Chapter
9

IMPACT ESTIMATION

How to understand strategies

GLOSSARY CONCEPTS

Baseline
Impact Estimate
Scale Impact
Scale Uncertainty
Incremental Scale Impact
Percentage Impact
Percentage Uncertainty
Performance to Cost Ratio
Credibility
Safety Factor
Safety Margin
Safety Deviation
Side Effect
Uncertainty

9.1 Introduction to Impact Estimation

Systems engineers and managers need a reliable way of analyzing how effective their design ideas or strategies are in meeting the requirements. Surprisingly, there are few methods being taught or used to do this. Impact Estimation (IE) is one of these methods. It is the only one that attempts to use any quantified rigor.

The intention of IE is that it helps answer the question of how our design ideas impact all a system's critical performance attributes (such as usability and reliability) and all its resource budgets (such as the financial cost and staff headcount) for implementation and operational running. This question is fundamental to systems engineering.

IE can be used for a wide variety of project purposes. Its most important uses include:

- Comparing alternative design ideas: "What's best?"
- Estimating the state of the overall design architecture: "Have we designed enough?"
- Analyzing risk: "Where are our biggest problems now?"
- Planning and controlling evolutionary project delivery steps: "Is the project on track?"

IE can be used at any organizational level and by different specialist staff roles (such as systems analyst, architect, risk analyst, project manager and purchasing manager) to evaluate any technical or organizational idea. In fact, IE is useful in permitting *integrated assessment* of technical and organizational design ideas. It is specifically helpful in *improving communication* about system design decisions across organizational levels and boundaries.

Impact Estimation Policy

1. All design ideas or strategies which can have a significant impact (5% or more) on any critical performance or cost requirement of a project must be evaluated in an IE table.
2. The design ideas must be specified in sufficient detail and clarity to support IE, irrespective of who would make or evaluate the estimates.
3. An IE table, together with all its related design and requirement specifications, must be quality controlled with respect to all the relevant rules. The level of estimated remaining major defects/page must be low enough to exit and it must be stated (ideally on the cover page of the document).
4. Significant proposed changes to the design ideas or architecture must be accompanied by a quality controlled IE table showing the net impact of the changes.

Figure 9.1
Impact Estimation Policy. Several of my clients have adopted a policy mandating use of IE. This ensures people use the method and helps management (assuming they are IE literate) make more informed decisions about proposed strategies.

IE can be used for a wide variety of purposes including:

1. Evaluating a single design idea. How good is the idea for us?
2. Comparing two or more design ideas to find a winner, or set of winners. Hint: Use IE, if you want to set up an argument against a prevailing popular, but weak design idea!
3. Gaining an architectural overview of the impact of all the design ideas on all the objectives and budgets. Are there any negative side effects? What is the cumulative effect?
4. Obtaining systems engineering views of specific components, or specific performance aspects. For example: Are we going to achieve the reliability levels?
5. Analyzing risk: evaluating a design with regard to 'worst case' uncertainty and minimum credibility.
6. Planning evolutionary project delivery steps with regard to performance, value, benefits and cost.
7. Monitoring, for project management accounting purposes, the progress of individual evolutionary project delivery steps and, the progress to date compared against the requirement specification or management objectives.
8. Predicting future costs, project timescales and performance levels.
9. Understanding organizational responsibility in terms of performance and budgets by organizational function.*
10. Achieving rigorous quality control of a design specification prior to management reviews and approval.
11. Presenting ideas to committees, management boards, senior managers, review boards and customers for approval.
12. Identifying which parts of the design are the weakest (risk analysis). Hint: If there are no obvious alternative design ideas, any 'weak links' should be tried out earliest, in case they do not work well (risk management). This impacts scheduling.
13. Enabling configuration management of design, design changes, and change consequences.
14. Permitting delegation of decision-making to teams. People can achieve better internal progress control using IE, than they can from repeatedly making progress reports to others, and acting on others' feedback.
15. Presenting overviews of very large, complex projects and systems by using hierarchical IE tables. Aim for a one page top-level IE view for senior management.
16. Enabling cross-organizational co-operation by presenting overviews of how the design ideas of different projects contribute towards corporate objectives. Any common and conflicting design ideas can be identified. Hint: This is important from a customer viewpoint; different projects might well be delivering to the same customer interface.
17. Controlling the design process. You can see what you need, and see if your idea has it by using an IE table. For example, which design idea contributes best to achieving usability? Which one costs too much?
18. Strengthening design. You can see where your design ideas are failing to impact sufficiently on the objectives; and this can provoke thought to discover new design ideas or modify existing ones.
19. Helping informal reasoning and discussion of ideas by providing a framework model in our minds of how the design is connected to the requirements.
20. Strengthening the specified requirements. Sometimes, you can identify a design idea, which has a great deal of popular support, but doesn't appear to impact your requirements. You should investigate the likely impacts of the design idea with a view to identifying additional stakeholder requirements. This may provide the underlying reason for the popular support. You might also identify additional types of stakeholders.

*Note: * In 1992, Steve Poppe pioneered this use at executive level while at British Telecom, North America.*

Figure 9.2
Purposes for the use of Impact Estimation. IE can have a wide variety of uses for a systems engineer, planner or manager: it can help from the earliest stages of evaluating potential ideas, strategies, architectures and purchases, to formally presenting proposals to management, to assessing the results of project delivery.

Strategy Comparison: Apples and Oranges

Objectives	Apples	Oranges
Eater Acceptance From 50% to 80% of People	70%	85%
Pesticide Measurement Reduce from 5% to 1%	50%	100%
Shelf-Life Increase from 1 week to 1 month	70%	200%
Vitamin C Increase from 50 mg to 100 mg per day	50%	80%
Carbohydrates Increase from 100 mg to 200 mg per day	20%	5%
Sum of Performance	**260%**	**470%**
Resources		
Relative Cost Local currency	0.50	3.00
Sum of Costs	0.50	3.00
Performance to Cost Ratio	5.2	1.57

Alternative Strategies

"Evidence" for these numbers should, of course, be available on a separate sheet (but not shown here)

Figure 9.3
Comparison of Apples and Oranges using an IE table. IE allows you to compare all kinds of strategies (solutions) against your requirements.

9.2 A Simple Practical Example of Impact Estimation

Now let's consider a practical example and show how you can use the IE approach. Assume you have an objective as follows:

Learning:
Gist: Make it substantially easier for our users to learn tasks <- Marketing.
Scale: Average time for a defined [User Type: Default UK Telesales Trainee] to learn a defined [User Task: Default Response] using <our product's instructional aids>.
Response: Task: Give correct answer to simple request.
Past [Last Year]: 60 minutes.
GN: Goal [By Start of Next Year]: 20 minutes.
GA: Goal [By Start of Year After Next]: 10 minutes.

Imagine you have an initial design idea to satisfy the goals GN and GA:

Handbook: Gist: Write a user handbook to define how to do the tasks.

Now, we could just write the handbook, and hope we shall meet our objectives. But the purpose of IE is to get us to think before we implement. So, let us make an estimate of how effective this idea is. How many minutes will be needed to learn the defined task 'Response' using the handbook? The likely initial answer is, "we cannot possibly know." "Why?" Well, maybe we don't even know the written handbook can, or will, be used by the user. Maybe we don't know if the handbook (assuming it can and will be used) is capable of reducing the learning time compared to last year's training methods (Past level). We might also not have a sufficiently clear and unambiguous definition of the task, Response. The conclusion to this line of thinking is that we need to have a much better design and more detailed specifications in order to make any assertions whatsoever. It is precisely this problem of inadequate design and lack of information that we want to identify and attack by using IE.

