The Engineering Design Cycle

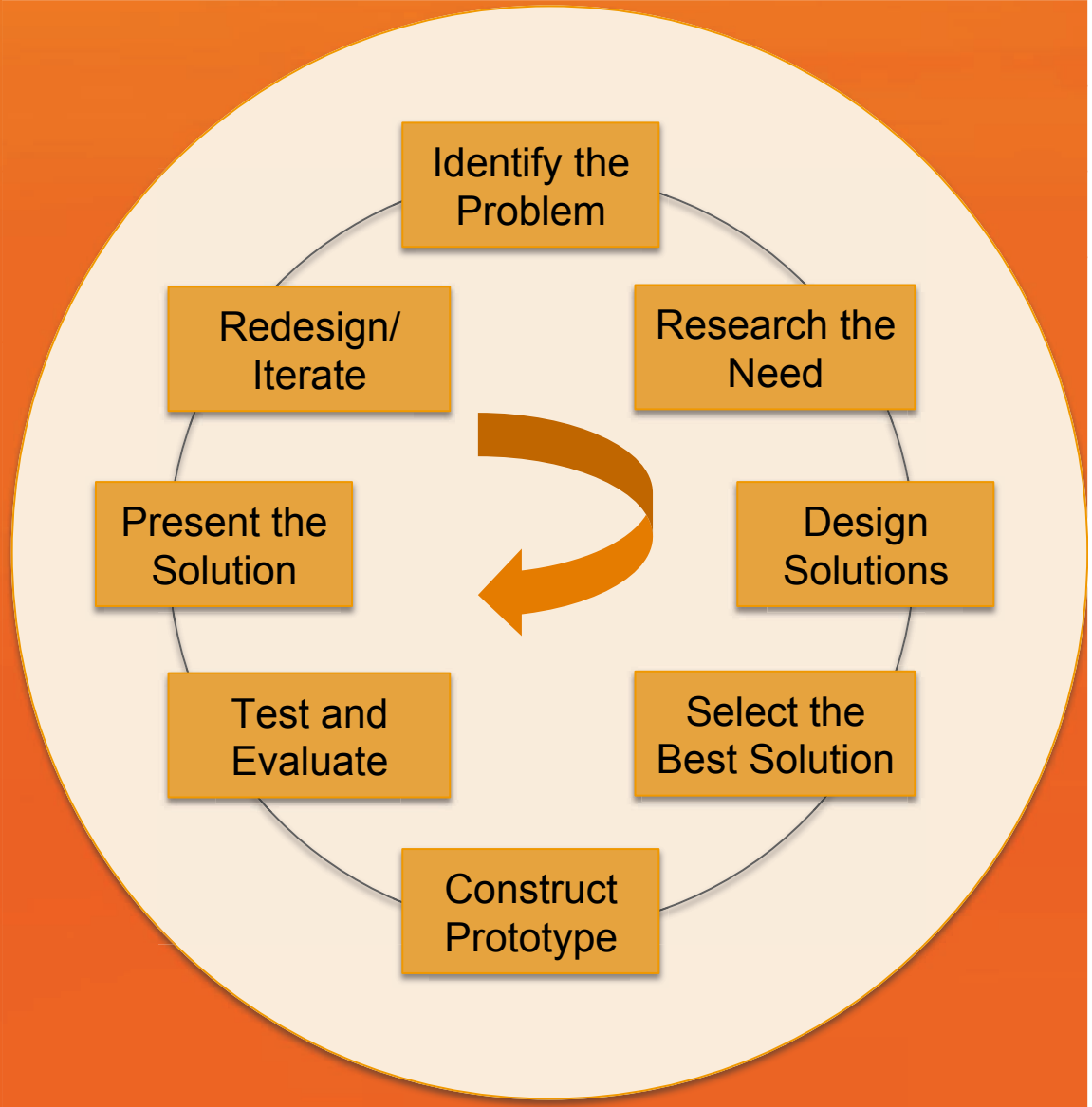
Choosing a Solution

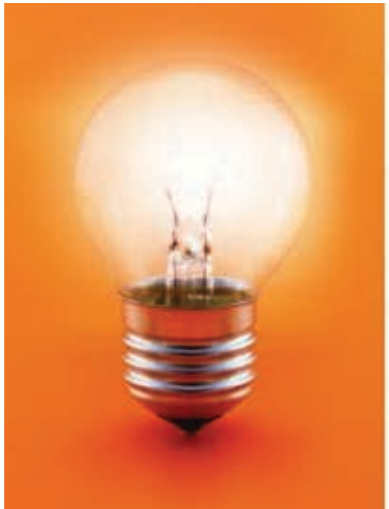
Once solutions to the design problem ranging from the incremental to the wild & crazy have been identified, it's time to methodically AND objectively choose the best solution.

The Engineering Design Cycle

A problem has been identified. The problem has been researched. The need to solve it has been proven with credible sources. A range of solutions have been identified. Now, it's decision time!

Selecting the best solution should not be a random or even a semi-random choice, but should rely on a careful and objective decision making process that in addition to helping to select the best solution, can also be used to offset failure, if it does happen!





Select the Best Solution

during

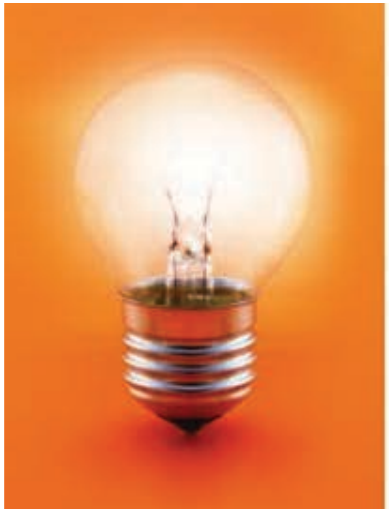
the Engineering Design Cycle

Decision Making with a Decision Matrix

Consider each solution for an accelerometer application:
Does each design provide the required performance metrics?

Design Specification (Performance Metrics)						
