, and subsequent conduct, of system-level integration and test, linked to whole-system requirements and flowed down to subsystems and modules.

Some final words on cost versus value:

- After 15% of project timescale has elapsed, 60% of your final costs are already committed. If you haven't corrected errors by then, no additional effort will recover the project. "Left-shift"!
- All the studies referenced cover cost and value prior to project handover. There is additional value to the owner-operator due to reduced cost of ownership and better performance of well-engineered systems delivered by the project.

SE can help any organisation involved with complex projects – not just aerospace and defence. Transportation, energy and healthcare sectors benefit from the systems approach too. SE brings people benefits as well. Their work will become less chaotic and stressful, resulting in improved quality.

Summary of Return on Investment

("The Elevator Pitch")

- Discovering errors in your system once it is deployed costs on average 250 times as much as correcting them before launching design.
- If you are spending less than 2% of a complex project development budget on SE activities, your average project overspend will be 50% and your ROI of investing in more SE is > 7:1.
- There is a strong correlation between SE capability and business outcomes. Investing in better Systems Engineering on complex projects reduces your risk exposure, and pays back with an ROI between 4:1 and 10:1.

Systems Engineering is:

"An interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis and system validation while considering the complete problem."

This leaflet, one of the 1-page "Z Guides", is intended to demonstrate the business benefits and return on investment of a Systems Engineering approach.

For further information and help, or to download copies of this leaflet and other Systems Engineering resources online, go to: www.incoseonline.org.uk.
For more information about the worldwide Systems Engineering professional community, go to www.incose.org

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How Systems Engineering Can Save your Business Money

The Value of SE

Do any of these Problems sound familiar?

- Your engineers arrive at project reviews reporting unforeseen integration problems, and needing more time and budget.
- Your Directors are called in by irate customers or partners, late in the project, to resolve escalated issues due to disagreements over requirements, performance and interfaces.
- Your delivered system gathers dust because it doesn't meet the customer need, and you look on helplessly as your competitor wins the repeat business at lower cost.

Is your programme running late?
Are your costs mounting?
Systems Engineering (SE) can help!
There is a strong evidence base that effective use of Systems Engineering can save over 20% of the project development budget.

It is not hard to know when Systems Engineering fails, because when something important goes wrong it usually makes the news fast. People get killed, buildings fall down, companies go bust, the law becomes involved.

But when Systems Engineering goes right, no-one notices – which is just how it should be. The control system works as expected, trains run on time, your flight lands smoothly with your baggage in the right place, and no-one gets mad.

Cost of fixing project errors

The fundamental reason for doing more, better and earlier SE

All projects above a certain size and complexity have errors introduced in the requirements, design or implementation phases. Some are detected and corrected quickly; others are not. A key study published through INCOSE looked at the phase of detection of errors, and the consequent cost of fixing them. Cost modelling was validated against a cross-industry range of defence and aerospace projects. Here is the resulting table:

Phase at which error is detected and fixed	Cost to Fix
Requirements	x1 (reference)
Design	x3 to x8
Build	x7 to x16
Test	x21 to x78
Operations	x29 to x1615, mean x250

The larger or more complex the project, the higher the cost to fix, and the higher the risk.

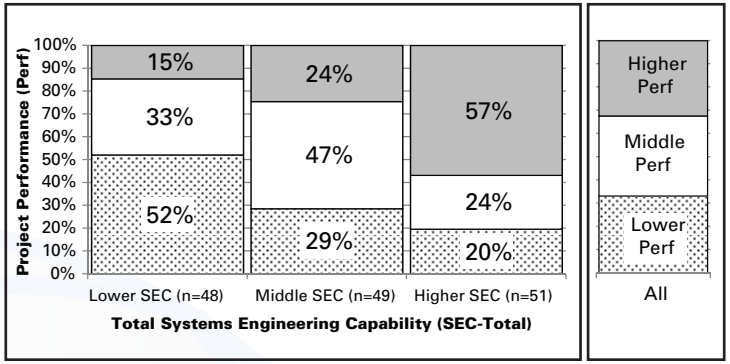
If it costs you $1 to fix an error if you discover it at the requirements stage, it'll cost $250 if you discover it in operation. A key role of SE is to prevent the latter from happening, and on this rests the ROI of SE.

Source reference: "Error Cost Escalation Through the Project Life Cycle", *Haskins et al*, Proceedings of INCOSE International Symposium 2004.

How does SE capability affect business outcomes?

From "the SEI study", an academically-refereed survey of 147 high-value projects

Carnegie-Mellon University analysed the anonymised data from the space and defence projects, examining the correlation between Systems Engineering capability (high, medium and low) and business outcomes (cost, timescale and technical quality). They corrected for bias, and for scale / complexity. Here is the key figure:



Business outcomes are divided into top third, middle third and bottom third. Hence low SE capability teams achieve top-third outcomes only 15% of the time, and so on. One can draw important conclusions from the study:

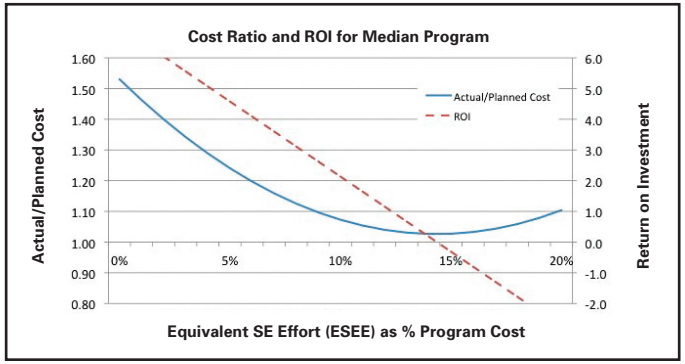
- For an average high-value project, using SE of A-team capability more than trebles your chance of project success compared to the C-team.
- For a higher-complexity project, using C-team SE capability gives a 92% probability of not getting top-third business outcomes.

Source reference: "The Business Case for Systems Engineering Study: Results of the Systems Engineering Effectiveness Survey", *Elm & Goldensen*, NDIA & CMU/SEI-2012-SR-009

How much Systems Engineering should we do?

From "The ROI of Systems Engineering", an academically-refereed analysis of 90 high-value projects

Eric Honour, a Past President of INCOSE, worked with the University of South Australia to analyse project overspends versus the percentage of development effort spent on system-level cross-disciplinary activities. A key outcome was a model of the Return on Investment (ROI) of allocating extra SE effort to a project. Here is the key figure:



This is the curve-fit through points plotted for all projects. On the left hand side of the blue curve, not enough SE is allocated and project overruns are prevalent. However, on the right-hand side one can deduce "paralysis by analysis".

- For a project spending only 1% on SE, the average overspend was 53% and the ROI of allocating more SE was 7:1.
- The average spend on SE was 7%, with overruns of 15% and the ROI of allocating more SE was still 3.5:1.
- The optimum SE spend is 12-14%.

Source reference: "Systems Engineering Return on Investment", *Honour EC*, PhD Thesis, University of South Australia 2013; www.honourcode.com/seroi