Well, let us for this example try a symbolic improvement of the design ideas to meet the goal. We need to identify some alternative design ideas and assess their impact on our Learning goals. We can draw on any previous experience with the use of a design idea. Say, on a different project, the design idea On-line Help had achieved Past [<similar task>] 10 minutes. What do we think based on that? Let us say, we guess a learning time of 10 minutes average (minimum 5 minutes, maximum 15 minutes):

Impact Estimate for impact of On-line Help on Learning $= 10 \pm 5$ minutes? <- Based on <similar design> used by Project A.

We can then express this guess as a 'percentage of the way to the goal.' We must decide on which of the goals, GA or GN? Say, the GA goal of 10 minutes. Well, the guess is also 10 minutes, so we have a design, which appears to get us 100% of the way to our GA goal. The uncertainty, ± 5 minutes, is 10% (from Past $= 60$ minutes to Goal $= 10$ minutes is 50 minutes improvement). So we can express the impact as either 10 ± 5 minutes (a Scale Impact estimate) or $100\% \pm 10\%$ (a Percentage Impact estimate).

In practice, we would have to evaluate the effect of all design ideas on all goals and budgets. See Figure 9.5. We are not 'done' until we have satisfied all performance goals (100% or more) within all budgets (100% or less). In the worst case, if the design ideas completely fail to meet the requirements and there are no additional design ideas that could be considered, we have to modify the goals and/or budgets (make 'tradeoffs'). There must be a correspondence between your plans and the realities of what you can actually achieve. Of course, do not lose sight of the fact that the real test is trying out the chosen design ideas in practice to see how they really work in reality.

Design Ideas

On-line Support: Gist: Provide an optional alternative user interface, with the users' task information for defined task(s) embedded into it.
On-line Help: Gist: Integrate the users' task information for defined task(s) into the user interface as a 'Help' facility.
Picture Handbook: Gist: Produce a radically changed handbook that uses pictures and concrete examples to *instruct*, without the need for *any* other text.
Access Index: Gist: Make detailed *keyword indexes*, using *experience* from *at least ten* real users learning to carry out the defined task(s). What do *they* want to look things up under?

Figure 9.4
Brief description of some design ideas to improve learning time.

Table 9.1 An Impact Estimation table showing the impacts of the design ideas described in Figure 9.4 on the Learning objective.

	On-line Support	*On-line Help*	*Picture Handbook*	*On-line Help + Access Index*
Learning 60 minutes <-> 10 minutes				
Scale Impact	5 min.	10 min.	30 min.	8 min.
Scale Uncertainty	±3 min.	±5 min.	±10 min.	±5 min.
Percentage Impact	110%	100%	60%	104%
Percentage Uncertainty	±6% (3 of 50 minutes)	±10%	±20%?	±10%
Evidence	Project Ajax: 7 minutes	Other Systems	Guess	Other Systems + Guess
Source	Ajax Report, p.6	World Report, p.17	John B	World Report, p.17 + John B
Credibility	0.7	0.8	0.2	0.6
Development Cost	120 K	25 K	10 K	26 K
Performance to Cost Ratio	110/120 = 0.92	100/25 = 4.0	60/10 = 6.0	104/26 = 4.0
Credibility-adjusted Performance to Cost Ratio (to 1 decimal place)	0.92*0.7 = 0.6	4.0*0.8 = 3.2	6.0*0.2 = 1.2	4.0*0.6 = 2.4
Notes: Time Period is two years.	Longer timescale to develop			

Notes: Here it is a case of comparing design ideas. It is not appropriate to assume that the effects of the different design ideas are cumulative. The design idea of Picture Handbook is seen as very cost-effective, but it doesn't on its own meet the goals. Maybe there is a complementary design idea that could be found? On-line Support is seen as achieving the goals (though the safety margin is not extremely comfortable) but, it is not very cost-effective compared to On-line Help and the development timescales need considering. Overall, there is a need to review the long term strategy. Short term, On-line Help seems an ideal design idea to start considering further.

9.3 Language Core: Impact Estimation

The *inputs* to IE include:

- Specified quantified **Performance Requirements** (objectives) **and Resource Requirements**. (This is usually for a specific system/ project deadline, and usually consists of the goals with supporting baseline information, and the budgets.)
- Specified **Design Ideas** with experience data (**Evidence**, **Sources** and basis for **Credibility** assessments).
- Standard **Credibility Ratings** and **Safety Margins**. (These will either exist in rules or policies or they must be decided locally by the project.)

The *outputs* from IE include:

- **IE tables**: 2- and/or 3-dimensional graphical diagram(s).
- **Estimations and calculations for the impacts of each of the specific design ideas on each of the specific goals and each of the specific budgets**:
  - **Scale Impact** and **Scale Uncertainty** values: What estimated impact does a specific design idea have on a specific goal or budget and, what is the margin for error or doubt? A Scale Impact is expressed as a numeric value on the defined Scale (For example, if the scale of measure was in hours, the value could be 10 hours). A Scale Uncertainty is the plus/minus error margin or experience range estimated for the Scale Impact value (for example, ±2 hours). Estimates must be based on experience data; **Evidence**, **Source** and **Credibility** must therefore be stated, or referenced, to support each estimate.
  - **Percentage Impact** and **Percentage Uncertainty** values: What percentage of the required change in a specific goal or budget does a specific design idea provide? For a goal (a performance objective), a Percentage Impact is calculated as the percentage change (that is, the ability to move) from the chosen baseline level (0%) towards a specified target level (100%). (0% would mean there was no change/improvement on the existing past level and 100% would mean the target goal was met exactly. All other percentage estimates are in relation to these two values.) For a budget, a Percentage Impact is the percentage of the budget that is estimated will be consumed or utilized. Percentage Uncertainty values for budgets are calculated in a similar way to goals. *Note: Sometimes it is appropriate to declare an overall Percentage Uncertainty (for example, ±50%) for the whole IE table or specified parts of it.*

  Calculated values for each individual design idea (the 'vertical sums'):

  - **Sum of Performance**: How 'good' is a design idea? Sum of Performance is the sum of all the estimated Percentage Impacts achieved by the design idea across all the performance requirements (objectives). There is also a need to sum the relevant Percentage Uncertainty impacts.

- **Sum of Costs or Sum of Scale Costs**: How costly is a design idea? Sum of Costs and Sum of Scale Costs are the sums of the Percentage Impacts or the Scale Impacts respectively that have been estimated for a specific design idea across all the appropriate budgets. (For example, it is likely to be 'appropriate' to use only the total financial cost figures, though the IE table might also show detailed person work-hours as a 'cost' row.) There is also a need for the sums of the relevant uncertainty impacts (the Percentage Uncertainty and/or Scale Uncertainty values as appropriate).
- **Performance to Cost Ratio**: How cost-effective is a design idea? The performance to cost ratios can be calculated either as Sum of Performance/Sum of Costs or, Sum of Performance/Sum of Scale Costs.