	Solution #1	Solution #2	Solution #3	Solution #4	Solution #5	Solution #6
Precision (0.1g)	Yes	Yes	No	Maybe	Yes	Yes
Stability (.01g/Day)	Maybe	Maybe	Yes	Yes	Yes	Yes
Dynamic Range (-2g to +2g)	Yes	No	Yes	Yes	No	Yes

Some designs may require preliminary models, hand calculations, or simulations to understand if the design is likely to meet the design specifications. If it is not clear whether or not the solution can meet the design specification, the team will have to decide if the solution is worth the risk to pursue it.



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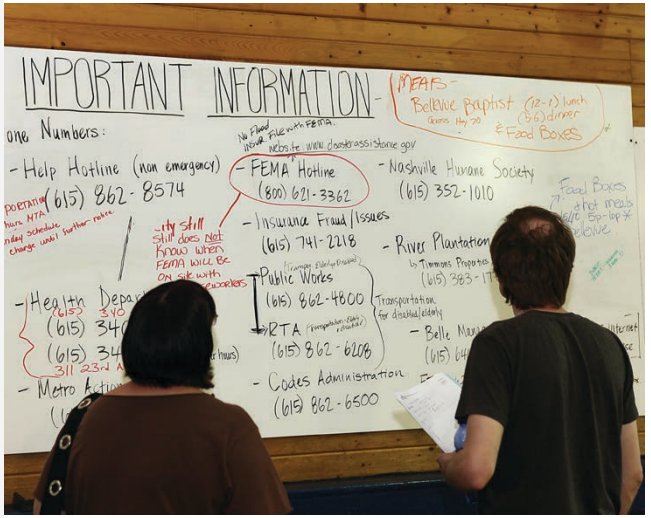
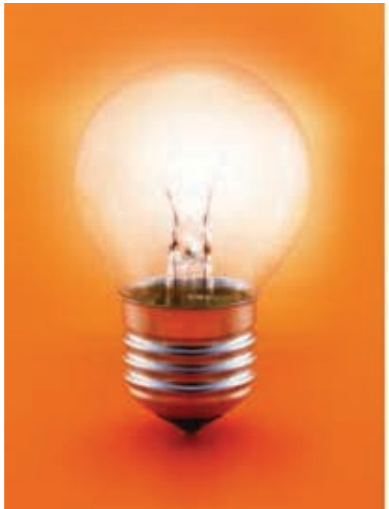
Stability (.01g/Day)	Maybe	Maybe	Yes	Yes	Yes	Yes
Dynamic Range (-2g to +2g)	Yes	No	Yes	Yes	No	Yes

Any design that does not meet one or more design specifications (in the case above, performance metrics) must be automatically rejected OR in some situations, it may be necessary to go back to the

- Research the Need or
- Design Solutions

phase of the engineering design cycle to understand if the specifications are too stringent and can be relaxed.