Calculated sums for each individual requirement (the 'horizontal' sums):

- **Sum for Requirement**: Is this requirement likely to be met and what is the margin for error or doubt? Sum for Requirement is the sum of the Percentage Impacts of the selected sets of design ideas on a specific requirement. The sums for the relevant Percentage Uncertainty impacts also need to be calculated.
- **Safety Deviation**: How much risk can be tolerated? This is the deviation of Sum for Requirement from the relevant Safety Margin. A minimum Safety Margin of factor 2 must be assumed by default (this translates to 200% for performance requirements and, to 50% for resource requirements). Include appropriate uncertainty ($\pm$) data.

Other IE Process Outputs:

- **Credibility-Adjusted Values**: The sums obtained by repeating all the calculations using the credibility-adjusted estimates (that is after multiplying each estimate with its relevant Credibility).
- **Credibility Averages**: The set of credibility-adjusted values for Sum for Requirement can be averaged to give a figure for the overall likelihood of meeting the requirements. Also the credibility-adjusted Performance to Cost Ratios for the selected design ideas can be averaged. There might be a specified design standard for performance to cost ratios, or stakeholder benefit to cost ratios that has to be exceeded before any budget will be allocated (for example, a specific ratio of Return on Investment (ROI)).
- **Revised Requirements**: Working through an IE table might lead to a revision of expectations, or some new requirements (especially objectives) might well be identified.
- **Revised Design Ideas**
- **Notes and Comments**: It is important to capture the ideas and assumptions that are identified while working through an IE table.
- **Conclusions and Presentations**: The results of analyzing an IE table including risk analysis, gap analysis and recommendations.

Table 9.2 Simple IE table illustrating some of the components of an IE table

Design Ideas-> *Requirements: Goals and Budgets*	*Idea 1 Impact Estimates*	*Idea 2 Impact Estimates*	*Sum for Requirement (Sum of Percentage Impacts)*[3]	*Sum of Percentage Uncertainty Values*[4]	*Safety Deviation*[5]
Reliability 300 <-> 3000 hours MTBF	1950 hr (1650 hr) ±0[1] 61% ± 0[2]	1140 hr (840 hr) ±240 31% ± 9%	92%	± 9%	−108%
Usability 20 <-> 10 minutes	19min. (1min.) ±4 10% ± 40%	14min. (6 min.) ±9 60% ± 90%	70%	±130%	−130%
Maintenance 1.1M <-> 100 K USdollars/year	1.1M $/Y (0 K$/Y) ±180 K 0% ± 18%	100 K S/Y (1 M$/Y) ±720 K 100% ± 72%	100%	±90%	−50%
Sum of Performance[6]	71%	191%			
Capital 0 <-> 1M USdollars	500 K (500 K) ±200 K 50% ± 20	100 K (100 K) ±200 K 10% ± 20	60%	±40%	−10%
Sum of Costs[7]	50%	10%			
Performance to Cost Ratio[8]	1.42 (71/50)	19.10 (191/10)			

Notes:

1. *Time Period: Within next 12 months.*
2. *Same Safety Margin of factor 2 has been declared for performance requirements and resource requirements. Factor 2 means minimum planned performance requirements > 200% of target (goal), and maximum planned costs <50% of target (budget).*
3. *Evidence, Source and Credibility not stated.*

Key:

[1] *Scale Impact estimate, (Incremental Scale Impact) and Scale Uncertainty estimate.*

[2] *Percentage Impact estimate with Percentage Uncertainty estimate.*

$61\% = (1650/(3000 - 300 = 2700)) \times 100$

$31\% = (840/(2700)) \times 100$, $\pm 9\% = (240/2700) \times 100$

$10\% = (1/(20 - 10)) \times 100$, $\pm 40\% = (4/(20 - 10)) \times 100$

$60\% = (6/(20 - 10)) \times 100$, $\pm 90\% = (9/(20 - 10)) \times 100$

$0\% = (0/(1.1\,M - 100\,K)) \times 100$, $\pm 18\% = (180\,K/(1{,}1\,M - 100\,K)) \times 100$

$100\% = (100\,K/(1.1\,M - 100\,K)) \times 100$, $\pm 72\% = (720\,K/(1.1\,M - 100\,K)) \times 100$

[3] *Sum of Percentage Impacts on a single requirement (Sum for Requirement).*

[4] *Sum of plus/minus Percentage Uncertainty impacts on a single requirement.*

[5] *Statements of deviation from required Safety Margins (Safety Deviation). Value calculated by (Sum for Requirement – Safety Margin). −108% = 92 – 200 (expressed as a negative value)*

[6] *Sum of all performance Percentage Impacts for a single design idea (Sum of Performance).*

[7] *Sum of cost Percentage Impacts for a single design idea (Sum of Costs).*

[8] *Calculation of the ratio of the sum of the percentage performance improvements to the sum of the percentage costs for each design idea (Performance to Cost Ratio).*

The results identify that Idea 2 is better than Idea 1.

9.4 Rules/Forms/Standards: Impact Estimation

Tag: Rules.IE.

Version: October 7, 2004.

Owner: TG.

Status: Draft.

Base: The generic rules, Rules.GS and the requirement specification rules, Rules.RS apply.

R1: **Table Format**: The requirements must be specified in the left-hand column. The design ideas must be specified along the top row.

R2: **Requirement**: Each performance requirement (objective) and each resource requirement must be identified by its tag and by a simplified version of the chosen Baseline<->Target Pair (B<->T pair). The B<->T pair should be written under the tag.

Each B<->T pair must consist of two reference points, the chosen baseline (Past) and the planned target (Goal or Budget). Each reference point must be stated as a numeric value or as a tag to a numeric value. The numeric values must be expressed using the chosen Scale for the requirement.

The baseline is stated first as it represents the 0% incremental impact point. Then usually an arrow '<->'. Then the planned target, which represents the 100% incremental impact point.

It must be possible to distinguish between multiple-level specifications for the same Goal or Budget statement. Where necessary, to be unambiguous, use a qualifier or tag the specific baseline and/or target for use in the IE table.

EXAMPLE

Reliability:
Type: Performance Requirement.
  Baseline<->Target Pair:
    Benchmark Reliability <-> 30,000 hours [USA, Next Year].
Note: Reliability and Benchmark Reliability are tags.

R3: **Qualifiers**: If there is one common set of qualifier [time, place and event] conditions for reaching all targets, this should be explicitly stated in the notes accompanying the IE table. If the qualifiers vary then they must be explicitly stated next to the relevant B<->T pair.

By default, the entire system is implied and no specific conditions are assumed. The deadline time period must always be explicitly stated.

R4: **Design Idea**: Each single column must identify a design idea or set of design ideas that could be implemented as a distinct Evo step. Each design idea must be identified by its tag. Multiple tags may be specified as a set of design ideas in a single column. All tags must be supported by a design specification, which must exist in the supporting documentation and must be sufficiently detailed to allow impact estimations to the required level of accuracy. As a minimum, each design specification must be sufficiently detailed to permit financial cost to be estimated to within an 'order of magnitude.'

R5: **Scale Impact**: For each goal or budget, the Scale Impact is the estimated or actual performance or cost level respectively (expressed using the relevant Scale) that is brought about by implementing the design idea(s) in each column.