Select the Best Solution

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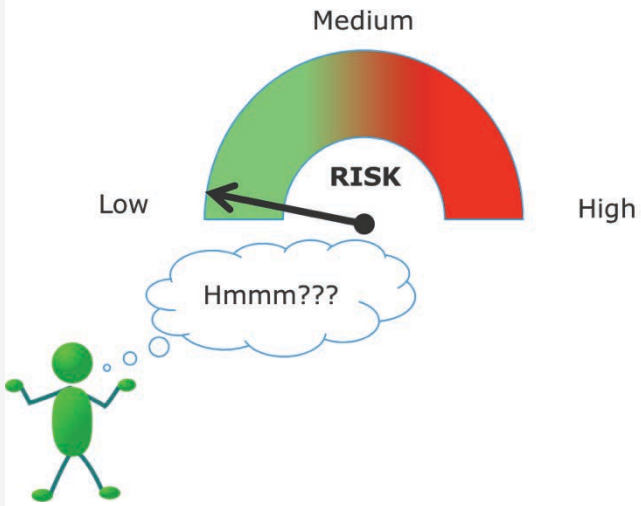
Decision Making with a Decision Matrix

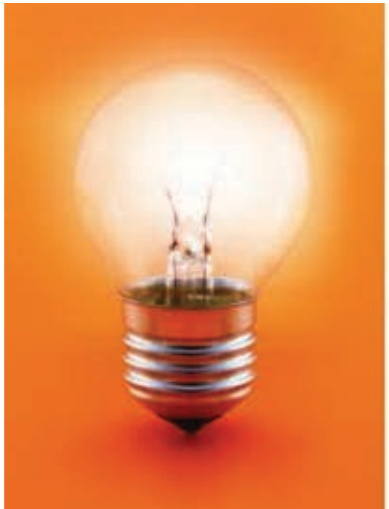
Consider each solution for an accelerometer application: Does each design remain within the specified constraints?

Design Specification (Constraints)						
	Solution #1	Solution #2	Solution #3	Solution #4	Solution #5	Solution #6
Power Consumed (0.1W, average)	No	Yes	Yes	Maybe	Yes	Yes
Cost ($25 per unit)	Maybe	No	Yes	Yes	Yes	Yes
Size (no greater than - 5cm x 5cm x 1cm)	Yes	No	Yes	Yes	No	Yes

Like performance metrics, some constraints may be impossible or difficult to estimate for some design solutions. These solutions may require:

- Returning to previous phases of the design cycle to see if the constraint can be relaxed.
- Identifying how much risk the design team is willing to take (and the consequences for failure).





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Decision Making with a Decision Matrix

Which Solutions pass the first pass (Decision Matrix)?

Design Specification (Performance Metrics)						
	Solution #1	Solution #2	Solution #3	Solution #4	Solution #5	Solution #6
Precision (0.1g)	Yes	Yes	No	Maybe	Yes	Yes
Stability (.01g/Day)	Maybe	Maybe	Yes	Yes	Yes	Yes
Dynamic Range (-2g to +2g)	Yes	No	Yes	Yes	No	Yes

Design Specification (Constraints)						
	Solution #1	Solution #2	Solution #3	Solution #4	Solution #5	Solution #6
Power Consumed (0.1W, average)	No	Yes	Yes	Maybe	Yes	Yes
Cost ($25 per unit)	Maybe	No	Yes	Yes	Yes	Yes
Size (no greater than - 5cm x 5cm x 1cm)	Yes	No	Yes	Yes	No	Yes

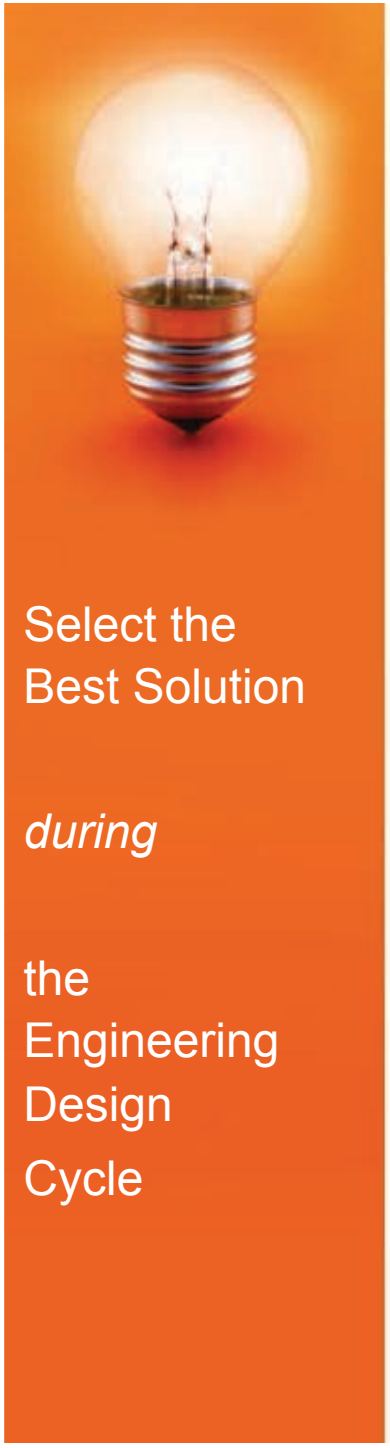
Solution #6 is the only clear winning solution here, but Solution #4 might also be viable. Which one should be selected to move forward into the prototyping phase?

The Engineering Design Cycle

When the Basic Decision Matrix is not Enough:

A more sophisticated planning method can be used to evaluate which design provides the best pathway toward a solution to the problem.

One such method, called SWOT (Strengths, Weaknesses, Opportunities, Threats), is a popular planning method which allows the project team to identify both internal factors in the design and design team (through strengths and weaknesses) and external factors that may also influence the design and design team (through opportunities and threats).



Select the Best Solution

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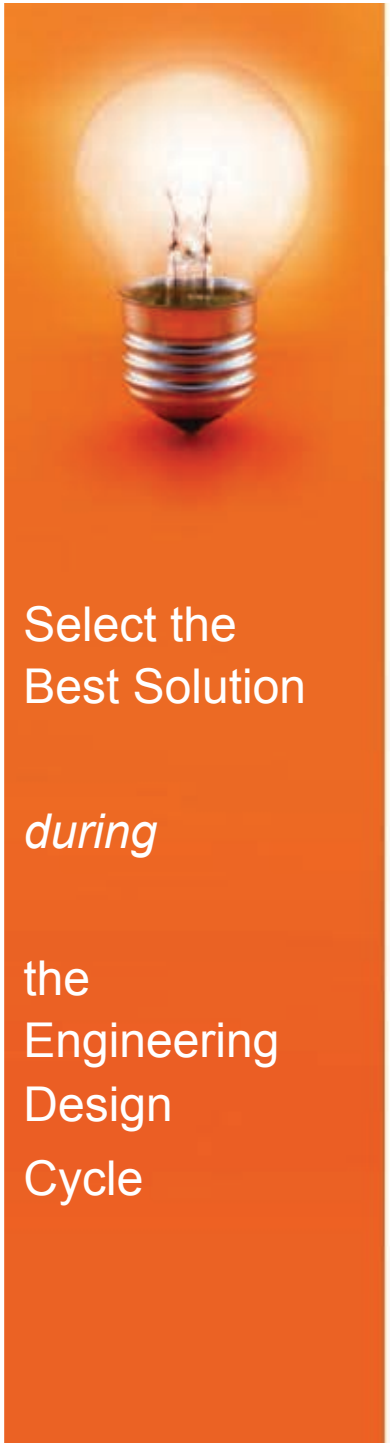
Decision Making with SWOT

Strengths - are the characteristics of the design or the design team that give a possible design solution an advantage over other competing options.