R6: **Percentage Impact**: The Percentage Impact is a percentage (%) value derived from the Scale Impact (see Rules.IE.R2). An estimate of zero percent, '0%,' means the impact of the implementation of this design idea is estimated to be equal to the specified baseline level of the objective. '100%' means the specified target level would probably be met exactly and on time. All other percentage estimates are in relation to these two points. Note: In an IE table, it is acceptable to specify either Percentage Impacts and/or the Scale Impacts (the absolute values on the defined scale of measure). *Examples: 60%, 4 minutes.*

R7: **Uncertainty**: The ± Uncertainty (based on the evidence experience borders) of the Scale Impact estimate shall normally be specified. Percentage Uncertainty values are then calculated in a similar way to the Percentage Impacts. *Example: 60% ± 20%.* Usually, the uncertainty values are calculated individually for each cell. An exception to this occurs when some overall uncertainty (such as ±50%) is declared for the whole table or specified parts of it. Another more fundamental exception can be when a decision is made to defer dealing with uncertainty data.

R8: **Evidence**: Each estimate must be supported by facts that credibly show how it was derived. Numbers, dates and places are expected. If there is no evidence, a clear honest risk-identifying statement expressing the problem is expected (such as 'Random Guess' or 'No Evidence'). The exact source of the evidence must also be explicitly stated. Note: Reference to a specific section of a document is permitted as evidence.

R9: **Credibility**: The evidence, together with its source, must be rated for its level of credibility on a scale of 0.0 (no credibility) to 1.0 (perfect credibility).

The relevant standard Credibility Ratings Table must be considered for use. Explanation must be given if alternative ratings are chosen.

R10: **Completeness**: All IE cells (intersections of a design idea and a requirement) must have a non-blank statement of estimated impact. This must be given as a numeric value using the relevant Scale units, or as a Percentage Impact as assessed against the defined Baseline <->Target Pair, or both. If there is no estimate, then a clear indication of this must be given.

R11: **Calculations**: All the appropriate IE calculations must be carried out and the arithmetic must be correct. Hint: Using an application, such as a spreadsheet, helps! The IE calculated values include:

- Percentage Impact: See Rule R6.
- Percentage Uncertainty: See Rule R7.
- Sum of Performance: For each design idea, an algebraic sum of its Percentage Impacts on all the performance requirements. (A 'vertical' sum.)
- Sum of Costs: For each design idea, an algebraic sum of all its Percentage Impacts on the selected resource requirements. ('Selected' as it might well not make sense to sum all the costs represented in an IE table.) (A 'vertical' sum)
- Sum of Scale Costs: For each design idea, an algebraic sum of all its Scale Impacts on the selected resource requirements. (A 'vertical' sum.)
- Performance to Cost Ratio: The performance to cost ratios are calculated using either (Sum of Performance/Sum of Costs or Sum of Performance/Sum of Scale Costs).
- Sum for Requirement: For each requirement, an algebraic sum of all the Percentage Impacts for the simultaneously applicable and compatible design ideas. (A 'horizontal' sum.)
- Safety Deviation: For each requirement, subtract the Safety Margin from the Sum for Requirement. The relevant standard safety margin must be considered for use. Explanation or justification must be given if an alternative safety margin is chosen for use. By default, a standard safety margin of factor 2 (200% for performance requirements, 50% for budgets) will be used. For example, if the required safety margin is 200% and Sum for Requirement for a performance requirement is 120%, then "–80%" is the deviation to be displayed. (A 'horizontal' sum.)
- Calculate all the relevant (±) uncertainty values. Base this on best case and worst case observations or estimates.

Table 9.3 Example of a Credibility Ratings Table

Credibility Rating	*Meaning*
0.0	Wild guess, no credibility
0.1	We know it has been done somewhere
0.2	We have one measurement somewhere
0.3	There are several measurements in the estimated range
0.4	The several measurements are relevant to our case
0.5	The method used to obtain the several relevant measurements is considered reliable
0.6	We have used the method/design/idea/strategy in-house
0.7	We have reliable measurements for the design idea in-house
0.8	Reliable in-house measurements correlate to independent external measurements
0.9	We have used the idea on this project and measured it (Evo step, pilot and field trial)
1.0	Perfect credibility, we have rock solid, contract-guaranteed, long-term and credible experience with this idea on this project and, the results are unlikely to disappoint us

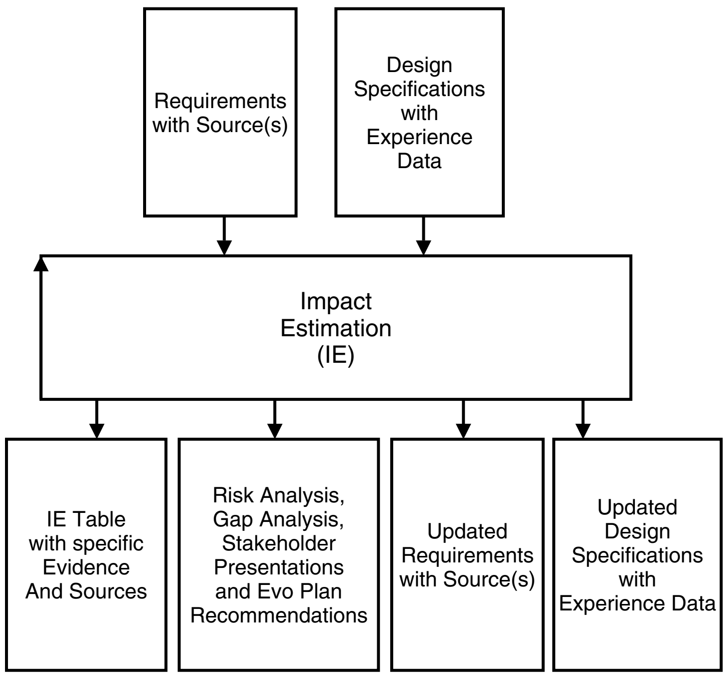

Figure 9.5
Overview of the Impact Estimation Process.

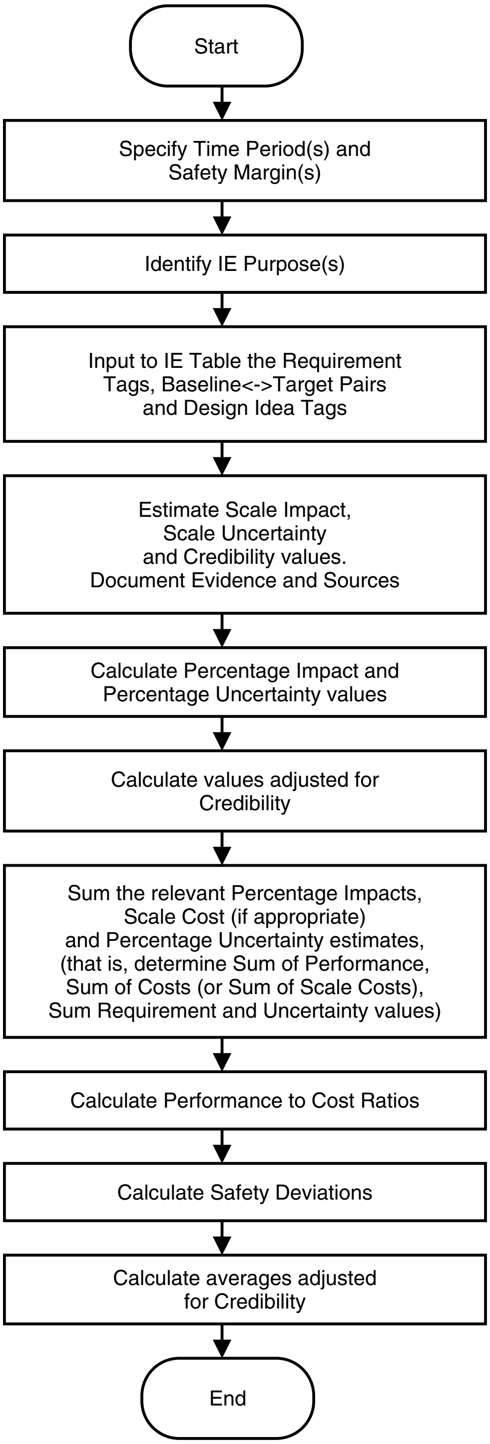

Figure 9.6
Creating an IE table.

R12: **Credibility-Adjusted Calculations**: *Do not get carried away with these credibility calculations if they are not adding significant value. They are meant to force you to think about risks.*

Multiply all the values for Scale Impact, Percentage Impact and Uncertainty by their Credibility. Repeat the calculations described in Rule R11 using the credibility-adjusted values.

For each Design Idea: Calculate the credibility-adjusted average (Design Idea Credibility Average) by dividing the sum of its credibility-adjusted Percentage Impacts for all the performance requirements by the number of performance requirements being considered. (A 'vertical' sum.)

For each Requirement: Calculate the credibility-adjusted average (Requirement Credibility Average) by dividing the sum of its credibility-adjusted Percentage Impacts for all the relevant design ideas by the number of relevant design ideas. (A 'horizontal' sum.)

9.5 Process Description/Standards: Impact Estimation

Process: Impact Estimation

Tag: Process.IE.

Version: October 7, 2004.

Owner: TG.

Status: Draft.

Entry Conditions

E1: The Generic Entry Conditions apply. The main input documents are the requirement specification and the design specifications.

Note: It is extremely important that the requirement specification is SQC exited. Note also that the Credibility of the Evidence and Source(s) will be independently rated during IE, regardless of whether the design specifications are SQC exited.

Procedure

P1: Identify your 'purpose' for the IE table. Decide how to use the table for your defined purposes. Are you using IE for 'self-analysis,' 'presentation to authorities,' 'control of design engineering or planning process,' 'project control,' 'comparison of alternatives' or others? The purpose and audience determine what you do with the table and how rigorous and formal you are. *See Figure 9.2, 'Purposes for the use of IE'.*

P2: Use the rules, Rules.IE, to fill out an IE table to the best of your ability. This implies that all the IE calculations are done, perhaps using a software application (see footnote 4 at the end of Section 9.9).

P3: Be honest and open. Document where insufficient information is available, and where guesses are being made. Make liberal use of '?' and other 'uncertainty' indicators. Remember, the IE table is there to help you see potential problems, not to cover them up!

P4: Analyze Risks. Specify risks in your report or presentation. For example, as footnotes to the IE table. Try the following:

- Study the requirements again. Which ones are 'shaky'? Look for '<fuzzy>', '?', dubious sources and admitted guesses.
- Study the design specifications again. Are they really specific and detailed enough to merit the estimates? Is the evidence really good enough to 'stand up in a court' of skeptics?
- Study the table itself for gaps to targets. For example, consider the gaps to the goal targets. Also look at the safety deviations. Document any gap problems that you identify and suggest actions.

P5: Identify the areas that deserve more time-demanding analysis, and work more on them. For example, you should select areas of the table with low credibility, high uncertainty and large shortfalls in meeting goals or budgets.

P6: Make improvements and changes to requirements, designs, and evidence. Re-calculate the table.

- The owners of these requirements and design must be involved ultimately. Are you being ambitious enough?

P7: Decide which issues need to be settled 'in the field' by (Evo steps, prototypes, market trials, field experiments).

- Make specific recommendations about which areas need early practical measurement. Show the estimated impacts of implementation of the different design ideas.

P8: Decide on presentation. Topics you should consider covering include the level of IE table, the requirement hierarchy, key 'focus' issues, graphics, alternative design ideas, risk analysis and suggested actions.

- Bring out the main conclusion. Bring out the risks and dangers. Show the effect of any suggested alternatives.

P9: Make presentations to (colleagues, formal reviews, stakeholders, experts, key managers).

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Hint: Choose to present first to informal friends, rather than making a fool of yourself by lack of preparation in front of your managers and stakeholders.

Exit Conditions

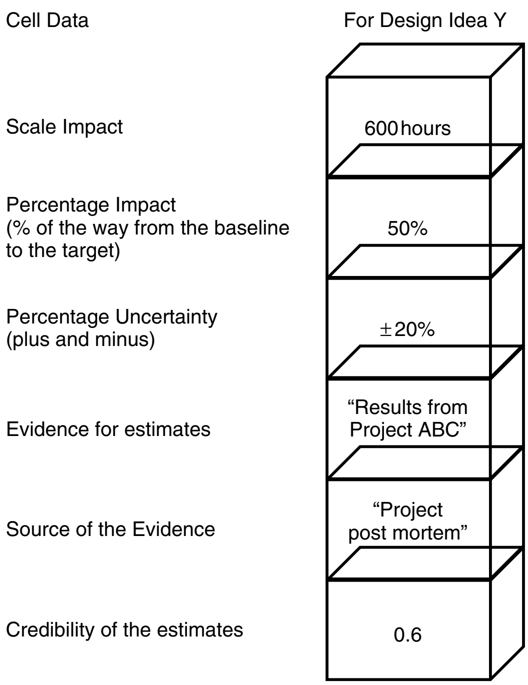
X1: The Generic Exit Conditions apply. The IE table and all its related data (such as evidence) shall exit from Specification Quality Control (SQC) with no more than one remaining major defect/page.

- Formally, the table can only be used in other processes when it has exited from SQC. In practice, the purpose and the audience, determine what you are going to demand as exit conditions. The precise exit conditions need to be defined locally.

9.6 Principles: Impact Estimation

1. **The Principle of 'Words being difficult to weigh'**
   Non-numeric estimates of impact are difficult to analyze and improve upon. A design idea described as 'excellent' could actually be worse than another merely described as 'good.'
2. **The Principle of 'Doubtful digits are better than none'**
   A bad numeric estimate, and its definition, can still be systematically criticized and improved. In fact, a random number is a better starting estimate than flowery, descriptive words.
3. **The 'Evident' Principle**
   Estimates without sources, evidence and credibility are not evident.
4. **The Principle of 'Uncertainty in no uncertain terms'**
   The uncertainty estimate is at least as important as the main estimate.
5. **The Principle of the 'Seat Belt'**
   A safety margin is as necessary with uncertain estimates, as a seat belt is with uncertain traffic.
6. **The Principle of 'Profitable Proposals'**
   The value of an idea is how well it meets objectives. The net value considers the costs too.
7. **The Principle of 'the Swiss Army Knife'**
   Impact Estimation is a multi-purpose method. It can help you in many situations: to evaluate, to compare, to present, to argue, to destroy, to find weaknesses, to cut fat, to see risk, to prioritize, to sequence and more.