	Helpful to achieving the objective	Harmful to achieving the objective
Internal origin (attributes of the organization)	Strengths (S)	Weaknesses (W)
External origin (attributes of the environment)	Opportunities (O)	Threats (T)

Examples:

- Design is conducive to fast and inexpensive protoyping.
- Design team member has previous expertise in a key area associated with a particular design.



Select the Best Solution

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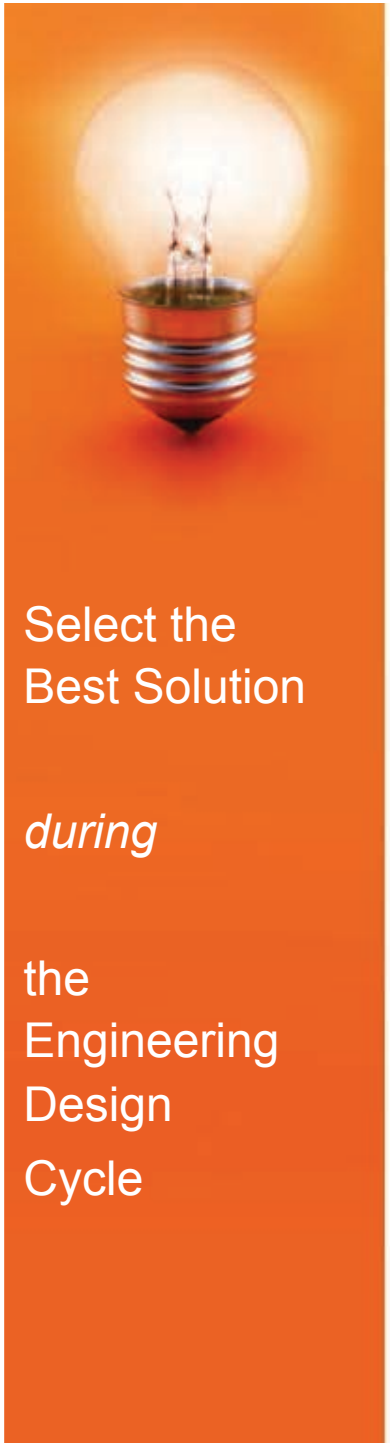
Decision Making with SWOT

Weaknesses - are areas that will be highlighted in the selection of particular design or characteristics of the design team that will need to be improved to make the design successful.

	Helpful to achieving the objective	Harmful to achieving the objective
Internal origin (attributes of the organization)	Strengths S	Weaknesses W
External origin (attributes of the environment)	Opportunities O	Threats T

Examples:

- Design requires extensive interviewing to identify market and the team is not particularly outgoing
- Design relies on a part that has limited availability and long lead time.