8. **The Principle of 'Always Useful'**
   Impact Estimation can assist a project throughout its lifecycle – from identifying requirements to assessing feedback data from implemented systems.
9. **The Principle of 'Multiplicity'**
   When stakeholders have multiple requirements, then we need to evaluate multiple design options against all those requirements including considerations of value, in order to make a reasonable choice.
10. **The Efficiency Principle**
    When real life has many stakeholder values, and many cost constraints, then evaluation of designs (strategies) must be done with respect to *both* the values and the costs.



Note other options include:

- Percentage Impact towards the Fail levels (Levels of no failures)
- Percentage Impact towards the Survival levels (Levels for survival)
- Other Percentage Impacts towards the Goal/Budget levels (target levels) for other qualifier conditions. (For example, different dates)
- Owner of estimate: Tom

Figure 9.7
The Data in an IE Cell for a Performance Attribute.

9.7 Additional Ideas: Impact Estimation

Understanding Mathematical Inaccuracy

Let me stress that IE provides only rough, practical calculations. Adding impacts of different, independent estimates for different design ideas, which are part of the same overall architecture, is dubious in terms of accuracy. There are bound to be interactions, which we are unable to predict in advance of implementation.

This admission of mathematical inaccuracy often annoys people; on one hand, I'm demanding numeric values and, on the other, I'm admitting to a lack of accuracy! There is no absolute defense for this, apart from saying we can only try our best; quantitative values far better convey understanding than words and they permit calculations to be carried out.

Let me add an additional cautionary note that I expect IE estimates only to be used as a rough indicator to help designers spot potential problems or select design ideas. Any real estimation of the impact of many design ideas needs to be made by real tests; ideally, by measuring the results of early evolutionary steps in the field.

Level of Detail

Understanding your specific purposes for using IE is key to how you actually use the method. These purposes determine how rigorous and formal you are. If you are using IE in brainstorming mode to generate new design ideas and to check you have the right set of requirements, then rough numeric estimates will suffice. If you are establishing which are the most cost-effective design ideas, then more detailed impact estimations will be necessary.

Coping with Interactions amongst Design Ideas

Considering Side Effects

Negative impacts do occur! It is fairly common for a design idea to impact on certain objectives very positively and yet negatively on others.

Dealing with Alternatives

Take care that you are not adding together the percentage impacts of mutually exclusive design ideas.

Dealing with Dependencies

Design ideas can be dependent on each other or their impacts can differ depending on what other design ideas have been implemented in *advance* of them, or even those implemented *later*. Consider grouping dependent design ideas into a set and evaluating as a set within an IE table.

Priority Management within IE

People often ask why I don't use 'ranking' or subjective weights for priority. The answer is that IE handles priority implicitly. You in-build the priorities when you specify the required performance levels over time (Goal levels with time conditions).

Note, this does not mean that you don't discuss priority. You do! You definitely need to understand the priorities when setting and modifying your requirements.

Can We Always Use the Stated Requirements to Determine Priority?

The stakeholder value derived from meeting a goal or other requirement, wholly or partly, has also to be considered. There are many factors, for example, meeting one goal can be very much more rewarding than meeting another, the value derived can vary from stakeholder to stakeholder, or the value can vary according to where the design idea is delivered. So, the question arises, should the project manager decide the priority by looking at the goals they have been given officially, or should they somehow try to figure out what the consequential value is for satisfying a requirement, and get closer to a more realistic priority?

Here are some possible answers:

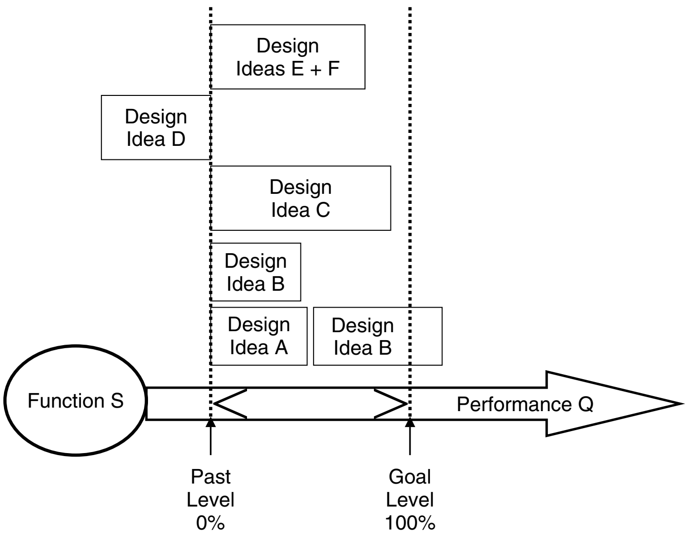
- they should stick to their official goals and other requirements
- they should look to any vision statement(s) and policy statement(s) for direction. If the requirements are not good enough to motivate them in the right direction (that is, do not live up to the vision and policy statement(s)), then this may be an indicator that they should get a reformulated set of requirements at the appropriate level, which reflect value better.
- they can ask key stakeholders exactly which of the unfinished requirements should have priority 'this week' (a common practice in Evolutionary Project Management).

Priority for a designer or manager is to reach the stated goals (performance targets) within the stated budgets (for people, time and money) under the stated conditions. Efforts must be focused towards trying to make the maximum progress, in the direction of immediate goals, at all times. If a specific goal has priority, it has claim on our resources (our budgets) for satisfying that goal.

This is not a simple static problem. Priority changes when any of the following change:

- The design or implementation distance to 'survival levels' (Survival) for a specific performance goal
- The distance to 'success levels' (Goal) for a specific performance goal
- The availability of a given type of resource (for example, if you don't have 'money', then use 'time' instead)
- The uncertainty of an idea: the factors effecting this are evidence, sources, plus/minus uncertainty and the credibility rating.

Such changes occur as a result of the order of implementing design ideas, feedback from the field and changes in the business



All proposed design ideas are supposed to contribute to our ability to reach the planned performance levels within the planned resource levels.

For a specific requirement, Performance Q:

- *Design Idea A is estimated to move us halfway towards a stated goal.*
- *Design Idea B, implemented after Design Idea A, is estimated to bring us the rest of the way, and perhaps give more than our goal.*
- *Design Idea B implemented first, before Design Idea A, is not as effective for this performance attribute.*
- *Design Idea C almost delivers all the required improved performance level on its own.*
- *Design Idea D has a negative effect on his performance attribute.*
- *Design Idea E and Design Idea F are totally dependent on each other and must therefore be considered together.*

  Insight: IE allows us to evaluate partial solutions in various combinations, and pick a satisfactory combination.

  Recommendation: Use IE to look at combinations of solutions, so that your selection is better.

Figure 9.8
Design Idea Contributions.

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environment; change in priority is almost inevitable. Priorities vary depending on the 'gaps' between the current level and the target level; the 'larger' a gap in relation to the other gaps, then the more likely it is to demand attention. We can use an IE table as a tool for determining, calculating and visualizing our current priorities.

It is our decision how we manage our priorities. We can use the IE table to manage both the initial design and implementation phases of projects, and ensure that projects are tailored to our current priorities.

Managing Risk: Building in Safety Margins

Priority management (above) is one way of managing risk. However, IE also has an additional mechanism – the use of safety margins. By explicitly designing to overreach your requirements, you can better ensure that you actually reach the requirements. Note that just because you have additional design ideas, does not mean that you have to implement them all!

Highlighting System Failure and System Survival Levels

Another way to control risk is to monitor it more explicitly by using Fail levels or Survival levels, rather than Goal levels, in IE tables. Fail levels reflect the levels of requirements that must be achieved to avoid any project failure. Survival levels reflect the levels of requirements that must *all* be reached for the project to survive. Obviously, when working with the project critical values, the choice of Safety Margin(s) becomes a crucial issue.

9.8 Further Example/Case Study: IE Table for US Army Personnel System Long Term Planning

Here are extracts from a larger study to show you use of the IE method in the 'real world'.

Table 9.4 was produced during a study of the improvement of a US Army Personnel system. The requirements (left column) were specified in detail and quantified. A sample of the Customer Service objective is given below to give the reader some idea of this detail. Notice that as well as the stakeholder objectives being evaluated on this chart, two of the cost aspects for the proposed strategies (design ideas) are also estimated. This makes it possible to see the relative 'bang for buck' of each strategy (by calculating the performance to cost ratio). Comparison

Table 9.4 Example of a real Impact Estimation table from a pro-bono client (US DoD, US Army, Persincom).

Design Ideas ->	*Technology Investment*	*Business Practices*	*People*	*Empowerment*	*Principles of IMA Management*	*Business Process Re-engineering*	*Sum Requirements*
Customer Service ? <->0 Violation of agreement	50%	10%	5%	5%	5%	60%	185%
Availability 90% <-> 99.5% Up time	50%	5%	5–10%	0%	0%	200%	265%
Usability 200 <-> 60 Requests by Users	50%	5–10%	5–10%	50%	0%	10%	130%
Responsiveness 70% <-> ECP's on time	50%	10%	90%	25%	5%	50%	180%
Productivity 3:1 Return on Investment	45%	60%	10%	35%	100%	53%	303%
Morale 72 <-> 60 per month on Sick Leave	50%	5%	75%	45%	15%	61%	251%
Data Integrity 88% <-> 97% Data Error %	42%	10%	25%	5%	70%	25%	177%
Technology Adaptability 75% Adapt Technology	5%	30%	5%	60%	0%	60%	160%
Requirement Adaptability ? <-> 2.6% Adapt to Change	80%	20%	60%	75%	20%	5%	260%
Resource Adaptability 2.1M <-> ? Resource Change	10%	80%	5%	50%	50%	75%	270%
Cost Reduction FADS <-> 30% Total Funding	50%	40%	10%	40%	50%	50%	240%
Sum of Performance	*482%*	*280%*	*305%*	*390%*	*315%*	*649%*	
Money % of total budget	15%	4%	3%	4%	6%	4%	36%
Time % total work months/year	15%	15%	20%	10%	20%	18%	98%
Sum of Costs	*30*	*19*	*23*	*14*	*26*	*22*	
Performance to Cost Ratio	*16:1*	*14:7*	*13:3*	*27:9*	*12:1*	*29:5*	

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of these performance to cost ratios can be used to decide what to invest in initially (in the early stages of the change process). The strategies were also detailed; only the strategy tag is given at the top of the table. One strategy, 'Technology Investment' is detailed at the Gist level below. The estimates are made in round numbers (nearest 5%). In the full study, Evidence and Sources were given. This was the first time anybody we had contact with there had seen an Impact Estimation table. The General insisted that the analysis and presentation work were taken seriously and done to a reasonable standard.

EXAMPLE

Customer Service: "An example of one of the objectives defined."
Gist: Improve customer perception of quality of service provided.
Scale: Violations of Customer Agreement per Month.
Meter: Log of Violations.
Past [Current Date]: <number of violations> <- Management Review on State of Persincom.
Record [NARDAC]: 0? <- NARDAC Reports [This Year].
Fail: <better than Past> <- CG.
Goal [By End of This Year, Persincom]: 0 "Go for the Record" <- Group SW.

EXAMPLE

Technology Investment: "An example of one of the strategies defined."
Defined As: Exploit investment in high return technology.
Impacts: Productivity, Customer Service.

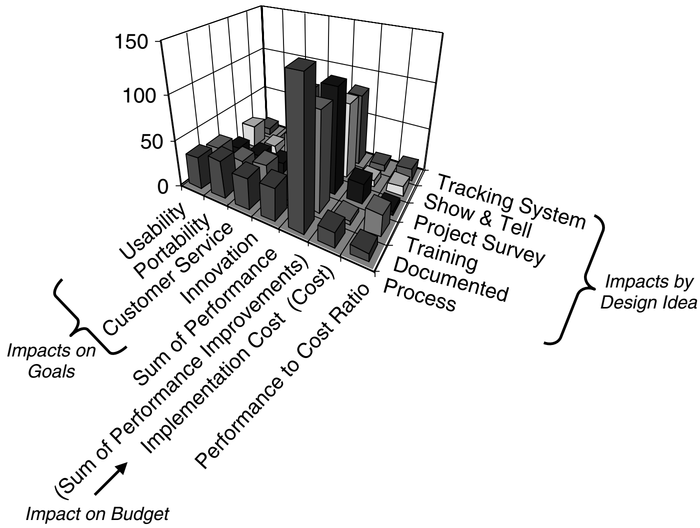
9.9 Diagrams/Icons: Impact Estimation

Presentation of IE Tables

Always consider your audience when presenting IE tables. It is very easy to present too much detail at once. If you are presenting to management, you must use a high-level representation of the IE table. However, always have the detailed version available to support their more searching 'tough' questions!

One possible way to simplify the IE results is to interpret the numeric values into, say, stars with a one to five rating. This works well in a meeting when there is little time.

Another approach is to use the performance to cost ratios and credibility-adjusted averages. Once management understands how these values are calculated, this can be a very rapid way of summarizing the key points.



Question: Look at Figure and try to identify the most cost-effective design idea and how much of the required performance attributes it is likely to deliver (see bottom of page for answer).

Figure 9.9
'Skyscraper' Representation of IE results (a 3-dimensional bar chart by spreadsheet). The figure shows a '3-dimensional' example of an IE table. This gives you an idea of the kind of useful information that an IE table combined with spreadsheet software can provide. Design ideas are along one axis and, performance targets (goals) and cost targets (budgets) are along another. The third axis graphically compares the levels of various types of impact (for example, contributions towards performance goals and performance to cost ratios).

Software Tools Supporting IE

Impact Tables are well suited to spreadsheet software. It is a major benefit to have the calculations automatically worked out and immediately available for analysis. It is also easy to produce pleasing graphics.[1]

Answer: The design idea of providing 'Training' is the most cost-effective. However, on its own it doesn't deliver sufficient levels of performance to be sure of the project's success. Other design ideas should be considered to supplement it, such as 'Tracking System.'

[1] My son, Kai Thomas Gilb has produced a simple working prototype using Microsoft Excel. We often use it for live demonstrations in the classroom. It is free and available at our website, www.Gilb.com. Some clients have made IE tools using Microsoft Access, which has a more pleasing human interface than Excel for entering data. We reckon the reader can easily make their own IE application from available software.