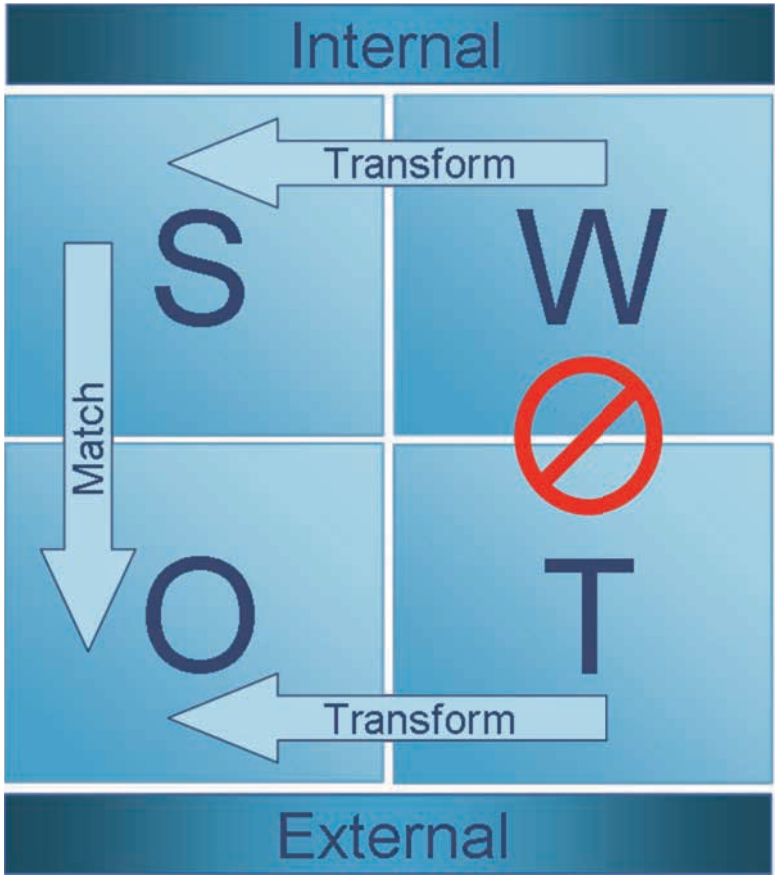


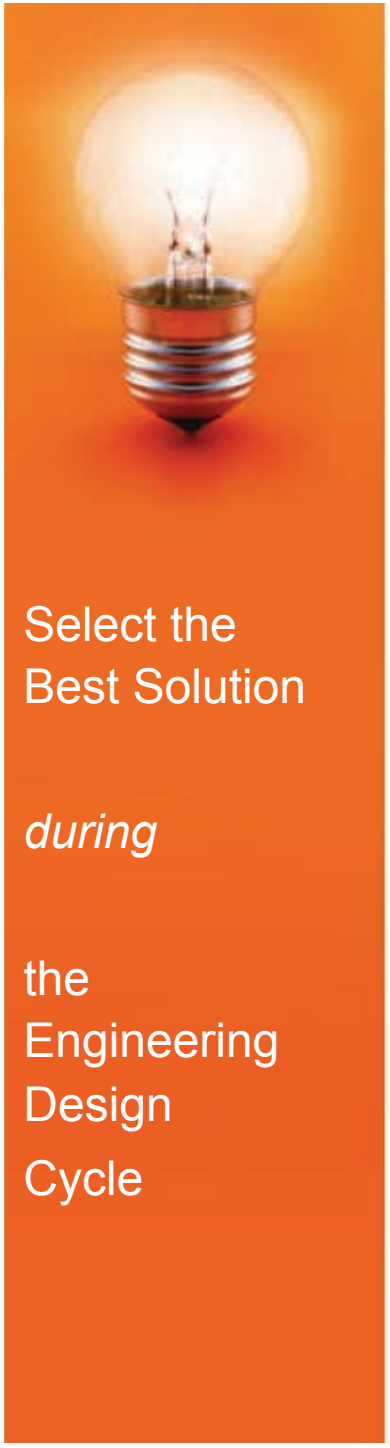
Decision Making with SWOT

Opportunities - are external elements (things out in the real world) that can be used or exploited to the advantage of the design or design team.

Examples:

- Certain consumers are so desperate for a product with a particular function that they are likely to tolerate non-idealities.
- A new federal requirement, regulation, or law is scheduled to take effect, stimulating a need for products in a particular design area.