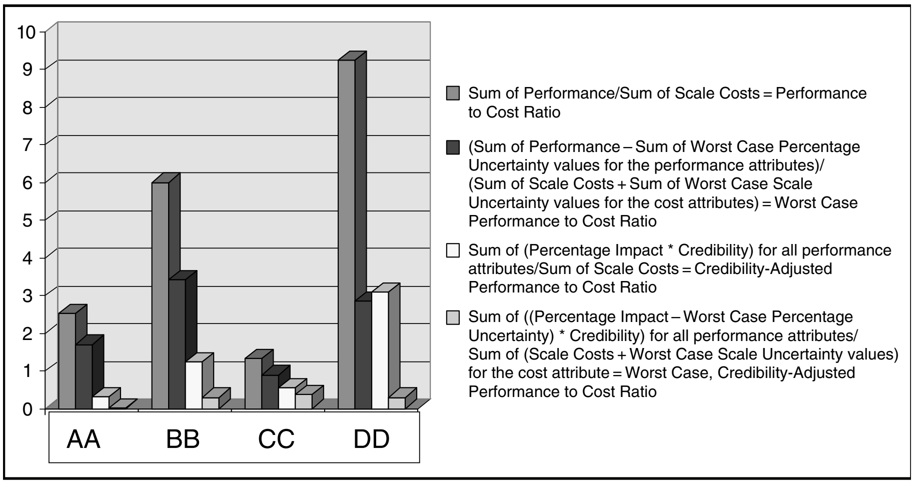


Figure 9.10
Impact Estimation Analysis of worst cases using Uncertainty and Credibility.

<table>
<tr><th>Concept</th><th>Keyed Icon</th></tr>
<tr><td>Impacts</td><td>-></td></tr>
<tr><td>Scale Impact</td><td>-|-|-.-></td></tr>
<tr><td>Percentage Impact</td><td>%.-></td></tr>
<tr><td>Impact Estimate</td><td>->.#</td></tr>
<tr><td>Cell</td><td>#</td></tr>
<tr><td>Side Effect</td><td>*.-></td></tr>
<tr><td>Uncertainty</td><td>±?</td></tr>
<tr><td>Percentage Uncertainty</td><td>%.±?</td></tr>
<tr><td>Scale Uncertainty</td><td>-|-|-.±?</td></tr>
<tr><td>Baseline</td><td>0%</td></tr>
<tr><td>Baseline to Target Pair</td><td><-></td></tr>
<tr><td>Credibility</td><td>±?.#</td></tr>
<tr><td>Safety Factor</td><td>X</td></tr>
<tr><td>Safety Deviation</td><td>X.±</td></tr>
<tr><td>Sum of Performance</td><td>Σ.O+</td></tr>
<tr><td>Sum of Costs</td><td>Σ.-O</td></tr>
<tr><td>Sum for Requirement</td><td>Σ.[@]</td></tr>
<tr><td>Performance to Cost Ratio</td><td>+%.-%</td></tr>
</table>

Figure 9.11
Keyed Icons for Impact Estimation.

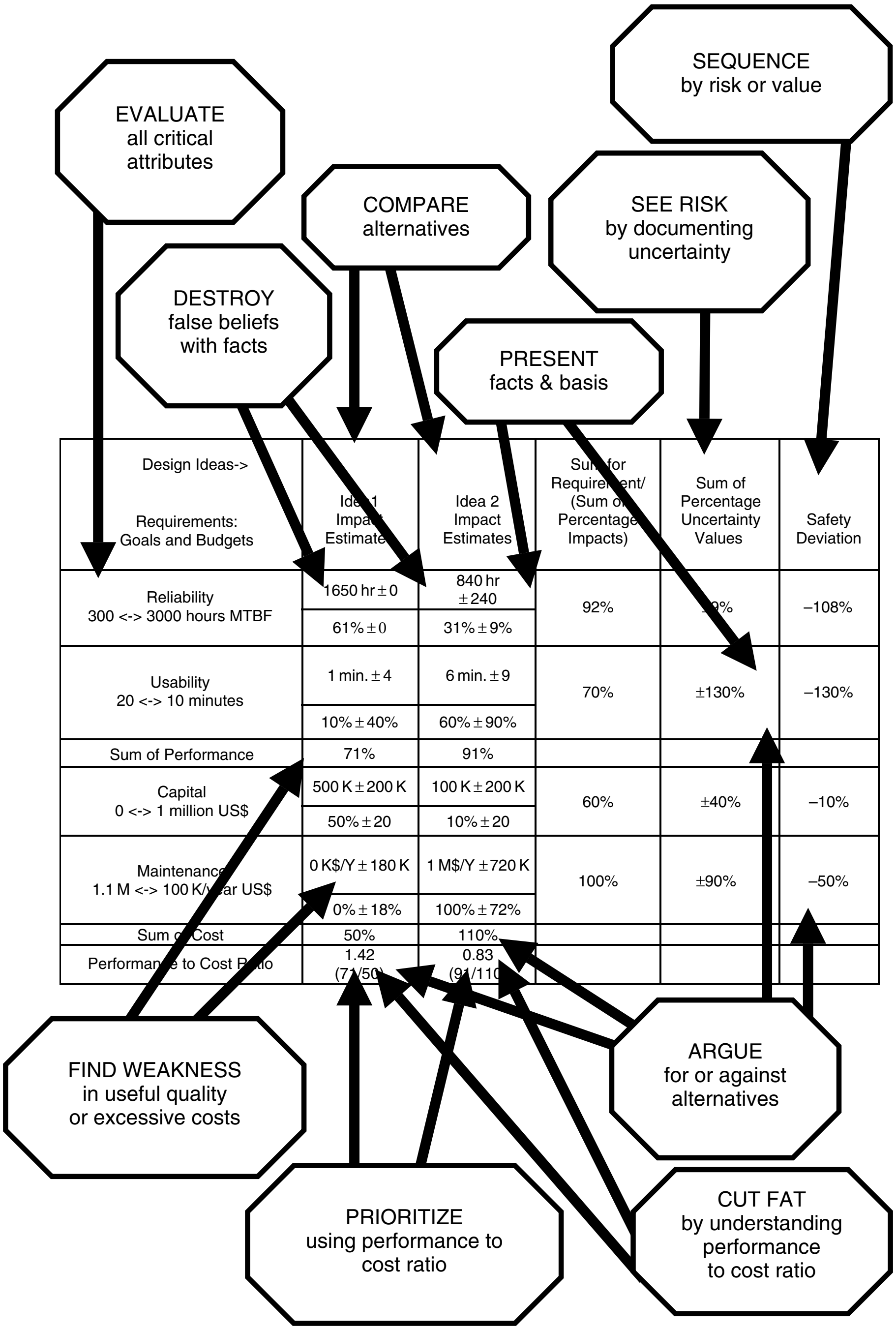


Figure 9.12
Multiple Purposes for IE. Impact Estimation serves many purposes. Here are some headlines and some symbolic pointers to the parts of the IE table which influence these purposes. A list of the main purposes can be found in Figure 9.2.

9.10 Summary

IE is a practical method that can be used throughout the entire lifecycle of a project to help identify and evaluate design ideas against system requirements. Specifically, IE promotes better, more informed design decisions as:

- it forces people to numerically evaluate the impact of design ideas and to provide evidence to support their estimates
- it helps communication about the key elements of the system design; the objectives, the budgets and the design ideas
- it provides a means of understanding and dealing with priority and risk.

In fact, the main problem currently facing people using IE tables is the lack of quantitative data. To make a start, we can use our practical experience data. However, there is a general need to gather more objective data about our technologies. Historically, the emphasis has been solely on cost data.