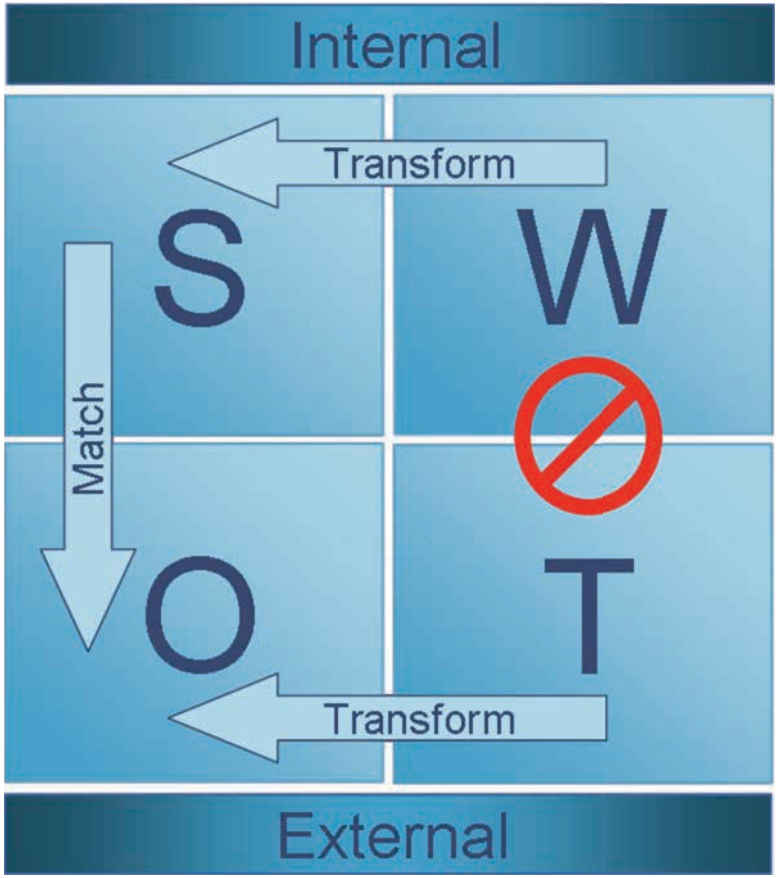


Decision Making with SWOT

Threats - are things out there in the real world that could cause trouble for the design.

Examples:

- A competing product is coming onto the market or has been proven and published via research publication, patent, or similar release.
- The application for the design could change drastically because of shifting consumer desires or alternative technologies emerging into the market.
- A social issue or constraint has the potential to submarine the design altogether.



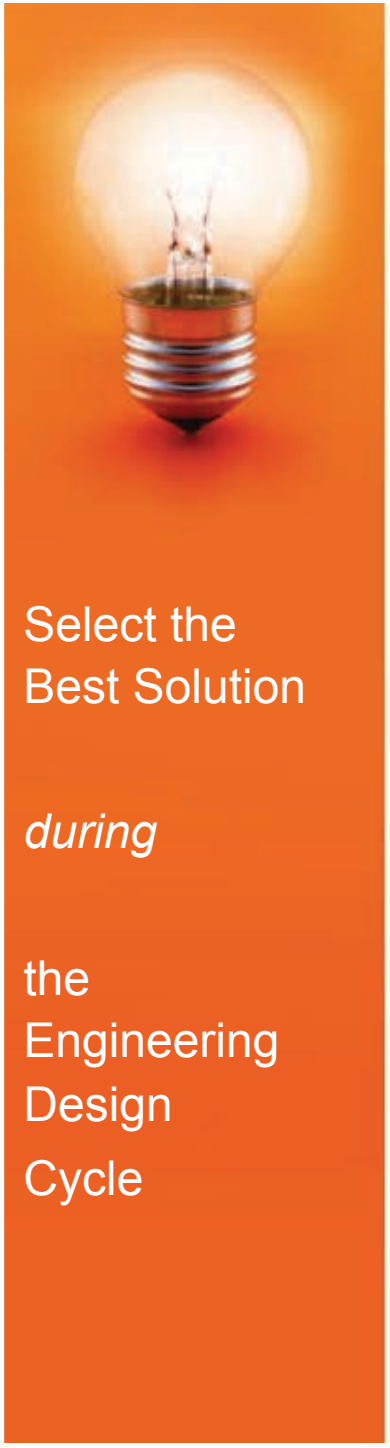
The Engineering Design Cycle

Caution - Is the Decision Biased or Subjective?

Even engineers are human and during the selection of a design solution, can show bias in preferring certain choices over others, despite the fact that objectively, these choices are not better than others.

Solution - Become a more objective Decision Maker

- Become aware of bias
- Know the types of bias each team member is most susceptible to
- Take steps to prevent bias from causing the design team to select non-optimal design choices.



Select the Best Solution

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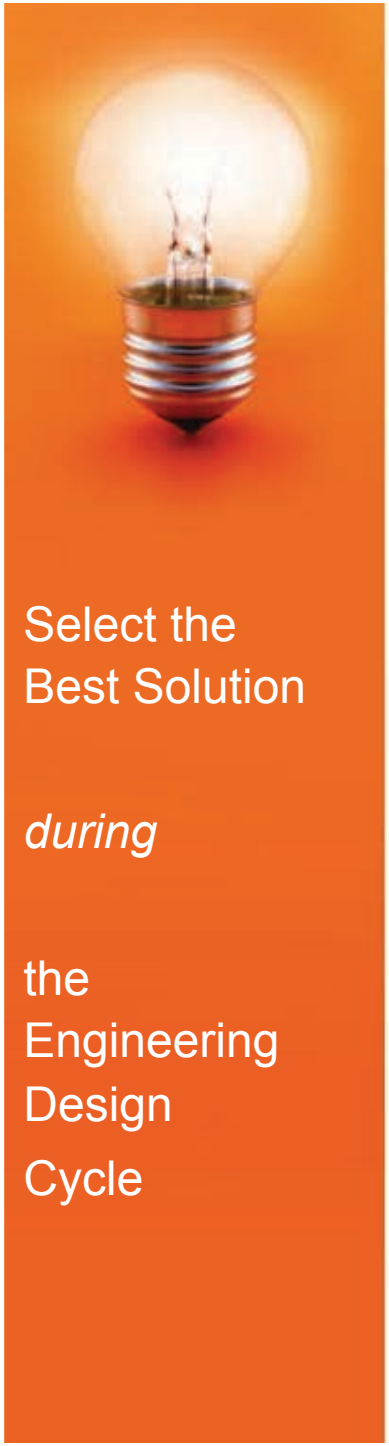
Objective Decision Making

Acknowledge your Biases in Design and in Decision Making!

- Do you resist stepping backward in the design process, even when it may be the best thing to do to avoid failure?
- Do you tend to pick the easiest solution?
- Do you pursue the most challenging solution?
- Do you (almost always) prefer incremental solutions?
- Do you automatically oppose the opinion/choices of certain others on your team?
- Are you prone to jumping ahead into the build and test phase of design because thinking about it is boring?
- Other biases?



Select the Best Solution

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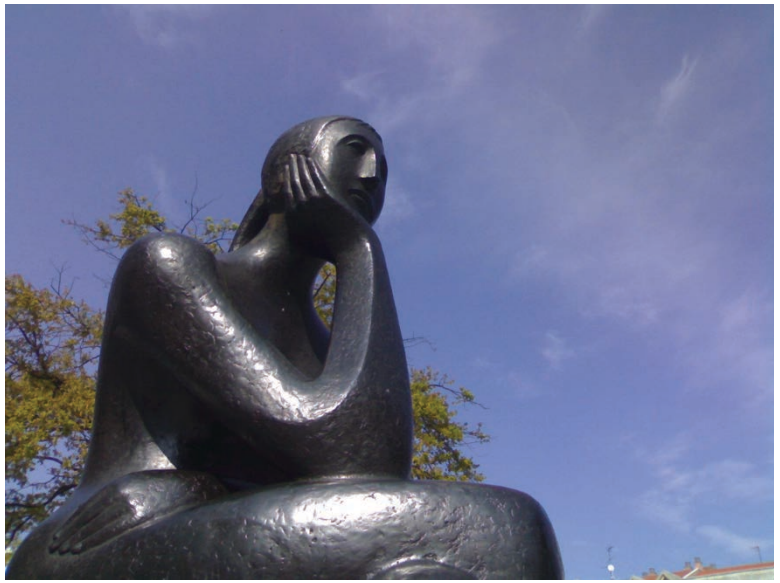
Objective Decision Making

Compensate for your Biases

- Imagine counseling a friend on the design choice
- Ask an outsider to evaluate your design choice
  - Those as or more knowledgeable than you
  - Those who know nothing about the design
- Strip the choice down to a smaller number of decision factors
- Use Reverse Line Thinking
  - What's the worst that can happen with one design choice over another?
  - How will the worst consequences change your future and livelihood?



Select the Best Solution

Select the Best Solution
using

1. Decision Matrices
    1. Design Specifications (Features)
    2. Design Specifications (Constraints)
2. SWOT Analysis
3. Other planning methods, as needed
4. Objective Decision Making